REPORT OF THE STUDY GROUP ON THE BIOLOGY AND ASSESSMENT OF DEEP-SEA FISHERIES RESOURCES

ICES Headquarters, 12-18 February 1998

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1 INTRODUCTION

Participants

O.A. Bergstad	Norway
W.R. Bowering	Canada
J.M. Casas	Spain
J.D.M. Gordon (Chairman)	United Kingdom
J.R.G. Hislop	United Kingdom
O. Jørgensen	Greenland
C.J. Kelly	Ireland
P.A. Large	United Kingdom
P. Lorance	France
P. Lucio	Spain
J.V. Magnússon	Iceland
O. Moura	Portugal
J. Reinert	Faroe Islands
M. Stehmann	Germany
V.Vinnichenko	Russia

1.1 Terms of Reference

At the 1997 Annual Science Conference, ICES Resolution 2:11:17 decided that the Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources [SGDEEP] under the Chairmanship of Dr J.D.M. Gordon, (UK) would meet at ICES Headquarters from 12–18 February 1998 to:

a) compile the available data on landings of deep-water species, including blue ling, ling and tusk, by ICES Sub-area or Division;

b) update descriptions of deep water fisheries in waters inside and beyond coastal state jurisdiction south of 63°N, for species such as grenadiers, scabbard fishes, orange roughy, forkbeards, sharks, ling, blue ling and tusk especially catch statistics by species, fleets and gear: and if possible the biological status of these stocks;

c) update the data on length/age at maturity, growth and fecundity provided in tabular form in the 1997 report and document other relevant biological information on deep-water species;

d) update information on quantities of discards by gear type for the stocks and fisheries considered by this group using the format proposed by the WGECO with a view to establishing a time series.

e) consider the possibility of carrying out assessments of fisheries for deep-sea resources and developing advice consistent with the precautionary approach.

The above terms of reference are set up to provide ACFM with the information required to respond to the requests for advice from NEAFC, the EC and OSPAR. SGDEEP will report to ACFM before its May 1998 meeting.

2 OVERVIEW

2.1 Background

The first ICES Study Group on the Biology and Assessment of Deep-Sea Fisheries Resources was held in 1994 (C.M. 1995/Assess:4). It provided the background information on what was known about deep-water fisheries within the ICES area and compiled landings data from both official statistics, where available, and from individual members of the Study Group. The report also summarised the current status of knowledge on the biology of these deep-water species. At this time ling, blue ling and tusk were the responsibility of the Northern Shelf Working Group.

The Study Group met by correspondence in 1995 (C.M.1995/Assess:21) but had little to report. The next meeting of the Study Group was in February 1996 (C.M.1996/Assess:8). Its terms of reference were to: (a) compile and analyse available data on a number of deep-water species (namely argentines, orange roughy, roundnose grenadier, black scabbard fish, golden eye perch (*Beryx splendens*) and red (blackspot) seabream (*Pagellus bogaraveo*)) in the ICES area and, if possible, provide assessments of the state of the stocks and the level of exploitation. and (2) provide information on the stocks and state of exploitation of the stocks of blue ling, ling, and tusk in Sub-areas IIa, IVa, V, VI, VII and XIV and identify outstanding data requirements.

Objective (a) compiled and analysed available data but the only significant assessment work was an evaluation of an Azorean report on *Pagellus bogaraveo*. Objective (b) provided a summary of the stocks of blue ling, ling, and tusk and presented the available data in tabular form. An opportunity was also taken to update information on descriptions of fisheries and biology.

The Study Group met by correspondence in 1997 (C.M.1997/Assess:17) and, in addition to updating descriptions of fisheries, the available information on length/age at maturity, growth and fecundity of deep-water species, including blue ling, ling and tusk, was presented in tabular form. The available information on discards was also compiled.

2.2 ACFM Evaluation

The 1996 report was evaluated by ACFM in May 1996 and concentrated mainly on Sections 6 to 14 dealing with status of the stocks of the species included in the terms of reference. There were many useful comments on the layout of the sections and the presentation of the information. It was suggested that in future greater use should be made of summary tables.

The 1997 report by correspondence was not presented to ACFM in May 1997. It was presented at ACFM in October 1997 where it was noted that more expertise in stock assessment was needed in the Study Group. It was suggested that the expertise of assessment experts in the Study Group on the Assessment of Other Fish and Shellfish Species (SGASSO) should look at the data, especially for ling, blue ling and tusk for which there are long established fisheries. A joint meeting between SGDEEP and SGASSO was suggested as the best way of ensuring that the most appropriate assessment methods might be applied to these species.

2.3 Data availability

The Study Group wishes to emphasise the fact that the DeLury and Production models fitted by the Group could be improved if more time had been available. Much of the data only became available towards the end of the meeting. The setting of confidence limits and boot strapping are issues that need to be addressed at future meetings.

In addition to the normal sources from ICES and individual institutes the following projects relevant to deep-water species were noted by the Study Group and the data were referenced or utilised where appropriate.

2.3.1 EC FAIR

In December 1995 The European Commission funded a three year DGXIV FAIR project entitled "Developing deep-water fisheries: data for their assessment and for understanding their interaction with and impact on a fragile environment (CT 95/655). The project aims to describe these fisheries, ensure that existing survey data are worked up and archived, scientifically record the species being landed or discarded and investigate aspects of the biology of both target and non-target species. The project which has 13 partners covers the continental margin from Iceland to Greece and the inputs of partners from Iceland, Norway, United Kingdom, Ireland, Germany, France, Spain and Portugal are relevant to the ICES area.

Under task 1 partners from Iceland, Norway, United Kingdom, Spain and Portugal have provided detailed descriptions of the deep-water fisheries of their countries. Task 2 involves the compiling of mainly historical survey data and where

appropriate its analysis. This is being undertaken by Iceland, United Kingdom, Ireland, Germany, and Spain. Task 3 is concerned with collecting and analysing discard data. France and the United Kingdom are sending observers on commercial trawlers fishing for deep-water species to the west of the British Isles. Norway is collecting data on the discards from the deep-water longline fisheries. Task 4 recognises that many deep-water species tend to be landed by grouped categories, for example deep-water sharks, and therefore involves sampling the landings. This is being carried out by Iceland, France, United Kingdom and Portugal. The final task, which involves all partners, aims to carry out research on the biological parameters of deep-water species. The work content varies considerably between partners but the key elements are distribution, age estimation, growth and reproduction.

The first and second progress reports of this project were available to the Study Group so that relevant areas of research could be referenced.

2.3.2 Nordic Countries

In 1993, a three year Nordic Council project on the fishery and biology of ling, blue ling and tusk was initiated with Iceland, the Faroes and Norway as collaborating partners. This provided the means for increasing the sampling activity of these species and for assembling new and historical biological data. A major activity in the project has been the development of ageing methods, and workshops and intercalibration exercises have improved significantly the consistency of age readings of ling and tusk. Results from the project are of great importance for the future research on these three species and have already provided significant supplements to the information now available to the Study Group such as e.g., age/length keys for ling and tusk (Magnússon *et al.*, 1997). Also, the species have been included in the regular sampling programme of the Faroes and Iceland.

2.3.3 Environment and biology of deep-water species *Aphanopus carbo* in NE Atlantic: basis for its management (BASBLACK)

This project, which is being funded by the European Commission (DGXIV in support of the Common Fisheries Policy), will begin in early 1998. The project is being coordinated by Portugal and also has partners from Spain and the United Kingdom. The main objectives are to establish a sampling programme of landings for CPUE and exploited population length structure data; to investigate biological parameters (especially growth, feeding, and reproduction); study stock discrimination; collect relevant oceanographic data and monitor the levels of mercury and other contaminants.

2.3.4 Seasonal changes in biological and ecological traits of demersal and deep-water fish species in the Azores

This project, which is being funded by the European Commission (DGXIV in support of the Common Fisheries Policy), will begin in early 1998 and is being coordinated by Portugal with the United Kingdom as a partner. The overall objective is to improve current knowledge on age estimation, growth and reproduction of some of the commercially important demersal and deep-water species exploited in the Azores. Investigations will also be carried out on stock discrimination using micro-satellite DNA. Ecological studies will include the relationship between local hydrography, topography, life-history parameters, and spatial scales of genetic differentiation in deep-sea fish for a better understanding of the population biology of the target species. Vertical and horizontal migrations, changes in the feeding habits and some other aspects of the biology of the target species between seamounts and islands margins will also be studied.

2.3.5 Deep-water demersal fishes:data for assessment and biological analysis

This two year project was funded by the European Commission (DGXIV in support of the Common Fisheries Policy: CT 94/017) and was completed in 1997. The project was coordinated by the Scottish Association for Marine Science (SAMS) and the main objective was to extract and analyse the data from deep-water surveys carried out by UK MAFF (now CEFAS) during the 1970s. Logbooks were available for six deep-water surveys of FRV *Cirolana* and all the information on trawl stations, catch composition and biological parameters were entered into a data base which will be transferred to CEFAS and will be available to ICES and the EU. Some work on age estimation of *Coryphaenoides rupestris* was carried out using 1970s CEFAS and 1990s SAMS otolith collections. Some preliminary work on age estimation of *Phycis blennoides* and *Trachyrinchus murrayi* was also carried out.

2.4 Summary of landings

The estimated landings of deep-water species by ICES Sub-area and division for the period 1988 to 1997 (preliminary data) are given in Table 2.1. The data in this Table are derived from a variety of sources. Study Group members have provided information that has filled some of the gaps in the STATLANT data base but an inspection of the more detailed information presented for each species in the following sections of this report will reveal that the data are still

incomplete. For this reason, some of the apparent trends and fluctuations during the ten year time series should be treated with caution.

In ICES Sub-area II there is a directed bottom and pelagic trawl fishery for *Argentina silus*. There is also a directed fjord fishery for roundnose grenadier. There are directed longline fisheries for ling and tusk. Roughhead grenadier are taken in the gillnet fishery for Greenland halibut.

In ICES Sub-area III there is a targeted trawl fishery for *Argentina silus* and this species is also a bycatch of the *Pandalus* fishery. Roundnose grenadier is caught as a bycatch of both these fisheries.

In ICES Sub-area IV there is a bycatch of *Argentina silus* from the industrial trawl fishery. There is a longline fishery for tusk and ling with roughhead grenadier as a bycatch. There is a bycatch of some deep-water species in the trawl fisheries targeting *Lophius* spp. and Greenland halibut

In ICES Sub-area V there are trawl fisheries which target blue ling, redfish and occasionally orange roughy. By-catch species are typically roundnose grenadier (*Coryphaenoides rupestris*), roughhead grenadier (*Macrourus berglax*), black scabbard fish (*Aphanopus carbo*), anglerfish (*Lophius piscatorius*), bluemouth (*Helicolenus dactylopterus*), Mora (*Mora moro*), greater forkbeard (*Phycis blennoides*), argentine (*Argentina silus*), deep-water cardinal fish (*Epigonus telescopus*) and rabbit fish (*Chimaera monstrosa*). There are traditional longline fisheries are ling and tusk. There are also targeted trawl and gill net fisheries for Greenland halibut and *Lophius* spp which have deep-water bycatch. There have been trap fisheries for the deep-water red crab (*Chaceon* (formerly *Geryon*) *affinis*).

In ICES Sub-areas VI and VII there are directed trawl fisheries for blue ling, roundnose grenadier, orange roughy, black scabbard fish and the deepwater sharks *Centroscymnus coelolepis* and *Centrophorus squamosus*. By catch species include bluemouth (*Helicolenus dactylopterus*), mora (*Mora moro*), greater forkbeard (*Phycis blennoides*), argentine (*Argentina silus*), deep-water cardinal fish (*Epigonus telescopus*) and rabbit fish (*Chimaera monstrosa*). In some years there are considerable bycatches of *Argentina silus* in the blue whiting fishery and *A.silus* has been targeted in some years. There are directed longline fisheries for ling and tusk and also for hake. Deep-water sharks are a bycatch of the longline fisheries. There are targeted fisheries for sharks in Sub-area VII.

In ICES Sub-area VIII there is a longline fishery which mainly targets deep-water sharks but is occasionally directed to Mora (*Mora moro*) and greater forkbeard (*Phycis blennoides*). There are also some trawl fisheries targeting species such as hake, megrim, angler fish and *Nephrops* which have a bycatch of deep-water species. These include *Molva* spp., *Phycis phycis*, *Phycis blennoides*, *Pagellus bogaraveo*, *Conger conger*, *Helicolenus dactylopterus*, *Polyprion americanus* and *Beryx* spp.

In ICES Sub-area IX some deep-water species are a bycatch of the trawl fisheries for crustaceans. Typical species are bluemouth (*Helicolenus dactylopterus*), greater forkbeard (*Phycis blennoides*) conger eel (*Conger conger*), blackmouth dogfish (*Galeus melastomus*), kitefin shark (*Dalatias licha*) and gulper shark (*Centrophorus squamosus*). There is a directed longline fishery for black scabbard fish with a bycatch of the gulper shark. There is also a longline fishery for *Pagellus bogaraveo.*

In ICES Sub-area X the main fisheries are by handline and longline and the main species landed are red (=blackspot) seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), conger eel (*Conger conger*), bluemouth (*Helicolenus dactylopterus*), golden eye perch (*Beryx splendens*) and alfonsino (*Beryx decadactylus*). There is also a directed fishery for kitefin shark (*Dalatias licha*) by hand line and gillnet.

In ICES Sub-area XII there are trawl fisheries on the Mid Atlantic Ridge for golden eye perch (*Beryx splendens*), orange roughy (*Hoplostethus atlanticus*) cardinal fish (*Epigonus telescopus*), black scabbard fish (*Aphanopus carbo*) and wreckfish (*Polyprion americanus*). There is also a targeted roundnose grenadier fishery on the Mid Atlantic Ridge. There is a multi-species trawl on Hatton Bank.

In ICES Sub-area XIV roundnose grenadier and roughhead grenadier are a by-catch, which is sometimes landed, of the Greenland halibut and redfish fisheries.

2.5 Aims

At the start of the meeting it was considered that some preliminary attempts at assessing some deep-water species might be possible and therefore an assessment sub-group was formed to discuss the working documents presented to the Study Group. The Study Group also took note of the comments of the ACFM evaluation of the 1996 report and decided to substantially change the layout of the report to conform with the format of assessment working group reports.

It was decided to carry out a major revision of the landings tables to remove some errors identified by ACFM and update provisional estimates from previous years.

The Study Group took note of various suggestions and recommendations on its future and in particular its relationship with The Study Group on the Assessment of Other Fish and Shellfish and the Study Group Elasmobranch Fishes, (See Section 18).

3 ASSESSMENT METHODOLOGY AND SOFTWARE

This section summarises the methods and software used by Study Group.

3.1 Methods

Catch curve analysis

The Group were aware of the assumption of constant recruitment implied when constructing catch curves within years. Lack of historical data frequently required this course of action rather than the preferred option of analysing individual year classes by cohort.

Depletion models

A catch and effort data analysis package (CEDA) was used to apply modified Delury constant recruitment models when sufficient data were available. The Study Group recognised that depletion models in general assume that data are from a single stock (i.e., there is no immigration or emigration) and that this approach should not be applied to components of stocks or fisheries. Notwithstanding these assumptions, and the lack of knowledge regarding the stock structure of deep-water species, the Group still felt these methods were worth trying as an investigative tool. The general procedure adopted was to use sensitivity analysis to evaluate the effect on results (goodness of fit, residual plots, parameter estimates- principally carrying capacity, catchability and current population size) of a range of assumptions for stock size in the first year as a proportion of carrying capacity and error models. Indexed recruitment depletion models could not be attempted because of a lack of recruit data.

Production models

CEDA was also used to fit a range of production models (Schaefer, Fox etc), all of which in CEDA are dynamic (i.e., non-equilibrium) models. Again sensitivity analysis of outputs was used to evaluate the effect of time lags and error models.

Pseudo-cohort analysis

Pseudo-cohort analysis corrected by effort proceeds by direct calculation down the catch at age vectors. The iteration begins with an assumed recruitment equal to 10^5 x the catch at the first age in the vector. The catch equation for this age group is then solved, and having an estimate of effort, a catchability is calculated. Multiplied by the effort in the previous year, this catchability allows F to be calculated during the previous year (for the same age group of the preceding cohort). The number of survivors of this (preceding) cohort at the beginning of the analysed year is then calculated from the survival equation. The catch equation is then solved and so on. At each step a catchability for one age group is obtained, the numbers at age of the successive age groups at the beginning of the year are calculated from the survivors of the recruitment after applying F at ages given by the products of catchability at age (calculated) and effort by year (input). The process is continued down to the terminal age and the next iteration starts with a recruitment corrected according to the difference between the input terminal F and the calculated value. A summary of the analytical steps and associated equations is given in Appendix 2.

Length and age-based VPA analysis

These methods were not used because suitable data are not generally available, and where they are, for *Pagellus bogaraveo* for example, the Study Group did not have access to these data.

***Ad hoc* methods**

Where *ad hoc* methods have been used these are described in the relevant species assessment sections.

3.2 Software

The main assessment software used at the Study Group was CEDA: Catch Effort data analysis, produced by MRAG Ltd, 27 Campden Street, London W8 7EP, UK.

4 PRECAUTIONARY APPROACH

Deep-water fishes continue to receive increased attention from national and international management authorities, conventions and non-governmental organisations. Increasing fishing effort in what are largely unregulated fisheries for species many of which are generally considered to be long-lived, slow growing, with low reproductive potential for replacement is a potentially serious threat to deep-water fish stocks in many parts of the world. Moreover, for most stocks the effect of increased levels of fishing is difficult to determine because of a lack of scientific data. However, this is now no longer justification for not introducing management measures. Article 7.5 of the FAO Code of Conduct states that:-

"*States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation or management measures. In implementing the precautionary approach, States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards on non-target and associated and dependent species as well as environmental and socio-economic conditions. States and subregional or regional fisheries management organisations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine stock specific limit reference points and, at the same time, the action to be taken if they are exceeded."*

The urgent need to implement the precautionary approach to manage deep-water fish stocks is exacerbated by the low survival rate of discarded species and escapees. Thus, increasing fishing effort will affect deep-water fish assemblages in general and not just species of commercial importance.

The Study Group had access to a draft of the section of the report of the Study Group on the Precautionary Approach to Fisheries Management (meeting the previous week) referring to deep-water fisheries resources. The feedback control rule suggested by Steffanson and Bell for fixing next year's catch as function of the current year's catch and recent biomass changes

$$Y_t = Y_{t-1} * (1 + g [(B_{t-1} - B_{t-2}) / B_{t-2}])$$

where:

Y is catch
B is biomass (index)
g is a proportionality factor named feedback gain

was noted, but concern was expressed concerning the sensitivity of the approach to the value of g used. It was felt that further guidance was required on this aspect. The Study Group recognised that this procedure is still under development.

