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COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 1.2.2002
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COMMISSION STAFF WORKING PAPER

REPORT OF THE SUBGROUP FISHERY AND ENVIRONMENT (SGFEN)

OF THE
SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES

DEEP-SEA FISHERIES

Brussels, 22-26 October 2001

This report has not yet been approved by the Scientific, Technical and Economic Committee for Fisheries and it does not necessarily reflect its view

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Chapter 1. Introduction. Terms of Reference.

The working group was asked to:

(1) Review and identify appropriate stock units for management of deep-sea fisheries

(2) Describe Community fisheries for deep-sea species in the Mediterranean and Antarctic areas, and in the North East Atlantic areas where new information is available.

(3) Compile and update the available data on species landings, species catch rates, discard rates and species and size composition of deep-water fisheries. Temporal trends by area and by species should be reported

(4) Identify sensitive marine habitats that might be affected by deep-sea fisheries.

(5) In the light of existing scientific evaluations indicate appropriate conservation measures for each stock unit in terms of:

   (a) Restrictions on use of fishing gear (trawl, static gear, type of gear, gear specifications, areas, seasons etc.)

   (b) Effort restrictions, with appropriate considerations of control measures

   (c) Appropriate catch levels.

(6) Identify technical interactions between fisheries for deep-sea species and species more traditionally fished on the continental shelf or on the upper part of the slope

(7) Indicate future research needs.

The NE Atlantic and the Mediterranean differ fundamentally both regarding deep-water /shelf areas and their fisheries. Also regarding the management problems and approaches to these the two sea areas differ very much. There are therefore treated separately in this report (A & B).

Due to lack of experts on EU fisheries in Antarctic waters, these fisheries are not dealt with in this report.

Chapters A.2 & B.2 (TOR item 1) provide overviews of the commercially important deep-water species both in the North-east Atlantic region (ICES region) and the Mediterranean. However, for the Mediterranean the coverage of the fisheries is only by the 4 member states Spain, France, Italy and Greece.

Chapter A.2 also gives overviews of the available biological criteria for defining stocks units associated with the species when possible. For the NE Atlantic only the stocks which are not included in the ICES regular assessments are further described here. The Commission has suggested 5 geographically determined management units for the deep-water species in the NE Atlantic. The Group has the view, that it is possible to identify potential management units on the basis of available information on stock structure, the geographical distribution of international landings of each species and the similarity of catch-rate trends (as an index of depletion) between ICES Sub-areas, and differences in fishing gear between fisheries. These management units are defined in terms of ICES areas. However, it is recognised that these areas may be somewhat imperfect.

For the Mediterranean The STECF group proposes four deep-water management areas: 1) The Western Mediterranean, 2) Central Western Mediterranean, 3) Eastern Central Mediterranean and 4) The Eastern Mediterranean. These management units are based on a bio-ecological point of view.

Chapters A.3 & B.3 (items 2 & 3 in TOR) give overviews of the current fisheries by country and major fleet in the various sub-areas. More detailed information on trends in landings is presented if available. In the NE Atlantic many of the long-line fisheries are long standing. The deep-water trawl fisheries have developed recently. A few of the line fisheries seem to be sustainable, but in general during the past 10-20 years most of the long-line fisheries have shown decreasing catch rates along with increasing mechanisation. For the deep-water trawl fisheries the typical development is a rapid increase in catches when a new resource is discovered followed by a decrease reflecting depletion of the resource. The trends in landings and CPUE for most deep-water fisheries currently indicate that fishing pressure is far beyond sustainability. Also data on discards and selectivity are presented in the report.

Many of the deep-water fisheries in the Mediterranean are characterised by fleets which frequently or even as a rule conduct fisheries both in the more shallow waters as well an in deep-waters (Chapter B.3). Even on a single fishing trip some vessels may wove between shallow and deep waters. Bottom trawl deep-water fisheries in the Mediterranean target Crustaceans such as Norway lobster and Red shrimps. A main target for the Mediterranean deep-water long-line fisheries is Hake. A special long-line fishery for the Six-gill shark is conducted in Aegean Sea. The catches of crustaceans species in the deep-water Mediterranean fisheries are relatively more important than in North-East Atlantic deep-water fisheries.

In general the official landings statistics are limited for the Mediterranean.

Chapters A.4 & B.4. (Item 4 in TOR) deal with sensitive areas/bottom communities.

In this chapter are short descriptions of the types of deep-water bottom communities for which there is evidence of changes due to fishing activities. For comparison, examples from Australian waters are also mentioned. From the NE Atlantic special attention is given to cold water coral communities, because the impact of trawl fisheries on this type of deep-water bottom communities already has been well documented in several cases. The group points out several bottom localities, also such which are not coral beds, which may be considered for special conservation measures.

In the Mediterranean both deep-water mud bottom communities and coral bottom communities are subject to impact of trawling. However, for the Mediterranean little has been documented on the impact of fishing on the mud bottom communities as most investigations have focused on the target species. However there are indications of changes in the species composition of the bottom fauna in locations with trawling both for mud bottoms and for coral beds.

Chapters A.5 & B.5 (Item 5 in TOR) list the various management measures ‘on the market’, i.e. technical measures, TAC regulation, effort regulation and, for some fisheries, moratoria. For the NE Atlantic the group recommends management measures based on some effort control of the various deep-water fisheries, most of which are mixed fisheries. It is furthermore the opinion of the group, that application of TACs for these mixed fisheries are not likely to be effective. Should the Commission proceed to introduce TACs, then these could only be regarded as ‘ad hoc’ emergency measures, until they can be replaced by effort-based management measures.

For the Mediterranean it is also concluded that TAC regulation of these fisheries would not be effective to control the exploitation rates. A number of more specific recommendations are presented.

Chapters A.6 & B.6 (item 6 in TOR) give examples of interactions between deep-water fisheries and shelf fisheries.

Chapters A.7 & B.7 (item 7 in TOR) list some areas of future research, as well as the current EU funded research related to deep-water fish resources and fisheries. In addition **Chapter 8** has a long list of references of various papers relevant to the topics of the report.

1. INTRODUCTION

1.1 List of participants.

CLARKE, Maurice
D'ONGHIA, Gianfranco
FARRUGIO, Henri
FIGUEIREDO, Ivone
GIL, Juan
GORDON, John
LARGE, Philip
LORANCE, Pascal
MASSUTÍ, Enric
MENEZES, Gui
MUNCH-PETERSEN, Sten (Chairman, member of STECF)
NEWTON, Andrew
PETRAKIS, George
SARDA, Francisco

STECF Secretariat

BIAGI, Franco (European Commission)

1.2 Terms of reference.

The subgroup was asked to address the following issues:

(1) Review and identify appropriate stock units for management of deep-sea fisheries

(2) Describe Community fisheries for deep-sea species in the Mediterranean and Antarctic areas, and in the North East Atlantic areas where new information is available.

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(7) Indicate future research needs.

1.3 Background for the meeting.

The background for this meeting is given in the 11th Report of the STECF Meeting, November 2000 (SEC (2001) 177). Here the STECF notes that:

"The EU has requested ICES for advice on management measures for the various deep sea fisheries. In particular to advise on the feasibility on application of :

- *TACs*
- *Geographical and/or temporal closures.*
- *Technical measures including regulation of mesh sizes , hook sizes and other gear structures.*
- *Effort limitation.*

ICES in its reply, points out that due to slow growth of deep sea species in general as well as low reproduction rates, the exploitation rate should be very low. Furthermore, in accordance with the 'Precautionary Approach', the exploitation rate should be maintained at a very low level, until more biological data on the various species are available. As an example ICES points out that in a fishery for a long lived species like Orange Roughy, the sustainable yield may be in order of 1-2 % of the virgin biomass.

ICES discusses a number of possible management measures including TACs and 'closed areas', but stresses that none of such measures be effective unless a strict and effective enforcement system is implemented. This should include satellite tracking of the vessels engaged in these fisheries. Specific log-books should be mandatory.

STECF agrees that additional management measures are required for deep-water resources. However, STECF stresses that applying TACs in the management of these fisheries will be problematic, since for these stocks there is a history of:

- *misreporting of catch levels, and of,*
- *misreporting of the species composition of the catches*

Such misreporting may complicate the allocation of TACs to member states and to individual species.

STECF also stresses that additional management measures are unlikely to be effective unless strict and effective enforcement is implemented. STECF advises that a comprehensive data collection system for these fisheries is required, if the status of these stocks is to be properly assessed.

STECF furthermore recommends that EU identify experts capable of looking further into the current problems concerning deep sea fisheries".

This STECF recommendation has resulted in the SG-FEN meeting on deep-sea fisheries in Community waters.

1.4 Deep-water areas, species and stocks considered in this report.

For the NE Atlantic area his group follows the definition by ICES (1998) of the term ‘deep-sea’ or ‘deep-water’ as to comprise waters of depth greater than around 400 m, even if some of the deep-water species also frequently are caught in more shallow waters. For the Mediterranean a clear definition of deep-water species and deep-water fisheries is even more difficult. Since no experts on Antarctic waters were available for this meeting, the fisheries in these waters have not been considered by the group.

Note that in this report the term ‘deep-sea’ has been used synonymously with the term ‘deep-water’, even if it in general has been agreed to reserve the term ‘deep-sea’ to depths beyond the shelf and slope (bathyal and abyssal areas of the oceans).

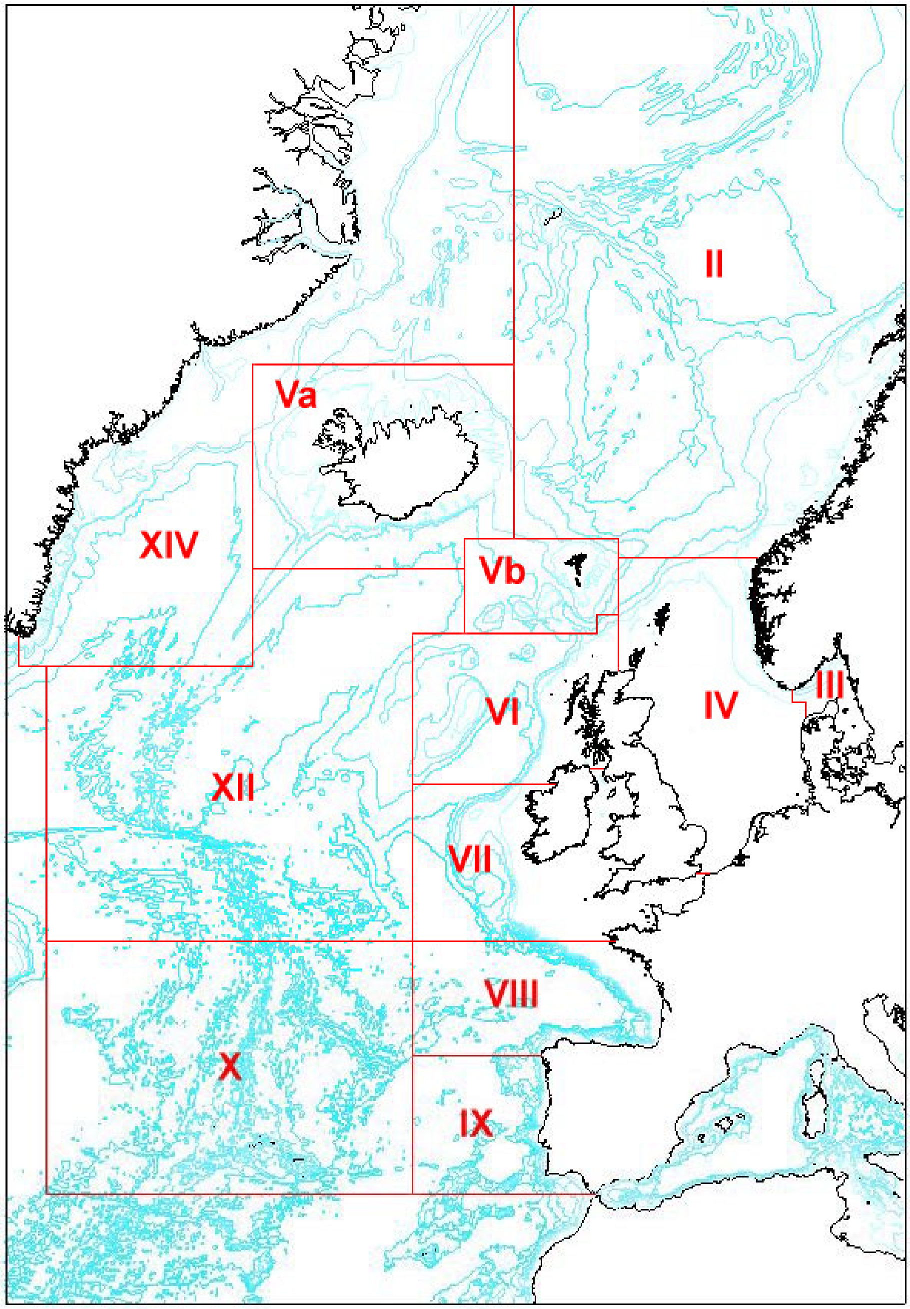


Fig A.2.1- The NE Atlantic with ICES sub-areas.

A.2 NORTH EAST ATLANTIC.

A.2.1 List of important species.

According to ICES (1998, 2000) the most important deep-sea species, which are landed by the fisheries in the NE Atlantic (see Fig. A.2.1), are the following:

Bony fishes

SMOOTHHEADS (ALEPOCEPHALIDAE)

Baird's Smoothhead (*Alepochephalus bairdii*)

ARGENTINES

Greater Silver Smelt *(Argentina silus)*

CONGER EELS (CONGRIDAE)

Conger eel *(Conger conger)*

DEEP-SEA CODS (MORIDAE)

Mora *(Mora moro)*

CODS (GADIDAE)

*Blue whiting, *(Micromesistius poutassou)*

Blue ling (M*olva dypterygia)*

Ling *(Molva molva)*

Tusk *(Brosme brosme)*

Greater forkbeard (*Phycis blennoides*)

GRENADIERS (MACROURIDAE)

Roughhead grenadier *(Macrourus berglax)*

Roundnose grenadier *(Coryphaenoides rupestris)*

ALFONSINOS (BERYCIDAE)

Red bream, Alfonsino(*Beryx decadactylus*)

Golden eye perch (*Beryx splendens*)

ROUGHIES, SOLDIER FISHES (TRACHICTHYIDAE)

Orange roughy (*Hoplostethus atlanticus*)

CARDINAL FISHES (APOGONIDAE)

Black (=Deep water) Cardinal fish (*Epigonus telescopus*)

SEA PERCHES (SERRANIDAE)

Wreckfish *(Polyprion americanus)*

SEABREAMS, PORGIES (SPARIDAE)

Red (=Blackspot) seabream (*Pagellus bogaraveo*)

SCABBARDFISH, HAIRTAILS (TRICHIURIDAE)

Black scabbardfish (*Aphanopus carbo*)

Silver scabbardfish *(Lepidopus caudatus)*

REDFISHES (SCORPAENIDAE)

*Redfish, Golden redfish *(Sebastes marinus)*

*Deep-water redfish *(Sebastes mentella)*

Bluemouth *(Helicolenus dactylopterus)*

Deep-sea Scorpionfish *(Trachyscorpia cristulata echinata)*

FLOUNDERS (PLEURONECTIDAE)

*Greenland halibut *(Reinhardtius hippoglossoides)*

*Megrim *(Lepidorhombus whiffiagonis)*

*Fourspot Megrim *(Lepidorhombus boscii)*

ANGLERFISHES (LOPHIIDAE)

*Anglerfish *(Lophius piscatorius)*

*Black Anglerfish *(Lophius budegassa)*

Sharks and rays.

SPURDOGS (SQUALIDAE)

Gulper shark *(Centrophorus granulosus)*

Leafscale gulper shark *(Centrophorus squamosus)*

Velvetbelly *(Etmopterus spinax)*

Great lantern shark *(Etmopterus princeps)*

Black dogfish (Centroscyllium fabricii)

Portuguese dogfish *(Centroscyllium coelolepis)*

Longnose velvet dogfish *(Centroscymnus crepidater)*

Kitefin shark *(Dalatias licha)*

Birdbeak dogfish *(Deania calceus)*

Knifetooth dogfish *(Scymnodon ringens)*

RATFISHES, RABBITFISHES (CHIMAERIDS)

Ratfish, Rabbitfish *(Chimaera monstrosa)*

Crustaceans

RED SHRIMPS (ARISTAEIDAE)

Giant red shrimp *(Aristaeomorpha foliacea)*

RED CRABS (GERYONIDAE)

Red crab *(Chaecon (Geryon) affinis)*

The species with an asterix (*), i.e. the Redfish species *Sebastes marinus*, *S. mentella*, Greenland halibut, *Reinhardtius hippoglossoides*, and the Blue whiting, *Micromesistius poutassou*, are already subject to special management advice by ICES and NAFO and are not considered further here. Also the two Anglerfish species (*Lophius piscatorius* and *L. budegassa* may be classified as a deep-sea species as well as the two Megrim species (*Lepidorhombus whiffiagonis* and *L. boscii*), but since they also are taken in more shallow waters and because ICES already provides management advice for the stocks of Anglerfish, they have also been omitted from further consideration in this report.

A.2.2 Stock identification.

A.2.2.1 Introduction

There have been very few studies of the stock-structure of deep-water fish species in the ICES area (ICES, 2000a, Menezes *et al*., 2001, Large et al., 2001). For assessment purposes, stock units have been defined on the basis of current knowledge of species distribution and similarity of observed catch-rate trends between ICES areas (ICES, 1998). Thus, stock units are currently individual or groups of ICES Sub-areas or occasionally ICES Divisions. This is not ideal because these ICES statistical areas were devised for the continental shelf and are, in many instances, inappropriate for deep-water fisheries (Coggan, 1997). For example, ICES Sub-area VI is divided into two Divisions. Division VIa covers the shelf along the continental margin and VIb the Rockall Plateau (Figure 00). Division VIa, however, includes both the Rockall Trough and a part of the Faroe-Shetland Channel. The deep-water fish faunas of these two areas have little in common (Gordon, 2001). Division VIb extends westwards from the Rockall Plateau and is contiguous with Sub-area XII at longitude 18°W and in doing so bisects the Hatton Bank, which has a rapidly developing deep-water fishery, which is in international waters. Sub-area XII covers a vast area of the northeastern Atlantic that includes large parts of the Mid-Atlantic and Reykjanes Ridges. Whilst it may be reasonable to assume a stock separation between the slopes of the Rockall Trough and Mid-Atlantic Ridges, the Hatton Bank probably has more affinity with the Rockall area. However, a proportion of the landings from Sub-area XII cannot be readily attributed to the Hatton Bank and are therefore excluded by the ICES Study Group from the assessments of the Rockall area. While it would be desirable to reconfigure some existing ICES areas so that they are biologically meaningful in terms of the distribution of deep-water species as suggested by Coggan (1997)it is unlikely that this will be a viable option in the short term.

A.2.2.2 Categories of Deep-water species

Following Koslow (1996) two different categories of deep water species can be defined:

- widespread species that occur at relativity low density in almost any location of their geographical distribution. The roundnose grenadier (*C. rupestris*) is a typical species of this category ;

- seamount (or other topographic or hydrographic feature) associated species that form dense aggregations in some particular habitats or at some time and have a very low density elsewhere.

In addition to their distribution pattern, at least, some "seamount associated" species have a different metabolism in consequence of adaptation to a particular life strategy, which allows for high local fish density in the food-limited deep-water environment. The aggregating characteristic of these species make them particularly vulnerable to fishing as high catch rates can be obtained from very small populations. Local aggregations can be fished down. In order to prevent the depletion of local populations, the proper management of such species should be at "seamount" scale. It is unlikely that each seamount is an independent genetic population as exchanges may occur in the larval, juveniles, adults or all stages.

However, from a demographic point of view, the likely low rate of exchange could explain the observed local depletion. For orange roughy, the fishery collapsed in Sub-area VI and not in VII (Lorance and Dupouy, 2001, ICES 2000b, Basson et al. in press). For blue ling, a spawning aggregation to the south of Iceland depleted in the early 1980s showed no sign of recovery 15 years later (Magnusson *et al.* 1997). The recovery from such local depletion, if not prevented by habitat alteration, may be a long process due to low recruitment of these species and their slow growth. For these species, maintaining the productivity of the whole stock probably requires each local aggregation to be kept at an adequate level.

A.2.2.3 Species/stock account

At the species level the ICES Working Group on the application of genetics in fisheries and mariculture provided an overview of available knowledge on stock identity of deep-water species in the ICES Area (ICES 2000a). One of the recommendations was that studies into the genetic identity of deep-water stocks should also be expanded.

Greater Silver Smelt (*Argentina silus*)

The following account is from the 1998 report of ICES SGDEEP. Icelandic life history studies suggest that a separate stock might exist in Sub-area Va. Irish investigations on stock discrimination in areas VI and VII are inconclusive. A study by Ronan *et al.* (1993), using morphometrics (box truss analysis) and meristic measurements, suggests that populations from the north of Sub-area VI and the south of Sub-area VII form either end of a shape cline with fish in intermediary populations exhibiting a mixture of northern and southern morphologies. Norwegian investigations in 1984–1987 in Divisions IIa, IIIa and IVa appear to show two separate populations in the winter but in the summer the species is widely distributed (Bergstad, 1993).

Ling (*Molva molva*)

The following summary is from the reports of ICES Study Group on the Biology and Assessment of Deep-sea Fishery Resources (ICES; 1998, 2000b). The relevant information on stock structure has been discussed in reports of Norwegian and Nordic projects (Bergstad and Hareide 1996; Magnússon *et al.* 1997). Ripening adult ling and ling eggs have been found in all parts of the distribution area of the ling, but the banks to the west and north of Scotland and around Iceland and the Faroes seem to be the most important spawning areas. There may well be egg and larval drift among all these areas, probably with a net northward and eastward transport. Nothing is known about subsequent migrations within the area of distribution. In recent Norwegian studies of enzyme and haemoglobin frequencies, characters with sufficient variation to study spatial differences could not be found (Bergstad and Hareide 1996). There is currently no evidence of genetically distinct populations within the ICES area. However, ling at widely separated fishing grounds may still be sufficiently isolated to be considered management units, i.e., stocks, between which exchange of individuals is limited and has little effect on the structure and dynamics of each unit. Since no quantitative data on migration exist, it is however, unclear which of the many fishing areas have units satisfying the criteria of stocks. It is tentatively suggested that Iceland (Va), the Norwegian Coast (II), and the Faroes and Faroe Bank (Vb) have separate stocks, but that the existence of distinguishable stocks along the continental shelf west and north of the

British Isles and the northern North Sea (Sub-areas IV, VI, VII and VIII) is less probable.

Blue ling (*Molva dypterygia)*

The species identity of blue ling has for long been subject to debate, two forms (*dypterygia* and *macrophthalma*) having been considered as different species or as sub-species of the same *Molva dypterygia*. They now have been defined as two species (http://www.fishbase.org) and the southern limit of *M. dypterygia* is expected to be around 51°N (Ehrich, 1983). Further south, the species *M. macrophthalma* is distributed in the Bay of Biscay, off Spain and Portugal and in the Mediterranean. In contrast to *M. dypterygia* it is not known to form dense spawning aggregations and is it not a target of any fishery. Thus, Sub-area VII appears to be the southern limit of the distribution of the blue ling (*M. dypterygia*) population(s).

Biological investigations in the early 1980s suggested that at least two adult stock components were found within the area, a northern one in Sub-area XIV and Division Va with a small component in Vb, and a southern one in Sub-area VI and adjacent waters in Division Vb. However, the observations of spawning aggregations in each of these areas and elsewhere suggest further stock separation. This is supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larval data from early studies also suggest the existence of many spawning grounds. The conclusion must be that the stock structure is uncertain within the areas under consideration. However, ICES SGDEEP, considered that because there were similar trends in the CPUE series from Division Vb and Sub-areas VI and VII, the blue ling from these areas could be treated as one unit (ICES 2000b).

Tusk (*Brosme brosme*)

Ripening adult tusk and tusk eggs have been found in all parts of the distribution area, but the banks to the west and north of Scotland, around the Faroes and off Iceland, as well as the shelf edge along mid and north Norway seem to be the most important spawning areas (Magnússon *et al.* 1997). Nothing is known about migrations within the area of distribution. In recent Norwegian studies of enzyme and haemoglobin frequencies no geographical structure could be found, hence it was concluded that tusk in all areas, at least of the North-east Atlantic, belong to the same gene pool (Bergstad and Hareide, 1996). ICES SGDEEP considered hat the widely separated fishing grounds may support separate management units, i.e., stocks. It is tentatively suggested that Iceland (Va) and the Norwegian coast (I and II) have self-contained units, while the separation among possibly several stocks to the north and west of the British Isles is less clear (ICES 2000b).

Roundnose grenadier (*Coryphaenoides rupestris*)

When the North Atlantic fishery for roundnose grenadier began in the late 1960s it was found that the fish from the western Atlantic were small and immature. On the other hand fish caught off southeast Iceland were large and mature. This led Russian scientists to propose that the waters off the Canadian and Greenland were the nursery and feeding grounds for the roundnose grenadier and the area from which the grown fish migrate to Iceland where they spawn. The eggs and larvae would then drift back to the nursery grounds with the prevailing currents. There have been various refinements of this hypothesis over the years and differences in the frequency of parasites and enzyme polymorphisms of fish from different areas have been cited as evidence for such a migration. Large, mature roundnose grenadier are now known to occur in waters deeper than those exploited by commercial trawlers off Canada and therefore there is no longer a need to propose such a migration. As for the migration hypothesis, parasitological and genetic evidence has been used to support the idea of separate stocks. The subject of stock identification in roundnose grenadier is likely to remain controversial until the genetic polymorphisms of a sufficiently large number of fish can be studied (Gordon and Hunter, 1994).

ICES SGDEEP considered that roundnose grenadier in Sub-areas II (Norwegian fjords) and III (Skagerrak) may represent separate stock(s) due to the physical boundary of the Wyville Thomson Ridge and fjord sills. For other populations, the stock structure remains unclear. Some preliminary evidence to support this view results from a study of otolith microchemistry (Gordon et al.,2001). The Study Group carried out assessment for Division Vb and Sub areas VI and VII combined implicitly considering these areas as a stock unit for this species. Sub-area XII was not included because catches in that area include catches from the Mid-Atlantic ridge and from the Western part of Hatton Bank. They cannot be re-allocated properly to each of these areas which are likely to support rather separated stocks units. Moreover, catches in Sub-area XII are likely to be significantly under-reported.

Roughhead grenadier (*Macrourus berglax*)

A study on the genetics of the stocks of *Macrourus berglax* in three areas (West Greenland, East Greenland and the Norwegian Sea) provided strong evidence that the roughhead grenadier population in the North Atlantic was not a single panmictic stock but was composed of stock units with their own gene pools (Katsarou and Naevdal, 2001).

Alfonsinos/golden eye perch (*Beryx splendens*)

The genetics of Beryx splendens was studied by (Hoarau and Borsa, 2000). They concluded that there was no evidence for spatial genetic variation (stock differentiation) within geographic regions for this species. They found little genetic variation between populations located in the Atlantic and Pacific. However, Menezes et al.(2001) point out that only four samples were obtained from the Atlantic, and consider the Pacific and Atlantic populations to be strongly differentiated. They conclude that there is probably a higher degree of genetic differentiation between oceans than previously thought. However, within the Azorean region the results were inconclusive and requires a better level of sampling.

Orange roughy (*Hoplostethus atlanticus*)

The genetics and orange roughy on a global scale have recently been reviewed by Branch (in press). These studies, which are almost entirely based on the southern hemisphere, have produced equivocal results. Those that have focused on environmental characteristics depend on the surroundings of the fish during its life and have generally found differences between stocks. Examples are otolith microchemistry, otolith structure, morphometric differences and parasite analysis which have found significant differences among virtually every stock examined. The mean radius of the transition zone in orange roughy otoliths differed among New Zealand populations and these differed from Namibian and Hatton Bank (west of the British Isles) populations (Horn *et al*. 1998). All of these studies suggest that adult orange roughy are relatively sedentary, and that stocks are fairly isolated from one another.

Genetic studies have generally failed to discriminate between stocks. Restriction site analysis of mitochondrial DNA has been used with the most success to distinguish stocks at a global scale eg. between Pacific and Atlantic. Branch (in press) considers that "genetic data may have poor discriminatory power because of the extreme longevity (> 100 y) of orange roughy, which has two important consequences. First, genetic changes accumulate very slowly in long-lived species, and second, the number of migrants per year need only be extremely small to allow genetic divergence".

Wreck fish (*Polyprion americanus*)

Wreckfish have a broad disjunct geographic distribution; juveniles are very rare in the western Atlantic but are common in the eastern Atlantic. There is also a different bathymetric distribution, juveniles are pelagic up to a length of 60cm and it is uncertain where and at what size they descend to bottom.

Studies of reproduction indicate that spawning occurs off the South Carolina, and unexploited stages are then dispersed to the eastern Atlantic via the Gulf Stream. Strong evidences on population structures of Blake Plateau, Azores, Madeira also supports this dispersion pattern cycle, moreover some doubts persists on the existence of a resident spawning population in the eastern Atlantic. Genetics studies based on data from Blake Plateau, Azores, Madeira; Mallorca and some other South Atlantic and Pacific areas indicated three composite types with a clear separation between northern and southern hemispheres. Genetic similarity between eastern and western Atlantic fish indicated gene flow between the Blake Plateau Azores, Madeira and the Mediterranean (Sedberry, et al.1999).

Red (blackspot) seabream, (*Pagellus bogaraveo*)

Information on red (blackspot) seabream, *P. bogaraveo*, has been split into three different components, as referred to in the 1996 and 1998 reports of SGDEEP (ICES1996,1998):

- *P. bogaraveo* in Sub-areas VI, VII and VIII
- *P. bogaraveo* in Sub-area IX
- *P. bogaraveo* in Sub-area X (Azores region)

This separation does not pre-suppose that there are three different stocks of *P. bogaraveo*, but it offers a better way of recording the available information. In fact, the inter-relationships of the red seabream from the Sub-areas VI, VII, VIII and the northern part of Division IXa, and their migratory movements within these sea areas have been confirmed in the past by tagging methods (Gueguen, 1974; ICES, 1996). A recent genetic study on red sea bream at the Azores considered that the populations in area could be considered as a single stock. There was evidence of small gene flow between the Azores and the Portuguese mainland (Menezes et al., 2001, Stockley et al.,2000)

Tagging of mature red seabream has been carried out in the Azores and the Strait of Gibraltar and recoveries indicate that there were no important movements. However, juveniles tagged in the southern Mediterranean region moved to the Strait of Gibraltar. A few fish moved from the Strait of Gibraltar to the Mediterranean. This suggests an important link between Spanish South Atlantic and the Mediterranean red seabream populations.

Black Scabbardfish (*Aphanopus carbo*)

Research into stock discrimination was carried out during the BASBLACK EC Study Contract (Anon 2000) The working hypothesis is that there is one stock extending from Faroe Islands to Madeira. The study involved genetics (DNA) and otolith micro-chemistry. Some genetic polymorphisms were identified but the results were inconclusive. The results of the whole otolith microchemistry were not conclusive (Swan et al., 2001). Some of the results from BASBLACK, namely length distribution and reproductive behaviour, are suggestive of migratory processes of components of the population.

Bluemouth (*Helicolenus dactylopterus*)

The genetic variation in the family Scorpaenidae was studied by Johansen et.al.(1993). The samples of blue mouth were collected around Shetland and the Faroe Islands in 1990 and analysed by starch gel electrophoresis and isoelectric focusing of haemoglobin and tissue enzymes. Intraspecific variation was low in blue mouth.

Recent and preliminary data from tagging/recapture experiments of this species made in several and sparse places in the Azores indicate no movements and a very sedentary behaviour. This could suggest the existence of separated populations in the North Atlantic that may be related to topographical barriers.

Deep-water sharks.

There is little information on stock identification in deep-water sharks, rays or chimaeras. Few genetic studies have been carried on deep-water chondrichthyans. One study considered the quantitative genetics of vertebrae and dorsal finspines in the velvet belly shark *Etmopterus spinax* (Tave, 1984). However there are some data that support the view that deep-water sharks are highly migratory. Clark and King (1989) found that smallest *Deania calceus* associated with large females in waters to about 800 m, and a progressive increase in their numbers moving west to east around North Island New Zealand indicating a cyclical migration around the north island. In addition it may be likely that breeding aggregations are localised, as suggested by Clark and King (1989). The continental slopes of Portugal are populated by *Deania calceus* of smaller size (Machado and Figueiredo, 2000) than those present west of Ireland or Scotland (Clarke et al. 2001). Gravid female *Centrophorus squamosus* have been recorded in Madeira and Portugal. However there are no records of any gravid females from west of Ireland or Scotland despite intensive sampling (Girard and Du Buit, 1999), where less than 15 % of female *Centrophorus squamosus* were mature. This may indicate a north-south migration in this species, similar to that known to occur off southern Japan.

Deep-water crustaceans.

Little is known about the stock structure of deep-water crustaceans

A.2.3 Identification of management units in NE Atlantic.

The Commission has suggested that appropriate geographic areas for managing deep-water species might be the 5 following:

1. The Northern North Sea
2. The Skagerrak
3. Western waters from the Arctic to the west of Ireland
4. Western Approaches and the Bay of Biscay
5. Iberian peninsula, Azores and Madeira

The Group feel that these units are somewhat arbitrary and take little account of differences in geographical distribution between species and other information available. Although it is widely recognised that information on the stock structure of commercially important deep-water species in the NE Atlantic is sparse (see above), the Group has the view, that it is possible to identify potential management units on the basis of available information on stock structure, the geographical distribution of international landings of each species and the similarity of catch-rate trends (as an index of depletion) between ICES Sub-areas, and differences in fishing gear between fisheries. These management units (**see figures in Appendix 1**) are defined in terms of ICES areas. It is recognised that these areas may be somewhat imperfect. New and developing fisheries are treated separately in the latest ICES advice on deep-water stocks (Anon., 2001), and this has also been taken into account in the proposed management units. ICES areas where landings are small (< 100 tonnes per annum) have been excluded. The Group suggest that fishing effort/TACs in these areas should be set at a nominally low level, firstly to avoid mis-reporting and, secondly, to prevent the rapid development of unsustainable fisheries. It is emphasised that the proposed management areas may require refining as and when further information on stock structure and migration pathways become available.

