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REPORT OF THE

WORKING GROUP ON ELASMOBRANCH FISHES

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International Council for the Exploration of the Sea

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1 INTRODUCTION

1.1 Terms of reference

The Terms of Reference for the **Study Group on Elasmobranch Fishes** [SGEF Chair: Dr Mike Pawson, CEFAS, England] as agreed by ACFM in October 2001 are that it will meet in Copenhagen, Denmark, from 6-10 May 2002 to:

a) Carry out preliminary assessments of the nine case study species (blue shark in the North Atlantic; Portuguese dogfish, black-mouthed dogfish, kitefin shark and spurdog in the NE Atlantic; cuckoo ray in VIIf,g,h & VIIIa,b; thornback ray in IV; lesser spotted dogfish in VIIIc) in conjunction with the EU-funded project DELASS, and evaluate the adequacy of these assessments for providing advice on stock status in relation to biological reference points;

b) report on the development and progress in the study and assessment of elasmobranch fisheries and stocks;

c) report on progress with plans for the NAFO Scientific Council Special Session, the Symposium on " Elasmobranch Fisheries: managing for sustainable use and biodiversity conservation " (ICES is a co-sponsor), to be held during 11-13 September 2002; and

d) report on progress in preparing for a joint ICCAT/ICES workshop on assessment of pelagic sharks in the North Atlantic in June-July 2002;

1.2 Participants:

Mike Pawson has acted as chair of SGEF since July 2001 in view of the long-term illness of Dr Paddy Walker. Paddy resigned as chair SGEF in March this year, and Mike has continued as chair for the remainder of what would have been Paddy's final year. The following members of SGEF and participants in the DELASS project took part in this meeting.

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1.3 Background to report

SGEF has not met formally since March 1999, when a meeting (ICES 1999/G:11) was held concurrent with that of a Concerted Action (FAIR CT98-4156) to prepare a proposal for stock assessment of some elasmobranch fishes in European waters. The proposal arising from the concerted action resulted in a 3-year project "Development of Elasmobranch Assessments" (DELASS, CFP 99/055), bringing together scientists in Europe who are currently working on the biology and assessment of elasmobranch species.

With respect to TOR a), ICES is required to provide advice on the status of important elasmobranch stocks by 2005 (Intermediate Ministerial Meeting, Bergen, 1997). Since the main task within DELASS is to explore and develop assessment methodologies that are appropriate to elasmobranch fishes, the opportunity was taken to present and review those preliminary assessments of the case study species that had been carried out at this joint meeting of SGEF and DELASS. The results are presented in section 4.

Given that the assessment of blue shark requires data from fisheries across the North Atlantic, a joint ICCAT/ICES workshop on assessment of pelagic sharks was scheduled to be held in June-July 2002 (TOR d). This has been superseded by a meeting of experts held in Dublin in January 2002, and a report on its outcome is presented in section 3.

In addition to stock assessments, other deliverables from DELASS include an evaluation of the application of analytical models to assess the status of stocks in relation to sustainable exploitation (in data-poor situations); stock identity (in relation to assessment and management) and structuring in populations of sharks, dogfish, skates and rays; and species identification in relation to the collection of catch etc statistics from fisheries. A brief report on the other tasks carried out within DELASS is given in section 2 (TOR b).

These topics will be covered by theme sessions at a NAFO Scientific Council Special Session, the Symposium on Elasmobranch Fisheries: managing for sustainable use and biodiversity conservation (TOR c), a progress report on plans and arrangements for which is presented in section 5.

One additional task has been given to SGEF for this meeting: to assist OSPAR in carrying out a review of the evidence upon which a priority list of threatened and endangered species and habitats (in this case elasmobranchs only) is proposed in relation to implementation of the OSPAR Commission's Biodiversity Strategy. This is dealt with in section 6.

The Study Group’s recommendations for the future of elasmobranch stock assessments within ICES are given in Section 7.

2 DEVELOPMENT AND PROGRESS IN THE STUDY AND ASSESSMENT OF ELASMOBRANCH FISHERIES AND STOCKS

2.1 Background

Last year's SGEF report (ICES 2001a) described progress made in the DELASS project up to August 2001. The Second Interim Report of DELASS was produced in January 2002, and this is summarised here and updated to May 2002 to inform ACFM of its progress. DELASS is an international research project in which 15 European research institutes and 2 sub-contractors participate. The duration of the project is three years (2000 - 2002), and its main objective is the improvement of the scientific basis for the management of fisheries taking elasmobranch species. By the end of the contract period (December 2002), DELASS aims to provide assessments of 4 species of NE Atlantic sharks, 3 dogfish and 2 ray species.

In order to increase the chance of useful assessments, a selection of case study species which are representative for either groups of elasmobranchs, or ecosystems was made. The criteria used to identify the species were that they represent the major ecotypes and production types, e.g. oviparous vs. viviparous, in the NE Atlantic; they are commercially important to the countries participating in the study and may require management; and there is a possibility of establishing stock assessment methods with the available data or a minimum of new data collection.

Nine species were chosen, in four categories:

Deep-water sharks: *Centroscymnus coelolepis* (Portuguese dogfish)
Centrophorus squamosus (leaf-scale gulper shark)
Dalatias licha (kitefin shark)
Galeus melastomus (blackmouth catshark)

Pelagic sharks: *Prionace glauca* (blue shark)

Skates and rays: *Raja clavata* (thornback ray)
*Raja (*now *Leucoraja) naevus* (cuckoo ray)

Coastal dogfish and catsharks: *Squalus acanthias* (spurdog)
Scyliorhinus canicula (lesser spotted dogfish)

The following sections summarise the work of each country carried out within DELASS through 2001 and early 2002.

2.2 Task 1: Species identification and biological sampling

The objective is to describe the elasmobranch fisheries of the NE Atlantic and enhance the quality of data from existing stock monitoring programmes through the production and application of field keys to common species of shelf rays, skates and deep-water sharks, training sampling staff in elasmobranch identification, and establishing agreed sampling protocols for elasmobranchs.

2.2.1 Species identification and market sampling

Denmark. Market sampling of rays and skates by DIFRES continued in 2001, though it has been very difficult to obtain samples from the scattered landings. Identification of skate wings from fish caught in the deeper parts of the north-eastern North Sea and on the slopes of the Norwegian Sea using the DELASS field key suggested that the most likely species would be common skate(*R. batis*), but examination of a whole specimen showed it to be a sailray (*R. lintea*) - unfortunately not included in the project's field key to ray wings. It is concluded that all individuals (except three *R. oxyrinchus*) sampled through the whole period were the sailray.

Netherlands. A length sampling programme of landings of rays and skates by beam trawlers at IJmuiden and Stellendam markets has continued through 2001. These landings came mainly from the south-west North Sea, and contained spotted ray (*R. montagui*), followed by thornback ray (*R. clavata*) and increasing numbers of blonde ray (*R. brachyura*). In order to prepare additional identification material, photographs were made of several other elasmobranch species.

UK.. Market and discard sampling work by FRS in Scotland intensified during the 2001 as it revealed more species landed than expected from previous landings of unsorted skates and rays: so far, 7 species have been identified: *R. montagui*, *R. naevus*, *R. batis*, *R. clavata*, *R. fullonica*, *R. alba* and *R. brachyura,* in order of importance. Monthly market sampling of deep-water sharks, *C. coelolepis* and *C. squamosus*, landed by trawlers at the west of Scotland port of Lochinver has continued, and SAMS carried out three discard trips on commercial trawlers engaged in deep-water fishing to the west of Scotland. CEFAS has sampled English landings of rays and skates from the North Sea by species since 2001.

Ireland. Poster keys used to train MI staff in identification of skates and of deep-water sharks were summarised as laminated leaflets as an aid to sampling staff and fisheries officers. In addition, a portable key for deep-water rays was produced. A preliminary market sampling study was carried out to develop protocols for rays and to develop guidance for optimal sample size, in preparation for Ireland's responsibility under the EU “Data Directive" commencing in 2002. Biological sampling of *S. acanthias* was carried out.

Belgium. An estimation of the species composition of *Rajidae* in landings was made separately for the North Sea, Eastern Channel and Celtic and Irish Sea, where catches were mainly *R. clavata* and *R. montagui* and to a lesser extent *R. brachyura,* with some *R. naevus* and *R. circularis*. *R. clavata* and *R. naevus* were found in the Bay of Biscay.

France. Information on fishing effort (in fishing days) and the weight and value of cuckoo rays landed monthly from 1986 to 1998 by French trawlers by ICES rectangle and statistical area and by fleet and fishing gear were selected from the data files of the IFREMER CRTS (Regional Centre of Statistical Treatment). Cuckoo ray catches (in weight and number by gender) from the EVHOE surveys were also selected from 1987 to 2000, together with length frequency data for each station. The percentage cuckoo ray/total rays by area from these French data were used to estimate cuckoo ray landings of European countries (1989-1998) from aggregated ray landings by ICES area in the FAO database (see section 4.9.2).

Spain. AZTI has prepared an identification manual and protocols for collecting biological data obtained in the fishing ports and during the surveys on board commercial vessels. This manual includes photographs and a brief description of all species identified in the ports and during surveys. Biological sampling of elasmobranch catches at Basque Country markets continued throughout 2001: from by-catches in the otter trawler fleet (“baka” type) working in ICES Divisions VIIIa,b,d, and Sub-areas VII and VI, and from artisanal long liners fishing pelagic sharks (*P. glauca, Isurus oxyrinchus, Lamna nasus*) in the Bay of Biscay (Div. VIII a,b,c,d). An overview (by fishery) of ray and skate landings in Basque Country ports in the period 1994 to 2000 includes a description of the species compositions (in weight) by fleet, month and ICES area.

Biological information on rays and lesser spotted dogfish was collected by IEO from ICES Division VIIIc, monthly from July 2000 to September 2001. Biological sampling was carried out for the conversion of landed weight of *Raja* species to live wet weight. The collection of data on elasmobranch landings in the fishing ports of north and north-west

Spain (outside the Basque Country) was completed in December 2001. Estimates were made of the percentage in number of each species landed and length distributions by gear and ICES area. Landings data by gear were recompiled for the period 1996-2000 of sharks and skates from the continental shelf in ICES Sub-area VII and divisions VIIIa,b, VIIIc and IXa. Data on discarding and survival of lesser spotted dogfish were collected during three fishing trips.

Portugal. Results from a pilot sampling programme to evaluate the diversity of ray species landed in mainland Portugal and to get a preliminary characterisation of the fishing fleet's activity that captures these species (chiefly artisanal gillnets, which provide nearly 70% of the total landings of ray species in Portugal), were used to guide sampling of ray landings in Matosinhos and Peniche ports from May to December 2001, funded by the SAMFISH EU study project 99/009.

2.2.2 Age determination

Netherlands. Samples of ray vertebrae were collected for age determination during the first quarter IBTS and the third quarter Beam Trawl Survey, but it has been difficult to make growth rings clearly visible and age determination itself was only partly successful so far.

Ireland. Age estimates of *C. squamosus*, based on sectioned dorsal fin spines, are now available (Clarke et al. 2002).

France. Two staining methods - alizarin red S (Officer *et al*., 1996) and- Stoelzner's cobalt method (Hoenig and Brown, 1988) have been tested to improve the visibility of calcified growth rings in vertebrae, both for routine use and to specify the time of ring formation in relation to spawning. Though Stoelzner's method gave the best results, rings in many vertebrae are not clear and the timing of ring formation is not obvious.

2.2.3 Biological parameters

Norway. Biological sampling was carried out on *C. Coelolepis* and *C. centrophorus* on board three Norwegian longliners fishing on Hatton Bank in 2001, and the data were worked up in early 2002.

UK. Scottish length and weight data for four Raja spp have been supplemented and run through Minitab to produce new length/weight relationships. The relationship for a number of other elasmobranch species will be re-evaluated during 2002.

Ireland. Length-weight conversion factors are now available for *C. squamosus, C. coelolepis* and *G. melastomus*. Data are available from biological sampling carried out on trawl and long-line surveys. Selectivity data for deep-water sharks, by trawl and long-line were analysed.

Belgium. Rays caught during August 2001 on RV 'BELGICA' (mainly of *R. clavata* and *R. montagui*) were measured for total length and disc width, and conversion factors were calculated to enable disc width measurements on the historical CLO-DvZ database to be converted to total length.

France. Work on reproduction and ageing of cuckoo ray used landings into Concarneau from Divisions VII e-k and VIII a,b. Determination of maturity stage, by observation of claspers and ovaries, indicated the size at maturity for males is 59 cm TL and females 62 cm TL. Monthly estimates of the proportions of mature males and females and the different stages of development according to ovocyte diameter, were used to delineate the spawning season. The proportion of females with large ovocytes ready to spawn (diameter >20 mm) is nearly 50 % throughout the year, and several other morphometric measurements (weight of the nidamental gland, ovary and uterus, and hepato somatic index) indicating individual reproductive behaviour have confirmed the absence of synchronism in the spawning behaviour of the cuckoo ray population of the Celtic Sea, where each female appears to follow its own cycle, independent of others. The number of large ovocytes (>15 mm diameter) is about 20 to 30 for combined ovaries, and no difference was observed between the two ovaries.

Spain. Biological samples have been used by AZTI to identify deep-water shark species which are landed without head, fins and skin (only the "trunks") and to increase the basic biological information on these elasmobranch species landed by Basque fleets, especially length/weight (total, gutted and "trunk" weights) relationships. Biological sampling by IEO on *S. canicula, R. clavata, R. montagui* and *R. naevu*s has provided length-total weight conversion factors and sex ratios, and total length-wing length, total length-disc length and total weight-wing weight relationships have also been estimated for the rays. For *S. canicula,* length-gutted weight and total weight-gutted weight relationships have been obtained, mature ovaries were removed to study fecundity, and maturity stage has been determined by monthly observation of claspers and ovaries and gonad weights during one year.

Portugal. Between January and July 2001, IPIMAR and FFCUL collected biological samples of Portuguese dogfish monthly at Sesimbra port. No sampling was conducted on leaf-scale gulper shark due to budget and personnel constraints. Elasmobranchs accounted for almost 33% of the total catch weight in IPIMAR's September 2001 deep-water research survey on the Portuguese continental slope, with the blackmouth catshark being the most important species. Data on total and standard lengths, total and gutted, liver and gonad weights, sex and maturity stage were collected for some elasmobranch species, and dorsal spines were removal when available.

Azores. Six freshly juvenile specimens of *R. clavata* were collected on fishing surveys to provide material with which to clarify recently emerged doubts regarding the correct identification of this common species.

2.3 Task 2: Stock discrimination / separation

2.3.1 Work done to satisfy the objective to describe the distribution of each species' population and the fisheries exploiting them, and to identify self-contained stocks which might serve as management units

Netherlands. A questionnaire has been sent out to all partners to gather relevant data for thornback ray. Because landings data are mostly reported for all rays together, these data could not be used for stock discrimination nor, probably, for stock assessment.

UK. SAMS has continued to compile scientific literature on the four deep-water shark species *C. coelolepis, C. squamosus, D. licha* and *G. melastomus* which will be incorporated into the project's annotated bibliography. CEFAS circulated the information requirements for stock identity of all case study species, and provided a worked example on spurdog to act as a model for other species co-ordinators. The available data in relation to stock identity of all species have now been compiled, and preliminary drafts of stock identity descriptions were presented and discussed at a species co-ordinators meeting on 29-30 October 2001, in IJmuiden (Netherlands), when the sea areas for each species for which assessments should be attempted were agreed (see 2.3.2). Draft stock identity descriptions have been prepared for all case study species and edited to a standard format.

Ireland. Catch and distribution data on case study species from Irish trawl and long-line surveys were compiled and mapped. A document was prepared on the stock structure of the blue shark, with particular reference to the NE Atlantic, making reference to US, Irish and UK tagging studies and various biological studies. Data, from the Central Fisheries Board tagging programme for *R. clavata* in Irish waters are being collated

Spain. IEO-Santander and AZTI prepared a review of information on the distribution of lesser spotted dogfish and the fisheries exploiting them to identify self-contained stocks which might serve as management units, and data on biology, landings (by year, month, area and gear) and length compositions for use in the assessment in Division VIIIc were exchanged. Data on tagging and the spatial distribution of elasmobranchs, and the number and biomass by species, from research surveys in the north of Spain (1983 - 2001), were compiled and analysed by IEO.

Portugal. A preliminary description of the trammel and gillnet net fisheries was prepared for each of the ports of Matosinhos and Peniche, comprising target and by-catch species, fishing gear, number of vessels, duration of fishing and fishing area. Target species varies with season, and several species of rays are captured as by-catches, with undulate ray (*R. undulata*), thornback ray and blonde ray (*R. brachyura*) being the most common. Only cuckoo ray are separated to species, as they attain the highest market prices.

Azores. Information from research vessel surveys in Azorean waters was compiled on geographic/ bathymetric distribution and abundance of elasmobranch species. Liver/muscle tissue samples were collected from *Etmopterus spinax*, *E. pusillus*, *Centroscymnus crepidater*, *Deania histricosa* and *D. profundorum* to provide material for DNA fingerprinting of species which are widely distributed in the study area.

2.3.2 Summary of the stock identity findings

2.3.2.1 Spurdog

Has a world-wide distribution, but tends to be coastal. France, United Kingdom, Norway and Ireland all take spurdog in directed fisheries and as an important by-catch. Iceland has a small fishery, but it is not known to which stock these fish belong. There are no detailed studies on parasites nor on genetics and, though life history parameters are well established, different methodologies have been applied which make comparisons difficult. Several tagging experiments have been carried out which show that very few individuals cross the Atlantic, and indicate one stock around the British

Isles and including the Norwegian Sea. Though there are *Squalus* spp landings in Sub-area VIII, these may be from a different species.

Stock to be assessed in DELASS: IIa, IIIa, IV, V, VI, VII. Still to be decided how to deal with Iceland (Va).

2.3.2.2 Lesser spotted dogfish

Though the species' geographical distribution extends from Senegal to Norway, it is generally not commercially exploited and the discard rate in the commercial fishery is very high (up to 90% in VIIIc). Some data are available for France and Portugal, but the only useful available data are from Div. VIIIc for Spain. Tagging has resulted in most recaptures being reported from within a distance of 10 miles from the release area and with no apparent relationship between time at liberty and distance travelled. It seems that the species' distribution is continuous but with localised aggregations which are consistent over time. In the Cantabrian Sea, juveniles are found mostly in the eastern part, in deeper waters than adults, and they also occur in colder water. However, no information is available from shallow coastal areas. English surveys almost never catch juveniles, though hundreds of egg cases are caught in the Bristol Channel. There have been few studies on life history parameters, though further north specimens grow bigger than in Spanish waters. Because lesser spotted dogfish do not show a clear geographical migration, an assessment could in principle be based on any arbitrary ICES division.

Stock to be assessed in DELASS: VIIIc (Cantabrian Sea).

2.3.2.3 Blue shark

Results of US and Irish tagging studies show the species to make extensive movements throughout the North Atlantic. There is little movement across the equator, or to the Mediterranean, indicating a single stock in the North Atlantic (see section 3).

Stock to be assessed in DELASS: North Atlantic.

2.3.2.4 Cuckoo ray

Cuckoo rays occur in the North Sea, Irish Sea (and perhaps further north to the west of Scotland) and Celtic Sea. Life history parameters are available for several areas, though ageing is difficult, and results from the Celtic Sea are similar to those obtained for the North Sea. For most rays, no landings data or length frequency distributions are available by species, but French data are available for cuckoo ray by area since 1985. Not much is known about migrations. Survey data are available from the IBTS surveys in western waters and there are additional English and Irish survey data.

Stock to be assessed in DELASS: Celtic Sea, area VIIg,h,j and VIII a,b

2.3.2.5 Thornback ray

Most commercial landings data are for all *Raja* species combined and data by species are only available for France. However, survey data are available by species from the IBTS, quarterly from 1991 to 1996. Tagging data illustrate that fish do not move far, and there seems to be little mixing between the North Sea and the English Channel. Based on available literature, and analysis of the distribution patterns in survey data, the composition of the commercial landings and tagging data, the central and southern North Sea has been defined as the area in which a stock unit for *R. clavata* is appropriate.

Stock to be assessed in DELASS: IVb and IVc.

2.3.2.6 Blackmouth catshark

This species is widely distributed over the NE Atlantic, and landings data are available for Spain and Portugal, with CPUE data from Norway and Ireland. It is heavily discarded in large-vessel fisheries in the north and in artisanal fisheries in the south. Abundance estimates and length frequencies are available from Portuguese and Irish deep-water surveys. Though it may be reasonable to nominate two stocks, one off the Portuguese continental coast and one in VII/VI, there are insufficient data to distinguish between them. It is possible that blackmouth catshark populations are essentially local (like lesser spotted dogfish), with one large population in which pseudo population segments can be distinguished.

Stock to be assessed in DELASS: area IXa (where there is a fishery for which information is available)

2.3.2.7 Portuguese dogfish

The Portuguese dogfish is distributed over the NE Atlantic from Iceland to Senegal and also occurs off South Africa in depths down to 3600 m. Landings data are available for France and Portugal, though France (and Ireland for 2000 and 2001) only have data for two species combined, *C. coelolepis* and *C. squamosus*, known as "siki". There are also data from experimental fishing and surveys, from Norway, IEO, SAMS, MI (Girard, 2000). Very few small individuals have been recorded in the NE Atlantic. There is a lack of knowledge on migrations, though it is known that females move to shallower waters for parturition and vertical migration seems to occur (Clarke et al. 2001). Stock identity is difficult given that, for many countries, deep-water sharks landings often consist of several species.

Stock to be assessed in DELASS: NE Atlantic.

2.3.2.8 Leaf-scale gulper shark

This species is distributed over the NE Atlantic from Iceland to Senegal, but landings data by species are only available for Portugal and the Azores. Data are available from the same experimental fishing and survey sources as for the Portuguese dogfish. Males and immature females dominate samples west of Ireland and Britain and at Hatton Bank, while individuals < 80 cm are only available in Portuguese surveys. Data on stock identity are inconclusive, though available evidence suggests that this species is highly migratory.

Stock to be assessed in DELASS: NE Atlantic.

2.3.2.9 Kitefin shark

The fishery at the Azores started in the early 1970s, but data are fragmented. There are no tagging data, and no knowledge of horizontal migrations, but kitefin shark are caught wherever temperatures are around 10-11 °C. Norwegian data (Hareide and Garnes, 2001) suggest that *D. licha* mainly occurs in area X.

Stock to be assessed in DELASS: Sub-area X.

2.4 Task 3: Data compilation and exchange

Historically, all institutes participating in DELASS have undertaken some research on elasmobranchs, ranging from survey information going back 30 or 40 years to establishing biological parameters, tagging etc. Thus, the first priority in DELASS was to make an inventory of all existing elasmobranch information in participating institutes. The main deliverable of the project is to use the existing available data in an appropriate assessment method for each of the nine case studies of elasmobranchs. A standard format has been used to provide data to the stock assessors.

Norway. Data from different exploratory fisheries have been computerised and standardised. Data from 2001 and some Norwegian data on *S. acanthias* still need to be compiled and worked up.

Germany. Elasmobranch data obtained from ISH standard surveys in the North Sea (mostly Divs IVb and IVa) and adjacent sea areas during 1975 – 2001 were evaluated, both from cruise records already entered on the Institute's server and from those found only as written protocols and logbooks (which have since been checked and computerised). A total of 198 surveys data sets for cruises on which elasmobranchs were caught are now available. Since, in most cases, biological data have not been collected or the individuals have not been identified to the species level, their usefulness for assessments will be very limited. German data for the deep water species *D. licha, C. squamosus* and *C. coelolepis* are available in standard format from the EU project FAIR (CT 95-655).

Denmark. Data from logbooks and sales slips for 1987-2001 have been used to extract data on *S. acanthias* landings by ICES rectangle, month and gear.

Netherlands. Data for the four major ray species in the North Sea, available from the ICES IBTS data base, were scrutinised and several mis-identifications were found. After consultation with the country that provided the data, most of them could be corrected.

Ireland. Survey data (IBTS) for elasmobranchs have been collated and mapped, and remaining data for deep-water sharks were collated and analysed, using the new biological database. Tagging and angler's logbook data for blue sharks and thornback ray are being input to shared database format as part of the US-Ireland collaborative research project.

Spain. Historical information on landings of elasmobranchs by gear, year and ICES area has been compiled from 1996 to 2001 by AZTI. IEO survey data for *S. canicula* and the three main rays species in Division VIIIc are available and have been analysed.

Portugal. Data on Portuguese dogfish and leaf-scale gulper shark collected in Sesimbra port, and those sent to IPIMAR by DELASS partners, have been reviewed and compiled.

Azores. The available historical and biological information of the kitefin shark fishery in the Azores from 1972 until the present were revised and compiled in a computerised format. Information on landings and effort (1972-1987) is available, as are length-frequencies and reproductive parameters. Effort data were collected from logbooks and inquiries made of former kitefin shark fishing vessels to fill in the gap for the period 1987-1998.

2.5 Task 4: Stock Assessment

The objective is to make available relevant assessment models and to apply these to a selected number of case studies with the aim of using this information to determine if the level of exploitation is sustainable.

Netherlands. Life history parameters have been summarised to aid the assessment of *R. clavata* (see 4.8.2).

Ireland. MI hosted an ICES-ICCAT-DELASS meeting in Dublin in January 2002, aimed at furthering co-operation between those institutes having an involvement in blue shark biology in relation to stock assessment (see section 3). Preliminary assessments were carried out using production and depletion models for the deep-water sharks, *C. squamosus* and *C. coelolepis* (see 4.4 and 4.6).

France. Analyses using a surplus production model used estimates of total international landings and discard data for *R. naevus*. The model was adjusted to the relationship between abundance index and theoretical effort calculated from several abundance indices estimated using GLM procedures. The results are presented in WD1 to SGEF and summarised in section 4.9.

Portugal. IPIMAR and FFCUL have used life-table models with Portuguese dogfish data from two sources: the Portuguese fishery for black scabbardfish and Norwegian exploratory long-line surveys. The results of a projection of the female population for the period 1999 - 2013 reflect uncertainties in this species' life cycle, and have shown in particular that improvements in our knowledge of population length structure and migratory processes are required for more reliable estimates using life table models (see section 4.4).

2.6 Work planned for 2002

Denmark. Data on species composition of landed "rays and skates" will be analysed**.**

Netherlands. Ageing of vertebrae collected from rays in the North Sea

UK. Work on length/weight relationships and further exploratory market sampling to establish the species composition of Scottish elasmobranch landings. Marine Laboratory staff aim to provide estimates of elasmobranch discards in Scottish fisheries, to identify historical data to species level and to extract distribution data for various elasmobranch species. During 2002, CEFAS will finalise descriptions of stock identity for the case study species and of the fisheries taking elasmobranchs in the NE Atlantic and further develop the analytical models used for assessing spurdog.

Ireland. Preliminary market sampling studies under the DELASS programme will be carried out by the MI within sampling programmes implemented under the "EU Sampling Directive".

Belgium. ClO-DvZ will obtain length frequency distributions for *R. clavata* for the North Sea and *R. naevus* for the Celtic Sea, and the species composition and total weight of other landed *Raja* spp. will be estimated. Total length and wing width measurements of rays caught during the RV 'BELGICA' summer surveys will be used to calculate conversion factors for males and females.

France. Statistical methods will be developed to evaluate the length of each reproductive stage for *R. naevus* and to determine the number of spawning periods during one year. As another sign of spawning, the size (width) of the nidamental gland according to maturity stage and weight of gonads will be studied.

Spain. AZTI will continue market sampling in Ondarroa during 2002, following the protocols used in 2001. Data on size and sex of fish caught, landings, effort and geographical and temporal distribution of pelagic sharks caught by the small artisanal long-line fleet in the Bay of Biscay obtained by AZTI and IEO in the period 1998-2001 will be summarised. Information will continue to be collected on fishing effort and elasmobranch catches of the trawler and artisanal long liner fleets by ICES division.

Data on ray species and lesser spotted dogfish by weight and number in landings from ICES Divisions from 1996 onwards and from scientific surveys in ICES Divisions VIIIc since 1983 will be compiled by IEO. In particular, information of catches and landings of lesser spotted dogfish in ICES Div. VIIIc will be processed and appropriate biological data collected. Conversion factors for whole body / wings of rays will be used on a national basis. Biological parameters: e.g. growth, sexual maturity, fecundity, evidence of seasonal movements and breeding patterns, dispersion with age/size, migrations (tagging, surveys); associations with particular prey; relation to environment (temperature) etc., will be estimated wherever possible for lesser spotted dogfish.

Portugal. Data collected on rays from May to December 2001 will be analysed and the ray sampling plan re-evaluated. A deep-water survey of the Portuguese continental slope is scheduled for the summer of 2002, during which data on all elasmobranch species caught will be collected. IPIMAR will compile all the available data on Portuguese dogfish and leaf-scale gulper shark to be analysed in the DELASS stock assessment.

3 JOINT ICCAT/ICES WORKSHOP ON ASSESSMENT OF PELAGIC SHARKS IN THE NORTH ATLANTIC (TOR D)

3.1 Background

Superseding the TOR for SGEF in 2001 to plan a joint ICCAT/ICES workshop on assessment of pelagic sharks in the North Atlantic in June-July 2002, the ICES ASC 2001 resolved that ICES would co-sponsor a meeting (Dublin, 2 days in December 2001) to co-ordinate data compilation for fisheries that catch blue shark in the North Atlantic and required for the assessment of blue shark to be conducted by the SGEF in May 2002 (C. Res 2001/2GSM). Plans were also made at the most recent ICCAT Standing Committee on Research and Statistics (SCRS) for a meeting to discuss the possibility of joint work on pelagic sharks by both organisations. This meeting was hosted by the Irish Marine Institute, Ireland on 24-25th January 2002 and included participants from the USA; Canada; Ireland (D Clarke, DELASS blue shark species co-ordinator); Netherlands (Dr. Heessen, Co-ordinator of DELASS Study Contact); Japan (Dr. Nakano, Convenor, ICCAT Sub-Committee on By-catch); England (Dr. Pawson, acting Chair of ICES SGEF); Azores; Portugal (Dr. Pereira, Chair, ICCAT Standing Committee on Research and Statistics, SCRS) and the ICCAT Secretariat (Dr. Restrepo, Senior Scientist, ICCAT). The aims were to further co-operation between ICES and ICCAT on the assessment of pelagic sharks in the North Atlantic and to enhance the links between researchers and institutes involved in pelagic shark assessment in the region.

The meeting began with an outline of the general remit of ICES with regard to elasmobranchs, viz.: to respond to the FAO IPOA on elasmobranchs; provide management advice on elasmobranch fisheries by 2005 (IMM, 1997); identify what data are available and which institutes have such data; and respond to the European Union and other coastal jurisdictions in the region that may make requests to ICES for management advice on elasmobranchs. This was followed by a brief presentation on the DELASS project, in relation to SGEF and assessments of blue shark and other elasmobranch species, and then by an outline of the work of ICCAT with regard to pelagic sharks. ICCAT has a remit to study species exploited by tuna fisheries and, as a consequence, to carry out assessments of some pelagic sharks. There have been three ICCAT pelagic shark meetings since 1995, the last being in Halifax, Canada in September 2001, at which available CPUE indices were reviewed and recommendations made for further collection and compilation of catch and effort data series by species and gear.

Whilst ICES primarily provides scientific advice only, for the ICES area (NE Atlantic, Baltic Sea, Barents Sea, part of Arctic Ocean), ICCAT also has a management role in addition to providing management advice. Together with member states' governmental agencies, other groups may be represented at ICCAT assessment meetings. ICCAT's remit also covers Mediterranean pelagic sharks, but, since tagging data suggest that a separate stock of blue shark resides in that sea, it was not considered relevant to discuss this further.

3.2 Existing biological information on blue shark in the North Atlantic

A summary of available biological data on blue sharks is presented in the report of the ICCAT Halifax meeting. Results of NOAA-NMFS tagging studies have already been published. Additional data reside with Bedford Institute of Oceanography, Canada and NOAA-NMFS, in particular from historic research long-line cruises. With survey data and observer records from domestic long-line fleets and Canadian observations on Japanese long-line vessels, these may help address concerns that there was very limited overlap in the time series described at the Halifax ICCAT meeting. Most of the available data for the North Atlantic relate to life history and population biology, and catch data are much less complete.

Within the DELASS project, catch and effort data for blue sharks are available from an observer scheme in the Azores (Portugal), and life history (length, weight, growth, sex, maturity) data are available from surveys carried out by the University of the Azores. Landings data are available from France, Portugal, Ireland and Denmark, though these data do not necessarily reflect biomass trends because of discarding and the opportunistic nature of landings. There are historical published life history parameters as well as unpublished data from the ongoing tagging study of Dr. John Stevens in England.

3.3 New biological information on blue sharks

A considerable data set of tagged and recaptured blue shark, tope and other elasmobranch species has been collected since 1970 by the Irish Central Fisheries Board (CFB) through its Sport Fish Tagging Programme, which is the second largest shark-tagging programme in the world. It appears that very few sharks tagged in Irish waters are recaptured there, and tag returns decline southwards and westwards of the Azores. There have been no recaptures from south of the equator (Fitzmaurice and Green, 2000). Blue sharks begin to appear in Irish coastal waters in mid June, when water temperatures rise above 14 - 15 ^{0} C, and up to 95% of those caught are females. Evidence of declining catches with relatively constant fishing effort from the CFB Angling Skippers Logbook Scheme (which began in 1978) suggests declining blue shark abundance. It was agreed that the MI will liase with the CFB to develop a joint Irish-US initiative to facilitate the collation and analysis of these blue shark tagging and logbook data, with NOAA providing database expertise and software for the input and storage.

3.4 Existing analyses and further work on blue shark stock status

Presentations were given on the recovery and standardisation of long-line observations from the NW Atlantic, using oceanographic data to enhance analyses of temporal and spatial variability in size-segregated populations, and on the analyses of recreational and commercial CPUE series. There are Canadian data for blue shark, as by-catches in the Canadian porbeagle fishery and from observer and recreational data, and standardised CPUE series from Japanese fisheries.

Work by the Wildlife Conservation Society on age- and sex-structured dynamic models, accounting for migratory movements, spatial heterogeneity in distribution and gear-specific selectivity and using a Bayesian approach to deal with the uncertainty in the model formulation and in the biological parameters, could be applied to blue shark assessments. In a separate study on the population dynamics of blue shark in the North Atlantic using CPUE data at the University of Washington, it is intended to use Azorean and American data to increase the spatial resolution and power of the analyses and to build new stochastic models in conjunction with NOAA-NMFS scientists.

3.5 Data availability for assessments

To assist with the identification of analytical possibilities for blue shark for the May 2002 SGEF meeting, the group developed an inventory of assessment approaches, their respective input data requirements and output types (Table 3.1). Table 3.1 is colour coded according to the time frame for collating data for each analysis, and suggests that at least Petersen analyses of tagging data, life table analyses and catch curve analyses could be carried out for blue shark at the present. These assessments will provide estimates of total mortality (and fishing mortality using an estimate of natural mortality) that can be related to sustainability using the life table approach with outputs as the rate of population increase and elasticities.

3.6 ICES/ICCAT co-operation on future assessment of pelagic sharks

Though SGEF conducted a preliminary assessment of blue shark at the May 2002 meeting, as part of the process of developing assessment methodologies, it is clearly understood that ACFM will not base management advice on the results until they appear robust. In contrast, it was noted that before an assessment is carried out in ICCAT, consensus is sought through an extensive consultation process on all aspects of the assessment (including an appraisal of data availability) within SCRS. Even if data were complete, a considerable amount of time is required to prepare for an assessment, the results of which must then be considered by contracting parties. Whilst it is planned to conduct assessments of pelagic shark within ICCAT in 2004, it is still unclear whether there will be sufficient data at that time. Though it was considered unlikely that ICCAT would be able to collate further data before May 2002, it was agreed that those scientists having data and who are in a position to participate in preliminary assessment of blue shark should be encouraged (through ICCAT or otherwise) to participate in the May SGEF meeting.

Given these differences in approach, the Dublin meeting prepared the following text to summarise the agreed position with regard to ICES/ICCAT involvement in developing assessments for blue shark in the North Atlantic:

> "The ICES SGEF will hold a meeting at ICES HQ, Copenhagen on 6th –10th May 2002. The main aim of this meeting is to carry out and review preliminary assessments of the nine case study species within the EU-funded DELASS contract. These analyses are seen as a step in the development of assessments for elasmobranch species, and there is no expectation that they will provide a basis for management advice in themselves.
>
> A meeting to discuss the possibilities of carrying out assessments for blue shark was held in Dublin, 24-25th January 2002. This meeting reviewed possible analytical methods and their data requirements, and the availability of relevant data on blue shark in the North Atlantic. Recognising the Trans-Atlantic distribution of the species and the variety of fisheries in which it is caught, the group recognised the need for continued collaboration between ICES and ICCAT experts. The group also concluded that at least three approaches – catch curve, life table and Petersen analyses – were possible at this time. It was agreed that these analyses should be attempted for the SGEF May meeting. The opportunity will also be taken to discuss the requirements for and progress the collation of data for carrying out analyses with more complete assessment outputs in the medium term.
>
> The DELASS blue shark co-ordinator, Dr. Maurice Clarke, will ascertain the availability of appropriate scientists in order to carry out the necessary tasks. ICES will formally invite them to participate in the SGEF/DELASS meeting. ICCAT has agreed to make appropriate data available for this meeting."

4 ASSESSMENTS OF CASE STUDY SPECIES

The ICES ASC 2001 resolved that SGEF should carry out preliminary assessments of the nine case study species (blue shark in the North Atlantic; Portuguese dogfish, blackmouth dogfish, leaf-scale gulper shark, kitefin shark and spurdog in the NE Atlantic; cuckoo ray in VIIf,g,h & VIIIa,b; thornback ray in IV; lesser spotted dogfish in VIIIc) in conjunction with the EU-funded project DELASS, and evaluate the adequacy of these assessments for providing advice on stock status in relation to biological reference points. Progress with the assessments presented at this meeting is described below.

4.1 Spurdog in Sub-areas IV, VI and VII

4.1.1 Description of the fisheries taking spurdog

Spurdog (*Squalus acanthias*) is a relatively small (<130 cm TL) squaliform shark that is one of the most important elasmobranchs caught in the NE Atlantic. During the early 1900's, spurdog were not of great economic value and landings were small. As in other parts of the world, they were viewed as a nuisance, as shoals of spurdog could cause considerable damage to nets in (e.g.) in herring fisheries. During the 1950's and 1960's, landings of spurdog in the North Sea increased rapidly and total annual landings rose to 58,000 t during the 1960's. In the 1980's, long-line fisheries for spurdog became relatively important in the Irish Sea, with boats targeting shoals of large females. This fishery subsequently declined. Spurdog are currently taken in mixed demersal fisheries (e.g. otter trawls) and also in gill nets, where they may be the target species. Since the late 1980's, total landings of spurdog from the NE Atlantic have declined and recent catches (1997-1999) have been around 15,000 $t.yr^{-1}$. The major fishing nations for spurdog are the UK, Norway, Ireland and France. Other countries (e.g. Germany, Denmark, Poland, Belgium, and Portugal) tend to have much smaller landings. The main fishing grounds are the Norwegian Sea (II), North Sea (IV), NW Scotland (VI) and the Celtic Seas (VII). Some landings are also made in the Skagerrak and Kattegat (IIIa) and off Iceland (V). They are also taken in small quantities in the Bay of Biscay (VIII) and off Greenland, although these areas are considered to be outside the main area of the NE Atlantic stock, which is also considered to be separate (at least for assessment and management purposes) from the NW Atlantic stock.

4.1.2 Data availability

Biological information: The spurdog is a relatively well known species and, in comparison to most other elasmobranch fishes, there is a considerable quantity of published information on its biology. Its reproductive biology is well documented and there are many estimates of size at maturity, gestation period, fecundity, size at birth and sex ratio of pups. Whilst these studies provide broadly similar results, some of these parameters could be usefully updated in future. Age and growth data are available, although validation of ages using dorsal fin spines is uncertain and published results should be used with caution. Norwegian, English and Scottish scientists tagged several thousand spurdog in the late 1950’s and 1960’s, and these data have been used to interpret the stock structure and could be used to provide supporting evidence for growth models. Although spurdog are known to segregate by sex and/or size, there is a lack of understanding of their behaviour and short-term movements.

Landings information: ICES landing statistics for the “dogfish” category over the period 1905 – 1960 are likely to be composed primarily of spurdog and, though data prior to 1932 do not include landings from Norway or France, these statistics are probably representative of spurdog landings during that period. After 1961, landings data for spurdog were identified separately, though French data for some years in the late 1960s and early 1970s are missing. The UK has an extensive data set of length-frequency data (by sex) from commercial fisheries (currently available for 1983 onwards) and also landings by port, month, sex and gear. Contemporary information on discards is available for some areas, although these data tend to be for recent years.

Survey information: Although spurdog may occur throughout the water column, research vessel surveys using otter trawls are considered to provide representative samples. Beam trawls are less suitable for catching spurdog. Most computerised databases and standard surveys do not extend back before the 1970’s, so the time period for fishery-independent data is limited. Survey information provides CPUE (numbers and biomass by sex) and length-frequency (by sex).

4.1.3 Model methods chosen

The data available for spurdog were used for preliminary analyses of trends in length-frequency and trends in CPUE. Subsequently, preliminary assessments were undertaken using two methods:

- Catch curve analysis and separable VPA using the length distributions sliced according to growth parameters derived from the literature
- Bayesian assessment using a stock production model, with a prior for the intrinsic rate of increase set by demographic methods.

4.1.3.1 Trends in length-frequency

Length distribution data from UK (E & W) commercial samples are available for all gear types combined for the years 1983-1999. Although there has been a substantial reduction in the numbers of spurdog sampled, as the volume of landings has decreased, the length range of the frequency distributions has not changed substantially. This is shown in Figures 4.1.1a and b, which illustrate the length frequency distributions in the samples of female spurdog for the years 1985-1989 and 1997–2001. During the period 1983-2001, there appears to have been no reduction in the prevalence of larger, older, females in the landings. In more recent years, there has been a reduction in the frequency of the smaller sizes within the distribution. However, the proportional contribution of these fish is noisy and the recent reductions lie within the noise associated with discarding, changes in gear selection, migration patterns etc.

Under an assumption of constant selection at length, an analysis of the time series of mean length in the catch data was carried out to examine trends that might indicate whether the level of exploitation has altered the structure of the length distributions. Length distributions by sex were available from commercial sampling at UK (E&W) ports and for three research trawl survey series, two from Scotland and a combined UK(E&W) series of surveys from Sub-areas IV and VII. Figures 4.1.2 - 4.1.4 illustrate the mean length in the samples.

Figure 4.1.2 shows a change in mean lengths for both sexes in the commercial landings data from the UK (E&W) fisheries. Means for two length ranges are presented: a mean of the whole distribution and a mean for fish >80 cm in the distribution. For each sex, the two series show an increasing mean length in the commercial catch distributions. Mean length at age has increased faster in the females than males, and the two series indicate that the proportion of small females in the commercial data has decreased.

Figures 4.1.3 and 4.1.4 illustrate the mean lengths of the two sexes from the UK (Scottish) and (E&W) surveys respectively. In both surveys, the mean length at age at the oldest ages has increased gradually during the available time series, whilst mean length at age over the whole length distribution has decreased in recent years. For the Scottish surveys, this has resulted from increased catches of small males and females. For the E&W surveys, apart from 1999, this results from an absence of larger fish. The differences between the survey and commercial length distributions at the youngest ages may result from spatial effects and more detailed analysis is required to resolve them.

4.1.3.2 Trends in CPUE

Figures 4.1.5 and 4.1.6 show the CPUE data available from eight research survey series carried out within the species' distribution area. The majority of the CPUE series exhibit a decline, especially those recorded within ICES Sub-areas IV and VII by the UK (E&W) survey series. This is in contrast to the Scotia GOV series carried out further to the north and in the Div. VIIa Lough Foyle survey. The data require further analysis for elaboration of the spatial differences in the signals from the survey series.

4.1.3.3 Catch curve analysis and separable VPA based on length Slicing

The assumption was made that the UK(E&W) length distribution data are representative of the composition of all landings from the spurdog fishery in ICES Sub-areas IV, VI and VII: the UK catch represents around half of total landings by weight. Von-Bertalanffy growth (VBG) curves derived from published parameters (Holden & Meadows, 1962, 1964; Nammack *et al.,* 1985; Fahy, 1988, 1989), were used to slice the length distributions into age distributions, independently for each sex, under the assumption of constant growth rates.

Catch curve analysis was used to estimate average F for the fully recruited ages, for each year of the time series and each sex. The results from the slicing are presented in Figures 4.1.7 and 4.1.8, where figure (a) presents estimates of Z and figure (b) presents the correlation coefficient for the regression data. Each of the series illustrates the estimates of mortality derived from a different growth model. Low values of Z estimated from catch curve regression may result from no information in the regression data (correlation coefficients close to zero), so the two figure must be considered together: ideally, confidence intervals would be presented for the estimates.