With regard to suitable biological reference points for deep-water stocks, given that the basic data available for these stocks is still comparatively sparse the Group felt that the measures of limit and pa reference points suggested for data-poor situations by the ICES Study Group on the Precautionary Approach to Fishery Management (ICES C.M. 1997/Assess:7) may be appropriate:-

$F_{lim} = F_{35\ \%SPR}$
$F_{pa} = M$

B_{lim} = 0.2 * B_{max} (may be a smoothed abundance index)
B_{pa} = 0.5 * B_{max}

The Group have attempted to comment on the state of stocks in relation to these reference points whenever possible.

5 STOCK SUMMARY

Table 5.1 Stock summary for species analysed by ICES Deep Sea Study Group.

Species	ICES Sub-area/division	Assessment type and final year of data	Salient features	State of stock[1]
Ling *(Molva molva)*	IIa,IVa,V,VI and VII.	Catch curve + CPUE. 1997	Strong decline in CPUE, average Z in recent years is about 0.6 for all areas.	Stock declining. Probably over-exploited
Blue ling *(Molva dypterygia)*	IIa, IVa, V, VII, XII and XIV	CPUE only. 1997	Strong decline in CPUE	Stock declining. Probably over-exploited
Tusk *(Brosme brosme)*	IIa,IVa,V,VI.	Catch curve + CPUE only. 1997	Strong decline in CPUE, particularly in Vb and VI. Average Z for recent years is 0.6 for all areas.	Stock declining. Probably over-exploited
Greater Argentine *(Argentina silas)*	Mainly IIa,III,V,VI,VI I	DeLury on Va. Historically acoustic survey in VI,VII & IVa (1993),IIa (1992) & IIIa (1992)	Estimated biomass for IIa stable at about 400kt Biomass for VI,VII & IVa down from 408kt (1990) to 208kt in 1993.	No new information since last year. Fishery in IIa considered be sustainable. Possible collap of local Irish fisheries in 1990
Orange Roughy *(Hoplostethus atlanticus)*	Mainly V, VI, and VII.	Modified Delury, Schaefer and raised biomass from surveys	Stock fished down very quickly. Catches have declined rapidly	Stock biomass in 1996 probab below B_{lim} in VI and B_{pa} in VI
Roundnose Grenadier *(Coryphaenoides rupestris)*	Mainly III,V, VI and XII. Data mainly from VI & VII	Modified DeLury, catch curves, pseudocohort analysis, survey indices 1997	CPUE stable. F appears low with little effect on stock	Biomass appears above B_{pa} an recent Fs below F_{pa}
Black Scabbardfish *(Aphanopus carbo)*	Mainly V,VI,VII,VIII and IX	Modified Delury. Historically catch curves and length based cohort analysis for VIII and IX only. 1993.	Slight decline in effort since 1990. Landings steady. DeLury results unreliable. Previous assessments indicate F= 0.53. D	No new information since last year. Uncertain. Probably sustainable in IX.
Golden Eye Perch *(Beryx splendens)*	Mainly X	No information		Unknown
Red (blackspot) Seabream *(Pagellus bogaraveo)*	X, IX, VI, VII and VIII	Analytical VPA for Azorean fishery only. 1993	Increasing trend in F to 0.8 in 1993. Similar increase in effort	Preliminary assessment for Sul area X suggests that F may be four times as high as Fmax. Historical trend of landings for other areas indicates a collapse stock

[1] The Study Group acknowledges that stock units are not well defined for the above species.

6 GENERAL

6.1 Descriptions of fisheries

6.1.1 Faroe Islands

In Division Vb the Faroese trawl fishery moved towards deeper waters in the late 1970s. A gill net fishery directed at monkfish and Greenland halibut started in the 1990s. A description of this fishery has been given in earlier reports of this study group and of the Northern Shelf Demersal Working Group. In addition a directed longline fishery on deepwater sharks has been initiated in recent years.

The fisheries on ling, blue ling and tusk are well established. Tables 6.1-6.3 shows for the years 1985–1996 the contribution of each fleet category to the landings of the three species. The main fleet fishing for ling are the longliners larger than 100GRT; this fleet takes more than 50 % of the catches. Next comes the pair trawler fleet larger than 1,000HP with almost 20 % of the catches Table 6.2). The blue ling is mainly taken by the single trawler fleet larger than 1,000 HP (Table 6.3) whereas the two longliner fleets take almost all catches of tusk (Table 6.1).

Since 1994 one vessel has been targeting orange roughy (*Hoplostethus atlanticus*) on the northern part of the Mid-Atlantic Ridge and to a lesser extend around the Faroe Islands and the Hatton Bank. In 1996 this vessel began landing increasing amounts of roundnose grenadier (*Coryphaenoides rupestris*). A vessel that used to fish for black scabbardfish on the Hatton Bank has, since 1996, changed to shelf fishing.

6.1.2 France

The main ports involved in deep-water fish exploitation remain Boulogne-sur-mer, Concarneau and Lorient. Some trawlers from Douarnenez are also involved in the deep-water fishery, but the landings in this port account for only 2 to 3 % of the total landings of these species. The boats from Lorient land most of their catch in Scottish ports for onward transport by road to markets in France. The same system is currently being tested by the Boulogne fleet.

The Lorient and Boulogne fleets are mainly industrial trawlers around 50 metres long. The Concarneau and Douarnenez vessels are termed semi-industrial according to French classification rules. These trawlers are mainly 25 to 35 metres long.

Some other boats can occasionally land small catches of deep-sea fishes, however the industrial and semi-industrial fleets of the four ports cited landed more than 99 % of the four main deep-water species in 1995 and 1996. That figure was previously lower because some freezer trawlers used to land some deep-sea fish. Their landings in 1996 were limited to 300 kg of *Coryphaenoides rupestris* and 2 000 kg of *Aphanopus carbo*.

In the same way, some artisanal trawlers from Le Guilvinec (South West Brittany) used to be involved in the fishery. From 1995 these boats shifted back to shelf fishery, mainly due to the recovery of the monkfish (*Lophius* spp.) stock producing better yields. They landed a few tons of deep-sea fishes in 1995 and less than one ton in 1996.

The change in the fleet size from 1995 to 1996 (Table 6.4) does not properly reflect changes in fishing effort as it is mainly due to part-time deep-sea fishing vessels. Some bigger changes occurred in 1997 due to accidental losses of two 100 % deep-water trawlers in Boulogne. The destruction of these two boats means a strong reduction in fishing effort from 1997.

The average age of the industrial fleet is 22 years the semi-industrial fleet is much younger (average age =13 years)

6.1.3 Germany

There have been no new developments since the 1996 report.

6.1.4 Greenland

In 1997 20 t of roundnose grenadier was caught in ICES Division XIVb as by-catch in the Greenland fishery for Greenland halibut. Out of this catch 8 t was discarded. There was no offshore longline fishery by Greenland in 1997.

6.1.5 Iceland

The Icelandic fisheries for deep-water species were briefly described in the Study Group Reports 1994 and 1996. No major changes have taken place in the fishery for ling, blue ling and tusk. They remain basically by-catch fisheries although a few vessels may occasionally aim for one or another of these species, in particular tusk. The landings of tusk remained at the same level from 1995 to 1997 while there was a decline in both landings of ling (11 %) and blue ling (26 %) during the same period. This decline, in particular for blue ling is in correspondence with the increased quota limitations in the redfish and Greenland halibut fisheries. On the other hand, the fishery on greater silver smelt (*Argentina* silus) has multiplied since 1995. The landings have increased from less than 500 t in 1995 to about 800 t in 1996 and about 2500 t in 1997. Lately, a new fishery has emerged. It is a longline fishery for Greenland halibut and “giant” redfish (*Sebastes marinus*), in deep water (800–1000 m) on the Reykjanes Ridge. Only very few Icelandic vessels have been engaged in this fishery. Minor landings of some other deep water fishes were taken as by-catches in this fishery, e.g.,. tusk and blue ling. Landings of other deep water species than those already mentioned are all by-catch

except the landings of orange roughy (*Hoplostethus atlanticus*). Although the landings of orange roughy are small, the fishery is an aimed one.

6.1.6 Ireland

Deep water species landed regularly in Ireland include ling, forkbeard, tusk and blue ling. Ling is mainly taken in Sub-area VII by bottom trawl. Smaller quantities are taken in Sub-area VI and by beam trawl and gillnet in Sub-area VII. A quarter of total landings of ling by Irish registered vessels are made into Spain. Forkbeard is taken mainly as a bycatch with bottom trawl, but there are some minor landings by gill net. Catches of forkbeard are mainly from Divisions VIIb, VIIj, and VIIk, with smaller quantities landed from Divisions VIa and VIb. Landings of this species into Spain by Irish registered vessels are over twice the quantity landed into Irish ports, there are very minor landings of this species into the UK by Irish registered beam trawlers. Small catches of blue ling taken by bottom trawl are landed into south-western Irish ports from Sub-area VII. There are occasionally minor landings from Sub-area VI. Tusk is caught only by bottom trawl and mainly in Divisions VIIa and VIIb. This species is not landed in any foreign port by Irish registered vessels. There are incidental landings of argentine from Sub-area VI from pelagic vessel(s). The quantity of these landings was approximately 700 t in 1997, 300t of this species was landed into the Faroes by an Irish pelagic vessel in 1997.

Landings of shark in Ireland classed as various (excluding spurdog, spotted dogfish) are less than 5t. Except for one landing of 90kg these are not believed to include any deep-water sharks.

There were minor landings of orange roughy and black scabbard (less than 1t) by a single Irish registered vessel in 1997.

6.1.7 Norway

Longline fisheries

The most important deep-water fishery in Norway is the longline fishery for ling (*Molva molva*) and tusk (*Brosme brosme*). In 1996, 57 fishing vessels longer than 70 feet were engaged in these fisheries which are mainly conducted in ICES Divisions and Sub-areas IIa, IVa, V, VI, VII, and XIV. Some data on the fisheries in the period 1974–1996, i.e., number of vessels, weeks at sea, distribution of effort by species and Norwegian Directorate of Fisheries statistical areas, are given in Table 6.5. The number of vessels declined until 1994, but the number increased again in the most recent years. Due to technological advances, effort in terms of number of hooks increased throughout the series despite the decline in number of vessels and number of weeks engaged in the fishery (see Hareide and Godø 1996; Bergstad and Hareide 1997; Magnússon *et al.* 1997).

At the important western fishing grounds (Shetland, Faroes, Hebrides, Rockall) catch per unit of effort of ling and tusk based on data from both official statistics and data from skipper's logbooks showed a rather clear downward trend since the early 1970s (Hareide and Godø, 1996). Since 1974–1975 the catch per thousand hooks has been reduced from 150–200 kg to around 50 kg in 1994. In 1996, the CPUE at the western grounds was estimated to be 43 kg/1000 hooks. The same trend is seen when an area-specific analysis is run but the variation is rather high (Bergstad and Hareide 1997; Magnússon *et al.* 1997). A problem in the CPUE analyses is splitting the catches by species. Given that tusk is normally a secondary species in the Norwegian fishery, the trends in the above analyses probably primarily reflect development in CPUE of ling.

Especially in the last two decades, there has been a rather clear inverse relationship between the effort devoted to ling and tusk, and the size of the cod and haddock quotas available to the longline fleet. This is also reflected in the catch statistics. Overall, there has been a transfer of effort from ling and tusk to cod and haddock in later years (Table 6.5), caused by diminishing returns from the former species and increasing quotas in the cod-haddock fishery in Division IIa.

In recent years a longline fishery developed off southeastern Greenland at depths down to 1500 m. The target species is Greenland halibut (*Reinhardtius hippoglossoides*), but probably as much as 30 % of the by-catch is roughhead grenadier (*Macrourus berglax*). The area of this fishery has recently expanded to eastern and western slopes of the Reykjanes Ridge south of Iceland.

In 1996, a dropline (and gillnet) fishery targeting “giant redfish” (*Sebastes marinus*) developed at the Reykjanes Ridge (Sub-areas XII and Division XIVb). Details on this new fishery were given in a Working Document to the Study Group by Hareide. In 1996, approximately 10 vessels were engaged in the fishery for a few weeks. Tusk (*Brosme brosme*) and Atlantic halibut (*Hippoglossus hippoglossus*) were significant landed by-catches. By-catches of the deep-water shark *Centroscyllium fabrici* and some other species were discarded. In 1997, the number of vessels participating dropped to 5 and the effort probably declined as much as 50 %.

Trawl fisheries

The relevant trawl fisheries were described in previous reports (ICES C.M. 1994/Assess:4; ICES C.M. 1996/ Assess:8). There have been no major changes in the recent years. In 1997, a single trawler fished for 2-3 weeks along the Mid-Atlantic Ridge north and south of the Azores (partly Sub-area X) catching mostly *Beryx splendens.* This trip should probably be considered exploratory and landings were at most limited to a few hundred t.

Argentina silus has been targeted in trawl fisheries off mid-Norway (Division IIa) and the Skagerrak (IIIa) since the late 1970s. These fisheries have continued as described in ICES C.M. 1996/ Assess:8, but the effort directed at *A. silus* varies strongly with market demand. In Division IIa landings declined from top levels at 10,000 –11,000 t in the mid 1980s, to about half that level or less in recent years (Table 10.1). This probably reflects a change of target species rather than a reduction in abundance of *Argentina*. The fishery in the Skagerrak is conducted by 1–3 trawlers and landings have dropped from 1,000–2,000 t/year to 100–200 t in 1994–1997. A slight increase was observed in 1997 reflecting increased market demand (Table 10.1).

No landings of by-catches of *Argentina silus* in the pelagic trawl fishery for blue whiting to the west of Scotland and Ireland (Sub-areas VI and VII) were recorded in recent years.

Argentina silus is also a by-catch in industrial trawl fisheries in the North Sea (IVa) and in the *Pandalus borealis* fishery in the Skagerrak (IIIa). By-catches in the industrial fisheries are regularly estimated based on sampling at the fish-meal plants. The by-catches were 200 t or less in the years 1992–1994 and insignificant in the recent years. There are no satisfactory estimates of the by-catch in the shrimp fisheries.

The roundnosed grenadier *Coryphaenoides rupestris* is caught in minor directed fjord fisheries with bottom trawls in mid-Norway (IIa). The fleet consists of 3–5 vessels. The species is also a by-catch in the shrimp and *Argentina silus* fisheries in the Skagerrak, but the bycatches which are not landed for human consumption have not been quantified. Interview-based estimates suggest a total catch of around 1000 t/year. In 1997, the recorded landings were 124 t.

6.1.8 Portugal

Detailed descriptions of the three main deep-water fisheries of mainland Portugal have been contributed to the EC FAIR Deep-fisheries project. These fisheries are also described in a Working Document provided to the Study Group by Moura *et al.* The three fisheries are the deep-water crustacean trawl fishery, the longline fishery for black scabbardfish and a longline fishery for deep-water sharks.

The crustacean trawl fishery targets rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) off the south and southwest coasts of Portugal. The fleet is made up of about 35 open decked trawlers (17-35 m) most of which are about 20 years old. There are also two trawlers registered to fish on the west coast from the port of Cascai. The fishing grounds exploited range from 200 to 700 m depth but taking the fleet as a whole deep-water fishing has not been a major part of the effort in recent years. Some 17 species of fish are caught as a bycatch and some such as European conger (*Conger conger*) Greater forkbeard (*Phycis blennoides*), blackmouth catshark (*Galeus melastomus*) and blackbelly rosefish (*Helicolenus dactylopterus*) are landed for human consumption.

The longline fishery for black scabbardfish began in 1983 and is based on the port of Sesimbra. In 1996 the fleet was made up of 22 vessels of which 15 are engaged all the year round. The fleet consists of wooden open decked vessels with lengths from about 8 to 22m which set their lines at depths between 800 to 1200 m. The bycatch consists of about six species of deep-water sharks which can generate extra income for the fishery. The fishery takes place on hard ground along canyon slopes.

The longline fishery for deep-water sharks targets mainly one species, the gulper shark (*Centrophorus granulosus*). It is based on the northern port of Viano do Castelo and was carried out by a fleet of six open decked vessels with a mean length of 18.6 m. in 1992. In 1997 there has been only one longliner engaged full time in this fishery. The lines are fished at depths of 800 to 1400 m and are fished closer to the bottom than those used for black scabbardfish.

6.1.9 Russia

Mid-Atlantic Ridge

In 1996 one mid-class trawler (length 62 m) carried out a fishery for roundnose grenadier on the Mid-Atlantic Ridge between 48 and 49^{o} N for 9 days in November (Table 6.6). In 1997 this vessel continued the fishery of roundnose grenadier in March-April in the same area. At the end of April a large-class trawler (length 120 m) began fishing for

roundnose grenadier. In May the vessels worked on the seamounts along Mid-Atlantic Ridge between 49-57^{o} N, but the fishing situation deteriorated and the trawlers left the area. At the end of August and in September one large-class trawler (length 82 m) operated on the Mid-Atlantic Ridge between 49-59^{o} N. There were no good concentrations of roundnose grenadier on the sea-mounts in that season.(Table 6.6).

In the first half of 1997 one mid-class trawler (length 62 m) carried out fishery for Golden Eye Perch in the North Azores area between 43 and 45^{o} N. Although exact data are not available, it was estimated that the catches were of the order of 600 t. The Fish concentrations were unstable, and therefore the vessel left the area in the mid summer.

Barents sea

In 1996/1997 one Russian commercial longliner targeting blue catfish (*Anarichas denticulatus*) and cod began to use bycatch of roughhead grenadier for processing fish fingers ashore (for further information see Section 17.1.11).

6.1.10 Spain

Most Spanish landings of deep water fishes from the Northeast Atlantic must be considered as by-catches of other directed demersal fisheries, especially those for hake, megrim, anglerfish and *Nephrops*. They originate from very different sea areas (Sub-Areas VI–VII, Divisions VIIIa,b,d (Bay of Biscay), VIIIc (Cantabrian Sea), northern Division IXa (Galicia) and southern Division IXa (South Atlantic region of Spain, i.e., Gulf of Cadiz), and different gears (trawl, longlines and gillnets). During the 1990s new directed deep water fisheries have been established, often in a rather experimental way and/or restricted to a part of the year, when licences or yields of traditional target species are depleting. The lifespan of these new fisheries has been very variable, some of them being very short-lived. In addition, there are traditional artisanal fisheries with a relatively high importance along the Cantabrian Sea coast and in the South Atlantic region. These are usually focused on particular targets, some of them deep water species. In 1996–1997 a very new and important trawl fishery has developed, mainly in Sub-area XII, aimed specifically at a suite of deep water species. Due to the individual peculiarities of all these fisheries and to the rather small importance of some of the deep water species in comparison to the traditional targets, the information is available only for some fleets and species.