The ICES sub-areas constituting the proposed new management units for each of the species mentioned below are indicated with Roman numerals.

<u>Greater Silver Smelt</u>

The majority of landings are taken from off the Norwegian Coast, the Skaggerak, northern North Sea, Iceland, Faroes, the west of Scotland/Rockall Trough and the west of Ireland/Westem Approaches. Very little is known about the stock structure of this species. Available information suggests that separate stocks may exist at Iceland, off the Norwegian coast, northern North Sea/west of Scotland/Rockall Trough/west of Ireland/Western Approaches, and in the Skagerrak. These areas should form the basis of management units.

Proposed management units:-
1. IIa
2. IIIa
3. Va

4. IVa, Vb, VI and VII (excl.VIIa,f,g,d,e)

Ling

Ling is widely distributed on the continental shelf and in deep-water down to around 800m. Substantial landings are made from most ICES areas north of the Iberian Peninsula. Although there is no evidence of genetically distinct populations, geographically separated fishing grounds may still be sufficiently isolated to be

considered as separate management units. It has been suggested that separate stocks may

be found at Iceland (Va), the Norwegian Coast (IIa) and at the Faroes (Vb). These should be treated as separate management units. The existence of separate stocks in the North Sea, west of Scotland, west of Ireland and western Approaches, Biscay and off the Portuguese coast is, however, less probable. These areas, with the exception of the North Sea, should be treated as a single management unit. There may be management reasons for keeping the North Sea and the Skagerrak separate.

Proposed management units:-
1. I and IIa
2. IIIa
3. IV
4. Va
5. Vb
6. VI, VII & VIII

Blue ling

The majority of landings are from the Norwegian coast (II), Iceland (Va), Faroes (Vb), west of Scotland and Rockall Trough (VI) and the Mid-Atlantic Ridge and Hatton Bank (XII). Landings from the west of Ireland and Western Approaches (VII) and further south are very small and may also comprise a separate species (see above). Studies in the 1980s suggest the presence of at least two adult stock components in the ICES area, a northern one at Iceland, west of Greenland (XIV) and a small component at the Faroes, and a southern component to the west of Scotland, at Rockall Trough and adjacent waters to the Faroes. However, observations of separate spawning aggregations within these areas and elsewhere may suggest further stock separation. Assessments carried out at WGDEEP treat the Faroes, west of Scotland, Rockall Trough and the Western Approaches as a single assessment unit and these areas, with the exception of the Faroes, should be treated as a single management unit. Spawning concentrations are found off the Faroes and these may be subjected to sequential depletion. It is suggested that this area be managed separately. Available knowledge, although sparse, suggests that the Mid-Atlantic Ridge and Hatton Bank (a developing fishery), Iceland and the northern North Sea/Norwegian coast/Svalbard(Spitsbergen) should also be treated as separate management units.

Proposed management units:-
1. II and IVa
2. Va

3. Vb
4. VI and VII
5. XII

Tusk

This species is also widely distributed on the continental shelf and at depths down to 800m. It has been suggested that separate stocks may be found at Iceland and off the Norwegian Coast. Stock structure to the north and west of the British Isles is unclear. Tusk is not taken in any quantity in Biscay or further south, and landings from the west of Ireland and the Western Approaches are relatively small. A possible way forward may be to treat the Faroes, west of Scotland/Rockall Trough and the west of Ireland/Western Approaches as a single management unit and have separate management units for Iceland, the Norwegian Coast/Barents Sea, North Sea, and Skagerrak. Landings from the Mid-Atlantic Ridge and Hatton Bank (XII) are currently small, but there may be the potential for a developing fishery here. This area should be treated as a separate management unit.

Proposed management units:-
1. I and IIa
2. IIIa
3. IV
4. Va
5. Vb, VI, VII
6. XII

Greater forkbeard

The majority of landings are from the west of Scotland/Rockall Trough, west of Ireland/Western Approaches, Biscay and off the Portuguese Coast. Landings from some areas also contain Mora. Very little is known about stock structure for greater forkbeard, and it is suggested that this species be managed by ICES Sub-area.

Proposed management units:-
1. VI
2. VII
3. VIII
4. IX
5. X
6. XII

Roundnose grenadier

The majority of international landings are from the Skagerrak (III), Faroes (Vb), west of Scotland and Rockall Trough (VI), west of Ireland and Western Approaches (VII) and the Mid-Atlantic ridge and western Hatton Bank (XII). Catches from Biscay (VIII) and further south are minimal. Although very little is known about the stock structure of this species, there is some evidence that there may be a separate stock in the Skagerrak. Catches from the Mid-Atlantic Ridge and Hatton Bank may be from separate stocks to the west (on the Mid-Atlantic Ridge) and the east (Hatton Bank). For assessment purposes, the Faroes, west of Scotland and Ireland and the western approaches are currently treated as a single stock and these areas should also be treated as a single management unit. Given concerns that catches from the Mid-Atlantic Ridge and Hatton Bank are possibly from two stocks and are also suspected to be significantly under-reported by non-EU countries, there may be good management reasons for treating this area as a separate management unit for this species. There is a localised fishery for roundnose grenadier in the Skagerrak and it is proposed that this be treated as a separate management unit. There is the potential for a new fishery for this species in waters off the Azores and therefore Sub-area X should also be treated as a separate management unit.

Proposed management units:-
1. IIIa
2. Vb,VI and VII(excl.VIIa,f,g,d,e)
3. X
4. XII

Alfonsino (*Beryx splendens* and *Beryx decadactylus*)

Very little is known about the stock structure of these species. Landings in the ICES area are quite small and are generally from more southern areas. These species are frequently found in small aggregations, often associated with topographical features. There is a strong scientific case for managing this species by individual ICES Sub-area.

Proposed management units:-
1. VII(excl.VIIa,f,g,d,e)
2. VIII
3. IX
4. X
5. XII
6. Madeira

Orange roughy

Substantial catches are/have been taken to the west of Scotland and Rockall Trough (VI), west of Ireland and Western Approaches (VII) and the Mid-Atlantic Ridge and Hatton Bank (XII). This species is found in localised aggregations, often associated with seamounts and other topographical features. It is not known if these are independent populations. The fishery to the west of Scotland and in the Rockall trough has almost collapsed and that to the west of Ireland and in the Western Approaches appears to be heading in a similar direction. The latter is thought to be sustained at a low level by the sequential discovery and depletion of new populations. The fishery on the Mid-Atlantic Ridge and Hatton Bank has developed in the last 4-5 years. There is a strong scientific case for managing this species by individual ICES Sub-area.

Proposed management units:-
1. VI
2. VII(excl.VIIa,f,g,d,e)
3. XII
4. X

Wreckfish

While the majority of international landings are from Sub-areas IX and X, there are also some from VI and VII. At the Mid-Atlantic Ridge (ICES sub-area X) there is information of captures of this species by 'Third Countries' and unfortunately there is no information about these catches. Landings from other ICES areas are negligible.

Proposed management units:-
1. IX & X
2. Madeira

Red (Blackspot) Seabream

Available information suggests that separate stocks may exist at west of Scotland/Rockall Trough/west of Ireland/Western Approaches/Biscay, off the Portuguese Coast, and at the Azores. These areas should form the basis of management units.

Proposed management units:-
1. VI,VII(excl.VIIa,f,g,d,e),
2. VIII
3. IX
4. X

Black scabbardfish

This species is widely distributed and substantial catches are taken to the west of Scotland and Rockall Trough (VI), west of Ireland and the Western Approaches (VII), off the Portuguese coast (IX) and off Madeira. It has been suggested that there is a single stock in ICES waters, however available evidence is inconclusive. Current assessments treat, firstly, Iceland, the Faroes, west of Scotland, Rockall Trough, west of Ireland, Western Approaches, Mid-Atlantic Ridge and Hatton Bank and, secondly, waters off the Portuguese coast as a single stocks and these areas should be treated as separate management units. There are also differences in the fishing gear used in the these units. Fisheries in the former are predominantly trawl fisheries, whilst traditional long-line fisheries occur in a restricted area (Sesimbra) off the Portuguese coast. Recorded landings from the Mid-Atlantic Ridge/Hatton Bank and from waters around the Azores are currently small, but there is a case for managing these developing fisheries separately. There is a long-standing fishery fishery off Madeira and this should be treated as a separate management unit.

Proposed management units:-
1. V, VI, VII(excl.VIIa,f,g,d,e)
2. IX
3. X
4. XII
5. Madeira

Deep-water sharks

Very little is known about the stock structure of deep-water sharks. It is possible that these species, in common with other sharks, range over wide areas. The main species taken at Iceland (Va), to the west of Scotland and in the Rockall Trough (VI) and west of Ireland and Western Approaches (VII) are Portuguese dogfish *(Centroscymnus coelolepis)* and the leafscale gulper shark *(Centrophorus squamosus).* These species are also important components in shark landings from Biscay (VIII) and off the Portuguese coast (IX). The identification of deep-water shark landings by species is slowly improving and the Group feel that it should be possible to manage these two species separately. The fishery for these two species off the Portuguese coast and developing fisheries on the Mid-Atlantic Ridge and Hatton Bank (XII), off the Azores (X) and off Madeira should be treated as separate management units.

The Group proposes that all other species of shark should be treated as a generic species group, and be managed by similar areas as described above. This should be seen as an interim measure and should be reviewed as and when landings data by species become available on a wider basis than at present. The only exception is *Dalatias licha* in Sub-area X (Azores), for which landings data are available for a localised fishery. The Group proposes that this be treated as a separate management unit. The group notes that some other squalid sharks, *Centroscymnus crepidater, Centroscyllium fabricii* are beginning to be landed from Sub-areas VI and VII.

Proposed management units:

***Centroscymnus coelolepis*:**

1. V, VI, VII(excl.VIIa,f,g,d,e), VIII
2. IX
3. X
4. XII
5. Madeira

Centrophorus squamosus

1. V, VI, VI(excl.VIIa,f,g,d,e)I, VIII
2. IX
3. X
4. XII
5. Madeira

Dalatias licha

X

All other shark species combined

1. V, VI, VII(excl.VIIa,f,g,d,e), VIII
2. IX
3. 3.X4
4. XII
5. XIV 6.
6. Madeira

A.3 FISHERIES IN THE NORTH EAST ATLANTIC.

A.3.1 Total landings.

Table A.3.1 gives the available landings figures for the considered deep-water species/species groups for the recent 10 years. Total reported landings have been fluctuating between 100000 and 200000 tons. It also appears from the table that on the average more than 50% of total landings come from the two ling species and tusk.

For comparison, total landings of Blue whiting in recent years amounted to more than 1 mill. tons and total landings of Redfish to around 200000 tons.

Table A.3.2 gives the landings by ICES area and Table A.5.1 gives the means of in official landings for three reference periods by the management units defined in Sect. A.2.3. It is seen that for for many species, e.g. Orange roughy, there are distinct trends with time in the landings, which may reflect either drastic changes in effort or in the state of the stock.

For most species the annual catches for the time periods considered are extremely variable with high coefficients of variation (CVs), see Table A5.1. Note the high CVs of the mean landings of most species from V,VI, VII. These data indicate that the mean landings from this management unit , either because of change in fishing effort or drastic changes in the stock or both, certainly are poor indicators of the recent stock situation. Only in the case of the Black scabbard fishery in VIII and IX, where the CVs are low, could the recorded landings reflect a more stable state of the stock.

A.3.2 Overview of current deep-water fisheries.

The most recent description of the various fisheries in the in the NE Atlantic presented below is taken from Gordon et al. (2001) Their account in turn is mainly based on the two quoted reports of ICES WG on the Biology and Assessment of Deep-Sea Fisheries Resources (ICES, 2000a, 2001a). In the NAFO symposium paper (Sept. 2001) by Large et al., (2001) a short overview of the development of the deep-sea fisheries in the ICES area is presented.

Below is presented the information on the fisheries as has been presented in the 2000 and 2001 reports of the ICES WG on The Biology and Assessment of the Deep-sea Fisheries Resources and further updated by Gordon et al. (2001)

ICES Sub-area II.

Sub-area II comprises the slope waters of western and northern Norway and Svalbard, where there are directed longline fisheries for ling and tusk, and trawl, longline and gillnet fisheries for redfish and Greenland halibut . There is also a directed bottom and pelagic trawl fishery for greater silver smelt or argentine (*Argentina silus)* (Johannessen and Monstad, 2001). In some fjords there are minor trawl fisheries for roundnose grenadier (*Coryphaenoides rupestris*) (EC Deep-fisheries Project: Gordon, 1999a). Roughhead grenadier (*Macrourus berglax*) is taken as by-catch in the trawl, gillnet and

Table A.3.1. Total landings (tons) of deep-sea fish in the North East Atlantic (ICES areas), 1991-2000.

	Year									
Species, Species group	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
ALFONSINOS (*Beryx spp.*)	371	464	729	1508	711	802	1143	578	460	277
ARGENTINES (*Argentina silus*)	15799	20675	15089	15233	28181	24825	26285	45564	32964	28094
BLACK SCABBARDFISH (*Aphanopus carbo*)	7056	8740	9475	7530	7979	8149	6825	5563	5443	5788
BLUE LING (*Molva dypterigia*)	10452	11763	14100	8031	8076	9530	12054	12107	17274	13489
GREATER FORKBEARD (*Phycis blennoides*)	2045	2128	2030	2041	2609	4118	2742	3764	4264	3095
LING (*Molva molva*)	30203	27951	29307	26745	29088	29761	45088	54992	44142	33809
MORIDAE	6	25	0	0	83	52	120	42	114	49
ORANGE ROUGHY (*Hoplostethus atlanticus*)	5021	5009	2952	2353	2114	2425	1977	1923	2027	1319
RABBITFISHES (*Chimaerids*)	499	106	3	62	107	21	47	0	166	2
BLACKSPOT SEABREAM (*Pagellus bogaraveo*)	1663	2071	2026	2203	2043	2070	2084	1958	1765	1463
ROUGHHEAD GRENADIER (*Macrourus berglax*)	829	431	188	5	2	15	57	85	1052	24
ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	19918	19105	16407	12073	12019	11310	20063	25150	25193	11929
SHARKS, VARIOUS	13198	17177	8697	7231	9950	9549	10918	11387	6883	3472
SILVER SCABBARDFISH (*Lepidopus caudatus*)	974	3561	4140	1427	6461	2052	2838	2151	11775	15
SMOOTHHEADS (Alepocephalidae)	0	10	3	1	1	230	3706	4632	6551	5
TUSK (*Brosme brosme*)	31796	29201	28972	21844	21123	22621	22314	28876	32668	30676
WRECKFISH (*Polyprion americanus*)	374	521	649	837	633	617	391	378	149	275
Totals:	140204	148938	134767	109124	131180	128147	158652	199150	192890	133781

Table A.3.2. Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

I+II	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (*Beryx* spp.)													
	ARGENTINES (*Argentina silus*)	11351	8390	9120	7741	8234	7913	6807	6775	6604	4463	7465	7075	6288
	BLUE LING (*Molva dypterygia*)	3537	2059	1413	1480	1039	1020	410	357	270	300	280	289	252
	BLACK SCABBARDFISH (*Aphanopus carbo*)													
	GREATER FORKBEARD (*Phycis blennoides*)	0	0	23	39	33	1	0	0	0	0	0		
	LING (*Molva molva*)	6119	7368	7628	7793	6521	7093	6309	5954	6219	5404	9195	7655	5951
	MORIDAE													
	ORANGE ROUGHY (*Hoplostethus atlanticus*)													
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (*Macrourus berglax*)	0	0	589	829	424	136	0	0	0	17	55		4
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)		22	49	72	52	15	15	7	2	106	100	56	4
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)													
	SHARKS, VARIOUS	37	15	0	0	0	0	0	0	0	0	0		1
	SILVER SCABBARDFISH (*Lepidopus caudatus*)													
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (*Brosme brosme*)	14403	19350	18628	18306	15974	17584	12566	11388	12634	9332	15280	17182	13945
	WRECKFISH (*Polyprion americanus*)													

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

III+IV	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (*Beryx* spp.)	0	0	1	0	2	0	0	0	0	0	0		
	ARGENTINES (*Argentina silus*)	2718	3786	2321	2554	4435	3275	1146	1082	2051	2721	1587	1590	113
	BLUE LING (*Molva dypterygia*)	385	481	514	642	592	436	434	503	194	290	289	252	129
	BLACK SCABBARDFISH (*Aphanopus carbo*)	2	0	57	0	0	0	16	2	4	2	9	5	3
	GREATER FORKBEARD (*Phycis blennoides*)	15	12	115	181	145	34	12	3	18	7	12	19	6
	LING (*Molva molva*)	11933	12486	11025	10943	11881	13985	12114	13960	13543	12322	14466	10418	9203
	MORIDAE													
	ORANGE ROUGHY (*Hoplostethus atlanticus*)													
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (*Macrourus berglax*)	0	0	0	0	7	0	0	0	0	36	30	24	
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	618	1055	1439	2053	4247	1929	2139	2312	1238	2301	4793	2617	32
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)													
	SHARKS, VARIOUS	5	16	20	17	139	63	99	39	56	91	64	54	10
	SILVER SCABBARDFISH (*Lepidopus caudatus*)	0	0	0	0	27	0	0	0	0	0	0		
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (*Brosme brosme*)	4490	6515	4319	4623	5015	5221	3429	3405	3446	2289	3459	2452	3332
	WRECKFISH (*Polyprion americanus*)													

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

Va	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (*Beryx* spp.)	0	0	5	0	4	0	1	0	0	0	0		
	ARGENTINES (*Argentina silus*)	206	8	112	247	657	1255	613	492	808	3367	13387	7243	5608
	BLUE LING (*Molva dypterygia*)	2171	2533	3021	1824	2906	2233	1921	1634	1323	1344	1153	1903	1682
	BLACK SCABBARDFISH (*Aphanopus carbo*)	0	0	0	0	0	0	0	0	0	1	0		
	GREATER FORKBEARD (*Phycis blennoides*)													
	LING (*Molva molva*)	5861	5612	5598	5805	5116	4854	4604	4192	4060	3933	4302	4642	3682
	MORIDAE													
	ORANGE ROUGHY (*Hoplostethus atlanticus*)	0	0	0	65	382	717	158	64	40	79	28	0	68
	RABBITFISHES (Chimaerids)	0	0	0	499	106	3	60	106	21	15		37	
	ROUGHHEAD GRENADIER (*Macrourus berglax*)	0	0	0	0	0	0	0	0	15	4	0		
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	2	4	7	48	210	276	210	398	140	198	120	129	0
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)													
	SHARKS, VARIOUS	0	31	54	58	70	39	42	45	65	70	1	0	1
	SILVER SCABBARDFISH (*Lepidopus caudatus*)													
	SMOOTHHEADS (Alepocephalidae)	0	0	0	0	10	3	1	1	0	0	0		
	TUSK (*Brosme brosme*)	6855	7061	7291	8732	8009	6075	5824	6225	6102	5394	5171	7289	6315
	WRECKFISH (*Polyprion americanus*)													

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

Vb	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (*Beryx* spp.)	0	0	5	0	4	0	0	1	0	0	0		
	ARGENTINES (*Argentina silus*)	287	227	2888	60	1443	1063	960	12286	9498	8433	17570	8201	6911
	BLUE LING (*Molva dypterygia*)	9 528	5 266	4 799	2 962	4 702	2 836	1 637	2 440	1 602	2798	2584	4987	2558
	BLACK SCABBARDFISH (*Aphanopus carbo*)	0	166	419	152	33	287	160	424	186	68	180	169	263
	GREATER FORKBEARD (*Phycis blennoides*)	2	1	38	53	49	22	0	9	7	7	8	33	27
	LING (*Molva molva*)	4488	4652	3857	4512	3614	2856	3622	4070	4896	5657	5359	5200	3700
	MORIDAE	0	0	0	5	0	0	0	0	0	0	0		
	ORANGE ROUGHY (*Hoplostethus atlanticus*)	0	0	22	48	13	37	170	420	79	18	3	46	155
	RABBITFISHES (Chimaerids)	0	0	0	0	0	0	0	1	0	0	0		
	ROUGHHEAD GRENADIER (*Macrourus berglax*)												31	
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	1	258	1549.05	2311.5	3817.5	1681.4	667.94	1223.4	1077.66	1112	1667	1779	1943
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)													
	SHARKS, VARIOUS			140	81	162	477	192	262	380	308	433	293	11
	SILVER SCABBARDFISH (*Lepidopus caudatus*)													
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (*Brosme brosme*)	5 665	5 122	6 181	6 266	5 391	3 439	4 315	3 977	3 310	3319	2710	3952	2961
	WRECKFISH (*Polyprion americanus*)													

* preliminary

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

VI+VII	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (*Beryx* spp.)	0	12	8	0	3	1	5	3	178	25	81	87	4
	ARGENTINES (*Argentina silus*)	10438	25559	7294	5197	5906	1577	5707	7546	5863	7301	5555	8855	9174
	BLUE LING (*Molva dypterygia*)	9288	9422	5964	6235	6645	5526	4355	4839	6915	6866	7278	8798	8773
	BLACK SCABBARDFISH (*Aphanopus carbo*)	0	154	1060	2759	3436	3529	3101	3278	3689	2995	1967	2239	2588
	GREATER FORKBEARD (*Phycis blennoides*)	1898	1815	1921	1574	1640	1462	1571	2138	3590	2335	3040	3798	2736
	LING (*Molva molva*)	28 092	20 545	15 766	14 684	12 671	13 763	17 439	20 856	20 838	16668	19863	15423	11105
	MORIDAE	0	0	0	1	25	0	0	0	0	0	0		44
	ORANGE ROUGHY (*Hoplostethus atlanticus*)	0	8	17	4908	4523	2097	1901	947	995	1039	1071	1503	929
	RABBITFISHES (Chimaerids)	0	0	0	0	0	0	2	0	0	0	0		2
	ROUGHHEAD GRENADIER (*Macrourus berglax*)												944	
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	32	2440	5730	7793	8338	10121	7860	7767	7095	7070	6364	8063	7743
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)	252	189	134	123	40	22	10	8	33	36	13	15	13
	SHARKS, VARIOUS	85	40	345	1438	3441	4818	5473	5516	5460	6224	5590	3904	910
	SILVER SCABBARDFISH (*Lepidopus caudatus*)	0	0	0	0	0	2	0	0	0	0	0		
	SMOOTHHEADS (Alepocephalidae)										7			
	TUSK (*Brosme brosme*)	3 002	4 086	3 216	2 719	2 817	2 378	3 233	3 085	2 417	1832	2240	1784	4112
	WRECKFISH (*Polyprion americanus*)	7	0	2	10	15	0	0	0	83	0	12	5	5

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

VIII+IX	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (*Beryx* spp.)	0	0	1	0	1	0	2	82	88	135	269	198	49
	ARGENTINES (*Argentina silus*)													
	BLUE LING (*Molva dypterygia*)	0	0	0	0	0	0	0	0	0	14	33	29	0
	BLACK SCABBARDFISH (*Aphanopus carbo*)	2602	3473	3274	3979	4389	4513	3429	4272	3815	3556	3152	2749	2818
	GREATER FORKBEARD (*Phycis blennoides*)	81	145	234	130	179	395	320	384	456	361	665	372	232
	LING (*Molva molva*)	1028	1221	1372	1139	802	510	85	845	1041	1034	1799	801	167
	MORIDAE								83	52	88			5
	ORANGE ROUGHY (*Hoplostethus atlanticus*)	0	0	0	0	83	68	31	7	22	27	15	41	39
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (*Macrourus berglax*)													
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	0	0	5	1	12	18	5	0	1	0	1	16	3
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)	826	948	906	666	921	1175	1135	939	1001	1036	831	540	526
	SHARKS, VARIOUS	5270	3397	1555	3876	4883	934	807	1596	1354	2498	3183	1569	1344
	SILVER SCABBARDFISH (*Lepidopus caudatus*)	2666	1385	584	808	1374	2397	1054	5672	1237	1723	965	3058	15
	SMOOTHHEADS (Alepocephalidae)										7			
	TUSK (*Brosme brosme*)	1	0	0	0	0	0	0	0	0	0	1	0	0
	WRECKFISH (*Polyprion americanus*)	198	284	163	194	269	338	409	393	294	214	227	144	8

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

X	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (*Beryx* spp.)	225	260	338	371	450	728	1500	623	536	983	228	175	224
	ARGENTINES (*Argentina silus*)													
	BLUE LING (*Molva dypterygia*)	18	17	23	69	31	33	42	29	26	21	13	10	13
	BLACK SCABBARDFISH (*Aphanopus carbo*)	0	0	0	166	370	2	0	3	11	3	99	104	113
	GREATER FORKBEARD (*Phycis blennoides*)	29	42	50	68	81	115	135	71	45	30	38	41	91
	LING (*Molva molva*)													
	MORIDAE	0	0	50	0	0	0	0	0	0	0	0		0
	ORANGE ROUGHY (*Hoplostethus atlanticus*)	0	0	0	0	0	1	0	0	471	6	177	2	31
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (*Macrourus berglax*)													
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	0	0	0	0	0	0	0	0	3	1	1	4	74
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)	637	924	889	874	1110	829	983	1096	1036	1012	1114	1210	924
	SHARKS, VARIOUS	1098	2703	1204	3864	4241	1183	309	1246	1117	859	995		
	SILVER SCABBARDFISH (*Lepidopus caudatus*)	70	91	120	166	2160	1722	373	789	815	1115	1186		
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (*Brosme brosme*)													
	WRECKFISH (*Polyprion americanus*)	191	235	224	170	237	311	428	240	240	177	139		262

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

XII	Species	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
	ALFONSINOS (*Beryx* spp.)	0	0	0	0	0	0	0	2	0	0	0		
	ARGENTINES (*Argentina silus*)	0	0	0	0	0	6	0	0	1	0	0		
	BLUE LING (*Molva dypterygia*)	263	70	0	47	440	1127	485	573	788	417	422	998	80
	BLACK SCABBARDFISH (*Aphanopus carbo*)	0	0	0	0	512	1144	824	0	444	200	154	177	3
	GREATER FORKBEARD (*Phycis blennoides*)					1	1	3	4	2	2	1	1	3
	LING (*Molva molva*)	0	0	3	10	0	0	5	50	2	9	2	2	1
	MORIDAE										32	42	114	
	ORANGE ROUGHY (*Hoplostethus atlanticus*)	0	0	0	0	8	32	93	676	818	808	629	435	97
	RABBITFISHES (Chimaerids)	0	0	0	0	0	0	0	0	0	32		129	
	ROUGHHEAD GRENADIER (*Macrourus berglax*)												39	5
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	10000	8000	2300	7610	2397	2341	1161	285	1728	9216	11978	12404	2076
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)	0	0	0	0	0	0	75	0	0	0	0		
	SHARKS, VARIOUS				3864	4241	1183	309	1246	1117	859	1106	1063	1190
	SILVER SCABBARDFISH (*Lepidopus caudatus*)	0	102	20	0	0	19	0	0	0	0	0	8717	
	SMOOTHHEADS (Alepocephalidae)	0	0	0	0	0	0	0	0	230	3692	4632	6551	5
	TUSK (*Brosme brosme*)	1	1	0	1	1	12	0	18	158	30	1		
	WRECKFISH (*Polyprion americanus*)													

Table A.3.2. (cont.). Estimated landings (tonnes) of deep-water species by ICES Sub-areas and Divisions, 1988-2000. Data for 1999 and 2000 are preliminary.

XIV	Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	ALFONSINOS (*Beryx* spp.)													
	ARGENTINES (*Argentina silus*)	0	0	6	0	0	0	0	0	0	0	0		
	BLUE LING (*Molva dypterygia*)	242	71	79	155	110	3725	384	141	14	4	55	8	2
	BLACK SCABBARDFISH (*Aphanopus carbo*)	0	0	0	0	0	0	0	0	0	0	2		
	GREATER FORKBEARD (*Phycis blennoides*)													
	LING (*Molva molva*)	3	1	9	1	17	9	6	17	0	61	6	1	0
	MORIDAE													
	ORANGE ROUGHY (*Hoplostethus atlanticus*)													
	RABBITFISHES (Chimaerids)													
	ROUGHHEAD GRENADIER (*Macrourus berglax*)	0	0	0	0	0	52	5	2	0	0	0	14	15
	ROUNDNOSE GRENADIER (*Coryphaenoides rupestris*)	52	45	47	29	31	26	15	27	25	59	126	125	54
	RED (=BLACKSPOT) SEABREAM (*Pagellus bogaraveo*)													
	SHARKS, VARIOUS	0	0	0	0	0	0	0	0	0	9	15	0	5
	SILVER SCABBARDFISH (*Lepidopus caudatus*)													
	SMOOTHHEADS (Alepocephalidae)													
	TUSK (*Brosme brosme*)	2	4	19	134	202	80	25	87	281	118	14	9	11
	WRECKFISH (*Polyprion americanus*)													

longline fisheries for Greenland halibut. There is also a significant by-catch of ling and tusk in various trawl and gillnet fisheries on the shelf. A gillnet fishery off mid-Norway targets ling and sometimes blue ling (*Molva dypterygia*), but the yield has declined to a very low level compared with the catches observed when this fishery developed in the early 1980s.

ICES Sub-area III.

The deep-water fisheries of this Sub-area are essentially in the Skagerrak (Division IIIa) where there is a targeted trawl fishery for roundnose grenadier and greater silver smelt. These species are also taken as by-catch in the *Pandalus borealis* trawl fishery, and probably only a minor part of this by-catch is landed.

ICES Sub-area IV.

The most significant target fishery in this Sub-area is the longline fishery in the Norwegian Deep and around Shetland and the Orkneys for tusk and ling with greater forkbeard (*Phycis blennoides*) as the major by-catch species. There is a by-catch of greater silver smelt from the industrial trawl fishery along the slope of the Norwegian Deep. In trawl fisheries targeting anglerfish (*Lophius piscatorius)* and Greenland halibut on the slope north and west of Shetland there is a by-catch of some deep-water species, including ling (Bullough et al., 1998; Gordon, 2001a). Greenland halibut and to some extent redfish is targeted at the upper slope front between the deep and cold Norwegian Sea water and overlying warmer Atlantic water and their distribution extends onto the Faroese slope (Division Vb) and across to Iceland (Division Va).

ICES Sub-area V.

ICES Sub-area V is divided into two Divisions and there are significant differences between the fisheries of the two divisions. Division Va covers the waters around Iceland and the northern part of the Reykjanes Ridge to the point where it merges with Sub-area XII. Division Vb covers the waters around the Faroe Islands. Within both Divisions the deep-water areas have widely differing hydrographic regimes resulting from the separation of the warmer Atlantic waters from the colder Norwegian Sea waters by underwater ridges.

DIVISION VA

Magnússon (1998) and Magnússon et al. (2000) have described the development and current status of the deep-water fisheries of Iceland in some detail and only a brief summary will be given here. Deep-water fishing was first documented around Iceland in the 1930s but it was not until the 1970s that the fisheries for deep-sea redfish (*Sebastes mentella*) and Greenland halibut became prominent. Other species that are targetted with varying intensity are blue ling, orange roughy (*Hoplostethus atlanticus*) and greater silver smelt. Incidental landings of other deep-water species include roundnose grenadier, roughhead grenadier and deep-water chimaerids and sharks.

Deep-water redfish (*Sebastes mentella)* was not recognised as being distinct species from *S. marinus* until 1951. The landings of the two species are combined and it is only since 1978 that the proportions of the two species in the catch have been estimated for scientific purposes. The bottom trawl fishery for deep-sea redfish occurs on the slope at depths of 500 to 700 m and is mainly along the west, south and southeast of Iceland.

Spawning aggregations are targeted by both bottom and midwater trawls on the Reykjanes Ridge and off the south coast during the autumn. Landings increased considerably from 1988 reaching a peak in 1994. This was accompanied by a decline in CPUE. Landings of deep-water redfish have continued to decline (ICES, 2001b)

The Greenland halibut bottom trawl fishery began in the 1960s mainly along the western slopes and was mainly prosecuted by foreign vessels. Iceland began a directed longline fishery off the north coast in 1969. The spring trawl fishery on aggregations to the west of Iceland continues but there are also landings from other areas throughout the year. Landings peaked in 1989 and since then there has been significant decline in landings and CPUE. The landings of blue ling are mainly a by-catch of the redfish fishery. In some years there have been directed fisheries on spawning aggregations. The landings of greater silver smelt are variable mainly because of technical and marketing problems. Landings of orange roughy are spasmodic and depend on fishing local aggregations that are difficult to locate.

DIVISION VB

The fishery for ling and tusk in Division Vb is mainly by Faroese and Norwegian longliners especially in the Vb2 sector. ICES (1998) gives information on how the Faroese landings of ling and tusk are distributed amongst the different sectors of the fleet. There has been an increase in the landings of ling in recent years (ICES, 2000b)

The main deep-water bottom trawl fisheries in Division Vb are associated with the warmer Atlantic waters and are closely linked with the deep-water fisheries of Sub-area VI (see below). The mixed bottom trawl fishery, mainly prosecuted by France and the Faroe Islands, lands species such as roundnose grenadier, black scabbardfish (*Aphanopus carbo*) and blue ling. There has been a steady decline in landings in recent years (ICES, 2000b). There are also targetted trawl and gillnet fisheries for Greenland halibut and anglerfish. The gillnets can yield a by-catch of for example deep-water red crab (*Chaecon* (formerly *Geryon*) *affinis*). There have also been trap fisheries for the deep-water red crab (Reinert, 1995). Exploratory fishing for orange roughy has also been carried out in this Division and over the wider ICES area (Thomsen, 1998).

ICES Sub-areas VI and VII.