Both sexes show a reduction in Z during throughout the time period. For females, the low values (~0.0) in 1991, 1997 and 1998 result from poor contrast in the regression data. The regressions for males give very low correlation values for recent years and for the complete series from two of the growth parameter sets. The results illustrate that conclusions drawn concerning the rate of mortality to which the population is subject are highly dependent on the growth parameters used for slicing.

The cause of the sensitivity in the estimates of Z to the growth equation parameters is illustrated in Figure 4.1.9, where the growth equations for males and females are plotted with the average frequency distributions for each sex. The value of L_∞ for each sex lies well within the upper range of the respective frequency distributions, so that substantial accumulations can occur in the plus group. In addition, small changes to the model parameters (which alter the curvature of the growth equation) and in the range of the lengths in the distribution (which shows the depletion of the population), will have a significant effect on the mortality estimated over that range. The sensitivity to growth model parameter uncertainty will be investigated in future work.

In order to examine the cohort structure of the numbers-at-age derived from the slicing procedure within a Separable VPA model, the individual sex length distributions were used with length - weight relationships for each sex taken from (Bedford *et al*., 1986) to calculate a sums of products for the UK(E&) data. The ratios of the combined sex SOP to the landings data for each year were used to raise the partial numbers at age to the total estimates.

Table 4.1.1 presents the numbers at age derived from the slicing and raising procedure. Figure 4.1.10 illustrates the structure of the values for each year. It is apparent that there is a substantial portion of the stock in the plus group set at age 26+. These proportions range from 9% in 1983 to 43% in 1998, and this increase through time is inconsistent with the decreasing numbers at the younger ages and needs to be examined further. The proportions will be sensitive to the assumed growth curve parameters discussed previously.

A Separable VPA model (Pope and Shepherd, 1982) was fitted to the raised catch-at-age data set, assuming a value of 0.1 for M, a terminal age selection of 1.0 and a range of terminal F values (F = 0.5*M, M, 2*M, 3*M). Figures 4.1.11 -

4.1.13 present the selection at age estimates from the model, the estimates of terminal F and the estimates of total population numbers for ages 11+, the ages considered by Holden & Meadows (1962) to represent the mature portion of the stock. The analysis is conditional on the assumed growth curve and the estimated mortality rates, and selection at age will be conditional on the growth parameters. The initial estimates of mortality rates indicate that the level of F is low throughout the time series and that the mature population has declined.

The possibility of applying an entirely length-based method (a modified catch-at-size analysis (CASA), Sullivan *et al.* 1990) which has been used in preliminary assessments of Northern Shelf anglerfish (Appendix 1 of ICES, 2001b) was also investigated. This method uses a size-transition matrix approach to project the population length distribution forwards in time. The size-transition matrix is obtained from a stochastic growth model with known VBG parameters. All population dynamics processes, such as recruitment and F, are assumed to be dependent on length rather than age. Estimates of yearly recruitment, length distribution of recruits, selectivity and F are then obtained by fitting the annual catch-at-length predicted by the model to the observed data.

Problems were encountered with this method due to the fact that a large number of individuals occurring in the catch are significantly larger than the values of L_∞ obtained from the literature. The model assumes that as length increases towards L_∞, the mean growth increment decreases to zero, which implies that growth beyond this length is impossible. The model is, therefore, unable to predict the high proportion of very large individuals appearing in the catch. A further analysis of the original growth data may provide growth parameters that prove to be more consistent with these catch-at-length data.

4.1.3.4 Bayesian assessment:

Single species stock assessments can be both biased and imprecise (Adkison and Peterman, 1996), as data for individual fish stocks are often uninformative about key population parameters. CPUE data are especially uninformative about the level of stock size when the population trajectory through the available time series shows only a decrease (Hilborn and Walters, 1992). We know from considerations of life-history that elasmobranchs are among the least productive of fishes (Holden, 1967, 1974), and demographic techniques allow us to estimate the maximum population growth rate (*r*) (McAllister *et al.*, 2001) which suggest upper constraints for *r* in the Schaefer biomass dynamic model (c.f. Hilborn and Walters, 1992). The methods of McAllister *et al.* (2001) were applied to spurdog, using demographic techniques to convert prior distributions for age-specific fecundity and M (the latter based on tagging data and assumed constant over ages) to prior distributions for *r*. The priors for *r* generated in this manner were then used in a Bayesian, Schaefer-model assessment fitted to RV survey (CPUE) data. Assessment results were thus coherent with life-history constraints.

The demographic analysis required age-specific estimates of length, fecundity, and maturity. Such information was based on published estimates of length at age, of length at 50% maturity (L_{50}) and of fecundity at length (Tables 4.1.2 and 4.1.3).

The proportion of mature fish at each age was based on age-specific estimates of the proportion of fish above L_{50}, obtained by assuming a lognormal distribution of length at age, with mode given by a published dataset, and σ estimated from the variability in published lengths at each age.

Fecundity at age, for mature females, was obtained from published fecundity-length relationships using the mean length at age. The assumed fecundity at age *x* (m_x) was computed by multiplying the fecundity and maturity at age, and dividing the result by 4, to account for the two-year gestation period and the 1:1 sex ratio of pups (Hanchet, 1988). Uncertainty in m_x was modelled using the variability in estimates of m_x obtained by employing data from five sources, *viz.* Holden and Meadows (1962, 1964), Gauld (1979), Nammack *et al.* (1985), Fahy (1988, 1989) and Jones and Ugland (2001). It was assumed that the life-history data used by these sources were relatively independent. A weighted average of the m_x estimates from these five sources was obtained; the weight assigned to each study being independent and lognormal (μ=0,σ=2).

The probability of surviving to age *x* (l_x) was estimated from tagging studies (on females above 80 cm in length) by Aasen (1964) and Holden (1968), who converted estimates of Z to estimates of M by subtracting estimates of F from stock assessments. Resulting estimates were converted to a prior for M, which was lognormal (□=-1.76, □=0.54). Then, l_0= 1 and l_x= l_{x-1}exp(-M).

The resulting estimates of l_x and m_x were then converted to estimates of *r*, using the numerical method described in McAllister *et al.* (2001). A maximum age of 40 was assumed.

The initial vector of female numbers at age is:

$$N_{x,o} = 1000 l_x \qquad (1)$$

The number of female pups for the following year is:

$$N_{0,t+1} = \sum_{x=0}^{40} m_x N_{x,t} \qquad (2)$$

and the numbers of older females is calculated as:

$$N_{x,t+1} = S_{x-1} N_{x-1,t} \qquad (3)$$

where S_{x-1} is the probability of surviving through age *x-1*. Using equations 2 and 3, the population was projected forward until the age structure stabilised (to within <0.00001%), which took a few hundred steps.

$$P_t = \sum_{x=0}^{40} N_{x,t} \qquad (4)$$

From the population at equilibrium *t* (P_t), r was computed:

$$r = \log\left(\frac{P_t}{P_{t-1}}\right) \qquad (5)$$

Computing a sample of more than 5000 such *r* estimates, with any negative values discarded, gave the prior distribution shown in Figure 4.1.14. The fact that this technique used numbers and not biomass (as in our assessment model) makes no difference.

A Bayesian Schaefer model assessment of spurdog was then fitted to survey data from England, Scotland and Northern Ireland (Table 4.1.4). Tables 4.1.5 and 4.1.6 show the number of hauls attempted and the number that caught no spurdog, respectively. Figure 4.1.15 shows the time series of landings from the NE Atlantic used in fitting this model. Given the relatively low catch levels prior to 1946, it is assumed that the population started from near carrying capacity *K*.

In fitting the model, it is assumed that each index *i* had its own catchability q_i and its own dispersion parameter σ_i^2. In accordance with precedent (McAllister *et al*. 2001; Walters and Ludwig 1994), these parameters were assigned non-informative priors, uniform in log space. The same prior was also used for Schaefer model parameter *K*.

Each index value in Table 4.1.4 was assigned a lognormal distribution, with mode equal $q_i B_y$, (where B_y is the predicted biomass in year *y*) and with dispersion parameter:

$$\sigma_{i,y}^2 = c_i CV_{i,y}^2 \sigma_i^2 \qquad (6)$$

where the $CV_{i,y}$ entries come from Table 4.1.7 and where

$$c_i = \left(\sum_y CV_{i,y}^2\right)^{-1} \qquad (7)$$

This specification allows nuisance parameters q_i and σ_i^2 to be integrated out, using a slight generalisation of equations in Walters and Ludwig (1994). If, for each index *i* we define:

$$\log(\hat{q}_i) = \frac{\sum_y \left(\log(O_{i,y}) - \log(B_y)\right) CV_{i.y}^{-2}}{\sum_y CV_{i,y}^{-2}} \quad (8)$$

Where *O* is an observation value from series i in year y, and the statistic:

$$SS_i = \sum_y \left(\log(O_{i,y}) - \log(B_y)\right)^2 CV_{i.y}^{-2} \quad (9)$$

then, upon integrating out both q_i and σ_i^2, the posterior kernel for index *i* becomes:

$$\left(SS_i - \log(\hat{q}_i)^2 \sum_y CV_{i,y}^{-2}\right)^{-\frac{(n-1)}{2}} \quad (10)$$

where *n* is the number of years of data in index *i.* If the $CV_{i,y}$ values were all 1, this result would be proportional (and therefore equivalent) to equation (18) of Walters and Ludwig (1994). With the nuisance parameters integrated out, the only remaining estimated parameters are the biological ones: *r* and *K.* We explored uncertainty in these by creating a grid of parameter values.

Note that, due to the presence of zero values in some indices, neither the Scotia Deep-water Trawl index nor the Scotia Monkfish Trawl index were used, and the 1999 observation from the Scotia Aberdeen Trawl index was discarded in view of the relatively low survey effort exerted (Table 4.1.5).

Assuming model assumptions are correct, the Bayesian approach indicated that most landings since 1946 are definitely above MSY and there are probably (i.e. probability of 73%) less than 100,000 tonnes of spurdog left and definitely less than 200,000 tonnes. It is 50% probable that the stock has been depleted to below 6% of its carrying capacity and 95% probable that the current population is below 11% of *K* (see Figures 4.1.16-4.1.21).

4.1.4 Discussion

The analysis of the spurdog data by the length-slicing method has established that the methodology could be taken forward to provide estimates of mortality rates and stock dynamics for the species. If the sensitivity of the results to the growth equations cannot be resolved by additional analysis (using tagging data etc.), then the model will allow an evaluation of recent trends, but not absolute levels of those dynamics. An approach that will be examined in future work will be to allow uncertainty in the growth equations in a similar approach to that used in the Bayesian stock production model.

The bayesian approach has used several assumptions and raised a number of points:

the approach discards some survey observations because of the presence of zeros

- the model assumes the stock was at the carrying capacity in 1946
- the model assumes that parameters *r* and *K* have remained constant since 1946
- the model ascribes no uncertainty to the landings data; and
- a Schaefer model was used instead of the more general Pella-Tomlinson version.

These issues will be pursued further during DELASS and discussed in a paper to be presented at the NAFO Symposium in September 2002.

	Year																
Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	0	1350	0	0	0	5385	0	336	0	0	0	0	0	0	0	345	0
4	45032	18110	8389	4878	372	17815	230	14610	4674	0	0	4570	277	1059	4904	0	6518
5	190856	29568	6945	5383	35546	78171	1490	38655	6596	1951	11845	18325	9306	38675	3901	14637	17809
6	486584	251577	47895	26477	147747	94675	33736	99804	40137	18935	84371	126878	22396	112053	40911	92547	38583
7	909636	412143	96563	40123	176029	123282	41411	190861	32631	24797	58293	109108	31645	97895	39570	15165	36439
8	1788286	899345	321586	154373	449347	177509	71534	341381	107748	75886	209178	315564	90111	533914	105469	72597	84991
9	2429852	1410277	598152	281056	891067	271072	191508	321632	245603	220343	317319	412592	288732	803470	165285	122774	115351
10	2484449	1738444	1056799	587686	1035078	506694	374911	601369	495996	415135	410044	583769	324558	694244	167796	85243	232622
11	2079588	1324129	1200179	833383	1137214	584439	327928	534596	326371	450213	465887	453744	690817	510370	181694	138771	154275
12	2499799	1551401	2013828	1398126	1951727	895848	634687	809454	1015793	802777	617961	493097	565572	1075088	203275	176376	220046
13	1995100	1555840	2254091	1420844	1945139	1098371	865634	906580	828421	583550	642228	453624	378032	580980	231618	288187	377595
14	1563513	1256277	1747693	1256855	1434998	1041275	869103	755010	742306	586578	509376	294486	299936	385199	198813	210589	186636
15	1252319	1076995	1718236	1147958	1438841	1123180	809815	807033	736396	560976	564996	303179	476549	262588	187769	197556	328157
16	716573	805830	1178593	766576	1001963	1008420	610891	401588	208607	326173	317305	227210	352773	185632	136918	143292	215674
17	1154195	1050368	1525486	1414528	1740304	1339852	980626	924198	643002	567333	454032	380435	573522	256317	287074	240161	320522
18	252670	407839	576336	428861	680936	639523	442142	296156	168942	187695	157940	122801	221893	121553	72975	37753	43783
19	560196	542817	736086	690176	960447	913281	532223	727159	528983	349994	306617	220546	388758	300716	226669	267436	181694
20	443388	773024	840027	882268	876231	1256440	773796	647626	349110	409333	293036	245685	339709	311615	159310	125286	150144
21	548518	582057	704228	733105	876531	679384	627640	590181	523743	427420	341642	224857	498937	326697	283027	177544	191907
22	162526	320293	297436	272385	537936	570984	353716	341156	237542	175303	139023	112776	181442	197774	106742	74441	107677
23	186807	363190	349562	282838	476210	426120	394690	345237	207024	243748	175756	134032	101255	145434	88811	47515	101708
24	129442	292202	252539	333614	347159	548483	432863	452776	194335	259889	175066	154963	228597	102188	70959	70542	63693
25	152890	316295	291669	300547	469674	459792	375833	287433	202687	227977	140044	171898	200881	144878	144773	136693	102998
26	2191869	2995314	2620392	2899526	3018905	2733770	2821595	2806576	4078940	3501782	2325960	2373846	1999831	1419320	2108151	2104961	1158572

Table 4.1.1 The catch numbers at age data derived from length slicing of the UK(E&W) commercial spurdog landings raised to the total recorded landings for all countries

Table 4.1.2: Source data for life history parameters

Parameter	Data and sources
Length at age	Data taken from: Aasen (1961); Holden and Meadows (1962, 1964); Soldat (1982); Nammack et al. (1985); Fahy (1988, 1989); Jones and Ugland (2001) [See Table 4.1.3]
Fecundity (assuming a linear relationship with length)	F = 0.1342L – 6.1045 (Fahy, 1988) F = 0.344L – 23.876 (Gauld, 1979)
Natural mortality (estimates)	0.10-0.31 (Aasen, 1964) 0.078-0.33 (mean=0.1) (Holden, 1968)
Length at 50% maturity (females)	82cm (Holden and Meadows, 1964) 83cm (Gauld, 1979) 78cm (Nammack et al., 1985) 74cm (Fahy, 1988) 81cm (Jones and Ugland, 2001)

Table 4.1.3: Published estimates of length at age

Source	Soldat (1982)		Jones & Ugland (2001)		Fahy (1988, 1989)	Holden & Meadows (1964)	Aasen (1961)	Holden & Meadows (1962)	
	NW Atlantic		Norway		Ireland	UK	NE Atl	UK	
Age	Males	Females	Females		Females	Females	-	Males	Females
1	26.8	27.1	.	.	.	.	29.1	41.3	39.6
2	34.2	34.0	.	.	.	.	34.1	44.5	43.6
3	40.9	39.5	.	.	.	.	38.6	51.6	51.1
4	45.7	47.1	.	.	.	.	42.8	55.5	56.2
5	49.5	50.6	.	.	.	.	46.8	60.2	62.8
6	53.0	53.5	.	.	.	.	50.7	65.3	64.5
7	59.5	59.0	.	.	.	.	54.6	68.8	67.7
8	64.0	63.7	.	.	.	73.7	58.3	70.8	75.9
9	66.6	70.9	.	.	.	76.6	62.1	71.3	75.3
10	69.8	72.6	77.7	78.7	.	79.3	65.7	73.2	81.0
11	73.0	77.0	78.4	79.4	.	81.6	69.4	74.1	82.3
12	74.3	80.5	79.0	80.2	69.7	83.7	73.1	74.8	83.9
13	76.2	82.8	79.7	80.9	72.2	85.6	76.6	75.4	85.8
14	77.3	85.2	80.4	81.6	74.5	87.3	.	78.9	86.7
15	77.0	86.3	81.1	82.4	76.6	88.8	.	74.5	90.3
16	77.5	85.7	81.7	83.1	78.5	90.1	.	78.3	89.5
17	76.5	87.5	82.4	83.8	80.2	91.3	.	82.5	90.8
18	80.7	87.0	83.1	84.5	81.8	92.4	.	.	87.5
19	81.0	92.0	83.7	85.3	83.3	93.3	.	82.5	92.5
20	85.0	93.2	84.4	86.0	84.6	94.2	.	.	97.5
21	.	93.3	85.1	86.7	85.8	95	.	.	97.5
22	.	96.0	85.7	87.5	87.0	95.6	.	.	.
23	.	97.5	86.4	88.2	88.0	96.3	.	.	.
24	.	90.0	87.1	88.9	88.9	96.8	.	.	.
25	.	99.5	87.8	89.7	89.8	97.3	.	.	.
26	.	96.7	88.4	90.4	90.5	.	.	.	.
27	.	.	89.1	91.1	91.2	.	.	.	.
28	.	.	89.8	91.8	91.9	.	.	.	.
29	.	.	90.4	92.6	92.5	.	.	.	.
30	.	.	91.1	93.3	93.0	.	.	.	.
31	.	.	91.8	94.0	93.5	.	.	.	.
32	.	.	92.4	94.8	94.0	.	.	.	.
33	.	.	93.1	95.5	94.4	.	.	.	.
34	.	.	93.8	96.2	94.8	.	.	.	.
35	.	.	94.5	97.0	95.1	.	.	.	.
36	.	.	95.1	97.7	95.4	.	.	.	.
37	.	.	95.8	98.4	95.7	.	.	.	.
38	.	.	96.5	99.1	96.0	.	.	.	.
39	.	.	97.1	99.9	96.2	.	.	.	.
40	.	.	97.8	100.6	96.5	.	.	.	.

Table 4.1.4: Mean catch per unit effort (kg.hr^{-1}) from English, Northern Irish and Scottish groundfish surveys

Vessel	Cirolana	Cirolana	Cirolana	Corystes	Explorer	Lough Foyle	Scotia	Scotia	Scotia	Scotia
Gear	GOV	Granton	PHHT	Granton	Aberdeen Trawl	Rockhopper Otter Trawl	Aberdeen Trawl	Deepwater Trawl	GOV	Monkfish Trawl
1977		2.50			147.19					
1978		10.23			11.35					
1979		2.41			11.54					
1980		9.44			0.54					
1981		7.53			12.53					
1982		5.72	12.67				1.21			
1983		6.15	2.66				0.66		6.22	
1984		3.30	16.25				0.69		2.84	
1985		4.95	13.82				1.66		35.95	
1986		28.56	11.23				1.08		9.20	
1987		13.54	22.83				7.62		0.35	
1988		4.69	5.68	8.36			2.55		8.91	
1989		1.20	5.26	0.39			0.71		2.97	
1990		2.30	5.14	3.55			0.78		7.04	44.48
1991	3.58	0.49	1.30	3.53		6.03	0.10		5.75	
1992	3.14		0.83	3.70		3.74	0.24		4.67	
1993	0.96		1.24			7.30	0.35		4.47	
1994	2.56		1.10			1.48	0.12		5.50	
1995	1.44		0.58			3.85	0.04		3.48	
1996	0.26					3.22	0.07	0.00	2.78	0.00
1997	0.53		1.18			2.54	0.19	0.00	1.61	
1998	0.32		0.81			5.04		0.62	1.97	0.00
1999	0.18		14.44			3.61	0.00	2.61	1.80	0.00
2000	0.06		0.94			3.42		0.15	6.25	14.39
2001	0.47		1.26			1.65			0.42	
Mean CPUE	1.23	6.87	6.28	3.91	36.63	3.81	1.06	0.68	5.90	11.78

Table 4.1.5: Survey effort in number of hauls, by gear and year.

	Cirolana	Cirolana	Cirolana	Corystes	Explorer	Lough Foyle	Scotia	Scotia	Scotia	Scotia	Total
Year	GOV	Granton	PHHT	Granton	Aberdeen Trawl	Rockhopper Otter Trawl	Aberdeen Trawl	Deepwater Trawl	GOV	Monkfish Trawl	
1977		126			24						150
1978		120			55						175
1979		126			41						167
1980		126			55						181
1981		125			65						190
1982		75	112				79				266
1983		74	41				82		50		247
1984		84	110				84		12		290
1985		75	110				85		67		337
1986		87	98				85		106		376
1987		84	121				143		68		416
1988		79	116	12			133		122		462
1989		89	64	12			129		110		404
1990		91	70	14			132		159	54	520
1991	68	89	62	20		70	132		253		694
1992	153		70	12		132	129		224		720
1993	150		71			132	137		218		708
1994	160		36			127	134		212		669
1995	168		23			77	132		221		621
1996	86					82	127	12	225	7	539
1997	81		80			89	131	32	245		658
1998	79		80			89		20	280	11	559
1999	78		87			86	13	45	332	6	647
2000	76		86			85		38	274	36	595
2001	79		73			102			320		574
Total	1178	1450	1510	70	240	1071	1887	147	3498	114	11165

Table 4.1.6: Number of hauls that caught no spurdogs, by gear and year.

	Cirolana	Cirolana	Cirolana	Corystes	Explorer	Lough Foyle	Scotia	Scotia	Scotia	Scotia	
Year	GOV	Granton	PHHT	Granton	Aberdeen Trawl	Rockhopper Otter Trawl	Aberdeen Trawl	Deepwater Trawl	GOV	Monkfish Trawl	Grand Total
1977		92			7						99
1978		77			27						104
1979		93			9						102
1980		94			48						142
1981		93			49						142
1982		50	76				58				184
1983		47	30				62		29		168
1984		63	75				68		5		211
1985		57	85				65		21		228
1986		68	50				73		77		268
1987		64	79				109		60		312
1988		66	78	6			120		99		369
1989		72	47	10			110		84		323
1990		69	48	12			119		121	17	386
1991	48	81	50	12		52	122		186		551
1992	122		53	8		98	114		155		550
1993	130		59			100	121		130		540
1994	121		32			101	123		148		525
1995	146		19			62	126		161		514
1996	79					60	122	12	160	7	440
1997	78		71			68	120	32	181		550
1998	72		72			67		19	218	11	459
1999	74		72			66	13	27	264	6	522
2000	75		74			61		36	213	16	475
2001	76		63			87			295		521
Total	1021	1086	1133	48	140	822	1645	126	2607	57	8685

Table 4.1.7: The coefficient of variation (CV) in survey CPUE (Table 2), for the survey indices used.

Vessel	Cirolana	Cirolana	Cirolana	Corystes	Explorer	Lough Foyle	Scotia	Scotia	
Gear	GOV	Granton	PHHT	Granton	Aberdeen Trawl	Rockhopper Otter Trawl	Aberdeen Trawl	GOV	Average
1977		0.26			0.68				0.47
1978		0.57			0.72				0.64
1979		0.27			0.37				0.32
1980		0.39			0.42				0.40
1981		0.65			0.40				0.52
1982		0.49	0.51				0.34		0.45
1983		0.50	0.44				0.35	0.54	0.46
1984		0.39	0.37				0.34	0.44	0.39
1985		0.40	0.45				0.38	0.36	0.40
1986		0.89	0.38				0.50	0.58	0.59
1987		0.53	0.45				0.74	0.36	0.52
1988		0.77	0.26	0.52			0.77	0.89	0.64
1989		0.36	0.45	0.79			0.39	0.58	0.51
1990		0.32	0.44	0.95			0.62	0.72	0.61
1991	0.28	0.48	0.48	0.54		0.60	0.35	0.64	0.48
1992	0.46		0.34	0.76		0.28	0.28	0.63	0.46
1993	0.27		0.41			0.76	0.36	0.27	0.41
1994	0.21		0.58			0.30	0.42	0.47	0.40
1995	0.31		0.54			0.57	0.52	0.62	0.51
1996	0.44					0.30	0.54	0.29	0.39
1997	0.64		0.49			0.37	0.45	0.21	0.43
1998	0.46		0.53			0.69		0.27	0.49
1999	0.73		0.89			0.31	0.00	0.22	0.43
2000	1.00		0.41			0.28		0.85	0.64
2001	0.67		0.48			0.51		0.54	0.55
Average	0.50	0.48	0.47	0.71	0.52	0.45	0.43	0.50	0.49

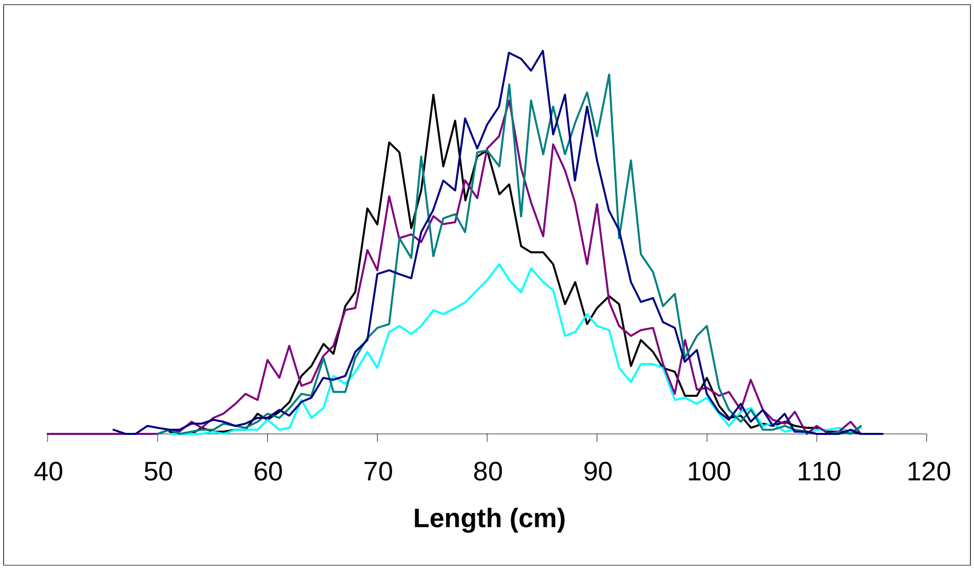


Figure 4.1.1a The frequencies at length in the sample distributions of female spurdog for the years 1985 - 1989.

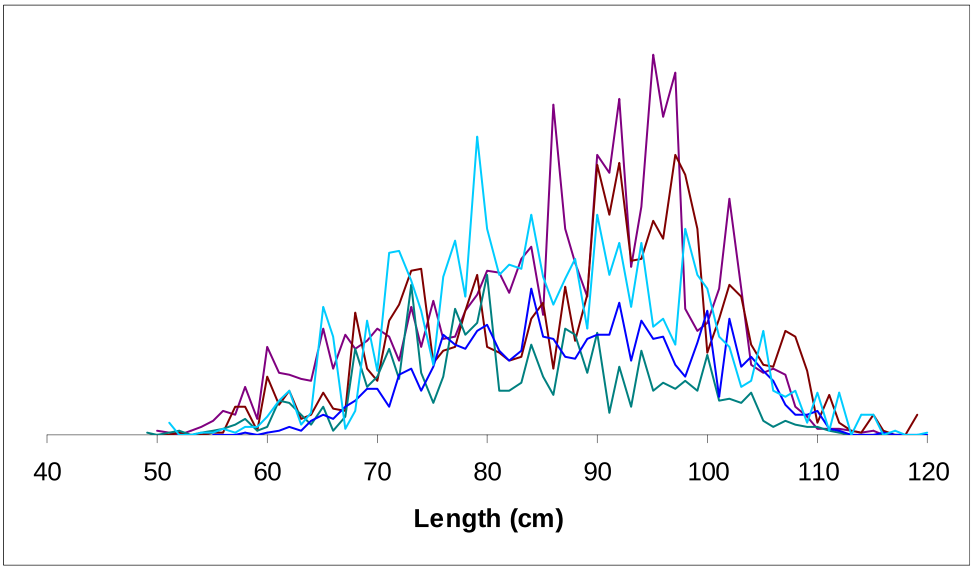


Figure 4.1.1b The frequencies at length in the sample distributions of female spurdog for the years 1997 - 2001.

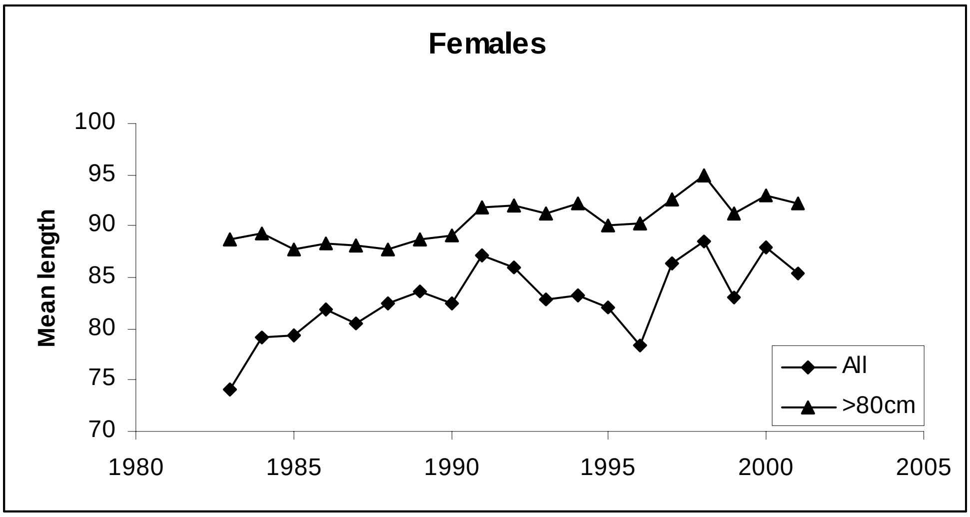


Figure 4.1.2a The change in mean lengths female spurdog in the commercial landings data from the UK (E&W).

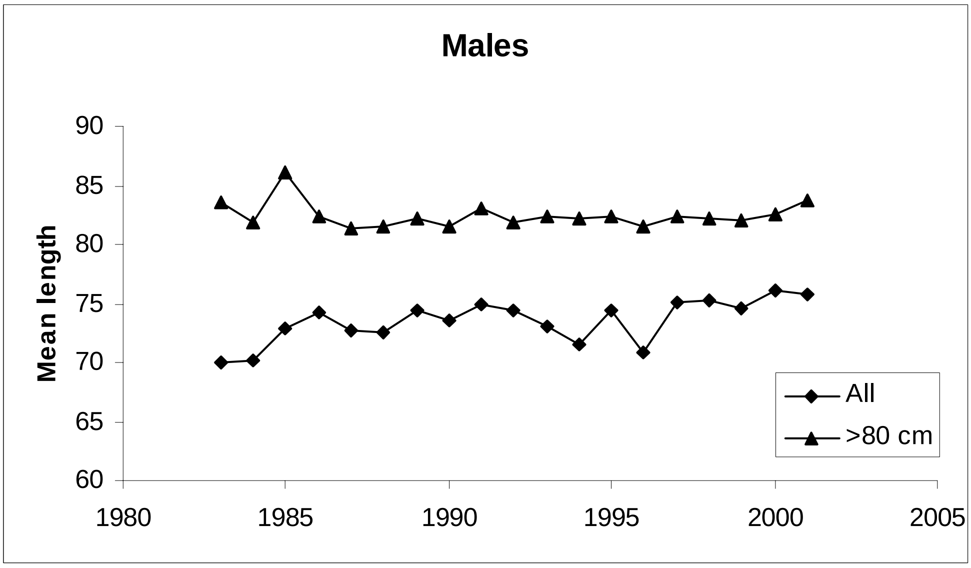


Figure 4.1.2b The change in mean lengths male spurdog in the commercial landings data from the UK (E&W).

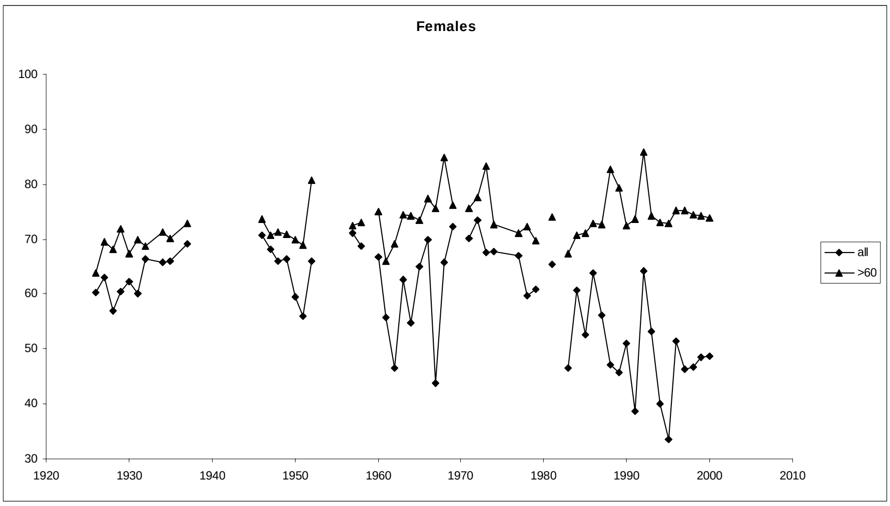


Figure 4.1.3a The mean lengths of the female spurdog recorded in Scottish trawl surveys.

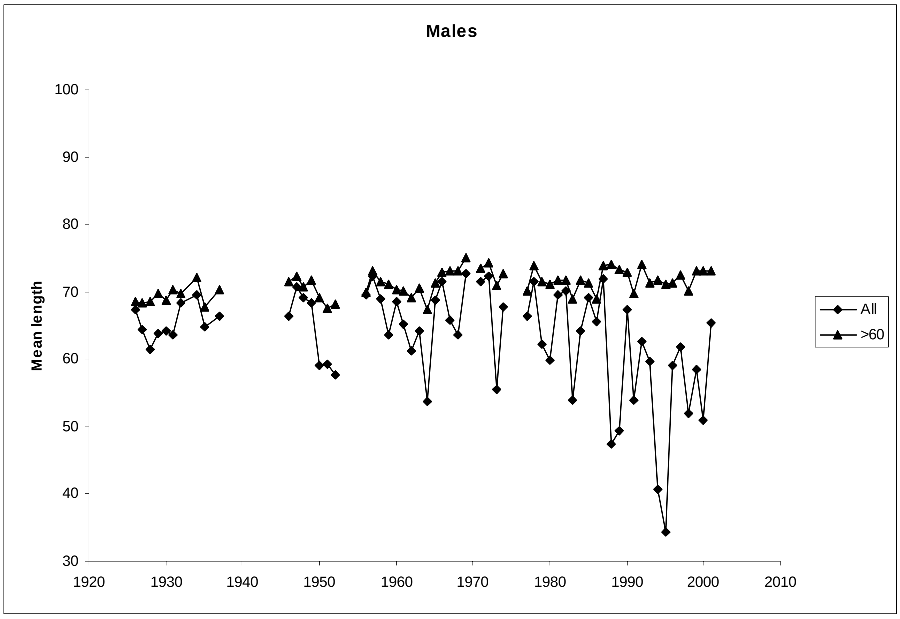


Figure 4.1.3b The mean lengths of the male spurdog recorded in Scottish trawl surveys.

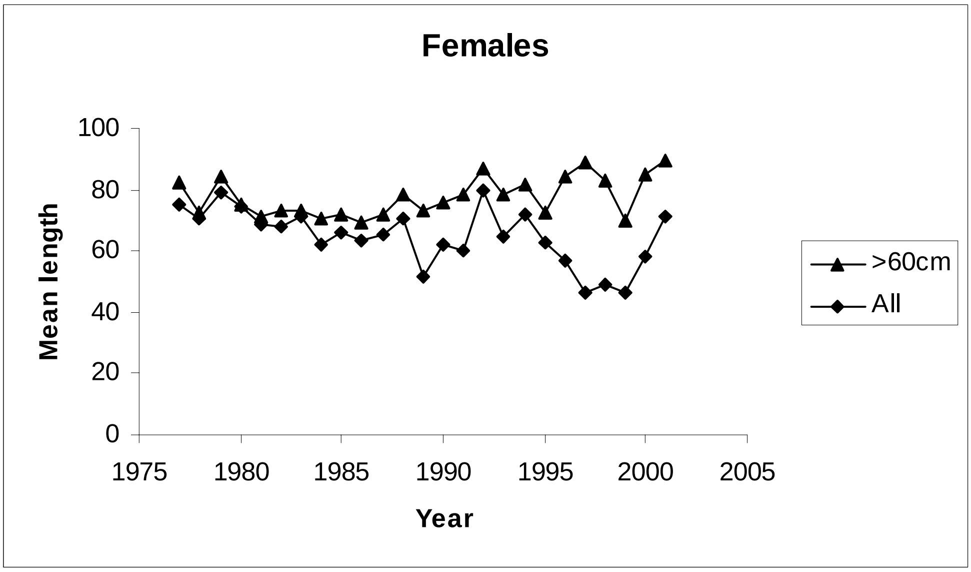


Figure 4.1.4a The mean lengths of the female spurdog recorded in UK(Eng&Wales) trawl surveys.

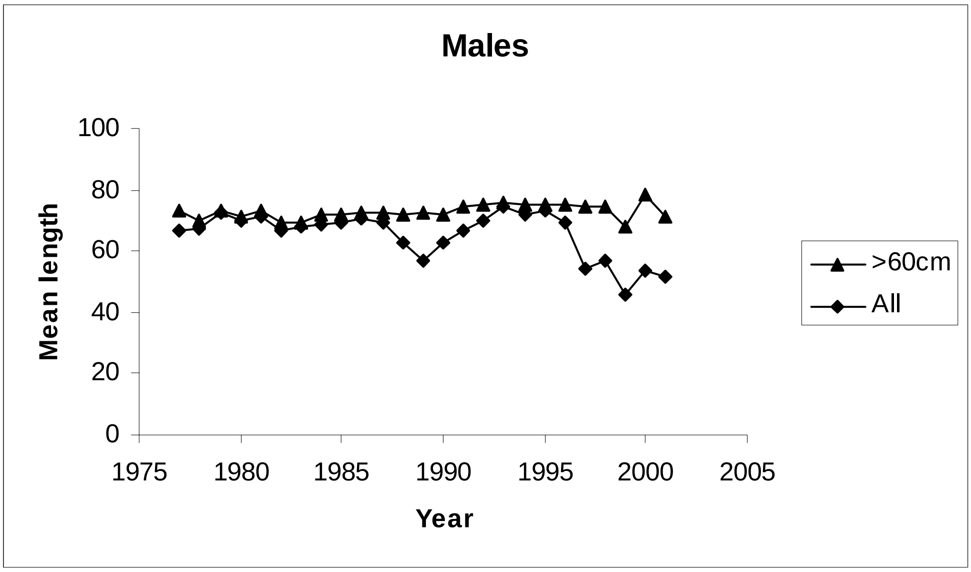
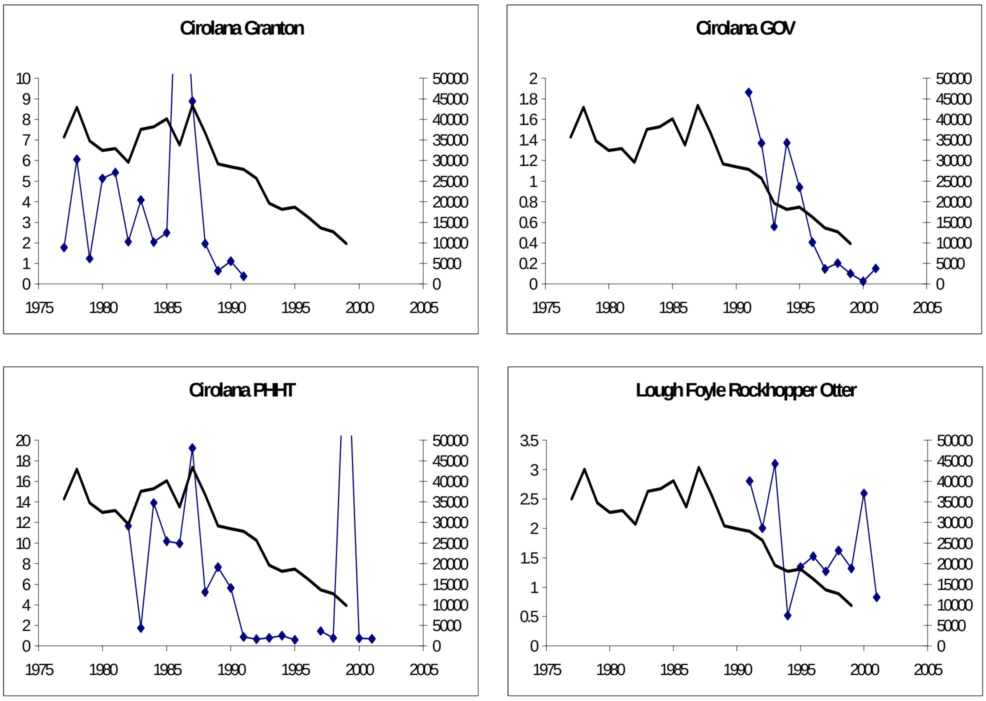
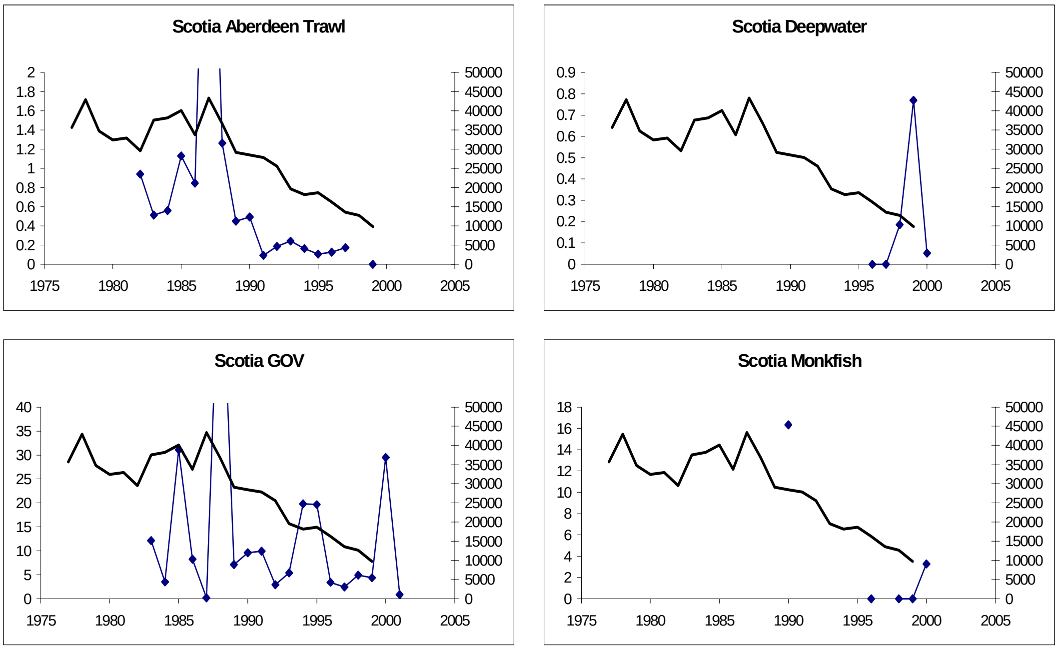


Figure 4.1.4b The mean lengths of the male spurdog recorded in UK(Eng&Wales) trawl surveys.



Figures 4.1.5 The CPUE data recorded from research trawl survey series carried out by UK(Eng&Wales) in ICES areas IV and VIIe,f,g and and Northern Ireland in ICES area VIIa.



Figures 4.1.6 The CPUE data recorded from research trawl survey series carried out by Scotland in ICES areas IV and VI.

Figures 4.1.7a Estimates of total mortality rates (-Z) calculated from length slicing and catch curve analysis of the UK(E&W) female spurdog commercial catch at length samples data. Each line presents the estimates derived from using a different set of growth parameters taken from the literature.

Figures 4.1.7b the correlation coefficient for the regression data used to estimate the total mortality rates for the female spurdog.

Figures 4.1.8a Estimates of total mortality rates (-Z) calculated from length slicing and catch curve analysis of the UK(E&W) male spurdog commercial catch at length samples data. Each line presents the estimates derived from using a different set of growth parameters taken from the literature

Figures 4.1.8b the correlation coefficient for the regression data used to estimate the total mortality rates for the male spurdog.