Since the description of the Spanish fleet given in 1996 (ICES C.M. 1996/Assess:8), there have been a number of changes (Casas, WD; Lucio and Artetxe, WD). These changes can be summarised as follows:

1. An important part of the longline fleet that since 1991 had been devoted to deep sea species, mainly to deep-water sharks, left this fishery in 1995–1996. These were mostly Galician ships in the Sub-areas VI and VII and Basque ships in Divisions VIIIa,b,d. This change was probably due to the fall of the price of shark livers (used for oil). Some of the longliners have returned to the traditional fishery of hake, and others, maybe the oldest ones, have been scrapped. Also the Basque longliners that fished for *Mora moro* in Divisions VIIIa,b,d during the second part of 1995 and the first part of 1996, are no longer interested in this fishery because of the relative low yields obtained. Another Basque ship (an old longliner) began to fish with big traps in the same sea area in 1996 but has ended this métier in 1997 for the same reasons. The small fishery focused on deep-water red crabs *(Geryon (Chaceon) affinis)*, which developed at the end of the 1980s on the "Banco de Galicia" (Division IXb) and later in some restricted areas of western Division VIIIc, has been completely abandoned in 1997.

2. In contrast, other new experimental fisheries have started in 1996 and 1997 and most of them continue at the present. Some Galician trawlers have begun to fish in deep waters on the continental slope of the NW of Spain (western Division VIIIc and northern IXa) in 1997, but their hauls in deeper waters are mixed with traditional hauls on the continental shelf. Another new fishery by longliners in the Bay of Biscay (Divisions VIIIa,b,d) started in 1996, focusing on different deep water species, and this is still in operation. A small Basque fishery with bottom gillnets also started in 1997 in the same Divisions; some of the catches are deep sea species.

3. Finally, five Galician trawlers with conventional deep-water trawl gears started a new multispecies fishery in the north-east corner of Sub-area XII (Hatton Bank), in the second half of 1996. Another Galician trawl ship, in the past devoted to traditional demersal species, began to fish for deep water species in Sub-areas VI and VII, in the second part of 1997.

Deep-water fisheries not directed (by-catches)

In Sub-areas VI–VII-VIII and northern Division IXa, Spanish trawlers and longliners fish deep-water species in a variety of locations (west of Scotland, Rockall Bank, Celtic Sea, Porcupine Bank, Bay of Biscay, Cantabrian Sea and NW of Spain), when they are fishing mainly for hake, megrim, anglerfish and *Nephrops*. A variable proportion of these

deep-water catches is discarded or landed as by-catch, depending on the price prevailing in the market, the facilities for processing them on board and the duration of the trips. In some ports, landings of similar species are usually sold together, depending on the local appreciation of the fish in the market. The by-catch species traditionally more appreciated in the fish market are: *Phycis spp, Molva molva* and *M. dypterygia* and *Pagellus bogaraveo*. Reliable data on these landings are usually obtained and reported.

It is to be noted that no Spanish gillnetters work in Sub-areas VI-VII. By error, some gillnet landings from these Sub-areas appeared in the Study Group Report prepared by correspondence (ICES C.M. 1997/Assess:17; Casas, WD).

No new information on discards of the deep-water species by the Spanish commercial fleets has been published since 1996. Then, according to the data obtained in 1994 under the EC Project "Spanish Discards of the Spanish Fleet in ICES Divisions" (Study Contract DGXIV Ref. n. PEM/93/005), it appeared that the main species discarded in Sub-areas VI and VII were deep-water species (*Argentina silus, Molva dypterygia, Chimaera monstrosa, Phycis blennoides,...*) and blue whiting.

Directed fisheries on deep-water species

In Division VIIIc (Cantabrian Sea), there is a deep-water longline fishery. The target species is *Phycis blennoides.* This fishery is seasonal (in winter and spring). Other longliners distributed along the Cantabrian focus their seasonal activity on other deep-water species, mainly *Beryx spp., Conger conger* and *Polyprion americanus.* Occasional catches of *Pagellus bogaraveo* are also obtained.

In the southern Division IXa, another traditional deep-sea fishery, until now not reported to the Study Group, is established in the south of Spain (Gulf of Cadiz) and it is focused on red seabream (*Pagellus bogaraveo*). It is named "Voracera" because of the local name of *P. bogaraveo* ("Voraz") and is based only on artisanal longliners from the ports of Tarifa (98 vessels) and Algeciras (15 vessels). The number of ships devoted to this fishery has increased in recent years. The fishery operates in Spanish waters in the southern part of Division IXa throughout the year. This fishery is quite important because of the amount of the catches and the high market price of red seabream (Casas, WD).

More recently (September 1997), in Sub-areas VI and VII, one trawler began to fish in deep-waters on the continental slope down to about 1000 m. This vessel alternates between fishing over deep-waters and hunting for traditional demersal species. The target deep-water species are mainly *Trachyscorpia cristulata* (Scorpenidae*), Phycis blennoides* and *Hoplosthetus atlanticus*. Among the main discarded species there are *Alepocephalus spp* and *Deania calceus*.

In Divisions VIIIa,b,d (Bay of Biscay), a recent directed deep water fishery also began in 1996 and it continues to the present. The technical characteristics of the fleet are very diverse (boat length: 9-32 m; engine power: 70- 900 HP; GRT: 14-264), according to the distance from the ports to the fishing area.

In northern Division IXa, three rather small trawlers (<500 HP) began to fish on the continental slope of Galicia in 1997 but in a scattered way. Deep hauls are usually carried out when traditional demersal fishery catches start to fall.

In the north-east corner of Sub-area XII (Hatton Bank), five Galician trawlers started a new deep-fishery with conventional deep-water trawl gears, in the second half of 1996. This is a multispecies fishery.

A few longliners remain at the present involved in the deep-water shark fishery in Divisions IXa, VIIIc and VIIIa,b,d. They fish seasonally (from October to March approximately). Only one ship, based in Fisterra (Galicia), fish all along the year. The discards of this shark fishery are generally very small (mainly rays and grenadiers). The by-catches are also small and consist of greater forkbeard (*Phycis blennoides*), blue ling (*Molva molva*) and black scabbard fish (*Aphanopus carbo*).

6.1.11 United Kingdom

England and Wales

The only substantial changes in the landings of deep-water species since the 1996 report relate to deep-water red crab (*Chaceon affinis*) and greater forkbeard. *(Phycis blennoides*). The landings of red crab increased and a high proportion of the catch is targeted by netters in ICES Division VIb. The fishery is still evolving and comprises 10 to 20 vessels landing to Spanish ports, especially Corruna. The main fishery is located to the NW and SW of Rockall Bank, in VIb, and the majority of catches are taken between autumn and spring. In summer months there is some evidence of switching to alternative target species, principally deep-water sharks and anglerfish (*Lophius* sp.). Recently there has been signs of a red crab fishery developing along the shelf-edge between Great Sole and Chapelle Banks.

Landings of greater forkbeard increased in 1996, 74 % of which was taken in VIIj and k, mainly by bottom trawlers landing to Spain

Landings of sharks, livers and oil have remained relatively unchanged. A small directed fishery has developed in VIa,b and VIIj,k in recent years, comprising long-liners and gill-netters the majority of which land to Spain. Landings in England and Wales are confined mainly to Newlyn, as a by-catch from gill and drift netters, and to Milford Haven by long-liners and gill-netters.

Scotland

The international deep-water demersal trawling activity to the west of Scotland can be considered as targeting three different types of fishery; a shelf fishery, and edge fishery and a truly deep-water fishery

Scottish vessels are involved in all three fisheries.

a) Shelf fishery. This is the traditional fishery which is mainly carried out at depths of less than 200 metres and where the dominant species are cod, haddock, whiting, plaice etc.
b) Edge fishery. Since the mid 1980s Scottish fishermen have realised that certain high value species, in particular *Lophius piscatorius*, extend into deeper waters and many boats have adapted their gear so that they can fish along the edge of the continental shelf down to a depth of 300+ m.
c) Deep fishery. A clear and concise definition of the deep water fishery is not available but it is becoming generally accepted that this fishery begins at about 400 ms and extends to perhaps 1800 metres off the west coast of Scotland. It is this fishery that yields the new (to UK fishermen) commercial species such as *Coryphaenoides rupestris* and *Aphanopus carbo*.

The main fleets involved in the deep-water fishery, which takes place mainly in the Rockall Trough, are French and Scottish. Both nations are engaged in the edge fishery and catch gadoids and high value species e.g., anglers (*Lophius piscatorius*). In the deep-water fishery the smaller Scottish vessels are restricted to depths shallower than about 800 m However, the French fleet have the capability to fish in deeper water to at least to 1400 m. The Scottish vessels are much more variable in their targeting of the deep-water fishery depending on the economics, quotas for traditional fish species and weather conditions.

The other deep-water fishery in which Scottish vessels are engaged is bottom trawling in the area of the Wyville Thomson Ridge and the Faroe-Shetland Channel (west of Shetland). The edge fishery in this area is similar to the west of Scotland with high value anglerfish being an important catch. At depths below about 500 m the water temperature decreases rapidly and in the transition area a fishery for Greenland halibut (*Reinhardtius hippoglossoides*) has developed.

6.2 International waters

The terms of reference of previous Study Groups have included a request from NEAFC for information on the proportion of the catch which is taken inside and beyond coastal state jurisdiction. Such data was never available to the group. Although no formal request had been received from NEAFC at the time of the Study Group meeting it was decided to address this question.

The Group tried to identify areas of the ICES area lying within international waters in which deep-water fishing was known to be taking place. These were some areas around Rockall Bank, Hatton Bank and smaller banks lying to the west of it, the Mid-Atlantic Ridge north of the Azores EEZ and parts of the Reyjanes Ridge south of the Icelandic EEZ.

The Study Group was aware of anecdotal evidence of landings from International waters which are not reported to ICES (see also recommendation 4)

The Study Group expressed some concern about deep water catches in international waters. A clear definition of these areas in the ICES area was not available to the Study Group. There was a also perceived to be a problem in the recording of catches and discards being made in international waters and the landings from these fishing grounds.

The ICES area covers most of these international waters under its Sub-areas X, XII and XIVb (part), however, species specific reports of deep-water fishes are scarce in ICES statistics in relation to the “international” component of the catch. It can be assumed, that at least a fair number of the relevant deep-water species (e.g., Alfonsinos, Black Scabbardfish, Orange Roughy, various squalid sharks) are highly migratory in the meso- and benthopelagic realms of

the northeastern Atlantic. They may spend only part of their life cycle along the continental slopes of western Europe. The fact that either juveniles or only mature specimens of certain species are found at the continental margin and on offshore banks or *vice versa* may be indicative of such migrations. On the assumption that at least some of the deep-water species may form a stock in the NE Atlantic, reliable information on additional fishing mortality, e.g., on the Mid Atlantic Ridge could be very important especially if these are important spawning areas. The more the commercial fisheries become regulated in areas under national and/or EC jurisdiction, the greater will be the tendency for exploration and unregulated exploitation of international waters. Increased exploitation in these areas could have an effect on the stocks of these species in waters under national jurisdiction.

6.3 Stock identity

The Study Group was not aware of any current results on stock identity of deep-water species. Two recently funded projects by DGXIV in support of the Common Fisheries Policy which involve stock discrimination were noted. One involves both DNA and otolith microchemistry of the black scabbardfish in the eastern Atlantic and the other is a study of seasonal aspects of deep-water demersal fish at the Azores which includes work on stock discrimination. (see Section 2.3)

Since the information on stock identity is very scarce and data are very limited for some areas many of the assessments have, as an initial measure, been carried out by ICES Division (e.g., Blue ling, Section 8). Nevertheless, in some instances it is still possible to make some general inferences assuming a wider distribution.

6.4 Discards

Data on the discarding from trawl and longline operations in Sub-area VI is given in Connolly and Kelly (1996). These data relate to catches taken from surveys on chartered commercial trawling and longlining and discarding was reported as kg of species discarded per tonne of roundnose grenadier landed (where grenadier was the target species). A general summary of this work showed that many more species were discarded from trawling operations than longline sets, and that based on size, there was a greater quantity of commercial species discarded form trawling operations. New data based on a trawl survey using repeat tows with and without a small mesh liner is given in (Clarke *et al.* In press), shows that in the case of roundnose grenadier individuals as small as 3cm (PAFL) are caught by a commercial 100mm (mesh) trawl and that a greater quantity of small fish (smaller than 8cm PAFL) are retained when a small mesh cod end liner (10mm mesh) is used. As many deep water fish have large rough scales and no mucus coating there is concern that there may be a very low survival rate amongst trawl escapees (non catch discards).

Quarterly discard rates from the French deep water trawl fleet (FAIR 1998) and Scottish trawl fleet are given in Table 6.7. These data are expressed as percentage of the landings which are discarded. A discard rate of 100 % represents a species which is not landed and is thus entirely discarded from the catch.

The main target species from the French trawl fleet is roundnose grenadier and the final column in Table 6.7 shows the weight of fish discarded per tonne of roundnose grenadier landed. There are some 60 species discarded from the French trawl fleet however only about 10 of these are caught and discarded on a regular basis. From the trips sampled in the dataset the depth range of fishing was 875m to 1300m. In general the French trawl fleet in Sub-area VI and VII discards approximately one tonne of fish per tonne of deep water species landed, and the main species discarded are *Alepocephalus bairdii*, *Coryphaenoides rupestris*, *Deania calceus*, *Lepidion eques* and *Trachyrhyncus murrayi*.

It would be useful to express discarding from the Scottish trawl fleet data as kg discarded per tonne of target species landed but this is not possible as the fleet fishes at various depths from the shelf to approximately 800m, for different targets. The wide variety of depths fished by the Scottish fleet is reflected in the number of species in the discard dataset. Total discarding from the Scottish fleet is less than 500kg per tonne of landings and the main deep water species discarded (from the dataset provided) appear to be *Argentina silus*, *Lepidion eques*, *Mircomesistius poutassou*, *Phycis blennoides* and *Helicolenus dactylopterus*. There are also several shallow water species discarded in similar or greater quantities when fishing above 500m.

These data highlight the mutispecies nature of the impact of deep water trawling, and the study group agreed that it would be important that such data should continue to be collected for the future.

6.5 Bycatch

It will be apparent from Section 2.4 and the discard Table in Section 6.4 that many of the deep-water fish species are the bycatch of other fisheries.

7 LING (MOLVA MOLVA)

7.1 Catch Trends

Landings by Division are given in Table 7.1. The major fishery in Division IIa is the Norwegian longline fishery (See Section 3), but there are also by-catches by other gears, i.e., trawls and gill-net. The preliminary total landings of 6,083 and 5,358 t in 1996 and 1997 respectively are lower than the average landings in the period 1988–1995. In Division IVa the total landings increased somewhat in recent years, primarily due to an increase in the landings of the United Kingdom. The UK landings declined in 1996, and in 1997 the Norwegian landings decreased substantially compared with recent years. In Divisions Va the catches have decreased from 5,600-5,800 t in the late 1980s to about 4,000 t in recent years. Landings in Division Vb1 varied without trend, whereas there has been a declining trend in Vb2. In Division VIa the statistics are incomplete for the period 1989–1993 (and 1997), and no conclusions on trends can be drawn other than that the United Kingdom landings increased in recent years. In Division VIb landings declined in the period 1994-96, primarily due to reduced Norwegian contributions. In Sub-area there appears to have been an increasing trend in the 1990s and landings in 1995 and 1996 were above 10,000 t. Also in this area there has been a gradual increase in the United Kingdom landings.

7.2 Stocks

Relevant historical and new information has recently been presented and 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.

7.3 Catch-effort data

Updated commercial catch and effort data by gear were available from the Faroes and Iceland (Sub-area V).(Tables 7.2 and 7.3). The extensive Norwegian longliner CPUE data based on skipper's logbooks presented in the 1996 report were unfortunately not updated after 1994. In 1996 new CPUE data were available from the French trawl fishery, and these were updated (Table 7.4). New CPUE data from Spain from the years 1994–1997 were also made available to the Study Group (Table 7.5, see also Working Document by Lucio and Artexte, 1998).

7.4 Length Distribution, Age Composition, Mean Weight and Maturity at Age

The quality and quantity of data improved significantly after 1993 due to an increased sampling effort in Iceland, the Faroes and Norway. The sampling has become routine in the Faroes and Iceland, but not in Norway. Data available from different countries and Divisions were indicated but not quantified in Tables 6.3.1–6.3.6 of ICES C.M. 1996/Assess:8. Extensive Icelandic otolith collections from Va are being processed. Table 7.6 lists the data available for Vb from the Faroes. Overviews of Norwegian samples from 1995 and earlier were given by Bergstad and Hareide (1996). Very little data were collected by Norway after 1995. In 1997, only a single sample from IVa (Shetland) was available.

Length and age compositions of the international landings from Division Vb from 1996 and 1997 are given in Figure 7.1 and Table 7.7. The distributions were adjusted to total catch using Faroese age-length keys. From Va, a series of age-distributions and associated catch-curves based on Icelandic data are given in Figure 7.2.

7.5 Biological parameters

Considerable information on biological parameters from many parts of the distribution area were presented in two recent project reports, i.e., Bergstad and Hareide (1996) and Magnússon *et al.* (1997). In the Nordic project (Magnússon *et al.* 1997) considerable effort was devoted to intercalibrate age readings. A manual for reading ling (and tusk) otoliths was recently presented (Bergstad and Hareide 1997). There is now a higher degree of confidence in the precision of age distributions and age-related population parameters being presented.

Scotland provided new length-weight relationships for gutted and ungutted ling based on data from a number of sources and years:

Gutted weight=.005201 * total length (cm)$^{2.99572,}$ n=number of fish measured and weighed= 444
Total weight=.004312*total length$^{3.05991}$, n=254
Total weight= Gutted weight* 1.1323, n=205

Iceland provided length-weight relationships from 1996 and 1997 from Division Va:

Total weight(g) =.0062*total length(cm)$^{2.9968,}$ n= 852
Total weight=.0091*total length $^{2.9084}$, n=897

7.6 Assessment: CPUE analyses and mortality estimates

Catch per unit of effort analyses of the Norwegian longliners operating in most of the Divisions under consideration indicated an overall downward trend since the early 1970s, and the same trend was indicated in an area-specific analysis (Figure 7.3; Hareide and Godø, 1996; Bergstad and Hareide 1996; Magnússon *et al.* 1997). These observations suggest that a reduction in abundance has occurred in several Divisions. The development in the period after 1994 is not clear due to the interruption of the Norwegian series. However, the 1996 combined longliner CPUE (based on official logbooks only) of ling and tusk at "western grounds" (Shetland, Rockall, Faroes, Hebrides) is 43 kg/1000 hooks, i.e., the same as or slightly lower than in 1994. Since the target species is ling in these fisheries, this estimate is primarily reflecting the availability of ling.

For the period 1986-96 catch, effort and CPUE from Faroese longliners fishing in Vb are available (Table 7.2 and Figure 7.4) The majority of the catch is taken by longliners, especially vessels greater than 100 GRT. The effort data were not adjusted for the likely increased efficiency following the introduction of swivel lines in the last 4-5 years. Taking this into account, there has most probably been a declining trend in the CPUE since 1994 as seen for the Norwegian longliners fishing in Division Vb.