It has become customary to consider the deep-water fisheries of Sub-areas VI and VII as a unit because a significant proportion of the landings are from the continental slope that extends from the north of Scotland to the northern Bay of Biscay. Sub-area VI also includes the slopes of the Rockall Bank, some other banks that form the northern boundary of the Rockall Trough and a part of the Hatton Bank (Division VIb). Part of the Hatton Bank lies within Sub-area XII and this can cause reporting problems (see below). Prior to the UK claiming a 200 mile fishery limit around Rockall in 1976 there were undoubtedly deep-water trawl fisheries, mostly by the USSR, in the international waters around these offshore banks. The UK relinquished its claim to a 200 limit in 1997 and since then there has been an uncontrolled expansion of deep-water fisheries to the west of the Rockall Bank and at Hatton Bank.

The deep-water fisheries of these Sub-areas have been described in some detail by (Gordon 2001a) who subdivided them into, bottom trawl, semi-pelagic, longline and gillnet fisheries. The bottom trawl fisheries are for mixed demersal species with blue ling and roundnose grenadier as the main target species and black scabbardfish and deep-water sharks are the main by-catch. On the upper slopes anglerfish is an important species, and in deeper waters, usually on steeper slopes, there is a targeted fishery for orange roughy. The semi-pelagic fisheries are for blue whiting (*Micromesistius potassou*) and greater silver smelt. There are two separate longline fisheries, one for hake and the other for ling and tusk. There are reports of gillnet fisheries for anglerfsh in international waters with a by catch of deep-water red crab.

ICES Sub-area VIII.

The status of Spanish deep-water fisheries in 1998 was reviewed by Pineiro et al.(2001) The Spanish longline fisheries in Division VIIIc are varied. On the northern coast of Spain the target species is often greater forkbeard, while the fishery based on the northwestern ports of Spain can target alfonsino (*Beryx splendens*), greater forkbeard or red (blackspot) seabream (*Pagellus bogaraveo*). The fishery is seasonal occurring in winter and spring. By-catch species are deep-sea cardinal fish (*Epigonus telescopus*) and black scabbardfish. There is also a directed fishery for deep-water sharks in Divisions VIIIa,b,c and d and in IXa. These fisheries, some of which take place throughout the year, are at depths between 900 and 1300 m and are prosecuted by vessels which formerly fished for hake. An important factor in determining the viability of the fishery is the value of the shark livers. Another longline fishery that lands a variety of species began in 1996 in the Bay of Biscay (Divisions VIII a,b and d). In Division VIIIc there is a specialised gillnet (‘rasco’) fishery for anglerfish.

There are also some trawl fisheries targeting species such as hake, megrim (*Lepidorhombus whiffiagonis*), anglerfish and Norway lobster (*Nephrops norvegicus*) that have a by-catch of deep-water species. These include ling, forkbeard (*Phycis phycis*), greater forkbeard, red (blackspot) seabream, conger eel (*Conger conger*), bluemouth (*Helicolenus dactylopterus*), wreckfish (*Polyprion americanus*) and alfonsinos.

The offshore Galician Bank lies partly in Division VIIIc and partly in Division XIb and has supported a small, but decreasing fishery for the deep-water red crab.

ICES Sub-area IX.

The Portuguese longline fishery for black scabbardfish is almost entirely centered on the port of Sesimbra and a detailed description is to be found in the reports of EC Deep-fisheries project (Gordon, 1999a). This fishery, which began in 1983 and may be classified as artisanal, takes place on hard bottoms along the slopes of canyons at depths ranging from 800 to 1200 m. In 2000 there were 15 vessels engaged in the fishery and the landings have decreased since 1995. The by-catch of the Portuguese dogfish (*Centroscymnus coelolepis*) has tended to increase in recent years. This probably reflects the trend for targeting squalid sharks because of their increasing commercial value (Figueiredo et al. 2001a).

A description of the deep-water crustacean bottom trawl fishery is given in the reports of the EC Deep-fisheries Project (Gordon 1999a). It targets the rose shrimp (*Parapenaeus longirostris*) and the Norway lobster and is mainly carried out off the south and southwest coasts of mainland Portugal at depths between 200 and 700 m. The deepest grounds (400 to 700 m) are only fished when Norway lobster is the target species. Landings of additional by-catch species can be important for profitability, especially when the catches of the target species are lower. By-catch species from the deeper fishing grounds include, blue and red shrimp *(Aristeus antennatus),* giant red shrimp *(Aristeomorpha foliacea),* conger eel*,* bluemouth*,* greater fork-beard and blackmouth catshark *(Galeus melastomus).* However, because of the over exploitation of *Nephrops* and the better yields of the shallower living rose shrimp, deep-water trawling does not occupy a major part of the effort of the fleet. The potential for the exploitation of other deeper-living shrimps, *A. antennatus, A foliacea* and *Aristaeopsis edwardsiana* has been discussed by Figueireido et al. (2001b).

There is a detailed description of the directed longline fishery for deep-water sharks in northern Portugal in the EC Deep-fisheries project. The bulk of the captures are comprised of only one species, the gulper shark (*Centrophorus granulosus*) but other deep-water species landed include the leafscale gulper shark (*Centrophorus squamosus*), Portuguese dogfish, blackspot seabream, greater fork-beard and conger eel. Since 1992, the catch rates have steadily decreased and the fishery is now almost finished. In Portugal the three species of scorpaenid fishes, red scorpionfish (*Scorpaena scrofa*), bluemouth and offshore rockfish (*Pontinus kuhlii*) are not always separated in the landings. An investigation carried out under the auspices of the EC Deep-fisheries Project found that in most landings the deep-water bluemouth were a by-catch of a longline fishery for conger eel.

The hake is fished by trawl, gill net, trammel net and longline. More than 60% of the landings are by the artisanal fleet using static gear. A semi-pelagic ("pedra-bola") longline fishery takes place on the continental slope of the southern coast of Portugal at depths between 200 and 700 m and has been described by Erzini et al., (2001). Hake accounted for 41% of the catch and most of the remaining diverse catch of 27 species of fish and invertebrates was discarded. Deep-water by-catch species landed include the larger blackmouth catsharks, Ray's bream (*Brama brama*)*,* conger eel, bluemouth and red (blackspot) seabream.

An artisanal hook and line fishery, known as '*voracera',* targetting red (blackspot) seabream at depths at depths of about 400 to 800 m began in the Straits of Gibraltar in the early 1980s. The number of vessels, which are all small (6-9 m in length), increased from about 25 to over one hundred in 1999 (Gil et al. cited in ICES, 2000b). There was a decline in the landings after 1997 and regulatory measures have now been introduced.

Three small Spanish bottom trawlers occasionally began fishing for deep-water species on the Galician slope (Division IXa) in 1997 (Pineiro et al., 2001).

ICES Sub-area X.

The deep-water fisheries of this oceanic Sub-area are confined to the slopes and seamounts of the Azorean Archipelago and parts of the Mid-Atlantic Ridge. Within the Azorean EEZ the main fisheries are by handline and longline. The main species landed are red (blackspot) seabream, wreckfish, conger eel, bluemouth, yellow-orange scorpionfish (*Pontinus kuhlii*)*,* greater forkbeard*,* golden eye perch (*Beryx splendens*) and alfonsino (*Beryx decadactylus*). Other species like mora (*Mora moro*) are increasing in their importance in the landings. Before the 1980s the fishery was mostly by handline and the major expansion took place in the early 1980s with the introduction of larger vessels and longlining technology, together with improved marketing opportunities and better preservation of the catch. The most traditional deep-water stocks of the Azores are now considered to be intensively exploited, and some local management actions have recently been implemented.

A deep water gillnet fishery for kitefin shark (*Dalatias licha*) expanded from the late 1970s until the early 1990s with landings of almost 1000 t in some years (Silva, 1987, Gordon, 1999b). Since then the landings have declined and are now considered to be accidental (Anon, 2000). In 2000 one or two vessels tried to restart the fishery but it was not successful because of marketing problems.

Since 1998 commercial longliners from Madeira have targeted black scabbardfish in this Sub-area. In 1998 and 1999 some commercial fishing experiments targeting deep-water crustaceans species (deep water crabs and shrimps), were also undertaken. During 2001 a major expansion of the black scabbardfish fishery in the Azores is anticipated. Exploratory fishing for orange roughy (*Hoplostethus atlanticus*) is also being carried out but no data are available.

Outside the Azorean EEZ there are trawl fisheries for alfonsino (*Beryx splendens*), orange roughy, cardinal fish, black scabbardfish and wreckfish. Russia is the main nation conducting this fishery and the main target specis is alfonsino. This fishery has been carried out with varying intensity since the 1970s (Troyanovsky and Lisovsky 1995; Vinnichenko, 1998).

ICES Sub-area XII.

This vast sub-area extends from 48 to 62° N and the areas relevant to deep-water fishing are the Mid-Atlantic Ridge, its northern extension the Reykjanes Ridge and parts of the Hatton Bank. The USSR/Russia began trawling on the Mid-Atlantic Ridge in the 1970s for species such as roundnose grenadier and alfonsino (*Beryx splendens*) (Vinnichenko, 1998; Vinnichenko and Khlivnoy, 2001 (cited in ICES, 2001c)). Russian and Icelandic vessels have occasionally reported catches of orange roughy from this area, but the most systematic search for orange roughy that eventually led to exploitation is by the Faroe Islands (Thomsen, 1998). Norwegian and Icelandic longliners began fishing for redfish (giant type) tusk and Greenland halibut in 1996 (Hareide and Garnes, 2001).

There is a multi-species trawl and longline fishery on Hatton Bank part of which lies in this Sub-area and part in Sub-area VI (see above). There is considerable exploratory fishing on the Hatton Bank, and effort seems to be increasing (see Anon. 2000, 2001b). The true scale of the Hatton Bank fishery is difficult to assess because with the current reporting system catches from that bank cannot be separated from either the Mid-Atlantic Ridge or the Rockall Trough.

ICES Sub-area XIV.

There are trawl and longline fisheries for Greenland halibut and redfish that have by-catches of roundnose grenadier, roughhead grenadier and tusk. Again, there is a problem separating catches from the western part of the Mid-Atlantic Ridge (Reykjanes Ridge) from those taken e.g. on the slope off East Greenland.

THE CANARY AND MADEIRA ISLAND GROUPS.

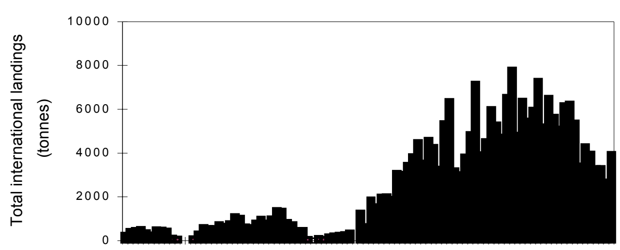
Although these island groups lie beyond the southern limit of the ICES area their fisheries have some affinities with those of the Azores. The deep-water fishery of Madeira is primarily for black scabbardfish and is long established (Merrett and Haedrich, 1997). The most important by catch is the Portuguese dogfish.

The deep-water fisheries of the Canary Islands are mainly prosecuted by either hand line or longlines from small boats. The fishery takes place throughout the year and targets a wide variety of species including alfonsinos, wreckfish, forkbeards and mora (Rico et al., 1999). A seasonal fishery for hake occurs in deep-water off Gran Canaria. There is a small trap fishery for the deep-water shrimp (*Plesionika edwardsi)* at depths between 150 and 300 m (Gonzalez et al., 1997).

A.3.2.1 Summary on the deep-sea fisheries in the ICES areas

Deep-sea fisheries in the ICES area are quite diverse. Long-line and trawl fisheries predominate, ranging from coastal artisanal fisheries to highly efficient, mechanised high-seas operations. Some fisheries are directed at single species but most are mixed fisheries with a few or many target species. Some fisheries have developed recently whilst others have been established for many decades.

The longstanding deep-water fisheries comprise the handline and long-line fisheries off the Azores for a range of species including red (blackspot) seabream (*Pagellus bogaraveo*), alfonsinos (*Beryx* spp) and, until recently, kitefin shark (*Dalatias licha*), off Madeira and Portugal (principally for black scabbardfish (*Aphanopus carbo*)) and off Iceland, Norway and the Faroes (for ling (*Molva molva*) and tusk (*Brosme brosme*)). The long-line fisheries for ling and tusk in ICES areas II, IV and V have very long histories and are now prosecuted on a large scale by highly efficient, mechanised vessels fishing over a wide geographical area in the northern parts of the NE Atlantic (Bergstad and Hareide, 1996; Magnússon *et al.* 1997). Although these species appear to have withstood increasing levels of fishing effort without becoming severely depleted, catch rates in most areas have now been declining for many years and this is a cause for concern. Taking tusk at the Faroes as an example, international landings gradually increased throughout the last century to a peak in the 1980s and then declined thereafter (Text figure 1). During the last two decades catch rates have declined by 50%.

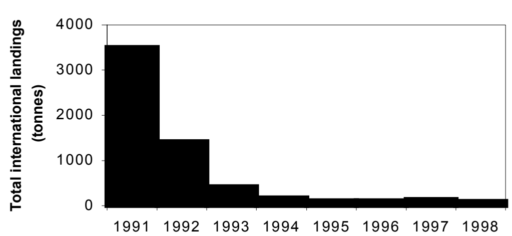


Text figure 1. Total international landings of tusk (*Brosme brosme*) from the Faroes (Large et al (2001) based on ICES data)

However, not all longstanding fisheries show signs of depletion. An example is the long-lasting (sustainable) and almost self-regulatory Norwegian fishery for greater argentine (*Argentina silus*) in deep water off the Norwegian coast (Johannessen and Monstad, 2001). This is a comparatively localised operation within the Norwegian EEZ, and a limited access policy and the use of landings only for a domestic human consumption market may have prevented overfishing.

In contrast to the line fisheries, the bottom trawl fisheries for deep-water species in the ICES area are a comparatively recent development. The origins of these fisheries can be traced back to the late 1960s, when the Soviet Union and other eastern bloc countries began to exploit roundnose grenadier (*Coryphaenoides rupestris*) and alfonsino in international waters to the west of the British Isles and on the Mid-Atlantic Ridge. In the early 1970s, German trawlers exploited blue ling (*Molva dypterygia*) for a few years. By the mid to late 1970s, French trawlers, which traditionally fished along the shelf edge for species such as saithe (*Pollachius virens*), had also moved into deeper water to exploit blue ling (Charuau *et al*., 1995). In the early years of this fishery the by-catch of species such as roundnose grenadier, black scabbardfish, deep-water sharks and many other less abundant species was discarded. It was only since 1989 that these former by-catch species were landed as a result of a marketing initiative by the French industry. Deep-water trawl fisheries then expanded quickly throughout the 1990s, partly as result of improving markets, and partly also due to the increasingly restrictive management regulations on the traditional fisheries because of decline of many of the stocks on the continental shelf. In contrast, deep-water stocks were largely unexploited and unregulated.

As an example of a recently developed deep-sea fishery is the Orange roughy fishery in the NE Atlantic. The prosperous Orange roughy (*Hoplostethus atlanticus*) fisheries in Australian and New Zealand waters stimulated the search for this species in the NE Atlantic by French and Faeroes trawlers. Spawning aggregations were located in ICES Sub-area V,I and a fishery quickly developed from 1991 onwards. After an initial peak, landings quickly declined to less than 200 t per annum (Text figure 2).



Text figure 2. Total international landings of orange roughy (*Hoplostethus atlanticus*) from ICES Sub-area VI. (Large et al. (2001) based on ICES data).

Fishing effort also quickly declined from an initial high level. These trends appear to be consistent with a 'mining' approach towards populations of this species. Aggregations are located and then fished out on a sequential basis.

There are also strong indications of other species showing fishery-induced depletion. Landings of the red (blackspot) seabream from ICES Sub-areas VI, VII and VIII peaked at 24,000 t in 1974 and have since declined continuously to around 100 t in recent years (ICES, 2000b).

Some trawl fisheries are for single species and have a relatively small by-catch of other species, e.g. fisheries for greater argentine, spawning aggregations of blue ling and orange roughy. Other trawl fisheries are mixed, have relatively few target species and the target species can change according to season and fishing depth. For example, to the west of Scotland the French fleet, when not fishing for blue ling, may target roundnose grenadier, and the quantities of other species landed, such as black scabbardfish and deep-water sharks, will depend on factors such as fishing depth.

In recent years, deep-water fishing activity in the ICES area has continued to increase for the reasons described earlier. Fishing vessels from France, Norway, Spain, Portugal, Russia, Ireland, United Kingdom, Iceland, Faeroes, Poland and the Netherlands are now actively involved in deep-water fisheries. Exploratory cruises by commercial fishing vessels continue to identify potential fisheries, particularly in international waters on the Hatton Bank and the Mid-Atlantic Ridge.

A feature of all deep-water fisheries, whether they be longstanding or new, artisanal or mechanised, is that almost all have developed without programmes in place to collect biological and fisheries data. Consequently, our understanding of the population dynamics of deep-water species and of the impact of fishing upon them has lagged behind exploitation.

A.3.2.2 Status of the stock/aggregations as observed by CPUE and landings.

The most recent information on the state of stocks in the ICES area is that given by ACFM in May 2001 (ICES, 2001c), based on assessments carried out in 2000 (ICES, 2000b), and this is summarised in the text table below. Most exploited deep-water species in the ICES area are at present considered to be harvested outside safe biological limits. The effect of this harvesting on the deep-water ecosystem, particularly by trawling, is also a concern because of the high mortality of escapees and discards.

Current state of deep-water stocks in the ICES area (Anon., 2001b)

Species	**ICES Sub-area/Division**	**Assessment type**	**State of stock**
Blue ling (*Molva dypterygia*)	Mainly II,V, VI, VII & XII	CPUE	Below U_{lim} in V, VI & VII. Unknown in other areas.
Ling (*Molva molva*)	Almost all areas	CPUE Catch curves	Uncertain and variable across its range. Below U_{pa} in some areas.
Tusk (*Brosme brosme*)	Mainly IIa, IV, V &VI	CPUE	Stock decline in all areas except Va. Probably below U_{lim} in Vb.
Roundnose grenadier (*Coryphaenoides rupestris*)	I, II, III, IV, Va, Vb, VI & VII,VIII, IX, X	DeLury Schaefer	Near to U_{pa} in Vb, VI & VII. Unknown in other areas.

Black scabbardfish (*Aphanopus carbo*)	Vb, VI,VII, VIII, IX, X & XII	DeLury Schaefer	Below U_{pa} & possibly below U_{lim} in V, VII,VII & XII. Uncertain in other areas.
Greater Argentine (*Argentina silus*)	I, II, III, IV, V, VII &VII	No assessment	Unknown
Orange roughy (*Hoplostethus atlanticus*)	Va, Vb, VI, VII, IX & XII	DeLury Schaefer	Below U_{lim} in VI Unknown in other areas.
Red (blackspot) Seabream (*Pagellus bogaraveo*)	IX, X & partly in VI,VII &VIII	No assessment	Unknown in X. Possibly below U_{lim} elsewhere.
Greater forkbeard (*Phycis blennoides*)	All areas but mainly VI, VII,VIII & IX	No assessment	Unknown
Alfonsino (*Beryx splendens*)	Mainly X	No assessment	Unknown
Deep-water squalid sharks	Va, Vb, VI, VII, VIII, IX & X	DeLury Schaefer	No information given by ACFM

A.3.3 Discards.

Despite the development of deep-water fisheries in recent years information on discards by the various fleets involve has lagged behind the available data on landings. Various countries have contributed discard information but only Ireland and Spain currently have an established programme of monitoring discard rates in the commercial deep-water fleet.

Much of the initial discard data arose from the EU contract Developing deep-water fisheries: data for the assessment of their interaction with and impact on a fragile environment FAIR CT 95/0655. Connolly and Kelly (1996) reported on discarding from trawl and longline operations in sub-area VI. A general summary of this work showed that many more species were discarded from trawling operations than longline sets. Blasdale and Newton (1998) compared the discard rates of French and Scottish trawlers working in sub-area VIa. Table A.3.3.1 shows the total discards for 1997 in this ICES region. Data was raised by reported effort that had been filtered. Scottish effort was only used if the blue ling landings for a particular landing exceeded 5% of the total landings for that particular vessel; French effort data was only used if roundnose grenadier and blue ling landings (either singly or combined) exceeded the 5% threshold. This filter was used to try to exclude those vessels that, although working in the general area of the deep-water fishery, were actually targeting the shelf fish occurring in shallower water. The data highlighted the very high discard rates of some non-commercial fish e.g. Alepocephalus bairdii (Baird's smoothhead) and Lepidion eques. However, the data also showed significant discard levels for Coryphaenoides rupestris (Roundnose grenadier).

The two fleets had very similar discard rates with an overall mean rate of 32% of catch.

Discard data from the Norwegian longline fishery for ling and tusk in the period 1993-1997 were also assembled as part of the same EU FAIR project. Most samples came from ICES area IVa, i.e. around Shetland and in the Norwegian Deep, and the catch composition and discards in terms of catch by 1000 hooks based on 51 longline settings is given in TableA.3.3.2. From area VIa (Hebrides), 7 settings were sorted, and the catch composition is given in Table A.3.3.3. *Phycis blennoides* was the main discard species in these areas. No new data were collected from this fishery after 1997.

From the experimental trawl fishery at the Hatton Bank in 1998, catch composition in terms of weight by depth zone is available (Langedal and Hareide, 1998). During the experiment 43 fish species were recorded, but the catches were dominated by *Coryphaenoides rupestris* (50% by weight), *Alepocephalus bairdii* (21 %), and *Centroscymnus coelolepis* (11 %). However, no breakdown of the discard element is provided.

From the exploratory longlining carried out by Norway in 1999 at 600-1800 m depth on the slope of the Hatton Bank (VIa) (Langedal and Hareide, 1999 and Working Document presented to the ICES Deep Water Study Group 2000), detailed accounts of catch composition by depth zone and discards were calculated. In contrast to the results from deep-water trawling in the same area in 1998, deep-water sharks dominated the longline catches (80.3%) (Table A.3.3.4), Although one of the aims of this experiment was to market unconventional species, about 36% of the catch in terms of weight was presently considered unmarketable and discarded. By comparison, about 50 % of the trawl catches from 1998 were considered unmarketable, and the discards were mainly juvenile *Coryphaenoides rupestris.*

Revised discard rates from deep-water trawling in the Rockall Trough in 1997 are reported by Clarke *et al* (1999). In 1998 and 1999 the Marine Institute, Dublin monitored discards of deep-water fish from trawlers in the multi-species fishery in the Faroe-Shetland Channel. The discard levels were low. The total estimate of discards was estimated at less than 8% of the catch. Roughhead grenadiers (*Macrourus berglax*) were the most important discard species by weight followed by the greater argentine. Numerically, however, blue whiting (*Micromesistius poutassou*) was the most common discard species.

Discarding from long lines was also investigated by the Marine Institute in 1997 and 1999 during surveys using chartered Norwegian vessels. The survey vessels used commercial Mustard auto-line systems and commercial size hooks. Discarding of teleosts from long lines was shown to be very low with the lines selecting for only marketable sized fish. However, discards of non-marketable chondrichthyan fish were very high (Clarke, Hareide and Hoey, in prep.). In the 1999 survey on the slopes of the Porcupine Bank and in the depth range 500 – 700 m, *Deania calceus* dominated the catch; though the livers of this species are retained by some vessels the carcasses are discarded. Furthermore, several other species of small chondrichthyans were also caught. See Table A.3.3.5

The most recent information on deep water discards was presented to the ICES Deep Water Working Group 2001 (ICES, 2001) and the following is a compilation of such data by country (extracted from working documents).

Spain

Information supplied to the Working Group concerning trawlers at Hatton Bank has been revised and updated (Munoz & Marcote, in press). Table A.3.3.6 shows the percentage retained and discarded for the period 1996-2000. The majority of roundnose grenadier and smoothhead catches were retained. Of particular interest is that Spanish vessels retain a large proportion of the catch of smoothhead (*Alepocephalus bairdii*), which ranged from 75% to 98% throughout the study period; other fleets (i.e. UK and France) tend to discard all this species. Retention rates of smoothheads have equalled or even exceeded those for grenadier, which points to the consolidation of fishing interest in smoothheads. In their entirety, Portuguese dogfish, blue ling and Greenland halibut were retained on board. A high percentage of black scabbardfish was also retained. The amount of 'various deep water sharks' retained was influenced by the type of processing employed on individual vessels. The roughhead grenadier and North Atlantic codling (Lepidion eques) were mainly discarded. The chimaeras present a variable discard rate (21%-41%). As regards the other fish species, the pattern is highly variable, depending on market conditions and the catch success for the main species.

Table A.3.3.7 shows the retained, discarded and total catches, effort and CPUE on the Reykjanes Ridge presented to the Working group. These data derive from one commercial vessel observed in this area during the year 2000.

Russia

Some discard information was reported in the Working Document by Vinnichenko and Khlivnoy (2001), but only for Sub-area I and II. The by-catch in various fisheries is Roughhead grenadier and sharks, of which the majority of the first and all of the second is discarded. The quantities discarded were not estimated. The discard patterns in other Sub-areas are unclear.

Ireland

In 2000 Ireland conducted two longline surveys on the Hatton, Rockall and Porcupine Banks (WD by Clarke, 2000). Discard rates were monitored during both surveys. In all areas, non-commercial catches were dominated by small sharks. On shallower settings where tusk or ling were targeted discards were mainly black mouth dogfish *Galeus melastomus* and rabbitfish *Chimaera monstrosa*. In waters deeper than 700 m bird-beak dogfish *Deania calceus* and small sharks were the main discard species. The selective properties of long-line gear for teleost fish were indicated by the fact that less than 5 % of ling or blue ling caught were below minimum size. The discard CPUE data are presented in Tables A.3.3.8 and A.3.3.9.

Gordon (1997) estimated that the escapees from commercial trawls could be as high as 66 to 86 % in terms of numbers and 10 and 45 % in terms of weight depending on fishing depth.

Gordon & Hunter (1994) and Gordon (2001) have commented on the survival rate of deep water fish. They frequently lack mucus, have large deciduous scales and this together with the effects of depth-related pressure and temperature change means that virtually all fishes retained by a trawl and brought to the surface will be dead. Thus after the fishes to be landed have been selected the remainder of the catch will be discarded as dead fish.

Fishes entering a trawl and subsequently escaping are also likely to sustain considerable external damage and as a consequence suffer a high mortality. These have sometimes been referred to as 'no-catch discards' and although they may comprise a smaller proportion of the total biomass, numerically they could represent a significant part of the juvenile stock of exploited species and an important component in the food chain. The fragility of the skin probably means that selectivity devices such as square mesh panels and sorting grids may be of little value for the conservation of deep-water fishes. It has been suggested that long lining might be a more selective method of exploiting deep-water fishes, but many of the target species such as roundnose grenadier and orange roughy do not take baited hooks.

In summary the following points can be made:

- There is a lack of cohesive and comprehensive data – much information is based on single discard studies
- Discard rates appear to vary with location e.g. the Irish and Spanish report very few discards in the Faeroe-Shetland Channel and Reykjanes Ridge whilst other reports highlight comparatively high discards in the Rockall Trough (32% by French and Scottish fleets) and on Porcupine Bank.
- Furthermore discard rates appear to vary between nations. In 1998 Norway reported an estimated discard rate of 50% for a trawl survey on Hatton Bank; in 2000 it was estimated that the discard rate for Spanish trawlers in the same area was 9%. Even excluding data for *Alepocephalus bairdii* (see next point) the Spanish discard rate in this area is only 11%.
- There are differences in the discard practices between nations e.g. Spain retains, on average, 88% of *Alepocephalus bairdii*; other nations discard all this species. (Spain appears to have developed a specialised market for smoothhead fillets).
- More deep water species are discarded from trawling operations than from long lines.
- Whilst long liners were more selective in the number of species they caught they also generated high discard rates for chondrichthyans
- In pursuit of catching commercial fish, deep-water operations also encounter a large number of other species which are regarded as non-commercial. The survival rate after capture has not been quantified by scientific investigation but given their delicate physical properties the rate can be assumed to be nil.

It is clear that more information is required on discard rates and composition and all nations should be encouraged to extent their activities in this field.

Table A.3.3.1. Scottish and French Discards in ICES sub-area VIa in 1997

Species	Scotland		France		Combined	
	Weight (Tonnes)	Numbers ('000)	Weight (Tonnes)	Numbers ('000)	Weight (Tonnes)	Numbers ('000)
Alepocephalus bairdii			5409	4210	5409	4210
Antonogadus macrophthalmus	9	19			9	19
Argentina silus	454	975	607	960	1061	1935
Centroscymnus crepidater	13	16	306	166	319	182
Chimaera monstrosa	31	38	520	632	551	670
Clupea harengus	6	35			6	35
Coryphaenoides rupestris	19	32	2361	4753	2380	4785
Cottunculus thomsonii			34	110	34	110
Deania calceus			252	106	252	106
Etmopterus princeps			119	103	119	103
Etmopterus spinax			5	55	5	55
Eutrigla gurnardus	6	36	101	418	107	454
Gadiculus argenteus	1	22			1	22
Glyptocephalus cynoglossus	2	22	12	51	14	73
Halargyreus johnsonii			9	129	9	129
Hariotta raleighana			103	62	103	62
Helicolenus dactylopterus	30	198	36	272	66	470
Hydrolagus mirabilis			89	192	89	192
Lepidion eques	134	839	498	3057	632	3896
Lepidorhombus whiffiagonis	7	63			7	63
Malacocephalus laevis	2	51			2	51
Melanogrammus aeglefinus	10	39	32	112	42	151
Micromesistius poutassou	60	693	20	134	80	827
Microstomus kitt	2	15			2	15
Molva dypterygia	27	34			27	34
Nezumia aequalis	1	16	5	73	6	89
Ommastrephidae			40	87	40	87
Others	45	73	135	271	180	344
Phycis blennoides	55	138	24	62	79	200
Pollachius virens	64	62	56	54	120	116
Raja fyllae	9	17	168	358	177	375
Scomber scombrus	44	95	49	139	93	234
Scyliorhinus canicula	11	11	57	55	68	66
Trachyrhynchus murrayi			199	2065	199	2065
Trachurus trachurus	53	133	271	648	324	781
Total	**1,095**	**3,672**	**11,517**	**19,334**	**12,612**	**23,006**

Table A.3.3.2 Mean catch and discards (kg) per 1000 hooks in area IVa in the years 1993-1997.

Species	1993	1994	1995	1997	Total	Discarded
Molva molva	115.01	88.04	98.05	87.04	91.61	
Brosme brosme	22.90	18.74	23.89	17.05	19.46	0.00
Pollachius virens	0.48	38.29	0.14	10.54	7.43	
Melanogrammus aeglefinus	0.40	33.57	2.68	5.95	5.25	
Gadus morhua	7.43	25.79	0.52	4.87	4.02	
Unidentified skates				5.23	3.28	
Phycis blennoides	0.91		8.25		2.62	2.62
Galeus melastomus	3.06		1.34	0.24	0.69	0.69
Squalus acanthias	0.68		1.43	0.30	0.67	0.67
Raja fullonica		4.80	0.17		0.15	
Chimaera monstrosa	0.52		0.31	0.01	0.13	0.13
Conger conger	1.20			0.09	0.10	0.10
Scyliorhinus caniculus			0.02	0.10	0.07	0.07
Helicolenus dactylopterus			0.21		0.06	0.06
Sebastes viviparus			0.19		0.06	0.06
Molva diptervgia			0.16		0.05	
Pollachius pollachius		2.07		0.01	0.05	
Etmopterus sp			0.15		0.05	0.05
Anarhichas lupus		1.20	0.03		0.03	0.03
Eutrigla gurnardus				0.04	0.03	0.03
Prionace glauca				0.03	0.02	0.02
Sebastes marinus			0.05	0.01	0.02	
Merlangius merlangus				0.02	0.01	
Merluccius merluccius				0.01	0.01	0.01
Raja radiata		0.36			0.01	0.01
Hippoglossus hippoglossus				0.02	0.01	
Lepidorhombus whiffiagonis				0.0024	0.0015	0.0015
Total	152.59	212.86	137.59	131.56	135.89	4.55

Table A.3.3.3 Mean catch and discards (kg) per 1000 hooks in area VIa in the years 1993-1995.

Species	1993	1994	1995	Total	Discarded
Molva molva	83.89	18.07	163.16	110.38	
Brosme brosme	8.79	100.33	11.36	36.41	
Gadus morhua		82.53	1.47	24.42	
Sebastes marinus		14.47	3.78	6.29	
Phycis blennoides	24.04	0.24	3.81	5.68	5.68
Galeus melastomus	1.48		3.97	2.48	2.48
Melanogrammus		7.26		2.07	2.07
Chimaera monstrosa	9.91		0.47	1.69	1.69
Helicolenus dactylopterus	5.23			0.75	0.75
Pollachius virens		2.38		0.68	
Squalus acanthias	1.35		0.46	0.46	0.46
Molva dipterygia	2.54			0.36	
Conger conger	2.14			0.31	0.31
Merlangius marlangus		0.37		0.11	
Etmopterus sp			0.08	0.05	0.05
Raja naevus	0.21			0.03	
Anguilla anguilla			0.03	0.02	0.02
Total	139.57	225.65	188.60	192.18	13.49

Table A.3.3.4. Summary of species composition in Norwegian exploratory longline and trawl catches on the slope of the Hatton Bank in 1998 and 1999.

Species	**Longline, 1999,** (Langedal and Hareide,	**Trawl, 1998** (Langedal and Hareide
Centrophorus squamosus	25.97	0
Centroscymnus coelolepis	17.16	10.9
Centroscymnus crepidater	12.24	0
Reinhardtius hippoglossoides	7.41	1.2
Centroscymnus fabricii	8.72	0
Molva dipterygia	7.05	1.4
Deania calceus	5.95	0
Etmopterus princeps	6.67	0
Mora moro	3.26	0
Coryphaenoides rupestris		49.7
Alepocephalus bairdii		20.9
Others	5.57	15.9

Table A.3.3.5. Discard levels, as percentage of total catch per haul, from Irish long line survey on Porcupine Bank and Sea Bight in December 1999.