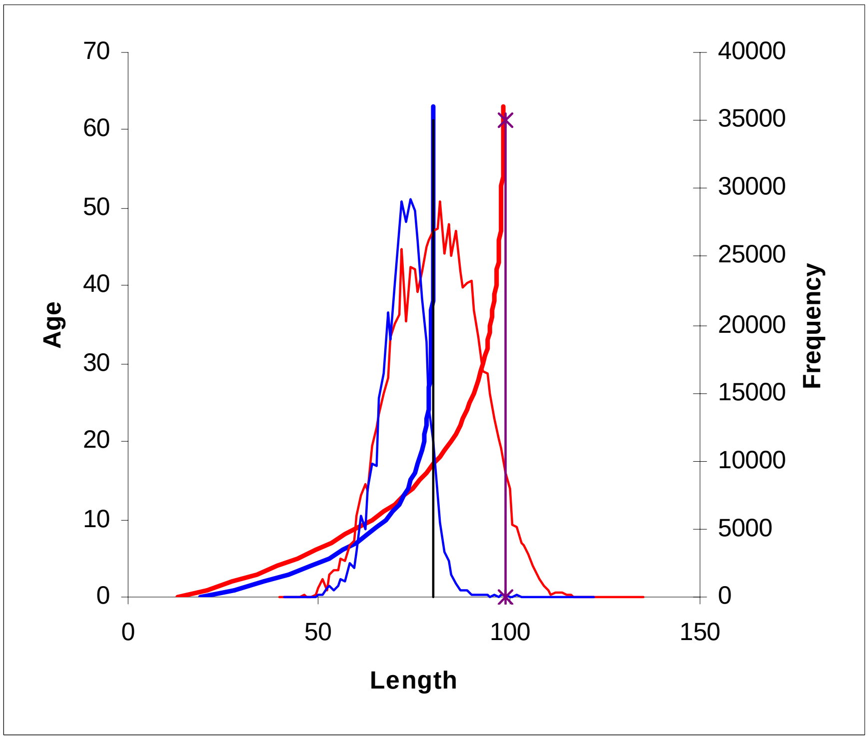


Figure 4.1.9 The average length frequency distribution of male and female spurdog recorded in the UK(E&W) commercial sampling data and the length to age von Bertelannfy growth curve used to slice the length frequaencies into ages. Note the high proportion of lengths greater than L∞.

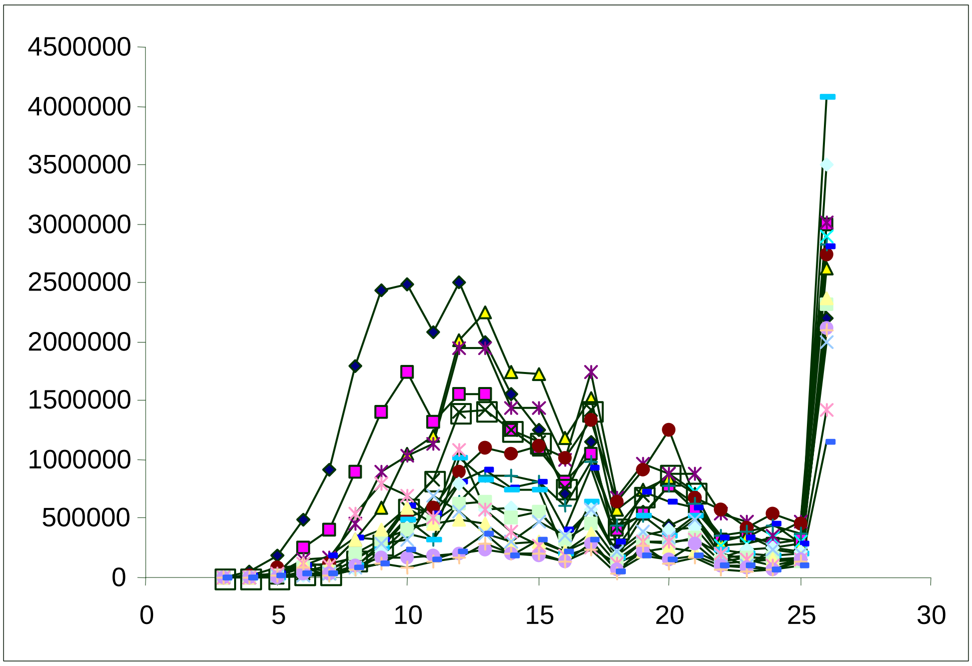
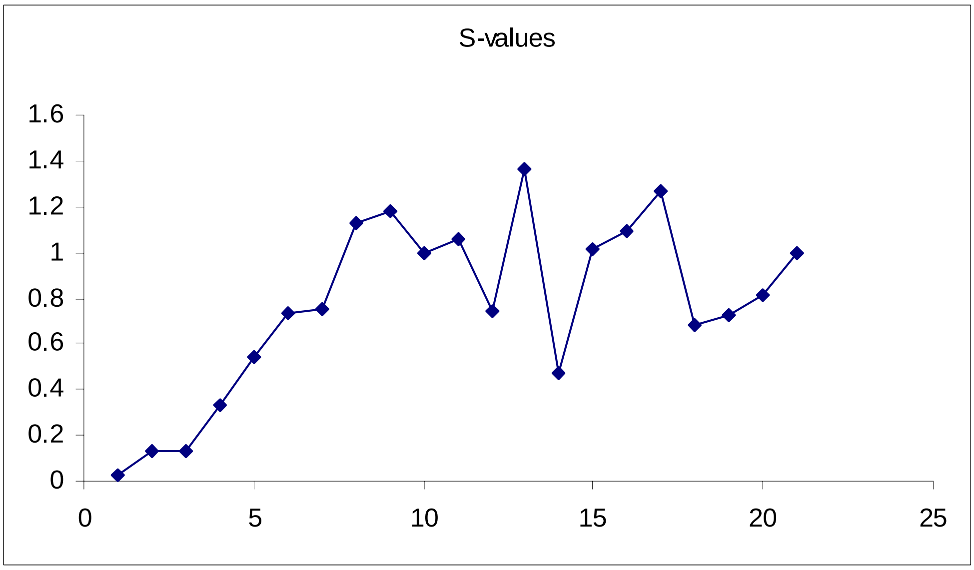
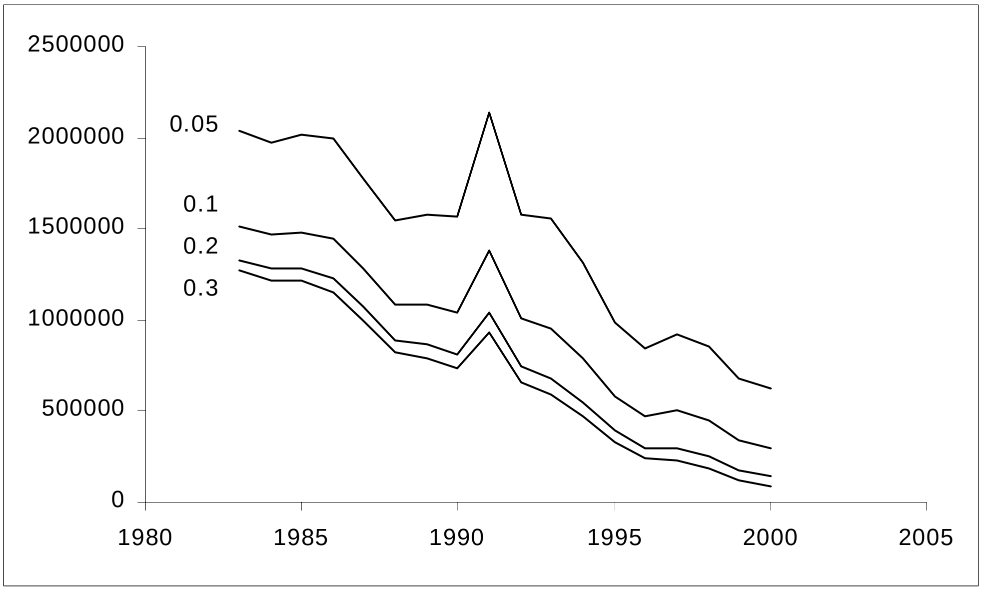


Figure 4.1.10 The catch at age data frequency distributions for derived from length slicing of the UK(E&W) commercial spurdog landings raised to the total recorded landings for all countries.



Figures 4.1.11 The selection at age estimated using a Separable VPA analysis of the catch numbers at age data derived from length slicing of the UK(E&W) commercial spurdog landings raised to the total recorded landings for all countries.

Figures 4.1.12 The trends in average fishing mortality estimated using a Separable VPA analysis of the catch numbers at age data derived from length slicing of the UK(E&W) commercial spurdog landings raised to the total recorded landings for all countries. Each line represents a different assumption for terminal F (0.05 - 0.3) on the reference age in the final year.



Figures 4.1.13 The trends in total population numbers of mature fish estimated using a Separable VPA analysis of the catch numbers at age data derived from length slicing of the UK(E&W) commercial spurdog landings raised to the total recorded landings for all countries. Each line represents a different assumption for terminal F (0.05 - 0.3) on the reference age in the final year.

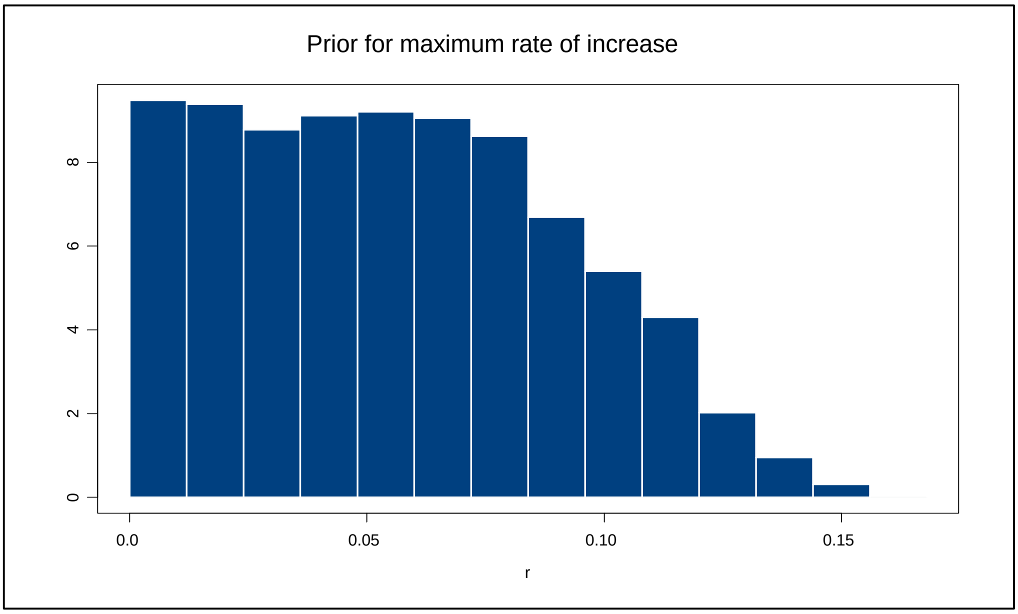


Figure 4.1.14: The prior for maximum rate of increase (r) resulting from our demographic computations.

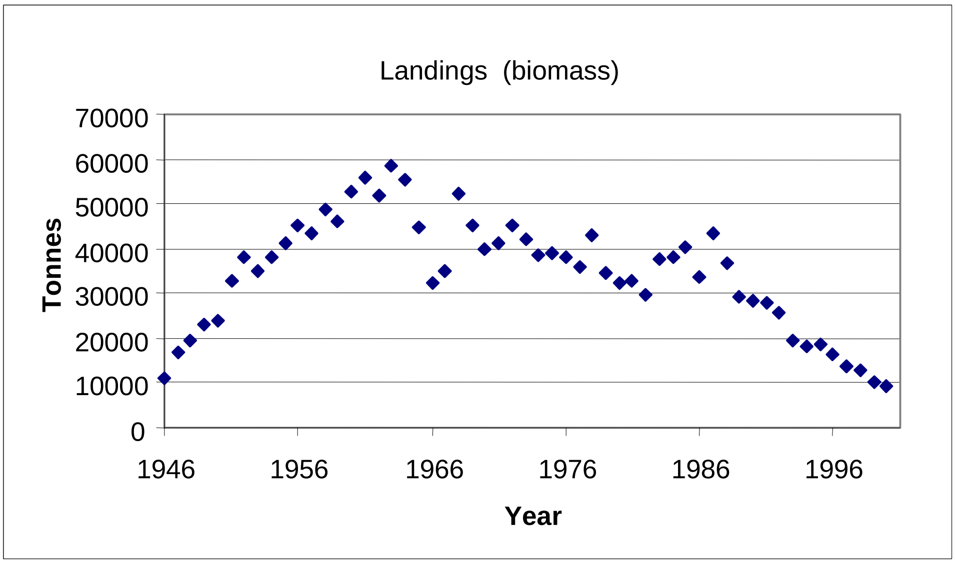


Figure 4.1.15: Landings time series for all of the Northeast Atlantic.

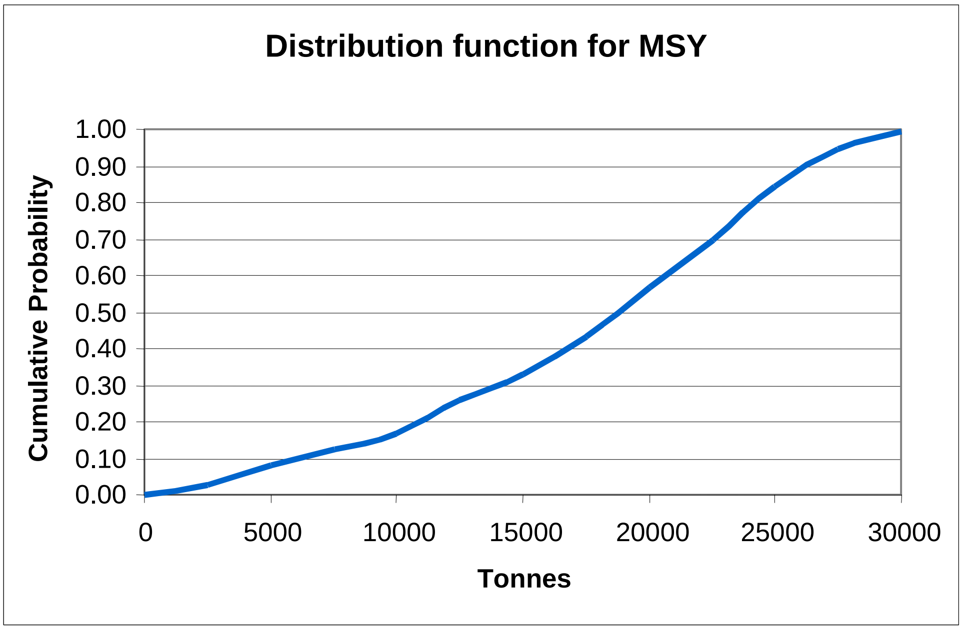


Figure 4.1.16: The posterior distribution function for MSY for NE Atlantic spurdogs as estimated from our assessment model.

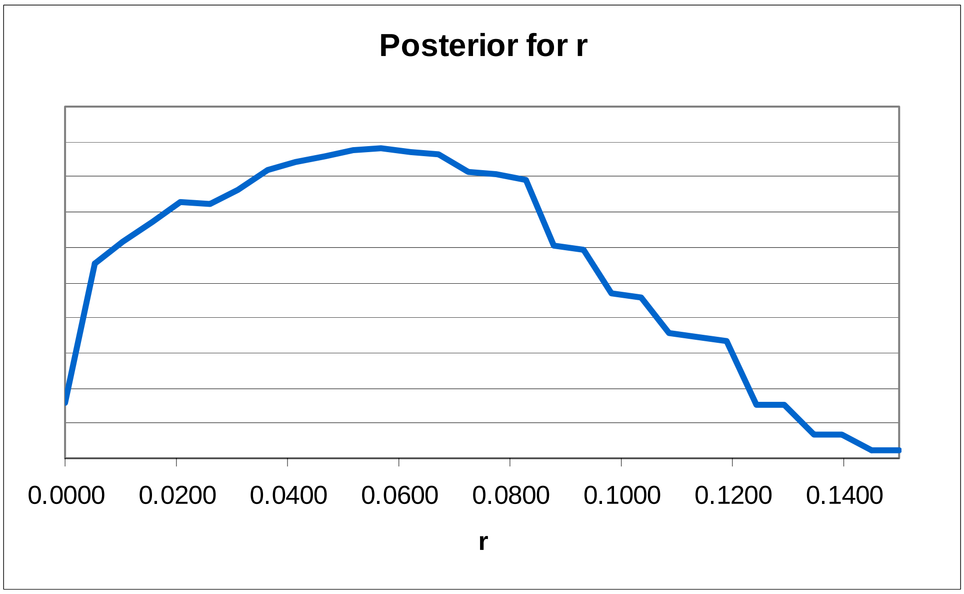


Figure 4.1.17: The posterior distribution for r differs little from the prior, indicating the data are uninformative about r.

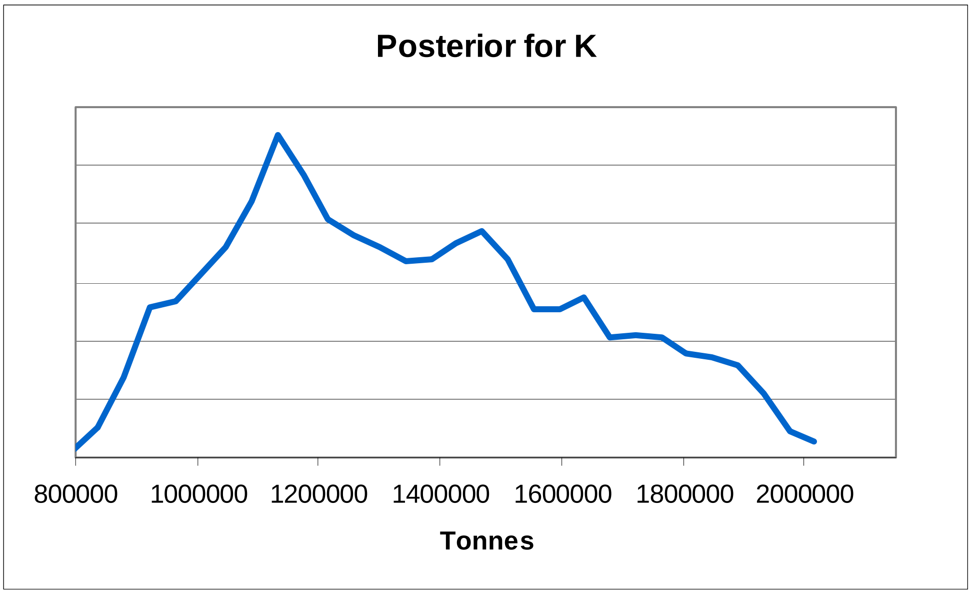


Figure 4.1.18: The posterior density for *K*, in the entire Northeast Atlantic, spans the range from 0.8 to 2.0 million tonnes.

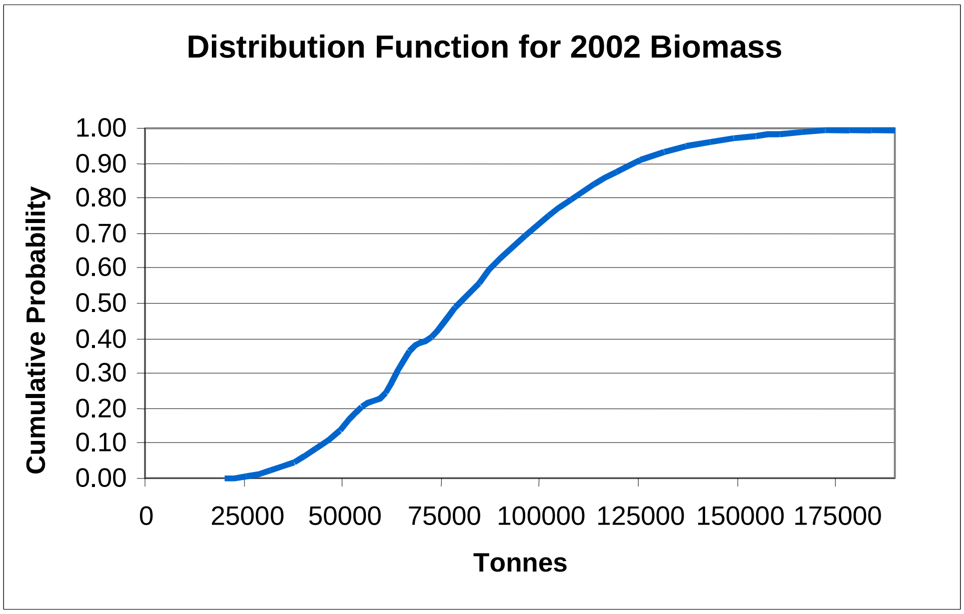


Figure 4.1.19: The posterior cumulative distribution function for 2002 biomass

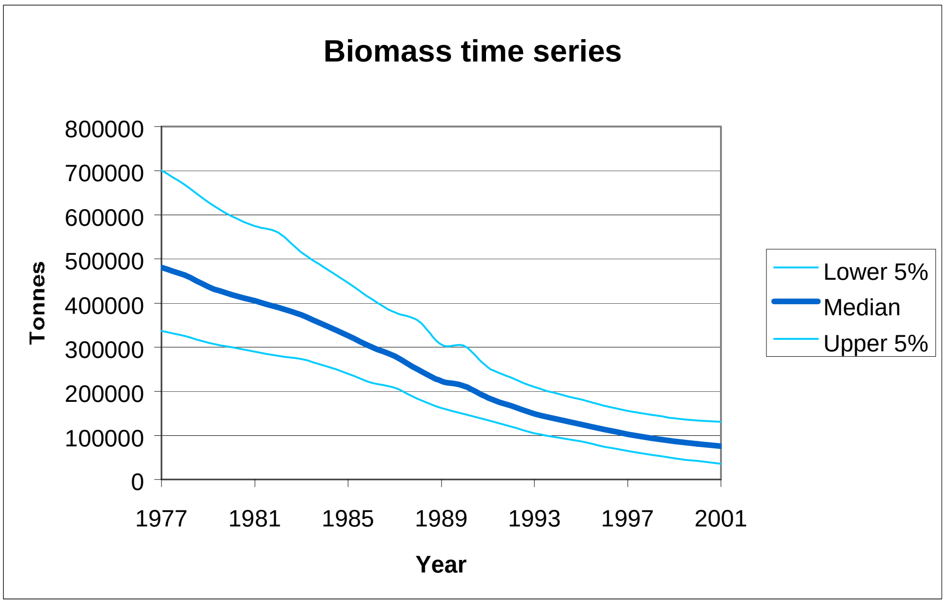


Figure 4.1.20: The biomass time series we estimated suggests a classic decreasing trajectory. Such trajectories are notoriously uninformative about population parameters.

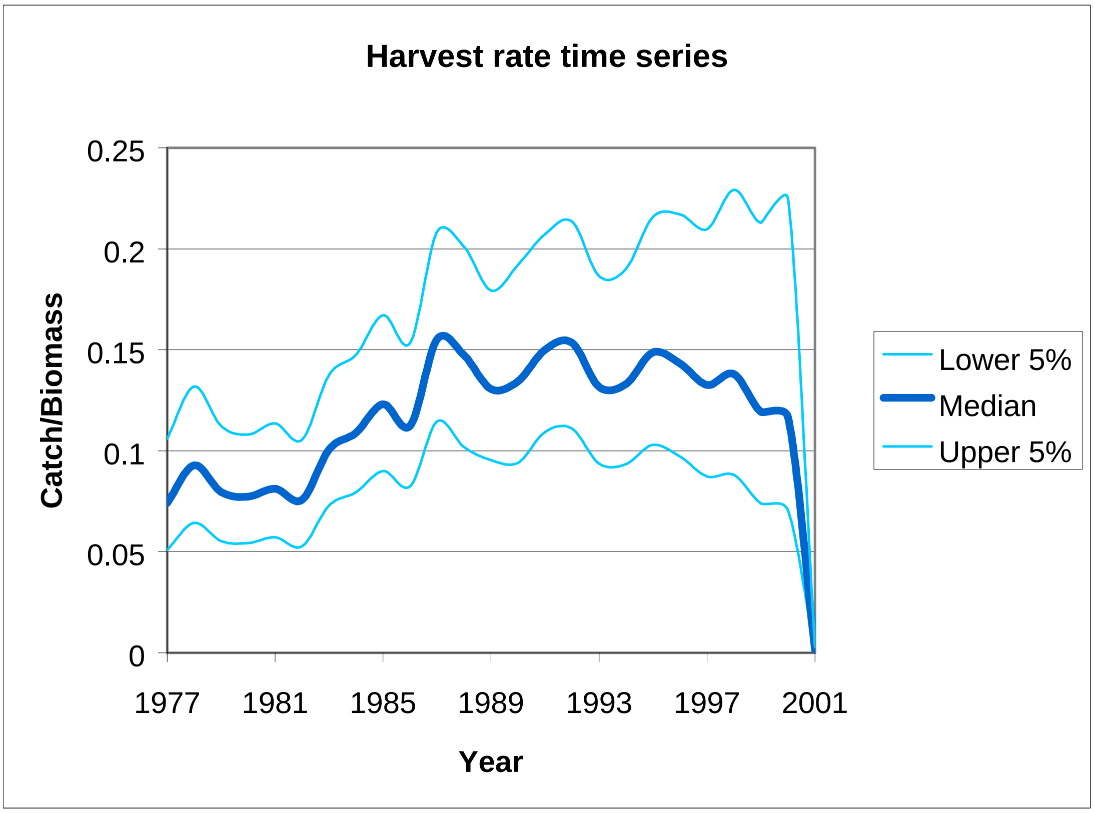


Figure 4.1.21: The harvest rate time series.

4.2 Lesser spotted dogfish in Div. VIIIc

4.2.1 Description of the fisheries taking lesser spotted dogfish

The demersal fishery along the north and north-west coasts of Spain catches many species with a great variety of gears, depending on their abundance and seasonality. With the exception of some local and seasonal fisheries targeting deep-water sharks and blue shark, most of the elasmobranch species are taken as a by-catch. Amongst these, one of the most important species is the lesser spotted dogfish (*Scyliorhinus canicula).*

In 1998, a total of 8756 vessels were counted fishing in the Cantabrian Sea(Div. VIIIc), from which 187 operated with trawl gear, 265 with longline, 184 with gillnet (volanta, rasco and beta) and the rest (about 8000) were small boats working near the coast with "artisanal" gears (90 % in the north-western area). Trawlers are the biggest vessels, with mean dimensions of 445 HP and 24 m length. Gillnet and longline vessels are similar in size, around 156-167 HP and 14 m length.

The majority of elasmobranch species are not commercially important in Spain, and landings come from the by-catch of different fishing gears; though most of this by-catch is discarded. A study carried out in 1994 in Div. VIIIc revealed that almost 90% of the total catch of lesser spotted dogfish is discarded, and other studies carried out in 1999 and 2000 estimated the proportion of discards between 78% and 82 % respectively. Statistics of lesser spotted dogfish landings at the main fishing ports by fishing gear have been compiled for 1996 to 2001, while data for previous years are available only for some fishing ports. In particular, Aviles has data recorded from 1991 to the present. This fishing port contributes 45.5 % of the total landings of dogfish by trawl in the Cantabrian Sea.

4.2.2 Data availability

Tagging data: Since 1993, a total of 6619 lesser spotted dogfish have been tagged with T-bar anchor tags and, from 162 recaptures received to date, 146 provide information on growth which have been used to obtained VBG parameters.

Landings and effort: Dogfish landings from VIIIc are only reported by the Spanish fishery. Landings data are available for the period 1996-2001, and estimates for trawl gear are also provided for 1991 to 1995, based on Aviles (Table 4.2.1). Most of the landings (approximately 91%) come from the trawl fleet and, since the series can be extended back to 1991, only this fleet has been used in the VPA (Figure 4.2.1). Annual landings into Aviles have been stable at around 80 t, with the exception of 1993 which was the lowest of the period. The total area landings also show this minimum in 1993, of less than 100 t, though there is an increasing trend with fluctuations between 1995 and 2000. The highest landings at nearly 220 t were in 2001.

The time series for effort of the trawl fleet during the study period reached a peak in 1992 (Table 4.2.2), though effort since 1992 shows a marked and continuous downward trend with a brief period of stability during 1996-99 (Fig. 4.2.1).

CPUE: The CPUE series shows an increasing trend from 1991 to 2001 with a pronounced peak in the last two years. This tendency is also observed for Aviles, though the peak in CPUE in the last period is not so noticeable (Fig. 4.2.1).

Length distributions: No commercial length distributions were available for analytical assessments, since this is a not commercial species, and data on commercial length distributions by gear and sex are only available for 2000 and 2001 (from a sampling programme carried out within DELASS, Table 4.2.3). The length distributions in trawler's catches is very similar to the one obtained in the bottom trawl surveys (Figure 4.2.3). The length distribution of the surveys has, therefore, been used in analyses. The mean size obtained from the trawl surveys series shows a constant pattern. Generally, the mean size is quite similar for all gears with the mean size of males being slightly higher than females, though not significantly.

Trawl survey abundance indices: Table 4.2.4 shows the abundance indices of lesser spotted dogfish on the Cantabrian shelf, as derived from bottom trawl surveys carried out in autumn to estimate hake recruitment. It appears that this species is quite abundant in the continental shelf and is one of the most important in biomass terms after the commercial species (blue whiting, horse mackerel, megrim, hake). The biomass indices show no trend, though there are annual fluctuations and high levels in 1990, 1997 and 2001 (Fig. 4.2.2).

General comments on quality of data and inputs

The fisheries statistics (landings and effort data) are considered to be of acceptable quality, although discard data are still very limited. Nevertheless, landings data could be improved for some years and fishing ports in which they are as yet unreported. Since lesser spotted dogfish is not a target species but is a by-catch of the bottom fishery (trawl, longline and gillnet) targeting hake and other commercial species, the fishing effort used in the analysis is fishing days for the trawl fishery in the Cantabrian Sea, provided by IEO. This fishing effort time series has also been used in a recent ICES assessment of the *Nephrops* fishery in the Cantabrian Sea.

4.2.3 Model methods chosen

4.2.3.1 Dynamic surplus production model

The available data on commercial fisheries and research survey catch, effort and CPUE were used to perform a simple analysis using a dynamic (non-equilibrium) Schaefer surplus production model. The discrete form of the Schaefer model used was that recommended by Hilborn and Walters (1992):

$$B_{t+1} = B_t + rB_t(1 - \frac{B_t}{K}) - qfB_t$$

Where **B** is biomass, **t** an index for years, **r** the intrinsic rate of increase, **K** the carrying capacity of the system, **q** is the catchability and **f** is effort.

The model was fitted to two sets of data for the lesser spotted dogfish. The first set (Table 4.2.5) includes estimates of the landings, but does not take account of discards. A second time series of total removals (landings plus dead discards) was estimated from these data using information on lesser spotted dogfish discards for three years: 92.8%, 77.4% and 82.6% of the catch was discarded at sea for the years 1994, 1999 and 2000 respectively (Pérez *et al.*, 1996). We assumed that, in years prior to 1994, the discard rate was the same as in 1994, and that the discard rate for 2001 was the same as in 2000. We then interpolated the expected values of discard rates for the years 1995-1998 using the discard rates of 1994 and 1999. Estimates dead discards were based on experimentally obtained data on the survival of this species during research surveys, which indicate that 70% of the fish survive for up to 6 hrs or more on deck and then swim away when returned to the sea (Rodriguez-Cabello *et al.,* 2001). Thus, we estimated dead discards as 30% of the total discarded, and used these values to obtain the time series of total removals from the population.

The 'Kernel' was used to estimate a relative measure of parameter uncertainty. The Kernel is equal to $SS^{-(t-1)/2}$, where t is the number of observations (years). This value was tabulated using Excel for a range of values of **K** and **r** in order to evaluate the most likely values of these parameters to provide the best fit to the data. In all cases, the CPUE calculated by the Schaefer model was fitted to the three available CPUE series, given that there was no information to ignore or favour any of them in particular.

The model was implemented in a spreadsheet and the non-linear algorithm 'solver' was used to find the best parameter values for **K**, **r**, **q** and the initial biomass in 1991 ($\mathbf{B_0}$). In order to fit the model to the data, we minimized the total sum of squares, which is simply the addition of the squared deviations of each predicted and observed CPUE for each of the three data series:

$$SS = \sum (CPUE_{y,a}-CPUE_{y,M})^2 + (CPUE_{y,b}-CPUE_{y,M})^2 + (CPUE_{y,c}-CPUE_{y,M})^2$$

Where y is an index for years, a-c indices for data series, and M denotes the CPUE predicted by the model.

Results

The Schaefer model had a relatively good fit to the landings CPUE series (Fig 4.2.4). Because all three CPUE time series indicate that the abundance of the lesser spotted dogfish has increased since 1991, the Schaefer model also predicted an increasing CPUE. Although the predicted CPUE series cannot fit the three data series simultaneously, the model parameters have plausible values.

B_0 = 226,146 t
r = 0.3832
K = 535,067 t
q = 0.00002

Experience with fitting surplus production models to fisheries data indicates that, in many cases, short time series of data such as these are commonly less informative about the changes in the stock and usually give unreasonable estimates of parameters (extremely small values for **r** or **q**, or immense values for **K).** Though the estimates may appear reasonable, there is considerable uncertainty about the true values (Figure 4.2.5). In short, a number of combinations of **r** and **K** values could predict equally well the various CPUE series, a function of the poor quality (contrast) in the data (Hilborn and Walters, 1992). It is probable that a longer time series of data with higher fishing mortality that drives down the abundance for a number of years would provide more information about the dynamics of the stock.

The model also fits equally well the different CPUE series when the data used include the estimates of dead discards. However, because of the large amount of dead discards, the estimates of **K** and $\mathbf{B_0}$ are raised, and **q** reduced, by one order of magnitude.

B_0 = 1,279,129 t
r = 0.3834
K = 3,024,983 t
q = 0.000002

Note that the estimates of **r,** the predicted CPUE, and the shapes of the surface plot of likely parameter combinations for **K** and **r** remain virtually unchanged (Figs. 4.2.6 and 4.2.7). The only difference between the two surface plots of likely values of **K** and **r** is the scale of the **K** axis, which has changed and reflects the effect of considering the dead discards in the calculations. This is a clear example of the importance of considering all the removals from the population when using surplus production models to estimate MSY levels and TACs, which could otherwise be severely biased in absolute terms. The marginal probability distributions for **K** and **r** are presented in Figures 4.2.8 and 4.2.9.

Conclusions

Although the results of the Schaefer model contain large uncertainties and should not be used to provide advice, it appears that the stock of lesser spotted dogfish is increasing in size. This assumes that the three available abundance indices truly reflect the abundance of the population. The fact that all of them were derived independently (though the two commercial CPUE series are almost exact images of each other, just at different scales), and that the survey index is a fishery-independent measure of abundance, suggests that there is reason to believe the increase is true. Possible explanations for this increase in abundance is the tradition of dumping most of the catch of lesser spotted dogfish alive, and that other discarded fish might be providing additional food sources for the dogfish (Olaso, *et al*., 1998; Olaso *et al.*, 2002).

4.2.3.2 Separable VPA

The separable VPA initially developed by Pope (1977) and finally by Pope and Shepherd (1982) was considered as another possible method to asses this stock. This model assumes that F at age and by year class is the result of the total mortality in one year and an age-dependent exploitation pattern.

Input parameters used in analytical assessments are presented in Table 4.2.6 In order to obtain the catch-at-age data needed to run the VPA, the slicing procedure has been executed with the help of the L2AGE4 software. The growth parameters introduced were obtained from previous tag-recaptured data analysis (paper in prep). The slicing procedure generates a maximum of 12 'age groups'. According to the data, 9 'age groups' were considered and 'age' 10 was adopted as the plus-group for the exploratory VPA run (Fig. 4.2.10.).

After different trials, age 4 was adopted as reference age. The selectivity at age was dome shaped in all cases, declining for older ages (Fig. 4.2.11). The value of 0.6 was chosen as the most appropriate value, which could be between 0.5 and 0.8. The residual plots of the catch for different values of F is shown in Figure 4.2 12. The high residuals found in 1991 can be explained by a lack of individuals in the first length groups that year. High residual values are also found in the first age, suggesting that this age group is not well represented in the catch. Results from initial runs with the selected values gave a very low F. This analysis was not considered further at the meeting as many of the parameter assumptions are untested and the results are at best tentative.

4.2.3.3 Survey-only methods

The survey-only method of Cook (1997) was also considered as a means of estimating the trends in this stock and was applied to age-disaggregated abundance indices obtained by slicing the length distributions obtained from the Spanish bottom trawl survey. The model assumes that F is separable into age and year effects, and that the population size of a cohort at a given age can be expressed as the product of its initial cohort strength and its cumulative mortality. On the assumption that age-disaggregated survey indices are related to abundance at age by age-dependent catchabilities, then the model estimates of these values can be fitted to the observations to obtain estimates of age, year and year-class effects. These parameters can then be used to obtain estimates of relative number at age, stock biomass and yield.

A further assumption of this model is that the ratio between the survey catchabilities (q) at age is known. Cook (1997) suggests that q is assumed constant above a certain age, and q on the youngest age is adjusted by trial and error to give a selectivity on the youngest age similar to that obtained from the conventional assessment. In the case of this stock, however, there is no conventional assessment and, therefore, difficulties arise in making choices about the validity of the estimated selectivity pattern and the assumed q values.

Results from initial runs of this model with various values of q at the youngest age gave either unrealistically high selectivity for this age class or very low mean estimated F. A closer consideration of the survey indices (Figure 4.2.13) indicates that the assumption of constant catchability at older ages may not be valid, as increasing numbers of individuals from the same year class are caught through time. This would explain the very low estimates of F obtained in these initial runs. Different assumptions about the relative q at age should be explored further.

4.2.4 Conclusions

Surplus production models can be used as stock assessment tools for lesser spotted dogfish, but only if reliable data on total catch (landings, discards and discards survival) and effort are available. Obtaining such data is a difficult task since this is not a target species.

VPA assessment models could be helpful for the assessment of this stock, but further analyses should be performed trying different scenarios. This method requires more information on the biological parameters of this species.

The main problem in elasmobranch fisheries, and for this species in particular, is that it is difficult to collect long time series of landings and effort. However, surveys can often provide more reliable data and longer time series than commercial fisheries, and survey-based models could provide a basis for advice and further development of these models should be considered.

Table 4.2.1. - Cantabrian Sea (VIIIc ICES Div.): Landings (tonnes) by gear 1991-2001

Year	Spain				Total
	Trawl	Longline	Gillnet	Purseine	
1991	144,1				
1992	131,5				
1993	96,6				
1994	169,2				
1995	192,7				
1996	177,3	3,4	0,3	0,1	181
1997	155,2	6,5	3,8	0,0	165
1998	162,5	12,7	11,0	0,0	186
1999	150,8	7,7	3,0	0,0	161
2000	214,9	17,1	13,0	0,1	245
2001	219,9	10,2	11,1	0,0	241

Table 4.2.2 - Cantabrian Sea (VIIIc ICES Div.): Effort (fishing days) of Spanish trawlers, 1991-2001

Year	Effort
1991	7045
1992	8110
1993	6948
1994	7505
1995	4608
1996	3809
1997	4049
1998	3845
1999	4232
2000	3367
2001 *	2031

Table 4.2.3. - Cantabrian Sea: a) Mean sizes (TL cm) of S.canicula in bottom trawl surveys.
b) Mean sizes (TL cm) of S.canicula landings by fishing gear in 2000-2001

a)

Year	**Survey**
1991	45,6
1992	39,6
1993	41,5
1994	40,4
1995	42,9
1996	41,5
1997	41,6
1998	39,4
1999	38,9
2000	40,2
2001	40,5

b)

Years	Landings					
	Trawl		Longline		Gillnet	
	Male	Female	Male	Female	Male	Female
2000	54,1	52,4	53,4	56,6	52,6	51,6
2001	55,1	52,6	55,9	54,9	57,6	56,4
Both	54,8	53,3	55,4	55,2	54,3	53,6

Table 4.2.4. - Cantabrian Sea (VIIIc ICES Div.): Mean stratified catches (MSC) and standard errors (SE) of S. canicula in bottom trawl surveys in the Cantabrian Sea, 1991-2001.

Year	**Kg / 30 min haul**		**Nº / 30 min haul**	
	MSC	SE	MSC	SE
1991	4,79	1,31	13,90	4,74
1992	6,13	1,17	23,10	4,02
1993	5,15	1,35	16,40	3,84
1994	5,33	1,22	17,60	4,06
1995	3,45	1,33	8,90	2,74
1996	5,34	1,47	15,80	3,27
1997	6,32	1,70	20,50	4,81
1998	5,19	1,16	18,00	3,45
1999	4,70	1,82	4,70	1,82
2000	6,26	1,38	21,20	3,96
2001	6,83	0,97	23,3	3,1

Table 4.2.5. - Cantabrian Sea S.canicula: Input data and parameters.

ICES Div. VIIIc			
FLEET	**Spain**	**GEAR**	**Trawl**

INPUT PARAMETERS		
Parameter	Value	Source
Years range	1991 to 2001	
Length range	10 cm -70 cm	Trawl surveys length distribution
Catch / Effort data	1991 to 2001	Fisheries statistics Spain VIIIc (trawl fleet)
Discard Survival	na	Not applicable - not all years
SEX COMBINED		
Growth - K	0,28	Based on growth estimation from tag data (unpublished)
Growth - L(inf)	63,9	Based on growth estimation from tag data (unpublished)
Natural mortality - M	0,2	Assumed
Length/weight - a	0,0023	Published data
Length/weight - b	3,099	Published data

Table 4.2.6. Catch, effort and CPUE data for the lesser spotted dogfish from Spain.

