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Report of the Benchmark Workshop on Deep-water Species (WKDEEP)

17–24 February 2010

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ICES
International Council for the Exploration of the Sea
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Contents

1 Executive Summary

The WKDEEP 2010 Benchmark Workshop was held at the ICES secretariat, Copenhagen from February 17–24 2010. The Workshop was chaired by Richard Hillary (Australia.), with support from ICES Coordinators Tom Blasdale (UK) and Phil Large (UK), and involved 24 participants. The primary objectives of the Workshop were to evaluate the appropriateness of the data and methods available for the following stocks: greater forkbeard in the Northeast Atlantic, tusk in Division Va, deep-water squaliform sharks in the Northeast Atlantic, red (blackspot) sea bream in Subarea X, greater silver smelt in the Northeast Atlantic, and roundnose grenadier in Division Vb and Subareas VI and VII; and also to discuss possible improvements on the assessment methodologies. The Stock Annexes are the most important product of this process, with each annex containing all relevant information that the Benchmark Workshop participants have identified as current best practice assessment inputs and models, providing sufficient detail to ensure that future assessment scientists can readily identified the basis for advice.

The WKDEEP came to following conclusions:

Benchmarking stocks that are mostly data poor (in the stock assessment sense) or do not as yet possess an existing stock assessment was a difficult task. The Group recommends that in future such benchmark meetings only three stocks are considered, to afford the group more time to perform a more in-depth review of the data, methods and their application. The Group was of the view that the templates provided (benchmark report and stock annex) and the protocol for completing them should take account of the problems specific to benchmarking data poor stocks.

Across all stocks several key issues require attention:

- *Historical catch, landings and effort data:* discarding and in some cases misreporting have been an issue in the past. Reliable commercial data are key to most stock assessments and to the understanding of the current status of the stock, relative to the past. It is strongly recommended that working to obtain both a reliable set of historical commercial data and the future collection of reliable commercial data is done.
- *Fishery-independent data:* Surveys provide a cost-effective way of obtaining information for use in stock assessment. Given many of the species are caught as bycatch the interpretation of commercial data in the assessment sense can be difficult. Existing surveys are strongly encouraged to continue and wherever possible work should be done to ensure these surveys cover as much of the life history and commercial exploitation range of the stocks as possible. Any future surveys are also strongly encouraged.
- *Stock identity:* clearly an issue for many of the stocks and a stock identity working group is recommended to address these problems using the variety of techniques available such as (physical and biological) oceanography, morphometrics and migration, genetics and bioregionalisation.
- *Harvest strategies for data-poor stocks:* for at least three of the stocks trends in indicators derived directly from survey information formed the basis for the stock assessment. While outside the mandate of the Benchmark the relevant ICES work and study groups are recommended to explore the issue given many of the stocks are unlikely to have the data available for an analytical stock assessment in the short to medium term.

Roundnose grenadier in Vb,VI,VII and XIIb

The following three methods and underpinning data were benchmarked:

A FLR-based Bayesian surplus production model (based on Pella Tomlinson biomass dynamic model) with agreed initial parameters for age of maturity, longevity, priors for Q and K and r and sigma shape and rate values. The abundance index used was the French trawl tallybook index supplied by French fishers. It was note that confidence limits around estimated around results (K, biomass estimates, r, etc) were wide and it was recommended that the results only be interpreted as indicative of trends. Estimates of MSY were considered to be poorly estimated.

Multiyear Catch Curve (MYCC model developed as part of the EU-DEEPFISHMAN project. Input data were age distribution of the French trawl landings and catch (landings and discards) data per year. Results for Z should be interpreted as indicative of trends only.

Biological indicators such as trends in mean length, ratio of mature/immature should be used to provide information on the state of stocks. Information from length distribution of landings and discards in addition to information on fishing depths were identified as useful indicators of trends in the fishery and in the population structures.

Lpues data based upon French tallybook data should be used as indicators of trends in abundance. Catch rates from surveys, where available, should be used to check the consistency of the analysis on the commercial cpues.

WKDEEP recommends that:- (i) roundnose grenadier effort data should be provided by all involved countries. *Coryphaenoides* sp. species, are frequently misidentified; (ii) that only observers with an experience in the identification of species of grenadier should be sent aboard fishing vessels catching species of grenadier; (iii) that some exercises be made to evaluate between observers (or for the same person) the quality of pre-anal fin length measurement, because the quality of pre anal fin length measurement is unknown; and (iv) that some trips should include full measurement of length of the catches and that because the length distribution of the stock per depth is poorly known, the depth of the haul should be reported.

Greater Silver smelt in all areas

For Division Va, greater silver smelt should be assessed based on trends in survey biomass indices (standard un-winsorized and winsorized) from the Icelandic Autumn survey and changes in age distributions from commercial catches and surveys. Supplementary data used should include relevant information from the fishery and surveys, such as changes in spatial (geographical and depth range) and temporal distribution, length distributions and maturity ogives.