CPUE data from French trawlers from Divisions VI for the period 1983 to 1994 showed a general decline, although with slight increase in 1993 (Figure 7.5). The CPUE has since remained at a low level (Table 7.4). In Divisions Vb there has been a decline since 1987. In Sub-area VII the CPUE is generally lower than in other areas and there is no clear trend. Spanish CPUE data from trawlers and longliners were available for the period 1994–1997. The number of longline vessels included in the analysis is very low and the trawler data, primarily from vessels targeting hake, should be considered more reliable. There was a consistent decline in the trawler CPUE of ling in Sub-area VI in the period with available data (Figure 7.6).

For Division Va, a time series of catch, effort and CPUE data from 1988 onwards was updated. The CPUE data are shown in Figure 7.7. There is no apparent trend for any of the gears. The catches in Division Va are bycatches in longline, gillnet and bottom trawl fisheries for other groundfish.

In 1994, the Northern Shelf Working Group undertook a production model analysis based on available CPUE data, but with limited success. Since the database had not changed significantly since then, the Study Group did not pursue this option except for Division Va. For the ling in Va, an attempt was made to fit a Schaefer production model using CPUE indices from the Icelandic fishery (Table 7.3). A DeLury model could not be tried because data were in weights rather than numbers and mean weight data, for conversion purposes, was not available. The data for trawlers is of limited duration so analyses were confined to gill net and long-line CPUE. The results (not presented but included in ICES files) were found to be unstable using gill net CPUE - estimates of carrying capacity, and catchability depended heavily on the assumptions made for the proportionality between starting stock and virgin biomass. Results using longline CPUE were somewhat more reliable although far from robust over a range of initial proportions and time lag values. Excluding outliers, these results suggested a MSY within the range of 5 to 10 kt. If this is the case this would indicate that the

international catch has been at or below MSY levels since the early 1970s. However, these results should be treated with extreme caution, not only because of concerns regarding the model, but also because it is suspected that there has been considerable improvements in fishing power in the Icelandic long-line fleet which have not been taken into account when preparing the CPUE index.

In 1996, estimates of total mortality, Z, were obtained for different Divisions by catch-curve analyses based on new age-distributions from Norwegian longliners in Divisions IIa, IVa and Vb (ICES C.M. 1996/Assess:8). The estimates were in the range 0.4–1.0, with a mean value of 0.6 (S.D.=0.2, n=9). These mortality estimates are also presented and discussed in Bergstad and Hareide (1996) and Magnússon *et al.* (1997). Emigration and variability in recruitment may affect these estimates, and they were considered preliminary. There are no Norwegian age distributions available for estimation of Z after 1995. New estimates of Z from catch curves based on Faroese samples from Vb in 1996 and 1997 were 0.7 and 0.8, respectively (Figure 7.8), i.e., as high or higher than previous estimates.

Most of the material on which the estimates of Z were based came from the period 1993–1995, and the range of years was too limited to estimate Z within rather across cohorts.

7.7 Comments on Assessment

It is still not possible to make analytical assessments for the ling stocks due to lack of good time series of data. The situation is likely to improve somewhat in the coming years, at least in Sub-area V. The cessation of the Norwegian sampling after 1995, constitutes a significant weakening of the basis of future analytical assessments in many important fishing areas. The Study Group is of the opinion that further improvement in the recording of effort and catch data from all fleets and areas should be encouraged, since CPUE analyses are used as an index of abundance and as basis of production analyses.

7.8 Management considerations

The Norwegian CPUE analyses presented to the Study Group in 1996 (Hareide and Godø, 1996) and discussed also by Bergstad and Hareide (1996) and Magnússon *et al.* (1997), support the conclusion drawn by the Northern Shelf Working Group in 1994 that there has been a downward trend in the stocks of ling, perhaps with the exception of the Iceland stock (Va). The Norwegian analyses of ling and tusk combined for 1996, suggest that the downward trend has continued. The same declining trends are seen in the updated Faroese and French CPUE data, and also in the new Spanish data from trawlers in Sub-area VI.

Both the steadily declining CPUE in all areas except Va and the high mortality estimates strongly suggest that the availability/abundance of ling has continued to decrease and that exploitation rate remains high. Under the assumption that the long-term CPUE from Norwegian longliners represents a valid reflection of biomass in the exploited areas, it is possible to compare present levels with the level in the early 1970s when the effort and exploitation was much lower (e.g., Table 6.5). The 1994–1996 estimate of ling+tusk at "western grounds" is about 50 kg/thousand hooks. The corresponding value for 1972–1974 is about 200 and 275 kg/1000 hooks from official and private logbooks, respectively. If this reflects a corresponding change in biomass, the present biomass level is only about 18-25 % of the level in the early 1970s when the major expansion of the fishery in western areas began. This may mean that the biomass in the most heavily exploited areas has declined below B_{pa} and may even be near or at B_{lim}.

8 BLUE LING (MOLVA DYPTERYGIA)

8.1 Catch trends

Landings of blue ling are given in Table 8.1.

Landings from Sub-area IIa are mainly catches in a gillnet fishery off mid-Norway. The landings declined from 3,500 t in 1988 to 1,000 t in 1993 have since declined to a very low level of 3-400 t in recent years.

The relatively minor landings from Sub-areas III and IV are bycatches in trawl fisheries.

In Division Va, blue ling has been taken mainly as a bycatch by trawlers engaged in the redfish and Greenland halibut fishery in recent years. Iceland takes most of the catches. During the years 1980–1984, a directed fishery for blue ling was carried out in a very limited area on spawning aggregations. No aggregation of spawning blue ling has been

detected in this area since then and consequently the catches have declined from about 8,500 t in 1980 to a level of 2,000–3,000 t since 1985. In the most recent years the catches have declined further to 1,000–1,500 t and must now exclusively be regarded as bycatches in other fisheries.

In Division Vb total catches fluctuated between 5,000 and 10,000 t during the 1980s, but have since then declined almost continuously to about 1,500 t in the two most recent years. Most of the catches are taken in the spawning time by trawlers; at other times the effort moves to other areas/species in order to maintain catch rates. In recent years most of the catches have been taken by Faroese vessels.

In Sub-area VI total catches peaked at about 13,000 t in 1985, but have since then declined to 3,000-5,000 t in the 1990s. French trawlers take more than 95 % of the total catch.

The landings from Sub-areas VII and X are very small as the blue ling is taken as bycatch in other fisheries only.

The landings from Sub-area XII peaked in 1993 at more than 3,300 t but have since declined to about 900 t in 1995 and 1996. Faroese and French trawlers take most of the catch. There are reasons to believe that the reportings of landings to Sub-areas VI and XII are not consistent from year to year.

In 1993 the Icelandic fleet fished on aggregations of spawning blue ling in a small area on the Reykjanes ridge at the border between Sub-areas Va and XIV. This resulted in landings by Iceland of more than 3,000 t from Sub-area XIV. The French fleet fished in this area prior to the Icelandic fleet but information on landings are lacking.

8.2 Stocks

Biological investigations in the early 1980s suggested that at least two adult stocks were found within the area, one in Sub-area XIV and Division Va with a small component in Vb, and another 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. For practical purposes the blue ling in Divisions Va and Vb and Sub-area VI, respectively, were treated as three separate units.

8.3 Catch-Effort Data

The time series of catch, effort and CPUE for different countries and Sub-areas were updated (Tables 8.2–8.4). Catch and effort data for the French trawl fishery in Sub-areas Vb, VI and VII, as presented in the 1996 report of this study group (ICES C.M. 1996/Assess:8) were only updated for Division Vb as reliable effort data were not available at the meeting. However, a multiplicative model was applied to a selection of French trawlers for the years 1992–1996 and the results were used together with the former information (Table 8.4).

CPUE series from three different Icelandic fleets show conflicting trends (Figure 8.1). The trawler fleet show a considerable increase in CPUE in 1993 associated with the fishery on a spawning aggregation. However, CPUE decreased again in 1994 to the 1992 level and has since declined further to very low levels in 1996 and 1997. This recent development seems to apply to the gillnets as well although this series is too short to base any firm conclusions on it. The longliner CPUE series shows, however, opposite trends to the CPUE of the trawler fleets which tentatively can be explained by the bycatch nature of the blue ling catches.

Catch, effort and CPUE values in March-May 1985–1996, i.e., the main fishing season for blue ling in Vb, were presented for the Faroese trawler fleet larger than 1,000HP (Figure 8.2). The CPUE declined from 1986 to a very low level 1991 and have since fluctuated at this low level. The same overall pattern is seen in the CPUE of the French trawler fleet fishing in Vb (Figure 8.3).

In Sub-area VI there was a consistent decline in both the catch and CPUE of the French trawlers in the period 1985–1990, and the decline has continued since although on a smaller scale (Figure 8.4).

8.4 Length Distribution, Age Composition, Mean Weight at Age, Maturity at age, Natural mortality

In the 1996 report of this study group (ICES C.M. 1996/Assess:8) all available data from different countries and Divisions were indicated but not quantified. Table 8.5 lists the sampling level of the Faroese catches in Division Vb.

Data on Age Composition, Mean Weight at Age and Maturity at age were available for many Sub-areas but are not presented in the report due to the difficulties in ageing of this species as stated in last years report. The Nordic project (see Section 2.3.2) did make some progress concerning age reading of the youngest fish (i.e., up to 3-5 years).

Data on length distributions in the catches in recent years were available for Divisions Va and Vb and for Sub-area XII as well as for the combined French trawler catches in Division Vb and Sub-area VI (Figures 8.5-8.8). Some differences are noted for the different areas and between years within an area.

No information was available on natural mortality.

8.5 Assessment

A modified DeLury constant recruitment model and a Schaefer production model were attempted using total international catch data for Vb, 1963-96, and Faroese CPUE data for long liners for March to May 1986 onwards. This is a spring spawning fishery and whilst it was recognised that spawning aggregation may mask any decline in CPUE, given the lack of assessments for blue ling it was considered worthwhile to proceed. For DeLury, annual catch numbers were available from 1980 onwards, but for earlier years catch numbers were derived by dividing annual catch by an average mean weight for the five year period 1980-84.

The results from DeLury (not presented but included in ICES folders) were very unreliable, reflecting a poor fit by the model for a range of assumptions of initial proportion of stock to virgin biomass and error models.

The results from Schaefer for a range of initial proportions and time lags were investigated using sensitivity analysis. A log normal error structure was assumed throughout. Table 8.6 shows the effect of varying the initial proportion of stock to virgin biomass for a constant time lag of 0 years. With the exception of extreme values of proportions the results for carrying capacity (K), catchability (q), MSY and final biomass are reasonably consistent. The residuals were fairly well behaved, relected a reasonable model fit (R^2=0.7), although a pattern was evident in residual catches (Figures 8.9, 8.10). This pattern was present for a range of error structures and parameter assumptions. Given the consistency of the results, and an *a priori* knowledge of the fishery, a range of time lags was then evaluated assuming an initial proportion of 0.9 (Table 8.7).

These results are reasonably consistent, with a range of MSY and final biomass of between 3.2 and 5.8 and 4.2 to 6.4 kt, respectively. Blue ling in Vb recruit at around age 6-7, although concern was expressed at accepting a time-lag of this magnitude given that growth is a significant component of biomass production. With this in mind, MSY may be considered to be in the range of 3.4 and 4.5 kt, commensurate to time-lags of between 7 and 1 years respectively. Likewise, final biomass in 1996 is probably within a range of 4.3 to 5.6 kt. The full results for a time lag of 4 years, chosen for example purposes only, are shown in Figures 8.9-8.10 and Table 8.8. Stock biomass at the start of the period (1963) and at the start of the CPUE series (1986) is estimated to be within the range of 69 to 94 and 23 to 25 kt, respectively.

8.6 Comments on assessments

Age related data were available to the group for Division Vb and Sub-area VI but as there still are problems with age reading of blue ling it was not felt worthwhile to carry out any analytical assessment at this time because essentially the results would be similar to those presented in the 1995 report of the Northern Shelf Demersal Working Group (ICES C.M. 1995/Assess:1). Length distributions from groundfish surveys in Vb have also been tried in length based assessment methods without success mainly because the survey catches of blue ling are so small and not representative of the stock as the survey only covers depths down to about 500 m (ICES C.M 1993/Assess 20).
Therefore it was decided to use the production model described in Section 8.5. The group felt that this gave sensible results, although the stock structure in the area is uncertain and the use of a CPUE series from a spawning fishery could be questioned. However, being from a spawning fishery, the observed decline in the CPUE series most likely is an underestimate. Consequently the fitted production model should give a conservative picture of the development in the stock. The quality of the effort in this CPUE series could also be questioned as it is only measured as the number of fishing days during the fishing season (March-May).

8.7 Management considerations

All available evidence from the trends in catches and CPUE series indicate that the stocks of blue ling in Va, Vb and VI are on a low level. The results of the Schaefer production model in Vb support the poor situation of the stock in this area. As there is no information on recruitment to these stocks it is difficult to predict any future changes in the stocks. From the production model it can be seen that the present stock biomass could be in the order of 25-30 % of the virgin biomass. If the CPUE series presented can be taken as reflecting the stock sizes they also reflect comparable declines in the stock biomasses.

Given this, the stock biomass in Divisions Va and Vb and in Sub-area VI seem to be far below B_{pa} and could be at or slightly above B_{lim}.

9 TUSK (BROSME BROSME)

9.1 Catch Trends

The landings of tusk are given in Table 9.1.

In Division IIa there has been a decreasing trend in the landings since 1989 and the total landing in 1996 was 12,046 t. In Division IVa the landings in 1994–1996 were reduced to 3,300 t from a level of 4,000–6,500 t in 1988–1993.

Preliminary landing figures indicate a further decline in IIa and IVa landings in 1997. In Va and Vb landings increased in the period 1989–1991 but decreased again in 1994–1996.

9.2 Stocks

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). As discussed for ling (Ch. 7.2), 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.

9.3 Catch and effort data

Catch per unit of effort data from Norwegian longliners were presented to the Study Group in 1996 (Hareide and Godo, 1996) and were further described in Bergstad and Hareide (1996). This series was not extended beyond 1994, and only official statistics for ling and tusk combined are available for the following years (See Ch. 6 and 7). Updated Faroese longliner CPUE for Division Vb and Icelandic data from Va were, however, available (see below).

Length Distribution, Age Composition, Mean Weight at Age, Maturity

Data available from different countries and Divisions were indicated but not quantified in Tables 8.3.1–8.3.6 of ICES C.M. 1996/ Assess:8. Extensive Icelandic otolith collections are being processed and will be made available for future assessments. The data for 1994–1997 were presented to the Study Group. Data series available to the Northern Shelf Working Group in 1994 were updated. The quality and quantity of data improved significantly after 1993 due to increased sampling effort in Iceland, the Faroes and Norway (Magnússon *et al.* 1997). The samples available from Vb from Faroese sampling are listed in Table 9.2. An overview of available Norwegian samples were given in Bergstad and Hareide (1996). Very little data were available from Norway after 1995. In 1997, only a single sample from IVa (Shetland) was available.

Length and age compositions of the international landings from Division Vb from 1996 are given in Figure 9.1 and Table 9.3. The distributions were adjusted to total catch using Faroese age-length keys. Age distributions and catch curves for tusk in Va based on Icelandic data are given in Figure 9.2 and Table 9.4.

From a Norwegian exploratory longline and trap survey at the Reykjanes Ridge (Sub-area XII) catch data, length and age compositions and biological data were made available (Langedal and Hareide, 1997; W.D. Hareide *et al.* 1998). The length distribution of longline and trap catches is reproduced in Figure 9.3.

9.4 Biological parameters

Considerable information on biological parameters from many parts of the distribution area were presented in two recent project reports, i.e., Bergstad and Hareide (1996) and Magnússon *et al.* (1997). In the Nordic project (Magnússon *et al.* 1997) considerable effort was devoted to intercalibrate age readings. A manual for reading ling (and tusk) otoliths was recently presented (Bergstad and Hareide 1997). There is now a higher degree of confidence in the precision of age distributions and age-related population parameters being presented.

Scotland provided new length-weight relationships for gutted and ungutted ling based on data from a number of sources and years:

Gutted weight(g)=.0095448 * total length (cm)$^{3.00954}$n=number of fish measured and weighed= 1029
Total weight=.006268*total length$^{3.13099}$ n=117
Total weight= Gutted weight*1.0958, n=101

Iceland provided length-weight relationships from 1996 and 1997 from Division Va:

1996: Total weight(g)=.0084*total length (cm)$^{3.0559,}$ n=998
1997: Total weight =.0043*total length$^{3.2035,}$ n= 199

Some new data on biological parameters for tusk at the Reykjanes Ridge (Sub-area XII) were presented based on Norwegian exploratory longlining in 1997 (Figure 9.3 and Table 9.4).

9.5 Assessment CPUE analyses and mortality estimates

The catch per unit of effort analyses of the Norwegian longliners operating primarily in Divisions IIa, IVa, Vb, VIa, and VIb presented to the Study Group in 1996 indicated an overall downward trend since the early 1970s (Figure 7.3; Hareide and Godø, 1996; Bergstad and Hareide 1996; Magnússon *et al.* 1997). The same trend was indicated in an area-specific analysis and from analyses of Faroese CPUE data from trawlers and longliners from the period 1986–94. These observations suggested that a reduction in abundance had occurred in several areas. The Norwegian CPUE series was not updated after 1995. The Faroese CPUE series suggests a further decline after 1994. (Figure 9.4 and Table 9.5).

In Division Va, the longlining effort decreased by about 50 % between 1993 and 1997. In the same period the CPUE more than doubled (Table 9.6, Figure 9.5). A decrease has been observed in both the abundance indices of fishable sizes and juveniles in the Icelandic groundfish survey, with a slight increase in 1997 (Figure 9.6, Table 9.7).

Length frequency distributions are available from Icelandic groundfish surveys carried out in Va since 1985 (Figure 9.7). Progression of modes in the length frequency distributions indicate that particularly strong year classes may occur in certain years, e.g., in 1986, which may support the fishery for several years. It is suggested that a relatively strong year class was born in 1994.

In 1994, the Northern Shelf Working Group undertook a production model analysis based on available CPUE data, but with limited success. Since the database had not changed significantly since then and the time series are still short, the Study Group did not pursue this option.

In ICES C.M. 1996/ Assess:8, estimates were given of total mortality, Z, from catch curves from Divisions IIa, IVa, Vb, VIa and VIb in the years 1993–1995 (and 1988 for IVa) based on age distributions of the Norwegian longline catches. The average Z was 0.6 (S.D.=0.2, n=12). These estimates were also presented in Bergstad and Hareide (1996) and Magnússon (1997).

Estimates of Z by catch curves based on commercial longliner data for each of the years 1994–1997 were computed for Division Va (Figure 9.2). A corresponding estimate was obtained for Vb for 1996. The Va estimates were high, and some were higher than the previous values from other areas. The Vb estimate was 0.4 which by comparison was rather low. It should be stressed that curves representing data for many cohorts depend to a strong degree on the variation in recruitment and on the sampling level.