Years	Landings at Aviles Port	Effort from Aviles Port	CPUE Aviles	Total landings	Total effort	CPUE total	Survey index
1991	65.555	7.681	8,53	144.077	7.045	20,45	4,79
1992	59.833	12.692	4,71	131.501	8.110	16,21	6,13
1993	43.967	7.635	5,76	96.630	6.948	13,91	5,15
1994	76.989	9.620	8,00	169.200	7.505	22,54	5,33
1995	87.682	6.146	14,27	192.708	4.608	41,82	3,45
1996	89.929	4.525	19,87	177.316	3.809	46,55	5,34
1997	77.551	5.061	15,32	155.196	4.049	38,33	6,32
1998	70.461	5.929	11,88	162.496	3.845	42,26	5,19
1999	79.078	6.829	11,58	150.768	4.232	35,63	4,7
2000	78.369	4.453	17,60	199.000	3.367	59,10	6,26
2001	68.682	2.385	28,80	213.000	2.031	104,87	6,83

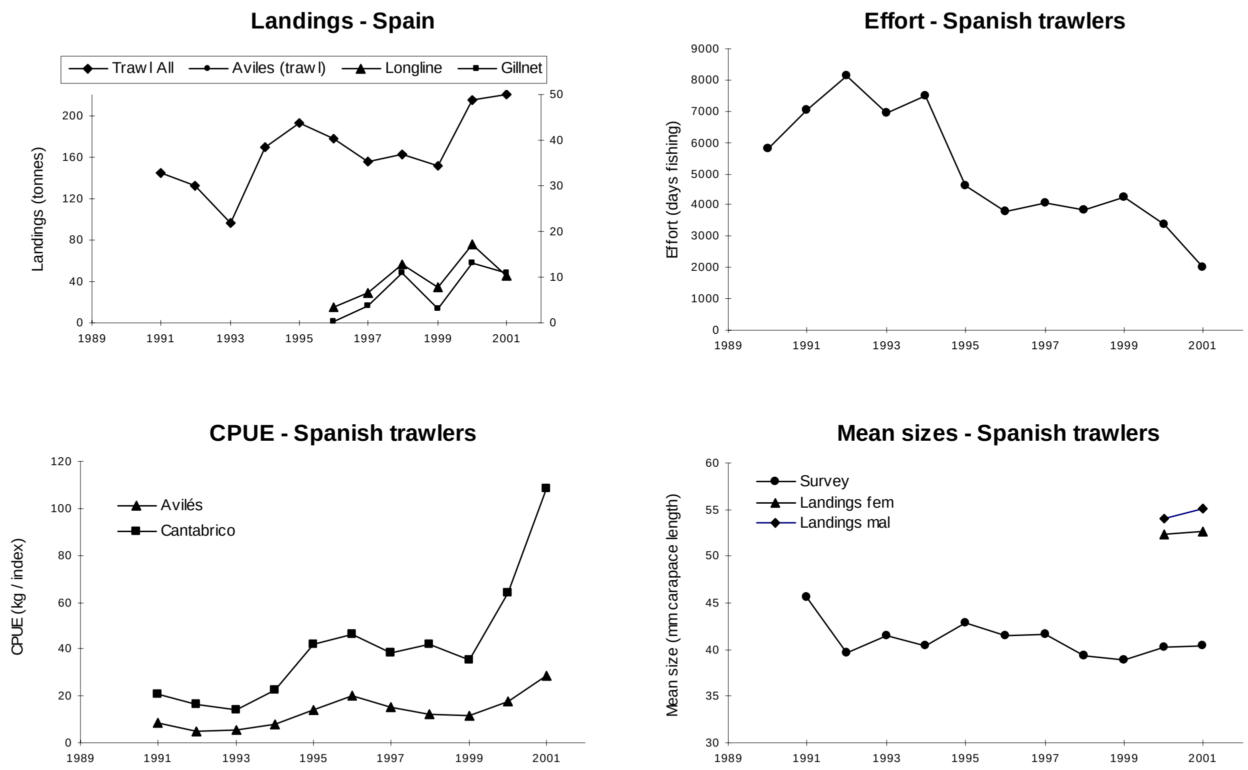


Figure 4.2.1. - Cantabrian Sea: Long-term trends in landings, effort, CPUEs and mean size of S. canicula

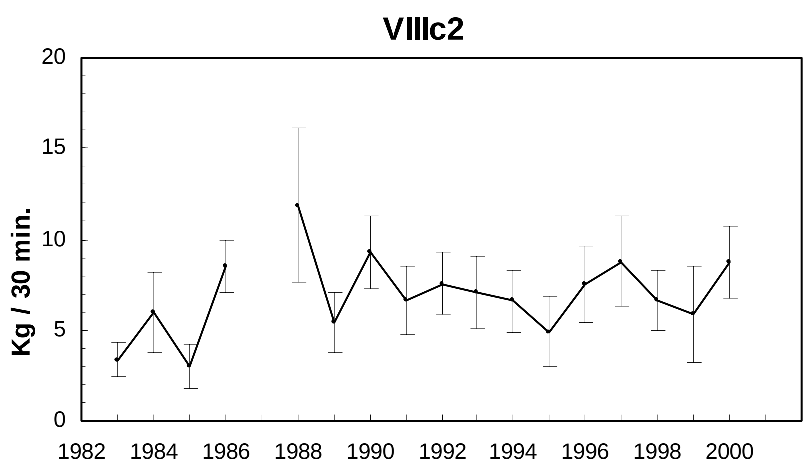


Figure 4.2.2. Historical series of biomass indices (Kg/30 min.trawl) and SE for S.canicula

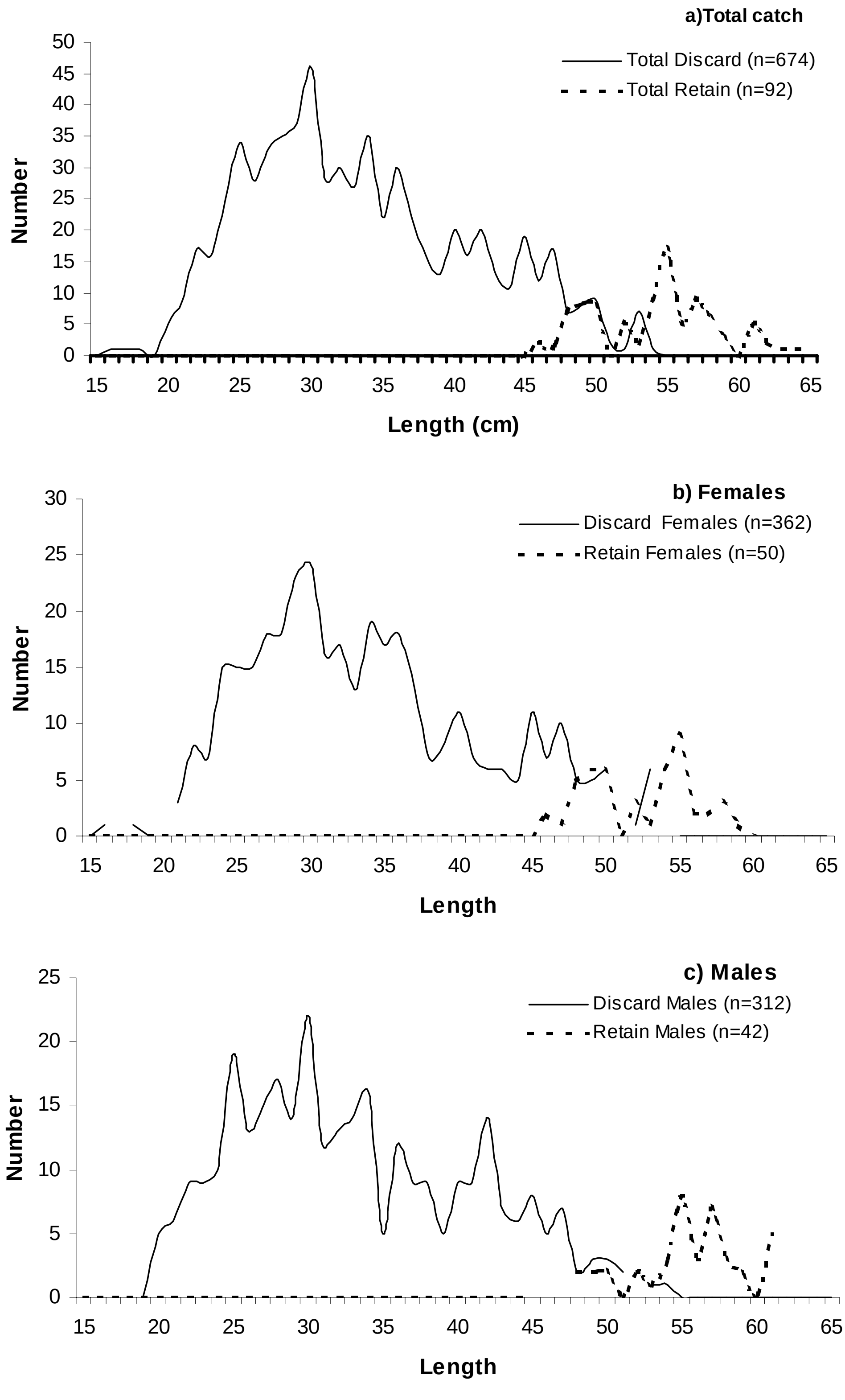


Figure 4.2.3. Length distributions of specimens caught and discarded on a commercial trawler. Data from a trip (7 hauls).

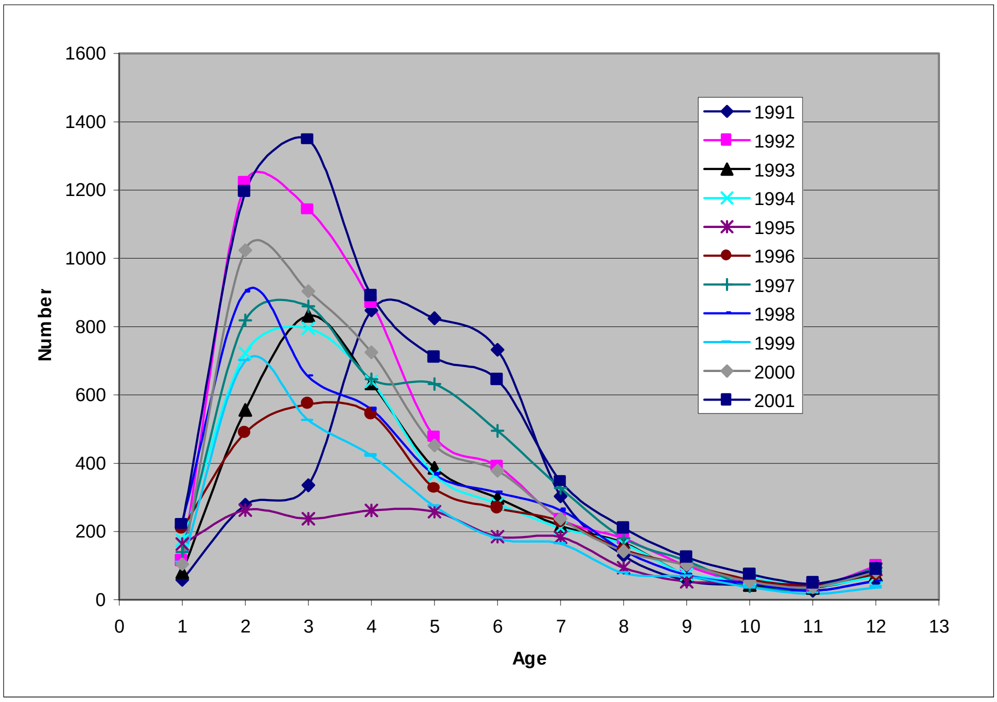


Figure 4.2.4. Catch number (thousands) by age during the time series

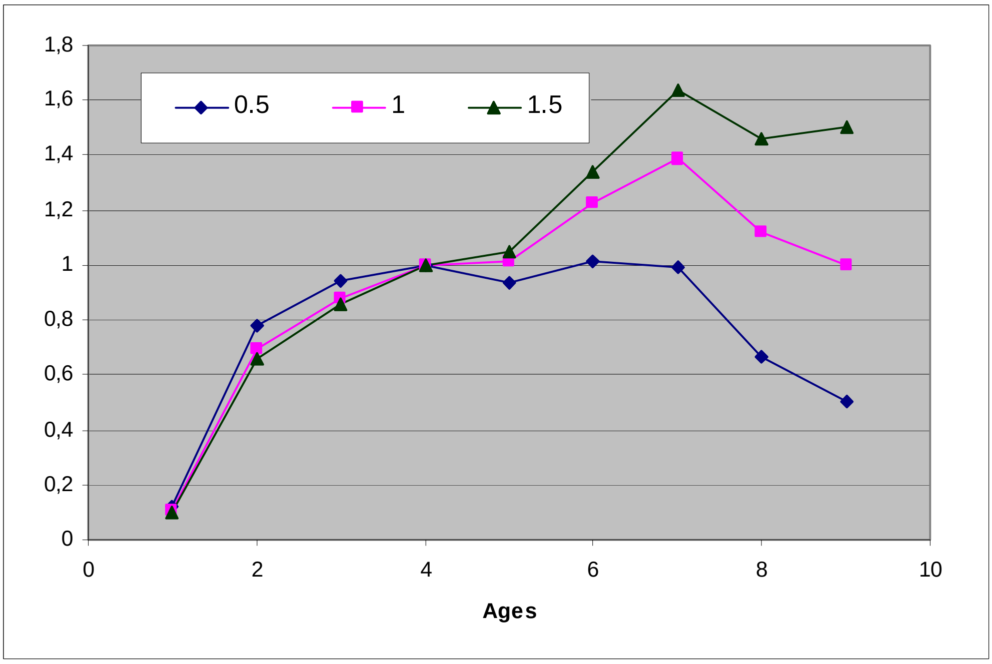


Figure 4.2.5. Plot of selectivity at age for reference age 4 and F=0.5

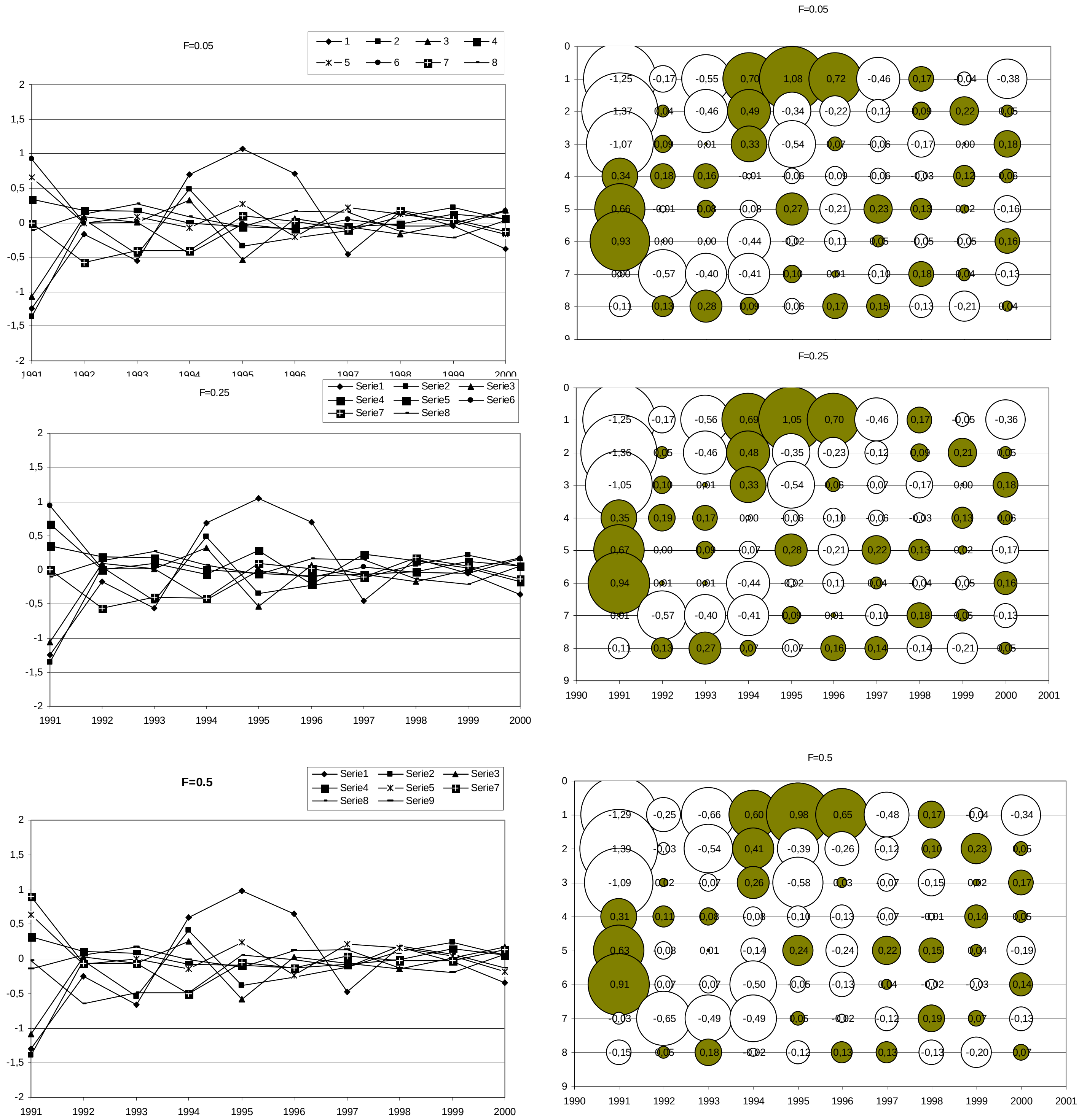


Figure 4.2.6. Residual plots of catch with different trials of fishing mortality.

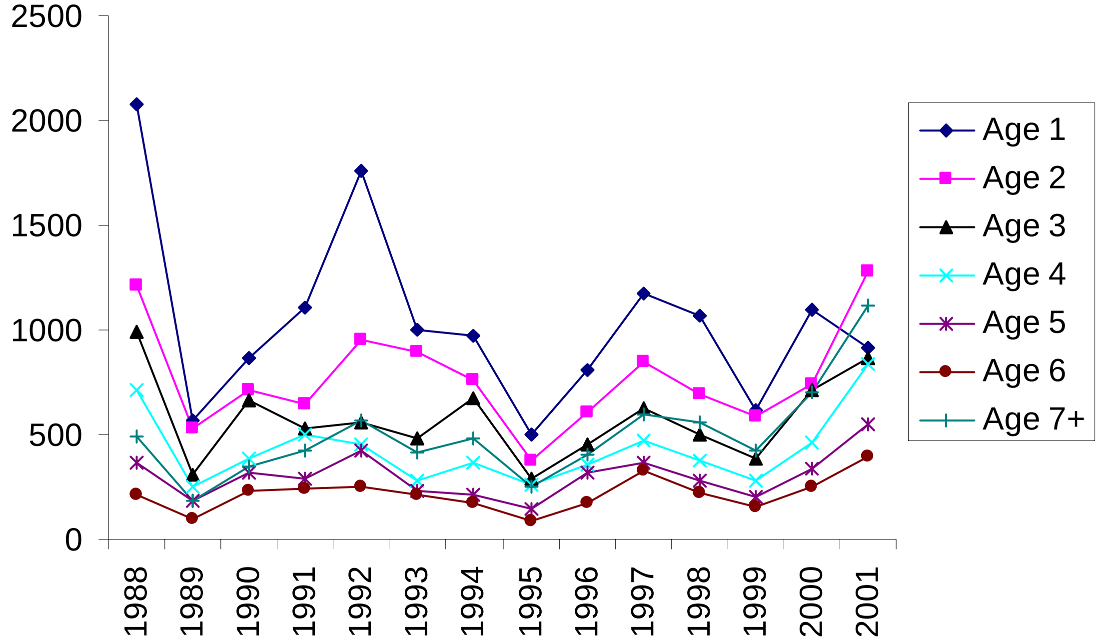


Figure 4.2.7. Spanish bottom trawl survey abundance index for S. canicula, division VIIIc ICES Div.

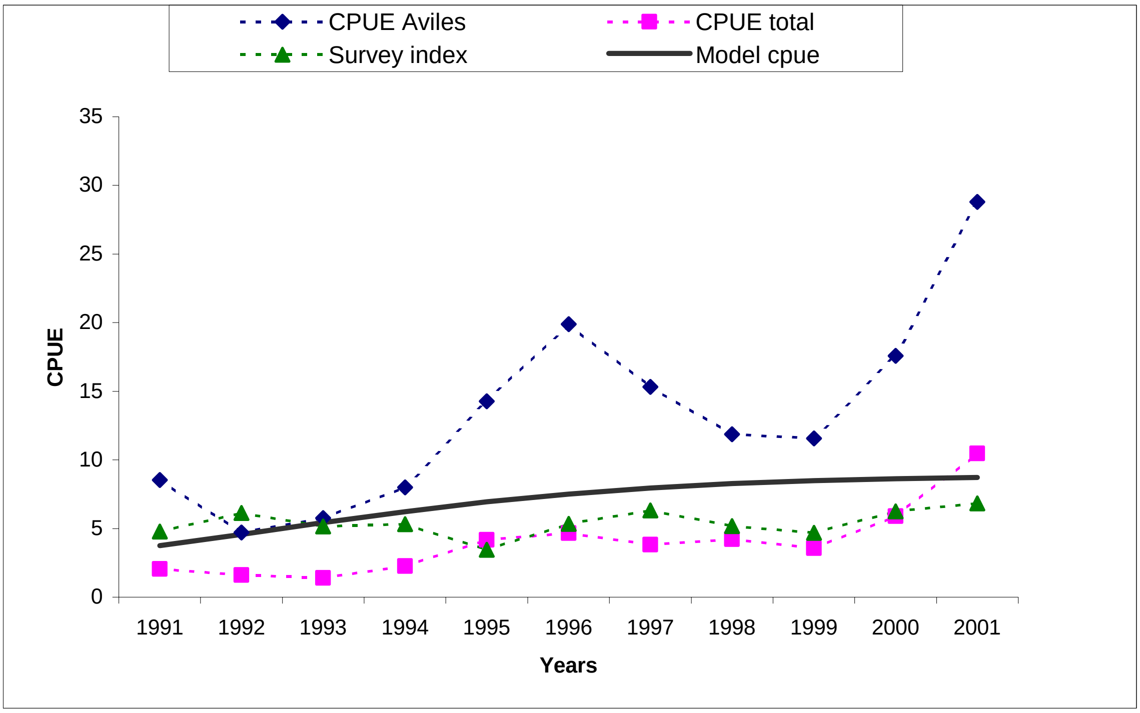


Figure 4.2.8. Schaeffer model predicted CPUE and three observed CPUE for the lesser spotted dogfish. Data used to fit the model include only landings.

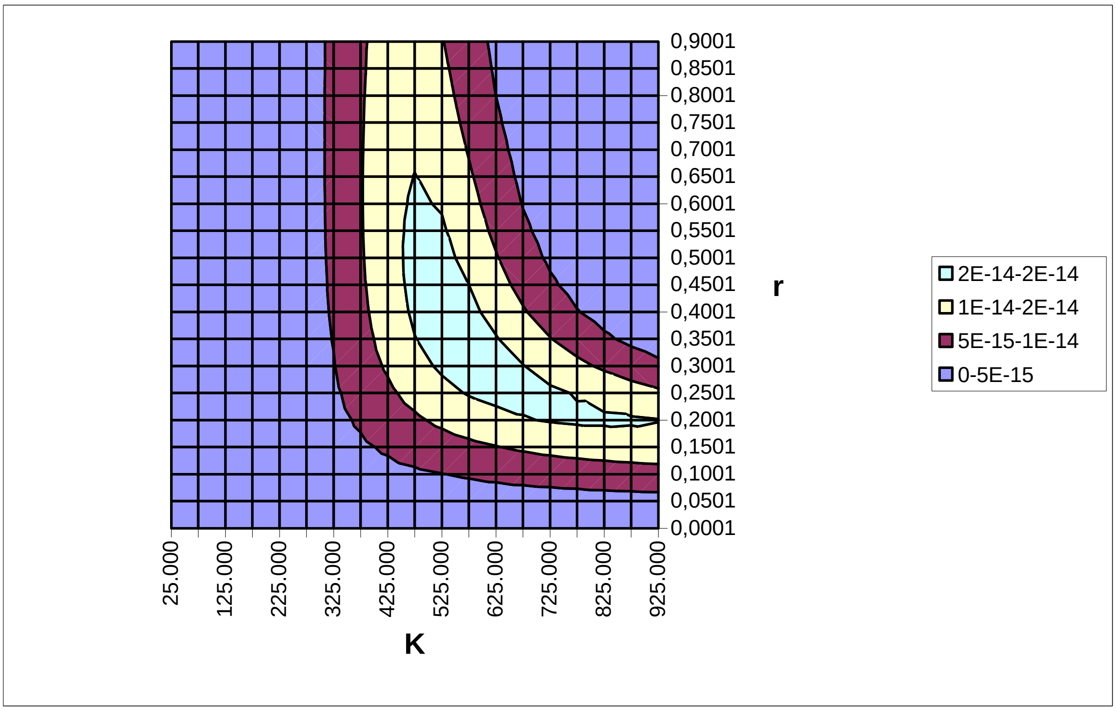


Figure 4.2.9. Surface plot of most psuedo-probability values for combinations of the parameters K and r. Larger numbers on the colour scale have a higher probability.

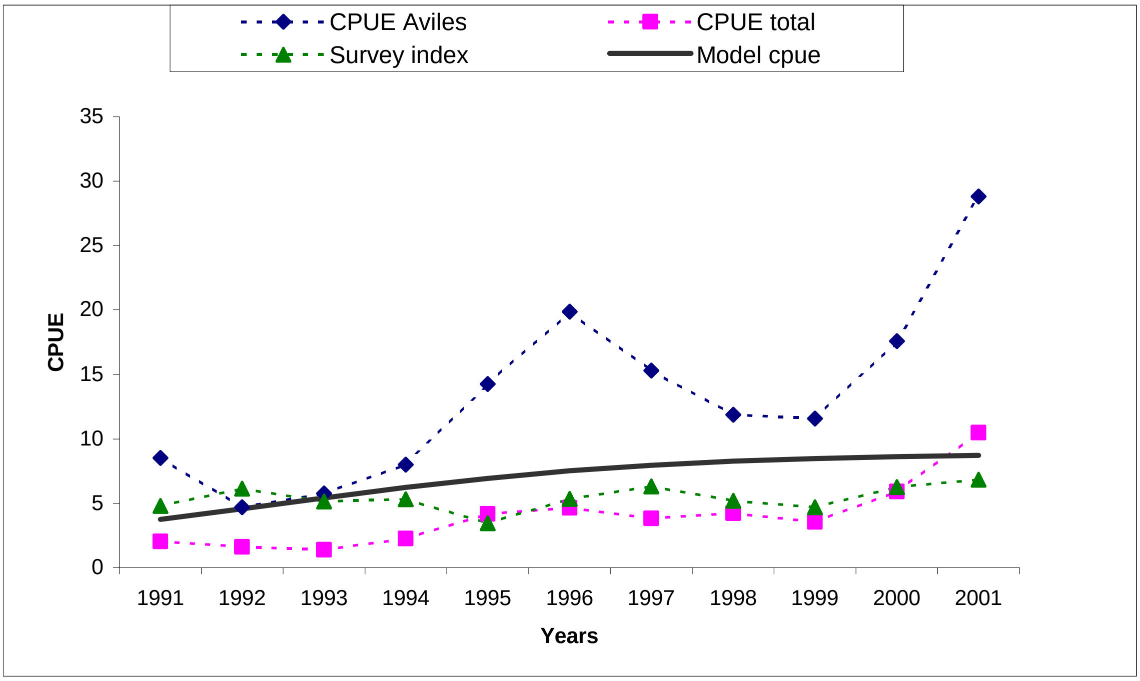


Figure 4.2.10. Schaeffer model predicted CPUE and three observed CPUE for the lesser spotted dogfish. Data used to fit the model include landings plus dead discards.

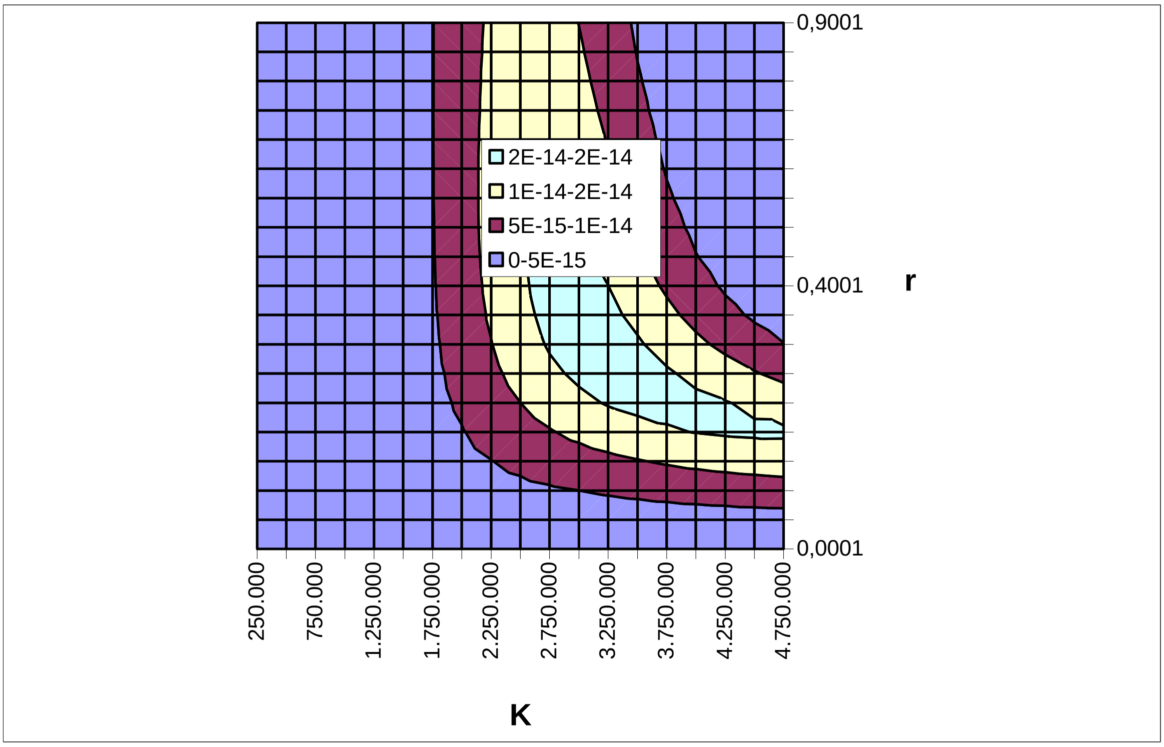


Figure 4.2.11. Surface plot of most psuedo-probability values for combinations of the parameters K and r. Larger numbers on the colour scale have a higher probability.

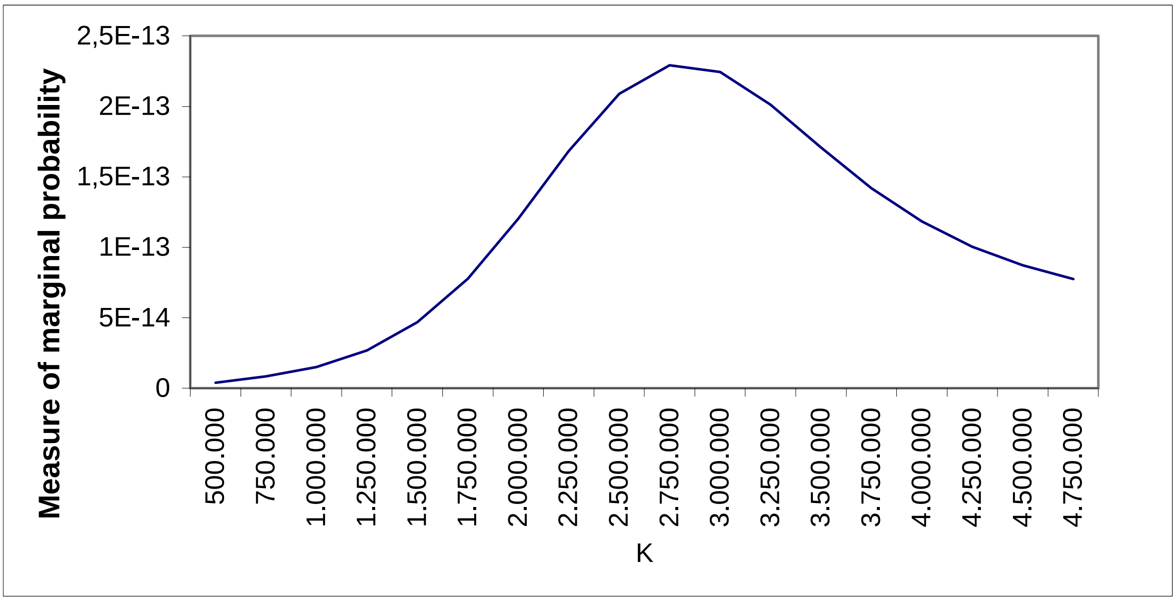


Figure 4.2.12. Plot of marginal probability values for the parameter K when total removals are considered

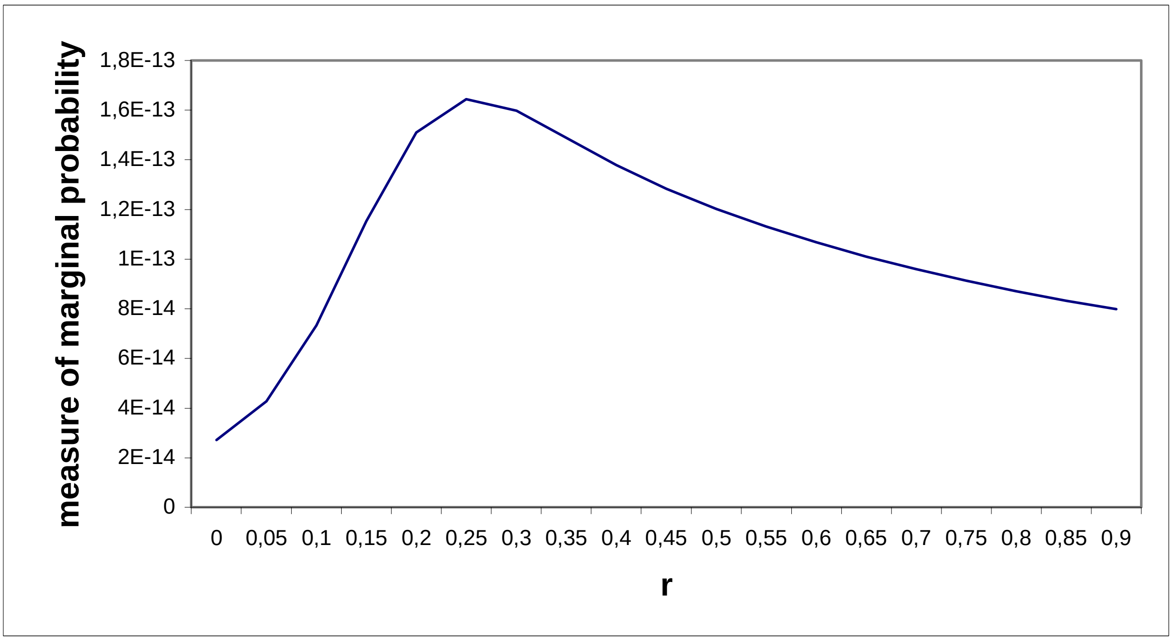


Figure 4.2.13. Plot of marginal probability values for the parameter r when total removals are considered

4.3 Blue shark

4.3.1 Description of the fishery

There are no large-scale directed fisheries for blue shark (*Prionace glauca*) and it is mainly taken as a by-catch in fisheries for tunas and billfishes. The entire catch is not retained on all fishing trips, so available landings data are not indicative of stock trends. There are recreational fisheries for blue shark in the USA, Ireland and the UK, and they are also caught incidentally in the Canadian porbeagle fishery (Bonfil, 1994). Japan, Taipei and the Korean Republic have high-seas fisheries for tuna and tuna-like fish and there is by-catch of blue sharks. Spain and Portugal have long-line fisheries for tunas and there is some by-catch of blue sharks. In addition, France, UK and Ireland have had gill-net fisheries for albacore tuna in which blue sharks are taken as a by-catch.

4.3.2 Data availability

ICCAT collects and collates catch and landings statistics from these commercial fisheries, but these data are not complete at present. Estimates of available landings data collated by ICCAT are presented in Table 4.3.1 (Anon. 2001). There are estimates of dead discards in some fisheries and some years. Tagging data from the USA were unavailable to the group, though they are being analysed at present. Catch curve data were not available either. Irish tagging data for blue sharks (Fitzmaurice and Green, 2000) will be compiled in 2002.

4.3.3 Model methods chosen

At the ICES-ICCAT-DELASS blue shark data discussion meeting (Dublin, January 2002, see section 3), three analysis types were considered possible in 2002; catch curve, Petersen estimates from tagging studies and life tables. The limited data availability on N Atlantic blue sharks permitted only the application of a life table analysis at this SG meeting. Life tables use the demographic characteristics of a population in the form of a schedule of the survivorship and fertility[1] at each age for the entire (female) population. These methods allow the calculation of reference parameters of population growth, such as generation time (**G**), net reproductive rate ($\mathbf{R_0}$), population doubling time ($\mathbf{t_{x2}}$), and the observed[2] rate of increase of the population (**r**). This last parameter has been used as an important input in stock assessment methods such as surplus production models.

The observed rate of increase of the population is an estimate of the intrinsic rate of increase of the logistic population growth model. Thus, **r** can be used to define likely values of the intrinsic rate of increase. More importantly, recent approaches have used life table estimates of **r** to define the prior probability distribution of the intrinsic rate of increase for use in a Bayesian Schaefer stock assessment model (McAllister and Pikitch 1998, McAllister et al. 2001) (see also section 4.1).

Another application of life table analysis is the ranking of species in a relative scale of 'productivity' or capacity to grow. By performing life tables analyses for a number of species and comparing the values of **r**, we can have an idea of each species' relative capacity for population growth (and by analogy of their capacity to withstand exploitation). Species with higher **r** should be able to recover faster from exploitation. A recent modification of life table approaches (Smith *et al*., 1998) allows for estimation of the 'rebound potential' of a population, a relative measure of the capacity of populations to return to their normal size after decreases in abundance due to fishing, and which includes density-dependent responses.

Data on life history parameters for blue sharks were obtained from the literature. Estimates of maximum age were taken from Stevens (1975; 20 years) and Skomal and Natanson (2001; 13 years). Age at first sexual maturity was estimated using the VBG parameters of Stevens (1975) and the size at maturity given by Pratt (1979; we used the midpoint of his range) and by Castro and Mejuto (1995). The last paper provides an equation relating litter size and mother size and was used together with the above mentioned VBG parameters to estimate the number of embryos produced at each age. In two cases we assumed no relationship between mother size and litter size and instead used the mean litter size provided by Aasen (1966) or one derived from the data of Castro and Mejuto (1995).

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[1] Fertility at age is the standard terminology used in life table analysis to express the number of females born to each female per year

[2] the 'observed' rate of increase of a population is the life table terminology used to denote the rate of increase of the population as calculated from survivorship and fertility at age

Survival at age was calculated as follows. Estimates of M for the species were obtained using three methods and two different variables. The methods of Hoenig (1983) and Annala and Sullivan (1996) rely on maximum age, we used 13 years and 20 years (from the age and growth studies cited above) as inputs for both methods. The equation of Pauly (1979) uses estimates of the VBG parameters and the average habitat temperature of the species. The VBG parameters of Stevens (1975) were used along with 15º and 20º C as average ambient temperature values. The different estimates of M for blue sharks thus obtained ranged from 0.151 (Pauly equation using 15º) to 0.354 (Annala and Sullivan method using 13 years as maximum age). The method of Hoenig using 20 years as maximum age provided an estimate of M=0.2, and this was chosen as the most likely value to derive survival rates for the base case scenario. The lowest and highest estimates of M were also used in some cases to examine the sensitivity of life tables to these assumptions. In all cases, we assumed age-specific survival rates for the first two ages (age 0 and 1) and constant survival (e^{-M}) for older ages. This is based on evidence from field studies that new-born sharks suffer higher mortality (Manire and Gruber, 1993). We assumed a 61% mortality for the first year (Michelle Heupel, pers. comm.) and calculated the midpoint of this value and the corresponding value used in each case for the rest of the age classes (depending on each case scenario) to estimate the survival for age 1 fish.

The length of the entire reproductive cycle is not well known for blue sharks, though Pratt (1979) describes a 2-year reproductive cycle for NW Atlantic blue sharks. Thus, litter size was divided by two to account only for females [the normal 1:1 sex ratio for embryos was assumed] and again by 2 to account for the length of the reproductive cycle. When TL had to be converted to FL, the equation of Kohler et al. (1995) was used.

Given the uncertainty in life history parameters derived from the literature, we analysed several scenarios as detailed in Table 4.3.3 in order to evaluate the sensitivity of model results to changes in the input parameters. The values chosen as the base case are the ones thought to represent the most likely scenario according to the best available knowledge about blue shark biology.

The equations used for calculation of demographic parameters are:

x = age

$I_x = No(e^{-Mt})$ = age-specific survivorship

m_x = age specific natality (female pups produced per female per year)

$R_0 = \sum I_x m_x$ = net reproductive rate

$G = [\sum I_x m_x x] / Ro$ = Generation time

$\sum I_x m_x e^{-rx} = I$ Euler-Lotka equation (solved by iterative methods to find **r**)
$t_{x2} = \ln 2/r$ = population doubling time

Though a stochastic life table routine was provided to the group by Dr. Enric Cortes, NOAA, USA, and has considerable utility, this approach was not pursued at the meeting.

4.3.4 Results

Estimates of the observed rate of increase of the population (**r**), net rate (**R_0**), generation time (**G**), and population doubling time (**t_{x2}**) for each of the eight case scenarios analysed are shown in Table 4.3.3. The values of **r** range from 0.03 to 0.244. For the base case scenario (most likely situation for blue sharks in the North Atlantic according to present knowledge), **r** has a value of 0.178. A graphical representation of the net reproductive rate **R_0** and the reproductive contribution of each age is presented in Figure 4.3.1.

The results suggest that accurate estimates of survival are relatively more important than accurate estimates of fecundity for evaluating species via demographic techniques. Compared to the base case, little change in demographic parameters was observed with a different assumption about blue shark fecundity (cases 2 and 8), especially when compared to the changes due to different assumptions about survival. Case 3 shows that an increase in survival causes a relatively large increase in **r** and a reduction in the population doubling time. Likewise, case 4 shows that a decrease in survival is followed by a considerable decrease in **r** and an increase in **t_{x2}**.

Life span (maximum age) and its effect on estimates of M also have a relatively large effect on estimated demographic parameters. If we assume that female blue sharks mature at 5 years of age and that M is that derived with the Annala and Sullivan equation with a maximum age of 13 years (case 7; a less likely but still plausible scenario than the base according to some published studies), then **r** could be as low as 0.05. Cases 5 and 6 show the effects of assuming higher survival rates for populations similar to that of case 7. These results provide further evidence of the relatively large effect of changes in survival on the demographic parameters **r**, $\mathbf{R_0}$ and $\mathbf{t_{x2}}$.

Other estimates of **r** for blue sharks exist. Cortes (in prep.) used stochastic life table analysis to estimate demographic parameters that incorporated uncertainty in life history parameters for 38 species of shark including *Prionace glauca*. His estimates of **r** ranged between 0.25 and 0.42, with a mean of 0.34. While he used very similar life history parameter values to those used here, there was an important difference in his approach. He assumed that survival was almost the same for all age classes, whereas we assumed a much lower survival for ages 0 and 1 than for the rest of the population in all of our runs. Thus, the much higher **r** estimates of Cortés can be mostly attributed to his different assumption about early survival. To use life table methods with confidence, a lot of attention should be put on obtaining realistic estimates of mortality for each age group.

4.3.5 Conclusions

The life table analysis method is limited in its application for stock assessment purposes. It provides only a static view of the population and it does not consider possible density-dependent responses to increased mortality. More importantly, this method does not provide any direct measure of how to set management targets**.**

However, life tables and modifications of these methods are still very useful for simple and preliminary analyses in situations of poor fisheries data availability, which is often the case. They are very useful in the absence of reliable historical fisheries data as they allow us to compare populations of different species or, if the information is available, different stocks of a single species, and to classify them along a continuum of relative capacity to withstand fishing. Species (or stocks) with higher **r** value should be able to better support fishing pressure than those with lower **r** values. More importantly, life tables when used wisely can offer valuable information on **r** that can be used to construct informed prior distributions of the intrinsic rate of increase for surplus production models.

Table 4.3.1. Landings estimates (tonnes) available in the ICCAT database for blue shark in the North Atlantic and unclassified sharks.

	1986	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
N. Atlantic	1	526	421	480	2129	3029	1767	5750	5880	6779	6080	3319	25161	24243	2678
Unclassified								1136	572				850		
Total	1	526	421	480	2129	3029	1767	6886	6452	6779	6080	3319	26011	24243	2678

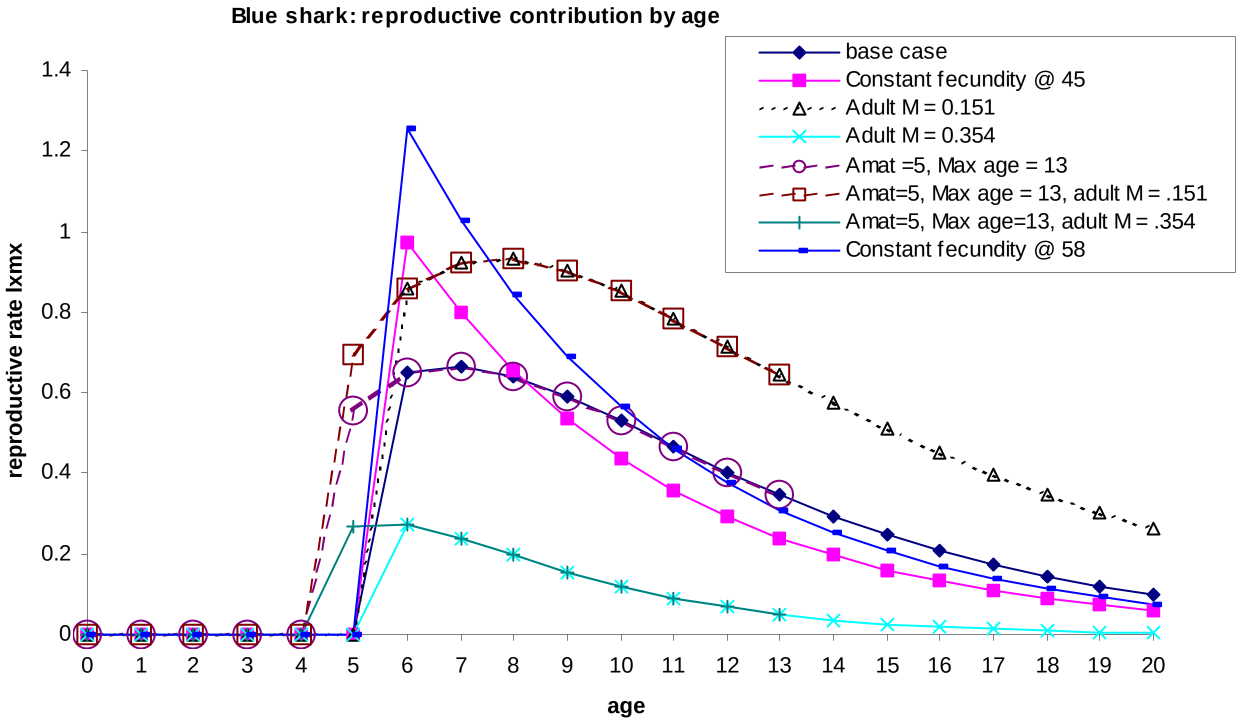
Table 4.3.2. Approaches to analysis of blue sharks in north Atlantic. Colour codes indicate the time frame for availability of each data type.