Latitude	Longitude	Mean Depth	Haul No.	*Deania calcea*	*G. melastomus*	*E. princeps*	*C.monstrosa*	*H. afinis*	*C.crepidater*	*C. fabricii*	*E. spnax*	*G. murinus*	*S. ringens*	*S. rostratus*	*S. grandis*	*S. kaupi*	*S. rostratus*	*L. eques*
53.88	13.30	988	1	47	0				5									
53.57	13.26	748	2	55	1		2											
53.56	13.23	557	3	48	5		1											
54.05	13.33	1277	4	19		18			10			1				1		
53.53	13.24	468	5		7		4			9								
53.55	13.26	745	6	63	3		2											
52.26	14.47	514	7		69		2											
52.25	14.47	585	8	4	70													
52.25	14.52	765	9	60	11		1											
54.24	15.01	944	10	34	0		1		2									
52.24	15.60	1097	11	40	0		1		0					1			1	
52.25	14.12	1304	12	3		2			2									
52.24	15.16	1378	13	2		8			8									
51.91	13.10	1227	14	7		6	1		7									
51.91	14.57	1038	15	27			1		5									
51.91	14.52	907	16	34	3				1				1					
51.91	15.21	1403	17	1		4			9									
51.61	13.49	695	18	1	71				2				8					
51.51	13.32	1209	19	7					2			1						
50.01	11.38	1251	20	51					3									
49.59	11.35	610	21	58					1									
49.57	11.31	883	22	76									1					
50.30	11.47	1798	23			1		45							6			
50.11	11.44	1720	24			19										1		
50.48	11.57	1974	25												14			
50.53	11.49	1823	26			1		16							1	32		
50.56	11.42	1603	27			17												
50.55	11.33	1444	28	7		26			12									
50.55	11.31	1188	29				23		18									2
50.49	11.28	1032	30	15					1									
50.55	11.25	849	31	6	26								13					
50.57	11.30	995	32	11	27				6									
50.57	11.32	988	33	30	3	4			2									
50.59	11.33	1105	34	38					4									
51.00	11.34	1071	35	14	1				2					1			1	
50.10	11.36	1071	36	24					5									
51.30	11.29	565	37		2													
50.20	11.37	1125	38	49					4				8					

Table A.3.3.6. Estimated retained catch and discard in percentages. Spanish multi-species deep sea fishery on Hatton Bank (1996-2000). %R = Percentage retained, %D = Percentage discarded

Species	**YEAR**									
	1996		**1997**		**1998**		**1999**		**2000**	
	%R	%D	%R	%D	%R	%D	%R	%D	%R	%D
Roundnose Grenadier	94	6	96	4	91	9	75	25	93	7
Smoothhead	77	23	97	3	98	2	75	25	92	8
Portuguese dogfish	100	0	100	0	100	0	100	0	100	0
Blue ling	100	0	100	0	100	0	100	0	100	0
Greenland halibut	100	0	100	0	100	0	100	0	100	0
Roughsnout grenadier	0	100	0	100	2	98	0	100	1	99
Blcak scabbardfish	100	0	99	1	98	2	100	0	99	1
NAtlantic codling	37	63	0	100	9	91	0	100	33	67
Deep water sharks	98	2	82	18	69	31	77	23	67	33
Chimaeras	79	21	69	31	57	43	89	11	58	42
Skates	98	2	99	1	34	66			29	71
Various fish species	93	7	99	1	67	33	63	37	34	66

Table A.3.3.7 Spanish observed retained, discarded and total catches, effort and CPUE on the Reykjanes Ridge. Commercial fishery in 2000. (ICES XIVb Division). Amounts < 0.04 ton, are noted as 0.0. Data from a single vessel.

Year: 2000 Gear: Bottom trawl	ICES XIVb Division	Data from one observed vessel				
Species		Retained (Tonnes)	Discard (Tonnes)	Catches (Tonnes)	Effort (Hours)	CPUE (Kg / Hour)
Blue ling	*Molva dypterygia*	76.3	0.1	76.4	78.6	972.2
Atlantic halibut	*Hippoglossus hippoglossus*	1.9	-	1.9	78.6	23.9
Redfish	*Sebastes sp*	0.9	0.0	1.0	78.6	12.5
Lantern shark	*Etmopterus sp*	-	0.0	0.0	78.6	0.2
Roundnose grenadier	*Coryphaenoides rupestris*	-	0.0	0.0	78.6	< 0.2

Table A.3.3.8. Discard CPUE (kg per 1000 hooks) during Irish longline survey on Hatton, Rockall and Porcupine Banks in August 2000.

Depth	Latitude	Longitude	*Anarhicus denticulatus*	*Coelorhynchus coelorhynchus*	*Centroscymnus crepidater*	*Chimaera monstrosa*	*Etmopterus princeps*	*Galeus melastomus*	*Helicolenus dactylopterus*	*Lepidion eques*	*Deania calceus*	*Synaphobranchus kaupi*
654	57 42.4	18 43.8								0.2	16.8	
679	57 44.1	18 45.4				0.8		66.8		0.1	211.4	
796	57 47.2	18 57.1			29.1			54.1		0.5	48.6	
1024	57 52.9	19 11.0			148.8	2.9	59.0	0.3				
1292	58 00.0	19 23.4		0.8			141.1					0.0
1536	58 02.5	19 36.1		0.1			3.4				21.7	
695	57 07.20	16 35.8			1.1	3.7		13.4		0.2	117.9	
956	57 08.6	16 36.4			62.7	1.2				0.4	49.2	
1130	57 05.9	16 42.7			69.7		23.1					
1202	57 10.5	16 44.6		0.1	11.7		149.3					0.0
1316	57 11.7	16 47.5			23.3						100.8	0.1
750	57 07.8	16 36.8			2.0			2.8		0.4		
167	56 57.8	14 38.1	0.8									
171	56 57.0	14 11.8	1.8									
168	56 57.4	14 42.3	5.9									
169	56 58.6	14 38.8	4.2						0.2		132.1	
682	54 18.7	11 23.5				10.9		0.6	28.5	1.1	109.4	
603	54 18.1	11 23.4				32.5		1.0	16.1	0.3	41.2	
505	54 17	11 25.5				69.4		0.1	37.7		16.8	

Table A.3.3.9. Discard CPUE (kg per 1,000 hooks) during Irish longline survey on Porcupine Bank in September 2000.

Depth	Latitude	Longitude	*Centroscymnus crepidater*	*Centroscyllium fabrici*	*Deania calceus*	*Etmopterus princeps*	*Etmopterus spinax*	*Galeus melastomus*	*Helicolenus dactylopterus*	*Lepidion eques*	*Synaphobranchus kaupi*
512	54 02.11	12 08.87							36.0		
536	54 00.56	12 14.46						5.9	99.7		
800	54 00.12	12 18.58			75.1		0.5	1.3	6.1	0.4	
1000	54 02.36	17 17.07	7.3		922.5	2.0			19.8	2.1	
1000	54 03.40	12 19.00			376.9	7.6			3.8	0.9	
1000	54 07.1	12 18.2			0.0	23.2					
1200	54 06.54	12 15.97	82.9	15.0	293.3	250.0				2.8	2.3
1200	54 06.90	12 09.00	47.7		123.2	257.1				0.8	0.4
1,600	54 08.9	12 17.10				0.4					
1800	54 10.5	12 18.2									
249	53 25.11	13 03.09				0.8				2.5	
239	53 25.45	13 06.16							16.1		
170	53 27.01	13 23.56							12.4		
173	53 26.3	13 19.2									
174	53 28.4	13 27.6									
1150	53 51.6	13 58.2									
450	53 45.78	13 47.4	48.4	6.3	24.4						1.6
600	53 47.18	13 50.9			12.0		0.9	2.8	33.0		
900	53 49.41	13 55.8			93.7		1.6	19.3	72.8		
560	53 45.55	13 51.56	23.3		851.7					0.3	
486	54 21.68	11 20.34					2.1	22.1	66.3		
800	54 24.10	11 24.06			2.4			0.4	28.4	0.4	
960	54 24.45	11 25.93			240.9					0.3	
718	54 24.9	11 21.0	43.4	2.9	400.5	5.1				0.4	
500	54 27.45	11.09.00			237.3				9.3	2.4	
650	54 24.33	11 13.52						4.5	45.4		
500	54 09.82	11 42.88			319.1		0.1	0.4	48.3	0.5	
308	53 50.45	11 50.64	1.3		6.3		2.6	1.1	23.5		

A.3.4 Gear Selectivity

There have been very few investigations into gear selectivity on deep-water species in the NE Atlantic.

A.3.4.1 Trawl Selectivity

In shallow water a wide variety of trawls have been designed for different fisheries and it is only by comparing their catches that a detailed picture of the fish assemblages of an area can be acquired. The amount of fishing in deep-water surveys has been very limited and often confined to a small number of specialised trawls and this could result in biased concept of what constitutes the deep-water assemblages. . Deep-water trawling surveys in the Rockall Trough and the Porcupine Seabight (ICES Sub-areas VI and VII) have used several trawls; multivariate analysis and other methods have been used to compare the total catches. Depth, followed by net type, were the most important factors determining the catch composition and abundance (Gordon and Bergstad, 1992; Gordon *et al*., 1996; Merrett *et al*., 1991). Research trawls fished on a single warp, a technique frequently used in Mediterranean deep-water shrimp fisheries, caught fewer of the larger, more mobile species such as sharks (Gordon 2001). There are difficulties when using data collected by different trawls to assess fishery impacts, but these can largely be addressed by using modelling methods as demonstrated in a recent study of the Rockall Trough (Basson *et al*. 2001)

A search of the literature yielded only one significant paper on cod-end selectivity in a trawl. Clarke *et al* (1999) report on an experiment made on the eastern slope of the Rockall Trough from St Kilda to the Porcupine Bank. The survey was conducted in November 1997 and carried out repeat tows, with and without a small mesh cod end liner (30mm), on a commercial 105mm trawl, in order to carry out a preliminary examination of *C. rupestris* selectivity. The landings and discards from both operations were measured (Fig A.3.4.1). These data show two distinct size modes representing the landed (12 to 25cm) and discarded (6 to 16cm) component of the *C. rupestris* catch. The length distributions of the catch are very similar and may indicate that cod end mesh size may not be a useful management tool for this fishery.

An independent, unpublished, Scottish investigation took place in 1996 (N. Graham, Marine Laboratory, Aberdeen, pers. comm.) which supports the conclusions of the Irish work.

Mesh selectivity trials were carried out on FRV Scotia in September and October 1996 on the Wyville-Thompson Ridge and the Faroe/Shetland Channel. A commercial rockhopper trawl was used during the trials; the cod-end was constructed from 100mm (nominal) double braided PE with an inside mesh size of 100mm. To assess the total population entering the cod-end an unhooped small mesh (20mm 210/24) cover was fitted over the cod-end to retain the fish escaping from the cod-end. A total of 22 successful tows were conducted, with 14 in 500m depth or greater. Catches of up to 45 baskets per hour were recorded and 60 species were observed. For the sake of analysis the species were divided

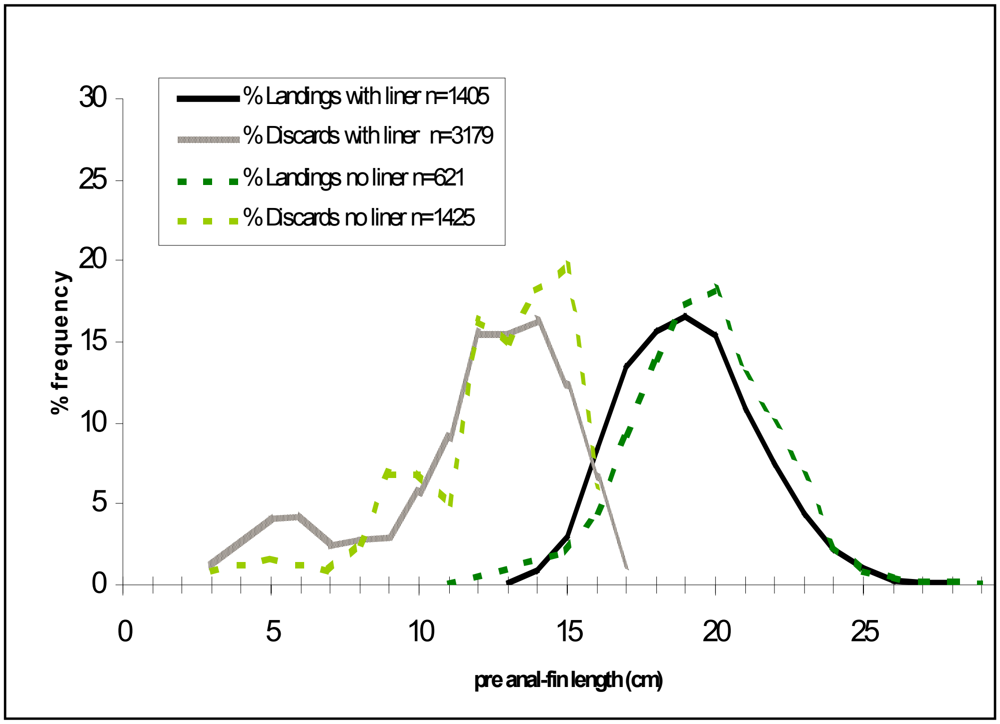


Fig. A.3.4.1. Length frequency of Roundnose grenadier from a commercial trawl (100 mm) with and without small mesh cod-end liner (25 mm).

into two components: commercial and non-commercial. Tables A.3.4.1 and A.3.4.2 show the percentage retained for each category of species.

It is clear from the results presented that the current minimum mesh size (100mm) retains almost all the commercial species entering the gear irrespective of length with the exception of blue whiting (*Micromesistius poutassou*), whiting (*Merlangius merlangus*) and the cod-like *Halargyreus johnsonii.* Generally, insufficient numbers of fish were caught to construct ogives; when obtained, poor length/retention relationships were usually found. The only species that showed any degree of size selectivity was blue whiting where only 24% of the total catch were retained. A selection ogive was constructed for this species which suggested a L_{50} of 22.5 cm with a selection range of 6.7 cm. It can be seen from the non-commercial species that the mesh size used resulted in poor selection for some species e.g. 100% retention, or close, for many species whilst for other species e.g. *Careproctus micropus* there was 0% retention.

Table A.3.4.1. Scottish selection experiments on the Wyville-Thompson Ridge. Commercial species.

Species	Nos in Cod-end	Nos in Cover	% Retained
0.1.1. Lophius piscatorius	17	0	100
Epigonus telescopus	33	18	65
Aphanopus carbo	272	8	97
Micromesistius poutassou	3049	9601	24
Chimaera monstrosa	405	19	96
Argentina silus	5750	235	96
Reinhardtius hippoglossoides	289	0	100
Phycis blennoides	7	0	100
Trachurus trachurus	1	0	100
Scyliorhinus canicula	0	1	0
Centrophorus squamosus	2	3	40
Macrourus berglax	16	0	100
Lepidorhombus whiffiagonus	1	0	100
Mora moro	1	0	100
Sebastes viviparus	8	3	73
Ommastrephidae	36	0	100
Centroscymnus coelolepis	11	0	100
Raja bathyphila	6	1	86
Sebastes marinus marinus	1	0	100
Deania calceus	6	0	100
Coryphaenoides rupestris	176	36	83
Raja fullonica	1	0	100
Sebastes marinus mentella	25	0	100
Brosme brosme	26	0	100
Etmopterus spinax	3	4	43
Merlangius merlangus	5	53	9
Glyptocephalus cynoglossus	5	5	50

Table A.3.4.2. Scottish selection experiments on the Wyville-Thompson Ridge. Non-commercial species.

Species	Nos in Cod-end	Nos in Cover	% Retained
0.1.2. Apristurus laurussonii	2	0	100
Bathyraja spinicauda	1	0	100
Raja hyperborea	6	3	66
Antonogadus macrophthalmus	0	13	0
Galeus melastomus	1	0	100
Notacanthus bonapartii	1	0	100
Careproctus micropus	0	1	0
Coelorhinchus coelorhinchus	1	0	100
Cottunculus sadko	13	24	35
Lycodes esmarkii	3	1	75
Zoarcidae	4	0	100
Raja fyllae	15	0	100
Halargyreus johnsonii	46	158	23
Myxine glutinosa	4	5	44
Hydrolagus mirabilis	5	0	100
Myctophidae	3	19	14
Notolepsis rissoi Kroyeri	4	19	17
Lepidion eques	686	433	61
Nezumia aequalis	9	18	33
Nansenia groenlandica	0	1	0
Paraliparis spp.	1	0	100
Alepocephalus bairdii	252	13	95
Gadiculus argenteus thori	164	542	23
Synaphobranchus kaupi	5	6	45
Xenodermichthys copei	3	79	4

Caution must be used in interpreting these results because:

it is known that an unsupported cod-end cover causes masking of the cod-end, hence altering the selectivity parameters. This can reduce the observed L_{50} by the order of 4 to 5 cm.

For many species only a few individuals were caught and this may skew the results.

However, it can be concluded that due to the diverse range (physical shape and size) of species targeted in this fishery it would be unreasonable to expect one mesh size to be selective for many of the species retained.

During the Scottish investigations, video tapes of fish behaviour in the trawl during the fishing have shown the amount of skin damage incurred and exhaustion experienced by the majority of species trapped in the net. The conclusion was that there is probably an extremely low survival rate for deep water species escaping from a trawl, although this has never been quantified.

A 3.4.2 Longline selectivity

Trawls and long-lines are fundamentally different fishing methods. Trawls herd fish into the opening of the net, while fish are attracted to long-lines by the smell of the bait. This results in both size and species selection (Hareide, 1995). Long-lines tend to select for larger teleost fish than trawls (Hareide, 1995; Jørgensen, 1995). Hareide points out that larger specimens of certain species avoid trawls but are caught on long-lines. Since the swimming speed of a fish is proportional to its body size, larger fish will be hooked more rapidly than smaller fish. Furthermore, research on cod *Gadus morhua* shows that larger fish tend to frighten away smaller ones from baited hooks (Bjordal and Lokkeborg, 1996).

Differing length frequencies from trawl and longline have been described for several deep-water teleost fish. Nederaas et al. (1993) and Jørgensen (1995) both describe how longlines selected for larger Greenland halibut *Reinhardtius hippoglossoides* than trawls. Similarly, Klein (1986) found that longlines selected larger sablefish *Anoplopoma fimbria* than trawls. The consequences of these differences have been illustrated in several studies. Klein (1986) found that yield per recruit for *Anoplopoma fimbria* was higher for longline than trawl - provided that fishing mortality F was kept below 0.7. Similarly Jørgensen (1995) found that longline produced higher yield per recruit and maximum sustainable yield for *Reinhardtius hippoglossoides* in the Davis Strait than trawls.

One effect of size selectivity is that more mature fish will be caught by long-lines, and with heavy fishing this could be harmful to the spawning stock of teleost fish. However Hareide (1995) suggests that fishing of the older part of the stock results in less risk of over-exploitation than fishing of the younger year classes. Based on the results of Clarke (2000) and Clarke et al. (*in press*) it seems that this statement may not apply to deep-water shark species because long-lines are not size-selective. Smaller specimens of both sexes of Portuguese dogfish *Centroscymnus coelolepis* and male birdbeak dogfish *Deania calceus* taken on long-lines were absent from trawl catches. Furthermore, squalid sharks as small as 27 cm TL were taken on long-lines (Connolly *et al*., 1999).

Bait size, rather than hook size is considered to be the most important parameter affecting teleost size selectivity, with smaller fish tending to favour smaller prey items (Bjordal and Lokkeborg, 1996). Results from Irish longline surveys (Clarke, 2000; Connolly et al., 1999) show that commercial (13/0 EZ) hooks and baits select for a broad size spectrum of squaliform sharks representing the entire length range of free-swimming specimens of the species under study. Thus while long-lines have been shown to be a size-selective fishing method for teleosts (Hareide, 1995; Jorgensen, 1995) they do not have any selective properties for squaliform sharks. It appears that small sharks are well adapted to prey on relatively large food items. The results of Irish longline surveys support Gordon's (1999) view that long-lines are not a selective fishing method for sharks. Furthermore deep-water sharks dominate discards from longlines (Connolly and Kelly, 1996).

Comparative trawl and longline surveys of the continental slopes of the Rockall Trough in 1997 were used to compare the size frequencies of squalid sharks. There were no significant differences in the length frequency distributions from trawl and longline for leafscale gulper shark *Centrophorus squamosus.* However there were significant differences for *Centroscymnus coelolepis* (KS test, $p<0.05$), for which longlines took both larger and smaller specimens (Clarke, 2000). Length frequencies for male *Deania calceus* from each fishing method were not significantly different (KS test $p<0.05$). However for this species longlines selected for significantly larger ($p<0.05$) females than trawls; modal length from trawling was 85 cm in contrast to 105 cm for longlines (Clarke *et al.* in press).

Whilst there are differences in size selectivity between trawl and longline, especially for teleost fish, it should be noted that not all species are taken by both gears. Roundnose grenadier, orange roughy and black scabbard are not taken by autoline longline systems, though black scabbard is taken on droplines in Portuguese waters. Portuguese investigations on experimental long line surveys in 1979 –1983 and 1985 off Seisembra showed that 42% of the sets only caught black scabbard, see the text table below. The lower quartile corresponds to 80% which highlights the reduced catches of other species.(I. Figureido, pers. comm.)

Text table. Occurrence of Black scabbardfish (BSF) in longline experimental surveys conducted by IPIMAR

	Percentage of BSF in the total catch by numbers.	No of sets equal	
Min	0%	7	3%
Max	100%	109	42%

	Percentage of BSF in the total catch by numbers	No of sets lower than	
Lower quart	80%	65	25%
Median	95%	133	51%
Upper quart	100%		

On the other hand, Tusk and Mora are taken mostly on long-line (autoline system). Sharks and rays are the most important groups taken by both gears. Other species that can be caught by both gears are Blue ling, Roughhead grenadier, Rabbitfish species, Bluemouth rockfish and Greater forkbeard. However Blue ling – a species that forms spawning aggregations – is not fished by long-line during these periods, as it is not attracted to bait during spawning.

In summary it is suggested that:

- It is unrealistic to manage such a diverse fishery as the deep-water trawl fishery by using a single mesh size.
- The survival rate of fish escaping from a trawl is likely to be extremely low.

- The fragility associated with deep-water species probably precludes the use of such technical measures as used in the shelf fisheries e.g. grids and panels.
- Long-lines have a size selectivity for teleosts as they tend to catch the larger, mature, component of the stock.
- Long-lines are inappropriate for catching target species such as roundnose grenadier and Orange roughy
- Heavy fishing by long-line may adversely affect the spawning stock of teleosts.
- There is no size selectivity of long-lines for squaliform sharks with the consequence that deep-water sharks dominate the discards from long-lines.

A.4 IDENTIFICATION OF SENSITIVE AREAS THAT MIGHT BE AFFECTED BY DEEP-SEA FISHING.

Deep-sea fisheries, especially those using bottom trawls, affect the sea bottom and its animal communities. The overall effect depends on the gear type and the type of bottom.

Because of the general slow growth of the deep-sea fauna the deep-sea bottom communities are considered to be much more vulnerable to bottom trawls than more shallow water communities because of the long regeneration time.

Disturbance of the seabed as a result of the action of fishing gear is of increasing concern and there were many papers published on the subject in a recent ICES Symposium on the *Ecosystem Effects of Fishing* (Hollingworth, 2000). Only one paper considered the ecosystem effects of fishing in deep-water (Koslow et al. 2000).

In the context of the North Atlantic the report of the 2000 **ICES Working Group on Ecosystem Effects of Fishing Activities** (WGECO) briefly considered deep-water fisheries, and the following extract is relevant as basis for any proposed action by the Commission on the effect of deep-sea fisheries:

“ Ecosystem Effects of Deep-Water Fisheries:

In Section 6, WGECO notes that effects of fishing gears on habitats are generally the most long-lasting and irreversible of all effects of fishing on ecosystems. In that context, WGECO takes note of the expansion of fisheries into new areas, as harvesting of deep-water species expands. WGECO has confidence in the approach taken by WGDEEP, in giving importance to the life history characteristics of many deep-water species, which indicate that those species can sustain only very low exploitation rates. However, WGECO would like to stress its concern about the physical and biogenic features of the deep-water habitats as well. To date, these are likely to have been much less impacted by bottom gears than habitat features on shelf seas in the ICES area, but the habitats are likely to be highly vulnerable for all the reasons described in Sections 6 and 7. WGECO urges ICES to attach priority in its advice, and management agencies in their regulations, to ensuring that these new and expanding fisheries are kept sustainable both with regard to the mortalities inflicted on all species (target and non-target) and effects on habitats.”

In the answer to EC request for advice on deep sea fisheries management ICES ACFM stated the following:

"The Commission should strongly support projects for *investigating the impact of trawl gear on the deep-sea floor."*

It is therefore this group's opinion that high priority should be given to identify such locations in all areas with expanding deep-sea fisheries.

A.4.1 Locations with cold water corals in NE Atlantic.

The group had at its disposal the Interim report of **the *ICES SG on Mapping the Occurrence of Cold Water Corals*** (ICES, 2001d), from which the following information has been extracted.

Cold-water corals refer to those coral species that contribute to reef formation in waters less than about 20^{o}C. In north-east Atlantic waters these include the azooxanthellate scleractinarian corals *Desmophyllum cristagalli, Enallopsammia rostrata, Lophelia pertusa, Madrepora oculata* and *Solenosmilia variabilis*.

The main reef building species is *Lophelia pertusa*. Other coral species often occur in association with *Lophelia pertusa* and none has been found forming reefs away without *Lophelia pertusa* being present.

Lophelia pertusa appears to prefer oceanic waters with a temperature of between 4 and 12^{o}C, and a relatively high water flow. It has also been proposed that the water needs to be relatively clean of entrained sediment. It has long been thought that the species also required a hard substrate to attach itself to, although recent evidence (see section 2.3.4 below) indicates that this is not always the case. Once established in an area, the species appears to be able to spread across the seabed by growing on dead and fallen pieces of itself (as with some other biogenic reef forming organisms). *Lophelia pertusa* can occur in a variety of forms; in larval form it can presumably move widely, but once settled it can grow upon itself, as mentioned above, to form large reefs or reef complexes.

The greatest of these reefs known in the north-east Atlantic (and globally) is on the Sula Ridge on the mid-Norwegian shelf. This structure is more than 13 km long and up to 450-500m wide. The average height is about 15m, but some individual sub-structures are 35m high (Dons 1944, Freiwald *et al*. 1999). This reef provides a habitat for a diverse associated community of marine life, with some associated fish species at much higher densities than surrounding waters (Jensen and Frederiksen 1992, Mortensen *et al*. 1995).

A.4.2 Distribution of reefs with *Lophelia pertusa* in the NE Atlantic.

The geographical locations of some of these *Lophelia* reef formations are well known, but the exact locations for many of these formations are still not known. However, as suitable environmental conditions (temperature, current) for this species is likely to be widely dispersed in the whole region, aggregations of commercially important deep-water fish may be indicators of such locations.

Until now locations with *Lophelia* reefs have been reported from Icelandic and Norwegian waters in the north, from waters west of the British Isles, for instance the recently discovered Darwin Mounds, from the waters west of Ireland and from the Bay of Biscay and the Galicia bank as well as in the waters around the Atlantic islands of Madeira, Canaries and Azores. The depth distribution of these localities varies between 200 and 1000 m.

A.4.3 Effects of fishing in *Lophelia Pertusa* Reefs

Trawling is very widespread in areas holding *Lophelia pertusa*. Photographic and acoustic surveys have recently located trawl marks at 200-1400 m depth all along the NE Atlantic shelf break area from Ireland, Scotland and Norway (Rogers 1999, Fosså *et al.* 2000, Roberts *et al.* 2000, Bett 2000). Any trawling over *Lophelia pertusa* is likely to cause harm.

The most obvious impact of trawling on *Lophelia pertusa* is mechanical damage caused by the gear itself. The impact of trawled gear will kill the coral polyps and break up the reef structure. The breakdown of this structure will alter the hydrodynamic and sedimentary processes as well as cause a loss of shelter around the reef. Organisms dependent on these features will have a much less suitable habitat and recovery may not be possible or could be seriously impaired. The scale of effects will depend on the scale and frequency of any trawling operations. Damage will range from a decrease in the size of the reef, and a consequent decrease in abundance and diversity of associated fauna, to a complete disintegration of the reef and its replacement with a low-diversity disturbed community (Fosså *et al*. 2000).

Fosså *et al*. (2000) estimated that between a third and a half of Norway's *Lophelia pertusa* reefs are damaged or affected by fishing. Damage is shown in a number of areas by comparing photographs In order to distinguish natural decay from impacts by human activities, such as bottom trawling, they looked for broken living colonies tilted, turned upside down and/or in unexpected/awkward positions on levelled sea bottom. The remains of fishing gear such as gillnets, anchors, and trawl nets among corals added to the evidence while recent furrows or scars in the sea bottom are unmistakable evidence of trawling activity.

A.4.4 Other sensitive deep-sea areas

Several hydrothermal vents fields in Azores EEZ, should be considered as sensitive marine habitats. It include deep water vent fields but also shallow vent fields in localized seamounts. Because this deep areas can superimpose with the fishing areas their protection should be anticipated in the present report. In this context those areas should be closed to any fishing activities trough the implementation of a "box" and a buffer zone enclosing those areas. Recently the Azores government began a process involving international scientific advising, in the view of submitting a proposal to UNESCO, for the recognition of those areas as World (Humanity) Heritage Sites due to their scientific and natural interest. The definition of the areas of interest, their justification, the buffer zones and sizes of the areas, etc, etc, are being worked and will constitute the base of the proposal.

Azores government is also studying the possibility of the implementation of effort and gear restrictions in several seamounts in the Azores EEZ, which can work as MPA's were certain practices of fishing must be achieved due to the sensitivity of these ecosystems.

A.4.5 Areas with Soft bottom sediments

While damage to hard bottom substrates may be the most obvious and readily explainable impact of fishing, it has to be recognised that most deep-water trawling takes place in areas of soft-bottomed sediments. Few fishermen, unless by accident or while searching for new grounds, will risk damaging their trawls by fishing on hard ground unless the rewards are high.

The impact of trawling on deep-sea soft bottom sediments and their biota is virtually unknown. However, photographic surveys frequently reveal the presence of trawl marks on the seabed. In one such survey such marks were visible in 2 to 12% of all photographs at depths between 700 and 1300 m (Roberts et al. 2000). Evidence of trawl marks were also found during the AFEN surveys (Bett, 2000). Bett (2000) also reports on surface on a box core sample from west of the Hebrides that was considered disturbed by the passage of a bottom trawl.

A.4.6 The experience from Australian and New Zealand waters.

The following information is taken from Koslow *et al*. (2000). In Australian and New Zealand deep waters between 600 and 1400 m depth, where trawl fisheries for Orange Roughy have been major fisheries of New Zealand and south eastern Australia since the 1980s, there is already several evidences of destruction of the fragile communities where these fisheries have taken place.

Both in Australian and New Zealand waters the fisheries for Orange Roughy takes place on sea mounts where large feeding and spawning aggregations of this species are found.

Substantial by-catch of coral is reported when these fisheries initially exploit a sea mount area. A benthic survey of fished and unfished seamounts on the continental slope south of Tasmania, Australia showed that the dominant benthic organism was a hard colonial matrix-forming coral, *Solenosmilia variabilis*, which served as substrate for a variety of hard and soft (gorgonian and antipatharian) corals, hydroids, sponges, as well as providing habitat for crustaceans and suspension-feeding ophiuroids and sea-stars Trawl operations effectively removed the reef aggregate from the most heavily fished seamounts. The benthic biomass of samples from unfished seamounts was 106% greater than from heavily fished seamounts and the number of species per sample was 46% greater. In 1999 a group of fourteen unfished seamounts in this area were set aside in a 'marine protected area'.

A.4.7 Conclusions on areas/locations sensitive to deep-sea fisheries.

The overall conclusion from the experience described above (NE Atlantic, Mediterranean as well as Australian and New Zealand waters) on the effect of trawling on deep-water coral beds is, that this effect is dramatic regarding species composition and furthermore seemingly long lasting. There also indications, although less profound, that even long lining and gill netting may cause changes in this fragile environment.

As stated in Sect. 4.6 the impact of trawling on soft bottom in not known. However, as it the impact of especially trawling on soft bottom areas in more shallow waters is known to cause a change of species composition, a similar effect is likely in the deep-sea soft bottom areas.

The WG points out the following areas with either fragile coral ecosystems or other features of special conservation value:

A.4.7.1 Rockall trough

Darwin Mounds south of the Wyville-Thompson Ridge (Fig. A.4.1) have been described and studied by British scientists. The knowledge of this cluster of mounds was summarised in the Interim report of the **ICES SG on Mapping the Occurrence of Cold Water Corals** (ICES, 2001d).

These mounds cover an area of approximately 100 km² and contain some hundreds of mounds in two main fields (referred to as Darwin Mounds East (about 13 km x 4 km with about 75 mounds) and Darwin Mounds West (13 km x 9 km with 150 mounds)(see Figure 6). Other mounds are scattered at much lower densities in nearby areas. Each of the mounds is approximately 100m in diameter and 5m high. Most of the mounds are also distinguished by the presence of an additional feature visible on the side-scan sonar referred to as a 'tail'. The tails are of a variable extent and may coalesce, but are generally a teardrop shape and are orientated south-west of the mound.

The mounds are comprised mostly of sand, interpreted as sand volcanoes. These features are caused when fluidised sand "de-waters". Sand volcanoes are common in the Devonian fossil record in UK and in seismically active areas of the planet. In this case, tectonic activity is unlikely; some form of slumping on the SW side of the Wyville Thomson Ridge being a more likely cause. The tops of the mounds have living stands of *Lophelia pertusa* and blocky rubble (interpreted as coral debris).

The tails also support significant populations of the xenophyophore *Syringammina fragilissima*. This is a large (15 cm diameter) single celled organism that is widespread in deep waters, but occurs in particularly high densities on the mounds and the tails. The corals themselves provide a habitat for various species of larger sessile or near sessile invertebrates such as sponges and brisingiids. Various fish have been observed, but not apparently at significantly higher densities than the background environment. This contrasts with studies at other *Lophelia pertusa* sites where elevated numbers of saithe *Pollachius virens*, redfish *Sebastes* spp. and tusk *Brosme brosme* have been found (Mortensen *et al*. 1995, 2001, Fosså *et al*. 2000).