New estimates were presented from the fishery conducted on what appeared to be a virgin stock at the Reykjanes Ridge in 1996 (Sub-area XII) (Magnússon *et al.* 1997), indicating a very low Z=0.1. A corresponding estimate from 1997 was 0.22 (Langedal and Hareide 1997). These estimates suggest that the natural mortality coefficient, M, of tusk may be in the range 0.1 - 0.2.

9.6 Comments on Assessment

It is not possible to make analytical assessments for the tusk due to lack of good time series of data. With the present level of sampling, this situation may improve in the future. The Study Group is of the opinion that further improvement in the recording of effort and catch data should be encouraged, since CPUE are used as an index of abundance and as the basis of production analyses.

9.7 Management considerations

The Norwegian CPUE analyses presented to the Study Group in 1996 (Hareide and Godø, 1996) and in Bergstad and Hareide (1996), and further analyses discussed in Magnússon *et al.* (1997), support the conclusion drawn by the Northern Shelf Working Group in 1994 that there has been a downward trend in the stocks, probably with the exception of the tusk at Iceland (Division Va). However, the official Norwegian effort statistics for longliners are not given by species and since tusk is primarily a bycatch species, the effort directed at tusk cannot readily be estimated. To get a species-specific CPUE, skipper's logbooks were used, but such detailed data were not updated after 1994. However, the Norwegian analyses of ling and tusk combined for 1996, suggest that the downward trend has continued. The same tendency is shown by the updated Faroese CPUE data for tusk.

Both the steadily declining CPUE in all areas, except Va, and the high mortality estimates strongly suggest that the availability/abundance of tusk has continued to decrease and that exploitation rate remains high. Based on available information, it is however difficult to determine at what level of abundance the stocks are at present in relation to unexploited states.

10 GREATER SILVER SMELT (*ARGENTINA SILUS*)

10.1 Catch trends

Table 10.1 shows the landings data for *Argentina silus* by ICES Sub-areas as reported to ICES or as reported to the Study Group.

Landings by Norway from Sub-areas I and II have declined from peak levels of 10,000 to 11,000 t to about half that level in recent years. This probably represents a change in target species rather than a decline in abundance of *A.silus.*

Landings in Sub-areas III and IV are mainly by Denmark and Norway. The Danish landings have remained around the 1000 t mark except for 1992 and 1993 when they were higher. The Norwegian landings have decreased from about 1000 to 2000 t to only 100 - 200 t

The landings of *A. silus* in Divisions Va and Vb by Iceland and Faroe Islands respectively have increased considerably in recent years. In 1996 and particularly 1997 the effort in the Icelandic fishery in Va greatly increased in a directed fishery for this species. At least in 1997 the catches were little mixed with other species.

There has been a considerable decline in the landings of *A. silus* from Sub-areas VI and VII from a peak in the late 1980s Only the landings of the Netherlands remained reasonably consistent between 1989 and 1995. The marked decline in the Irish catch since 1990 was noted in ICES C.M. 1996/ Assess:8.

10.2 Stock structure

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 IIA, IIIa and IVa appear to show two separate populations in the winter but in the summer the species is widely distributed (see also Section 5.1.10 of ICES C.M. 1996/ Assess:8).

10.3 Commercial catch-effort and research vessel surveys

Catch and effort data are available from the Icelandic trawl fishery for the years 1991 to 1995 in Sub-area Va (Table 10.2) .

Norwegian research vessel catch and CPUE data and acoustic survey data exist for Division IIa (1980–1994), IIIa (1987, 1989 and 1992) and IVa (north) VI and VII (1989 to 1994) (see Section 9 and Table 9.1 of ICES C.M. 1996/ Assess:8) but were not available in a format suitable for inclusion in this report. There have been no research surveys since 1994. Similarly historical catch and CPUE for Sub-areas VI and VII from German and UK research surveys carried out during the 1970s and early 1980s has been or is being archived but is not yet available in a format suitable for assessment purposes.

10.4 Length and Age compositions and mean weights at age

It was noted that Icelandic and Faroese length and age composition data are available for Sub-areas Va and Vb but were not in a format suitable for presentation to the Study Group. There are also Irish data for mean length and weight at age but these were not in a format suitable for the Study Group.

10.5 Biological parameters

The following account updates biological data not previously cited or reported to the group. A paper on the biology of *A. silus* in Sub-area Va has been published (Magnússon, 1996). The Von Bertalanfy growth parameters for pooled data from 1985 to 1995 were as follows:

	$L\infty$	k	t^o
Males	51.816	0.0952	-4.337
Female	55.786	0.0875	-4.339

The length weight relationship for both sexes combined was:
Wt (g) = 0.0023*L (cm) $^{3.3222}$ r= 0.975

The maturity ogives by length and sex for pooled data are given in Table 10.3 This species spawns all year round in Icelandic waters but appears to be most intensive between April and July and in December.

A sample of 4,713 otoliths examined in Ireland from 1992 to 1993 showed fish ages from 0 to 36 years. The otoliths were read flat and age groups above 20 were difficult to determine. Otoliths from the southern part of Sub-area V were more difficult to interpret having more split rings. Data on Von Bertalanffy growth parameters and fecundity are given below. Ronan *et al* (1993) found that there was an increase in fecundity with size. A maturity ogive for females with age is shown in Table 10.4. Irish data for Sub-areas VI and VII suggests that spawning in this species is prolonged and is possibly year round.

	L_∞	k	T_0	Fecundity
Males	41.51	0.16	-2.01	
Females	44.37	0.14	-2.35	20,000

10.6 Assessment

The Norwegian acoustic surveys in the 1980s and early 1990s provided considerable information on the distribution of *Argentina silus* in the shelf areas from Ireland to northern Norway and in the North Sea. In some years attempts were made to estimate abundance (See Table 9.1 of ICES C.M. 1996/ Assess:8). It should be stressed that these estimates remain uncertain due to several factors i.e., the choice of density coefficient or target strength, extensive mixing with other species, and difficulties with using acoustics at great depths.

Along the Norwegian shelf (Division IIa) the acoustic estimates from the 1980s and early 1990s suggested a total biomass of 400–500,000 t. The directed fishery then exploited fish of total length greater than around 30 cm which were 6 years old and older. However, more than 50 % of the landings were fish of 15 years old and older. This size- and age-structure seemed stable through the 1980s and up to 1992 when sampling was interrupted. The size- and age-distributions were similar in the Skagerrak landings from the directed trawl fishery and research surveys in 1987

(Bergstad, 1993). Length- and age data from 1992 showed the same structure (Bergstad, unpublished). A report by Mahon and Molloy (unpublished) showed that the majority of fish landed from the period of the Irish fishery in Sub-area VI were age group 20 or greater.

In order to prevent an uncontrolled increase in effort, Norway introduced a national TAC for the fishery in IIa in the 1980s. The landings never reached the level of the TAC, and there has been no expansion in the fishery in recent years. The landings are only 2 % or less of the acoustic abundance estimates. Since 1992, no TAC has been imposed on the fishery because further increase in effort seemed unlikely. There has been no TAC for the fishery in Division IIIa.

Argentines in Va

Argentina silas is a semi-pelagic species and consequently in common with other pelagic, shoaling species, CPUE based assessment methods are probably inappropriate. However, in view of the lack of recent assessments of this species an attempt was made to fit a modified DeLury constant recruitment model to total international catch data for Va, 1986-97, and Icelandic CPUE data for bottom trawl from 1991 onwards.

The results from DeLury (not presented but included in ICES folders) were very unreliable, reflecting a poor fit by the model for a range of assumptions of initial proportion of stock to virgin biomass and error models. Prior to 1997 Icelandic landings were a bycatch in a redfish fishery, but even when the 1997 point, based on a new directed fishery, was excluded the fit remained poor. The data-series although showing some contrast is comparatively short and this may also have contributed to the poor fit.

11 ORANGE ROUGHY (*HOPLOSTETHUS ATLANTICUS*)

11.1 Catch trends

The landings data for the ICES area are shown in Table 11.1.

There are currently two fisheries for Orange Roughy in the North East Atlantic. A French fishery mainly in ICES Sub-area VII and an Icelandic fishery exploiting fishing grounds in Sub-area XII. The French fishery started in 1991 and peaked at 4462 t in 1992 and has since declined to around 1300 t. The first fishing grounds exploited in Sub-area VI have been fished down and the catch in that area is now low. The Icelandic fishery began in 1993 and 1994 and landed less than 100 t, it increased in 1995 and 1996 and landed 800 t in 1997. Some catch has been reported from other areas (Va,Vb and X) but there is no known established fisheries in these areas. Very sporadic landings had been reported before 1991.

11.2 Stocks

The fishing grounds discovered till now in the North Atlantic have appeared to be concentrations of small amounts of fish. Whether or not these are independent populations is not known. However, with time, the probability of finding, in the northern Atlantic, stocks comparable in size to the stocks exploited in the south Pacific is decreasing.

11.3 Commercial CPUE

French CPUE data have been computed for the period 1992–1996 (Table 11.2). The CPUE calculated for the whole deep-sea fleet is not accurate because the fishery for this species is on concentrations which are targeted by a limited part of the fleet. From 1992 to 1996, the number of vessels targeting orange roughy has declined. It is the CPUE of these vessels which has been used in the assessment

11.4 Length and age composition

The length composition of the French landings in 1996 is shown in Figure 11.1. No age composition is given for the species as no complete ALK is available for this species. Otoliths of small fish (up to 25cm) can be read whole. For large fish, thin slice methods are used. Ages from thin slices suggest that orange roughy can be up to 100 years old. However, these ages are as yet unvalidated. On the large stocks exploited in the south west Pacific, only the ages of juvenile fish have been validated. According to the size at age of these juveniles and the numbers of rings see on larger fish, ages of up to 125 years are considered likely and the stocks are managed under an assumed natural mortality of 0.04 (Annala et Sullivan, 1996). Age validation is currently under investigation in France.

No length samples are available from the Icelandic landings, but a concentration of orange roughy was discovered during a survey in June-July 1997 on a seamount at about 800 m depth west of the Reykjanes Ridge, not far from the continental shelf. The length of these fishes ranged from 46 to 65 cm total length. The mean length of males was 55.9 cm and 57.6 for females.

11.5 Biological parameters

The fecundity of the species has been studied in terms of mean length at first maturity, seasonality in development of gonads and fecundity per weight and individual fish. These studies are part of the FAIR Project (see 2.3.1). The mean length at maturity is shown in the Table 11.3. Spawning occurs during a short period in January-February. In March all females are spent.

The fecundity has been estimated as 48, 500 eggs/kg of body weight and 168 000 eggs per female. These values appear to be higher than the those of the south west Pacific stocks.

The fish caught from the Iceland survey in 1997 were almost exclusively mature.

11.6 Assessment

Data for assessment of this species are poor for in the North Atlantic. It should be noted that the important stocks exploited in the South West Pacific are not assessed by analytical models. These assessments mainly rely on survey data

in term of estimates of the biomass from acoustic and trawling surveys or the two combined. Eggs surveys are also carried out to back calculate SSB. These data are not available for the North Atlantic.

An estimate of the virgin biomass in Sub-area VI and Divisions VIIb,c was presented to the study group as a working document, (Dupouy et Lorance, WD). This estimate relies on densities observed during the German surveys from 1974 to 1980. A total biomass of 38 000 t in the depth range 800 to 1400 m was calculated assuming a trawl efficiency of 50 %. For Orange Roughy, this depth range should cover most of the depth distribution of the species (in the German surveys no fish were caught from 400 m to 800 m) however, the fish is known to occur in slightly deeper depths than 1400m. This estimate should be considered with caution. In addition to the concerns regarding the methodology described in the section on roundnose grenadier (Section 12), the sharp decline in the catch rate in the first year of the fishery suggests that orange roughy can be very vulnerable to trawling and that the assumed trawl efficiency of 0.5 may be an underestimate. Moreover, since this species occurs in dense aggregations density estimates may be unreliable if they do not take into account a stratification consistent with the aggregation areas.

For this present assessment, a modified DeLury constant recruitment model and a Schaefer production model were attempted using total international catch data for VI and VII from 1992 to 96, and French directed CPUE data for otter trawlers over the same five year period. Sub-areas VI and VII were analysed separately on the assumption that separate aggregations occur in each area.

Sub-area VI

The results from DeLury appeared robust for a wide range of input values of the ratio of initial stock to virgin stock (Table 11.4 and Figures 11.2 and 11.3). Estimates of catchability and carrying capacity were fairly consistent and population biomass in 1996 was estimated to be in the range between around 280 to 370 t. This equates to around 12 % of carrying capacity (K).

The results from Schaefer for a range of initial proportions and time lags were also fairly robust and in a comparable range to the results from DeLury (Table 11.5 and Figures 11.4 and 11.5). Biomass in 1996 is estimated to be between 18 and 27% of carrying capacity. MSY is estimated to be between 250 and 350 t approximately. This equates to around 12% of carrying capacity which is high considering the likely dynamics of the species and estimates for stocks in the South Pacific. It should be noted that the analysis is based on five points only and although there is contrast in the data, parameter values are likely to be estimated with some imprecision.

Sub-area VII

The results from DeLury again appeared to be reasonably robust for a wide range of input ratios of initial stock to virgin stock (Table 11.6 and Figures 11.6 and 11.7). Estimates of catchability and carrying capacity were fairly consistent and population biomass in 1996 was estimated to be in the range between 4650 to 5471 t. This equates to between 28 and 41% of carrying capacity.

The results from Schaefer for a range of initial proportions were reasonably robust, although less so when different time lags were assumed (Table 11.7 and Figures 11.8 and 11.9). Estimates of biomass in 1996 were substantially lower than from DeLury. Biomass in 1996 is estimated to be between approximately 55 and 66% of carrying capacity. MSY is estimated to be between approximately 1600 and 2300 t. This equates to between 40 to 67% of carrying capacity which is clearly too high. In addition to concerns regarding the small number of data points, the intrinsic rate of growth (r) also appears to be high. A contributory reason for the difference in population in 1996, compared with DeLury, is that the Schaefer model takes greater account of the increase in CPUE observed in 1996.

11.7 Comments on assessment

The results for MSY from Schaefer for both Sub-areas are high in relation to estimated carrying capacity, and in view of the small number of data points a production model is inappropriate at the present time. The results from DeLury, however, are more robust and probably give a reasonable estimate of current stock in relation to virgin biomass. Combining the estimates for VI and VII gives a carrying capacity of between 15 and 20 kt, compared with 38 kt estimated using German survey data.

11.8 Management considerations

The results presented in this assessment should be treated with caution because they are based on limited data and little is known about the general distribution of orange roughy in these areas. However, our analyses indicate that $B_{current}$ at the end of 1996 was below B_{lim} for Sub-area VI and below B_{pa} in Sub-area VII.

12 ROUNDNOSE GRENADIER (*CORYPHAENOIDES RUPESTRIS*)

12.1 Catch trends

Landings for roundnose grenadier are given in Table 12.1. Landings from Sub-area II are from a bottom trawl fishery in the Norwegian fjords. The total weight of landings has not exceeded 100t to date.

Landings from Sub-areas III and IV have decreased from a maximum of 4,247t in 1992 to 1,185t in 1996. Catches are mainly from the directed fishery in the Skagerrak by Danish bottom trawl and bycatch from Norwegian shrimp fishery which are sometimes discarded or landed for non food products (C.M.1996/Assess:8).

Landings from Sub-area V are mainly from the directed trawl fishery by the French fleet. Landings from Faeroes vessels represent bycatch in the past three years. The overall catch in Sub-area V has declined from 2,038t in 1992 to 570t in 1996.

The major fishery for this species in the ICES area is in Sub-areas VI and VII. The majority of the catch is taken by the French trawl fleet. Landings here have remained relatively constant since 1991 at 7,000 to 8,500t. Recent information on discarding (FAIR 1998, Connolly and Kelly 1996) has estimated that discarded grenadier may comprise up to 30 % of the landings by weight (See Section 6.4). This implies that total catches in the Sub-areas could be as high as 9,000 to 11,000t.

Landings of grenadier in Sub-areas VIII and IX represent bycatch from the French trawl fishery. The total weight of landings has remained below 20t since 1989.

The landings of roundnose grenadier in Sub-area XII have declined since 1992. There are two fisheries in this Sub-area. Russian and Latvian catches are taken on the Mid Atlantic Ridge north of the Azores and are from a directed trawl fishery on roundnose grenadier. Landings from this fishery declined from 9,495t to 675t between 1989 and 1994. Recent Russian landings from this area (208–1297t, 1996–1997) are from three vessels only. There is anecdotal evidence that a small number of Polish vessels fished roundnose grenadier on the Mid Atlantic Ridge for 6 months in 1997, however no catch data were available to the Study Group for this fleet. A Spanish fishery targeting a range of deep water species has developed on the Hatton Bank and to the west of Rockall since 1996. Landings of roundnose grenadier by Spanish vessels now represent over 50% of the total landings (3,097 t) from this Sub-area.

Landings in Sub-area XIV have remained constant and at a low level (<55t) since 1988. The majority of the landings are bycatch from the German trawl fleet targeting redfish (*Sebastes* spp.) east of Greenland and on the Reykjanes Ridge.

12.2 Stocks

The issue of roundnose grenadier stocks was discussed in the 1994 Study Group Report (ICES C.M. 1995/Assess:4) and there are no new data on this topic. 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, along the north Atlantic rim and Mid Atlantic Ridge, the idea of a central spawning population seems unlikely, due to the distance between areas and the local presence of ripe adults and juveniles. However there are no physical oceanic boundaries to prevent the movement of fish and/or eggs and larvae. The study group considers it likely that there may be some small scale interchange between local populations in areas where there are no physical oceanographic boundaries to movement by the fish or their eggs and larvae. It should be noted that eggs and larvae of this species have only been recorded from Sub-division IIIa (Skagerrak) (Bergstad and Gordon, 1994) and from the Mid Atlantic Ridge (Sub-area XII).

12.3 Commercial CPUE and Research Surveys

Information on commercial CPUE is available for the French fleet from ICES Sub-area VI and VII combined. The entire deep-water French fleet is mainly composed of trawlers, however it is not homogeneous in terms of size, power, deck

equipment and vessel age. CPUE data was extracted for a reference fleet of industrial trawlers of the same size and comparable equipment which have been permanently fishing for deep-water species since 1992. Before 1992 the fishery was in a developmental stage and the CPUE values reflected this. The monthly catch and effort from the French reference fleet is shown in Table 12.2. Two series of catch and effort data are given for the French fleet (total catch and effort, and relevant catch and effort). The relevant catch and effort take into account two thresholds: a) for each trip catch and effort per statistical rectangle are only relevant if the catch of roundnose grenadier comprises more than 10 % of the total catch; b) only when 20% or more of total yearly effort of the vessel is directed at roundnose grenadier.

An attempt was made to fit a modified DeLury constant recruitment model to total international catch data and French Trawl CPUE data for 1992 to 1996. The results from DeLury were very unreliable, reflecting a poor fit by the model for a range of assumptions of initial proportion of stock to virgin biomass and error models (Figures 12.1 and 12.2). Possible explanations may be that the data series is comparatively short and exhibits limited contrast.