Analysis	Inputs																												Outputs					
	Stock ID	Intra-stock segregation	Total catch	Landings	Effort	Discards	Tag recaptures	Mortality from tagging	Movements from tagging	Length frequency data	Length weight relationships	Longevity	Length at age	Catch numbers at age	Growth parameter	Sex ratio	Maturity	Fecundity at size	Pups per female per year	Indices of abundance (fish. indep.)	Indices of abundance (fish. dep.)	Natural mortality	Steepness parameter	Catchability by gear and age	Recruitment index	Time lag	Stock recruitment	Total mortality	Relative abundance	Instantaneous total mortality	Exploitation rate	Biological reference points	Stock recruitment	Relative stock status
Petersen	x						x																								x			
Life table	x											x					x	x	x			x										x		
Catch curve Zs	x									x				x	x															x		x		
Paloheimo's Zs	x				x					x					x															x		x		
Time trend in length	x									x																								x
Stock production	x		x		x																								x	x	x	x		x
Stock mixture	x						x																											
Yield per recruit	x										x				x							x		x								x		
Delay difference	x		x												x					x	x	x		x					x	x	x	x	x	x
Age structured model	x		x		x					x	x			x	x	x				x	x	x		x					x	x	x	x	x	x
Length structured models	x		x		x					x	x				x	x				x	x	x		x					x	x	x	x	x	x
Depletion models	x		x		x															x	x								x	x	x			x
Time trend in fecundity	x																x	x																x
Index of recruitment	x																			x	x				x							x		x

Unlikley to be available in less than 2 years

Could be available within 2 years

Available in 2002



Blue shark: reproductive contribution by age
base case
Constant fecundity @ 45
Adult M = 0.151
Adult M = 0.354
Amat =5, Max age = 13
Amat=5, Max age = 13, adult M = .151
Amat=5, Max age=13, adult M = .354
Constant fecundity @ 58
reproductive rate lxmx
age
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

4.4 Portuguese dogfish

4.4.1 Description of the fishery

Portuguese dogfish (*Centroscymnus coelolepis*) is taken in several mixed trawl fisheries in the Northeast Atlantic and in mixed and directed long-line fisheries. In most cases the species is taken along with leaf-scale gulper shark (*Centrophorus squamosus*, section 4.6). Descriptions of these fisheries and landings data are presented in the report of WGDEEP (ICES, 2002, Table 17.2). Hareide et al. (WD) present detailed information on the Norwegian long-line fishery on Hatton Bank (Sub-area XII and Division VI b), where these two species are mainly taken as a by-catch in a directed fishery for Greenland halibut (*Reinhardtius hippoglossoides*), blue ling (*Molva dypterigia*) tusk (*Brosme brosme*) and mora (*Mora moro*). There is also a Spanish trawl fishery for roundnose grenadier (*Coryphaenoides rupestris*) in this area, which takes them as a by-catch. Portuguese dogfish is taken in mixed species trawl fisheries prosecuted by French, UK (Scottish) and Irish vessels in Sub-areas V, VI and VII. The French trawl fishery began to target blue ling in the late 70's, when species such as roundnose grenadier, black scabbardfish (*Aphanopus carbo*) and some deep-water sharks were discarded. Only in 1989 did these species began to be landed, as a result of a marketing initiative by the French fishing industry. There have been directed Spanish long-line fisheries for deep-water sharks (Pineiro et al. 2001) since the early 1990's in Sub-areas VI, VII and VIII, where it is taken with other squalids, forkbeards (*Physis* spp) and mora. On the Portuguese coast (Division IXa), they are a by-catch from the artisanal black scabbardfish long-line fishery that operates within 25 miles of the port of Sesimbra (Figueiredo et al. WD). Detailed landings data for Portuguese ports are presented in Table 4.4.1.

Portugal, Iceland and the Faeroe Islands collect species-specific landings data for these species, and there are species specific data from Spanish vessels on Hatton Bank. France, UK (Scotland, England and Wales), Ireland and Norway have – for varying periods of time - collected landings data for Portuguese dogfish and leaf-scale gulper shark combined. Discarding is not considered to be a feature of fisheries for these species, that are marketed for their flesh, liver and sometimes fins and skin.

4.4.2 Data availability

There are few data to assess stock status. Given the lack of species-specific landings data, stock structure is poorly understood, though specimens of Portuguese dogfish smaller than 70 cm are very rarely encountered in Sub-areas V, VI, VII ,VIII and IX. Smaller leaf-scale gulper shark, and mature and gravid females, are absent west of Ireland and Scotland and at Hatton Bank, though they are present in Portuguese trawl surveys and at Madeira, suggesting that its life stages have widely separate distributions. In the absence of information, a single assessment unit of the Northeast Atlantic was chosen for both species.

Estimates of 21-70 years of age based on dorsal spines readings were obtained for Portuguese dogfish taken west of Ireland by Clarke et al. (2002), but the absence of smaller specimens prevented an adequate fitting of growth models. Reproductive data, presented by Cadenat and Blache (1981) and Girard and DuBuit (1999), suggest that this species has a lower fecundity than and leaf-scale gulper shark. Given that most catch and effort data are for both species combined, it should be noted that they have different life-history traits.

Length frequencies for Portuguese dogfish by year from Irish research surveys, Norwegian long-line surveys (Hareide et al. WD) and Spanish commercial fishing on Hatton Bank are presented in the WGDEEP report (ICES, 2002 Figs. 17.3 – 17.5). Portuguese length frequencies were also presented in ICES (2002, Fig. 17.8). The reproductive parameters are well described (Girard and DuBuit, 1999), though there are no published age estimates for this species.

A CPUE series from a reference fleet of French trawlers for Portuguese dogfish and leaf-scale gulper shark, collectively called "siki", was presented to WGDEEP (ICES. 2002, Table 17.3) for 1990 to 2001. This series was calculated from total landings from these vessels and total effort directed at all deep-water species combined. A different CPUE series was presented at SGDEEP (ICES 2000b, Table 17.2), based on the same fleet of French trawlers, but calculated from catches by vessels whose effort was considered to be directed at squalids, i.e. if it produced more than 10% of total catch or 20% of total annual catch, by statistical rectangle (Lorrance and Dupouy, 2001). The WGDEEP 2002 series produced lower abundance estimates in each case.

The time series for Sub-area VI, where most effort takes place, both displayed downward trends until 1998. The WGDEEP 2002 series did not display the high peak in the SGDEEP 2000 series for 1991, though the value for 2001 was the highest since 1994. There is no similar upward trend for the other sub-areas, and the reasons for this trend are unclear. However, the series for the Sub-areas combined displayed the same trend, indicating the importance of Sub-area VI effort on these sharks. Indeed, the 2001 value is the highest recorded in the combined series.

There is no anecdotal evidence from the fishery to suggest that there is an upward trend in abundance of "siki" in 2000 or 2001. Survey data were available from Norway (autoline) and Ireland (autoline and trawl) for several years from 1991 to 2000 and were compared with these commercial CPUE data. The Norwegian and Irish surveys are directly comparable, using the same autoline long-line gear configurations (Table 4.4.2). Survey CPUE included in the analysis were only for the mid-range (1,100 – 1,600 m) of the bathymetric distributions of Portuguese dogfish (Clarke *et al.,* 2001). These data were not directly comparable because the commercial data are for the two species combined, so survey CPUE were pooled for both species, including those catches where their bathymetric ranges overlap. There is no evidence of an upward trend in CPUE in Sub-area VI for Portuguese dogfish, and the pooled species data from autoline surveys displayed a downward trend from 1997 to 2000. Thus, survey data do not mirror the upward trend in CPUE from the French commercial fishery. In Sub-areas VII and XII there is some evidence of a decline in CPUE throughout the 1990's.

A preliminary assessment on Portuguese dogfish and leaf-scale gulper shark combined was attempted by SGDEEP (Anon. 2000) using as inputs the available series of catch and effort from French reference fleet trawlers. This series is no longer available. The series of CPUE data presented in WGDEEP (ICES 2002, Table 17.3), formed the basis of assessments attempted for teleosts, but these proved inconclusive and were not included in the WGDEEP report (ICES 2002). SGEF attempted an assessment using these data as inputs, in order to investigate the utility of the currently available series; French CPUE for Sub-areas V, VI and VII. It was not clear how the CPUE for these combined areas was calculated. Therefore, the summed catch and effort data presented in ICES (2002) were used to recalculate CPUE (Fig 4.4.1), which did not display as marked an upward trend as displayed in the ICES (2002). Both CPUE data sets were used as inputs.

It was recognised that Portuguese dogfish and leaf-scale gulper shark are taken as by-catch and that non-targeted CPUE is generally not considered as a reliable estimator of stock abundance. However Portuguese dogfish is not found in dense aggregations and may be considered to be evenly distributed through its optimal depth range (Fig. 4.4.2). Therefore, by-catch CPUE is considered to be a more accurate estimator of stock abundance in this species than in species displaying a more aggregating behaviour, and it was considered appropriate to use the non-target commercial CPUE series for the investigation of possible assessment approaches.

4.4.3 Model methods chosen

An attempt at assessment was made using the Schaefer production model. The WGDEEP CPUE data for "siki" representing non-directed effort were used as inputs to a Schaeffer Production Model, using the CEDA package. This model and package were chosen to allow comparisons to be made with the previous assessment attempted using this approach by SGDEEP in 2000. A sensitivity analysis was used to evaluate the effect of error models and ratio of initial to virgin biomass. A time-lag of zero was used, because the time-series of catch and CPUE were too short to explore the effect of recruitment in this fishery. It was assumed, therefore, that growth rather than recruitment was the main contributor to biomass production. The available time-series data of CPUE show a gradual decline across most of the time period studied. Given this sort of pattern, caution is needed because of the "one-way trip" (Hilborn and Walters, 1992) resulting in highly unreliable estimates of the parameters of this model.

In addition, a Leslie Depletion method for closed populations was applied (Hilborn and Waters, 1992). This method can be conceptualised as a linear regression of relative abundance and cumulative catch, and is based on the assumption that the population gains no new recruits or immigrants and loses no animals to natural mortality or emigration. The behaviour of such populations can be described by the model;

$N_t = N_1 – K_{t-1}$

Where K_{t-1} is the cumulative catch taken prior to time t.

Based on the assumption that all fish are equally vulnerable to exploitation, the population at time t can be estimates by substituting the above equation into observation model Y = qN, giving:

$Y_t = qN_t = q(N_1 - K_{t-1}) = qN_1 – qK_{t-1}$

The last expression is in the form of a linear regression y = a + bx, where the intercept parameter **a** is qN_1, the slope parameter **b** is q, and the regression X is $–K_{t-1.}$ The slope should estimate q and the ratio a/b (intercept of regression line on the abscissa) should estimate N_1.

4.4.4 Results

The estimated parameters of the Schaefer model are presented in Table 4.4 3. A value of the ratio of initial stock to virgin stock was chosen as 0.7, based on sensitivity analysis. An initial to virgin ratio of 0.9 was used in Schaefer production models used in SGDEEP (ICES 2000b) because of by-catch in earlier blue ling fisheries. Runs of the Schaeffer model were attempted, and the fit of the model was very poor when all years, except 1990, were included. It was considered reasonable to exclude years 1991-1993 because this was the learning phase of the fishery when it was changing in character and target species and catchability was probably different. The directed CPUE series (ICES 2000b) displayed a peak in 1991. However non-directed CPUE did not display a first peak until 1993 and this was considered to reflect the targeting of the (now depleted) orange roughy fishery in Sub-area VI at that time. Fisheries-independent survey data were considered to be a more reliable indicator of recent abundance, and years 2000 and 2001 were also excluded because there was no supporting evidence of an upward trend in stock abundance in these years.

Two scenarios are presented in Table 4.4.3, using the WGDEEP CPUE and that calculated from catch and effort data presented at WGDEEP. The intrinsic rate of population increase (r) and maximum sustainable yield were poorly estimated, and did not have meaningful confidence intervals. Thus, the outputs of these runs should be treated with caution and they should not be considered reliable estimators of stock status. Catchability (q) and carrying capacity (K) were estimated with narrower confidence intervals, however. Runs of the model appeared to fit the downward trend on abundance quite well, for the years considered (Figure 4.4.3).

Leslie depletion models are presented in Table 4.4.4 for four scenarios, representing combinations of total shark and deep-water shark landings and of presented and derived French commercial CPUE. A good fit was obtained (Figures 4.4.4 – 4.4.7) in each case. Choice of CPUE series does not greatly affect the estimate of K. In addition, a reasonable agreement was found between 1993 biomass estimated from the Leslie method and the K value estimated from the Schaeffer production model. It should be pointed out that the estimates of K from the Leslie models may be too high, because recruitment was not considered.

Values of K were very sensitive to landings data used as inputs, which indicates that a full assessment of these combined species data would require accurate landings data for deep-water sharks. Since these data may never become available for the 1990's, such approaches to assessment have a very limited utility. Though they do indicate a downward trend in abundance, the assumptions of no recruitment and no inward or outward migrations are almost certainly not met in this type of analysis.

4.4.5 Conclusions

It is suggested that non-target CPUE is a reliable estimator of the trends in abundance of Portuguese dogfish and leaf-scale gulper shark combined for the period when catchability is considered to have been constant - excluding the years as described above. Many of the output parameters from the Schaeffer model are poorly estimated. K was sensitive to the landings data, which may be an overestimate since they represent various sharks. MSY and r are not estimated with meaningful confidence intervals and, therefore, should not be used. However K and q are estimated with narrower confidence intervals.

Given that the estimates of K are sensitive to the total landings data used, the absence of species-specific data, or even combined data for Portuguese dogfish and leaf-scale gulper shark in some fisheries, is a cause for concern. Given that the two species have different bathymetric distribution, the combined series may mask important trends in the abundance. Member states should assign a high priority to collecting and refining existing species-specific data for these two species, perhaps considering other reference fleets. Such work would be particularly valuable in the case of the fisheries that have taken place for the longest periods of time (French trawl and Portuguese long-line fisheries).

In the interim, models using known life history information should be investigated for these species. Figueiredo *et al.* (WD) presents a matrix population model approach, which should be pursued further by the group. Given the absence of many life history parameters for both species, more biological data are required. Of the two, Portuguese dogfish has higher fecundity than leaf-scale gulper shark, but might be more vulnerable to exploitation since pregnant females are exposed to exploitation in the main area of the fishery.

Table 4.4.1. Annual landings of Leafscale gulper shark and Portuguese dogfish at the three most important landing ports of Portugal mainland.

Viana do Castelo

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
L. gulper shark	0.6	1.8	0.1	2.8	0.3	1.0	0.0	13.1	38.7	40.2
Port. dogfish	42.7	98.0	95.2	29.5	31.1	20.4	42.0	23.7	35.9	21.0
Total	542.8	815.0	805.4	218.6	284.1	124.7	132.0	58.0	216.5	61.2

Peniche

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
L. gulper shark	2.2	1.8	6.8	2.7	2.3	1.8	1.4	3.4	2.4	0.5
Port. dogfish	16.9	13.5	8.6	12.3	7.9	9.1	10.2	12.4	11.5	2.0
Total	186.0	183.6	126.4	107.3	125.5	83.6	120.7	87.0	122.7	19.3

Sesimbra

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
L. gulper shark	286.7	372.1	281.0	530.9	511.9	380.5	370.4	330.6	420.0	321.0
Port. dogfish	586.3	577.2	484.8	529.8	762.9	740.7	865.5	812.4	713.3	467.0
Total	917.0	964.4	780.2	1075.6	1286.6	1148.1	1277.6	1169.0	1169.7	796.4

Table 4.4.2 CPUE (kg/1,000 autoline hooks; kg/hour trawled) data from Norwegian and Irish research surveys in the NE Atlantic. Gear configurations were the same for both countries.

Sub Area	Country	Date	Gear	*C. squamosus* 600 - 1,000	*C. coelolepis* 1,100 - 1,600	Combined 600 -1,600
VI	Ireland	1997	Autoline	218	70	133
VI	Norway	1999	Autoline	219	83	178
VI	Norway	2000	Autoline	42	92	86
VI	Ireland	2000	Autoline	24	76	38
VII	Norway	1996	Autoline	221	227	264
VII	Ireland	1997	Autoline	56	158	69
VII	Ireland	1999	Autoline	51	107	61
VII	Ireland	2000	Autoline	73	166	81
XII	Norway	1999	Autoline	100	128	174
XII	Norway	2000	Autoline	78	98	113
XII	Ireland	2000	Autoline	38	19	33
XIV (b)	Norway	1991	Autoline	8		8
VI	Ireland	1993a	Trawl	55		62
VI	Ireland	1993b	Trawl	63	8	49
VI	Ireland	1995	Trawl	15	11	14
VI	Ireland	1996	Trawl	48	9	37
VI	Ireland	1997	Trawl	24	25	20
VII	Ireland	1993a	Trawl	6		32
VII	Ireland	1995	Trawl		242	197
VII	Ireland	1996	Trawl	30	26	27
VII	Ireland	1997	Trawl	6	15	15

Table 4.4.3. Estimated carrying capacity (K), catchability (q), intrinsic rate of population increase (r) and maximum sustainable yield from Schaefer production model, using French CPUE data and also as calculated from French catch and effort presented to WGDEEP 2002, for Sub-areas V, VI and VII. All five scenarios fitted using a least squares error model.

CPUE Series	Total landings data used	Points eliminated	Parameter	Estimate	Lower CI	Upper CI
WGDEEP CPUE	**Deep + various**	1990 only	**Initial ratio**	0.7		
			K	34505	9.74E+03	2.62E+05
			q	0.003	4.67E-04	1.28E-02
			r	0.688	1.18E-06	2.41E+00
			MSY	5937	6.27E-02	1.16E+04
			Final Biomass	21625		
			r^2	0.301		
WGDEEP CPUE	**Deep + various**	90, 91, 92, 00, 01	**Initial ratio**	0.7		
			K	62638	1.43E+04	1.16E+05
			q	0.002	1.28E-03	9.41E-03
			r	0.139	1.10E-07	1.41E+00
			MSY	2179	2.86E-03	5.12E+03
			Final Biomass	10939		
			r^2	0.955		
WGDEEP Recalculated CPUE	**Deep + various**	90, 91, 92, 00, 01	**Initial ratio**	0.7		
			K	99389	1.76E+04	1.08E+05
			q	0.002	1.33E-03	7.55E-03
			r	0	6.84E-08	1.08E+00
			MSY	0	1.71E-03	4.79E+03
			Final Biomass	13530		
			r^2	0.974		
WGDEEP CPUE	**Deep only**	90, 91, 92, 00, 01	**Initial ratio**	0.7		
			K	63982	1.60E+04	7.02E+04
			q	0.003	2.21E-03	9.06E-03
			r	0.000	1.72E-07	6.28E-01
			MSY	0.002	2.77E-03	2.52E+03
			Final Biomass	7928		
			r^2	0.948		
WGDEEP Recalculated CPUE	**Deep only**	90, 91, 92, 00, 01	**Initial ratio**	0.7		
			K	28238	2.08E+04	6.20E+04
			q	0.005	2.50E-03	6.67E-03
			r	0.236	3.01E-07	4.23E-01
			MSY	1663	4.60E-03	2.19E+03
			Final Biomass	0		
			r^2	0.981		

Table 4.4.4. Estmates of q and initital biomass (1993) for the two deep water sharks combined

Scenario	Catch data	CPUE data	q	r^2	Biomass in 1993	EstimatedCpue in 1993
1	Total sharks	DWWG	0.0013	0.92	80000	101
2	Total sharks	Revised	0.0013	0.92	78000	97
3	DWWG data	DWWG	0.0021	0.90	47000	102
4	DWWG data	Revised	0.0022	0.90	44000	99

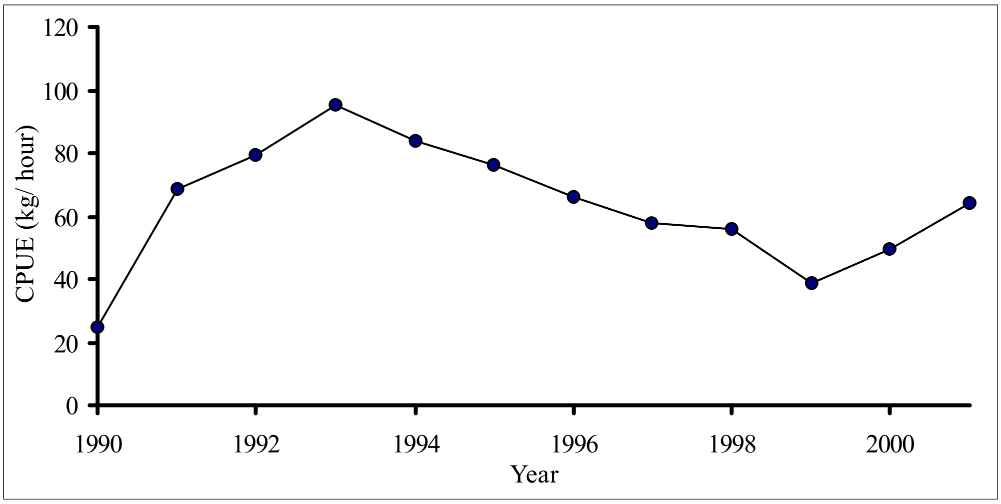


Figure 4.4.1. CPUE for *Centroscymnus coelolepis* and *Centrophorus squamosus* derived from catch and effort from reference fleet as presented to WGDEEP (Anon. 2002).

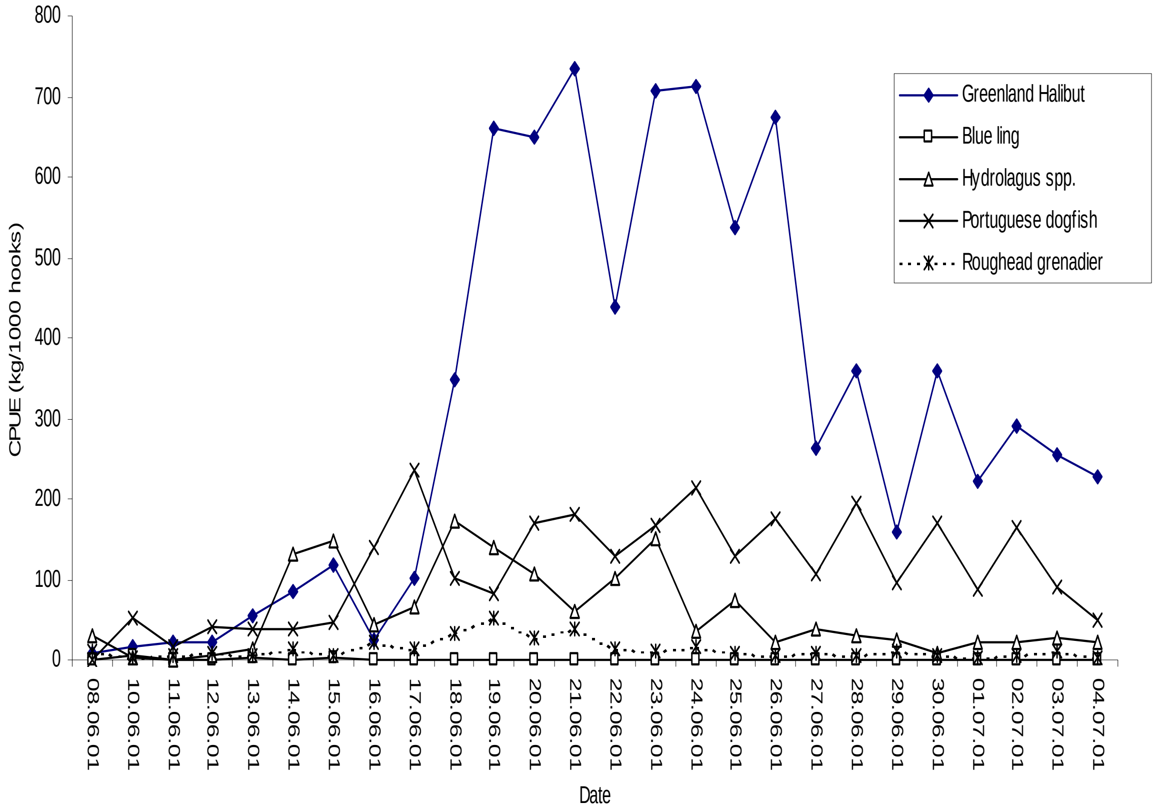


Figure 4.4.2. CPUE for one longline vessel fishing in depths between 1200 and 1600 meters. The period between June 8 and June 17 was used for searching. The vessel found good concentrations of Greenland halibut and fished on these concentrations between June 18 and July 4. The data for C. coelolepis suggest that by-catch CPUE is a useful index of stock abundance in this species.

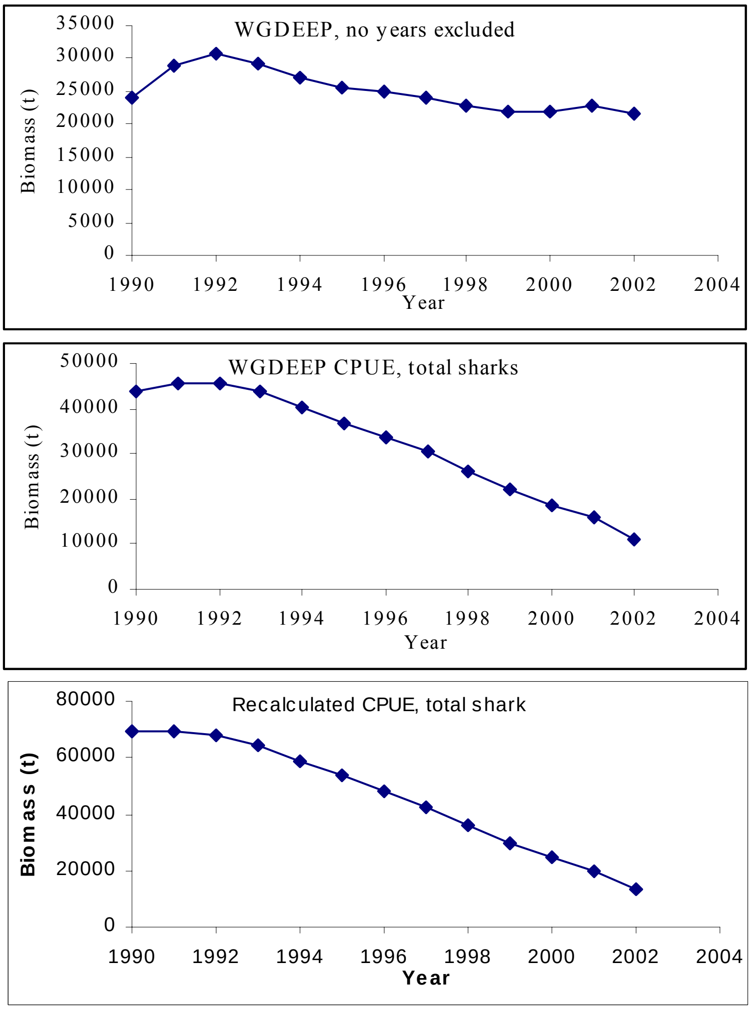


Figure 4.4.3. Biomass trends based on Schaefer production model. CPUE data as inputs are as provided in WGDEEP and recalculated from catch and effort presented in the WGDEEP report, for Sub-areas V, VI and VII. Top plot includes 1991 to 2001 as inputs, middle and bottom show results when 1991, 1992, 2000 and 2001 are excluded.

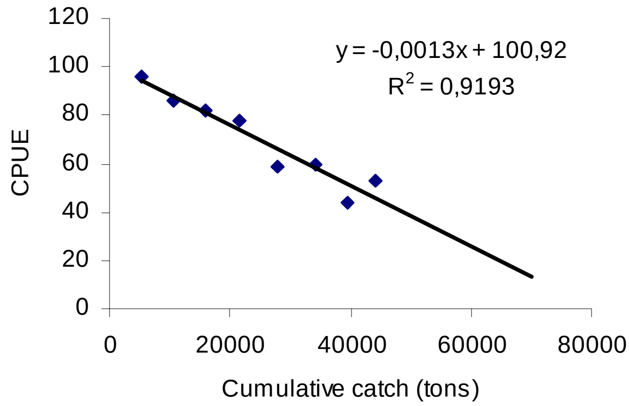


Figure 4.4.4. Closed population estimate of *C. Squamosus* and *C. Coelol*epis combined Sub-areas V, VI and VII combined, using CPUE presented in Anon. (2002) and total shark landings (these species and various sharks including some of these species).

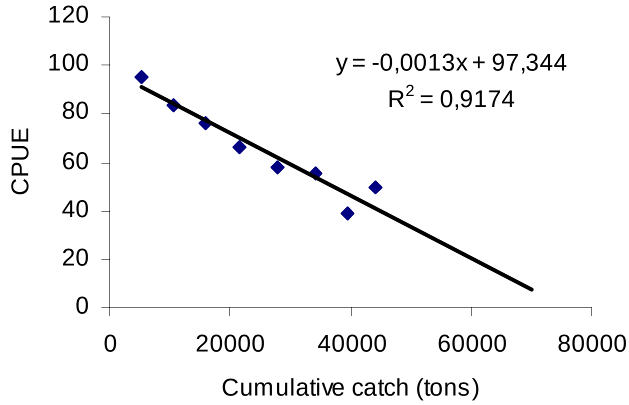


Figure 4.4.5. Closed population estimate of C. Squamosus and C. Coelolepis combined Sub-areas V, VI and VII combined, using CPUE recalculated from the data presented in Anon. (2002) and total shark landings (these species and various sharks including some of these species).

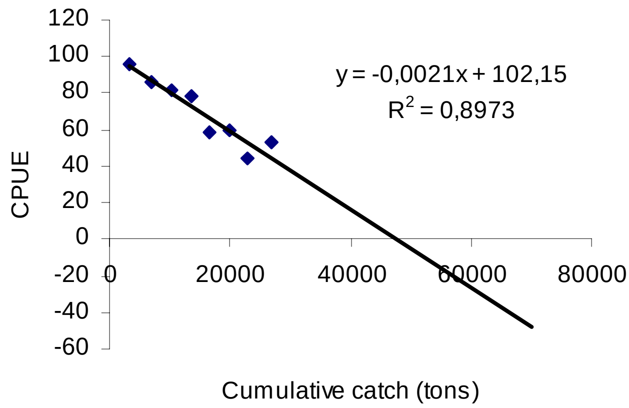


Figure 4.4.6. Closed population estimate of C. Squamosus and C. Coelolepis combined combined Sub-areas V, VI and VII combined, using CPUE presented in Anon. (2002) and only landings known to be deepwater sharks.

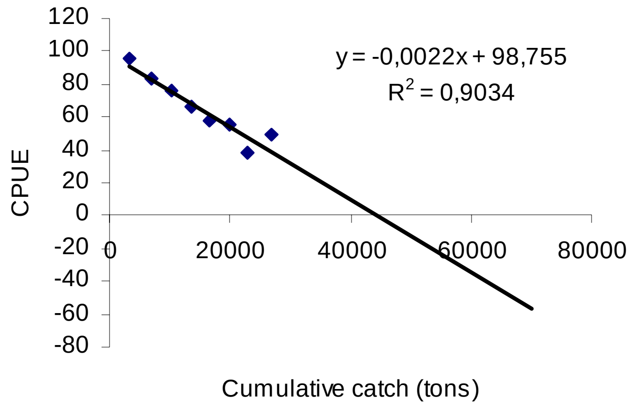


Figure 4.4.7. Closed population estimate of C. Squamosus and C. Coelolepis Sub-areas V, VI and VII combined, using CPUE recalculated from the data presented in Anon. (2002) and only landings known to be deepwater sharks.

4.5 Blackmouth catshark in Div. IXa

4.5.1 Fishery description

Although there is a fishery from the Portuguese mainland targeting blackmouth catshark (*Galeus melastomus*), this species is mainly taken as a by-catch of artisanal crustacean fisheries along the south-west and south coasts. Landings data presented in Table 4.5.1 and Figure 4.5.1 should be treated with caution as they are preliminary in nature.

4.5.2 Data availability

Though data on the annual landings of this species are not fully reported, annual fluctuations are apparent during the last decade. In 2000 and 2001, landings remained stable at around 35 t. Deep-water surveys conducted by IPIMAR in the summer provide abundance indices of blackmouth catshark in Algarve (south) and Alentejo (west) regions. In the Algarve region, its abundance has fluctuated over the last decade without any marked trend, and its abundance off Alentejo has been stable throughout the series. There are no estimates of discards of this species.

The length distribution of blackmouth catshark off the Portuguese mainland ranges from 10 to > 70 cm total length (Fig. 4.5.2). Large individuals tend to be more abundant on deeper grounds, and Figueiredo *et al.* (1995) only found specimens above 70 cm in water deeper than 500 m.

Data for this species are available from Norwegian longline surveys in Sub-area VI and XII, Irish trawl and longline surveys in Sub-areas VI and VII, and discarding from Irish shelf demersal fleets. There are also data from the French fishery.

4.5.3 Models used

The lack of data means that assessment models cannot be used and more information is needed, particularly on stock structure and species dynamics, and estimates of discards.

4.5.4 Results

There are no results to present.

4.5.5 Conclusions

Survey catch rates observed on the south and west coasts of Portugal indicate that there has not been a substantial change in stock levels since 1991. There are no other indicators of stock status of this by-catch species.

Table 4.5.1 – Portuguese landings in tons (ICES division IXa) of Blackmouth catshark.

Year	Black. catshark
1991	18
1992	17
1993	23
1994	39
1995	31
1996	36
1997	32
1998	25
1999	25
2000	35
2001	35

Table 4.5.2 – Mean annual density values (10^{-3} kg/ mn^2) of Blackmouth catshark in two different regions of the Portuguese continental slope (Algarve and Alentejo).

Year	Algarve	Alentejo
1990	0.36	0.93
1991	0.29	0.37
1992	0.51	1.55
1994	0.30	1.70
1995	0.44	1.70
1997	0.41	N/A
1998	0.49	N/A
2001	0.35	N/A

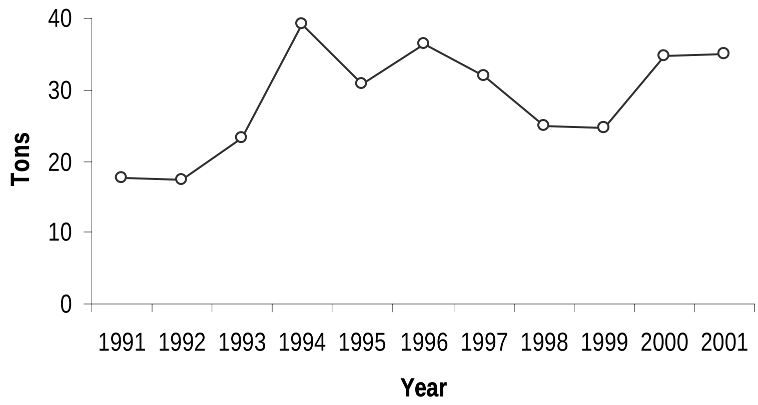


Figure 4.5.1. Landings (tonnes) of blackmouth dogfish by Portugal in Division IX a.

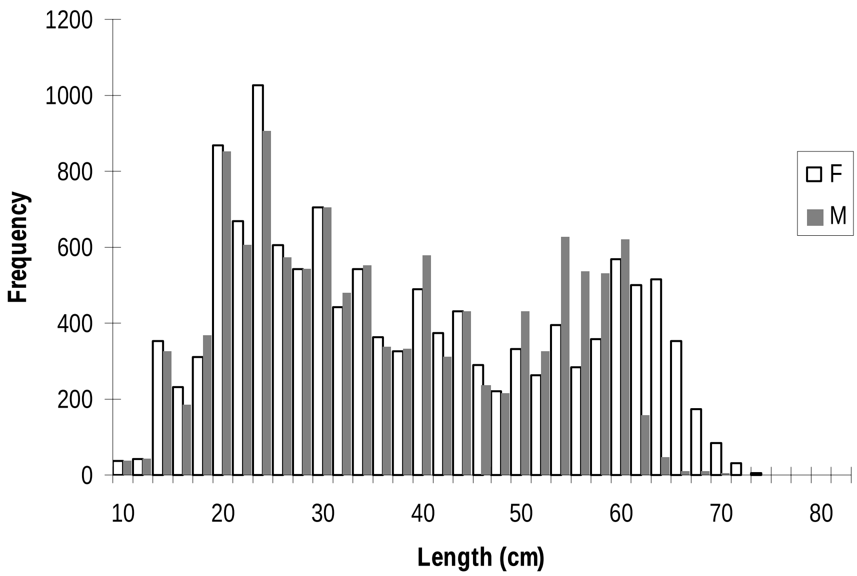


Figure 4.5.2 – Length frequencies distribution by sex of blackmouth catshark captured during deep-water surveys held off the Portuguese continental coast (Period: 1994-1998).

4.6 Leaf-scale gulper shark (*Centrophorus squamosus*)

Fisheries, data availability and analyses for this species are given in section 4.4, because leaf-scale gulper shark and Portuguese dogfish are not identified separately in most landings data.

4.7 Kitefin shark

4.7.1 Description of the fishery

The kitefin shark (*Dalatias licha*) is taken in a directed long-line fishery in Sub-area X (Azores), and its distribution is mainly in the southern part of the ICES area. Hareide and Garnes (2001) found this species along the Mid-Atlantic Ridge north to 45° N. It is rare at Hatton Bank and to the west of Ireland and Scotland.

Landings data from artisanal long-line fisheries at the Azores are presented in Anon. (2002). Landings have declined to very low levels, possibly because of the low market price of livers, and this species is now taken as by-catch in other demersal long-line fisheries (Gordon, 1999). Landings in Division IX a (Portugal) have declined to a level of around 7 t in recent years.

4.7.2 Data availability

A survey (1993 - 2000) and a commercial CPUE series (1987 – 1998) are available from Sub-area X (Azores). However, these data were not presented at this meeting. Silva (1983) presented early fishery data for this species. Biological data, including age estimates from length frequencies are presented by Silva (1988).

4.7.3 Models used

No further analyses were carried out at this time.

4.7.4 Results

There were no analyses.

4.7.5 Conclusions

In the absence of any analyses for this species, no conclusions can be made. Landings data are quite complete, but may not reflect stock trends in the Azores because of liver oil marketing considerations.

4.8 Thornback ray (*Raja clavata*) in IVb,c

4.8.1 Description of the fishery taking thornback ray in the North Sea

Although there have been directed fisheries for rays and skates in the North Sea throughout the last century, mainly using longlines, these have now almost completely ceased, and only a small-scale directed fishery with tangle nets still exists off the English south-east coast. Rays and skates are predominantly taken as by-catch in demersal mixed fisheries in the North Sea, where they have been subjected to intensive exploitation for many years.

4.8.2 Data availability

Catch and effort data: In most countries, all rays and skates are landed together, most often sorted in particular size categories, rather than by species. With the exception of France, catch statistics are, therefore, only available for all species of rays and skates combined. Data on total international landings for North Sea rays and skates are available since 1903 (Bulletin Statistique, Statlant forms). Landings data by country for the period 1973-2000 are shown in Table 4.8.1. There are no effort data specifically for North Sea rays and skates.

Market sampling: Starting in 2000, some exploratory market sampling programmes for North Sea rays and skates were carried out under the DELASS project in England, Scotland, Denmark, Netherlands and Belgium. At this SGEF meeting, only some preliminary results were available for England and the Netherlands.

Survey data: The main survey for which data are available for North Sea rays and skates is the ICES co-ordinated International Bottom Trawl Survey (IBTS). Another survey that could provide useful information is the Beam Trawl Survey (BTS), but this has not yet been considered by SGEF.

Historically, rays and skates have had a low priority in both fisheries management and scientific surveys, and survey catch records of rays and skates might be missing or species may have been wrongly identified. Although attention is being paid to quality assurance of the ICES IBTS data base, it probably still includes mis-recorded species and some catches may also be missing.

Data for North Sea rays and skates were made available from the ICES IBTS database for the period 1965-2002. As it was not certain whether all catches of rays and skates had been recorded, especially during the earlier years, surveys (a combination of year, quarter, and ship) with no recorded catch of any rays and skates were excluded from the analysis. However, even though the Dutch RV 'Isis' had twelve surveys without catching rays and skates since 1981, its records were included as all species were known to have been recorded. All surveys made by RV 'Thalassa' (vessel code THA and THA2) were excluded, due to problems with species identification in some years (Y. Vérin, pers. comm.). One haul of 30 minutes by RV 'Tridens' in ICES rectangle 35F0 in 1991 with an exceptionally large (confirmed) catch of more than 2500 *R. clavata* and also *R. montagui* was also excluded. The remaining data were used in the analyses.

The IBTS data include surveys from quarter 1 in the years 1967-1990, surveys in all quarters in the period 1991-1997, and surveys in quarters 1 and 3 from 1998 onwards. The average catch in number per hour by year and species was calculated from the average catch per ICES rectangle and quarter.

Some survey data for the early 1900s were available for the English RV 'Huxley' and the Dutch vessel 'Wodan' (see also Rijnsdorp *et al.*, 1996). These data allow a comparison of the recent and historic distribution of thornback ray.

4.8.2.1 Data exploration

Landings: Total international landings of North Sea rays and skates, all species combined, were approximately 13,000 t at the beginning of the 20th century (Fig 4.8.1). They peaked after both World Wars, when fishing had almost ceased for some years, but declined steeply thereafter. The decrease after World War II continued until the mid 1970s, when landings stabilised until the early 1990s. Since then they have decreased to the lowest level observed. In the southern North Sea, landings of rays and skates have declined since 1948, whereas the major decline in the northern and central areas started around 1965 (Walker, 1999).

Distribution: A hundred years ago, the thornback ray (*R. clavata*) was a common ray species throughout the southern North Sea (Redeke, 1935). It can be seen from historic survey data that, in the first decade of the 20th century, thornback ray were widely distributed over the southern North Sea, with centres of abundance in the south-western North Sea and in the German Bight, north of Heligoland (Fig 4.8.2).

The results of the quarterly IBTS surveys in the years 1991-1996 (Fig 4.8.3) indicate that thornback ray are presently found mainly in the south-western North Sea. No clear changes in seasonal distribution can be seen. Some catches reported in the north-eastern North Sea in quarter 4 have still to be confirmed. They may be based on mis-identification or possibly input errors. Comparison of research vessel catches from the early 1900s with recent data clearly shows that the area over which the species is distributed in recent years is much smaller than 90 years ago. Thornback ray have disappeared from the south-eastern North Sea (German Bight), and catches in the Southern Bight have become limited to the western part only.

Abundance: Figure 4.8.4 shows time series of abundance for the major ray species caught during the IBTS since 1975. Starry ray (*R. radiata*) is by far the most abundant species and, having limited commercial value is usually discarded. IBTS catches of starry ray increased up to the end of the 1980s and have since decreased slightly.

The other three main species in the IBTS are thornback ray, spotted ray (*R. montagui*) and cuckoo ray (*R. naevus*). Catches of thornback ray were more or less stable until the end of the 1980s, but have been at a lower level since. No clear trend is shown in catches of the spotted ray, and catches of cuckoo ray are fairly stable except for one outlier in 1978. Other species are only caught occasionally.

<u>Species composition</u>

Results of exploratory sampling in English North Sea ports since mid 2001 show that English ray landings are dominated by thornback rays, other species being mainly spotted ray and blonde ray. Negligible amounts of cuckoo ray and starry ray are also landed. In the Netherlands, landings of beam trawlers in 2000 and 2001 had the same species composition, but they were dominated by spotted ray. Whereas some blonde ray are landed, the species is only rarely caught during the IBTS, possibly because landings are mainly from the flatfish fleet using beam trawls, whereas a light otter trawl is used during the IBTS.

Figures 4.8.5 and 4.8.6 show the relative species composition in the North Sea IBTS averaged over four periods (1967-1976, 1977-1985, 1986-1992 and 1992-2001). Starry ray is included in Fig 4.8.5, but excluded in Fig 4.8.6. In both figures, a gradual shift in species composition can be seen, confirming the relative increase of starry ray and the relative decrease of thornback ray, compared to the total catch of rays.

Length frequency distributions

Length frequency distributions for thornback ray caught during the IBTS are shown in Fig 4.8.7 for 10 cm length classes for four periods. In all periods, the length classes 30-39 and 40-49 cm dominated the catches. No consistent trend in relative abundance of individual length classes can be seen over time.

4.8.3 Model methods chosen

Survey data are the major historical data source for thornback ray in the North Sea. Commercial fisheries data, e.g. CPUE, might be seriously biased as thornback ray is mainly caught as (a negligible) by-catch, and to some extend discarded. In addition, landings are mainly sold and recorded as a mix of skate and ray species, such that landings data are of a limited value. For the last two years, market sampling has been carried out by some countries, and data will supply valuable information about the present species composition. Taking these considerations into account, the analysis for thornback ray presented in this report was based on survey data only.