The mound-tail feature of the Darwin Mounds is apparently unique globally. The mounds are also unusual in that *Lophelia pertusa* appears to be growing on sand rather than a hard substrate. Prior to research on the mounds in 2000, it was thought that *Lophelia pertusa* required a hard substrate for attachment.

Trawling has had a severe impact on the Darwin Mounds, and this fishery continuing. If protected, this area will by include corals bed in all conditions (unimpacted, moderately altered, severely impacted, completely destroyed). The SGCOR study group considered that some impact on the Darwin Mounds way already be permanent, however, the impacted area was estimated to be about half the whole coral coverage on the Darwin Mounds so that protection of this area may both provide effective benthic community and fish habitat conservation and allow for study of the possible recovering dynamic when the cause of damage is removed.

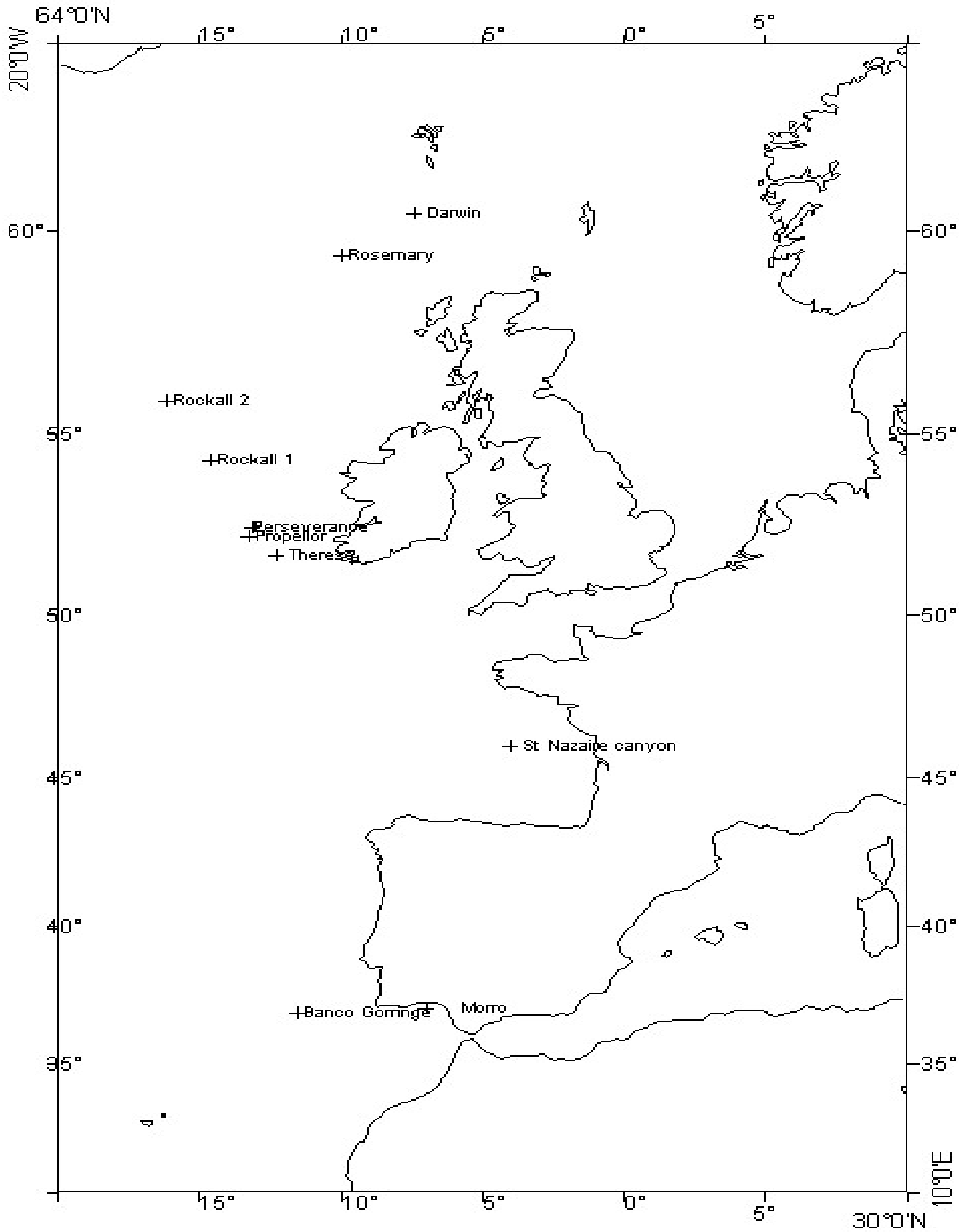


Figure A. 4.1. Location of some potential MPA in the NE Atlantic allowing for conservation of corals and other benthic fauna. The conservation of this fauna along the slope requires several zone distributed from north to south due to likely latitudinal changes in the fauna. Note that the locations on this map only refer to the few areas mentioned in the text.

A.4.7.2 West of Ireland

The outer slope of the Porcupine bank seems to be colonised by large coral communities. A fishery is developing in this area, and recent research cruises has observed that the coral mounds were in good conditions, but that there were signs in the bottom of trawl tracks. Also lost gillnets were observed. The surrounding sedimentary bottom is subject to trawling activities, but the vessels operating in this area seem to avoid trawling over coral communities.

A.4.7.3 Bay of Biscay

Several coral locations have been recorded in the bay of Biscay. The status of these benthic communities is unknown, however the deep water trawling is little developed in the bay of Biscay as a consequence of the topography of the slope in this area. However, due the availability of deepwater charts and the decline in the catch rates in other areas, the industry may try to find new fishing grounds in this area. Moreover, fisheries with static gears are already well developed in the bay of Biscay. Such gear and in particular gill net may severely affect both the benthic fauna itself as coral communities are broken when the net is hauled in as a result of the entanglement of the net if the structure. Moreover, some gear may be lost (as seen west of Ireland) and they are very likely to exert ghost fishing as they would keep both "properly" set because they are hold by the corals and clean because the coral grow in areas with low suspended matter load. In the bay of Biscay the corals seem to be more abundant between depths of 200 to 500 m (Zibrowius, 1980 ; Rogers, 1999). There are unconfirmed indications that the upper parts of Canyons at the shelf break are colonised by large communities.

Then, a protected area in the bay of Biscay should include a Canyon head. In order to protect an area far enough from the Porcupine/Celtic sea area, the location should be toward the south. However, the very should east of the bay is a sedimentary area of sediments brought by rivers. A location by 46°North and 4°W should allow to achieve this goal (to be specified according to depth).

A.4.7.4 Southern areas, west of Portugal.

Two areas to the south west of Portugal are of particular interest:

Banco Gorringe (36°30'30N ; 11°20'W). This is a seamount formation, but it has not yet been investigated whether or not it is colonised by corals. However, there is no doubt that this particular seamount in this area is of high importance for the local invertebrate and fish fauna;

Morro area. This area includes a seamount formation influenced by the Mediterranean outflow current. There are indications that it is colonised by corals. It is characterised by a high level of species diversity, which is in contrast to that in the adjacent waters.

A.4.8 Reference areas

4.8.1 Rockall Trough - soft bottom sediment area

A expert workshop on “Managing risks to biodiversity and the environment on the high seas, including tools such as marine protected areas” (Thiel and Koslow, 2001) provided an indicative list of aspects of the marine environment which give rise to concern. Among these were the ecosystems of seamounts, cold water coral communities, deep-sea fish and unique scientific reference areas. The latter, further defined as areas that have been thoroughly studied and therefore provide a reference in space and time, could well be applied to the Rockall Trough. Indeed it is interesting that WWF have selected the whole Rockall Trough/Channel as a potential marine protected area (MPA). However there is one area of the Rockall Trough (recently reviewed by Gordon, 2001) that has special significance in a fishery context. There have been numerous, multinational fishery surveys in the area of the Hebridean Terrace (56 - 57° N; 08 - 10° W) since the early 1970s and these continue to the present. The European Commission has supported the analysis and archiving of much of the data from these surveys. The physical and biological oceanography of this area has also been extensively studied. It has been subjected to considerable commercial fishing effort since the early 1990s. The effect of fishing in this and adjacent areas have been investigated by Basson et al. (2001). This soft bottom area might be considered for protection and offer an opportunity to observe the recovery from the effects of deep-water fishing.

A.5. MANAGEMENT.

Most deep-water species in ICES area are long-lived, slow growing and have a very low reproductive capacity. These species are, therefore, very vulnerable to exploitation and once depleted will recover very slowly. A further concern is that recruitment for some species, e.g. orange roughy, may be episodic with pulses of recruitment occurring infrequently, possibly on a decadal scale. Given the vulnerability and fragility of these stocks, fisheries should be managed rigorously as they develop and steps taken to ensure that extensive biological monitoring is in place to facilitate stock assessments and an understanding of the status of stocks. Critically, fishing effort should be restricted initially, until it is established that stocks can sustain higher levels of effort in the longer term.

A.5.1. Management measures for deep-water fisheries.

In contrast, exploitation of almost all deep-water species in the ICES area has been completely unregulated and new fisheries continue to develop without any management structure in place. The collection of biological information and data for use in assessments has lagged behind exploitation. Consequently, current assessments are based on short time-series of data and are imprecise. Notwithstanding, time-series catch-per-unit effort data show a strong declining trend for most species and areas, and it is widely recognised that most stocks are over-exploited and some have already collapsed or are close to collapsing, for example, blue ling in all areas, orange roughy in VI, red (blackspot) seabream in VI, VII and VIII. This is confirmed by the latest ICES advice, which states that most deep-water stocks in the ICES are over-exploited and outside safe biological limits (below U_{pa}), and in some cases close to or below U_{lim} (in danger of or have already collapsed). It is important to note that this advice is based on assessments carried out in 2000, using fisheries data up to and including 1998. Thus, current advice on the state of stocks refers to the situation three years ago, and given that over the last three years levels of fishing effort have been sustained and for some species have increased, the current state of some stocks is likely to be worse than previously estimated.

The Commission is committed to proposing a regulation for fisheries for deep-water species in the NE Atlantic to be introduced on 1st January 2002, and is now carrying out a consultation exercise to establish the type of management instruments to be used. These measures fall into four broad categories: technical measures, TACS, effort regulation and a moratorium of fishing.

A.5.1.1 Technical measures

It is widely recognised that mesh size regulations and selectivity grids will not be effective technical measures for deep-water species. Most deep-water species have fragile skins and suffer considerable damage in trawls. Consequently, there is a very high mortality of escapees. An additional factor is that the unusual size and shape of some deep-water species may result in fish being retained in nets irrespective of fish length and mesh size.

Closed areas/no trawl areas may be an effective management measure for species which aggregate into well-defined spawning concentrations, blue ling for example, and for species such as orange roughy which are found in localised aggregations associated with seamounts and other topographical features. Closed areas will also be particularly useful to protect areas of diverse benthic habitats. The size of any proposed closed areas should be commensurate with control and monitoring capabilities.

A.5.1.2 TACs

lthough TACs provide a relatively straightforward method of allocating quotas between member states and are easy to administrate through recorded landings by the fishing industry, there are a number of strong concerns regarding using TACs as a management measure for deep-water species.

Data available for stock assessment, although improving, remain relatively sparse in comparison to data available for shelf-based stocks. Consequently, current assessments of deep-water species are relatively unsophisticated and do not provide any indication of the relationship between landings and fishing mortality, past, current or future. Thus, it cannot be established that a reduction in TACs will result in a commensurate reduction in fishing mortality. Critically, this why ICES has couched advice for deep-water stocks in terms of fishing effort rather than catches.

In recent years, ICES has repeatedly stated that, for various reasons, TACs alone are not effective in regulating fishing mortality. In the case of stocks which are severely overexploited or depleted, TACs alone may even have a delaying effect on stock recovery, because effort may continue unregulated

A further strong concern is that many deep-water fisheries are mixed fisheries and TACs for different species may be taken at different rates. Thus, when TACs for some species are exhausted fleets will continue fishing on under-subscribed species and discard over-quota species. It is widely known that skin damage and the effects of severe pressure change results in the total mortality of discards. Reduced TACs may not, therefore, significantly reduce fishing mortality in mixed fisheries.

There is considerable concern regarding the effects of fishing on deep-water communities. Discards from trawls also include non-commercial species and, in some areas, large invertebrates, sea-stars, shrimps, all of which die. Trawling also has a very damaging effect on corals and other smaller marine organisms. Fishing effort along the continental slope and on seamounts and other topographical features is very concentrated spatially and by depth, and reductions in TACs will do little to conserve deep-water communities and habitats in these areas.

It is suspected that a significant level of misreporting of catches and landings is taking place in some fisheries. The introduction of TACs, particularly if they are restrictive, may result in higher levels of misreporting and may also encourage high-grading. This problem will be exacerbated if enforcement procedures are not robust across all Member States participating in deep-water fisheries.

Some deep-water stocks straddle international and EU waters. Misreporting in international waters by third party countries will be a problem if TACs are confined to EU vessels. If TACs are introduced they should be harmonised across all participating countries. However, even if TACs are fixed both for the EU and NEAFC regulatory area, there is a significant risk of under-reporting of catches outside national EEZs.

A.5.1.3 Fishing effort regulations

These broadly fall into two categories, licensing of vessels and restrictions of actual fishing effort expressed as days at sea, kilowatt*hours, number of long-lines, number of hooks etc.

Vessel licensing is a well-established method of controlling fishing effort in fisheries around the world, on the Great Barrier Reef Marine Park Authority, Queensland, off the Falklands and in the Mediterranean, for example. Licensing is generally easy to administer and has a major advantage over TACs in that it is easy to enforce.

Regulation of actual fishing effort expressed as Kw/hours, number of long-lines/days is a more complex matter, and depends on detailed effort data being available for all participating fleets. Such a scheme is already in force in waters to the west of the British Isles (Council Regulation 2027/95), but has never been a constraint because effort thresholds were set very high in relation to actual effort.

In contrast, regulation of effort expressed as days at sea would be far less complicated and relatively straightforward to introduce. It would also be very difficult for fishing vessels to misreport.

Fishing effort regulations have a considerable advantage over TACs in that substantial reductions in fishing effort, of the order currently advised by ICES for most deep-water stocks, will result in significant reductions in fishing mortality. This is because there is a close relationship between fishing effort and fishing mortality.

If deep-water stocks are managed by effort regulation, the impact of fishing on deep-water fish communities, and the discard problems that will arise if mixed fisheries are managed by TACs, will be significantly reduced.

A.5.1.4 Moratoria

ICES has advised that there should be a moratorium on directed fishing for blue ling in all areas. The effectiveness of this approach depends totally on the enforcement measures applied. If stocks of other species decline to below levels of Ulim then moratoria should be considered. In mixed fisheries it may become necessary to close the entire fishery. A general concern regarding moratoria, however, is that time-series data used in assessments will be truncated. This is important because there is an almost total lack of research vessel time-series data available for deep-water species in the ICES area.

A.5.1.5 The view of this group on management measures.

It is the opinion of this WG that since the deep-sea fisheries in the NE-Atlantic in most cases can be considered as mixed fisheries, this alone suggests that TAC management of the fisheries will not be effective. This view was also expressed in a Commission Staff Working Paper in 1993 (Sec(93)/1791). In addition, insufficient control and surveillance of these fisheries including discarding on the grounds further weakens the TAC as a management tool for these fisheries. This view is also in line with that of ICES (ICES, 2001c), where, even if the data basis is the same as given in this report, the current advice consists of effort reductions by stock/fishery. On the same grounds as given in

Sect. A.5.1.2, no TACs are included in the current ICES advice for the deep-water fisheries.

In conclusion, this Group recommends that if the Commission proceeds with the introduction of TACs for deep-water species then this could only be regarded as an 'ad hoc' emergency measure until it can be replaced by effort-based management measures A firm time-scale should be identified for Stage 2 of the Commission's strategy for the management of deep-water stocks.

If, for whatever reason, management measures are delayed the Group feel that fishing on deep-water species should be significantly reduced to levels only sufficient to maintain time-series data for assessments. Given the vulnerability of these stocks, this would be consistent with a precautionary approach.

A.5.2 The Commission's current position

According to recent documents released for discussion, the Commission is considering a two-stage management strategy for managing deep-water species. Allocated TACs will serve as the main management instrument in the short term (2002). The Commission will then introduce a programme of actions aimed at leading towards the development of a management system better tailored to the characteristics. This will be developed in consultation with scientific experts, but the following elements have been identified:-

1. A licensing scheme under which vessels may only disembark deep-sea species at a number of designated ports. Licensing conditions will include high resolution VMS monitoring, prohibition to tranship, obligations to carry observers on a sample of vessels and specific log-book reporting conditions.

2. A scientific work programme, co-ordinated through NEAFC and ICES, which would be based on log-book reports, observer information and specific surveys. The objective of the work would be to provide information about specific areas within which unacceptable biological risks are being incurred.

3. Conservation by effort limitation in specific areas. Vulnerable areas would then be candidates for local closures or possibly effort limitations. VMS would be the principal monitoring tool.

The Commission intends to develop a proposal concerning the first stages of such a management system in early 2002.

A.5.2.1 Reference landings for calculation of catch options.

The Commission has proposed that if TACs are introduced as emergency conservation measures, they should be based on mean international landings over a reference period 1989-1998 or 1994-1998, whichever is the lower, see Table A.5.1. Considerable concern has been expressed regarding this procedure. There is a marked declining trend in international landings for some species and areas, such that high values in earlier years may bias the mean upwards. Thus, TACs, even if reduced to 30 or 50% of the reference mean, would be higher than catches in recent years. The Working Group investigated this problem using international landings data (ICES, 2000b) for the above reference periods and also for the most recent three year period: 1997-99. Landings data were aggregated by the new management units proposed by the Group (see Section A.2.3), or a close approximation to these units where landings data lacked sufficient spatial resolution. It was suggested by the Commission that these reference means then be adjusted for the latest ICES advice. Since the ICES advice is based on % effort reduction and not on TACs, using the advised percentage reductions for estimating TACs is very crude and unsatisfactory, especially in view of the opinion and recommendations given by the group in Sect. A.5.1.5.

These calculated suggestions for TACs or ‘catch options’ were compared with international landings data for 1999, the last year with reasonably complete landings data (Table A 5.1).

A ten year reference period gave spectacularly poor results for many species and management units, including increases on 1999 landings levels of 20-40% rather than the reductions of 30-50% for some species advised by ICES. Furthermore, calculated ‘catch options’ for species for which current advice is 'status quo' were extremely variable, some showing large increases compared with landings in 1999, others showing a marked reduction. Using a five-year reference period gave improved results, but compared with landings in 1999 the ‘catch options’ for many species were still seriously out of line with current ICES advice. A three-year reference period gave quite reasonable results for the majority of species/management units, but there remain a number of anomalies, particularly where advice is 'status quo'. The underlying problem is that the international landings data for some species are extremely variable and have high CVs (Table A.5.1); the occasional high or low value can have a profound effect on estimates of mean landings. If a three year mean is used it will be necessary to adjust the final ‘catch options’ for some species on an ad hoc basis, so that they are in line with current ICES advice.

Table A.5.2. Reference mean landings data for three time periods and suggested ‘catch options’. CVs for each reference mean are also shown. The percentage difference between suggested ’catch options’ and reported landings in 1999 is compared with the current ICES advice.

Species	**Management Area** *data not available for management area recommended by group	**ICES advice** (The % indicate reduction in effort)	**1999 landings** tonnes	**Mean reference landings and suggested reductions (TACs)** 1989-1998 Catch options	1989-1998 Mean	1989-1998 CV	1994-1998 Catch options	1994-1998 Mean	1994-1998 CV	1997-1999 Catch options	1997-1999 Mean	1997-1999 CV	Actual % reduction 1989-1998	1994-1998	1997-1999
Alfonsinos	CECAF 34.1.1	Status quo	2	5	5		5	5		3	3		138	138	50
Alfonsinos	VI+VII	Status quo	87	32	32	180	58	58	127	64	64	53	-64	-33	-26
Alfonsinos	VIII+IX	Status quo	198	58	58	154	115	115	85	201	201	33	-71	-42	1
Alfonsinos	X	Status quo	175	602	602	65	774	774	63	462	462	98	244	342	164
Alfonsinos	XII	Status quo					0	0	224	0	0				
Black scabbard	CECAF 34.1.1	Status quo	4,402	3,207	3,207	21	3,667	3667	15	4,285	4285	5	-27	-17	-3
Black scabbard	V,VI, VII	50%	2,408	1,707	3,415	20	1,605	3210	21	1,270	2539	19	-29	-33	-47
Black scabbard	VIII and IX*	50%	2,749	1,893	3785	13	1,822	3645	12	1,576	3152	13	-31	-34	-43
Black scabbard	X	Status quo	104	65	65	185	23	23	183	69	69	83	-37	-78	-34
Black scabbard	XII	Status quo	177	328	328	122	324	324	99	177	177	13	85	83	0
Blackmouth dogfish	IX	Status quo	23	24	24	33	30	30		25	25		4	32	7
Blue ling	Va	no direct fishing	1,903	0			0			0			-100	-100	-100
Blue ling	Vb	no direct fishing	4,987	0			0			0					
Blue ling	VI and VII	no direct fishing	8,798	0			0			0			-100	-100	-100
Blue ling	XII	no direct fishing	998	0			0			0			-100	-100	-100
Deepwater Sharks	V,VI,VII, VIII + IX *	Status quo	4,673	27,523	27,523	34	6,606	6606		6,730	6730		489	41	44
Deepwater Sharks	X	Status quo		1772	1772	76	905	905	40	927	927	10			
Deepwater Sharks	XII	Status quo	1,063	1,741	1,741	84	927	927	40	1,009	1009	13	64	-13	-5
Greater argentine	I and II (Man. area II a)	Status quo	7,075	7,351	7,351	18	6,423	6423	18	6,334	6334	26	4	-9	-10
Greater argentine	III + IV	Status quo	1,590	2,496	2,496	44	1,717	1717	40	1,966	1966	33	57	8	24
Greater argentine	Vb, VI and VII (Man. Area + Iva)	Status quo	17,056	13,193	13,193	60	16,144	16144	38	18,638	18638	21	-23	-5	9
Greater forkbeard	VI+VII	Status quo	3,798	2,109	2,109	33	2,535	2535	31	3,058	3058	24	-44	-33	-19
Greater forkbeard	VIII+IX	Status quo	372	327	327	50	437	437	31	466	466	37	-12	18	25
Greater forkbeard	X	Status quo	41	68	68	51	64	64	67	36	36	16	65	56	-11
Greater forkbeard	XII	Status quo	1	2	2	58	2	2	48	1	1	43	100	140	33
Gulper shark	IX	Status quo	92	472	472	77	164	164	18	142	142	34	413	78	55
Kitefin shark	IX	Status quo	6	13	13	121	6	6	45	5	5	22	117	7	-11
Kitefin shark	X	Status quo	31	432	432	69	182	182	78	32	32	7	1294	487	2
Leafscale gulper shark	CECAF 34.1.1	Status quo	20	19	19	47	18	18	53	22	22	26	-7	-9	8
Leafscale gulper shark	IX	Status quo	428	441	441	19	449	449	23	380	380	11	3	5	-11
Leafscale gulper shark	V,VI,VII + VIII	Status quo		0	0		0	0		0	0				
Leafscale gulper shark	X	Status quo	6				4	4		6	6		-100	-33	0
Leafscale gulper shark	XII	Status quo					0	0		0	0				

Table A.5.2. (cont.) Reference mean landings data for three time periods and suggested ‘catch options’. CVs for each reference mean are also shown. The percentage difference between suggested ’catch options’ and reported landings in 1999 is compared with the current ICES advice.

Species	Management Area *data not available for management	ICES advice (The % indicate reduction in effort)	1999 landings	Mean reference landings and suggested reductions (TACs) 1989-1998			1994-1998			1997-1999			Actual % reduction 1989-	1994	1997
	area recommended by group		tonnes	Catch options	Mean	CV	Catch options	Mean	CV	Catch options	Mean	CV	1998	-1998	-1999
Ling	I + II*	30%	7,655	4,864	6,948	16	4,631	6616	22	5,193	7418	26	-36	-39	-32
Ling	IIIa	30%	220	312	446	27	255	365	28	174	248	22	42	16	-21
Ling	IV	30%	9,717	8,198	11,711	11	8,704	12435	8	8,086	11551	17	-16	-10	-17
Ling	Vb	30%	5,200	3,017	4,310	20	3,305	4721	18	3,784	5405	4	-42	-36	-27
Ling	VI, VII	30%	16,098	12,786	18,266	12	13,393	19133	13	12,123	17318		-21	-17	-25
Orange roughy	VI	50%	196	302	605	182	66	132	21	74	148	19	54	-66	-62
Orange roughy	VII	Status quo	969	1,147	1,147	79	1,059	1059	35	1,022	1022	16	18	9	6
Orange roughy	X	Status quo	1,210	66	66	233	131	131	157	62	62	162	-95	-89	-95
Orange roughy	XII	Status quo	435	306	306	121	605	605	49	624	624	30	-30	39	43
Portuguese dogfish	CECAF 34.1.1	Status quo	0	8	8	108	5	5	157	0	0				
Portuguese dogfish	IX	Status quo	544	806	806	5	806	806	5	742	742	23	48	48	36
Portuguese dogfish	V,VI,VII + VIII	Status quo		0	0		0	0		0	0				
Portuguese dogfish	XII	Status quo		0	0		0	0		0	0				
Red seabream	IX	Immediate reduction	536												
Red seabream	VI+VII+VII	Immediate reduction	143												
Red seabream	X	Immediate reduction	1,210												
Roundnose grenadier	Vb, VI + VII	50%	9,842	770	1,540	64	4,190	8381	5	4,343	8685	12	-92	-57	-56
Roundnose grenadier	X	Status quo	4	1	1	194	1	1	122	2	2	87	-88	-75	-50
Roundnose grenadier	XII	Status quo	12,404	4,702	4,702	87	4,874	4874	110	11,199	11199	15	-62	-61	-10
Tusk	I + II a	30%	17,156	9,598	13,712	26	8,490	12129	18	9,707	13867	30	-44	-51	-43
Tusk	IIIa	30%	31	41	59	42	26	38	31	19	28	21	33	-15	-38
Tusk	IV	30%	2,421	5,800	8,285	29	2,217	3168	16	1,894	2706	24	140	-8	-22
Tusk	Vb, VI + VII **	30%	5,736	2,718	3,882	53	4,261	6088	19	3,695	5279	8	-53	-26	-36
Tusk	XII incl. Part of Hatton Bank	Status quo	6,551	22	22	220	41	41		16	16		-100	-99	-100
Wreckfish	X, IX and VIII	Status quo	144	3,081	3,081	22	552	552	35	300	300	45	2039	283	109

A.6. TECHNICAL INTERACTIONS WITH OTHER FISHERIES.

According to the ICES definition, deep-water fisheries are those operating deeper than 400 m. This depth limit has also been the basis for the effort allocation to national fleets in the regulation 2027/95.

The main species in the Northeast Atlantic, that straddle the "shallow" (0-400m) and "deep" (>400m) habitats include:

Hake (*Merluccius merluccius*)
Anglerfish (*Lophius piscatorius* & *L. budegassa*)
Megrim (*Lepidorhombus wiffiagonis* & *L. boscii*)
Ling (*Molva molva*)
Tusk (*Brosme brosme*)
Greater forkbeard (*Phycis blennoides*)
Red blackspot seabream (*Pagellus bogaraveo*)
Spanish spotted dogfish (*Galeus melastomus*)
Rays
Crustaceans (*Nephrops norvegicus* and shrimps)

These "depth-straddling" species may be fished either together with shelf species or with species confined to the deep-waters such as Orange roughy, Roundnose grenadier, Black scabbardfish, Deep-sea squalids or deep-sea scorpionfish (*T. cristulata echinata*).

Deep-water fleets include both large offshore vessels having a wide operating range and smaller artisanal vessels. The large offshore vessels may move from one area to another according to available quotas. As a consequence, the status of major shelf resources such as the North Sea roundfish stocks (saithe, cod, haddock) and the current management regulations on the exploitation of these resources have an effect on the level of fishing effort that is exerted to other resources.

The shelf fisheries and deep-water fisheries are interacting in several ways:

1. The deep-water fisheries exert additional fishing mortality on some species already over-exploited on the shelf. This fishing mortality may apply to some age groups that were not exploited before the development of deep fishing.

2. The effort allocated (as a result of both market conditions and fishery regulation) to offshore shelf areas has a direct effect on the fishing mortality of the "depth-straddling" species.

3. The regulation of shelf fisheries has resulted in effort to be re-directed towards deep-water species. This effect is likely to be continuing.

1. Large spawners of anglerfish (*Lophius* spp.) occur along the continental slope, and the fishing mortality of these large individuals has increased with the development of deep-water fishing. They have even become the target ‘species’ of one fleet (deep-water gillnetting off Ireland), while previously these old and large specimens constituted a ‘reserve of spawners’ for this species, where fishing mortality on the shelf is high.

2. Further restrictions on the fisheries for species already managed by TAC such as Hake, Megrims and Anglerfish as well as technical measures in the framework of the hake rebuilding plan are likely to reduce the fishing mortality of "depth straddling" species. But at the same time these fleets may deploy their effort deeper water, i.e. towards mid-slope species. It should be stressed that fleets fishing for hake may easily move to target species in deeper waters, which are close to the traditional grounds. Fishing gear and equipment need not to be changed significantly

3. In the case of high sea vessels, the fishing effort may be diverted from areas such as the North Sea as a consequence of management regulation and re-directed to deep-water species. In this respect, the development of the deep-water fisheries may be regarded as a result of the reducing catch rates and available quotas for shelf species.

A.6.1. Examples of interactions by fishery

The French deepwater fleet comprises (Lorance and Dupouy, 2001):

- Vessels fishing almost exclusively at great depths targeting either blue ling, orange roughy or a mixture of Roundnose grenadier, Black scabbardfish and deep-water squalids with a by-catch of blue ling.

- Vessels that practice a more diversified activity exploiting both shelf and slope species during each fishing trip.

The latter fleet component can distribute its fishing effort over depth according to the market, the available quotas and the catch rates. The potential geographical flexibility of the effort of the former is lesser and restricted to fishing opportunities in third countries waters or to large increases of the available TACs for shelf species.

UK deepwater fleets are mainly fishing for Hake, Megrims, Anglerfish, Greater forkbeard, Blue ling and Roundnose grenadier at the upper slope. These fleets are susceptible to increase or reduce effort according to catch rates and quotas available on the shelf.

The Spanish trawlers, longliners and gillnets, which operate mainly in the Celtic Sea, Porcupine Bank, Rockall Bank, Bay of Biscay and the Cantabrian Sea while fishing for Hake, Megrim, Anglerfish and *Nephrops*, also catch deep-water species. A variable proportion of these deep-warter species is discarded or landed as by-catch depending on the species market price (Piñeiro et al, 2001).

The Portuguese deep-water bottom trawl fishery targets the rose shrimp (*Parapenaeus longirostris*) and the Norway lobster *(Nephrops norvegicus*). Fishing is mainly carried out off the south and southwest coasts of mainland Portugal. The deepest grounds (400 to 700 m) are only fished when Norway lobster is the target species. In the past the fleet has switched between these two target species according to the market demands. However, in more recent years fishing activity of the fleet has been mainly directed towards Rose shrimp. The high levels of Rose shrimp recruitment and the overexploited state of the *Nephrops* stock in this area have been the main reason for this change in fishing strategy.

A.7. FUTURE RESEARCH NEEDS AND AND ONGOING EU FUNDED RESEARCH IN THE NE ATLANTIC.

A.7.1 Future research needs.

The deep-water species include a large number of species with a great variety of life strategies as well as distribution areas. In recent years scientific effort on their study is being increased and several international co-operative studies were developed, which greatly contributed for a better understanding of their dynamics. Nevertheless there is still a large amount of unanswered questions that need to be addressed in order to improve the quality of advice necessary for the increasing management requests:

- Despite the DELASS EU Project is making an effort to gather data as well as to prepare an inventory of methods suitable for deep-water shark assessments, important aspects of the biology and ecology as well as the geographic distribution of deep-water sharks are still poorly known. Several priority areas of study should be addressed, particularly those related to the reproductive strategies and spatial dynamics of the different species. In future these studies should be addressed to international co-operative research programs, probably by-passing the European frontiers.

- Monitoring research surveys targeting deep-water species study which should be integrated into a global European monitoring plan.

- Studies of the deep-water communities on seamounts and along the Middle-Atlantic Ridge.

- Innovative developments concerning the development of methodologies and standardization of criteria for age determination of deep-water fishes.

- Improvement of the quality of fishery data, particularly in terms of species discrimination, fishing effort, geographical distribution of the fisheries, sampling of landings for collecting biological data, such as size and sex.

- Continuous follow-up studies of the impact on deep-water communities and their habitat after the establishment of Marine Protected Areas (MPA) as well as other special areas, where fishing restrictions have been established.

A.7.2 EU studies related to deep water resources in the NE Atlsantic, which have been used for the elaboration of this document:

EC DGXIV 92/10 Biological parameters of deep-water fish species.

CEE DGXIV 1992/12 Estimation de parametres biologiques de l'empereur et du grenadier

EC DGXIV Study Contract 94/028 An intensive fishing experiment in the Azores

EC DGXIV 94/017 Deep-water demersal fishes:data for assessment and biological analysis

EC DGXIV Study Contract 94/034 Design optimisation and implementation of demersal cruise surveys in the Macaronesian Archipelagos

EC FAIR Contract 95 0655 Developing deep-water fisheries: data for the assessment of their interaction with and impact on a fragile environment understanding their interaction with and impact on a fragile environment (Deep-fisheries)

EC DGXIV 97/84 Environment and biology of deep-water species *Aphanopus carbo* in NE Atlantic: basis for its management (BASBLACK)

EC DGXIV 97/081 Seasonal changes in biological and ecological traits of demersal and deep-water fish species in the Azores

EC FAIR 98/4365 Otolith microchemistry as a means of identifying stocks of deep-water demersal fish (Otomic)

ECDG XIV Study Contract 98/096 Distribution and biology of anglerfish and megrim in waters to the west of Scotland

ECDG XIV Study Contract 99/055 Development of Elasmobranch Assessments (DELASS)

B.2. THE MEDITERRANEAN.