For other areas: For Division Vb, trends in stock biomass should be evaluated using abundance indices derived from the Faroese summer survey and from trends in mean length for the mature and immature greater silver smelt from the spring- and summer surveys for cod, haddock and saithe. For Subarea VII, biomass indices and length frequencies from the Spanish Porcupine survey should be evaluated.

WKDEEP recommends that a large-scale study on greater silver smelt stock identity be implemented. An age calibration exercise (otolith exchanges and workshops) is also needed, between the national institutes that are reading greater silver smelt otoliths.

Tusk in Va

A Gadget model was accepted as indicative of stock trends. The data used were length disaggregated survey indices from the March Icelandic groundfish survey, length distribution data from the Icelandic commercial catches, and age–length keys and mean length-at-age from the Icelandic commercial fishery.

Red (blackspot) sea bream in Subarea X

This stock should be assessed based on trends in the mean length of mature and immature from the Azorean longline survey using the entire survey area and also individual survey statistical areas, and trends in abundance in survey and standardize commercial cpue series. The data to be used are Azorean longline survey abundance indices and length compositions and standardized commercial cpue.

WKDEEP recommends a small-scale otolith exchange between the two institutes that are currently ageing this species (DOP- Portugal and EIO- Cadiz, Spain). A workshop on maturity staging of hermaphrodite species (or on red blackspot sea bream in particular) should be held.

Greater forkbeard in all areas

Survey based population indicators of greater forkbeard should be calculated from all relevant surveys. The recommended indicators are: abundance, log abundance, mean length, quantiles of mean length, biomass, per strata and for the whole survey. Interpretation of trends by survey and strata should be used to define the overall trend in areas where greater forkbeard is caught.

The surveys to be used are: the Spanish IBTS in the Cantabrian sea (Division VIIIb), French western IBTS survey (EVHOE) in the Bay of Biscay (VIIIab and Celtic Sea (VIIf,g,h,j), Spanish survey on the Porcupine Bank, Irish bottom-trawl survey and Scottish IBTS in VIa.

There is a problem in the species-specific identification of landings. Landing tables could include significant landings of *Phycis* spp, *Urophycis* spp species. WKDEEP recommends the edition of a guide and training of observers in the identification of the most common *Phycis* species.

Few countries supply discard data and WKDEEP recommends an increase in the number discard samplings (% of trips covered by observers) on commercial vessels.

Deep-water squaliform sharks in all areas

For the leaf-scale gulper shark and the Portuguese dogfish a combination of standardized Portuguese cpue, French lpue and presence/absence in the depth-aggregated Scottish and Irish surveys were recommended for the purposes of assessment. Members of the Group made considerable progress during the meeting in terms of the robust construction of a plausible catch and effort history for both species. A novel approach to assessing such species as deep-water sharks was presented at the meeting using a subset of the data on Portuguese dogfish and was agreed by WKDEEP to be a highly promising approach, pending the acceptable reconstruction of the aforementioned catch and effort data, and its further development and possible future application is to be strongly encouraged.

Taxonomic problems on the identification of species include in the *Centrophoridae* family particularly those occurring at NE Atlantic (e.g. *C. granulosus*, *C. lusitanicus*).

WKDEEP recommends studies to improve deep-water sharks identifications, namely by means of genetic approach.

Some tentatives were already essayed to age *C. squamosus* and *C. coelolepis* and others are now being tried. Most of the approaches rely on dorsal spine analyses. WKDEEP recommends that a collaborative work between labs needs to be done to: i) critically revise the procedures adopted as well as the results data ii) propose a standardization of methods and methods to assigned ages.

2 Introduction

The requirements for benchmark workshops were detailed by ACOM in 2008 (ACOM December 2008 22/12/2008 FINAL document). Terms of Reference for the Benchmark Workshop on Deep Water Species (WKDEEP 2010) is available at (Annex 2). The key aspects of the Terms of Reference are:

- to compile and evaluate data sources for stock assessments,
- to solicit relevant data from industry and other stakeholders, and to update the relevant Stock Annexes to include what benchmark participants identify as current best practice assessment inputs and methods, providing sufficient detail to ensure that assessment scientists can readily replicate assessments without the need to have been previously involved in such assessments.

Single stock assessment case studies are also being carried out in a new EU Project, DEEPFISHMAN, which commenced in April 2009 and will complete in 2012. The aim of DEEPFISHMAN is to develop a monitoring, assessment and ecosystem-based management framework for deep-water stocks in the NE Atlantic. The project includes a dedicated work package to develop new assessment methods and to trial assessment methods used on deep-water stocks elsewhere in the world and on other species. This work will be carried out on a wide range of case study stocks including blue ling, redfish, orange roughy, red (blackspot) sea bream and black scabbard fish in the NE Atlantic.