Of a total of 13,923 hauls in the IBTS, only 605 hauls had a catch of thornback ray (Table 4.8.2). The high frequency of zero catches in combination with a few, in some cases, high catches were analysed statistically using a two-stage model approach. First, the probability of getting a catch with at least one thornback ray was made using a GLM with a binomial distribution and a logit link function. Non-zero catches were then modelled using a Gamma distribution and a log link function. Both models include season, area and period effect:

Binomial model: $\log(p/(1-p)) = \text{area} + \text{season} + \text{period}$

Gamma model: $\log(\text{Catch numbers}) = \text{area} + \text{season} + \text{period}$

where **p** is the probability of a haul with a catch, and "**1-p**" is the probability of a haul without a catch of. thornback ray. ICES roundfish areas were used for the definition of the area parameter; quarter of the year for the season parameter; and the years 1967-1976, 1977-85, 1986-92 and 1993-2002 as the period parameter.

Individual models were fitted for each 10 cm length class and for all length classes combined. The models were implemented using the SAS® GEMOD procedure.

4.8.4 Results

The model parameters area and season are highly significant (Pr < 0.0001) for all length groups in the model of the probability of getting a haul with a catch of at least one specimen of thornback ray (Table 4.8.3). The seasonal effect is highly significant for some length groups. The probability of having a haul with at least one thornback ray is estimated to be 16 times higher for the period 1967-1976 compared to the most recent years, 1993-2002. This temporal trend is the same for the individual length classes up to 60 cm, while the probability of a catch of fish > 60 cm is estimated to have been highest in the period 1977-1992. The probability of a catch is largest in roundfish area 5 (south-western North Sea) for all length classes.

The results for the model for non-zero catches of thornback ray (Table 4.8.4) show a less consistent pattern to that observed for the model of the probability of a catch. For all length classes combined, the area and period parameter is highly significant, but this is due to the individual length classes 30-39 cm and 40-49, which are the most abundant in the catch. The average catch in numbers of the non-zero catches in the period 1967-1976 is estimated to be 52% of the catch in numbers in 1993-2002. There is no clear pattern in the period effect on catches by length class: in general the estimated period factor varies by less than two. Catches are largest in roundfish area 5, but the differences between areas are generally small and, in most cases, not statistically significant.

Bringing the results of the two models together, there has been a steep decline in the number of fishing positions with a catch of thornback ray since 1967. For such fishing positions, the average catch in number seems, however, to have increased slightly. This could be interpreted as the commercial fishery having fished down the patches with a historically lower density of thornback ray, such that the remaining patches provide relatively larger catches. These remaining patches might have been less attractive for the commercial fleet, due to factors such as bottom type and low abundance of commercially important fish. Local populations of thornback ray seem to survive there, even though the average fishing pressure for the North Sea is probably too high for a steady population (Walker and Hislop, 1998).

The model for the probability of a catch of thornback ray estimates a consistent declining trend for length groups up to 60 cm over the whole period, while the probability of a catch of larger individuals has been highest in the middle of the survey period. Length at maturity is around 72 cm, so the estimated declining probability for a catch of immature individuals throughout the period seems not to be linked directly to the spawning stock biomass. Part of the explanation may be that immature individuals seek areas (e.g. shallow waters) where they have experienced increasing exploitation through the period, while the mature part of the stock has mainly stayed in areas with a stable and lower fishing mortality. Such conditions would result in the estimated decline in the probability of a survey catch of immature fish, though not in an increase in the middle of the period for the mature part. The length distribution of survey catches shows no consistent trend over the years, which support the hypothesis that the stock decline has not been caused only by a general recruitment overfishing.

4.8.5 Conclusions

The model approach seems relevant for the analysis of survey data for rarely-caught species with a clustered distribution pattern.

The North Sea stock of thornback ray has steadily declined since the start of the 20th century. One hundred years ago, the distribution area of the stock included almost the whole North Sea. Today, survey data show a concentration in the south-west North Sea (from the Thames Estuary to the Wash), and this reduced distribution area is confirmed by the steep decrease in the probability of a catch including thornback ray estimated by statistical models. Apparently, there are still patches left in the North Sea with stable local populations. Whether these areas are self-sustaining and whether the number of patches will remain high enough for a sustained North Sea population is, however, unknown.

Table 4.8.1. Landings of rays combined (tonnes) in sub-area IV as officially reported to ICES.

species RAYS
and division IV

	COUNTRY													
	BEL	DEN	ENG	FAR	FRA	GER	ICE	IRL	NED	NOR	POL	SCO	SWE	All
YEAR														
1973	941	97	1360	23	231	159			185	377		1826	2	5201
1974	659	77	1227	19	353	24			283	223	33	1582		4480
1975	461	55	1235	3	169	20			283	454		1496		4176
1976	725	48	1366	8	171	17			325	479		1594		4733
1977	769	39	1290	14	162	2		1	287	362		1887		4813
1978	994	59	1414	6	246	29		2	280	304		1838		5172
1979	971	61	1399		179	4			617	680		1562		5473
1980	751	22	1325		199	2			305	779		1552		4935
1981	643	23	1246		2572	1			278	551		1386		6700
1982	739	32	1192		131	2			344	402		1398		4240
1983	1183	28	1263		220	3			408	478		1641		5224
1984	1463	27	1138		292	3				512		1801		5236
1985	1273	17	1098	1	284	5				608		1890		5176
1986	708	24	1085		202	5				263		1917		4204
1987	768	51	1040		252	7				417		2570		5105
1988	670	31	975		181	6				304		2514		4681
1989	459	24	974		110	3				430		1578	1	3578
1990	531	35	1037		132	4				347		1575	2	3662
1991	701	18	1149		129	2				261		1658	0	3918
1992	717	23	1446	1	110	1				297		1891	0	4486
1993	905	18	1440		128	4				408		1683	0	4586
1994	660	31	1546		70	7				325		1810	0	4450
1995	577	28	1336		76	6				286		1892		4201
1996	692	49	1020		76	10				180		1964		3991
1997	428	33	1009		52	35				106		1494	0	3157
1998	373	20	794		47	9			544	180		1381		3348
1999	336	45	618			15			475	151		965	0	2605
2000	332	93	517			22			623	161		860		2608

Table 4.8.2 Number of survey hauls, and number of hauls with catch of *R. clavata* by ICES roundfish area and length class.

		Length Group (cm)							
Roundfish Area	No. of hauls	10-19	20-29	30-39	40-49	50-59	60-69	>=70	All
1	3416	7	15	39	60	7	3	6	101
2	2633	18	34	77	108	32	1	3	156
3	1828	7	15	24	20	7	4	4	56
4	850	3	11	13	19	11	9	22	57
5	518	23	24	62	60	42	42	57	140
6	3524	3	4	17	19	12	4	6	53
7	1162	7	7	15	29	15	0	0	42
All	13931	68	110	247	315	126	63	98	605

Table 4.8.3 GLM model results by length class. Probability of a haul with catch of at least one R. clavata

Significance test of model parameters (probability of ChiSqure value in a type III test)

	Length class (cm)							
	10-19	20-29	30-39	40-49	50-59	60-69	>=70	all
Source								
Season	0.2608	0.0535	<0.0001	0.0008	0.1333	0.7559	0.0039	0.0003
Area	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Period	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Paratemter estimates (Estimate), estimate given as factor (Factor)
and significance test (Pr>ChiSq) of the parameter estimate against the estimate for the period 1993-2002

	10-19 cm			20-29 cm			30-39 cm			40-49 cm		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Period												
1967-1976	7.265	1.983	<0.001	11.04	2.401	<0.001	12.74	2.545	<0.001	17.61	2.868	<0.001
1977-1985	3.269	1.184	0.002	5.024	1.614	<0.001	3.680	1.303	<0.001	5.272	1.662	<0.001
1986-1992	1.008	0.008	0.984	1.751	0.560	0.107	1.331	0.286	0.204	1.775	0.574	0.006
1993-2002	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.

	50-59 cm			60-69 cm			>=70 cm			all		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Period												
1967-1976	4.517	1.508	<0.001	1.517	0.417	0.604	0.675	-.394	0.609	16.53	2.805	<0.001
1977-1985	4.817	1.572	<0.001	2.541	0.932	0.045	3.890	1.358	<0.001	5.881	1.772	<0.001
1986-1992	2.044	0.715	0.014	5.058	1.621	<0.001	2.979	1.092	<0.001	2.167	0.773	<0.001
1993-2002	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.

Paratemter estimates (Estimate), estimate given as factor (Factor)
and significance test (Pr>ChiSq) of the parameter estimate against the estimate for area 7

	10-19 cm			20-29 cm			30-39 cm			40-49 cm		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Area												
1	0.433	-.836	0.121	1.009	0.009	0.985	1.294	0.258	0.409	1.037	0.037	0.876
2	1.186	0.171	0.703	2.320	0.842	0.045	2.530	0.928	0.001	1.849	0.615	0.005
3	0.635	-.455	0.398	1.377	0.320	0.489	1.017	0.017	0.959	0.421	-.865	0.004
4	0.584	-.537	0.438	2.190	0.784	0.109	1.095	0.091	0.819	0.830	-.186	0.550
5	9.364	2.237	<0.001	9.640	2.266	<0.001	14.46	2.671	<0.001	6.839	1.923	<0.001
6	0.083	-2.49	0.002	0.164	-1.81	0.004	0.301	-1.20	0.001	0.168	-1.78	<0.001
7	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.

	50-59 cm			60-69 cm			>=70 cm			all		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Area												
1	0.187	-1.68	<0.001	1.152	0.141	0.863	1.425	0.354	0.559	1.147	0.137	0.478
2	1.014	0.014	0.965	0.500	-.692	0.549	0.928	-.075	0.919	1.864	0.623	0.001
3	0.307	-1.18	0.010	2.979	1.092	0.154	1.749	0.559	0.406	0.846	-.167	0.433
4	0.944	-.057	0.889	12.48	2.524	<0.001	20.64	3.027	<0.001	1.976	0.681	0.002
5	7.135	1.965	<0.001	110.6	4.706	<0.001	98.21	4.587	<0.001	15.21	2.722	<0.001
6	0.231	-1.46	<0.001	1.000	<0.001	.	1.000	<0.001	.	0.324	-1.13	<0.001
7	1.000	0.000	.	.	.	.	.	.	.	1.000	0.000	.

Table 4.8.4 GLM models results by length group. Average catch numbers from hauls including at least one R. clavata

Significance test of model parameters (probability of ChiSqure value in a type III test)

	Length class (cm)							
	10-19	20-29	30-39	40-49	50-59	60-69	>=70	all
Source								
Season	0.9284	0.8280	0.0267	0.3426	0.0015	0.0038	0.6199	0.0151
Area	0.0605	0.1061	0.0001	0.0020	0.0002	0.0375	0.0010	<0.0001
Period	0.0461	0.0427	<0.0001	<0.0001	0.0179	0.0031	0.1016	<0.0001

Paratemter estimates (Estimate), estimate given as factor (Factor)
and significance test (Pr>ChiSq) of the parameter estimate against the estimate for the period 1993-2002

	10-19 cm			20-29 cm			30-39 cm			40-49 cm		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Period												
1967-1976	0.662	-.412	0.237	0.545	-.607	0.034	0.290	-1.24	<0.001	0.397	-.925	<0.001
1977-1985	1.062	0.060	0.846	0.509	-.675	0.012	0.446	-.808	<0.001	0.778	-.251	0.240
1986-1992	1.436	0.362	0.200	0.808	-.213	0.435	0.623	-.474	0.022	0.823	-.195	0.321
1993-2002	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.

	50-59 cm			60-69 cm			>=70 cm			all		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Period												
1967-1976	0.683	-.381	0.219	1.459	0.377	0.647	0.617	-.483	0.576	0.520	-.654	<0.001
1977-1985	1.124	0.117	0.652	1.562	0.446	0.325	1.689	0.524	0.233	0.805	-.217	0.190
1986-1992	1.603	0.472	0.059	3.561	1.270	<0.001	2.390	0.871	0.042	1.080	0.077	0.613
1993-2002	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.

Paratemter estimates (Estimate), estimate given as factor (Factor)
and significance test (Pr>ChiSq) of the parameter estimate against the estimate for area 7

	10-19 cm			20-29 cm			30-39 cm			40-49 cm		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Area												
1	1.726	0.546	0.090	1.529	0.424	0.225	1.365	0.311	0.245	1.186	0.170	0.370
2	1.068	0.066	0.802	1.528	0.424	0.169	1.198	0.181	0.494	1.119	0.112	0.520
3	0.667	-.405	0.194	0.970	-.031	0.924	0.525	-.645	0.033	0.583	-.539	0.028
4	0.539	-.619	0.121	0.941	-.061	0.861	1.617	0.481	0.183	1.545	0.435	0.083
5	1.017	0.017	0.953	0.863	-.147	0.633	0.955	-.046	0.861	1.222	0.200	0.364
6	0.508	-.678	0.198	0.777	-.252	0.589	0.537	-.623	0.056	0.609	-.497	0.052
7	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.	1.000	0.000	.

	50-59 cm			60-69 cm			>=70 cm			all		
	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test	Factor	Estimate	test
Area												
1	1.057	0.055	0.879	1.249	0.222	0.796	0.339	-1.08	0.098	1.034	0.033	0.862
2	1.159	0.147	0.573	1.209	0.190	0.867	1.479	0.391	0.603	1.288	0.253	0.163
3	0.418	-.872	0.013	1.001	0.001	0.999	0.506	-.681	0.346	0.501	-.692	<0.001
4	0.495	-.704	0.042	1.834	0.606	0.383	1.127	0.119	0.828	0.930	-.072	0.734
5	1.529	0.425	0.103	3.828	1.342	0.032	2.422	0.885	0.085	1.864	0.623	<0.001
6	0.531	-.632	0.040	1.000	0.000	.	1.000	0.000	.	0.477	-.741	<0.001
7	1.000	0.000	.	.	.	.	.	.	.	1.000	0.000	.

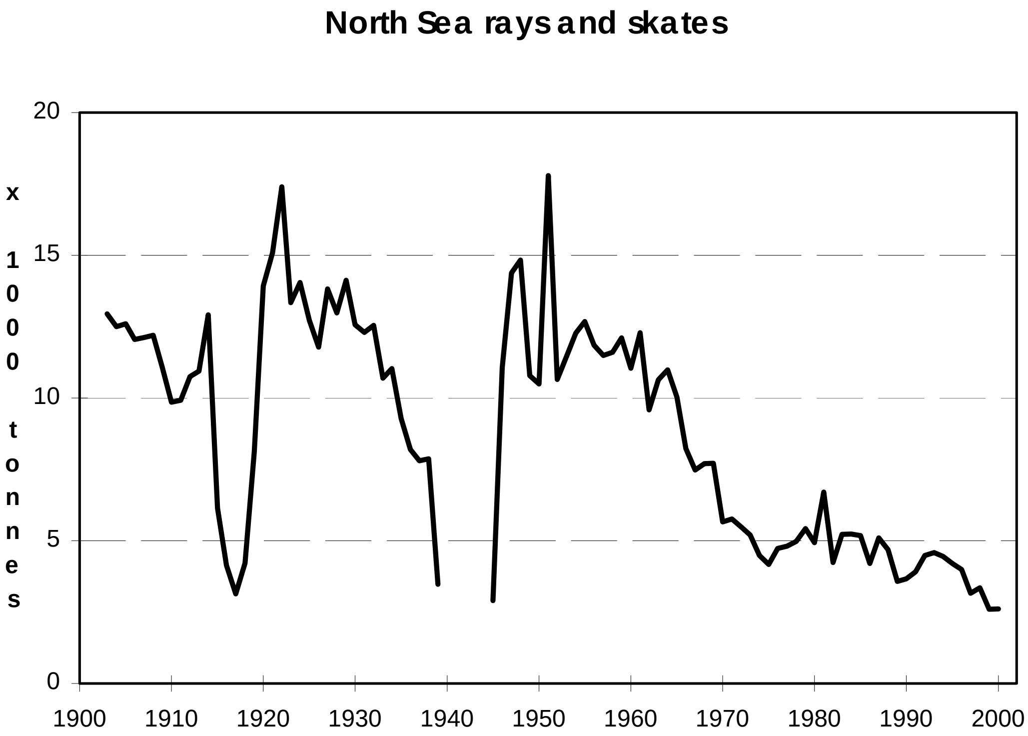
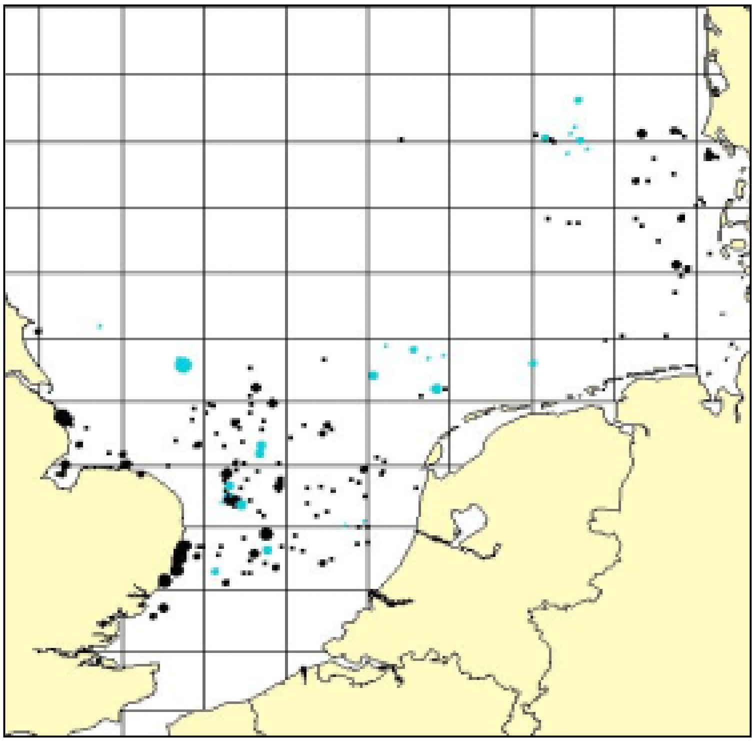


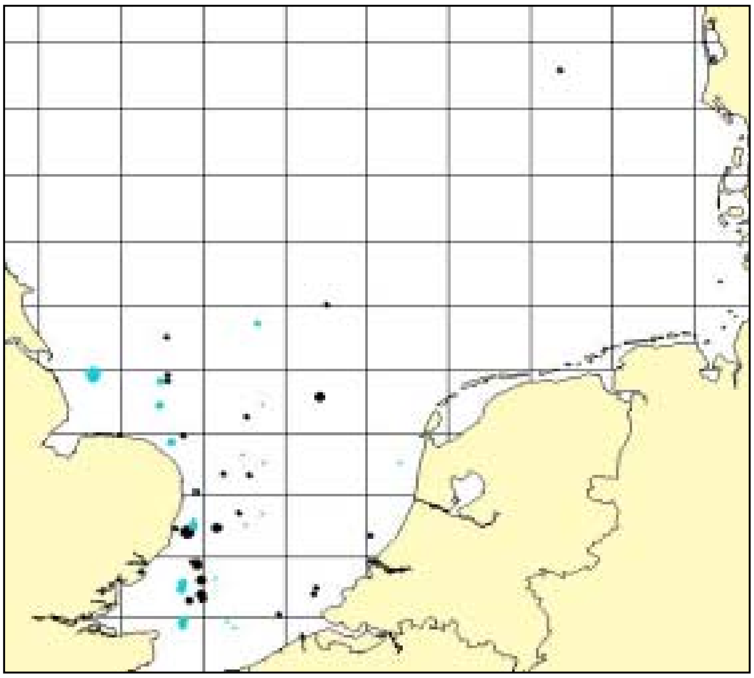
Figure 4.8.1 Total international landings of rays and skates from the North Sea as reported to ICES

Figure 4.8.2 Distribution of thornback ray (*Raja clavata*) in the southern North Sea based on English and Dutch research vessel surveys in the early 1900s and international data from the International Bottom Trawl Survey and the Beam Trawl Survey in the 1990s (see also Rijnsdorp et al., 1996)

1900



1990



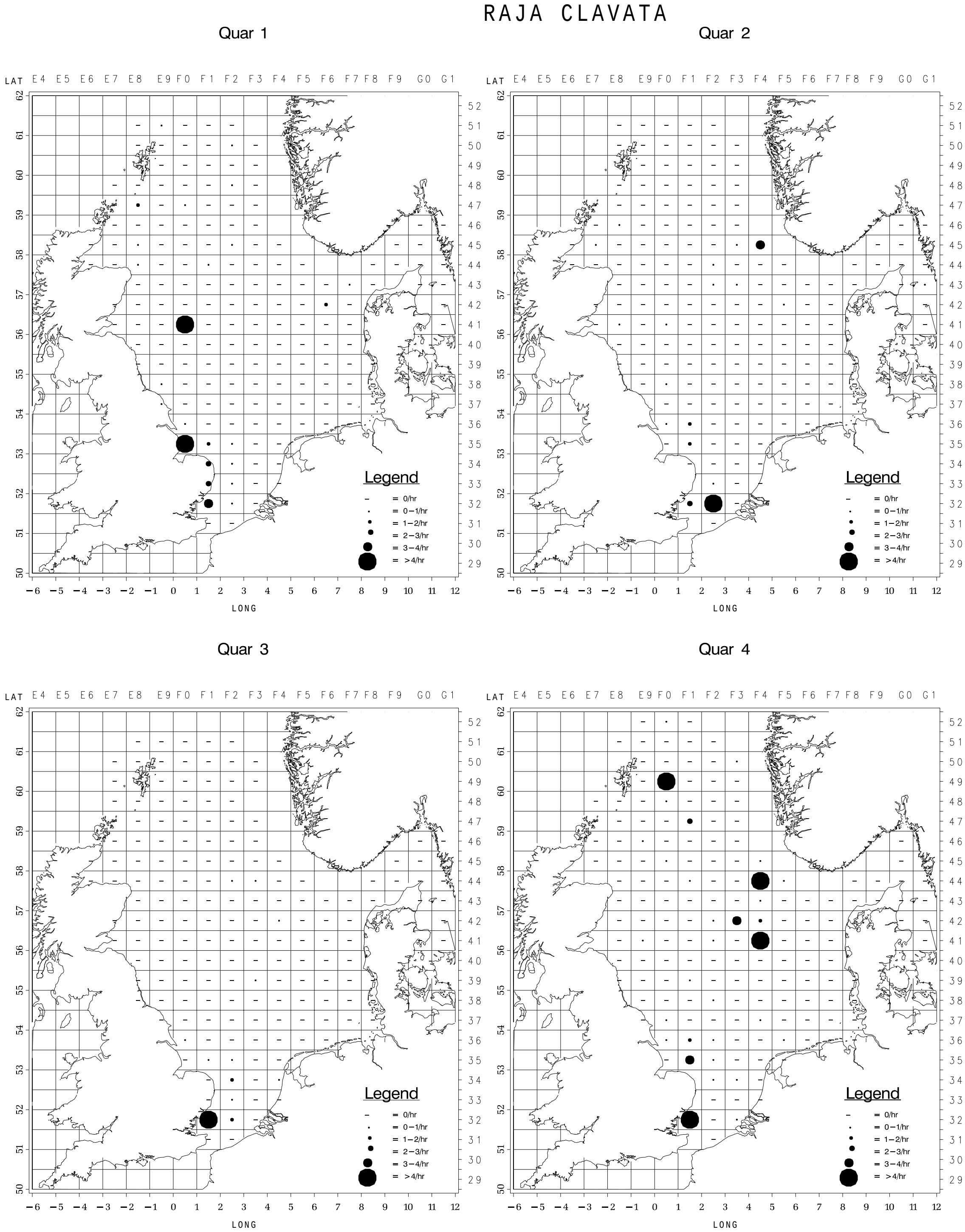


Figure 4.8.3 Quarterly distribution of thornback ray (*Raja clavata*) in the North Sea, based on data from the International Bottom Trawl Survey IBTS in the years 1991-1996.

Figure 4.8.4 Time series of abundance (number per hour) for 8 ray species caught during the quarter 1 International Bottom Trawl Survey in the North Sea

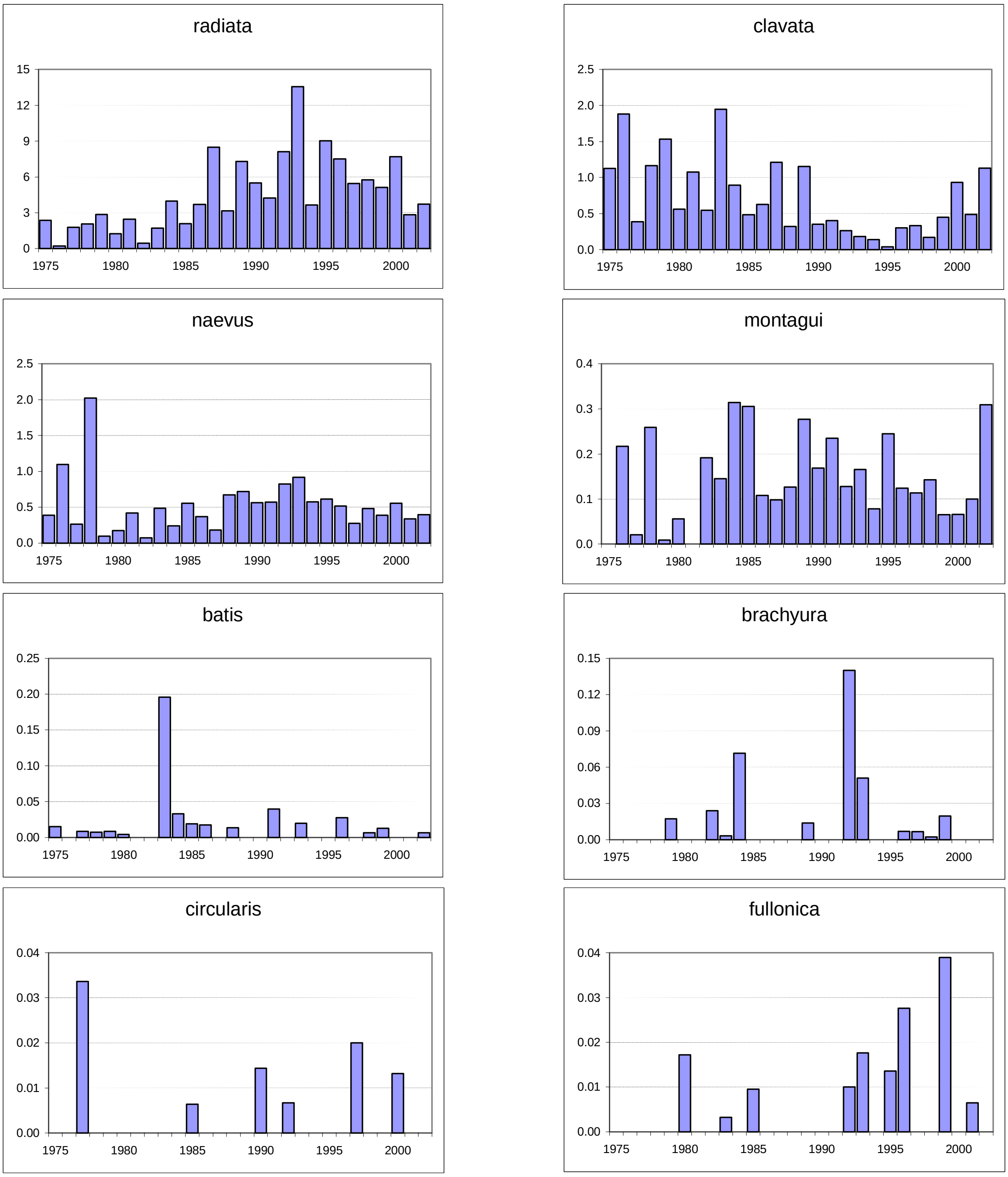


Figure 4.8.5 Relative species composition (numbers) in IBTS survey catches. All species included.

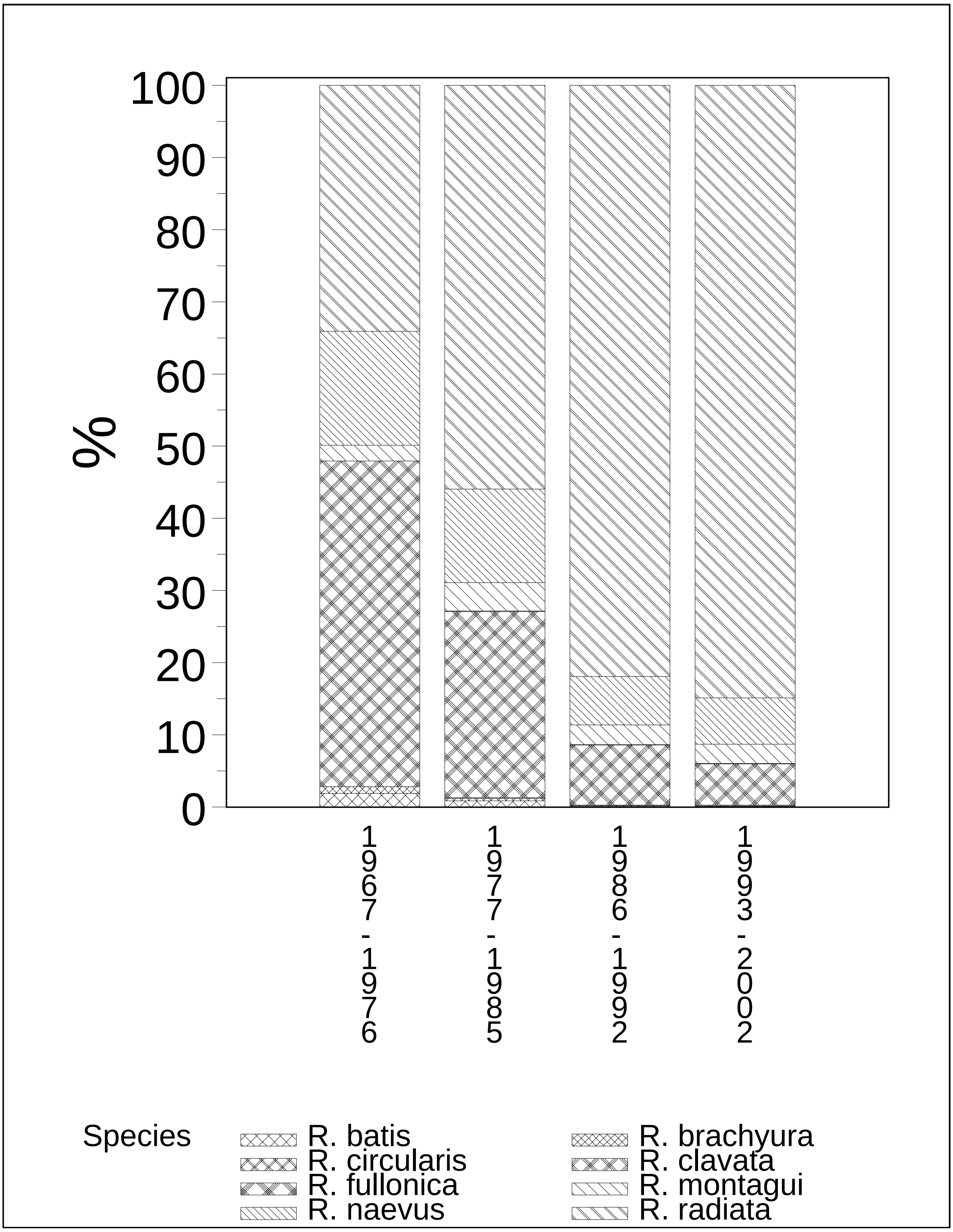


Figure 4.8.6 Relative species composition (numbers) in IBTS survey catches. *Raja radiata* excluded.

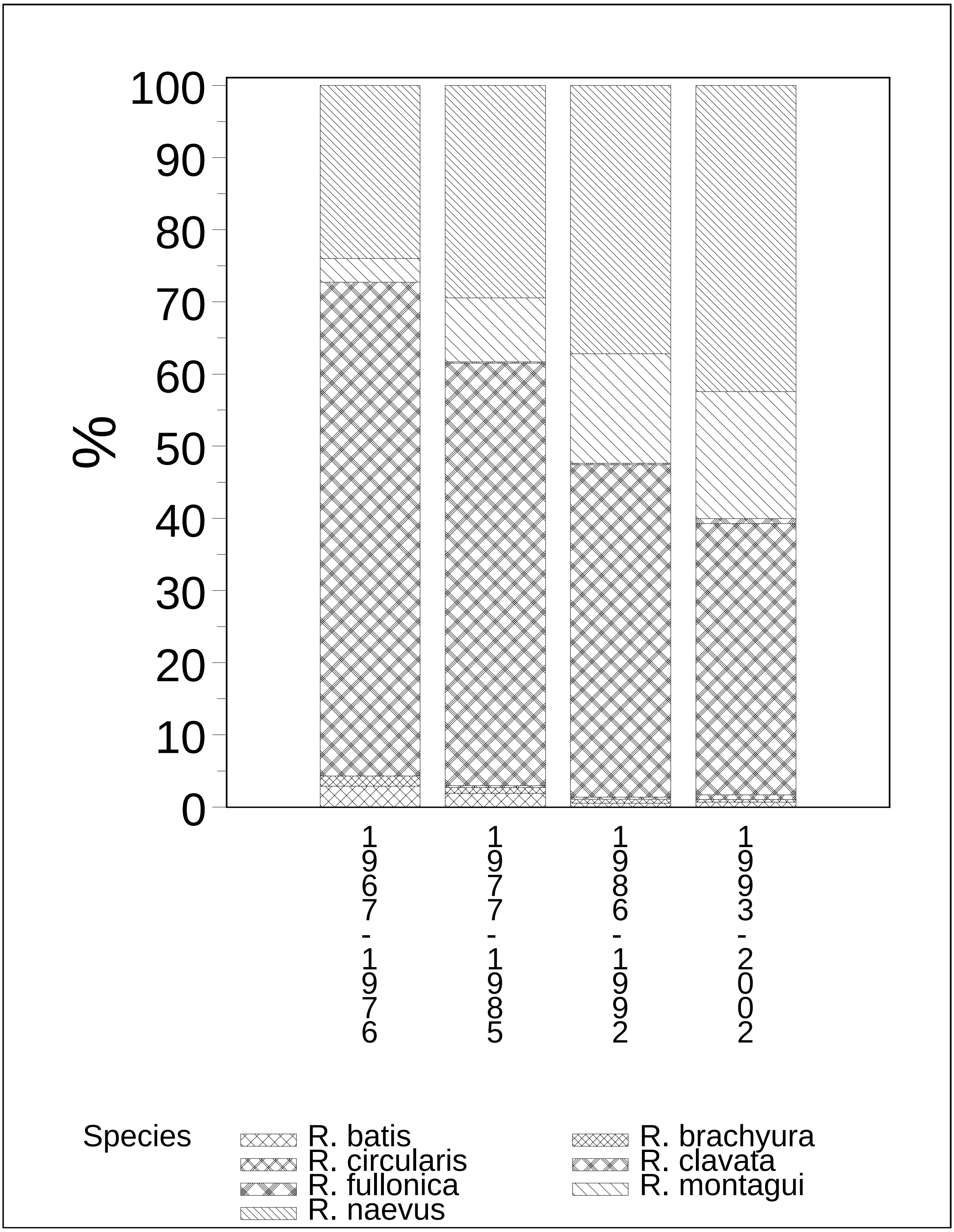
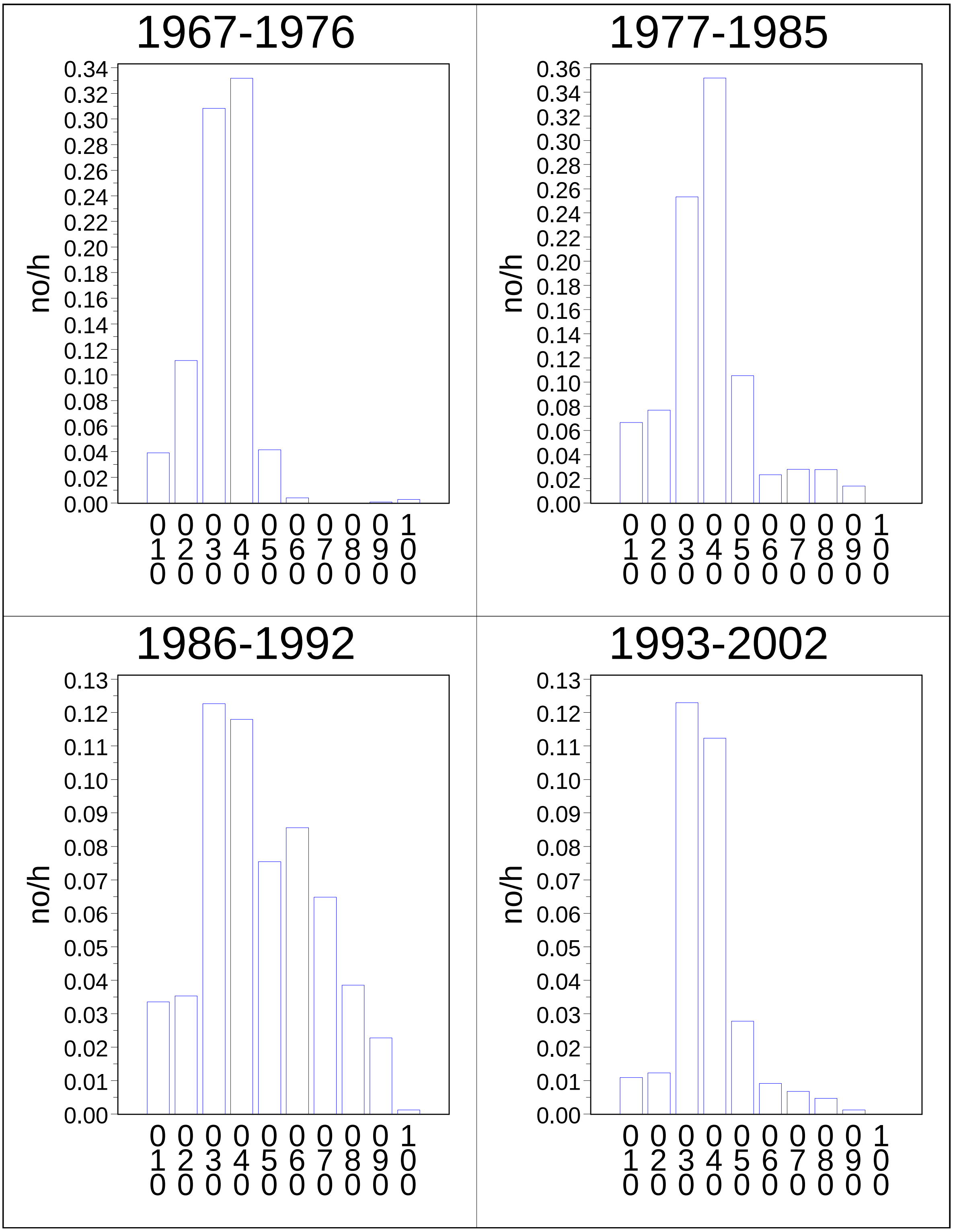


Figure 4.8.7 Length distribution of *R. clavata* averaged over four periods. Length is given as lower length of 10 cm length classes.



4.9 Cuckoo ray (*Leucoraja naevus*) in sub-areas VI, VII and VIII

4.9.1 The fishery

Total landings of rays in European waters between 1973 and 2000 and percentage by country are presented in Tables 4.9.1 and 4.9.2 respectively for Sub-areas V-VIII. Landings in Sub-area IV are presented in Table 4.8.1. France takes on average 55 % of the international landings (1980-1998). In the years 1988-1998, the proportion of cuckoo ray in the French landings from Sub-areas VI and VII has fluctuated between 26 and 53%. None of the French fleets are targeting cuckoo ray, although it is an important by-catch for:

- High sea trawlers in Division VIa (West of Scotland)
- Mid sea trawlers in the Bay of Biscay and north Celtic Sea
- Small-scale off-shore trawlers in the Celtic Sea
- Small-scale inshore trawlers in the Bay of Biscay, carrying out day trips.

The main harbours for cuckoo ray landings are Concarneau, Lorient and Le Guilvinec, and the main fishing gears are otter trawl and, increasingly, twin trawl. The latter was introduced in the early 1990s, but only appeared in the French statistics in 1996.

Discarding of cuckoo ray is assumed to be important. Estimates of discard levels are in the order of 50% in numbers (1974 estimate) or between 13 and 35% in weight (1997 estimate).

4.9.2 Data

4.9.2.1 Data availability

A working document was presented to SGEF with a description of the available data and the methods and results of a number of analysis (WD 1). The available data for cuckoo ray assessments consist of total landings of all skates and rays per ICES sub-area (1973-2000), though note that French data for 1999 and 2000 are missing. These include total landings of cuckoo ray (kg and sale value) and effort (hours) by rectangle, fleet, gear and month (1986-1998) and ray species composition of the French landings per ICES sub-area (1988-1998), with length composition of the cuckoo ray landings (1989-1997) and discards (1997) for all areas combined. Evhoe survey data (weight and number) are available by station (depth and latitude) and sex from 1987 to 2000).

4.9.2.2 Data exploration

The **Species composition** of the international landings of rays is based on French data by ICES area (Table 4.9.3). The landings data are derived from the FAO database. The estimation of cuckoo ray landings by area was carried out by calculating the ratio of the French cuckoo ray landings to the total French ray landings by ICES area, and applying this ratio to the total international ray landings by area. This may introduce an bias in the estimated landings.

Length compositions of the landings and discards are presented in Figure 4.9.1 and Table 4.9.4 (a and b). It should be noted that the discards length compositions are derived from the sampling in one year only (1997), which are extrapolated to other years based on the number of rays below 40 cm in the landings.

Growth of cuckoo ray has been studies by several authors and results are summarised in the text table below.

Method	Gender	K (year^{-1})	L_{inf} (cm)	t_0 (year)	source
Skeletochronology	M & F	0.11	92	0.5	Du Buit, 1974
Powell	M	0.22	71		Chareau & Biseau, 1989
	F	0.20	72		
	M & F	0.21	71		
Incremental growth	M	0.16	85	0.9	Chareau & Biseau, 1989
	F	0.16	85	1.2	
	M & F	0.16	84	1.1	

The **length-weight relationship** is derived from Chareau and Biseau (1989):

$W = 2.36\ 10^{-6} * L^{3.233}$
with weight in grams and length in cm.

Age compositions were derived using NORMSEP software (Abrahamson, 1971) and used the parameter estimates from the Incremental Growth method (Chareau & Biseau, 1989). The age compositions were not separated for discards and landings. The sensitivity to growth parameters was explored in the working document (WD 1). The estimated age compositions are shown in Figure 4.9.2 and Table 4.9.5.

CPUE data were derived from the French logbook data. The available data were summarised by fleet segment (denoted by a code number which could not be translated into a segment name at the meeting). The two fleet segments with the highest landings of cuckoo ray were selected and landings and effort were used to calculate CPUE by year (Table 4.9.6).

4.9.3 Assessment methods

4.9.3.1 GLM analysis

GLM analyses have been carried out on both the commercial CPUE data and the EVHOE survey data (WD 1). Three analysis were carried out on the commercial CPUE data:

- log CPUE = month rect year*fleet*gear (GLM 1)
- log CPUE = year season*rect (GLM 2)

log CPUE = month year*division (GLM 3)

with *fleet* being either large or small trawlers, *season* either summer or winter, and *division* is the ICES sub-division.

The analysis of the EVHOE survey data consisted of the following models:

- log CPUE = year latitude depth (GLM 4)
- log CPUE = year latitude_stratum*depth (GLM 5)

with *latitude* being an 8-classes grouped variable, *latitude_stratum* is divided into 2 groups: north of 49°N and south of 49°N and *depth* divided into 8 depth classes.

4.9.3.2 Biomass dynamic model

The Aspic production model was used to assess the trends in the stock, based on the total international landings of cuckoo ray and the CPUE series of the two French fleets with the highest overall landings of cuckoo ray. ASPIC is a computer program that fits a non-equilibrium logistic (Schaefer) production model to the catch and effort data (Prager 1994, 2000; Quinn and Deriso, 1999). ASPIC incorporates several extensions to classical stock-production models. A major extension is that ASPIC can fit data from up to 10 data series. These may be catch-effort series (from different gears or different periods of time), biomass indices, or biomass estimates made independently of the production model. ASPIC was run both as a deterministic run and as a bootstrapped analysis (n=500).

4.9.3.3 Catch curve analysis

A catch curve analysis was carried out on the catch-at-age matrix that was constructed from the length data and the growth parameters. The average catch number per age over the period 1989-1997 was calculated and the log of the average catch number (C) was regressed against age.

$\log C = \text{intercept} - (Z * \text{age})$

4.9.3.4 VPA analysis

A VPA analysis was explored where the terminal F was taken as an average over the last 3 years, with a scaling parameter so that the sensitivity to the absolute value of the mortality could be explored. The F on the oldest true age was assumed to be the same as the average F of the preceding 3 ages (see WD 1). The results were considered exploratory only and will not be presented in this report.