B.2.1. List of commercial important species

Bony fishes

GREENEYES (CHLOROPHTHALMIDAE)

Short-nose green-eye (*Chlorophtalmus agassizi*)

CONGER EELS (CONGRIDAE)

European Conger eel *(Conger conger)*

CODS (GADIDAE)

Blue whiting, (*Micromesistius poutassou*)

Greater forkbeard (*Phycis blennoides*)

HAKE (MERLUCIDAE)

Hake (*Merluccius merluccius*)

SEA PERCHES (SERRANIDAE)

Wreckfish *(Polyprion americanus)*

SEABREAMS, PORGIES (SPARIDAE)

Red (=Blackspot) seabream (*Pagellus bogaraveo*)

SCABBARDFISH, HAIRTAILS (TRICHIURIDAE)

Silver scabbardfish (*Lepidopus caudatus*)

GURNARDS (TRIGLIDAE)

Piper gurnard (*Trigla lyra*)

REDFISHES (SCORPAENIDAE)

Rockfish (*Helicolenus dactylopterus*)

Scorpion fishes, (*Scorpaena sp.)*

FLOUNDERS (PLEURONECTIDAE)

Fourspotted megrim (Lepidorhombus boscii)

Megrim (Lepidorhombus whiffiagonis)

ANGLERFISHES (LOPHIIDAE)

Anglerfish (*Lophius piscatorius*)

Black Anglerfish (*Lophius budegassa*)

Sharks and rays

COWSHARKS (HEXANCHIDAE)

Bluntnose six-gill shark (*Hexanchus griseus*)

SPURDOGS (SQUALIDAE)

Spurdogs, Dogfishes (*Squalus* spp.)

DOGFISHES (SCYLIORHINIDAE)

Blackmouth catshark (*Galeus melastomus*)

RAYS (RAJIDAE)

Rays (*Raja sp.*)

Crustaceans

ARISTEID SHRIMPS (ARISTAEIDAE)

Giant red shrimp (*Aristaeomorha foliacea*)

Blue and red shrimp (*Aristeus antennatus*)

PENAEID SHRIMPS (PENAEIDAE)

Deepwater pink shrimp (*Parapenaeus longirostris*)

DEEP-WATER SHRIMPS (PANDALIDAE)

Golden shrimp (Plesionika martia)

Striped soldier shrimp (*Plesionika edwardsii*)

SPINY LOBSTERS (PALINURIDAE)

Spiny lobsters (*Palinurus elephas* and *P. mauritanicus*)

NORWAY LOBSTERS (NEPHROPIDAE)

Norway lobster (*Nephrops norvegicus*)

RED CRABS (GERYONIDAE)

Mediterranean geryon (*Geryon longipes*)

Cephalopods

SQUIDS AND CUTTLEFISH (DECAPODA)

Broadtail squid (*Illex coindetii*)

Lesser flying squid (*Todaropsis eblanae*)

European flying squid (*Todarodes sagittatus*)

Common bobtail (*Sepietta oweniana*)

B.2.2. Stock identification

Although some biological, ecological and geographical aspects have been investigated in the Mediterranean in the framework of several projects, providing indications on the species distribution and stock limits, the available information on the deep-water species are still rather scanty to distinguish their stock units.

In 2001, the GFCM (General Fisheries Council for the Mediterranean) divided the Mediterranean Sea (FAO Area 37) into 30 new Geographical Areas, adopted according to: (i) GFCM statistical divisions; (ii) national boundaries; (iii) meridians and parallels; (iv) main islands have their own geographic area.

Considering the following points:

- Spatio-temporal distribution of deep sea shrimps
- Benthopelagic behaviour and capacity of mobility
- Bathyal broad distribution
- Relative abundance of the two deep shrimp species in different areas
- Shared stocks according to both latitudinal and longitudinal gradients
- Above mentioned GFCM geographic areas

The STECF working sub-group propose the following four deep-sea management areas from a bio-ecological point of view (Figure B.1):

- Area I (Western Mediterranean): 1, 2, 3, 4, 5, 6, 7, Ligurian Sea (North 9), West Corsica (West 8), West Sardinia (West 11).
- Area II (Central Western Mediterranean): North Thyrrhenian (South 9), East Corsica (East 8), East Sardinia (East 11), 12, 13, 14, 15, 16 and 10.
- Area III (Central Eastern Mediterranean): 18, 19, 20 and 21.
- Area IV (Eastern Mediterranean): 22, 23, 24, 25, 26 and 27.

This division does not exclude the use of GFCM geographic areas for the management of specific fisheries.

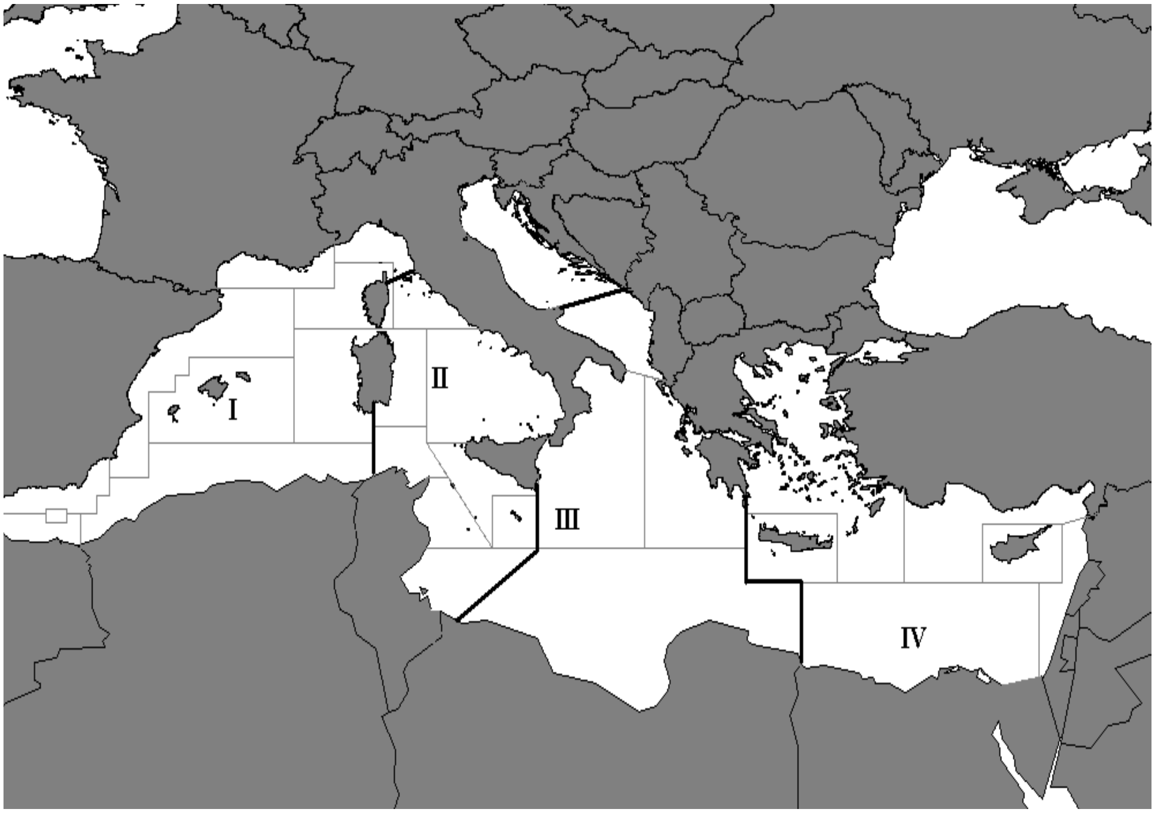


Fig. B.1. The Mediterranean with the management areas for deep sea resources.

B.3. FISHERIES

B.3.1 Overview of current Mediterranean fisheries

Considering that deep-water fisheries operate deeper than 400 m, two main categories can be identified in the Mediterranean:

Bottom trawl fishery targeting the red shrimps *Aristeus antennatus* and *Aristaeomorpha foliacea* and Norway lobster below 400 m.

Longline targeting European hake (*Merluccius merluccius*) down to 800 m depth.

At a lesser extend, some other local small-scale fisheries exist targeting European hake, blackspot seabream (*Pagellus bogaraveo*), bluntnose sixgill shark and wreckfish with gillnet and longline.

The fleet is composed of typical Mediterranean boats and is almost exclusively artisanal in structure, except for some areas (e.g. Sicilian Channel), where larger trawlers operate on a more industrial scale.

Trawl fisheries in deep waters target mainly red shrimps but, since the by-catch species represent an important part of the catch, the fisheries can be characterised as multispecies ones. Moreover, the bottom trawl fleet exploits indistinctly (in some cases during the same day) the upper slope as well as the continental shelf. For these reasons, it is difficult to quantify the effective fishing effort targeting specific deep water species.

Some examples of Mediterranean deep water fisheries are given below. It must be pointed out that although official statistic data exist on several countries, the kind of data reported is still often far from the reality.

B.3.1.1 Bottom trawl fishery off Spain.

In 2000, the Spanish bottom trawl fleet operating in the western Mediterranean consists of 1,013 vessels (45,122 GRT and 276,521 HP, from official data). Although, on average, these vessels are 40 GRT and 300 HP, the real engine power of these boats ranged between 300 and 1,400 HP.

The red shrimp fishery is the most important deep-sea fishery in the area. It was initiated in the 1950's and it has been largely developed in last years. As an example, off Balearic Islands, in comparison with the 1970's, the total power of the red-shrimp vessels has doubled and a large part of the fishing effort of the trawl fleet during the last twenty years has been directed towards the slope. Actually this fishery is developed over the continental upper slope, between 500 and 800 m depth (in the Catalan coast can reach ~1000 m), along the whole Iberian coast between cape of Gata to cape of Creus and around Alboran Island. Its main fishing grounds are Almería and Alboran Island, Murcia and Levantine zone, Ibiza Channel, North Catalonia (northwards cape Salou) and Mallorca and Minorca Islands. This fishery can be considered as monospecific.

As in other areas, this bottom trawl fleet exploits indistinctly (in some cases during the same day) the upper slope as well as the continental shelf. For this reason, it is difficult to quantify its fishing effort directed to deep water resources. However, some estudies have been developed to identify the fishing effort by target species (e.g. MED98/053 project). It has been observed that between 32 and 70%, depending of the ports, operate almost exclusively on slope targeting to Norway lobster and/or rose shrimp.

B.3.1.2 Bottom trawl fishery off France

During the last 20 years, several experimental surveys have been done by IFREMER on the bottoms between 150 to 1,000 m along the whole french Mediterranean coast, to investigate the possibilities of development of a deep sea fishery for crustaceans. During these surveys, most of the catches have been obtained at depths comprised between 180 and 350 m. The red shrimp (*Aristeus antennatus)* exists mainly between 500 and 800 m in the Gulf of Lions, but it seems that the abundance of this species is very variable from one year to another.

B.3.1.3 Bottom trawl fishery off Italy

Excluding North and Central Adriatic where deep-water fishing does not occur, along the Italian coast the fishing fleets comprise over 11000 fishing vessels (about 177000 GRT) (ISTAT, 1993; Relini *et al.*, 1999). Most of these are recorded as multiple-gear vessels and are generally of small gross tonnage (11 tons GRT on average). The remaining vessels are trawlers (about 1204 in number and 70348 GRT). Longliners and purseiners represent a small percentage of the total fleet. Most of trawlers are located in Sicily Channel (425 in number; 34,862 GRT) and in South Adriatic (336 in number; 20,691 GRT). However, in this latter basin the deep-water fishing is less important than the coastal one. In the other basins the following number of trawlers are reported by official data for 1993: 43 in Ligurian Sea (1,289 GRT); 86 in North Tyrrhenian (2,950 GRT); 94 in Central Tyrrhenian (3,380 GRT); 86 in South Tyrrhenian (3,412 GRT); 41 in Sardinian seas (2,189 GRT); 93 in the Ionian Sea (1,580 GRT). Longliners are mainly distributed in the Strait of Sicily, Ionian Sea and Southern Adriatic. The fishing with deep-water gillnets is carried out in some areas, such as around Sardinia and North Tyrrhenian Sea.

Mazara del Vallo (Sicily Channel) is the most important Mediterranean fishery targeting *A. foliacea*. Data from IRMA of Mazara reported around 210 active trawlers (~26,000 GRT) between 1985 and 1992 (STECF Sub-group on balance between resources and exploitation; F. Fiorentino, 2001). By contrast, official data reported a number up to 260 trawl vessels (~34,000 GRT). In the context of this fleet, mainly large vessels are directed to red shrimps, while the smaller can target species (both shallower and deeper) according to availability of the resources.

In the North-western Ionian Sea, where deep water shrimps are intensively exploited, the main fisheries are: Crotone (about 100 trawlers, 2,734 GRT), Gallipoli (about 80 trawlers, 1,312 GRT) and Taranto (about 60 trawlers, 575 GRT). In the Ionian basin, large vessels, mainly coming from Southern Adriatic Sea, operate from the shelf to deep-water shrimp bottoms.

As an estimation of trawl fishing effort in deep waters, recently it has been evaluated that between 7 and 77% of the trawl fleet, depending on the ports, operate almost exclusively on the slope targeting deep water shrimps (MED97/0018 project). Generally, the most intensive fishing activity takes place in summer, when the sea-weather conditions are better and it is possible to reach the fishing grounds far from the home harbours.

B.3.1.4 Longline for European hake developed in the Gulf of Lions

The European hake in the Gulf of Lions is exploited with bottom longline by Spanish fleet since 1980s. This fishery operates mainly on the slope along the canyons between 160 and 600 m depth off western Gulf of Lions. Although maximum depth and fishing grounds are progressively expanding at deeper waters and eastwards, respectively. In 2000, a total of 20 boats (average: 130 HP and 12 GRT) were working in this fishery.

B.3.1.5 Gillnet European hake fishery in the Gulf of Lions

The French fleet has been exploiting the European hake with gillnet in the Gulf of Lions since 1970's. In 2000, a total of 95 boats on average 6.5 m (3.9-11.3) and 2.3 GRT (0.7-9.9) operated to this fishery.

B.3.1.6. The Greek bottom trawl fishery.

Bottom trawl fishery is carried out mainly in Ionian Sea, in the North Aegean Sea and in Cretan Sea. In all areas the fishery is opportunistic and takes place mainly late spring when is the end of the bottom trawl fishing period in Greece and the shallower water stocks are exhausted. Some Italian bottom trawlers are working in the International waters close to the Greek coasts of Ionian especially during summer when the weather is better and when the Greek trawlers are not working. Target species in waters 400 to 800 m are *A. antennatus, A. foliacea N. norvegicus, M. merluccius, M. poutassou, T. lyra, H. dactylopterus* and *Scorpaena spp.*.The contribution of the two red shrimps in the total catch, during sampling in the deep water project, in depths between 300-500 m was 6% and in depths 500-750 m 30%. A common conclusion of the research project that has been carried out so far is that *A. foliacea* is more abundant than *A. antennatus*. The average (during one year of the sampling period) catch per hour of *A. foliacea* was 13 Kg/hour in depths 500-750 m and 3 Kg/hour in depths 300-500 m whereas of *A. antennatus* was 3.3 and 0.3 per depth zone, respectively.

B.3.1.7 The Greek Hake fisheries.

Longline fishery targeting hake occurs around the Greek coasts where there are appropriate depths and substrates. The fishery is carried out in depths from 400-700 m on muddy bottoms. The length of the vessels ranges from 9-16 m and they are equipped with bythometer and hydraulic winch. Each trip last 1-3 days. The catch per day was about 100-200 Kg of *M. merluccius* and they are generally large specimens (>35 cm). Commercial by catch species are *P. americanus*, S. *blainvillei, H. dactylopterus* and *Raja sp.*. Non commercial by catch species are *Galeus melastomus*, *Lepidopus caudatus* and *Raja sp*. Gill nets are used in a lesser degree for hake fishery in deep waters mainly in Central Aegean Sea and in Cretan Sea. The mesh size is 80 mm. Fishing is carried out on muddy bottoms at depth down to 600 m. The daily catch was about 100-120 Kg.

B.3.1.8 Greek fisheries for Pagellus bogaraveo.

Gill nets are used for *Pagellus bogaraveo* fishery in Ionian Sea, East and South Aegan Sea. The fishery is carried out all the year round but it is more intensive during summer time, because the weather is better and the prices are higher. The depths are extended from 200 m to 600 m on rocky banks. The mesh size of the gill nets used is 80-100 mm. The vessels are equipped with freezer, bythometer and with hydraulic winch. Their length ranges from 10-16 m. The crew is consisted of 2-3 persons. The catch is consisted almost exclusively of *P. bogaraveo*. Daily catch ranged from 50-150 Kg. By catch species are *M. merluccius*, *H. dactylopterus* and *S. blainvillei*. Long lines have been used to fish the species around the Greek coasts but now they used only in a small part in South-Eastern Aegean Sea. A total catch of about 80-100 Kg per day was common. By catch species are S. *blainvillei* and *H. dactylopterus*. Now this fishery has almost disappeared because the stock has been exploit heavily by the use of gill nets.

B.3.1.9 The Greek fishery for Hexanchus griseus.

The fishery is carried out with longlines in the Central and South Aegean Sea in depths from 600 to1500 m. The species has a low commercial value, but the catch is quite high and the fishery is profitable. The length of the longlines is about 15-20 Km. The duration of each trip is 1-5 days. The fishery is carried out during all the year. The catch consists of large specimens (100-200 Kg each one). The daily catch could be 1000 Kg. By catch species are mainly *Conger conger* and *Squalus* spp.

B.3.1.10 The Greek fishery for Wreckfish (Polyprion americanus).

The species was quite abundant some years ago but now the stock has declined. The fishermen target *P. americanus* very scarcely and more often it appears as by catch in other deep water long line fisheries. Main by catch species are sharks.

B.3.2. The available data on species landings, species catch rates, discards rates and species and size composition.

B.3.2.1 Landings.

In the Mediterranean, it is difficult to obtain good statistical landing data due the high number of landings sites and that fish are mostly sold fresh and important quantities are sold directly from the fisherman to the final consumer. For this reason, although official statistic data exist on several countries, the data reported are still often far from the reality.

Since 1991, a sampling program was initiated by IEO for assessment purposes, including log-books, sale sheets and on board sampling of fleet from several ports along the Mediterranean Iberian coast. Actually, around seven ports with deep-sea fisheries are being monitored, in which the following landings has been reported during 2000: (i) 394 tons for red shrimp; (ii) 130 tons for Norway lobster; (iii) 1,852 tons for blue withing; (iv) 67 tons for great fork-beard.

Although, as mentioned above, total catches are difficult to be reported, it can be estimated a total catch for red shrimp and Norway lobster in the Mediterranean Iberian coast (~30 main ports) around 2,500 and 1,500 tons, respectively.

The deep-water shrimps are caught in all Italian seas apart from Northern and Central Adriatic. According to the official statistics (ISTAT, 1993) the total production of the Italian fishing fleets, excluding North and Central Adriatic, was about 236,264 metric tons. Almost half of this production consisted of demersal and bottom fish while all crustaceans represented about 7% of the total yield. The proportion of the different species varies largely among the basins. From official ISTAT data, during 1985-1993, the Italian total landings of “red shrimps” showed an oscillating trend between 3091 and

5065 tons. However, apart from the low reliability of these data, several species are grouped within the same commercial category of "red shrimps" (*A. antennatus*, *A. foliacea*, *P. martia*, other pandalids, etc.). The landing of Norway lobster in Italian seas fluctuated between 1691 and 5848 tons with an increasing trend in the period 1979-1995.

For the European hake fishery of the Gulf of Lions annual landings varied from 125 tons during 1988-91 period to 128 tons during 1998-2000 period for the Spanish longline. For French gillnet, the landings varied from 369 tons during 1988-91 period to 501 tons during 1998-2000 period.

B.3.2.2 Catch rates.

The deep-sea shrimps present frequent seasonal fluctuations or movements that influence strongly the catches.

In the Spanish trawl fishery, *A. antennatus* average catch rates (CPUE) have been reported around 65 kg/boat/day off Barcelona and Mallorca Island. This is equivalent to around 15 Kg/Km^2. In Garrucha and Ibiza Channel catch rates has been reported around 43 Kg/boat/day and 29 Kg/boat/day, respectively. In the Catalan and Balearic coast, yields of Norway lobster are between 30 and 40 Kg/boat/day during the highest productive seasons (winter and spring).

For all Italian seas, experimental CPUE were recorded during GRUND and MEDITS projects since 1985 and 1994, respectively. *A. antennatus* is mostly caught in the Ionian Sea, in Ligurian Sea, off West Sardinia, in the Tyrrhenian seas (apart from the Northern side) and in the Sicilian Channel. It is totally absent from the Northern and Central Adriatic and is rare in the Southern Adriatic. The yields of *A. antennatus* show seasonal and annual fluctuations. During 1999, MEDITS trawl survey the highest average biomass index of *A. antennatus* recorded in the Ionian Sea was 26.27 Kg/Km^2 (29.2 CV). Greater CPUE values are generally obtained from Italian bottom trawl net used in GRUND surveys in comparison with the bottom trawl net used in MEDITS ones. *A. foliacea* is relatively more abundant in Sicilian Channel, Tyrrhenian Sea (mainly on the Central and Central-Southern sides) and off East Sardinia. As the companion species, it is totally absent from the Northern and Central Adriatic. In the Southern Adriatic *A. foliacea* is relatively more abundant than *A. antennatus*. In the Ligurian Sea its abundance has been drastically reduced over time (Relini & Orsi Relini, 1987). During 1999 MEDITS trawl survey, the highest average biomass index of the giant red shrimp recorded in the Sicily Channel was 25.6 Kg/Km^2 (27.9 CV). Also for this shrimp, during GRUND surveys greater CPUE values than MEDITS are generally shown. Catch rates from commercial fishing were recorded during some MED projects. The catch of Norway lobster showed an increase from 1985 to 1995. Its highest yields are obtained at greatest depths in Ligurian Sea, Tyrrhenian and Sardinian waters. Norway lobster is also abundantly caught in shallow waters of Adriatic Sea. An analysis of a 12 year historical series of catches in the Ligurian Sea showed that a decreasing period (1985-1992) was followed by an increasing phase (1994 and successive years) (Relini *et al*. 1998).

There are no data on catch rates of the deep water species coming from commercial vessels in Greece. However, some information can be reported from experimentals surveys. *A. antennatus* was present in the 300-500 m depth zone from January to March (maximum value in February 2.42 Kg/hour). In the 500-750 m depth zone the species was caught all the year and the CPUE ranged from 0.8 to 7.69 Kg/hour. The CPUE of *A. foliacea* in the 300-500 m depth zone ranged from 0.5 to 8.1 Kg/hour. In the depth zone 500-750 m the CPUE ranged from 9.1 to 20.1 Kg/hour. In the 300-500 m depth zone the CPUE of the fish was higher than the CPUE of the crustaceans. The CPUE of fish ranged from 37.8 to 146.7 Kg/hour. The CPUE of the crustaceans was lower and ranged from 0.1 to 16 Kg/hour. In the deeper depth zone 500-750 m, the CPUE of the fish and of the crustaceans was almost the same, except June to September when the CPUE of the fish was higher. The CPUE of the fish ranged from 7.2 to 51.5 Kg/hour, whereas the CPUE of the crustaceans ranged from 8.1 to 33.6 Kg/hour. The fish were more abundant in the 300-500 m depth zone whereas the crustacean more abundant in the 500-700 m depth zone.

B.3.2.3. Size compositions

The size composition of red shrimp (*A. antennatus*) catches along the Spanish coast showed clear differences between sexes. The length of females ranged between 15 and 65 mm and of males ranging from 18 to 39 mm CL. Big mature females account for about 70% of the total catches by weight from late winter to early summer. There are high similarities between areas. However, in some areas as Balearic Islands, a decline of size at first capture and an increase of juveniles in catches have been reported.

Catches of Norway lobster off Spanish coast are mainly composed of ages two and three, near the length of first maturity. For this species, the size composition of the landings has been estimated on 13-59 CL for females and 16-70 mm CL for males.

In Italian waters both juveniles and adults of *A. antennatus* are exploited. The greatest average sizes are generally found in Ionian Sea, Sardinian waters and Ligurian Sea. Concerning the former area, apart from a slight decrease from spring 1994 to autumn 1995, the mean size computed showed a rather stable trend. Differences in population parameter among the various Italian areas are mainly due to the different size structures, levels of exploitation and method used to estimate them. Juveniles represent the bulk of the catch of *A. foliacea* in most areas. The greatest mean sizes are observed in Sicilian Channel and, at lesser extent, in Central Southern Thyrrhenian and East Sardinia. In the Ionian Sea, the mean size showed a fluctuating trend from 1985 to 2001. Norway lobster in Italian waters shows sizes between 24 and 75 mm CL. The most common lengths ranged from 30 to 50 mm CL. Males growth to a larger size than females.

The size composition below is based in the first survey in the west coast of Greece in the framework of the “Deep water fisheries” project. The females *A. antennatus* composed 87% of the catch. The length of males ranged from 9 to 42 mm CL and the bulk occurred between 23 and 29 mm CL. The length of females ranged from 11 to 62 mm and the bulk occurred between 27 and 45 mm. The males of *A. foliacea* composed 54% of the catch. Their lengths ranged between 18 and 44 mm and the bulk occurred between 30-36 mm CL. The length of females ranged between 16 and 62 mm CL and the bulk was at 36 and 50 m.

Size composition of hake catches from Spanish longline fishery in the Gulf of Lions ranged between 30 and 96 cm, with average length of 61.7 cm for females (7.6 years) and 52.5 cm for males (8.7 years). In last ten years, mean size of catches has increased, probably due to the expansion of fishing grounds to unexploited areas, deeper and more distant from the ports.

Size composition of hake catches from French gillnet fishery in the Gulf of Lions ranged between 13 and 74 cm, with an average size of 40 cm. The decrease of mean size of catches from 43 to 40 cm has been observed between 1988 and 1998-2000 periods.

The length of *P. bogaraveo* in the gill net fishery in Ionian Sea (Greece) ranged from 150-410 mm (Project 00/046) and 88% of the individuals had lengths between 180 and 300 mm.

B.3.2.4 By-catch species.

The main by-catch commercial species from bottom trawl are the fishes European hake, greater forkbeard, blue whiting, rockfish, megrims, anglers, blackspot seabream, scabbard fish and European conger, the crustaceans golden shrimp (*Plesionika martia*), striped soldier shrimp (*Plesionika edwardsii*), and deep-water pink shrimp and the cephalopods broadtail squid and European flying squid.

The main by-catch commercial species in the longline fishery for hake are greater forkbeard, rockfish, blackspot seabream, scabbard fish, blue whiting and European conger.

B.3.3 Discards

Discards of red shrimps in the Spanish and Italian deep water bottom trawl fisheries can be considered nil. In these fisheries, discards (15-40% of total yields) correspond to species without any commercial interest (e.g. Myctophidae, Notacanthidae, Alepocephalidae, Apogonidae, Trachichthydae, Cynoglossidae and Macrouridae) and small individuals of *Lepidion lepidion*, *Mora moro*, *Galeus melastomus*, *Phycis blennoides* and *Helicolenus dactylopterus*. In the Norway lobster fishery, discards (~40% of total yields) also correspond to species without any commercial interest (e.g. *Glossanodon leioglossus*, *Synchiropus phaeton*, *Lampanyctus crocodilus*, *Gadiculus argenteus*, *Chauliodus sloani*, *Stomias boa*, *Coelorhynchus coelorhynchus* and *Hymenocephalus italicus*) and small individuals of *Scyliorhinus canicula*, *Galeus melastomus* and *Phycis blennoides*. Both catches per unit effort and discard rate varied between hauls and seasons, reflecting differences in species composition and at lesser extent in local market demand.

There are no information on the discarding practice in deep waters in Greece from professional vessels. Some estimations can be done from research survey data in Ionian Sea. A bias is expected since the criteria of the crew to discard or not a fish are different of the criteria of a scientist who examines the data set and classifies them in discarded or landed. There are some species that are always discarded and for them there is agreement, but the problem exists for the small individuals of the species with commercial value. In the estimation below discards are fish that characterized as discards and belong exclusively to species without any commercial value. During the surveys the small shrimps (mainly *Plesionika spp*) were not sorted at species level but they recorded as “small shrimps”. Some of them had commercial value but in the estimation below all of them considered discarded. So the proportion of the discarded fish is underestimated (since small specimens of some species like *P. blennoides* or *L. boscii* are discarded) but the proportion of the discarded crustacean is over-estimated.

The proportion (by weight) of the discarded fish in depths 300-500 m was 70% (of the total fish yield) and 52% in depths 500-750 m, whereas the proportion of the crustaceans was 30% and 15%, respectively. In real values the discarded fish in the depth zone 300-500 m was 38 Kg/hour and in the depth zone 500-750 m 17.5 Kg/hour, whereas of the crustaceans 2 Kg/hour and 3.2 Kg/hour, respectively.

Almost all the crustacean that are classified as discards belong to *Plesionika spp*. in both depth zones. *Chlorophthalmus agassizi* (32.3%), *Argentina sphyraena* (8.8%), *Hoplostethus mediterraneus* (5.6%), *Galeus melastomus* (5.6%) and *Gadiculus argenteus* (2.8%) were the most important discarded fish species in the depth zone 300-500 m. In the depth zone 500-750 m *C. agassizi* (13.94%), *H. mediterraneus* (10.59%), *G. melastomus* (7.49%), *Chimaera monstrosa* (3.58%) and *Nezumia sclerorhynchus* (3.33%). *C. agassizi* composed about 50% of the discards in the 300 to 500 depth zone and about 25% in the 500-750 m depth zone.

B.4 SENSITIVE MARINE HABITATS THAT MIGHT BE AFFECTED BY DEEP-SEA FISHERIES

B.4.1 Mud bottom communities.

In the context of the biocoenosis of the bathyal mud, the most widespread *facies* in the Mediterranean are: a) that of the viscous mud with a very fluid superficial layer characterized by the big sea pen *Funiculina quadrangularis* and the crustaceans *Parapenaeus longirostris* and *Nephrops norvegicus*; b) that of firm and compact muds characterized by cnidarian species *Isidella elongata* and *Actinauge richardi*, the crustaceans *Aristeus antennatus, Aristaeomorpha foliacea, Plesionika edwardsi, Plesionika martia, Munida intermedia* and the cephalopods *Sepietta oweniana, Neorossia caroli, Pteroctopus tetracirrus*. Within these two *facies* the strictly benthic species *Funiculina quadrangularis* and *Isidella elongata* have almost completely disappeared from the trawlable bottoms of the most Mediterranean areas.

The studies on the effects of fishing on marine ecosystem in the Mediterranean Sea have mostly been directed to the population structure and dynamics of target species while little is known on the fishing impact on benthic communities, non-target species and biodiversity.

The effect of bottom trawl fisheries on marine habitats can be analyzed taking into account the fishing grounds actually exploited and the possible expansion of fishing exploitation to deeper areas.

Fishing grounds for Norway lobster (<500 m) are more fragile habitats than those for red shrimp (>500 m). The preservation of the substratum at lower level of disturbance can allow or increase the burrowing behaviour of Norway lobster and hence its protection against fishing.

Some of red shrimp fishing grounds are located in the margin of submarine canyons, areas which can act as recruiting grounds. Other areas can act as reservoir of mature specimens of species such as European hake and rockfish. These specimens has escaped to trawl fisheries developed in shallower waters and renew annually the exploited portion of the stock, sustaining the recruitment under conditions of high fishing mortality on the immature age groups (the spawning refugia paradigm of the Mediterranean fisheries). As an example, the effect of bottom trawl fishing on the rockfish population has been demonstrated along the Iberian Mediterranean coast. Here, the highest abundance indices and the existence of a well-developed spawning stock has only been found in the western part of the Alboran Sea, where open slopes remain unexploited by bottom trawl below 500 m depth.

Among the biological components of the marine ecosystem, the selachian species seem to be particularly vulnerable to the fishing. Indeed, the species that once were widespread and abundant are now uncommon and rare (e.g. *Hexanchus griseus* and rays in some Mediterranean areas). The reduction of several species, mostly on the continental shelf, seem to be related to the development of trawl fishing. The fact that *Galeus melastomus* and *Etmopterus spinax* are the most widespread and abundant species might be linked to their depth distributions are beyond those of the trawling grounds, thus less vulnerable to the fishing.

B.4.2 Coral bottom communities.

A broad biocoenosis of white-corals has been identified in the North-West Ionian, at depths between 450 and 1100 m, during the INTERREG-II Italy-Greece project. Alive colonies of the branched species *Madrepora oculata* and *Lophelia pertusa* with the solitary species *Desmophyllum cristagalli* were found. The calcareous clumps are made up of white and living branches at the top and dead darkened corals at the base. The epibiotic fauna is dominated by sponges, bivalves and polychaete worms. This biocoenosis, which provides refuges for marine fauna, is vulnerable to the otterboard of the trawl net and at same time represents a deterrent for this kind of fishing gear since the net might get entangled in it. Moreover, also deep bottom gillnets and traps, sometime employed in this area, might get entangled in the coral branches and act as "ghost fishing". This kind of biocenosis is also present in other areas such as Sicilian Channel and South Adriatic and probably it could exist in other Mediterranean areas.

B.5 MANAGEMENT

B.5.1. Diagnosis

Differences in the estimated population parameters of deep-water species between the various Mediterranean areas are mainly due to the different size structures, levels of exploitation and different estimation methods. It is difficult to establish a global diagnosis of exploitation state of deep sea stocks for the four whole areas because actually the available data on fishing patterns concern only local areas.

Aristeus antennatus seems to support a sustainable fishery in part of Areas I, II and III despite the high fishing pressure. This might be due to the very wide depth distribution in bathyal waters and to the fact that part of the population is not vulnerable to trawling. Another reason could be the high fecundity of this species. However, the application of yield per recruit models showed overexploitation in several areas (e.g. some parts of the Areas I and II). This suggests that a more conservative management strategy is necessary. Also for *Aristaeomorpha foliacea*, where exploitation rate differs among the geographical areas and ranges from fully exploitation (e.g. Sicilian Channel) to growth over-fishing (e.g. West Ionian Sea), conservative management measures are needed. However, the population of the species in the East Ionian Sea is under-exploited.