CPUE data for 1993 and 1995 to 1997 from a series of Irish surveys conducted in ICES sub-area VI was reviewed. Given the purpose of the surveys (to locate biological samples) this series was not considered to give an accurate reflection of abundance.

12.4 Age and length composition

Catch numbers at length from French commercial data are given in Table 12.3 and Figure 12.3. The greater occurrence of smaller fishes in recent years is due to a change in the pattern of discards/landings (some smaller fish now landed that would not have been accepted on the market at the beginning of the fishery). Considering only the large fish, no clear trend was seen from these data.

As a result of improvements in otolith reading methodology the readings made in the earlier years gave lower age estimates than the more recent ones. The trend in catch numbers at age visible in the 1996 report (towards the catch of a higher proportion of older fish from 1990 to 1993) was due to progressive improvement in age estimation. Readings made in 1996/1997 were agreed by the otolith workshop held within the FAIR Project (95-655). The catch in numbers at age for 1990 to 1997 were calculated combining the yearly catch numbers at length with the 1996/1997 age length given in (FAIR, 1998) Table 12.4.

Percentage numbers at age are available for Russian data (1974–1984) from Sub-area XII (Anon 1996), but it is not known how the aged sample relates to the total catch. These figures have not been updated since 1984.

12.5 Biological data

A wide range of biological information is available for this species, a summary of the information available is given in Table 12.5. The problems in assigning age groups to this species have been outlined in the 1996 Study Group report ICES C.M. 1996/ Assess:8. An attempt to address some of these problems was made at a workshop held in conjunction with FAIR project (95 655) in 1997. The workshop noted that a primary difference in age group estimates was the interpretation of the first few rings. The results of this workshop will be available in the final report of the FAIR project at the end of 1998. For ICES Sub-areas VI and VII there are growth rates for periods pre and post exploitation (Gordon and Swan 1997). However comparison of these growth rates is not possible due to the different ageing methodologies and length measurements. Estimates of the growth parameters are shown in Table 12.6. Mean length at age data is also available for these Sub-areas for periods of pre and post exploitation.

There appear to be problems with the length weight relationship for this species. Data from ICES Sub-area VI show large differences in predicted weight at lengths greater than 20cm (PAFL) Figure 12.4.

Estimates of age at first maturity for roundnose grenadier exist for Sub Division IIIa, and Sub-areas VI and XII. If the age group estimates are correct, these show that recruitment to the spawning stock occurs at 8–10 years in ICES Sub Division IIIa, 14–16 years in ICES Sub Division Va (Bergstad, 1990), 7–11 years in ICES areas VI and VII (Kelly *et al.* 1997) and 12–13 years in Sub-area XII (ICES C.M.1996/Assess:8) (Table 12.7). A raw dataset is available for Sub-area

Va. These data indicate that male and female roundnose grenadier mature at 9−10cm and 12−13cm (PAFL) in Sub-area VI.

12.6 Assessment

Three working papers addressing the roundnose grenadier assessment were presented to the working group. A first paper (Dupouy and Lorance) relies on biomass estimates according to fish densities calculated from the swept area method from a series of German surveys (Erhich, 1983). Having been carried out from 1974 to 1980 these German surveys are believed to provide data on the virgin stock within the studied area, namely ICES Sub-area VI and the adjacent ICES divisions VIIb, c in the depth range 400 to 1400 m.

The horizontal surface of this area has been estimated from the chart "Continental margin around the British Isles" (Laughton *et al.* (1975)) by 200m depth strata. This depth stratification has been maintained to ensure consistency with Ehrich (1983) to display fish density results.

Multiplying the strata areas by the fish densities a "minimum biomass" per stratum is obtained. A total biomass is then calculated by multiplying the minimum biomass by 2 to take into account an assumed trawl efficiency of 0.5 (Gordon et Hunter, 1994). Summing up the total biomass per stratum gives an absolute biomass in the area (see text table).

	Tot. Biom. t.	M and F	$E = F/Z(1-e^{-Z})$	MSY	Landings (not incl. discards)	Estimated discards
Grenadier	334 104	0.13	0.115	38 420	26 940	11 480

Based on absolute biomass, an estimate of MSY was calculated from an assumed value of the natural mortality coefficient and considering MSY is reached when F≈M. The exploitation rate expression $E = \frac{F}{Z}(1-e^{-Z})$ applied to the absolute biomass gives an estimate of MSY. Lastly, MSY represents a total catch including discards. Therefore, in the case of roundnose grenadier, estimates of potential landings and discards have also been provided above (Figures 12.5 and 12.6).

Some concerns have been expressed about this approach as follows:

1) the trawl efficiency on deep sea species is unknown and may be highly variable
2) bentho pelagic species have some variable distribution in the water column which can make the swept area method less reliable, a filtered volume method could be more accurate and account for variations in the headline height during the surveys; nevertheless, current estimates are therefore conservative
3) dealing with the slope, the horizontal surface may not be an appropriate estimate of the surface of the seabed
4) the origin of the hypothesis "MSY is reached when F≈M" was unknown to the study group
5) the expression used for the exploitation rate refers to stock numbers and is applied to biomass. The proper calculation should be to convert the biomass to stock numbers or better to stock numbers at length or age and then to apply F to give MSY
6) the results are highly sensitive to estimates of trawl efficiency and M.

The second Working Document (Lorance *et al.* 1998) is a trial assessment of roundnose grenadier using pseudo-cohort analysis. The data used are the French commercial catch at age for 1996 and 1997 in Sub-areas V, VI and VII (Table 12.4). The French fishery catches roughly 90 % of the international landings of the species originating from these Sub-areas. Estimates of M have been derived using two methods as follows:

1) Maximum age method. The maximum age is defined as the age to which 1 % of a cohort survives. According to the age composition of the catch, an expected conservative figure is 45 years. M is then computed from a re-arrangement of the usual survival equation. $M = (Ln100) / a_{max}$;

   where a_{max} is the maximum age. For a_{max} = 45, M=0.1.

2. Some other estimates have been calculated by applying the age-length key from the French sampling of the landings and discards to the length data from surveys (Bridger, 1978, Ehrich, 1983). In both cases, the data given as total length distribution were converted to pre anal length distributions and then to age distributions. Fitting catch curves give Z estimates that should approximate M since the population was unexploited up to the time of the surveys. The

estimates of M from this method range from 0.13 to 0.29 (text table below). The estimates of M are very sensitive to the range of ages used in the regression.

	Origin of length data	
Age range used	Bridger, 1978	Ehrich, 1983
21 to 60	-0.21	-0.189
25 to 40	-0.29	-0.25
21 to 35	-0.14	-0.13

Possible explanations (bias, senescence) of the higher M estimates when older fish are included are discussed in the paper. Estimates from the range up to 35 years are believed more likely as with M over 0.15 at all age less than 1 % of the fish would survive over 30.
According to these preliminary estimates, M was set at 0.1 in the pseudo-cohort analysis, considering it should be a conservative estimate.

The pseudo cohort analysis was corrected for changes in fishing effort. This method takes into account changes in fishing effort in the years before the one analysed. An account of this method is given in Section 3 and Appendix 2, the full model can be found in Bertignac (1988). According to the French effort, the correction factor on effort was set to 1 for the range of years 1997 backward to 1990, to 0.5 in 1989, and to 0.1 in 1988 and 1987. This procedure corrects for successive cohorts not exploited at the current rate from their recruitment.

Terminal age was set at 32, older ages being scarce in the catch at age and the ALK looking less reliable after this age (poorer numbers and variations in the mean length at age). A range of Ft was input and the convergence appeared to be very poor (Figures 12.7 and 12.8) (which is an indication of a low exploitation level). However, the F at age should be rather stable after age 20 or so. That condition is not reached for F higher than 0.12. Accordingly, an F= 0.1 is used in the paper as the most likely current estimate of F.

Following the pseudo-cohort analysis, a yield per recruit simulation was done. This one has been set on spreadsheet in order to include a selectivity at age curve and a discards to landings ratio at age. The selectivity has been simulated to match the catch curve for young fish, the discards to landings ratio is the one observed from French sampling. This simulation gives Catch and landings per recruit (Figure 12.9). Beyond the estimates of MSY which is very sensitive to the recruitment estimates from the pseudo-cohort, this yield per recruit simulation shows the effect of discards on this stock. As the discarding occurs in a wide range of age, when F increases, less fish reach the first age (size) of landing. The ratio discards/landing increase. With the current fishing pattern and an M of 0.1 at all ages, MSY would be reached around F= 0.1.

A third Working Document (Kelly, 1998) was presented which attempted to estimate biomass and spawning stock biomass in Sub-area VI. The estimates were based on adjusting population indices to absolute values from an Irish survey during November 1997 using known maturity rates, assumptions about M and average fishing mortality estimates as derived from catch curve analysis. It was recognised that the exercise represented only point estimates that were very sensitive to the mortality parameters in which slight adjustments gave a broad range of population sizes. The study group felt that such exercises should be pursued with additional surveys, however, considered it premature to rely on the values currently provided.

In addition to these papers catch curves were computed using age data provided from both Irish research surveys in Sub-area VI during 1993 and 1995 and the French commercial fishery in Sub-areas VI and VII during 1996 and 1997. Results represent average Z values over many years on the fully recruited portion of the population age structure under the assumption of constant recruitment. The Irish and French data indicated Z estimates of 0.15 and 0.21, respectively (Figure 12.10). Assuming an M of about 0.10 (as with other long lived species such as redfish) the results would suggest that average fishing mortality rates from these data are quite low.

12.7 Comments on assessments

Long term estimates of fishing mortality based on catch curve analysis as well as pseudo-cohort analysis suggest that catches during the recent period of the fishery have generated low levels of F possibly as low as, or lower than M. These results are representative at least for the stock components in the areas investigated (ICES Sub-areas VI and VII). The lack of contrast in the commercial catch rates indicate that the stock is stable and that the removals from the stock are possibly too low to affect any appreciable change in stock size given the above observations on fishing mortality. This is supported, in part, by the relatively constant pattern in the length composition data of the commercial catches (and the stock) which may indicate that current catch levels have little negative effect on size structure of the resource; on the

other hand, significant changes in some stocks are often required before the latter changes become especially evident. It should be noted also that the distribution of the species extends beyond the depths normally associated with commercial fisheries and the assessment of the stock, in fact, could be viewed as conservative.

12.8 Management considerations

Although the assessment of roundnose grenadier is based on quite limited data and analyses, it is likely, nevertheless, that $F_{current}$ is at or below F_{pa} and $B_{current}$ is above B_{pa} considering the proposed precautionary approach reference points. This assessment, however, is only reflective of events occurring in Sub-areas VI and VII for which the data have been provided.

13 BLACK SCABBARDFISH (*APHANOPUS CARBO*)

13.1 Catch trends

Table 13.1 shows the landings data for *Aphanopus carbo* by ICES Sub-areas as reported to ICES or as reported to the Study Group.

Only landings of France in Sub-areas VI and VII and Portugal in Division IXa reach more than 1,000 t.

Portuguese landings fluctuate around 4000 t, showing no clear trend. French landings rose until 1993, when the fishery was becoming established, and stabilise after this year.

13.2 Stock structure

No information is available on stock structure. Nevertheless, the absence of adult fish to the West of British Isles suggests this area is a feeding area of pre-adult fish which belong to a population whose other stages are distributed elsewhere.

13.3 Commercial catch-effort

Catch -effort data are available from the Portuguese longline fishery at Sesimbra for the years 1984 to 1992 in Division IXa (Table 13.2).

Catch-effort data are also available for French trawl fleet in Sub-area VI from 1992 to 1996 (Table 13.3).

13.4 Length and Age compositions and mean weights at age

Portuguese length composition data are available for Sub-area IX (Table 13.4: from Martins *et al.*, 1994).

The data shows stable length distribution patterns over the years, with modal lengths ranging from 100 cm (1993) to 112 cm (1984). The maximum length observed was 136 cm in 1990. The same data also indicates that fish smaller than 80 cm were present in the commercial landings in a very low quantity, not achieving 1 % of the total catch.

Length composition from Icelandic research vessels shows a modal length of 103–105 cm both for 1995 and 1997 data. The analysis of the same data by sex shows that modal length is larger for females (106 cm) than for males (102 cm).

Length composition from French research vessel survey in Hebrides Terrace (Sub-area VI) in 1996 shows modal lengths at 95, 97 and 102 cm (Table 13.5).

13.5 Biological parameters

Growth parameters were estimated from Portuguese length frequency data and were as follows (Martins *et al.*, 1989):

Linf = 145 cm
K = 0.11

The following length weight relationship was derived from the application of the allometric equation from laboratory samples collected at Sesimbra harbour (Martins, 1989)

$W = 0.000376 * L^{3.27}$
weight in kg
length in cm

number of fish = 1042
length range 66–132 cm
correlation coefficient = 0.7020

Another length-weight relationship was obtained from samples collected in a French research survey conducted in 1996 at Hebrides Terrace (Lorance, pers.com.):

$W = 5.97*10^{-5}*L^{3.676}$; length range 69–120cm

From Icelandic research surveys data it was possible to establish a maturity ogive for both males and females.

The July 1996 French research survey only caught immature individuals.

The analysis of monthly frequency distribution of mature individuals per length class from samples collected at Sesimbra harbour from December 1987 to May 1989 shows that the majority of females sampled were not mature (75 %) and males were mature (74 %). This could indicate a different age of first maturity since the mean total length do not differ between sexes (females 107 cm; males 104 cm).

13.6 Assessment

Division IXa

Assessment analysis has been carried out in Division IXa where there is data from a Portuguese longline fishery in deep water off Sesimbra. The most recent assessment was in 1994 (Martins *et al.*, 1994).

Length based catch curves and length cohort analysis indicate that Z is around 0.7. Natural mortality was calculated using Pauly's empiric formula relating M with growth parameters and mean ambient temperatures, and is estimated at 0.17. This gives a F of 0.53.

Estimates of yield per recruit were performed for different levels of fishing mortality (F) and they have provided a flat-topped shaped curve. Yield corresponding to F0.1 was adopted deriving a value of F close to the current level of fishing mortality. This result suggests that it is advisable to manage this fishery by keeping the present level of fishing effort.

Sub-area VI

An attempt was made to fit a modified DeLury constant recruitment model to total international catch data and French trawl CPUE data for 1992 to 1996.

Although the overall fit was good (R^2=0.9) and the residuals were reasonably well behaved, the results appear unreliable and depend heavily on the choice of proportionality between initial and virgin biomass. Estimates of final population biomass are not realistic given that the total international catch in 1996 was around 3000 t.

Initial proportion	K=Carrying capacity (tonnes)	q	r^2	Final popn (tonnes)
0.25	27559	8.11E-05	-22.371	0
0.35	13605	7.09E-05	0.86	3
0.45	13435	6.31E-05	0.87	171
0.55	12952	4.81E-05	0.89	652
0.65	12503	3.93E-05	0.90	1101
0.75	12221	3.53E-05	0.90	1383
0.85	11951	3.21E-05	0.90	1653
0.95	11693	2.96E-05	0.91	1912

Although the data do exhibit contrast these results may simply reflect the fact that the time-series is too short for this type of analysis.

14 RED (=BLACKSPOT) SEABREAM (*PAGELLUS BOGARAVEO*)

14.1 Catch trends

Table 14.1 shows the landings data for red (blackspot) seabream, *Pagellus bogaraveo*, by ICES Sub-areas as reported to ICES or as reported to the Study Group. No data on discards have been presented to the Study Group.

Landings in the Sub-areas VI, VII and VIII, available from 1988 onwards, tend to decline more or less continuously year by year in all Sub-areas. Landings from France, Portugal, Spain and UK started to decline in the mid−1970s, after peaking at more than 24 thousand tons in 1974. In the recent years, they have fallen from more than 460 t in 1989 to 75 t in 1996. The preliminary data for 1997 (33 t) suggest that the decline is continuing. Most of the catches are taken by the longliner fleet, but trawlers also occasionally land red seabream. Catches of all countries (except for Ireland in Sub-area VI-VII and for Portugal in Sub-area VIII) have declined.

Most of the catches in Sub-area IX are made by the longliner fleet. Portuguese landings data are available from 1988 and Spanish data from 1993 onwards. The maximum catch was obtained in 1994 (1004 t) and minimum in 1995 (713 t). Data for 1997 (700 t) are not yet complete. There are signs of decreasing tendency in the landings during the rather short period when the statistics from both countries were available..

Landings data in Sub-area X (Azorean region) are available from 1988 onwards. Catches have ranged from 637 t (in 1988) to 1096 t (in 1996). Data on 1997 (813 t) are not yet complete. No clear tendency is apparent in the catches of this Sub-area in recent years. All catches are obtained by the Azorean fleet, which are mainly longliners.

In Sub-area XII, landings data are available from only one year (1994). They amount to 75 t.

14.2 Stock identity

Information on red (blackspot) seabream, *P. bogaraveo*, has been split into three different components as in the 1996 Report (ICES C.M.1996/Assess:8).

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

This separation does not presuppose that there are of three different stocks of *P. bogaraveo* but it offers a way of recording the available information in some sort of order. 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 in these sea areas have been confirmed in the past by tagging methods (Gueguen, 1974; ICES, C.M.1996/Assess:8). Studies on possible links between red seabream of the Azorean region with the southern Sub-area IX, Sahara Bank and Sub-areas VI-VII-VIII and the northern part of Division IXa have not yet been carried out.

14.3 Commercial CPUE and Research Surveys

No data are available on commercial CPUEs.

In the spring of 1995 the University of the Azores carried out an longline survey, to obtain estimates of relative abundance for several demersal and deep-sea exploited fish species, mainly red sea bream, in the Azorean region (Menezes, 1996). The results on red seabream abundance, length frequency distributions and demersal and deep-sea communities by stratum, geographical area and depth were presented to the 1996 Study Group (ICES, C.M.1996/Assess:8).

14.4 Length and Age compositions

No new data since 1996 were available to the Study Group in relation to Sub-area X. In that year length and age compositions of the catches in this area were presented over the period 1983−1993 (ICES, C.M.1996/Assess:8), Krug, 1995; da Silva and G. Menezes, W.D.1996). No data on length and age compositions in the other Sub-areas have been presented to the Study Group.

14.5 Biological parameters

No new biological parameters on length-weight relationship, length and age at 50 % maturity, spawning season, depth distribution and others biological items from Sub-area X (Azorean region) and from Sub-areas VI-VII and VIII have been presented since the 1996 Report (ICES, C.M.1996/Assess:8).

14.6 Assessment

No new assessment was attempted by the Study Group due to the lack of basic data. In 1996 the Study Group presented the results of the assessment carried out on the *Pagellus bogaraveo* in Sub-area X by Krug (1995), although some concerns were expressed by the Study Group in their report.

14.7 Biological reference points

As no assessment was carried out by the Study Group, no biological reference points have been considered.

14.8 Comments on assessment

No comments because no assessment.