4.9.4 Results

4.9.4.1 GLM analysis

Detailed results of the GLM analyses can be found in WD 1 and are only summarised in this SG report.
GLM 1 estimates the spatial distribution of the CPUE of French trawlers and indicates a continuous distribution of cuckoo ray catches from north of Scotland to the Bay of Biscay. Highest CPUE is observed in the Celtic Sea and the Irish Sea. The interaction term (year*fleet*gear) could be used to standardise the fishing effort, but this is not pursued further at present.

GLM2 gives an estimate of the seasonal changes in CPUE in relation to the area, and shows that CPUE in the area north of 50°N is higher in the winter period.

Both GLM2 and GLM4 and 5 give estimates of trends in abundance over time (Figure 4.9.3). The trends are further discussed in section 4.9.5

4.9.4.2 Biomass dynamic model

The ASPIC model was run on the data as explained in section 4.9.3.2. The error in the model were assumed to be conditional on effort. Input to the model is shown in Table 4.9.7 and results are shown in Table 4.9.8. The time series of observations and model predictions for the two CPUE series are shown in Figure 4.9.4. The confidence intervals generated from the bootstrap analysis are shown in Figures 4.9.5 and 4.9.6, where the estimates of F and biomass are expressed relative to the MSY reference points. Since the estimated F_{msy} is around 0.4, this suggest that current F is above 0.4. The analysis suggests that F is above F_{msy} for this stock and the stock below B_{msy}. However, the high value of F in 1997 appears to be an anomaly.

4.9.4.3 Catch curve analysis

Results of the catch curve analysis are presented in Figure 4.9.7 and suggests, in contrast to the ASPIC model, that Z is around 0.3. Given that the assumed M is around 0.15 (Biseau et al, 1999), the estimated F would be around 0.15 and thus substantially lower than the estimates from the biomass model.

4.9.5 Discussion

The stock identity of the cuckoo is ray is unclear, and there are no genetic studies or tagging experiments available to ascertain its structure. In the exploratory assessments carried out by SGEF and the analysis presented in WD 1, the delimitation has also not been very clear. Some analysis were presented for all areas combined (IV-VIII), whereas others have focussed on VI and VII only. There is a need to identify the extent of the stock that will be considered in future assessments.

Figure 4.9.8 presents a comparison of trends from the GLM analysis (CPUE and EVHOE) and the ASPIC model, regarding biomass developments of the cuckoo ray stock. There appears to be a general agreement that the stock experienced a low size in the early 1990s, followed by a recovery in the later part of the 1990s. The stock trends in the most recent years are unclear as there was no data available from the commercial fishery. The survey suggest that the stock may be decreasing since the late 1990s.

The estimates of F from the production model and the catch curve analysis do not seem to be consistent. Further work is needed to explore the F estimates from the production model (notably the very high F in 1997) and a catch curve analysis based on length data could be explored.

The relevant parameter estimates from the bootstrapped production model are presented in the text table below.

	Bias-corrected estimate	Approx 80% lower CL	Approx 80% upper CL
K	**47550**	35300	55770
r	**0.78**	0.57	0.90
MSY	**9222**	6264	10870
Bmsy	**23780**	17650	27890
Fmsy	**0.39**	0.28	0.45

This suggests that the currently estimated landings of around 6000 t are well below MSY and that the stock size in 1998 (9000 t) is also well below B_{msy}. This may point to inconsistencies in the model with the current data.

Overall, there are conflicting indications about the trends for this stock. In the absence of a long time series, it is not possible to evaluate where the current status of the stock is in relation to historical levels.

4.9.6 Further work

The following issues need to be addressed to further the assessment of cuckoo ray:

- Provide a clear definition of the stock area and enhance the consistency of the data sources used for this assessment.
- Explore the adequacy of using the French species compositions of rays for other countries and the contribution of the discards length compositions on the age-based analysis.
- Use most recent years (1999 onwards) CPUE and catch data in production model. Incorporate CPUE estimates from the survey in the production model.
- Re-evaluate the growth parameters: which data were used and which parameters where selected.
- Investigate the use of : length-based catch curve analysis; catch-at-size analysis (Sullivan et al, 1990); separable VPA; and life table analysis to derive estimates of r.

Table 4.9.1a. Landings of rays combined (tonnes) in sub-area V as officially reported to ICES.

	COUNTRY												
	BEL	DEN	ENG	FAR	FRA	GER	ICE	NED	NOR	POR	SCO	USS	All
	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum
YEAR													
1973	59		444	230		122	364		30		327		1576
1974	51		220	148		74	275		27		213		1008
1975	62		240	150	30	85	188	1	46		219		1021
1976	36		155	171	57	56	333	1	46		234		1089
1977	41		10	238	159	57	442		48		164		1159
1978	23		5	228	12	55	424		67		99		913
1979	27		4	239	14	14	402		39		104		843
1980	36		2	219		7	196		21		66		547
1981	28			160	4	1	229		27		11		460
1982	11			244	3	3	257		14		32		564
1983	15			284	6	3	200		42		20		570
1984	15			305	23	3	221		38		1	86	692
1985	19			298	38	1	134		19		1		510
1986	18			258	6	1	150		22				455
1987	22	1	1	179	14	1	255		11		1		485
1988	20			94	14		191		29				348
1989	22			138	21		252		84		1		518
1990	6			118	17		383		96		2		622
1991	9		1	212	5	1	588		81				896
1992	6			256	1	1	680		37		5		986
1993	3		12	206		1	570		75		1		868
1994	0		3	170		3	1510		20		5		1711
1995			3	229	2		2018		14		4		2270
1996				167	2	0	1693		60		4		1926
1997			6	180	2		1564		14	1	5		1772
1998				151	3	2	1372		45		7		1580
1999				180		2	1097		45		6		1329
2000			23			1	1197		50		12		1283

Table 4.9.1b Landings of rays combined (tonnes) in sub-area VI as officially reported to ICES.

	COUNTRY															
	BEL	DEN	ENG	FAR	FRA	GER	ICE	IRL	NED	NOR	POL	POR	RUS	SCO	SPA	All
	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum
YEAR																
1973	13		275	109	861			281		116	64			1864		3583
1974	10		266	95	1330	1		336		127				1308		3473
1975	3		264	43	816			458		193				1700		3477
1976	4		373	43	962			425	1	122				1869		3799
1977			400	24	663	1		342		156				1884		3470
1978			328	15	859	2		242		371				1849	2	3668
1979			265	61	731	1		268		298				1692		3316
1980	2		89	44	583			343		475				1758		3294
1981	1		97		2322			474		236				1648	63	4841
1982	2		99	23	749			537		293				1661	19	3383
1983			112	22	895			806		549				1827	11	4222
1984			145	18	961			836		463				2031	20	4474
1985	2		65	3	1002	1		574		231				2092	12	3982
1986	1		62	6	649			440		275				1840	60	3333
1987	3	1	66		728			367		293				2170	55	3683
1988	2		84		768	1		690		276				2209	44	4074
1989	3		71		724	1		630		543				2569		4540
1990			61		714			150		274				2083		3282
1991	2		88		634			200		286				2093	57	3360
1992			84		603			350		316				1662		3015
1993	1		91		610	6		355		226				1489		2778
1994	2		129		437	27		288		281				1527		2692
1995	7		211		553	17		564		250		56		2077		3734
1996	1		276		526	50		749		124				2689	375	4789
1997	2		174		384	30		619		121		25		1970	468	3793
1998	2		291		333	52		503	0	148		26		1561	552	3468
1999	4		214			74		416		88		24		1447	356	2623
2000	2		264			77		311		169		29	5	1520	132	2509

Table 4.9.1c Landings of rays combined (tonnes) in sub-area VII as officially reported to ICES.

	COUNTRY												
	BEL	DEN	ENG	FRA	GER	IRL	NED	NOR	POL	POR	SCO	SPA	All
	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum	Sum
YEAR													
1973	895		2501	8152	18	1235	1	4	24		62		12892
1974	989		2400	6847		1395	1		28		69		11729
1975	845		2593	8926		1300	4	1			53		13722
1976	989		2292	9244		1497	8				39		14069
1977	731		2282	9115		1281	14	4			47		13474
1978	593		2072	9389		1207	6				53	48	13368
1979	632		2177	9757		1270	1				58		13895
1980	657		2333	10059		1393					133		14575
1981	770		2358	15109		1567					82	124	20010
1982	714		2631	9720		1365					89	63	14582
1983	668		2491	9937		1342	2	69			87	53	14649
1984	702		2737	9362		1666		1			193	55	14716
1985	902		2869	10032		2452		2			219	3	16479
1986	1056		2783	11495		1893		150			225	115	17717
1987	1017		3627	10894		2359					321	139	18357
1988	875	1	3685	11530		2558					211	90	18950
1989	982	2	3196	10113		2498		52			184		17027
1990	758	1	3428	10561		2261		39			241		17289
1991	609		2748	10199		1868		83			178	145	15830
1992	662	2	2992	9098		1920		87			117		14877
1993	519	0	2737	8012	7	1401					131		12806
1994	642		2690	7640	18	1237		92			129		12447
1995	683		2943	7741	3	1534		25			115		13044
1996	658		3241	8405	4	1463		46			113	1894	15824
1997	823		3266	9224	9	2095		16			118	2367	17919
1998	846		3421	8101	17	1617	6				119	2794	16921
1999	1002		3081		11	1867	5	30		0	156	3238	9390
2000	891		3178		21	1784	8	12			275	1489	7658

Table 4.9.1d Landings of rays combined (tonnes) in sub-area VIII as officially reported to ICES.

	COUNTRY						
	BEL	ENG	FRA	POR	SCO	SPA	All
	Sum	Sum	Sum	Sum	Sum	Sum	Sum
YEAR							
1973			3935				3935
1974			3184				3184
1975			999				999
1976	1		1063				1064
1977			1363				1363
1978	2		1492			15	1509
1979			1850				1850
1980	2		1696				1698
1981	2	1	1518			38	1559
1982			1743			1428	3171
1983	3		2200			1318	3521
1984		2	2479			972	3453
1985	1	15	2557			1236	3809
1986	5	67	2639			1098	3809
1987	1	79	2572	6		1178	3836
1988	2	57	2344	18		1320	3741
1989	12	20	2321	8		1050	3412
1990	4		2162	8		1120	3294
1991	1	7	1956	4		712	2681
1992	1	2	1734	4			1741
1993	2	16	1653	6			1677
1994	2	25	1746	11			1784
1995	9	21	1934	8		540	2512
1996	12	22	1822	11		1694	3561
1997	6	76	2089	7		2783	4961
1998	11	13	1988	10		3559	5581
1999	10	7		4		3189	3211
2000	7	2		4		5125	5138

Table 4.9.2a Percentage of landings of rays combined by country in sub-area V as officially reported to ICES.

	COUNTRY												
	BEL	DEN	ENG	FAR	FRA	GER	ICE	NED	NOR	POR	SCO	USS	All
	%	%	%	%	%	%	%	%	%	%	%	%	%
YEAR													
1973	7		20	20		13	7		13		20		100
1974	7		21	21		14	7		7		21		100
1975	6		18	18	6	12	6	6	12		18		100
1976	6		17	17	6	11	6	6	17		17		100
1977	8		8	23	8	15	8		23		8		100
1978	8		8	23	15	8	8		23		8		100
1979	7		7	21	21	7	7		21		7		100
1980	8		15	23		8	8		23		15		100
1981	8			25	8	8	8		25		17		100
1982	8			25	17	8	8		25		8		100
1983	9			27	9	9	9		27		9		100
1984	8		0	25	8	8	8		25		8	8	100
1985	9		0	27	9	9	9		27		9		100
1986	11	0		22	22	11	11		22		0		100
1987	7	7	7	21	21	7	7		14		7		100
1988	10			30	30	0	10		20		0		100
1989	10			30	20		10		20		10		100
1990	11			22	22	0	11		22		11		100
1991	11		11	22	11	11	11		22		0		100
1992	9		0	27	9	9	18		18		9		100
1993	8		15	23		8	23		15		8		100
1994	8		8	25		8	25		17		8		100
1995			8	25	17	0	25		17		8		100
1996			0	25	17	8	25		17		8		100
1997			8	23	15		23		15	8	8		100
1998			0	27	9	9	27		18		9		100
1999			0	27		18	27		18		9		100
2000			11			22	33		22		11		100
All	6	0	7	23	10	9	13	1	19	0	10	0	100

Table 4.9.2b Percentage of landings of rays combined by country in sub-area VI as officially reported to ICES.

	COUNTRY															
	BEL	DEN	ENG	FAR	FRA	GER	ICE	IRL	NED	NOR	POL	POR	RUS	SCO	SPA	All
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
YEAR																
1973	8		17	17	17			8		8	8			17		100
1974	9		9	9	18	9		9		18				18		100
1975	10		10	10	20	0		10		20				20		100
1976	8		17	8	17	0		8	8	17				17		100
1977			18	9	18	9		9		18				18		100
1978			14	7	29	7		7		14				14	7	100
1979			15	8	31	8		8		15				15		100
1980	10		20	10	10	0		10		20				20		100
1981	9		18		18			9		18				18	9	100
1982	6		11	6	44			6		11				11	6	100
1983			15	5	50			5		10				10	5	100
1984			14	5	50	0		5		9				9	9	100
1985	4		8	8	46	4		4		8				8	8	100
1986	5		15	5	40	0		5		10				10	10	100
1987	5	5	14		43	0		5		10				10	10	100
1988	5		15		40	5		5		10				10	10	100
1989	6	0	13		44	6		6		13				13		100
1990			13		56			6		13				13		100
1991	5	0	10		52	0		5		10				10	10	100
1992		0	13		53			7		13				13		100
1993	5	0	9		50	9		9		9				9		100
1994	5	0	11		42	11		11		11				11		100
1995	5	0	11		42	5		11		11		5		11		100
1996	5	0	10		38	10		10		10				10	10	100
1997	5		9		36	9	0	9		9		5		9	9	100
1998	4	0	9		35	9		9	4	9		4		9	9	100
1999	7	0	14			14		14		14		7		14	14	100
2000	7		13			13		20		13		7	7	13	7	100
All	4	0	13	3	36	5	0	8	0	12	0	1	0	12	5	100

Table 4.9.2c Percentage of landings of rays combined by country in sub-area VII as officially reported to ICES.

	COUNTRY												
	BEL	DEN	ENG	FRA	GER	IRL	NED	NOR	POL	POR	SCO	SPA	All
	%	%	%	%	%	%	%	%	%	%	%	%	%
YEAR													
1973	18		27	18	5	14	5	5	5		5		100
1974	19		24	29		14	5		5		5		100
1975	20		28	24		12	8	4			4		100
1976	18		25	36		11	7				4		100
1977	17		24	34		10	7	3			3		100
1978	12		17	51		7	2				5	5	100
1979	10		18	61		6	2				2		100
1980	18		29	32		14	0				7		100
1981	20		32	24		12	0				4	8	100
1982	11		17	60		6	0				2	4	100
1983	8		15	61		5	2	3			2	3	100
1984	9		18	58		5		2			4	4	100
1985	6		13	72		4		1			1	3	100
1986	7		14	68		4		3			3	3	100
1987	6		16	70		5					1	2	100
1988	6	1	16	67		5					2	2	100
1989	6	2	13	69		5		2			2		100
1990	5	1	14	69		4		2			5		100
1991	5		13	68		4		1			4	4	100
1992	5	2	14	71		3		1			4		100
1993	5	1	13	66	1	7		0			6		100
1994	5		13	67	1	7		1			5		100
1995	5	0	13	66	1	8		1			5		100
1996	5		11	61	2	8		1			5	8	100
1997	5		12	61	2	7		1			6	8	100
1998	5		11	59	4	8	3				5	7	100
1999	13		28		6	13	9	2		2	13	15	100
2000	13		27		13	19	4	2			10	13	100
All	8	0	16	58	1	7	1	1	0	0	4	3	100

Table 4.9.2d Percentage of landings of rays combined by country in sub-area VIII as officially reported to ICES.

	COUNTRY						
	BEL	ENG	FRA	POR	SCO	SPA	All
	%	%	%	%	%	%	%
YEAR							
1973			100				100
1974			100				100
1975			100				100
1976	33		67				100
1977	0		100				100
1978	13		75			13	100
1979			100				100
1980	25		75				100
1981	25	25	25			25	100
1982		0	80			20	100
1983	9		82			9	100
1984		8	83			8	100
1985	7	7	80			7	100
1986	6	6	81			6	100
1987	5	5	80	5		5	100
1988	5	5	80	5		5	100
1989	6	6	78	6		6	100
1990	5	0	86	5		5	100
1991	4	4	75	4		13	100
1992	5	5	86	5	0		100
1993	5	5	86	5			100
1994	5	5	85	5			100
1995	4	4	83	4		4	100
1996	4	9	65	4		17	100
1997	4	8	65	4		19	100
1998	4	8	65	4		19	100
1999	20	20		20		40	100
2000	25	13		13		50	100
All	6	6	74	4	0	10	100

Table 4.9.3 Derivation of the international landings data of Cuckoo ray. Derivation is based on the French species composition by ICES sub-area which is applied to the total international ray landings.

	Total Rays	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Europe	IV	4165	3014	3146	3510	4054	4031	4024	3811	3686	2966	2557
	V	136	98	88	103	81	137	231	310	707	692	321
	VI	2914	3199	2214	2348	2027	1821	1939	2629	3437	2608	2123
	VII	7343	6705	6592	5466	5532	4716	5817	5045	7183	8645	5976
	VIII	1397	1090	1132	724	7	24	158	38	1739	2872	34
	IV-VIII	**15955**	**14106**	**13172**	**12151**	**11701**	**10729**	**12169**	**11833**	**16752**	**17783**	**11011**

	Ratio (Cuckoo ray/Total Rays)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
France	IV	0.36	0.37	0.34	0.18	0.22	0.29	0.15	0.24	0.09	0.03	0.20
	V	0.08	0.03	0.01	0.01	0.31	0.00	0.00	0.01	0.01	0.00	0.00
	VI	0.47	0.41	0.43	0.35	0.32	0.32	0.30	0.34	0.28	0.26	0.29
	VII	0.47	0.48	0.48	0.45	0.42	0.42	0.46	0.47	0.49	0.53	0.53
	VIII	0.68	0.68	0.73	0.75	0.68	0.62	0.69	0.72	0.75	0.75	0.76

	Cuckoo rays	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Europe	IV	1494	1108	1061	642	912	1165	588	916	349	91	513
	V	12	3	1	1	25	0	0	4	9	0	1
	VI	1370	1313	962	823	653	582	580	902	957	669	605
	VII	3447	3211	3158	2444	2343	1981	2660	2368	3535	4611	3148
	VIII	955	741	828	545	5	15	109	27	1309	2164	26
	IV-VIII	**7278**	**6376**	**6009**	**4456**	**3938**	**3743**	**3938**	**4218**	**6159**	**7535**	**4293**

Table 4.9.4a International DISCARDS numbers at length for Cuckoo ray.

Discards (thousands)									
Lcm	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	15	16	14	11	8	17	10	16	17
13	20	21	18	14	11	23	14	22	23
14	20	21	18	14	11	23	14	22	23
15	41	43	38	30	23	47	29	45	48
16	83	85	81	66	54	83	67	91	94
17	101	104	98	79	64	103	80	110	115
18	143	147	138	112	92	145	114	156	162
19	86	90	82	67	54	88	67	94	98
20	88	91	83	69	56	87	68	94	98
21	47	50	45	35	29	51	38	54	56
22	95	98	91	75	61	95	75	103	107
23	160	166	154	124	101	166	129	179	186
24	149	157	140	112	90	160	118	169	177
25	183	194	170	135	107	204	135	204	215
26	151	159	142	114	91	162	116	168	176
27	134	142	125	99	80	145	104	151	159
28	126	131	120	96	78	131	103	142	148
29	195	200	187	152	125	191	168	221	228
30	160	168	149	121	98	166	126	178	186
31	261	271	249	202	164	269	205	286	298
32	221	228	210	172	141	220	182	246	255
33	245	250	235	197	164	224	217	273	279
34	225	232	215	179	148	214	193	251	258
35	155	157	148	127	106	134	143	173	176
36	184	187	176	148	124	164	168	208	212
37	173	179	162	141	116	157	146	188	193
38	189	191	185	154	130	167	179	216	219
39	190	197	178	149	123	181	164	214	220
40	188	191	182	155	130	165	170	209	212
41	213	221	197	173	142	191	176	228	234
42	145	147	138	119	100	123	136	163	166
43	131	132	125	106	90	110	129	152	153
44	131	133	126	106	90	115	124	150	153
45	166	167	160	138	118	133	162	188	189
46	151	152	148	123	105	131	148	175	177
47	54	55	52	43	36	50	49	62	63
48	50	51	48	41	35	41	52	60	60
49	25	24	25	20	17	21	25	29	29
50	8	8	7	6	5	6	7	8	8
51	11	10	10	8	7	9	11	13	13
52	0	0	0	0	0	0	0	0	0
53	1	1	1	1	1	1	1	1	1
54	0	0	0	0	0	0	0	0	0
55	10	11	10	7	6	12	7	11	12
56	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0
63	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0
67	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0
73	0	0	0	0	0	0	0	0	0
74	0	0	0	0	0	0	0	0	0
75	0	0	0	0	0	0	0	0	0
Sum	**5123**	**5279**	**4880**	**4042**	**3332**	**4925**	**4374**	**5723**	**5898**

Table 4.9.4b International LANDINGS numbers at length for Cuckoo ray.

Landings (thousands)									
Lcm	1989	1990	1991	1992	1993	1994	1995	1996	1997
10	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	2	16	0
33	0	0	0	0	0	0	0	16	0
34	0	0	0	0	0	0	0	0	0
35	0	0	1	0	1	0	0	16	0
36	5	0	0	0	2	13	0	63	4
37	0	0	9	1	1	21	11	33	25
38	0	4	17	4	5	41	4	54	10
39	30	7	17	24	6	38	23	40	22
40	27	20	48	39	22	128	25	96	62
41	61	25	43	48	27	117	31	75	108
42	51	45	74	68	55	154	102	182	85
43	81	82	94	93	56	148	111	181	110
44	123	99	110	138	74	176	81	105	180
45	168	89	109	136	71	118	97	166	192
46	104	109	128	118	83	91	107	114	136
47	182	157	132	118	84	95	73	132	136
48	226	189	133	167	111	94	106	124	270
49	155	167	133	124	113	96	111	163	183
50	167	187	159	158	128	123	113	293	219
51	248	203	164	116	92	105	148	250	199
52	203	209	186	135	125	88	160	246	92
53	154	173	191	110	97	110	163	177	180
54	166	160	231	109	106	101	106	116	68
55	132	162	175	107	110	100	120	177	130
56	120	143	232	125	107	131	155	188	123
57	120	131	217	129	78	132	88	105	131
58	162	185	186	132	94	125	67	143	132
59	180	258	158	119	112	93	101	129	125
60	196	226	184	174	135	112	121	163	164
61	171	250	172	174	124	112	116	206	133
62	258	260	187	219	152	145	113	167	180
63	236	186	189	161	149	123	119	142	150
64	226	168	153	94	122	126	141	124	222
65	210	158	130	131	114	123	114	116	99
66	146	132	95	94	76	92	160	57	120
67	90	88	80	75	69	69	139	44	97
68	75	48	21	45	47	46	71	4	49
69	40	31	11	41	25	14	65	26	83
70	15	13	11	21	16	14	46	1	8
71	3	2	1	1	1	7	36	24	8
72	3	3	0	3	0	7	9	0	0
73	2	0	1	0	0	0	7	0	0
74	0	0	0	0	0	0	16	0	0
75	0	0	0	0	0	0	0	0	0
Total	4536	4368	4182	3553	2792	3430	3379	4475	4235

Table 4.9.5 International catch numbers at age (discards + landings) for Cuckoo ray.

Age group	1989	1990	1991	1992	1993	1994	1995	1996	1997
0	581	601	557	450	363	605	450	635	660
1	2074	2177	1952	1576	1278	2105	1636	2272	2403
2	1734	1706	1718	1427	1188	1907	1636	2409	2058
3	1790	1744	1666	1636	1152	1725	1503	1887	2242
4	926	871	498	489	444	181	451	1013	736
5	480	574	1081	429	455	580	702	615	293
6	338	325	414	330	156	320	9	264	515
7	478	916	325	474	365	154	448	430	240
8	527	241	377	285	277	307	1	377	331
9+	734	595	479	493	434	471	913	298	658

Table 4.9.6 Landings (top) and effort (bottom) data of French fleets fishing for cuckoo ray.

Landings of Cuckoo ray (kg)

Sum of Weight (non-gutted)	Type of Fleets						
Year	40	20	50	30	46	41	Grand Total
1986	453	129829	47134	1416764	503235	2592684	4690099
1987	1792	150330	139496	1189127	566823	3068687	5116255
1988		176721	153958	926223	533547	3224986	5015435
1989		157112	149767	858026	888495	3115859	5169259
1990		144790	130370	748953	1002969	3297057	5324139
1991		59741	69635	565875	1030430	2985319	4711000
1992		38803	57091	441221	909040	2625503	4071658
1993		25903	43815	369798	935215	2167299	3542030
1994		13488	168577	292389	1119848	2476908	4071210
1995		10214	269231	286140	1247785	2774540	4587910
1996		3585	190305	244928	1270216	3039330	4748364
1997		9033	189926	230353	1277375	3599315	5306002
1998		692	135091	236363	843001	3128207	4343354

Effort (hours)

Sum of Fishing Effort (hours)	Type of Fleets					
Year	20	30	50	46	41	Grand Total
1988	72866	792911	1060115	777151	2819989	5523032
1989	76130	925217	1566487	1344050	3354673	7266557
1990	70314	830901	998594	1376222	3417060	6693091
1991	58368	769843	1007813	1720684	3388653	6945361
1992	51498	682538	909648	1981390	3421070	7046144
1993	45488	599794	1064730	1625217	3134559	6469788
1994	44142	495779	1263609	1508086	2904951	6216567
1995	23937	527256	1198821	1577530	3206817	6534361
1996	31155	472950	868647	1127274	3221750	5721776
1997	39616	407394	566318	1196661	3226693	5436682
1998	21401	404209	551822	1117710	2908522	5003664

Table 4.9.7 Cuckoo ray in area IV-VIII. Input to the ASPIC program.

```
'BOT'                   ## Mode (FIT, IRF, BOT)
'Cuckoo ray'
'EFF'                   ## Error type ('EFF' = condition on yield)
 2                      ## Verbosity (0 to 4)
 500                    ## Number of bootstrap trials, <= 1000
 1 10000                ## Monte Carlo search enable (0,1,2), N trials
 1.0E-8                 ## Convergence crit. for simplex
 3.0E-8                 ## Convergence crit. for restarts
 1.0d-4                 ## Convergence crit. for estimating effort
 3.0d0                  ## Maximum F when estimating effort
 0.0d0                  ## Statistical weight for B1 > K as residual
 2                      ## Number of data series (fisheries)
1.0d0 1.0d0 1.0d0 1.0d0 1.0d0 1.0d0 1.0d0 1.0d0    ## Statistical weights for fisheries
1.0d0                   ## B1-ratio (starting guess)
2.0d4                   ## MSY (starting guess)
0.1d0                   ## r (starting guess)
1.0d0 1.0d0 1.0d0 1.0d0 1.0d0 1.0d0 1.0d0 1.0d0    ## q (starting guess)
1 1 1 1 1 1 1 1 1 1 1 1 ## Flags to estimate parameters
1.0d2   4.0d4           ## Min and max allowable MSY
5.0d-5  2.0d0           ## Min and max allowable r
9126738                 ## Random number seed
11                      ## Number of years of data.
'Fleet 41 and Total catch' ## Title for first series
'CC'                    ## Type of series ('CE' = effort, catch)
1988    1.143616518 7278
1989    0.928811541 6376
1990    0.964881214 6009
1991    0.880975125 4456
1992    0.767450827 3938
1993    0.691420707 3743
1994    0.852650527 3938
1995    0.865200602 4218
1996    0.943378599 6159
1997    1.115481082 7535
1998    1.07553149  4293
'Fleet 46'
'I1'
1988    0.686542255
1989    0.661057996
1990    0.72878431
1991    0.598849062
1992    0.458789032
1993    0.57544008
1994    0.742562427
1995    0.790973864
1996    1.126803244
1997    1.067449344
1998    0.754221578
```

Table 4.9.8 Cuckoo ray in area IV-VIII. Results from the bootstrapped ASPIC run.

08 May 2002 at 15:22.30

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.77) BOT Mode

Author: Michael H. Prager
National Marine Fisheries Service
Southeast Fisheries Science Center
101 Pivers Island Road
Beaufort, North Carolina 28516 USA

ASPIC User's Manual
is available gratis
from the author

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	11	Number of bootstrap trials:	500
Number of data series:	2	Lower bound on MSY:	1.000E+02
Objective function computed:	in effort	Upper bound on MSY:	4.000E+04
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	5.000E-05
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	2.000E+00
Relative conv. criterion (effort):	1.000E-04	Random number seed:	9126738
Maximum F allowed in fitting:	8.000	Monte Carlo search trials:	10000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

	1	2
1 Fleet 41 and Total catch	1.000 11	
2 Fleet 46	0.517 11	1.000 11

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	0.000E+00	N/A	
Loss(1) Fleet 41 and Total catch	1.971E-01	11	2.190E-02	1.000E+00	1.111E+00	0.177
Loss(2) Fleet 46	2.462E-01	11	2.736E-02	1.000E+00	8.892E-01	0.586
TOTAL OBJECTIVE FUNCTION:	4.43337750E-01					

Number of restarts required for convergence:	33	
Est. B-ratio coverage index (0 worst, 2 best):	0.1711	< These two measures are defined in Prager
Est. B-ratio nearness index (0 worst, 1 best):	0.4213	< et al. (1996), Trans. A.F.S. 125:729

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1988	4.171E-01	1.000E+00	1	1
MSY	Maximum sustainable yield	9.488E+03	2.000E+04	1	1
r	Intrinsic rate of increase	7.938E-01	1.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	Fleet 41 and Total catch	1.161E-04	1.000E+00	1	1
q(2)	Fleet 46	9.119E-05	1.000E+00	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	Related quantity
MSY	Maximum sustainable yield	9.488E+03	Kr/4	
K	Maximum stock biomass	4.781E+04		
Bmsy	Stock biomass at MSY	2.391E+04	K/2	
Fmsy	Fishing mortality at MSY	3.969E-01	r/2	
F(0.1)	Management benchmark	3.572E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	9.393E+03	0.99*MSY	
B-ratio	Ratio of B(1999) to Bmsy	4.206E-01		
F-ratio	Ratio of F(1998) to Fmsy	1.171E+00		
F01-mult	Ratio of F(0.1) to F(1998)	7.689E-01		
Y-ratio	Proportion of MSY avail in 1999	6.643E-01	2*Br-Br^2	Ye(1999) = 6.303E+03
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	Fleet 41 and Total catch	3.419E+03	r/2q(1)	f(0.1) = 3.077E+03

Table 4.9.8 continued

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1988	0.786	9.971E+03	9.261E+03	7.278E+03	7.278E+03	5.925E+03	1.980E+00	4.171E-01
2	1989	0.790	8.618E+03	8.068E+03	6.376E+03	6.376E+03	5.322E+03	1.991E+00	3.605E-01
3	1990	0.877	7.565E+03	6.855E+03	6.009E+03	6.009E+03	4.659E+03	2.209E+00	3.164E-01
4	1991	0.731	6.214E+03	6.094E+03	4.456E+03	4.456E+03	4.221E+03	1.842E+00	2.600E-01
5	1992	0.642	5.980E+03	6.134E+03	3.938E+03	3.938E+03	4.245E+03	1.617E+00	2.501E-01
6	1993	0.559	6.286E+03	6.700E+03	3.743E+03	3.743E+03	4.572E+03	1.408E+00	2.630E-01
7	1994	0.511	7.115E+03	7.709E+03	3.938E+03	3.938E+03	5.131E+03	1.287E+00	2.976E-01
8	1995	0.462	8.308E+03	9.124E+03	4.218E+03	4.218E+03	5.857E+03	1.165E+00	3.476E-01
9	1996	0.615	9.947E+03	1.001E+04	6.159E+03	6.159E+03	6.282E+03	1.550E+00	4.161E-01
10	1997	0.818	1.007E+04	9.207E+03	7.535E+03	7.535E+03	5.898E+03	2.062E+00	4.213E-01
11	1998	0.465	8.433E+03	9.240E+03	4.293E+03	4.293E+03	5.914E+03	1.171E+00	3.528E-01
12	1999		1.005E+04						4.206E-01

RESULTS FOR DATA SERIES # 1 (NON-BOOTSTRAPPED) Fleet 41 and Total catch

Data type CC: CPUE-catch series Series weight: 1.000

Obs	Year	Observed CPUE	Estimated CPUE	Estim F	Observed yield	Model yield	Resid in log scale	Resid in yield
1	1988	1.144E+00	1.075E+00	0.7858	7.278E+03	7.278E+03	-0.06185	0.000E+00
2	1989	9.288E-01	9.365E-01	0.7903	6.376E+03	6.376E+03	0.00825	0.000E+00
3	1990	9.649E-01	7.957E-01	0.8766	6.009E+03	6.009E+03	-0.19281	0.000E+00
4	1991	8.810E-01	7.074E-01	0.7312	4.456E+03	4.456E+03	-0.21941	0.000E+00
5	1992	7.675E-01	7.120E-01	0.6420	3.938E+03	3.938E+03	-0.07494	0.000E+00
6	1993	6.914E-01	7.777E-01	0.5587	3.743E+03	3.743E+03	0.11758	0.000E+00
7	1994	8.527E-01	8.948E-01	0.5108	3.938E+03	3.938E+03	0.04829	0.000E+00
8	1995	8.652E-01	1.059E+00	0.4623	4.218E+03	4.218E+03	0.20215	0.000E+00
9	1996	9.434E-01	1.162E+00	0.6153	6.159E+03	6.159E+03	0.20838	0.000E+00
10	1997	1.115E+00	1.069E+00	0.8184	7.535E+03	7.535E+03	-0.04284	0.000E+00
11	1998	1.076E+00	1.073E+00	0.4646	4.293E+03	4.293E+03	-0.00273	0.000E+00

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 1

```
                   -1       -0.75      -0.5     -0.25       0       0.25       0.5      0.75        1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1988    -0.0619                                           ==|
1989     0.0082                                             |
1990    -0.1928                                     ========|
1991    -0.2194                                    =========|
1992    -0.0749                                          ===|
1993     0.1176                                             |=====
1994     0.0483                                             |==
1995     0.2022                                             |========
1996     0.2084                                             |========
1997    -0.0428                                           ==|
1998    -0.0027                                             |
                   -------------------------------------------------------------------------------------
```

RESULTS FOR DATA SERIES # 2 (NON-BOOTSTRAPPED) Fleet 46

Data type I1: Year-average biomass index Series weight: 1.000

Obs	Year	Observed effort	Estimated effort	Estim F	Observed index	Model index	Resid in log index	Resid in index
1	1988	1.000E+00	1.000E+00	0.0	6.865E-01	8.445E-01	-0.20713	-1.580E-01
2	1989	1.000E+00	1.000E+00	0.0	6.611E-01	7.357E-01	-0.10701	-7.466E-02
3	1990	1.000E+00	1.000E+00	0.0	7.288E-01	6.251E-01	0.15348	1.037E-01
4	1991	1.000E+00	1.000E+00	0.0	5.988E-01	5.558E-01	0.07469	4.310E-02
5	1992	1.000E+00	1.000E+00	0.0	4.588E-01	5.594E-01	-0.19825	-1.006E-01
6	1993	1.000E+00	1.000E+00	0.0	5.754E-01	6.110E-01	-0.05989	-3.552E-02
7	1994	1.000E+00	1.000E+00	0.0	7.426E-01	7.030E-01	0.05477	3.957E-02
8	1995	1.000E+00	1.000E+00	0.0	7.910E-01	8.320E-01	-0.05055	-4.101E-02
9	1996	1.000E+00	1.000E+00	0.0	1.127E+00	9.128E-01	0.21059	2.140E-01
10	1997	1.000E+00	1.000E+00	0.0	1.067E+00	8.396E-01	0.24012	2.279E-01
11	1998	1.000E+00	1.000E+00	0.0	7.542E-01	8.426E-01	-0.11086	-8.842E-02

UNWEIGHTED LOG RESIDUAL PLOT FOR DATA SERIES # 2

```
                   -1       -0.75      -0.5     -0.25       0       0.25       0.5      0.75        1
                    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |    .    |
Year   Residual    -------------------------------------------------------------------------------------
1988    -0.2071                                     ========|
1989    -0.1070                                         ====|
1990     0.1535                                             |======
1991     0.0747                                             |===
1992    -0.1982                                     ========|
1993    -0.0599                                           ==|
1994     0.0548                                             |==
1995    -0.0506                                           ==|
1996     0.2106                                             |========
1997     0.2401                                             |==========
1998    -0.1109                                         ====|
                   -------------------------------------------------------------------------------------
```

Table 4.9.8 continued

RESULTS OF BOOTSTRAPPED ANALYSIS

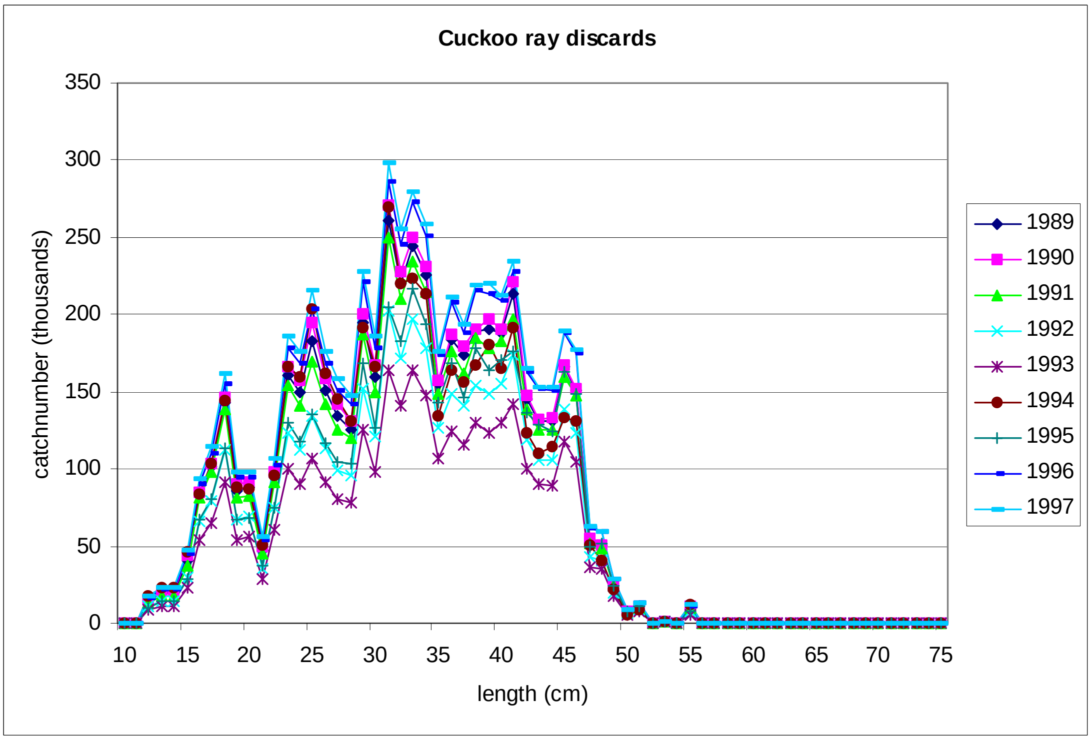
Param name	Bias-corrected estimate	Ordinary estimate	Relative bias	Approx 80% lower CL	Approx 80% upper CL	Approx 50% lower CL	Approx 50% upper CL	Inter-quartile range	Relative IQ range
B1ratio	4.291E-01	4.171E-01	-2.79%	3.577E-01	7.120E-01	3.881E-01	5.279E-01	1.397E-01	0.326
K	4.755E+04	4.781E+04	0.55%	3.530E+04	5.577E+04	4.376E+04	5.040E+04	6.638E+03	0.140
r	7.801E-01	7.938E-01	1.76%	5.664E-01	9.022E-01	6.896E-01	8.422E-01	1.525E-01	0.196
q(1)	1.141E-04	1.161E-04	1.69%	7.739E-05	1.384E-04	9.374E-05	1.266E-04	3.284E-05	0.288
q(2)	8.934E-05	9.119E-05	2.08%	6.221E-05	1.080E-04	7.387E-05	9.895E-05	2.508E-05	0.281
MSY	9.222E+03	9.488E+03	2.89%	6.264E+03	1.087E+04	7.658E+03	1.011E+04	2.449E+03	0.266
Ye(1999)	6.338E+03	6.303E+03	-0.56%	5.581E+03	7.165E+03	5.970E+03	6.779E+03	8.090E+02	0.128
Bmsy	2.378E+04	2.391E+04	0.55%	1.765E+04	2.789E+04	2.188E+04	2.520E+04	3.319E+03	0.140
Fmsy	3.901E-01	3.969E-01	1.76%	2.832E-01	4.511E-01	3.448E-01	4.211E-01	7.627E-02	0.196
fmsy(1)	3.414E+03	3.419E+03	0.17%	3.123E+03	3.929E+03	3.240E+03	3.609E+03	3.697E+02	0.108
fmsy(2)	4.335E+03	4.353E+03	0.40%	3.981E+03	4.913E+03	4.152E+03	4.578E+03	4.253E+02	0.098
F(0.1)	3.511E-01	3.572E-01	1.58%	2.549E-01	4.060E-01	3.103E-01	3.790E-01	6.865E-02	0.196
Y(0.1)	9.130E+03	9.393E+03	2.86%	6.202E+03	1.076E+04	7.582E+03	1.001E+04	2.425E+03	0.266
B-ratio	4.294E-01	4.206E-01	-2.05%	3.272E-01	6.679E-01	3.697E-01	5.099E-01	1.401E-01	0.326
F-ratio	1.187E+00	1.171E+00	-1.38%	1.024E+00	1.383E+00	1.101E+00	1.286E+00	1.848E-01	0.156
Y-ratio	6.746E-01	6.643E-01	-1.53%	5.474E-01	8.897E-01	6.027E-01	7.598E-01	1.570E-01	0.233
f0.1(1)	3.072E+03	3.077E+03	0.15%	* * * * *	0.108				
f0.1(2)	3.902E+03	3.917E+03	0.36%	* * * * *	0.098				
q2/q1	7.901E-01	7.856E-01	-0.57%	7.252E-01	8.631E-01	7.572E-01	8.311E-01	7.394E-02	0.094

NOTES ON BOOTSTRAPPED ESTIMATES:

- The bootstrapped results shown were computed from 500 trials.
- These results are conditional on the constraints placed upon MSY and r in the input file (ASPIC.INP).
- All bootstrapped intervals are approximate. The statistical literature recommends using at least 1000 trials for accurate 95% intervals. The 80% intervals used by ASPIC should require fewer trials for equivalent accuracy. Using at least 500 trials is recommended.
- The bias corrections used here are based on medians. This is an accepted statistical procedure, but may estimate nonzero bias for unbiased, skewed estimators.

Trials replaced for lack of convergence:	4
Trials replaced for MSY out-of-bounds:	0
Trials replaced for r out-of-bounds:	0
Residual-adjustment factor:	1.1376

Figure 4.9.1 Cuckoo ray in sub-areas IV-VIII. Total international length compositions of the landings and discards based on the French species- and length compositions. Note that the discards length compositions are based on the discards length composition collected in 1997 and extrapolated to other years.



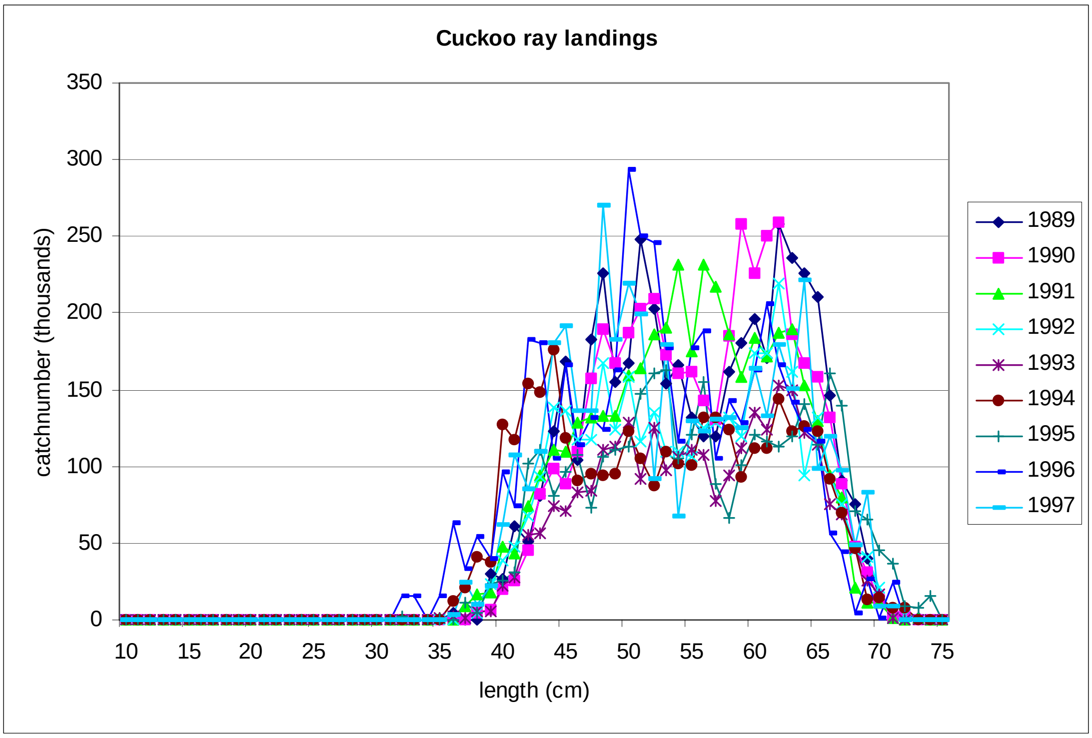


Figure 4.9.2 Cuckoo ray in sub-areas IV-VIII. Total international age compositions of the landings and discards combined, based on the French species- and length compositions and a growth curve to divide lengths into ages.