Norway lobster stocks are overexploited in parts of Areas I and IV (e.g. Catalan coast, Aegean Sea) and fully exploited in part of Areas II and III. In Area I, the Y/R models showed that after a reduction of around 20% of fishing effort the stocks would increase with about 10-15% of Y/R about six years after implementation of effort reduction (Sardà *et al.*, 1998).

In the Mediterranean, hake is mainly exploited by bottom trawl in shallow waters. Most of the fisheries show growth over-fishing. Since in many areas spawners are exploited in deep waters by selective gears (e.g. longline and gillnet), there is a risk of recruitment overexploitation.

In our knowledge, at least two deep water fisheries have collapsed in Mediterranean: *Hexanchus griseus* in Ionian Sea and *Polyprion americanus* in Ionian and Aegean seas.

B.5.2. Current management measures.

Mediterranean fisheries in EU waters is generally regulated by licensing system, which does not allow an increase of fishing effort in a number of vessels. For the trawl fishery, other technical measures as the cod-end mesh size (40 mm) also is in force and other effort restrictions and technical measures are enforced in the various countries:

- In Spain, France and parts of Italy the maximum fishing periods are 5 days per week and 12 hours per day.
- In Greece, bottom trawl fishing is close from June to September (4 months).
- In Italy, 45 days closed period occurs since 1988.
- A maximum engine power of 500 HP in Spain and 430 HP in France is established.
- Subsidies for demolition fishing units are given in all Member States.
- Minimum landing sizes exists for several species (e.g. hake, Norway lobster and anglerfish).

Alt these regulations (technical measures) are generally adhered to by the fishery, with the exception of real engine power which has increased regularly during last years. However, effective control of fishing effort in the Mediterranean has failed. This failure could be attributed not only to the illegal increase of the engine power but also to the technology creeping (materials of nets, trawl design, echo sounder, navigational positioning, better manoeuvring, remote control of fishing gear). Furthermore, subsidies for replacing and improving existing boats are also given.

In addition, in some species the established minimum landing size is smaller than the length of first maturity (e.g. hake, Norway lobster and anglerfish) and there is not an effective control of this measure.

The experience from the management of many of the NE Atlantic stocks shows that TACs have proven not to be sufficiently efficient in preventing stock declines. Although in certain cases the TAC system has succeeded in the rebuilding of some stocks, *generally speaking it is considered useful just as a political tool in the sharing of resources, rather than a means of managing exploitation rates. Furthermore, this management system is particularly unfitted for the areas where there is high species and gear diversity, where the landing sites are very large-spread, and where it is very difficult to collect reliable catch and effort data, of which Mediterranean is a typical example.*

B.5.3. Recommendations

To improve the quality of catch and effort statistics. In this sense it is also necessary to know the true engine power of the trawl fleets.

To control the true engine power of trawl fleet as a realistic measure to control effective fishing effort in these fisheries.

Reduction of 20% of the bottom trawl effort in deep waters by reducing time at sea and/or engine power, except for Area IV and the East of Area III, where the resources are under-exploited.

To establish the minimum landing size in relation to the size at first maturity.

To protect juveniles and/or spawners by closing seasons and/or closing areas. Spring-summer is considered the best season to protect deep-sea resources. East of Area III and Area IV is excluded of this recommendation.

Improving selectivity of bottom trawl. For deep water shrimps a mesh size of 28 mm (side length) in the cod-end or other selectivity measures (e.g. grids or square meshes) are recommended together with other management options such as temporary closures.

A mesh size bigger than 90 mm is recommended for the gillnet *P. bogaraveo* fishery in Greece.

A recovery plan for wreck fish and a conservation plan for *P. bogaraveo* in Eastern Mediterranean should be examined.

The sub-group agree with the recommendations of GFCM Working Group on demersal species (Tunisia, March 2001) in relation to the long-line and gillnet fisheries for hake in the Gulf of Lions.

B.6 INTERACTIONS BETWEEN FISHERIES FOR DEEP-SEA SPECIES AND SPECIES MORE TRADITIONALLY FISHED ON THE CONTINENTAL SHELF OR ON THE UPPER PART OF THE SLOPE

Although long-line and gillnet are selective gears which do not affect the habitats, it must be taken into account that development of these fishing techniques could affect spawning stock of some species (e.g. hake). These spawners maintain the level of recruitment in trawl fisheries developed in shallow waters and based in a high percentage on juveniles.

B.7 FUTURE RESEARCH NEEDS AND CURRENT EU STUDIES RELATED TO DEEP WATER RESOURCES IN THE MEDITERRANEAN.

B.7.1 Future research needs

The species to be given priority in future research on deep sea Mediterranean fisheries are *Aristeus antennatus, Aristaeomorpha foliacea, Nephrops norvegicus* and *Merluccius merluccius.* However other species listed in point 2.2.1 are also considered as important.

The research needs on these species are the following:

- To improve the quality of the catch and effort statistics.
- To optimise the current trawl surveys according to the distribution, seasonality and rythmicity of the deep sea resources at a mesoscale level.
- To carry out new exploratory surveys to reach the above mentioned objectives and to improve the knowledge on the biogeographical characteristics of deep sea populations.
- To study the relationship between environnement, life cycles and fisheries based on seasonal fixed monitoring stations in different habitats.
- To study the links between recruitment and environment.
- To study and to improve selectivity of gears employed in deep sea fisheries.
- To study interspecific and trophical relationshops in order to apply ecological modeling to deep sea resources.
- To study gillnet and longline metiers in deep waters.

B.7.2 EU studies related to deep water resources in the Mediterranean which have been used for the elaboration of this document

(i) FARWEST Study for assessment and management of Western Mediterranean Fisheries (Co-ordinator: H. Farrugio, IFREMER Séte, France).

(ii) MED92/005 Survey of red shrimp fishing in the Western Italian basins (Co-ordinator: A. Di Natale, Aquastudio, Messina, Italy).

(iii) FAIR CT 95 0655 Developing deep-water fisheries: data for their assessment and for understanding their interaction with and impact on a fragile environment (Co-ordinator: J. Gordon, SAMS, Scotland).

(iv) MED97/0066 Mediterranean Landings pilot project (Co-ordinator: A.Tursi, University of Bari, Italy).

(v) MED97/0018 Analysis of the Mediterranean (including North Africa) deep-sea shrimps fishery: catches, efforts and economics (Co-ordinator: F: Sardà, CSIC, Barcelona, Spain).

(vi) MED00/046 *Pagellus bogaraveo* gillnet metier in the Ionian Sea: gillnet selectivity, assessment and biology (Co-ordinator: S. Kavadas, NCMR of Athens, Greece).

(vii) MEDITS International bottom trawl surveys (Co-ordinator: G. Relini, University of Genova, Italy);

(viii) MED 94/027 Discards of the Western Mediterranean trawl fleets (Co-ordinator: A. Carbonell, IEO Palma de Mallorca, Spain).

(ix) MED 94/065, MED 95/061 and MED 97/044 Discards operation in the Central and Eastern Mediterranean (Co-ordinator: N. Tsimenides, Institute of Marine Biology of Crete, Greece).

(x) MED 94/055 Trawl efforts and landings in the Ligurian Sea. (Co-ordinator: G. Relini, University of Genova, Italy).

(xi) MED 98/053 Factors affecting catch rates of NW Mediterranean trawl fleets and derivation of standardised abundance indices (Co- ordinador: F. Álvarez, IEO Pama de Mallorca, Spain).

(xii) INTERREG II Italy-Greece, funded in cooperation by the EC, the Italian and Greek governments. Protection of marine environment. Sub-topic: Distribution of renewable deep marine resources. (Co-ordinated by NCMR of Athens and University of Bari).

(xiii) MED 00/39 Exploratory survey to collect data of the exploited and virgin stocks of deep-sea shrimp, *Aristeus antennatus*, of interest to the CFP. (Co-ordinator: F. Sardà, CSIC, Barcelona).

(xiv) Mapping of Italian Demersal Resources (Co-ordinator: G. Ardizzone, University of Rome).

(xv) MED/92/015 Density, abundance and structure of population of red shrimps, *Aristeus antennatus* and *Aristaeomorpha foliacea*, in the Ionian Sea (Southern Italy)" (Co-ordinator: A.Tursi, University of Bari, Italy).

(xvi) MED 95/031 Biological study of the Mediterranean hake (*Merluccius merluccius*): spawning stock unavailable to trawl fishery. (Co-ordinator: A. Tursi, University of Bari, Italy).

(xvii) MED 92/010 Study of the selectivity and assessment of the coefficient of retention of the trawl nets used for red shrimps fishing, *Aristaeomorpha foliacea* Risso, 1827 and *Aristeus antennatus* Risso, 1816; Crustacea. Aristeidae, in the Sicilian Channel, Central Mediterranean Sea. (Co-ordinator: S. Ragonese, IRMA-CNR, Mazara del Vallo).

(xviii) MED98/053 Factors affecting catch rates of NW Mediterranean trawl fleets and derivation of standardised abundance indices. (Co-ordinator: F. Alvarez, IEO, Palma de Mallorca, Spain).

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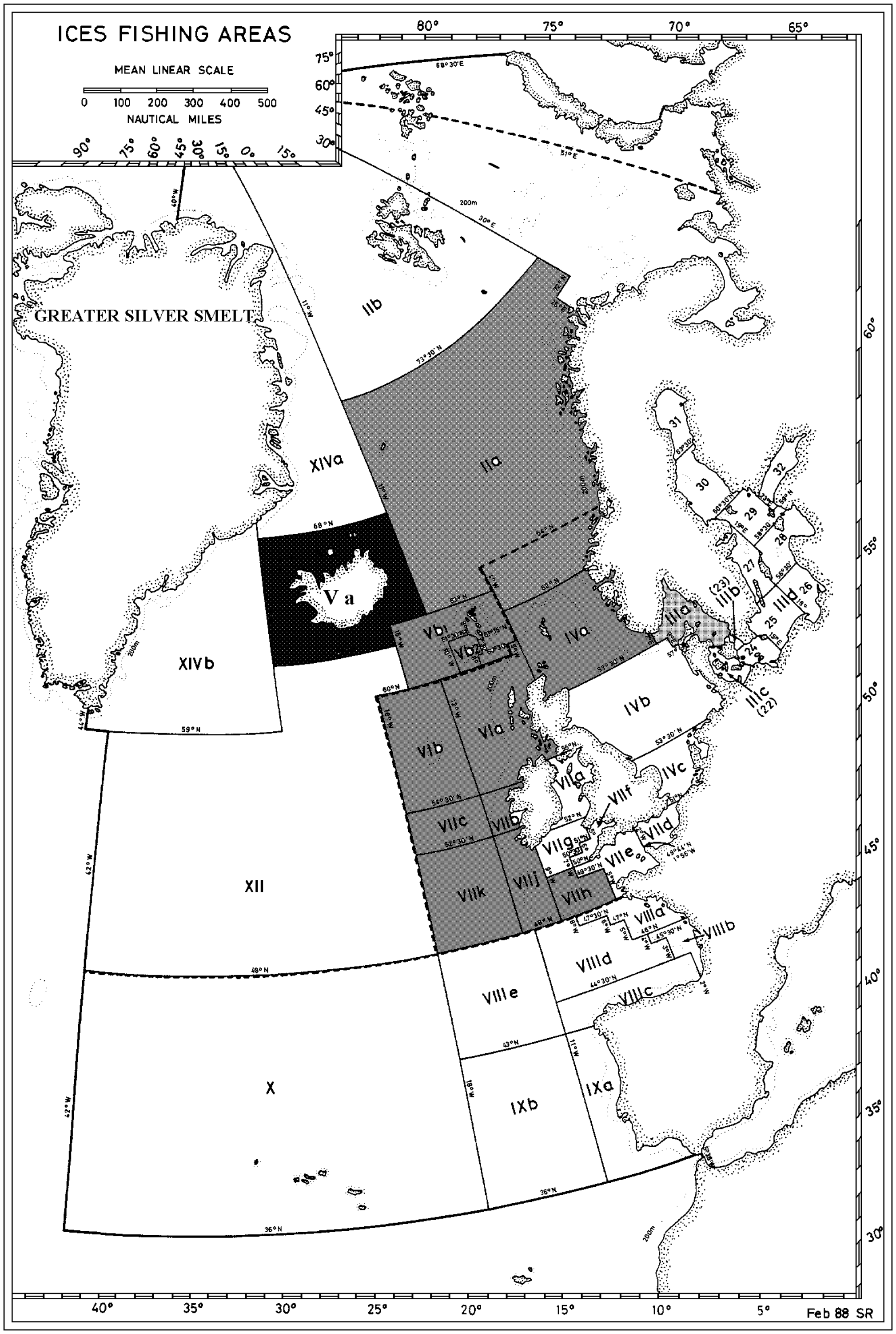
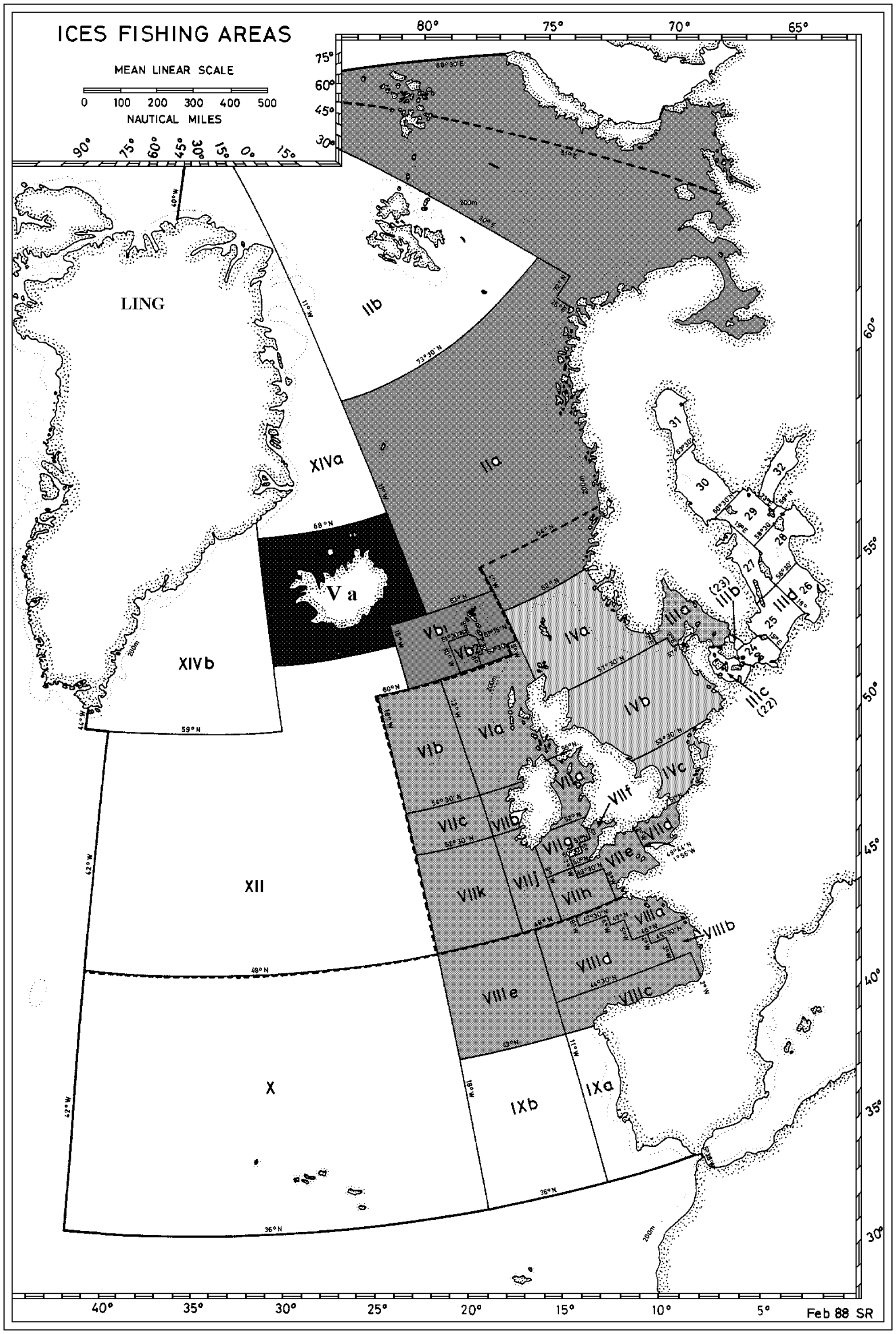
APPENDIX 1:

MAPS OF THE NORTH EAST ATLANTIC MANAGEMENT AREAS FOR DEEP SEA RESOURCES




ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
LING
IIb
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IVa
IVb
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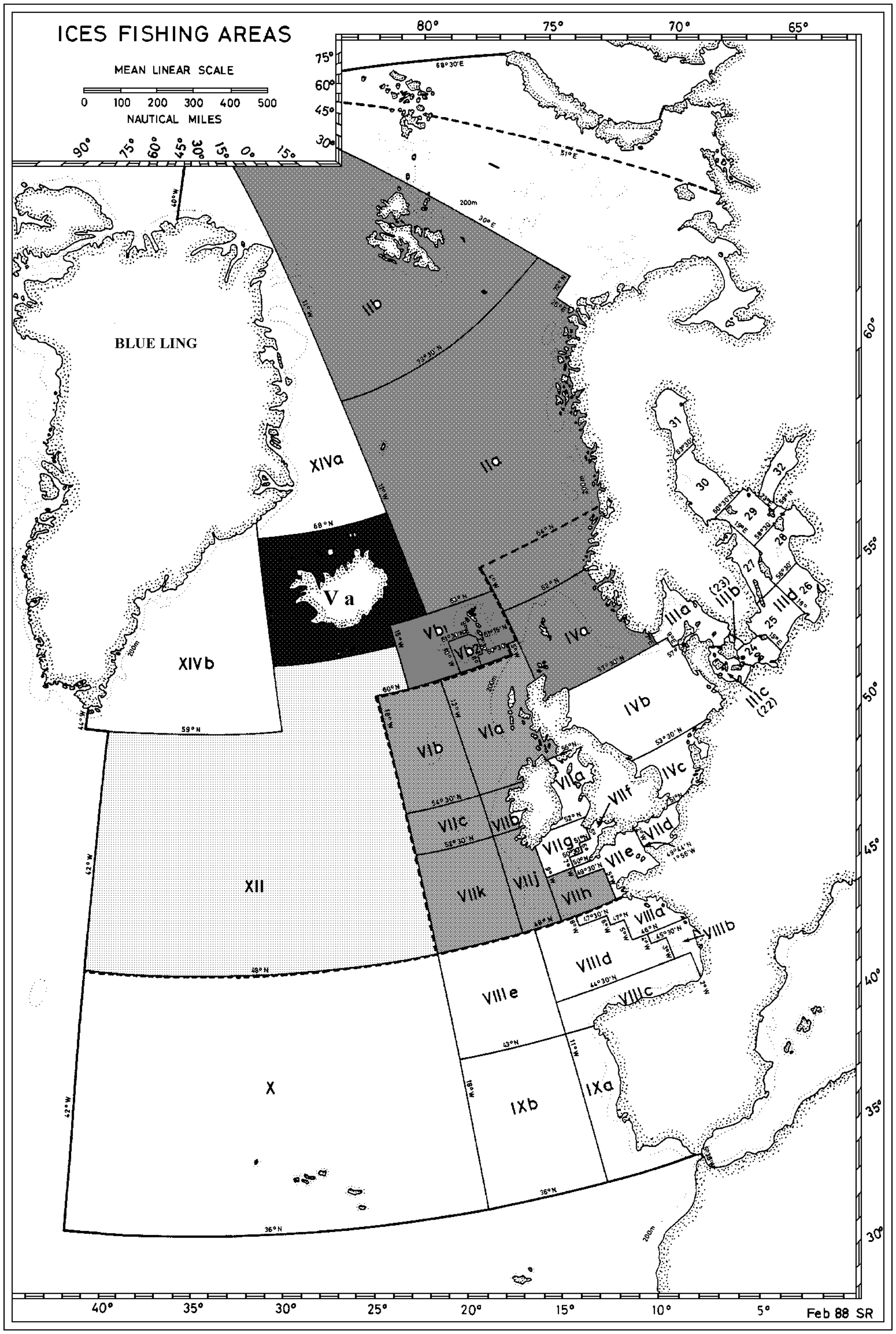
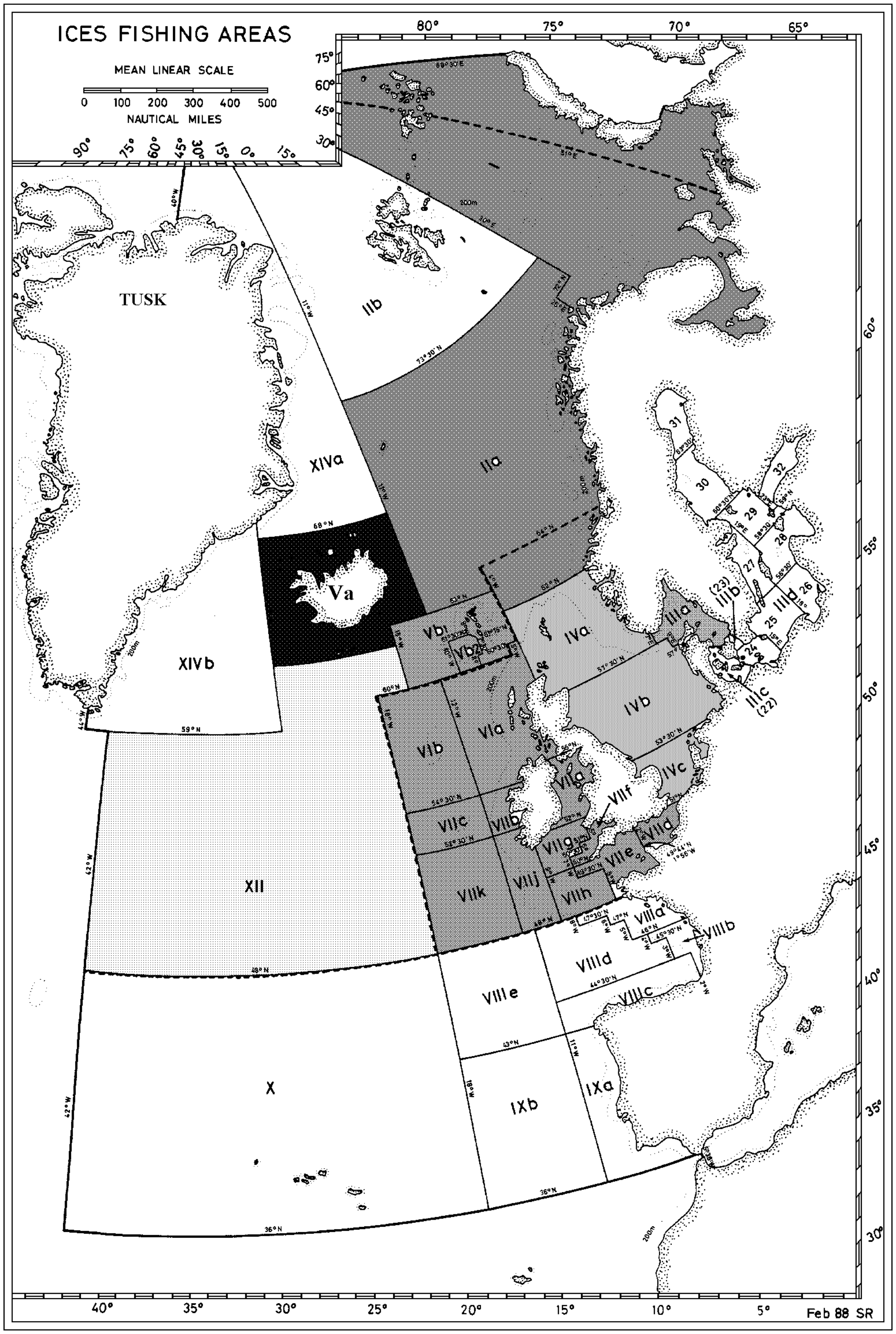
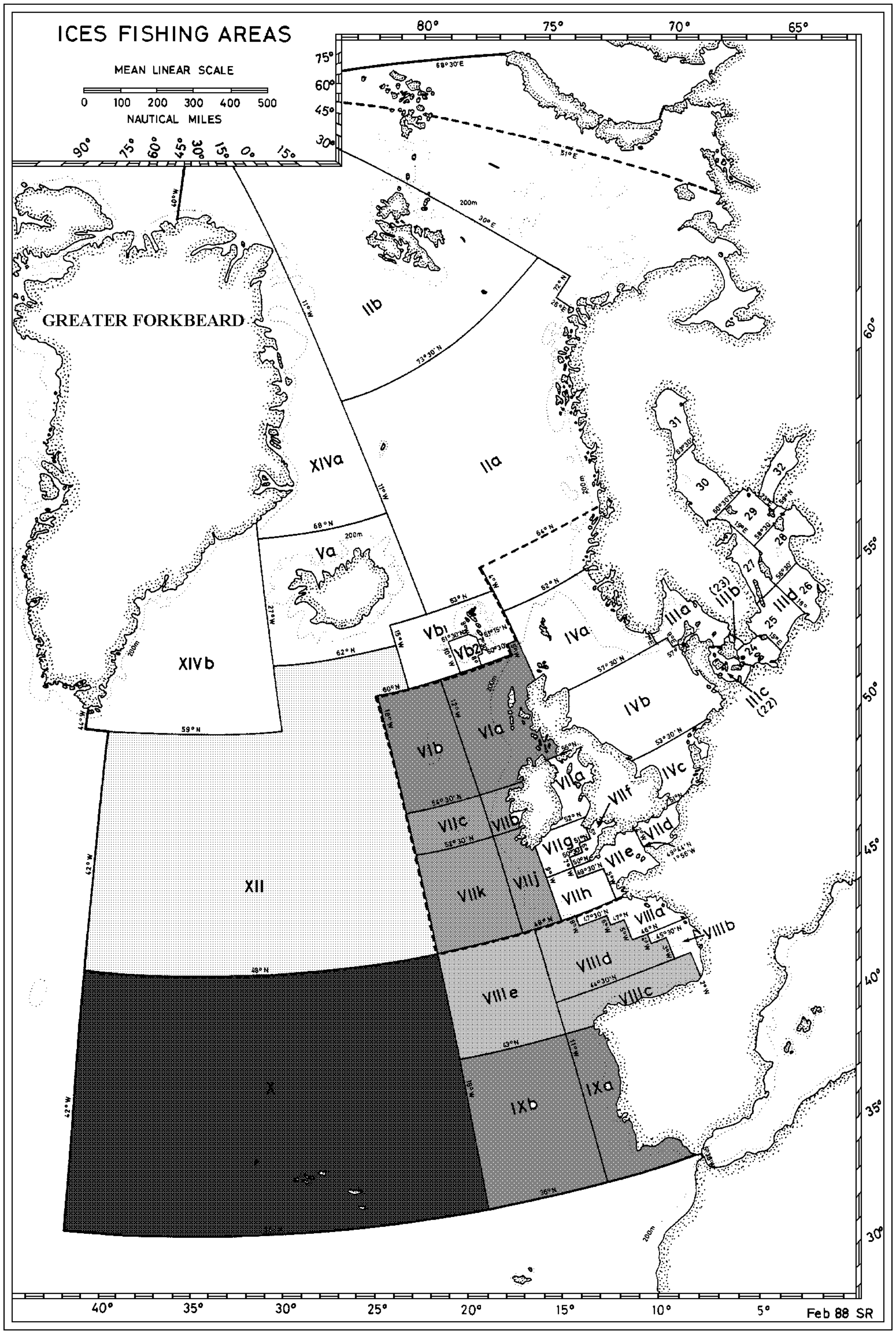
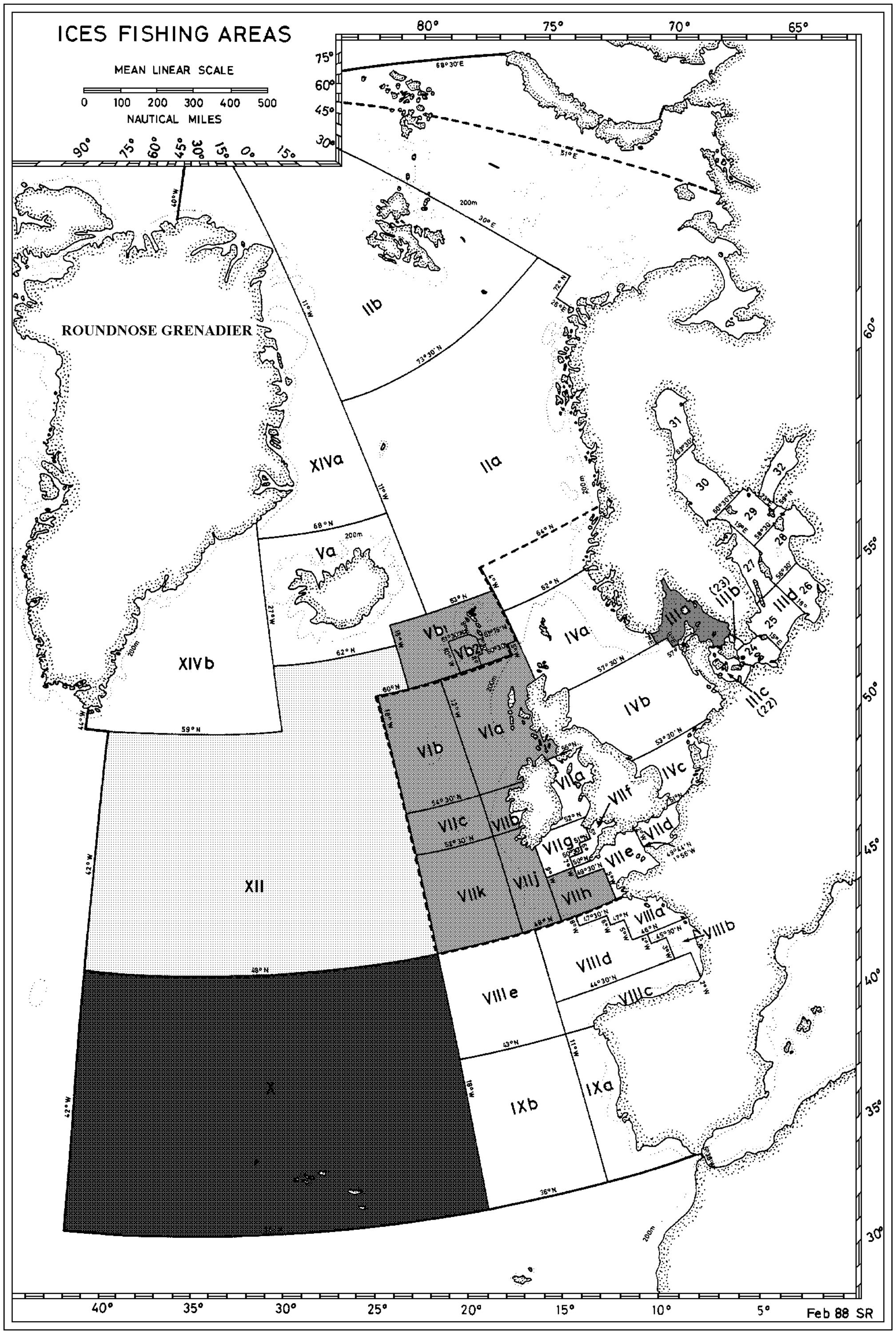
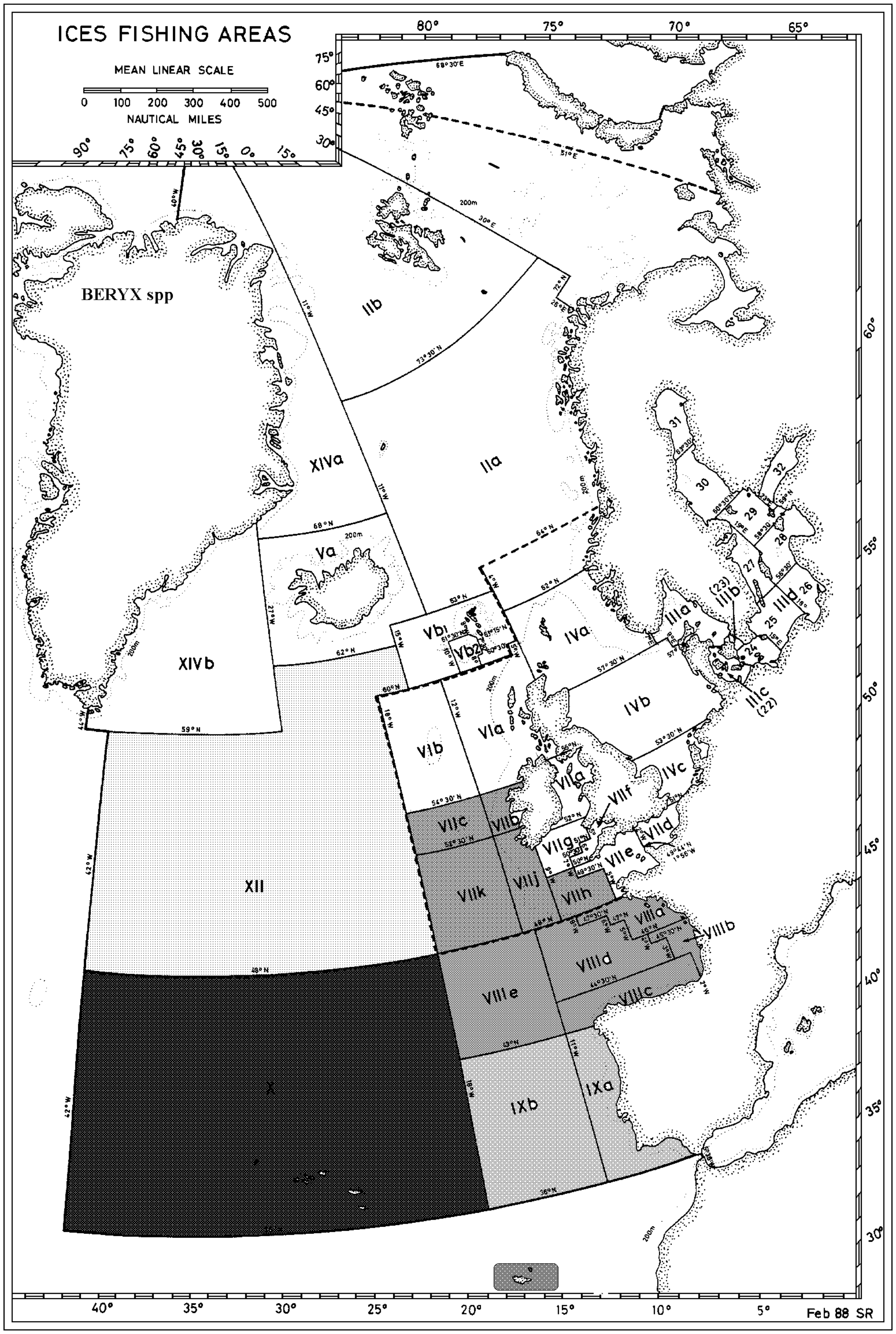
VIIId
VIIIe
IXa
IXb
X
XII
24
25
26
27
28
29
30
31
32
Feb 88 SR