14.9 Management considerations

In relation to Sub-areas VI, VII and VIII, there have for many years been no directed fisheries on *Pagellus bogaraveo* due to the very low yields obtained since the 1980s. Therefore most of the catches must be considered as very occasional bycatches of the fleet, mainly longliners, which is targeting other demersal species. For this reason, in spite of the apparent “collapse” of this traditional fishery, no special management considerations can be suggested.

15 GREATER FORKBEARD (*PHYCIS BLENNOIDES*)

15.1 Introduction

The greater fork-beard (*Phycis blennoides* Brunnich, 1768) is a gadoid fish which is widely distributed in the north-eastern Atlantic from Norway and Iceland to Cape Blanc in West Africa and the Mediterranean (Svetovidov, 1986; Cohen *et al.*, 1990). It is distributed along the continental shelf and slope in depths ranging between 60m and 800m, but recent observations on board of commercial longliners and research surveys extend the depth range to below 1000 m (Stefanescu *et al*, 1992a).

Phycis blennoides may be considered as a bycatch species in the traditional demersal trawl and longline fisheries for different target species (hake, megrim, monkfish, ling, blue ling etc.).

The information has been split into four different components according to the importance of the catches and the geographical distribution:

Greater forkbeard in Sub-areas I, II, III, IV, and V.
Greater forkbeard in Sub-areas VI, VII and XII(Hatton Bank).
Greater forkbeard in Sub-areas VIII and IX.
Greater forkbeard in Sub-areas X (Azorean region)

This separation does not presume the existence of four different stocks of *P. blennoides*

15.2 Catch trends

The landings of *Phycis blennoides* by ICES Sub-areas as reported to ICES or as reported to the Study Group are given in Table 15.1.

In Sub-areas I, II, III, IV and V the small landings registered mainly by Norway have drastically declined since 1993. In Sub-areas VI and VII the landings decreased from about 1900 t in 1988 to about half that level in 1993. The reasons for this is the lack of French landings' data and the decline in Spanish data to about half of the landings recorded in 1988. In recent years the landings have increased up to 3600 t in 1996, mainly due to the increase in the UK and Spanish landings. The changes in the landings probably represents a change in target species rather than variations in the abundance of *P. blennoides.*

In Sub-areas VIII and IX the bulk of the landings are Spanish and have increased from 81 t in 1988 to 456 t in 1996. This is probably because of the start of a longline directed deep-water fishery.

In the Sub-area X (Azorean region) landings by Portugal have declined from peak levels of 135 t in 1994 to 45 t. in 1996.

15.3 Commercial CPUE and Research surveys

In Sub-area VI all the CPUE data is survey data are from Irish surveys by chartered commercial vessels in 1993 and 1995 to 1997. (C. Kelly, personal communication.)

In Divisions VIIIc and IXa there exist preliminary CPUE data from Spanish research surveys from 1995 (FAIR, 1998). There are also data from a research survey of R/V “Noruega” (IPIMAR). Density and biomass estimates were calculated in 1994, 1995 and 1997 from the Alentejo area (South west of Portugal) and Algarve area (South of Portugal) (Moura, *et. al* .WD 1998).

Table 15.2 shows this preliminary information. In Sub-area VI, Divisions VIIIc and IXa (NW of Galician and SW of Portugal) the CPUE and density data indicated an overall downward trend. However in the Division IXa (S of Portugal) the density index increased from 1994 to 1997. All these preliminary results have to be interpreted with caution because of the scarcity and poor quality of the information.

15.4 Length and Age composition

In Sub-area VI, data on length composition were obtained for the years 1996 and 1997 from sampling program in Scottish ports (FAIR, 1998). The length distribution (Figure 15.1), shows in general way a unimodal distribution, with a length range between 36 and 72 cm and a modal size of around 54 cm. It was observed that the variations in the mean

length are related to depth. It is thus likely that variations observed in monthly length frequencies may be a function of movements of fishing effort up or down the slopes as well as seasonal movements of fish stocks. (FAIR, 1998).

Data on the length composition from the Spanish longline directed fishery in Division VIIIc is shown in the Figure 15.2. The maximum recorded length was 81 cm TL. and the minimum was 17 cm TL.. The high selectivity of this fishery results in very small amounts of discards.

In the Spanish demersal trawl fishery, *P. blennoides* is considered as bycatch but it is mostly discarded due to the small length of the specimens caught. The composition of these catches is shown in the Figure 15.3. Generally, all specimens less than 25 cm are discarded.

In August and September 1996 an experimental fishing survey "EXP96" was carried out on the continental slope of the NW of Spain (ICES Division VIIIc and Ixa), between 500 and 1200 m depth (Pineiro *et al.* 1996). An analysis of the lengths by sex in the catches shows a strong segregation by sex (Figure 15.4). Therefore, practically all specimens with length smaller than 42 cm were males and all specimens with lengths greater than 47 cm were females.

250 otoliths of *P. blennoides* were collected, age-length key by sex elaborated (Table 15.3) and the growth curves by sex of *P. blennoides* (Figure 15.5) were constructed (Casas, W.D. 1998). The mean length corresponding to first year (17.3 cm), was calculated from the otoliths collected in the annual demersal trawls survey "DEM96" carried out by the I.E.O in ICES Division (VIIIc and IXa), during the months September and October 1996. The age length key is not validated, but the length corresponding with the age group 1 agrees with the length resulting from the Bhattacharya method applied to the length distribution of *P. blennoides* caught in "DEM96" (Figure 15.6).

The growth curves for each sex were adjusted from Marquard't algorithm (Fishparm) and the following estimates for the growth parameters were given:

males:	$L\infty = 48.9$;	K= 0.371:	T_0= 0.285	n= 112
females:	$L\infty = 108$;	K= 0.113:	T_0= -0.0939	n= 139

It is important to point out the different models of growth shown by each sex. However the small quantity of males greater than 46 cm and females less than 40 cm, do not permit an accurate assessment of the existence of different growth models for each sex.

15.5 Biological parameters

In the Sub-area VI, length/weight relationship exists (Newton, personal communication):

W_{gutted} (g) = 0.007126 * $L^{3.02381}$ N=1221
W_{total} (g) = 0.006737 * $L^{3.086}$ N=56

Also there is the preliminary information about age at maturity: 3 and 2 years for males and females respectively.

In Divisions VIIIc and IXa Length/weight relationship calculated from EXP96 are:

male:	W_{total} (g)= 0.0214 *$L^{2.703}$	N=128: R^2= 0.761	length range (22-49cm)
female:	W_{total} (g)= 0.0075 *$L^{3.015}$	N=167: R^2= 0.919	length range (28-81cm)
Total:	W_{total} (g) = 0.0059 *$L^{3.068}$	N=310: R^2= 0.944	length range (22-81cm)

15.6 Assessment

No assessment was attempted by the Study Group due to the lack of the basic data in all sub-areas.

15.7 Biological reference points

As no assessment was carried out by the study group, no biological reference points have been considered.

15.8 Comments on Assessment

No comment because no assessment.

15.9 Management considerations

No special management considerations can be suggested because there is no assessment. Also, the general character of this fishery as a bycatch means that CPUE data are unreliable.

16 ALFONSINOS/GOLDEN EYE PERCH (*beryx splendens*)

16.1 Catch trends

Table 16.1 shows the landings data for Golden eye perch (Alfonsinos), *Beryx* spp, by ICES Sub-areas as reported to ICES or as reported to the Study Group. No data on discards have been presented to the Study Group. In most cases the statistics refer to both species combined (*Beryx splendens* and *Beryx decadactylus*). In general, except for Sub-area X, it is not known if the annual variations in landings are due to changes in fish abundance, changes in the direction of the fisheries or to more accurate reporting or monitoring of the landings, which are usually the bycatch of demersal fisheries targeting other species.

Landings reported from Sub-areas IV-V are very small (a maximum 6 t in 1990) and all of them were made by French vessels.

In Sub-areas VI-VII, landings used to be small and very variable, ranging from 12 t (in 1989) to 1 t (in 1993). In 1996, however, landings of 178 t were reported by Spain, taken as a bycatch of the demersal, mainly longline, fisheries in Sub-area VII.

In Sub-areas VIII-IX, the reported landings were very small (1-2 t) and scattered but have increased from 1995 onwards. In 1996 they amounted to 88 t. Most of these landings can be regarded as bycatches of the Spanish and Portuguese demersal (longline) fisheries.

Most of the landings of *Beryx* spp are from Sub-area X. They are mainly from longliners within the Azorean EEZ and by trawlers north of that area. Landings from the Azores have been increasing steadily from 108 t in 1987 to 635 t in 1994. The sudden decrease in the landings from 1995 is at least partly due to the fact that in recent years only the catches of one species (*B. decadactylus*) are reported. Catches by former USSR trawlers were 1800 t during 1978–1979 and 964 t during 1994–1995. In the first half of 1997 one medium sized Russian trawler (length 62 m) carried out a fishery for Golden eye perch in North Azores area between 43° and 45° N. Though exact data were not available, the estimated catch was in the order of 600 tons. Fish concentrations were unstable, therefore the vessel left the area in the mid summer (V.I. Vinnichenko, pers. com.).

Finally, in Sub-area XII, catches (2 t) were reported only in 1995, by the Faroe Islands.

16.2 Commercial CPUE and Research Surveys

No data are available on commercial CPUEs.

In the spring of 1995 the University of the Azores carried out a longline survey to obtain estimates of relative abundance for several demersal and deep-sea exploited fish species, mainly red sea bream, in the Azorean region (Menezes, 1996). The results on Golden eye perch; abundance, length frequency distributions and demersal and deep-sea communities by stratum (geographical area and depth) were presented to the 1996 Study Group (ICES, C.M.1996/Assess:8).

16.3 Length and Age compositions

No new data were available to the Study Group for Sub-area X. In the 1996 Report length and age compositions of the catches in this area were presented for the period 1983–1993 (ICES C.M.1996/Assess:8); da Silva and G Menezes, 1996). From the other Sub-areas no data on length and age compositions in all the time series considered have been available to the Study Group.

16.4 Biological parameters

Information on length-weight relationship, spawning season, depth distribution and others biological items from Sub-area X (Azorean region and in the Mid-Atlantic Ridge) were reported in 1996 (ICES, 1996: da Silva *et al.* 1996). New data are available on length and age maturity of both species in Sub-area X (Krug & Mendonça, pers.com.):

	ICES	Length at maturity (cm)			Age at maturity (years)		
Species	Sub-area	Males	Females	All	Males	Females	All
Beryx decadactylus	X	30.3	32.5	32	4	5	5
Beryx splendens	X	22.9	23	22.9	2	2-3	2

16.5 Assessment

No assessment was attempted in 1998 by the Study Group due to the lack of the basic data.

16.6 Biological reference points

As no assessment was carried out by the Study Group, no biological reference points have been considered.

16.7 Comments on the Assessment

No comments because no assessment.

16.8 Management considerations

No management considerations.

17 OTHER SPECIES

This section will consider only bycatch and/or discard species not specifically dealt with under Sections 7 to 15.

Most of the new biological and other information gathered since the last report in 1996 (C.M. 1996/Assess:8) originates from the current multinational EC FAIR Project (95/655) entitled *Developing deep-water fisheries: data for their assessment and for understanding their interaction with and impact on a fragile environment* which is described in Section 2.3.1. The results are summarised in the first and second unpublished progress reports (FAIR, 1996 and FAIR 1998).The information will become available with the release of the FAIR project's final report in 1999 and subsequent dissemination by the individual partners, if not already published.

17.1 Research and Exploratory Surveys

The following Table 17.1 lists relevant cruises by country of either research vessel surveys, or exploratory operations with observers on board commercial vessels directed totally or in part to deep-water fishes and discard studies. Only activities since the 1996 Study Group report are listed.

17.1.1 Faroe Islands

The trawl surveys of the R/V 'Magnus Heinason' to the Mid Atlantic Ridge in January 1997 and February. 1997 and February 1998 focused on Orange Roughy (*Hoplostethus atlanticus*) as main target species, but all bycatch species were also recorded.

An experimental longlining survey with a chartered fishing vessel took place in August 1997 to the Reykjanes Ridge. Bottom and vertical longlines were used at 585–1685 m depth, and 23 fish species were taken. Giant redfish was most abundant in the upper part of the depth range, where tusk was also taken in small numbers. Sharks of *Etmopterus* spp. were the major catch with bottom longlines everywhere. Greenland halibut and roughhead grenadier were only taken at the greatest depths. In total the results were rather unsatisfactory (Smirnov & Vinnichenko WD).

17.1.2 France

In the course of the FAIR Project (95-655), discard studies on board commercial trawlers were carried out by IFREMER from 1995 to 1997, with a total of 55 bottom trawl hauls at 875–1300 m depth within the Rockall Trough. Some 60 fish species were represented in catches, of which 10 were landed regularly, another 50 were mostly discarded. Only about 10 of these 50 species were landed regularly (FAIR; 1996,1998). More detailed biological studies centred on roundnose grenadier and orange roughy.

Studies on the reproduction of two deep-water squaloid sharks (*Centroscymnus coelolepis*, *Centrophorus squamosus*), caught in the Rockall Trough and landed under the combined vernacular name *Siki*, were also part of the project work by the CollПge de France. More than two thirds of the former species, the Portuguese shark, were mature specimens both sexes, while three quarters of males and one fifth of females of the latter, the leafscale gulpershark, were mature (FAIR,1998).

French FAIR project work also resulted in length frequency, vertical and horizontal distribution data for a number of non-target deep-water species within the Rockall Trough and beyond, as well as good information on the faunal composition (FAIR, 1998).

17.1.3 Germany

Apart from the preliminary landings data of 1997 for a selection of the deep-water species, Germany has not carried out deep-water research activities or sampling during 1997. Historical German research data on deep-water surveys from 1974–1986 with FRV 'Walther Herwig', mainly in the Rockall Trough area, are being reworked and analysed in the course of the FAIR Project (95-655) by the Institute for Sea Fisheries Hamburg and will become available, together with historical biological information, to the Study Group and for assessment purposes.

17.1.4 Greece

Although not a member of the Study Group, Greece is mentioned here because it is a participant in the FAIR Project (95/655). Studies include reworking of historical Greek data from 1983 to 1985 in the Ionian Sea, from 1991 to 1993 in the Thracian Sea and from 1990 to 1992 in the Aegean Sea. A new seasonal deep-water trawling survey is being carried out in the Ionian Sea. These studies of discards and biological parameters of species, including crustaceans, which occur in both the Mediterranean and the northeastern Atlantic could be of interest to the Study Group (FAIR, 1996,1998).

17.1.5 Greenland

No surveys in ICES areas in 1997.

17.1.6 Iceland

Since the meeting of the Study Group in 1996, a considerable amount of biological data on deep-water species has been collected during three surveys. Two of these surveys were groundfish surveys for Greenland halibut and deep-sea redfish carried out in October 1996 and 1997. They covered the deep slope area from 500 m to 1200 m around Iceland (ICES Division Va). In both surveys, a great variety (90 - 100) of non-target deep-water species were caught. The third survey was for the EC funded project (FAIR 95/655) and carried out in June/July 1997. This survey was directed to the deep water area of the Reykjanes Ridge in Division Va, Sub-area XII and Division XIVb. During this survey, about 80 species of fish were recorded but the most commonly caught and the most numerous one was the roundnose grenadier (*Coryphaenoides rupestris*). Other common species were, e.g., Smoothheads (Alepocephalidae: *Alepocephalus bairdii* and *A. agassizii*) but also *Sebastes mentella* and *Reinhardtius hippoglossoides* were quite frequently caught. A catch of about 5.5 tonnes of orange roughy (*Hoplostethus atlanticus*) was obtained in one haul, but otherwise this species was observed only at very few localities. Black scabbard fish, (*Aphanopus carbo*) roughhead grenadier (*Macrourus berglax*), blue antimora (*Antimora rostrata*) and North Atlantic codling (*Lepidion* eques) were, e.g., also frequently caught, as well as a number of various sharks and dogfishes.

Information on areal- and depth distribution, length, weight, sex and maturity was collected during these cruises on a great number of deep water fish species. Otolith samples were collected from some species, and stomachs of a few species were examined.

A regular sampling programme of data on ling, blue ling and tusk has been incorporated in the regular sampling programme of the Marine Research Institute (MRI). The data sampling on greater silver smelt or argentine (*Aregentina silus*) has been greatly increased in correlation with the increased landings. Age determinations have been carried out on ling, tusk and greater silver smelt.

During the three surveys mentioned above, a great number of deep water fish species were caught and sampled. Part of these data are being made available in a report which will be published in Hafrannsóknastofnun Fjölrit (Magnússon *et al.*, in press). Table 17.2 indicates, what kind of information will be made available for the selection of species shown.

17.1.7 Ireland

A trawl survey in 1996 (Kelly *et al.*, 1997) and two exploratory surveys in 1997 for deep-water bottom trawling (Clarke, 1997) and longlining (Connolly, 1997) in ICES Division VI contributed to the Irish participation in the FAIR Project (95-655). Of the latter two, the longlining operation was considered successful with a catch rate of about 10 % of the baited hooks. The longlines were especially notable for the large catches of deep-water sharks and data on length, weight, maturity, fin spines, vertebral centra, gonads were collected. Attention was also paid to the level of contamination in body tissues of the long lived deep-water fish, and samples from species of potential commercial interest will be analysed. The 1997 trawl survey was also successful and special attention was given to discards and otolith sampling. The Irish studies also focus on the biology and ageing of deep-water, mainly squaloid sharks. A lot of new biological information on deep-water fishes is to be expected from the Irish contribution to the FAIR Project.

17.1.8 Italy

Though not being a member of the Study Group, Italy is mentioned here because it is a participant in the FAIR Project. Field work and studies during 1996 and 1997 (six trawl surveys) were in the northwestern Ionian Sea. The emphasis was on discards in relation to mesh size and biological parameters. Studies were carried out on the reproduction and growth of target and non-target species, including crustaceans, some of which also occur in the northeastern Atlantic (FAIR; 1996, 1998).

17.1.9 Norway

Norway is also a participant in the FAIR Project and contributes to discard studies from Norwegian longline fishery in the North Atlantic, as well as to investigations on biological parameters, e.g., age and reproduction, and on the horizontal and vertical distribution of target and non-target fish species. The Norwegian deep-water fishery with trawlers and longliners is wide ranging in the North Atlantic, e.g., including the Reykjanes and Mid Atlantic Ridges, and valuable new information is to be expected, especially on distribution and migration patterns of various deep-water species (FAIR, 1998).

In a working paper to the Study Group (Hareide, WD) describes the Norwegian longline fishery on the Reykjanes Ridge since 1996. This fishery rapidly developed and expanded from about 61° N south to 54° N operating near the summits of seamounts and coral areas. There were considerable losses of gear and the commercial fishery changed from bottom to vertical longlines. Though giant redfish, tusk and Greenland halibut were the main target species in a depth range between 400–1700 m, considerable bycatches of grenadiers, morids, squalid sharks and chimaeras was taken and the discards were recorded. This fishery declined in 1997 because of reduced catch rates and an increase of by catch species.