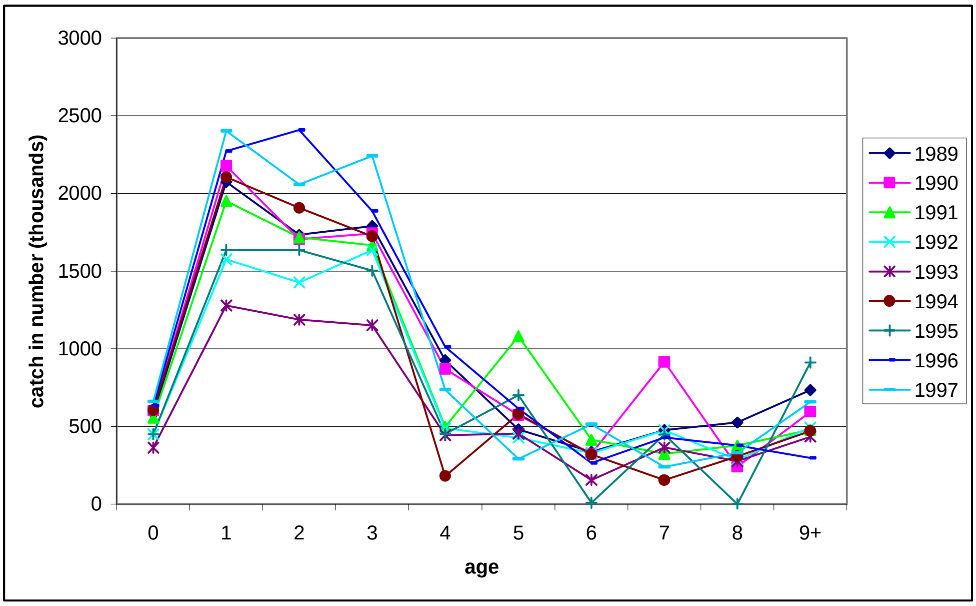
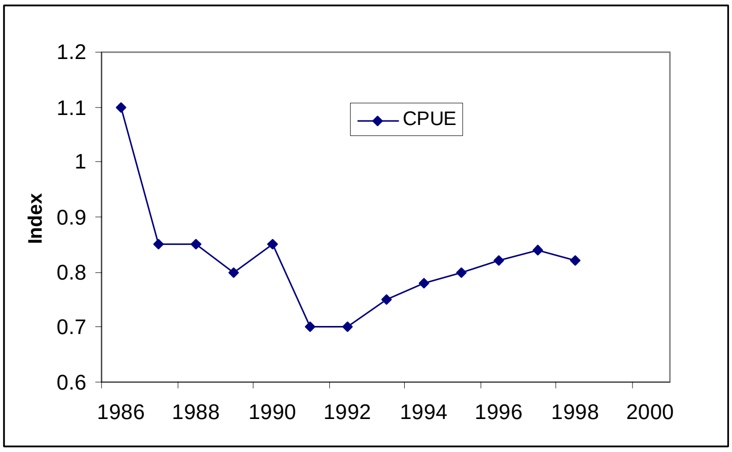


Figure 4.9.3 Cuckoo ray in sub-areas IV-VIII. Results of GLM analysis for CPUE data and survey data (EVHOE). Index of year effects.



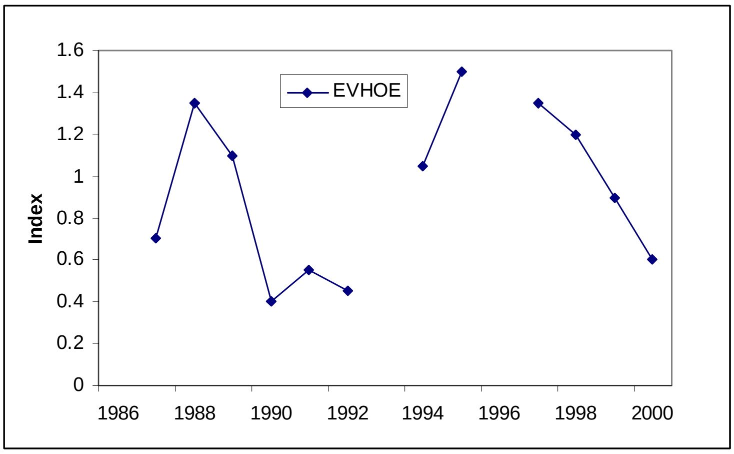
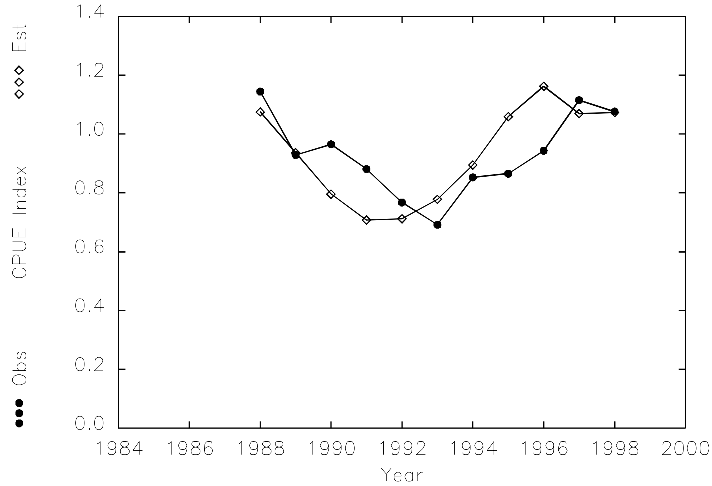


Figure 4.9.4 Cuckoo ray in sub-areas IV-VIII. Results of ASPIC analysis for French CPUE model (observed and predicted CPUE trends).

Fleet 41



Fleet 46

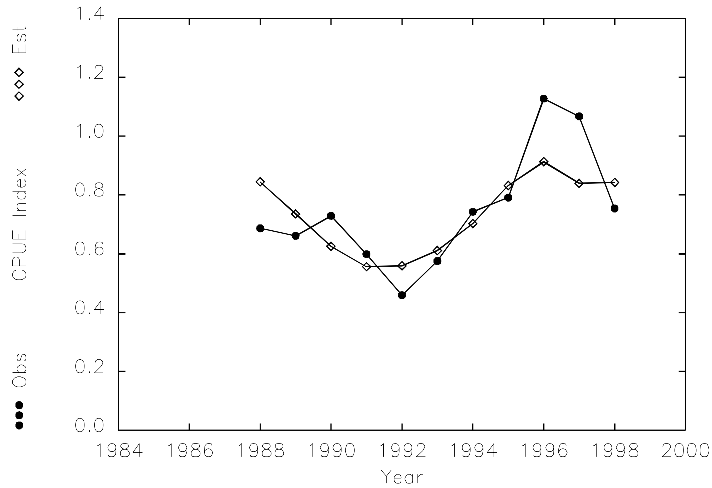


Figure 4.9.5 Cuckoo ray in sub-areas IV-VIII. Results of ASPIC analysis with French CPUE data. Estimated Biomass vs B_{msy} with 80% confidence intervals.

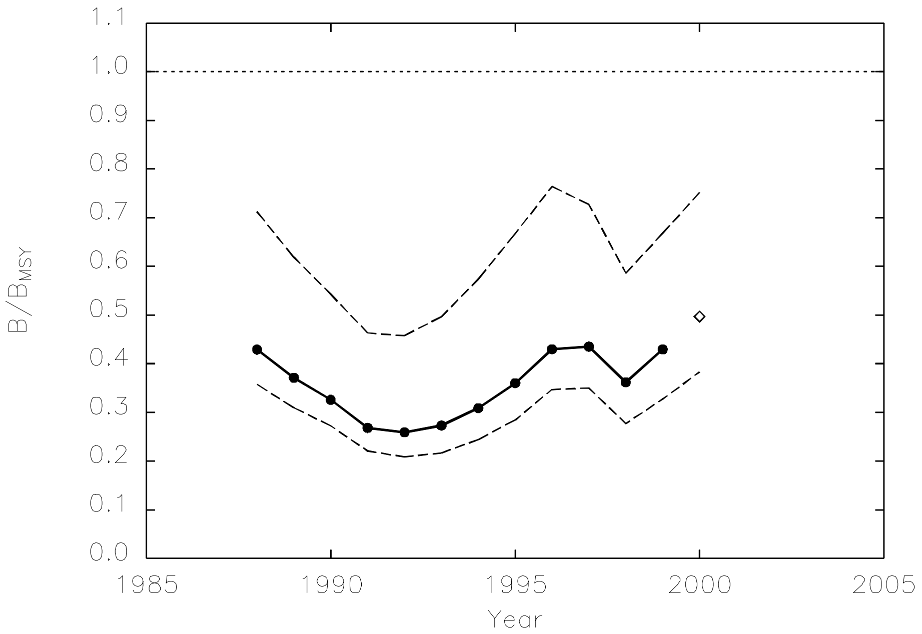


Figure 4.9.6 Cuckoo ray in sub-areas IV-VIII. Results of ASPIC analysis with French CPUE data. Estimated Fishing mortality vs F_{msy} with 80% confidence intervals

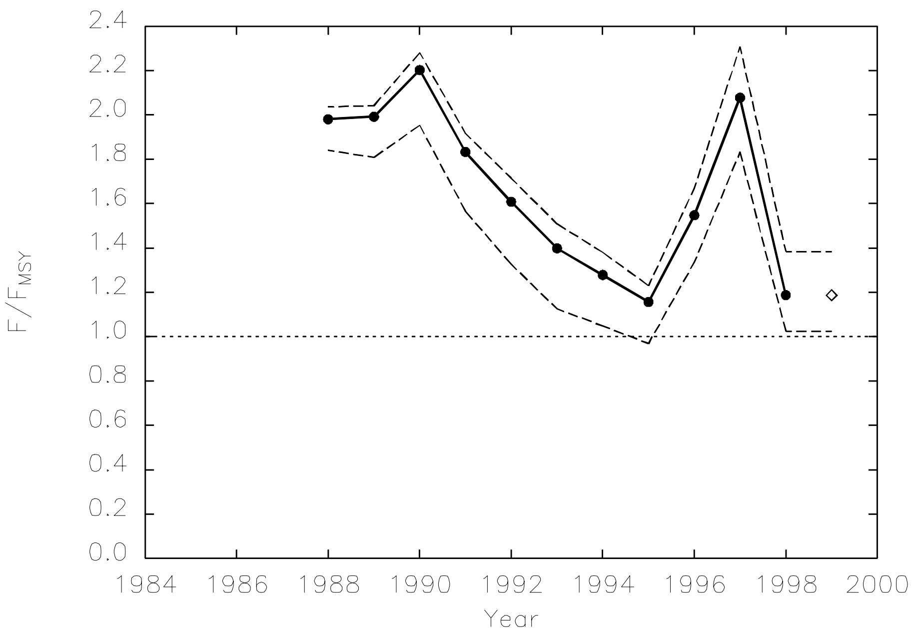


Figure 4.9.7 Cuckoo ray in sub-areas IV-VIII. Results of age based catch curve analysis. Catch includes both landings and discards.

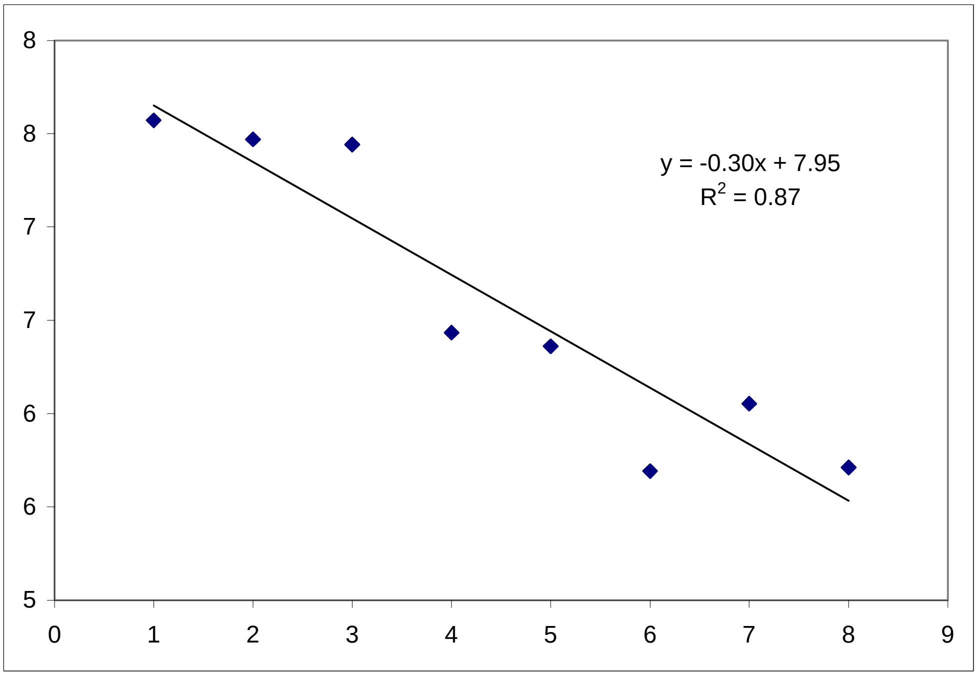
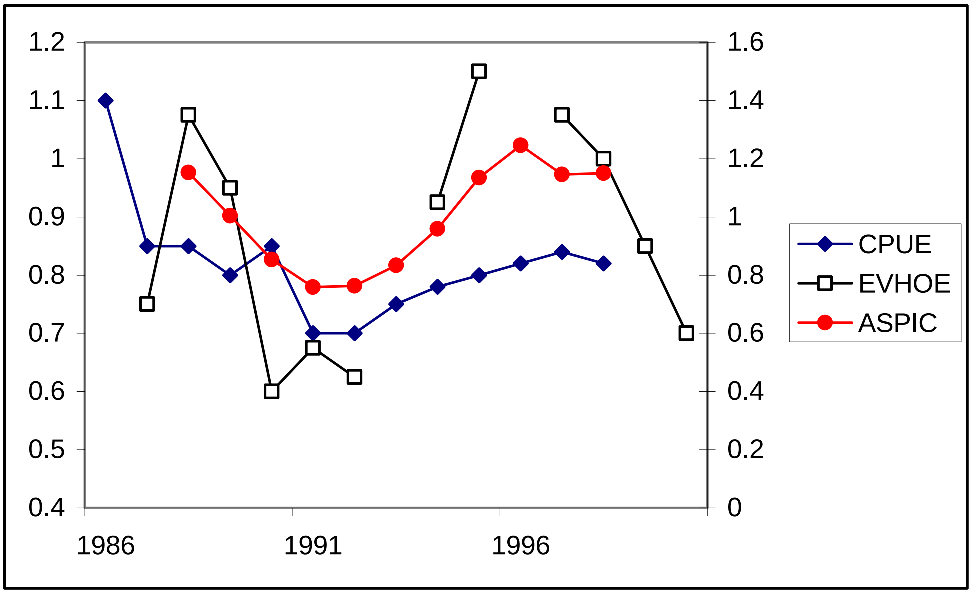


Figure 4.9.8 Cuckoo ray in sub-areas IV-VIII. Comparison of relative biomass estimates from the GLM analysis (CPUE and EVHOE) and the ASPIC model.



4.10 Discussion

In this section, the main findings of the explorations towards stock assessment of the nine case study species presented above is discussed and general recommendations for further development of assessments of elasmobranch stocks are made.

4.10.1 Landings data

The collection of landings data for elasmobranch species is still considered to be a problem. In particular, landings need to be separated to the species level and, in most fisheries, this is not the case. There has been some improvement in, e.g. the identification of deep-water sharks to the species level. Also, exploratory market sampling programmes have been carried out, aimed estimating the species and length composition of landings (e.g. for rays).

Some elasmobranch species may be subject to substantial discarding rates (e.g. lesser spotted dogfish). In these cases, the collection of discard data is of great importance if we are to give reliable estimates of the stock size in the future.

Figure 4.10.1 show the general evolution of all elasmobranch landings as officially reported to ICES. The overall level appears to have remained relatively constant, but the distribution over areas has changed. Landings from the North Sea have decreased, whereas landings in Sub-areas IX, X and XII have an increased.

4.10.2 Life table models

Life table models use the demographic characteristics of a population in the form of a schedule of the survivorship and 'fertility' at each age for the entire (female) population. These methods allow the calculation of reference parameters of population growth, such as the generation time (G), net reproductive rate (R_0), population doubling time (t_{x2}), and the observed rate of increase of the population (r). This last parameter can be used as an input parameter for stock assessment methods such as surplus production models, or to define the prior probability distribution of the intrinsic rate of increase for use in a Bayesian Surplus production model (McAllister and Pikitch 1998, McAllister et al. 2001) as is illustrated for spurdog (section 4.1).

In order to be able to use life table models, biological parameters for the species are required. In this report, life table models have been applied to blue shark with reasonable success (discussed in section 4.3). However, it was found that the biological basis for the application of life table models is often relatively weak. Therefore, it is important that more ageing and growth studies are carried out, and also that estimates of maturity and fecundity at age and at length become available. Since the life table models are heavily dependent on the calculated survivorship, the estimates of natural mortality also need to improved.

4.10.3 Surplus production models

For many elasmobranch species, length- or age-based data are either limited or not available. In these cases, surplus production models may provide a suitable alternative. These models are generally applicable when historical series of catch are available and CPUE series from either fisheries or surveys.

CPUE data from the commercial fisheries can, in principle, be the cause of pitfalls. In order to be able to use CPUE as an indicator of stock size (as is done in a surplus production model), the catchability should be constant. If catchability is not constant during the history of the fishery (e.g. due to technological improvements or specific targeting of certain species), CPUE may just as well be an indicator of the technological success of the fishery, rather than of the size of the stock.

In order to be able to run surplus production models, it is not strictly necessary to have data at the species level. In this report, an example is provided for two combined deep-water sharks (so-called 'Siki', section 4.4). However, this approach runs the risk of missing the separate trends in the species, as opposite trends could be hidden. For that reason, species-specific data are urgently needed.

The 'Siki' assessment also showed the need to define strict procedures for determining when CPUE can be considered to be an indicator of stock size when issues such as a developing fishery and possible mis-reporting whilst creating track records when TACs are announced are applicable.

In addition to 'Siki', surplus production models have been explored for Cuckoo ray (4.9) and lesser spotted dogfish (4.2).

4.10.4 Growth models

Growth models like the Von Bertalanffy equation and the associated parameters play an important role when direct age compositions of catches or surveys are not available. Growth parameters are essential for the life table models and for the slicing of length distributions into age compositions (from the commercial fishery or from research surveys). Growth parameters are also important for purely length-based models, such as the catch at size method (Sullivan et al, 1990).

For many of the stocks considered, several studies with growth data were available. However, the estimated growth parameters were often found to be dependent on the method or the data used to estimate growth, and thus cannot be generically applied. There is clearly a need to evaluate the sensitivity of the assessment models to the growth parameters used.

A problem that was identified for a number of stocks was that the $L\infty$ from the growth model was substantially lower than the maximum length found in the length compositions of the commercial or survey catches. This created problems in slicing length distributions and also in applying the catch at size method (e.g. spurdog, 4.1).

It should be noted that reliable growth data will be difficult to collect when age information is scarce and seldom validated. Tagging data could be an important remedy for this deficiency.

4.10.5 Length-based methods

Two length-based methods were explored by the Group: length-based catch-curve analysis and catch at size analysis. Both aim to give estimates of the level of exploitation experienced by the stock.

The length-based catch-curve analysis is not presented in this report, but could be an alternative to an age-converted catch curve. However, its successful application to elasmobranch data has still to be demonstrated.

The catch at size method was explored for spurdog and lesser spotted dogfish. This method uses a size-transition matrix, obtained from a stochastic growth model with known VBG parameters, to project the population length distribution forwards in time. All population dynamics processes, such as recruitment and fishing mortality, are assumed to be dependent on length rather than age. Estimates of yearly recruitment, length distribution of recruits, selectivity and temporal fishing mortality are then obtained by fitting the annual catch-at-length predicted by the model to the observed data. Problems were encountered with this method because a large number of individuals occurring in the catch were significantly larger than the values of L_∞ obtained from the literature. The model assumes that growth beyond L_∞ is impossible and is, therefore, unable to predict the proportion of large individuals appearing in the catch. Further work on this method is encouraged, since SGEF considers it to be potentially very useful.

4.10.6 Catch at age analysis

Catch at age analysis of elasmobranchs has so far only been based on length-converted age compositions, as there are no direct estimates of frequencies at age available from the landings.

A separable VPA may be used to explore the consistency of the catch-at-age matrix (however that is derived) and the sensitivity of the model to different assumptions of terminal F at age and terminal selection at the oldest true age. A separable VPA was explored for spurdog and lesser spotted dogfish.

When age-based information is available from surveys, a separable model of survey-only catches could be applied (Cook, 1997). This model assumes that F is separable into an age and year effect, and that the population size of a cohort at a given age can be expressed as the product of its initial cohort strength and its cumulative mortality. Assuming that age-disaggregated survey indices are related to abundance at age by age-dependent catchabilities, then the model estimates of these values can be fitted to the observations to obtain estimates of age, year and year-class effects. These parameters can then be used to obtain estimates of relative number at age, stock biomass and yield.

Results from initial runs of this model applied to lesser spotted dogfish with various values of q at the youngest age gave either unrealistically high selectivity for this age class or very low mean estimated F. A closer consideration of the survey indices indicated that the assumption of constant q at older ages may not be valid, as increasing numbers of individuals from the same year class were caught through time. This would explain the very low estimates of F obtained in these initial runs. Other assumptions about the relative catchabilities at age may, therefore, be more appropriate and these should be further explored.

4.10.7 General Linear Models (GLM) analysis

Although not formally listed as a 'stock assessment method', it was found that the application of GLM could provide a very useful insight into the development of some stocks. This method was mainly applied to the two ray species. In the example of thornback ray in the North Sea, GLM analysis enabled the modelling of CPUE indices from the IBTS survey. This gave insight in structure of the catches, first in terms of the number of hauls where thornback rays were caught, and second in the number of individuals in hauls where they were caught. This led to the conclusion that the number of successful hauls had decreased, but that the number of fish per successful haul was more or less constant. Further work in this direction is to be encouraged as survey data of relatively high quality and readily available.

4.10.8 Bayesian methods

The Bayesian methods, such as that applied to spurdog, are a general class of statistical methods that could be applied to evaluate the contribution of uncertainty in a wide range of input data (e.g. growth, CPUE, catch) on the stock assessment results. Although Bayesian analyses may take a long time to compute, there are also major advantages. The possibility to define prior distributions of parameters from comparable species or species groups, for example, allows the application of these methods even when estimates of certain parameters for the stock considered are not available.

4.11 Overall conclusions

The overall conclusions and expectations of SGEF regarding stock assessments of elasmobranch species are:

- Considerable progress has been made in making input data for stock assessment of elasmobranch species available. The application of several stock assessment models to the case study species proved to be fruitful and can direct future research in this areas.
- The SG expects that, in the near future, better documentation of the input data will be available and that a formalised exchange format for data will be implemented.
- The SG further expects that the consistency of different assessment models can be evaluated for most of the stocks considered. A major aim of the SG has been to explore different modelling approaches to the same data, so that the perception of the status of the stock can be confirmed (or shown to be false) from different models. Based on these analyses, it will be possible to identify the most suitable models for each stock.

ICES will be probably asked to provide advice on elasmobranchs from 2005 onwards. The SG considers that a lack of data is the main obstacle for achieving that objective. Therefore, the focus should continue to be on the collection of catch and effort data, survey data and biological data.

5 PROGRESS WITH PLANS FOR THE NAFO ELASMOBRANCH FISHERIES SYMPOSIUM IN 2002

In the Report of the Scientific Council Meeting, 31 May-14 June 2001, the NAFO Council noted that, during the Annual Meeting of NAFO in Santiago de Compostela, Spain, the Scientific Council Special Session, Symposium on Elasmobranch Fisheries: Managing for Sustainable Use and Biodiversity Conservation, will be held on 11-13 September 2002. This Symposium, in part, is intended to inform the preparation of Shark Assessment Reports and Plans of Action by countries and various regional management bodies around the world in response to FAO's International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks, where the term ‘shark’ includes all elasmobranchs). This has two main thrusts: the sustainable and rational use of targeted and by-catch species through responsible management, and conservation of biodiversity through management of by-catch.

The organiser, David Kulka (Canada's designated expert for elasmobranchs) and co-convenors Mike Pawson (ICES representative), Jack Musick (VIMS, USA) and Terry Walker (MFRI, Australia) have assembled a programme based on 63 oral and 23 poster abstracts that have been submitted from 49 institutions or companies in 19 countries. The Symposium will be opened by the Chair of Scientific Council, followed by an introduction by the convenors and by two invited speakers, covering elasmobranch management issues and biodiversity conservation. Programme themes will be covered within sequential sessions, as follows:

Life history and demographic analysis (number in brackets refers to number of papers)
 Life History (21)
 Demographic analysis (3)

Stock identity
 Distribution using various methods (3)
 Abundance survey (fishery independent) (11)
 Abundance (fishery dependent) (4)
 Genetic (2)
 Tagging (3)

Stock assessment
 Age-structured & modelling (3)
 Biomass dynamics/Catch-effort trend analysis (10)
 Fishery description/monitoring (8)
 Various methods (2)

Harvest strategies and biodiversity maintenance
 Harvest strategy evaluation through modelling (2)
 Gear selectivity (2)
 Finning issue (1)
By-catch (discards) evaluation (5)
By-catch management/fishery description (2)
 Ecosystem structure and function (6)

Contributors have been asked to provide a copy of their paper in Research Document format by 15th August. These documents will be posted on the NAFO web site. Subsequently, authors will be invited to submit a paper for publication in a special edition of the NAFO journal.

Since NAFO Symposia are considered as Special Sessions of the Scientific Council meeting, such aspects of the Symposium as costs of meeting space, IT and other equipment, announcements, flyers, communication with participants, and publication of Abstracts and resulting papers, are funded as part of the NAFO Annual meeting budget. A significant budget item that is not fully covered by NAFO is the support for "invited", "keynote" or speakers. Other sponsors for this Symposium include ICES and Fisheries and Oceans (Canada).

A major objective of DELASS was that research carried out within the project would be published through this Symposium, and papers arising from the DELASS partners that will be presented in Santiago de tela include:

Life history and demographic analysis

The distribution of chondrichthyan fishes around the British Isles and their conservation status. J. R. Ellis, B. B. Rackham and S. I Rogers (CEFAS).

Growth estimates of the lesser spotted dogfish (Scyliorhinus Canicula) in the Cantabrian Sea. C. Rodriguez-Cabello and F. Sánchez (IEO – poster).

Distribution and biological aspects of deep-water sharks in NNE and Central Atlantic. P. D. Muñoz & E. Román (IPIMAR).

Distribution and Biology of Portuguese Dogfish (*Centroscymnus coelolepis*) and Leaf-scale Gulper Shark (*Centrophorus squamosus*) at Hatton Bank and The Mid-Atlantic Ridge (33°-61°N). N-R. Hareide, G. Garnes, G. Langedal and J. E Dyb (Norway).

Growth estimates of lesser spotted dogfish (*Scyliorhinus canicula*) in the Cantabrian Sea. C. Rodriguez-Cabello and F. Sanchez (IEO).

Stock identity

Stock identity of elasmobranchs in the NE Atlantic in relation to assessment and management. M. G. Pawson and J. R. Ellis. (CEFAS).

Stock assessment

DELASS Development of Elasmobranch Assessments. H. Heessen (RIVO - poster).

Stock assessment of elasmobranchs in the NE Atlantic: making most of the data. M. Pastoors (RIVO).

Bayesian assessment of NE Atlantic spurdog using a stock production model, with prior for intrinsic rate of increase set by demographic methods. T. R. Hammond, C. Darby, J. R Ellis and M. G. Pawson (CEFAS).

Finding trends in the fishery and abundance of kitefin shark, *Dalatias Licha* (Bonaterre, 1788), from off Azores through a GIS spatial analysis. P. B. Machado (IPIMAR).

Approaches to the assessment of deep-water sharks in the NE Atlantic. M. W. Clarke, M. Girard, P. Lorance and R. Officer (MI & IFREMER).

First approach to the application of life table models to the Potuguese dogfish (*Centroscymnus coelolepsis*). L. Carvalho, M. Quaresma and I. Figueiredo (FFCUL & IPIMAR).

Approaches to the assessment of deep-water sharks in the NE Atlantic. M.W Clarke, M. Girard, P. Lorance and R. Officer (MI & IFREMER).

Harvest strategies and biodiversity maintenance

The by-catch of rays in the Dutch flatfish fisheries. H.J. L. Heessen (RIVO - poster).

Comparisons of trawl and long-line catches of deep-water elasmobranchs west and north of Ireland. M. Clarke, R. Officer, D. Stokes and P. Connolly (MI).

Deep-water elasmobranchs and the commercial fishery to the west of the British Isles: a current review. P. Crozier, J.D.M. Gordon, and P. Vas (SAMS).

Deep-water sharks fisheries from off the Portuguese continental coast. I. Figueiredo, L. S. Gordo and P. B. Machado IPIMAR & FFCUL).

Description of an experimental artisanal fishery targeting blue shark in the Bay of Biscay, 1998-2000. P. Lucio, V.Ortiz de Zarate, G. Diez, C. Rodriguez-Cabello and M. Santurtun (AZTI & IEO).

The role of elasmobranchs in the Cantabrian Sea shelf ecosystem and the impact of fisheries on them. F. Sanchez, C. Rodriguez-Cabello and I. Olaso (IEO).

Trophic relations of lesser spotted dogfish (*Scyliorhinus canicula*) and blackmouth catshark (*Galeus melastomus*) in the benthic and demersal communities of the Cantabrian Sea. I. Olaso, F. Valesco, F. Sanchez, A. serrano, C. Rodriguez-Cabello and O. Cendrero (IEO).

Overview of continental shelf elasmobranch fisheries in the Cantabrian Sea. A. Fernandez, R. Gancedo, A. Punzon, C. Rodriguez-Cabello I. Olaso, F. Sanchez, and O. Cendrero (IEO - poster).

6 EVALUATION OF THE QUALITY AND SUITABILITY OF DATA FOR THE LISTING OF THREATENED AND DECLINING ELASMOBRANCHS BY OSPAR

6.1 Background

The OSPAR Biodiversity Committee agreed in November 2001 that a list of threatened and endangered species and habitats should be developed for approval by the committee at its meeting in late 2002/early 2003. This list must be supported by a justification of how and why the species and habitats were selected, and the Biodiversity Committee noted that Quality Assurance of the data used in identifying threatened species/habitats is very important. Hence, the OSPAR commission has requested that ICES contribute to the peer-review process.

The draft OSPAR Priority List of Threatened and Endangered Species and Habitats currently contains 29 species and habitats identified as of concern across the whole of the OSPAR maritime area, and 10 identified as of concern in one or more of the five OSPAR sub-regions. These sub-regions are I-Arctic; II-North Sea; III-Celtic Seas; IV-Bay of Biscay and Iberian waters and V-Wider Atlantic. The criteria that are used in identifying species in need of protection/conservation are (i) global importance, (ii) local importance, (iii) rare, (iv) sensitive, (v) keystone species and (vi) decline. Overall, 12 elasmobranch species were proposed by member states (Table 6.1).

6.2 SGEF response

SGEF has examined these proposed listings and made the following comment as to whether or not they fulfil the OSPAR Criteria.

6.2.1 Basking shark (*Cetorhinus maximus*)

Basking shark was nominated by four parties (WWF, JNCC, DEFRA and Portugal), with some minor inconsistencies in the application of the OSPAR criteria. Basking sharks are circum-global (although it is not known whether populations in, for example the NE and NW Atlantic, are genetically distinct) and so the OSPAR region is not globally important for this species (WWF stated it was). Two proposals (Portugal, WWF) stated basking shark were rare, the other two nominations (DEFRA, JNCC) said they were not.

The Portuguese nomination said they were locally important, other nominations said they were not. They are known to congregate in areas with a high zooplankton biomass (e.g. fronts) and, therefore, may be locally important, but the locations of these areas are variable. All nominations stated that they were either sensitive or very sensitive. Biological data are limited, although all lamniform sharks have a very low fecundity and late age at maturity and they are likely to be sensitive to additional mortality.

The Portuguese nomination stated that there was a high probability of decline, with the other nominations stating that there was a significant decline. Most documented declines arise from the interpretation of landings data from localised fisheries targeting basking shark (Gubbay, 2001, p10). Without CPUE data, however, changes in commercial landings can be a poor estimator of abundance/stock size. There are insufficient fishery-independent data sets that provide evidence in basking shark numbers over the OSPAR area. The observed declines in these fisheries could be due to various factors (e.g. local depletion of the fishable population, a change in basking shark distribution or economic factors). Indeed, recent studies have highlighted the important role that oceanographic conditions can play in affecting basking shark distribution. Similarly, increases in availability of squalene-rich liver oil from deep-sea sharks could also be an important reason for declines in the basking shark fishery. The proposals did not consider trends in the market value of liver oil.

There are currently no targeted fisheries for basking sharks in the OSPAR region, and today only incidental by-catch and sea traffic collisions are possible contributors to mortality. Furthermore, little is known about global stock structure of this species and there are no assessment data. An ongoing UK study using archival pop-up tags will provide information on the scale of movements of individual sharks. SGEF considered that the supporting evidence did not represent the data available, with many important scientific publications uncited.

In summary, SGEF considered the evidence provided to be insufficient to evaluate whether or not there have been severe declines in basking shark. The group also noted that local populations (if such exist) would be very sensitive to targeted fisheries.

6.2.2 Common skate (*Dipturus* (formerly *Raja*) *batis*)

Three parties proposed common skate for listing (JNCC, The Netherlands and Belgium). Two nominations stated that it was not locally important, whereas JNCC stated it was. Common skate are widely distributed along the shelf edge and in deeper waters, and it is possible that areas of local importance may refer to localised refuge populations in, for example, Scottish sea lochs. All nominations considered them rare and (very) sensitive. Evidence for significant declines in both catches and spatial distribution in the North Sea and Irish Sea is strong. SGEF were concerned that that report (Gubbay, 2001 p10) highlighted Belgian waters, as this downweights the documented decreases in the more extensive areas that are representative of OSPAR areas II and III. French fisheries still catch common skate (400 t in 2000) in the deeper parts of Sub-areas VI and VII, and they have recently been recorded from the Mid-Atlantic ridge. Gubbay (2001, p10) stated that the depth range of common skate was 90-220m, but they have been taken from as deep as 1000m. This could mean that part of the stock population in the deeper waters of the Atlantic has been subject to deep-water fisheries since 1990. There was little information about the species' status in the Bay of Biscay/Iberian coast, although market sampling indicates that common skate account for <2% of commercial ray landings at Basque country ports (Divisions VIII a,b,d). Hence, although it has declined in inshore waters, there is uncertainty in the status of offshore populations, and the proportion of the overall species range that has been affected.

SGEF considered that the evidence supplied showed that common skate were sensitive to fishing impacts and had severely declined in shelf waters in the OSPAR area. The group also noted that the fisheries operating on the edge of the continental shelf and continental slope could result in similar impacts as had been recorded in the North Sea and Irish Sea.

6.2.3 Angel shark (*Squatina squatina*)

Two parties (JNCC and Belgium) proposed angel shark as it was considered (very) sensitive and that there were anecdotal observations and catch data indicating significant declines. SGEF considered that citing low abundance in the southern North Sea, and highlighting Belgian waters (Gubbay, 2001 p20), was of little value, as this could be towards the northern limits of this species' natural distribution. Nevertheless, there are data to indicate declines in the western English Channel and Irish Sea. SGEF also considered there to be a high probability of significant declines elsewhere. For example, angel shark are now rarely landed in France and Spanish landings ceased in the 1960s, although there is little numerical data to support this view. SGEF felt that there is strong anecdotal evidence that this sensitive species has severely declined in the shelf waters of the OSPAR area.

6.2.4 White skate (*Rostroraja* (formerly *Raja*) *alba*)

Portugal proposed white skate in Iberian coastal waters as it was locally important, rare, sensitive and with a high probability of population decline. There was no data on its current status (Gubbay, 2001 p30), which is not surprising given its apparent rarity. The nomination did not supply any evidence indicating white skate were locally important. Nevertheless, SGEF considered that there was a high probability of population decline, both in the Bay of Biscay and Iberian coast, and in the Celtic Seas. For example, there was a directed long-line fishery in Douarnanez (Brittany) in the 1960's that collapsed (white skate are no longer listed on French fishery statistics), and a similar decline is thought to have occurred in the Irish Sea.

6.2.5 North Sea species

Thornback ray (*Raja clavata*) in the North Sea was nominated by The Netherlands and Belgium. It was stated that it was not locally important in the wider OSPAR region, although it was suggested that it might be considered locally important in the North Sea. It was listed as sensitive and to have declined severely (Gubbay, 2001 p19). SGEF considered there to be strong evidence of a severe decline in the south-eastern North Sea (e.g. it was common in Dutch waters up to the 1940s and is now very rare). Elsewhere in the North Sea, it had declined since the 1960s and its distribution has receded, and it is now most common in the south-west North Sea (from the Thames Estuary to The Wash). This also explains the perception of 'local importance'. SGEF considered the data used in this nomination to be sufficiently reliable for the North Sea and this is one of the elasmobranch stocks currently being assessed within DELASS. It was noted that thornback ray is still one of the dominant rajids in the English Channel and Irish Sea.

Belgium proposed **spurdog** (*Squalus acanthias*) in the North Sea on the basis that it is a sensitive species and had declined significantly in their national waters (Gubbay, 2001 p20). The distribution in the North Sea has moved west and there is evidence of a decline (although no data were included in the Belgian proposal). Nevertheless, spurdog remain an important fishery resource in the North Sea and migration patterns are known to change over time, which might explain changes in distribution and relative abundance. Assessments for spurdog within DELASS will address this concern. SGEF considered the data used in this nomination to be insufficiently reliable and noted that the spurdog is not extirpated from the North Sea (mean landings for the 1990's were approximately 6,000 $t.yr^{-1}$).

Belgium proposed **stingray** (*Dasyatis pastinaca*) in the North Sea on the basis that it is sensitive and has declined (Gubbay, 2001 p17). SGEF considered that there was reasonably strong evidence for a decline in stingray in the North Sea, although, once again, highlighting Belgian coastal waters is of dubious benefit. Stingray is a more southerly species and, as with the angel shark, the absence from northern limits should not be used to gauge population trends over the OSPAR area as a whole. Data on population trends from more southerly areas are lacking.

Belgium also proposed **spotted ray** (*Raja montagui*) and **lesser-spotted dogfish** (*Scyliorhinus canicula*) in the North Sea on the basis that they were sensitive and had declined severely in Belgian waters (Gubbay, 2001 p19). Whilst they may have declined off Belgium, both species are frequently caught in the western areas of the North Sea where there is no evidence of a decline. Surveys from parts of other OSPAR regions also indicate that these species are not declining. SGEF considered the data used in this nomination to be insufficiently reliable.

6.2.6 Sharks in the wider Atlantic

The Azores proposed **tope** (*Galeorhinus galeus*), **blue shark** (*Prionace glauca*) and **porbeagle** (*Lamna nasus*). These species were stated to be sensitive, keystone species which had declined significantly (Gubbay, 2001 p35). SGEF considered that tope and blue shark could be regarded as sensitive and porbeagle, due to its very low fecundity, very sensitive. Nevertheless, these species were not considered keystone species and, though the evidence supporting significant declines was not robust, it is known that landings of porbeagle in the OSPAR area and NW Atlantic had declined. Furthermore, tope is primarily a coastal species (the proposal stated that they preferred water <200m deep), and so attempts to list them in the offshore waters of the wider Atlantic is inappropriate. The proposal suggested that tope around the Azores were probably "isolated and (genetically) distinct", although no evidence is provided to support this. SGEF considered the data used in these nominations to be insufficiently reliable.

Table 6.1: Elasmobranchs species and their conservation status as nominated by member states:

Species	Proposed by	Area	Rationale
Basking shark ***CETORHINUS MAXIMUS***	WWF, JNCC, DEFRA	OSPAR maritime area	Very sensitive, severely declined
Common skate ***DIPTURUS BATIS***	JNCC, The Netherlands, Belgium	OSPAR maritime area	Regional importance, rare, very sensitive, severely declined
Angel shark ***SQUATINA SQUATINA***	JNCC, Belgium	OSPAR maritime area	Very sensitive, severely declined
Stingray ***DASYATIS PASTINACEA***	Belgium	North Sea	Rare, sensitive, severely declined
Thornback ray ***RAJA CLAVATA***	The Netherlands, Belgium	North Sea	Rare, sensitive, severely declined
Spotted ray ***RAJA MONTAGUI***	Belgium	North Sea	Rare, sensitive, severely declined
Lesser-spotted dogfish ***SCYLIORHINUS CANICULA***	Belgium	North Sea	Rare, sensitive, severely declined
Spurdog ***SQUALUS ACANTHIAS***	Belgium	North Sea	Rare, sensitive, extirpated
White skate ***ROSTRORAJA ALBA***	Portugal	Bay of Biscay and Iberian coast	Locally important, rare, sensitive, probability of significant decline
Tope ***GALEORHINUS GALEUS***	Azores	Wider Atlantic	Very sensitive, keystone species, severely declined
Porbeagle ***LAMNA NASUS***	Azores	Wider Atlantic	Very sensitive, keystone species, severely declined
Blue shark ***PRIONACE GLAUCA***	WWF, Azores	Wider Atlantic	(very) Sensitive, keystone species, severely declined

7 RECOMMENDATIONS

7.1 Future of elasmobranch work within ICES

ICES is required by the EU to provide advice on specific elasmobranch stocks by 2005 (Bergen IMM, 1997), but has only once previously included such advice (on rays and skates in the North Sea), in the 1997 ACFM report (ICES, 1998). This advice was based on fishery and survey data and an evaluation of the relative vulnerability of five rajid species based on life history characteristics presented by SGEF (ICES, CM1997/G:2). There have been no analytical assessments of elasmobranch stocks in the ICES Area, and the SGEF has used the EU-funded DELASS project to compile data and develop appropriate stock assessment methodologies. DELASS ends in December 2002, and it is important that an assessment working group is set up to ensure that the progress being made under this initiative is continued and built upon. There are a number of related issues that need to be taken into consideration:

- Most importantly, that elasmobranch stock assessments often require a considerable input of biological information. Therefore, the group must have competence in this scientific discipline, and SGEF recommends that member countries of ICES give a priority to the collection of such information.
- Management advice for elasmobranch species is likely to be required in relation to biodiversity and nature conservation issues in addition to the sustainability of fisheries (the two are linked), and this justifies retaining the group under the Living Resources Committee.
- The DELASS project has compiled a biological and fisheries database for NE Atlantic elasmobranch species, which is available to ICES. Continued collection of biological and fisheries data in the ICES area will require co-ordinated international sampling schemes, both within the EU (e.g. through the Data Collection Regulation) and for assessing straddling and highly migratory.
- It is important that this group maintains its close communication with WGDEEP on its work with deep-water sharks, and with ICCAT on blue shark and other pelagic shark assessments.

Consequently, SGEF recommends that this Study Group should be continued as a Working Group. The medium-term remit of this WG will be to adopt and extend the methodologies and assessments for elasmobranchs prepared by the EU-funded DELASS project; to review and define data requirements (fishery, survey and biological parameters) in relation to the needs of these analytical models and stock identity; and to carry out such assessments as are required by ICES' customers.

In 2003, the first meeting of this group should review the final DELASS report, consider national and international sampling schemes, including those carried out under the EU Data Collection Regulation, and report to PGCCDBS, and make arrangements to carry out assessments for such elasmobranch stocks as are required by ICES' customers.

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