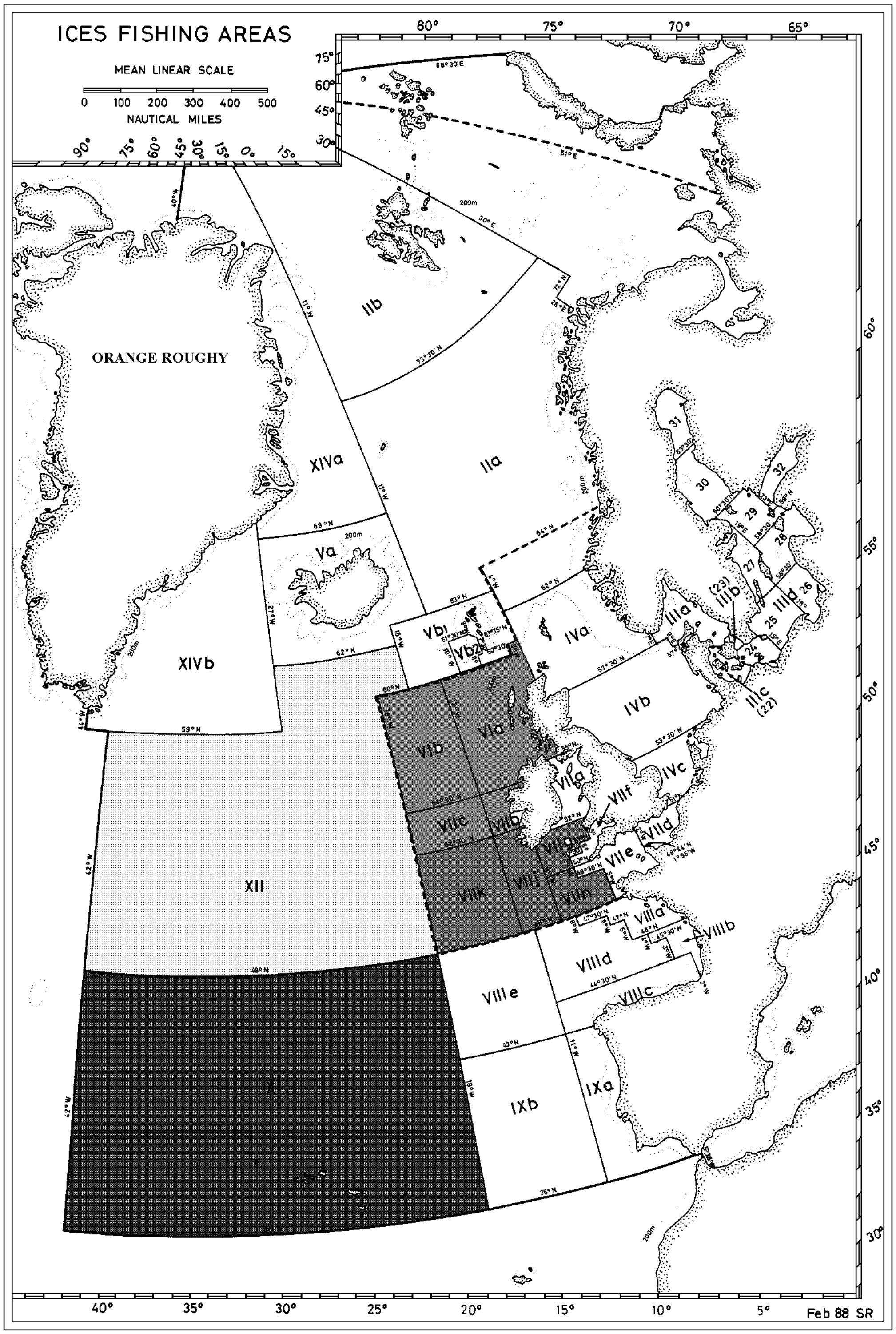

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
BLUE LING
IIb
IIa
XIVa
Va
XIVb
Vb1
Vb2
IVa
IVb
IVc
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
IIIa
IIIb (23)
IIIc (22)
IIId
24
25
26
27
28
29
30
31
32
Feb 88 SR

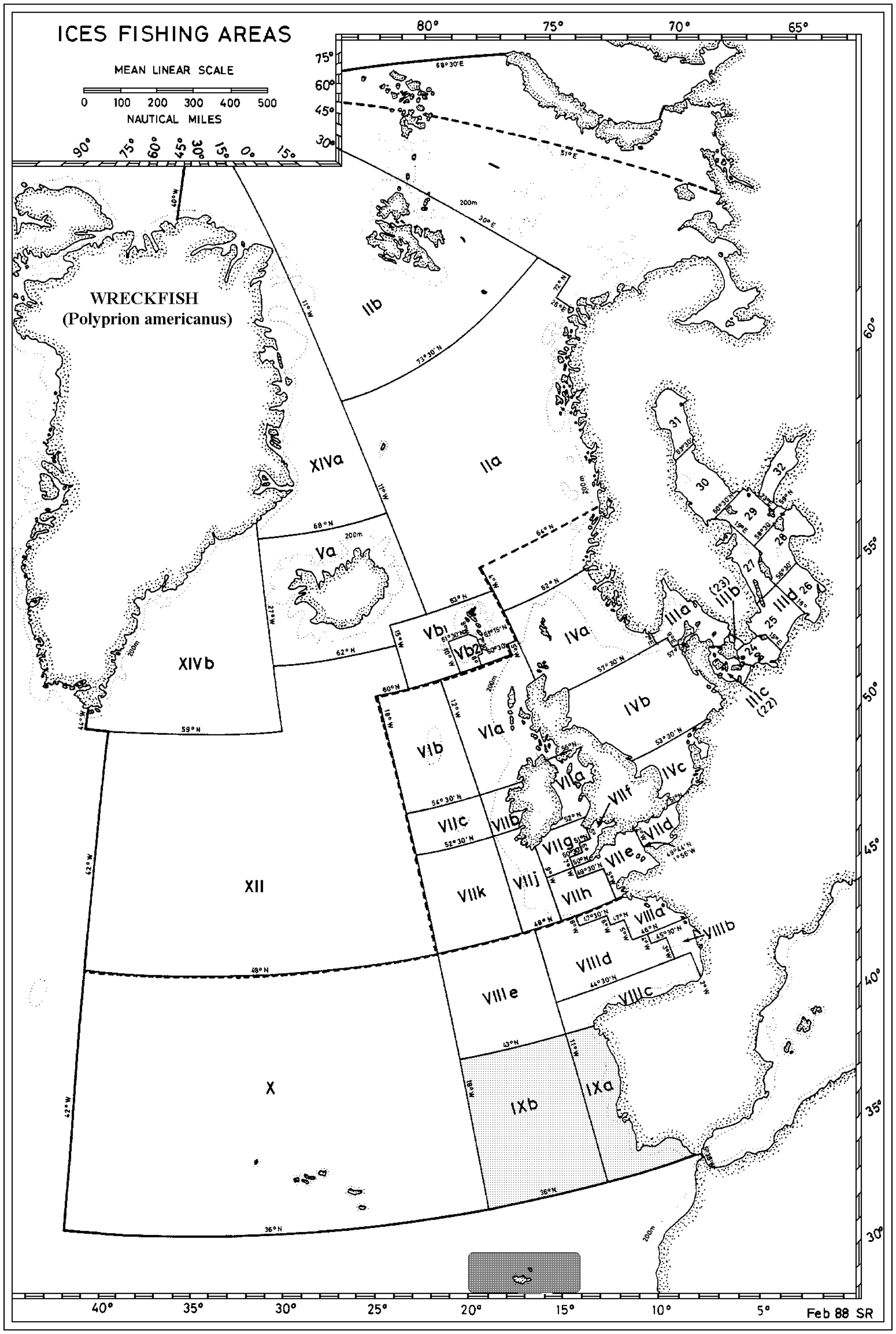

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
TUSK
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
IIIa
IIIb (23)
IIIc (22)
IIId
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR


ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
GREATER FORKBEARD
IIb
IIa
XIVa
Va
XIVb
Vb1
Vb2
VIb
VIa
IVa
IVb
IVc
IIIa
IIIb
IIIc
IIId
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR

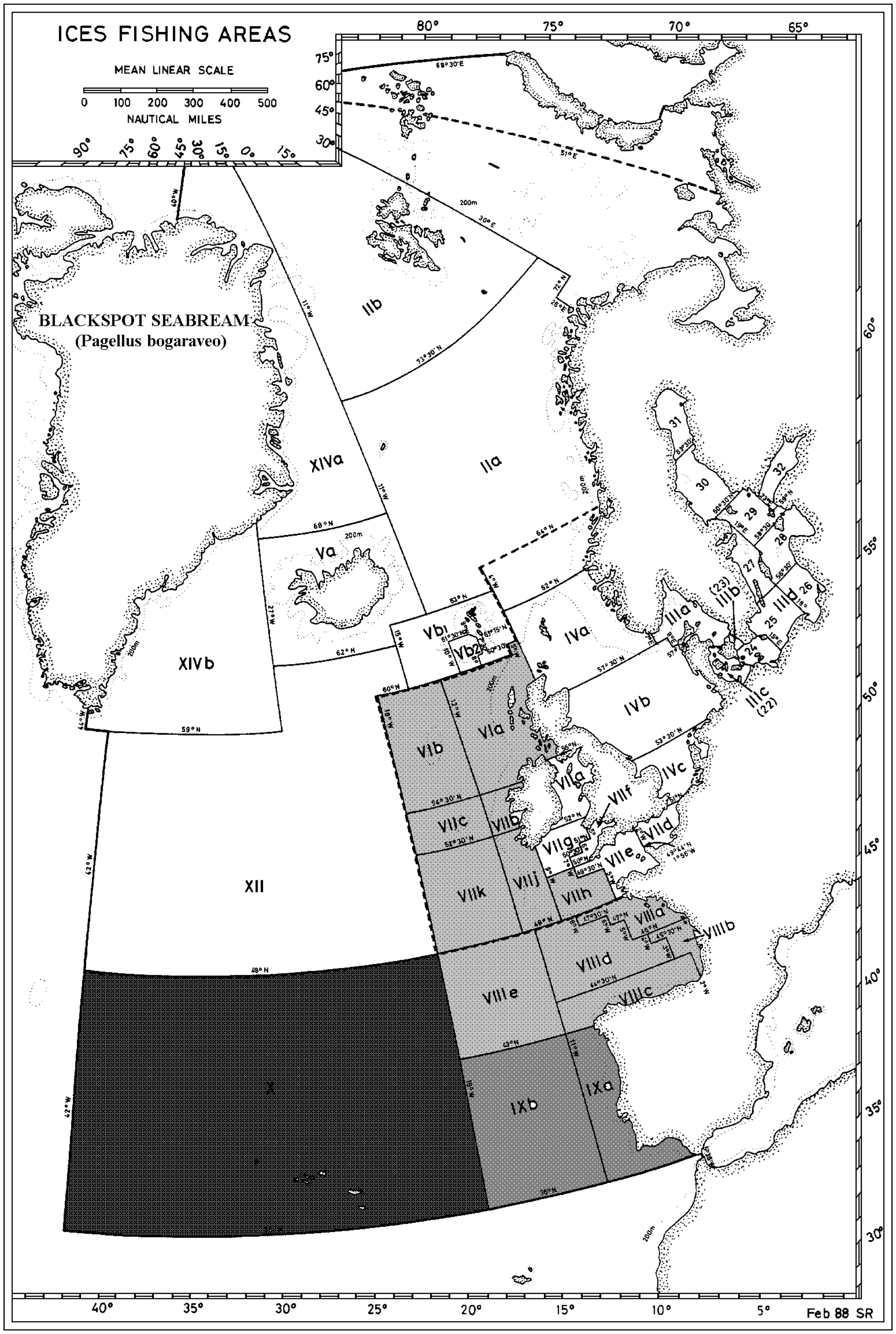

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
ROUNDNOSE GRENADIER
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
IIIa
IIIb
IIIc
IIId
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR

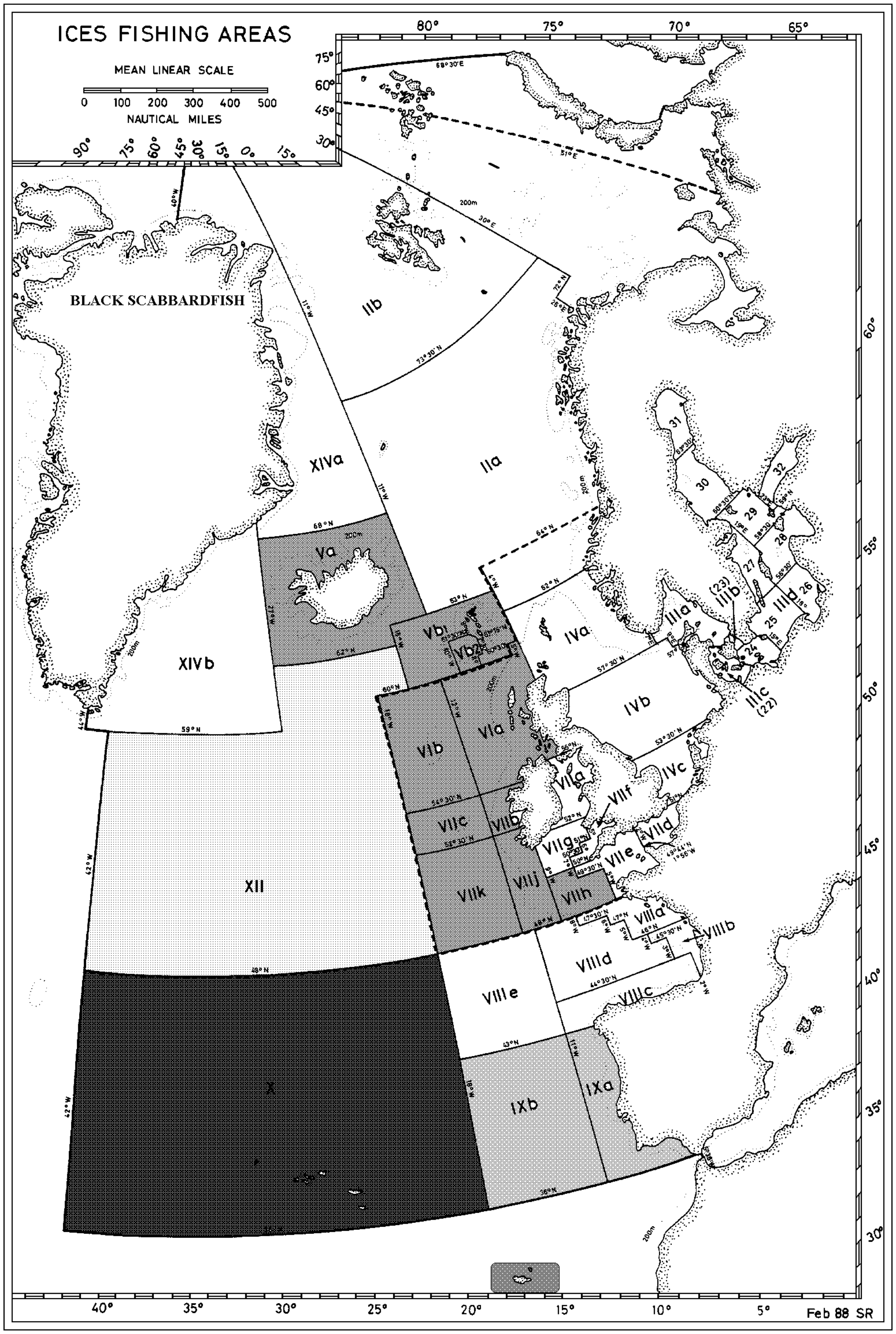

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
BERYX spp
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
IIIa
IIIb
(23)
IIIc
(22)
IIId
24
25
26
27
28
29
30
31
32
Feb 88 SR

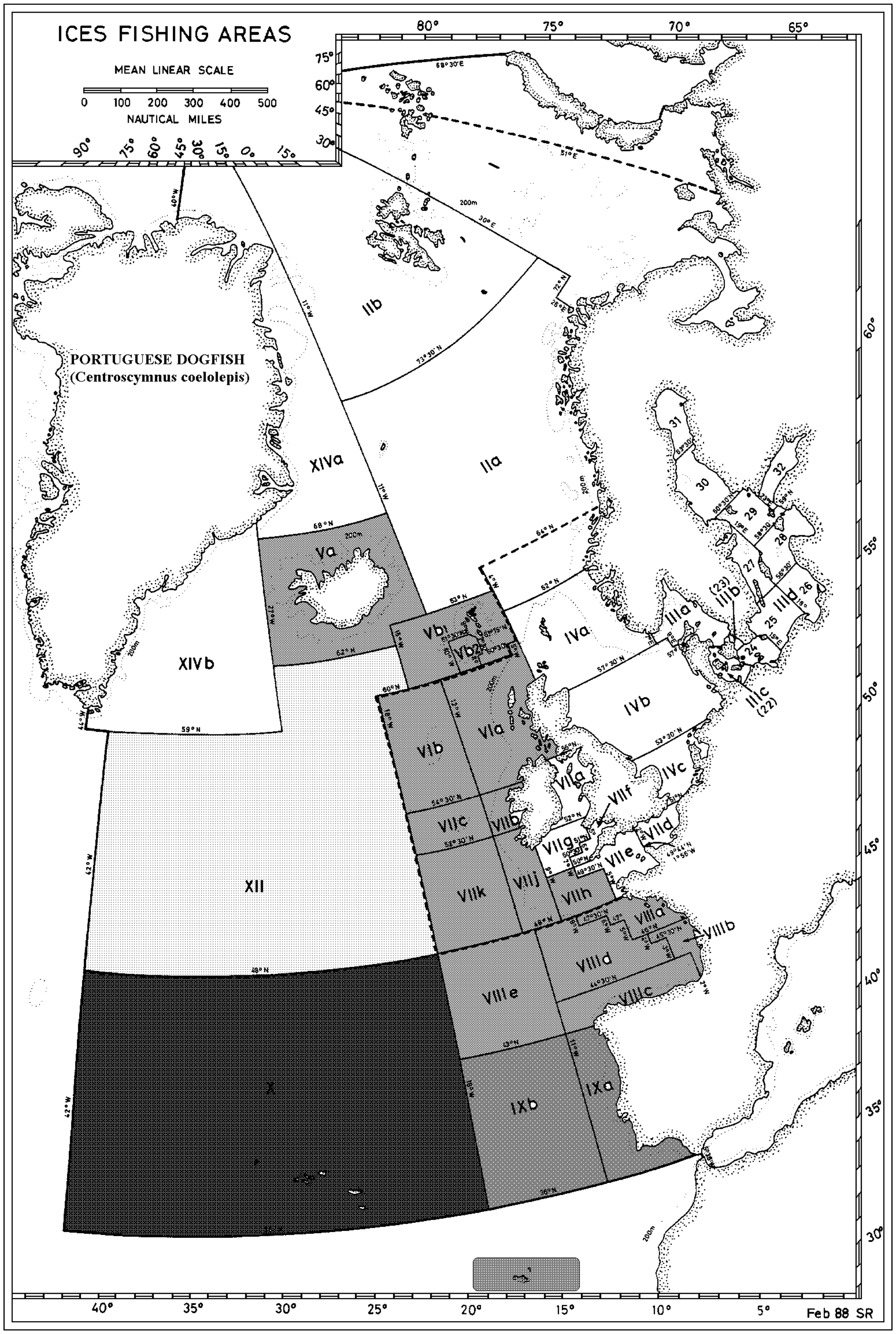

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
ORANGE ROUGHY
IIb
IIa
XIVa
Va
XIVb
Vb1
Vb2
IVa
IVb
IVc
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
XII
X
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
IIIa
IIIb (23)
IIIc (22)
IIId
24
25
26
27
28
29
30
31
32
Feb 88 SR

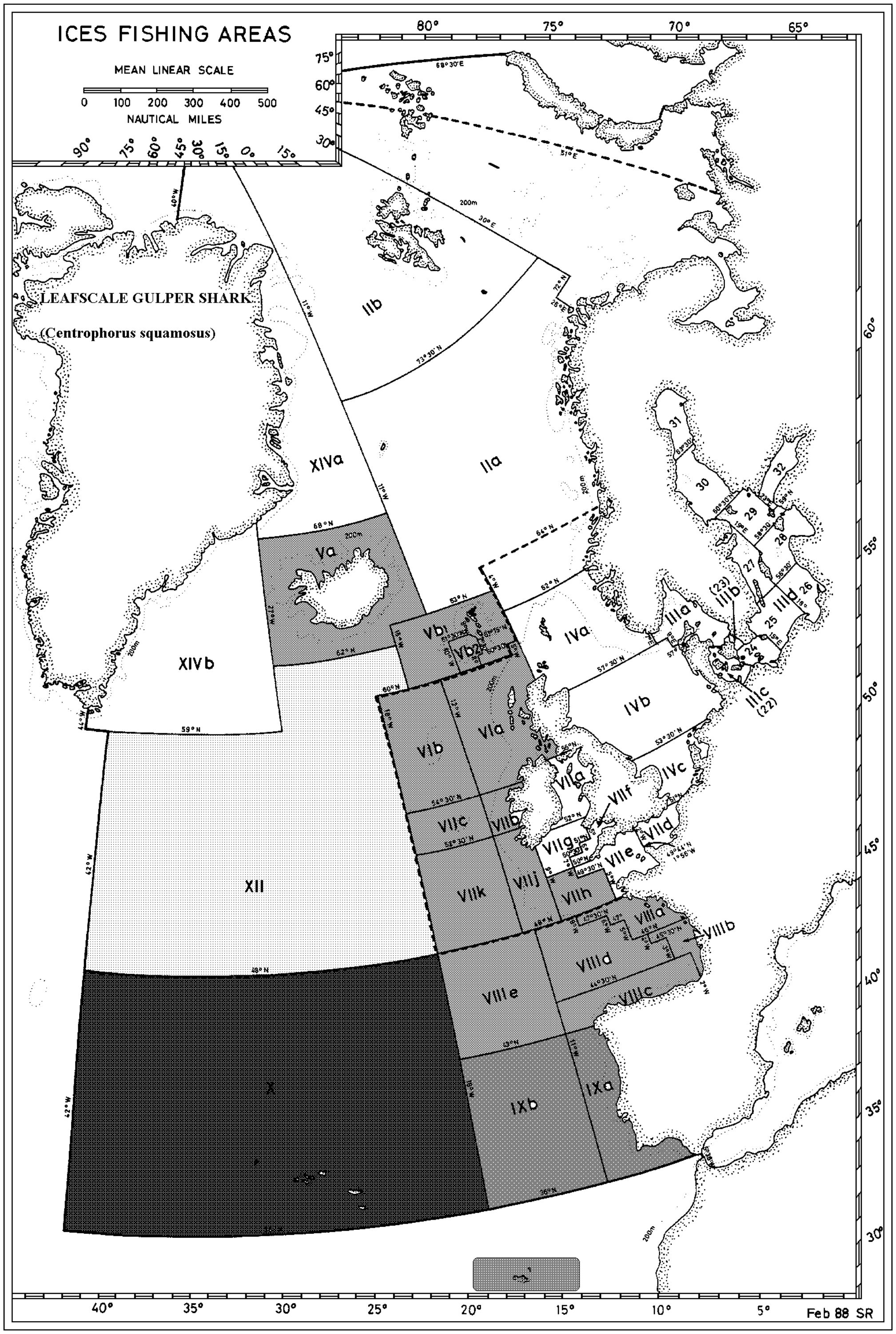


ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
WRECKFISH
(Polyprion americanus)
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
IIIa
IIIb
IIIc
IIId
(22)
(23)
24
25
26
27
28
29
30
31
32
Feb 88 SR

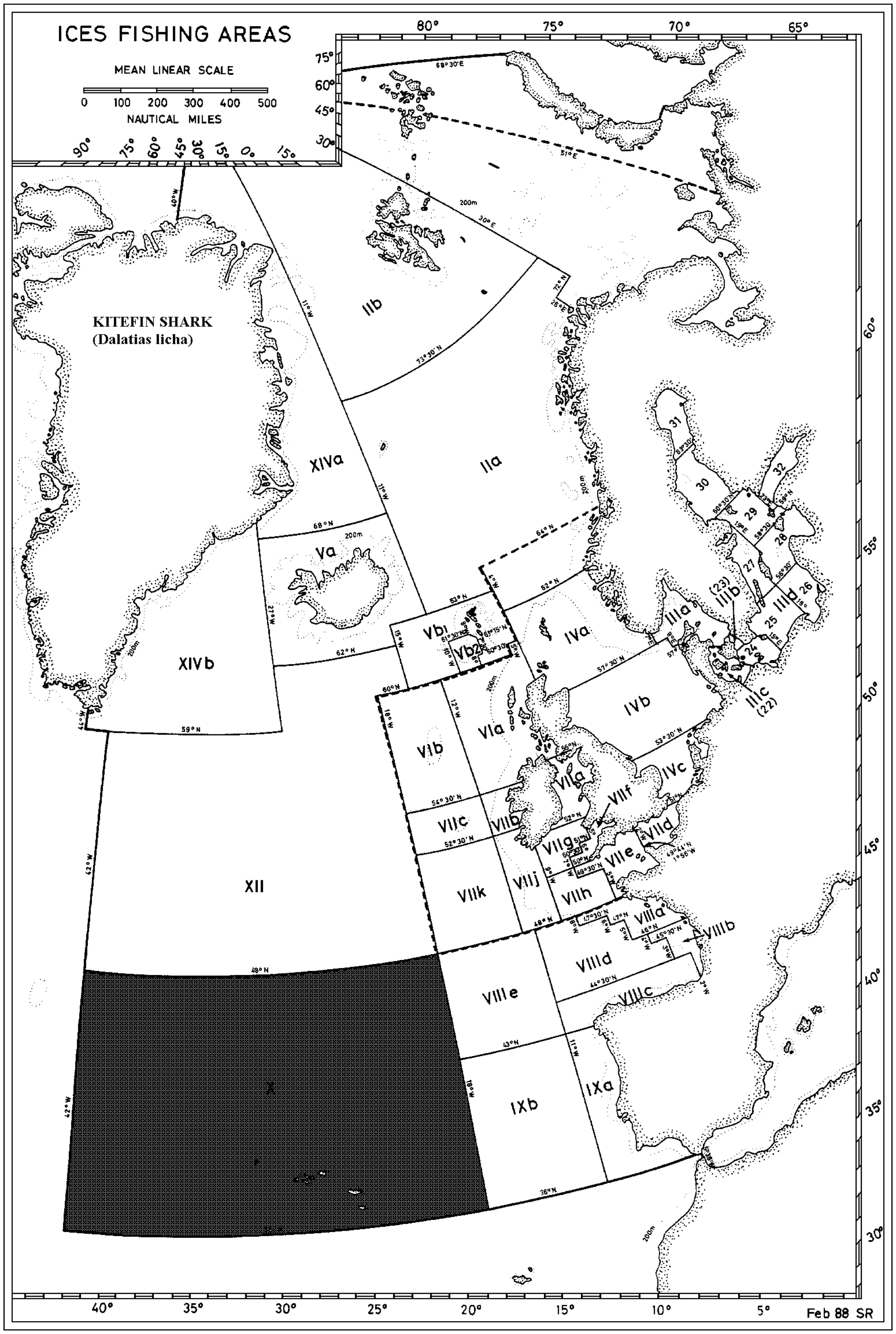

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
BLACKSPOT SEABREAM
(Pagellus bogaraveo)
IIb
IIa
XIVa
Va
XIVb
Vb1
Vb2
IVa
IVb
IVc
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
IIIa
IIIb
IIIc
IIId
Feb 88 SR

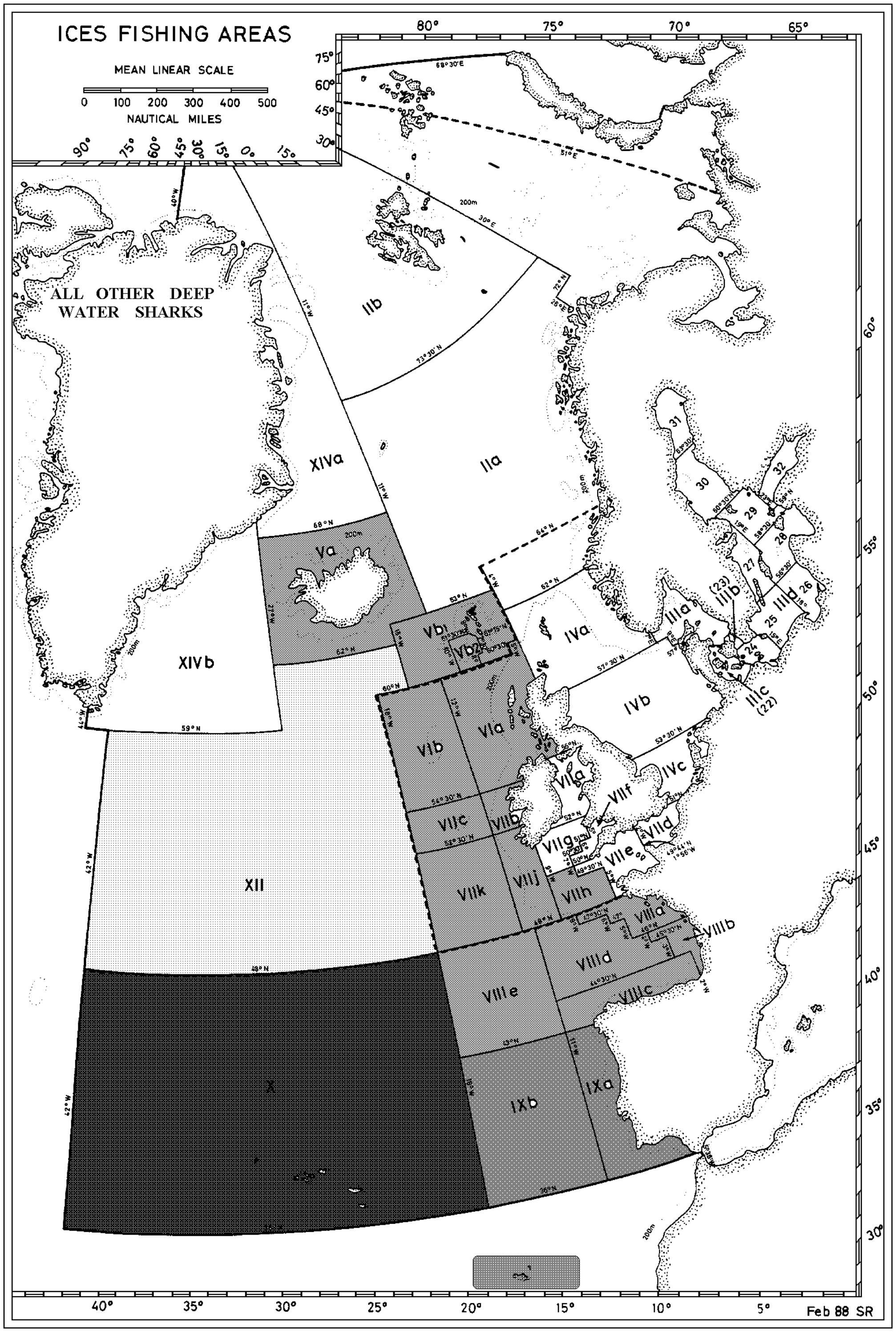

ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
BLACK SCABBARDFISH
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
IIIa
IIIb
IIIc
IIId
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR


ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
PORTUGUESE DOGFISH
(Centroscymnus coelolepis)
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
IIIa
IIIb
IIIc
IIId
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR



ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
LEAFSCALE GULPER SHARK
(Centrophorus squamosus)
IIb
IIa
XIVa
Va
XIVb
Vb1
Vb2
VIa
VIb
IVa
IVb
IVc
IIIa
IIIb (23)
IIIc (22)
IIId
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR


ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
KITEFIN SHARK
(Dalatias licha)
IIb
IIa
XIVa
Va
XIVb
Vb1
Vb2
IVa
IVb
IVc
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
IIIa
IIIb
IIIc
IIId
(22)
(23)
24
25
26
27
28
29
30
31
32
Feb 88 SR



ICES FISHING AREAS
MEAN LINEAR SCALE
0 100 200 300 400 500
NAUTICAL MILES
ALL OTHER DEEP WATER SHARKS
IIb
IIa
XIVa
XIVb
Va
Vb1
Vb2
IVa
IVb
IVc
IIIa
IIIb
IIIc
IIId
VIa
VIb
VIIa
VIIb
VIIc
VIId
VIIe
VIIf
VIIg
VIIh
VIIj
VIIk
VIIIa
VIIIb
VIIIc
VIIId
VIIIe
IXa
IXb
X
XII
Feb 88 SR