In another Working Document by Hareide *et al.* a report is given of the exploratory deep-water longlining and trapping on the Reykjanes Ridge in July 1997. Operational areas on the Ridge were seamounts between 52 and 57° N and 30 and 35° N. The Table 17.3 summarises the biological samples and data obtained.

Roughhead grenadiers (*Macrourus berglax*) were taken at a depth range of 750–1750 m, and length frequencies by sex were recorded. Blue catfish (*Anarichas denticulatus*) was most abundant between 450 m and 1400 m, and also length frequencies by sex were recorded, plus lengths separated for catches by longlines and traps. Catch results were considered to have been distinctly less than those in 1996 for target species giant redfish, tusk and Greenland halibut, probably because of overexploitation of these species in the area for several years.

17.1.10 Portugal

17.1.10.1 Portugal, Mainland

For mainland Portugal, most of the recent information originates from participation in the FAIR Project (95/655) and concerns fisheries for and studies on crustaceans and fish. The trawl fishery for shrimps and *Nephrops* in deeper water along the Portuguese slope takes a considerable bycatch of deep-water fish, with some of these species now becoming of commercial interest and being landed. A directed longline fishery for deep-water sharks is based in the north of Portugal, with fishing grounds at 800–1400 m or deeper off the Galician coast of Spain. The dominant species in catches and landings is the gulpershark (*Centrophorus granulosus*), along with smaller quantities of leafscale gulpershark and Portuguese shark and a bycatch of various bony fishes. At the start of the fishery only the shark livers were kept on board, for squalene oil production, and the carcasses were discarded at sea. Now the sharks are gutted, skinned on board and landed without the head for human consumption. However, since 1992 catches of these deep-water sharks have steadily decreased, which may result from overexploitation.

Landings of deep-water species were also investigated at two ports on the west and south coast of Portugal to quantify the spectrum of species and the reliability of species identification. The latter was fairly well done by the fishermen, with a low rate of unspecified landings and very few misidentifications mainly among squaloid sharks.

Biological parameters of selected deep-water species are also among the project tasks and focus on distribution, abundance and population dynamics of fish and crustaceans, as well as on age determination of selected bony fishes and sharks. (FAIR 1996, 1998).

17.1.10.2 Portugal, Acores

Some biological information on size/age at first maturity of six bony fish species, plus fecundity of one of these, which all result from investigations under EEC DG-XIV Study Contract 95/032, were supplied to the Study Group by Menezes (Table 17.4). In addition, some landings data for 1997 (up to October) were provided (Table 17.5).

17.1.11 Russia

Russian deep-water investigations and fisheries during 1996 and 1997 were focused on the roundnose grenadier on the Mid Atlantic Ridge (Section 12).

The Russian member of the Study Group reported on the recent longline fishery at 200-500 m depth in the western Barents Sea. Target species were cod and blue catfish (*Anarichas denticulatus*), but a bycatch of roughhead grenadier (*Macrourus berglax*) was landed. Though exact data were not available, it was estimated that the catch was in the order of 20-30 tonnes in 1996, when this fishery began, and about 50 tonnes in 1997. The roughhead grenadier is processed ashore for the manufacture of good quality fish fingers (Vinnichenko, pers. comm. 1998).

17.1.12 Spain

Spanish deep-water fisheries in the northeastern Atlantic harvested mainly bycatches obtained in mixed fisheries with different kinds of gear and thus covered a wide area of operations (ICES Sub-areas VI and VII, XII, and Divisions VIIIa-d and IXa). Only in recent years have new directed deep-water fisheries been established. These are primarily on a small scale, i.e., as experimental fishing, for only part of the year, and including artisanal fisheries along the Cantabrian and south coast of Spain. (Casas, WD).

17.1.12.1 Galicia

The deep-water fisheries of ICES subareas VI and VII and divisions VIIIc and IXa have been described as part of the FAIR Project. This has included descriptions of the Spanish fleets involved in the fisheries, species composition of catches for both, target and non-target species, estimates of landings and discards quantitatively and by species, investigations of distributions and biological data. Vessels from Cantabria and Galicia operating in ICES Sub-areas VI, VII and Divisions VIIIa-c fished for deep-water fishes rather temporarily and opportunistically. Historical research vessel survey data since 1983 are also being analysed. An exploratory cruise in 1996 with two commercial trawlers fished the slope off Galicia at 600−1300 m. (FAIR, 1998).

17.1.12.2 Basque Country

A consistent and progressive decline of fishing effort by the Basque fleet has been observed during 1994−1997 for individual trawlers of two different types, whereas pair-trawlers showed increasing activities. Operational areas were nearly identical to those specified above for the Galician activities, and a variety of deep-water bony and cartilaginous fishes have been taken as bycatch of directed fisheries for hake, anglerfish and megrim. Landings of such species very much depend on appreciation of the market but have decreased during 1997, except for *Conger* eels and deep-water sharks. Discard information is not available, but landings of various species were registered on monthly basis. (Lucio and Artetxe, WD).

17.1.12.3 Baleares Islands

Though not being a member of the Study Group, Mediterranean Spain is mentioned here in context with its participation in the FAIR Project through the CSIC at Mallorca and the CSIC Barcelona. The research project investigates the deep-water resources in the Catalan Sea. Studies include evaluation of historical research data from this area. Biological, bycatch and discard studies of fish and shrimp fisheries might be of interest in comparison with NE Atlantic investigations, as many species are common to the deep-water faunal communities in both regions. (FAIR; 1996, 1998).

17.1.13 United Kingdom

In the course of the FAIR Project, the Scottish Association for Marine Science has focused on biological studies of both, target and non-target species. New biological data was obtained from two cruises of RRS *Challenger* FRV *Scotia.* A study of the notacanthid species was completed (Coggan *et al.*, in press). A detailed study of the non-target macrourid, *Nezumia aequalis*, is nearing completion. Age and growth studies, including validation, of macrourid fishes are continuing. The distribution and abundance of deep-water squalid and scyliorhinid sharks on the continental slope to the west of the British Isles have been described (Gordon and Swan, 1997). Establishing age-length keys for a variety of species and discard studies on the Scottish deep water fleet are other important contributions by Marine Laboratory, Aberdeen to the FAIR project (FAIR, 1996,1998).

17.2 Elasmobranchs (Sharks and Skates)

It was a recommendation of this Study Group that in future all aspects of deep-water sharks and skates should be dealt with by the Study Group for Elasmobranch Fishes (Section 18).

Information and data presented here results from unpublished FAIR Project (95/655) reports, Study Group Working Documents and contributions by Study Group members.

Iceland has obtained new information, mostly from Division Va and research surveys, on length frequencies by sex, weight and maturity stages for most of the following species: *Centroscyllium fabricii*, *Centroscymnus crepidater*, *C. coelolepis*, *Deania calcea*, *Etmopterus princeps*, *Apristurus laurussoni*, *Galeus murinus* (Magnússon, pers. comm.)

A working document to this Study Group by Smirnov & Vinnichenko reported on an experimental longline cruise by the Faroe Islands to the Reykjanes Ridge in 1997. In catches with bottom longlines, sharks predominated everywhere, with *Etmopterus* species being the most numerous. Peak mean catches of nearly 350 kg/1000 hooks of sharks, skates and chimaeras were taken at about 800 m depth. Sharks alone comprised about 30-50 kg/1000 hooks from ca. 650-850 m

depth. All chondrichthyans constituted 47 % of the total weight of the catch. Table 17.6 summarises chondrichthyan results of this survey.

Another working document to the Study Group by Moura *et al.* provided landings data for mainland Portugal and the Acores of *Chimaera monstrosa*, *Galeus melastomus* and a number of deep-water squalid sharks. Targeted and bycatch fisheries are commented on in relation to fishing gear, fleet, form of landings, particular fishing areas and depth range.
Another working document by Casas reports on target and bycatch fisheries on deep-water sharks in Spain, including landings at different ports mainly in northern Spain. Some biological information is also given on sex separation and length- weight relationships for several shark species, as well as length ranges.

The Working Document by Hareide describes the Norwegian longline fishery in 1996 on the Reykjanes Ridge and reports on by-catch of chondrichthyans at 61^{o} N at depths between 400 and 1900 m with bottom lines. Vertical lines at 56^{o} N in the 400–1000 m depth range yielded about one third of the total catch weight of great lantern sharks (*Etmopterus princeps*) as well as other species of sharks and chimaeras.

Another Working Document by Hareide *et al.* reports on longline and trapping experiments on the Reykjanes Ridge in July 1997 at several seamounts and submarine banks between 52-57^{o} N and 30-35^{o} N. Among several species of chondrichthyans, the great lanternshark (*E. princeps*) was very abundant in vertical line catches at 750-950 m, but on bottom lines it was found down to near 1600 m, with largest numbers taken between 760 m and 1030 m. On vertical lines, this species represented at some stations the largest number of fish taken, with maxima up to 1300 kg/1000 hooks. Interestingly, the length distribution of *E. princeps* varied considerably between the different banks.

The second interim report of the FAIR Project (FAIR, 1998) provides some general and detailed information by various project partners on chondrichthyan fishes with regard to fleet structure, catches and landings, utilisation, discards, and a variety of biological data. As this document is an unpublished internal report and the entire project results will become available only with the final project report to be released in 1999, plus published dissemination to follow, only brief reference is given here to what might be expected.

Gordon & Swan (1997) have summarised the distribution and abundance of deep-water sharks on the slope to the west of the British Isles. These were nine squalid sharks (*Centrophorus squamosus, Centroscyllium fabricii, Centroscymnus coelolepis, C. crepidater, Dalatias licha, Deania calcea, Etmopterus princeps, E. spinax, Scymnodon ringens*) and three scyliorhinid sharks (*Apristurus spp., Galeus melastomus, G. murinus*). Although deep-water sharks, especially squalids, account for a significant portion of bottom trawl and longline catches, only a few species are landed, and sometimes only the liver is retained. Discard information is scarce, and there are major problems with the correct identification of both discards and landings by species. Data on depth distribution (to 3 000 m) and catch rates for the species are also given.

French contributions to the FAIR report (FAIR 1998) specify some chondrichthyan discards in the French trawl fishery for roundnose grenadier in ICES subareas VI and VII. Results on the reproduction of deep-water sharks (*Centrophorus squamosus* and *Centroscymnus coelolepis*) from the Rockall Trough region, from material obtained on board commercial vessels at 700–1200 m depth, are also given in the FAIR report.

The Irish contribution to the FAIR Project provides survey results from the Rockall Trough and includes biological information on deep-water squalid sharks. Studies on age estimation and reproduction are key areas and commercial landings data are also provided (FAIR 1998).

Descriptions of the Portuguese deep-water shark fisheries, including by-catch and some discard studies, and their fishing areas and the gears used are given in the FAIR report (FAIR, 1998). *Centrophorus granulosus* is the most abundant species utilised, and sex ratios plus length frequencies are given for several, mainly squalid species.

The Spanish contribution to the FAIR report includes a description of deep-water shark fisheries mainly from northern Spain and further north into the Rockall Trough area. Landings and discards are given for few squalid shark species and *Galeus melastomus.* Biological information includes length ranges, length-weight relations and sex ratios.

17.3 Landings reports

Tables 17.7 to 17.13 give updated landings information, as reported to the Study Group, for species which have been included in previous reports and are not included in Sections 7 to 16 of this report.

18 RECOMMENDATIONS

1) The Study Group noted the comments made at the Joint Session of the Demersal Fish and Pelagic Fish Committees at the 1997 ICES Annual Science Conference and some discussion notes provided by the Chair of the Study Group on Elasmobranch Fishes (SGEF) on the possible merger of the Groups. A suggested merger with the Study Group on Assessment of Other Fish and Shellfish Species (SGASSO) was also noted. In view of the continuing development of assessment expertise within the Group it was considered that it was the availability of data rather than the methodology that was the limiting factor. The members were united in the view that SGDEEP should maintain its separate identity. The Study Group therefore recommends that it should not be merged with any other group.

2) The suggestion made at the October meeting of ACFM (draft minutes) that a joint meeting be held with Study Group on Assessment of Other Fish and Shellfish Species (SGASSO) was discussed. It was considered that such a meeting was inappropriate at the present time for the reasons mentioned in Recommendation 1, but that members should be encouraged to participate in both groups. The Study Group therefore recommends that a joint meeting with SGASSO is unnecessary at the present time.

3) The Study Group considered the proposal that deep-water sharks and rays should be included in its terms of reference but was of the opinion that they were more appropriately placed to the Study Group on Elasmobranch Fishes (SGEF). Assessment methods for elasmobranch fishes are likely to be very specialised and are still under development. The Study Group therefore recommends that all aspects of the biology, assessment and management of deep-water elasmobranch fishes should be included in the terms of reference of the Study Group on Elasmobranch Fishes.

4) The Study group recommends that member states should be encouraged to collect catch and landings data from fishing activities in the parts of the ICES Area which lie outside EEZs and report them to ICES.

5) The catch and effort assessment methods used by the Group suggest that time series of effort and CPUE may be particularly valuable for the assessment of deep-water species. The Study Group recommends that member states maintain and refine long-term data series and where possible collate historical data.

6) The Study Group noted that the final report of the EC FAIR project (Developing deep-water fisheries: data for their assessment and for understanding their interaction with and impact on a fragile environment) should be available in the summer of 1999. This would contain a great amount of information of value to the Group. The Study Group therefore recommends that their next meeting be held in late 1999.

7) The Study Group recommends that stock and assessment coordinators be appointed to encourage intersessional work.

8) The Study Group recommends that the members be encouraged to provide discard and fish community data.

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APPENDIX 1
LIST OF PARTICIPANTS

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Dr John D.M. Gordon (Chairman)	Dunstaffnage Marine Laboratory P.O. Box 3, Oban, Argyll PA34 4AD Scotland United Kingdom	+44 1631 567822	+44 1631 565518	jdmg@dml.ac.uk
Dr Odd Aksel Bergstad	Institute of Marine Research Flødevigen Marine Research Station N-4817 His Norway	+47 370 59 019	+47 370 59 001	odd.aksel.bergstad@imr.no
W. Ray Bowering	NW Atlantic Fisheries Center P.O. Box 5667 St. John's, NF Canada A1C 5X1	+1 709 772 2054	+1 709 772 4188	bowering@athena.nwafc.nf.ca
José Miguel Casas	Instituto Español de Oceanografía C.O. de Vigo Apartado 1552 36200 Vigo Spain	+34 86 49 21 11	+34 86 49 23 51	mikel.casas@vi.ieo.es
John Hislop	FRS The Marine Laboratory P.O. Box 101, Victoria Road Aberdeen AB11 9DB Scotland United Kingdom	+44 1224 295412	+44 1224 295511	hislopjrg@marlab.ac.uk

NAME	ADDRESS	TELEPHONE	FAX	E-MAIL
Ole A. Jørgensen	Greenland Institute of Natural Resources P.O. Box 2151 Pilestræde 52 1016 Copenhagen K Denmark	+45 33 69 34 61	+45 33 69 34 06	grfioaj@inet.uni2.dk
Dr Ciaran Kelly	Marine Institute Fisheries Research Centre Abbotstown Dublin 15 Ireland	+353 18210111	+353 18205078	ckelly@frc.ie
Philip Large	CEFAS Lowestoft Laboratory Pakefield Road Lowestoft, Suffolk NR33 0HT United Kingdom	+44 1502 562244	+44 1502 524511	p.a.large@ cefas.co.uk
Pascal Lorance	IFREMER 150, quai Gambetta B.P. 699 62321 Boulogne-sur-Mer France	+33 321 99 56 10	+33 321 99 56 01	pascal.lorance@ ifremer.fr
Paulino Lucio	AZTI Instituto Tecnologico Pesquero y Alimentario Txatxarramendi Irla s/n 48395 Sukarrieta Bizkaia Spain	+34 4 6870700	+34 4 6870006	paulino@rp.azti.es
Jutta V. Magnússon	Marine Research Institute Skúlagata 4 P.O. Box 1390 121 Reykjavík Iceland	+354 552 0240	+354 562 3790	jutta@hafro.is
Olga Moura	Instituto de Investigação das Pescas e do Mar Av. Brasilia 1400 Lisboa Portugal	+351 1301 0814	+351 1301 5948	
Jákup Reinert	Fisheries Laboratory of the Faroes Nóatún P.O. Box 3051 FR−110 Tórshavn Faroe Islands	+298 15092	+298 18264	jakupr@frs.fo
Dr Matthias Stehmann	Bundesforschungsanstalt für Fischerei Institut für Seefischerei Palmaille 9 22767 Hamburg Germany	+49 40 38905 217	+49 4038905 263	106241.1657@ compuserve.com
Vladimir Vinnichenko	PINRO Knipovich st. 6 183763 Murmansk Russia	+7 81 52 47 43 24	+47 789 10 518	inter@pinro. murmansk.ru

APPENDIX 2

Method of the pseudo-cohort analysis corrected by effort. (see section 11)

This pseudo-cohort analysis proceeds by direct calculation (forward the ages).
The catch at the first age group caught is:

$$C_1 = R \cdot \frac{F_{1,I}}{F_{1,I} + M}(1 - e^{(F_{1,I}+M)}) \quad (1);$$

where:
$F_{1,I}$: the fishing mortality of age 1 in year I (the analysed year);
M: natural mortality;
R: Recruitment (number of the first age group appearing in the catch at the beginning of year I).

Iterate resolution of (1) gives $F_{1,I}$; then, the catchability of age 1 can be calculated as:

$$q_1 = F_{1,I} \Big/ E_I \quad (2)$$

where E_I is the fishing effort in year I.

Passing to the next cohort in the catch at age vector is done by calculating the number of survivors of this cohort at the beginning of year I from its catchability as age 1 under effort E_{I-1} in the previous year:

$$F_{1,I-1} = q_1 \cdot E_{I-1} \quad (3)$$

And the number of survivals at the beginning of year I was:

$$N_{2,I} = R \cdot e^{-[(q_1 \cdot E_{I-1})+M]} \quad (4)$$

Then

$$C_2 = N_{2,I} \cdot \frac{F_{2,I}}{F_{2,I} + M}(1 - e^{(F_{2,I}+M)}) \quad (5)$$

Can be solved.

and $q_2 = F_{2,I} \Big/ E_I$ (6)

Then the number of survivors of cohort *I-2* at the beginning of year I is obtained from:

$$N_{3,I} = R \cdot e^{-((q_1 \cdot E_{I-2} + q_2 \cdot E_{I-1})+2M} \quad (7);$$

(7) can be generalized as:

$$N_{a,I} = R \cdot e^{-(\sum_{k=1}^{a-1} q_a \cdot E_{I-(a-k)} + (a-1)M)} \quad (8);$$

The catch equation of age a is:

$$C_a = N_{a,I} \cdot \frac{F_{a,I}}{F_{a,I} + M}(1 - e^{-(F_{a,I}+M)}) \quad (9);$$

It allows to calculate catchability of age a:

$$q_a = F_{a,I} \Big/ E_I$$

The program works out this analysis by iterations in order to find the input terminal F. The iterations on the recrutement are initiated with $R = 10^5 \cdot C_1$.