From a single-stock assessment perspective, WGDEEP recommended that, to maximize overall stock coverage, the Benchmark meeting should exclude those stocks to be studied in DEEPFISHMAN. This was agreed by ICES. Notwithstanding, the Benchmark candidate stocks addressed below reflect a wide range of likely assessment problems (largely driven by differences in biology, species distribution and fishery types) and data availability.

The first days of this Benchmark were devoted to background presentations of each stock focusing on biology, life history, ecology, history of the fishery, history of past assessments methodologies and data used. The following days were then focused on resolving the assessment issues to the extent possible, with a view to revising the Stock Annexes for adoption for the following years and to set recommendations for future work. The detailed Agenda is available at Annex 2.

The Workshop was chaired by Richard Hillary (Australia). Malcolm Clark (New Zealand) and Jerald Ault (USA) were invited experts. Tom Blasdale (UK) and Phil Large (UK) were the ICES Coordinators. Other participants included members of the WGDEEP and WGEF ICES Expert Groups, and industry representatives. A full list of participants is provided in Annex 1. A numbered list of Working Documents considered by the WK, and subsequently archived by ICES, is given in Section 13.

3 Greater forkbeard (*Phycis blennoides*) in the Northeast Atlantic

3.1 Current stock status and assessment issues

According to the ICES Advice for 2009 and 2010 (the same as the Advice given in 2006): Fisheries on greater forkbeard should be accompanied by programmes to collect data. The fishery should not be allowed to expand unless it can be demonstrated that it is sustainable.

ICES has to date assumed a single-stock unit for Greater forkbeard.

No assessment was required for this stock before. Although WKDEEP agreed to carry out the assessment in a Single Assessment Unit corresponding to the Subareas VI, VII and VIII.

Taken into account these considerations and the quality of data available the coordinators of Greater forkbeard proposed the use of a modification of the Stock Depletion Model (SDM) developed by Roa-Ureta and Arkhipkin (2007). This model has been previously used to assess the stocks of squids and *Macruronus magellanicus* in Falklands Islands and Pacific Chilean waters respectively and is especially useful without length composition stratified data.

3.2 Compilation of available data

3.2.1 Catch and landings data

Fishery data and biological information are quite limited for this species. The most abundant and best quality of data, (specially the historical series of effort by statistical rectangle, and discards) belongs to the Spanish (Basque Country) fleet in Subareas VI, VII and VIII. Few countries supply discard data to the WG, and the area covered by discard data available (VI, VII and VIII) is much smaller than the area of stocks defined in the WGDEEP. For the rest of subareas only basic information of annual landings were available.

Historically the species-specific identification of *P. blennoides* in landings reported to the WGDEEP has been a problem. Therefore annual landings in subarea VIII could include significant landings of *Phycis* spp, *Urophycis* spp species. However, the use in the model of the data of the Basque Country trawler fleet avoided this problem because the landings of this fleet are well identified for this species. The time-series of official landings collected by WGDEEP (2009) is shown in Table 1.

Discard rates for French fleets were computed (Table 2). Because catches of greater forkbeard are small compared with other species, estimates of discards might have large confidence intervals. Nevertheless, these discards are probably significant with respect to the size of the greater forkbeard population. For some shelf métiers discards are high compared with landings (Table 2).

Table 1. Working Group estimates of greater forkbeard (*Phycis blennoides*) landings (tonnes).

GREATER FORKBEARD (PHYCIS BLENNOIDES) ALL ICES SUBAREAS								
Year	I+II	III+IV	Vb	VI+VII	VIII+IX	X	XII	TOTAL
1988	0	15	2	1898	81	29	0	2025
1989	0	12	1	1815	145	42	0	2015
1990	23	115	38	1921	234	50	0	2381
1991	39	181	53	1574	130	68	0	2045
1992	33	145	49	1640	179	91	1	2138
1993	1	34	27	1462	395	115	1	2035
1994	0	12	4	1571	320	136	3	2046
1995	0	3	9	2138	384	71	4	2609
1996	0	18	7	3590	456	45	2	4118
1997	0	7	7	2335	361	30	2	2742
1998	0	12	8	3040	665	38	1	3764
1999	0	31	34	3455	379	41	0	3940
2000	0	11	32	4967	417	91	6	5524
2001	8	27	102	4405	497	83	8	5131
2002	318	585	149	3417	493	57	79	5098
2003	155	233	73	3287	427	45	153	4373
2004	75	143	50	2606	500	37	43	3454
2005	51	83	46	2290	384	22	61	2937
2006	49	139	39	2081	321	15	0	2644
2007	47	239	56	1995	586	17	0	2940
2008	116	245	41	1281	172	18	0	1874

Table 2. Landings and discards by French métiers in Subareas VI, VII and VIII.

Subarea VI

DCF MÉTIER	OTB_DEF	OTB_DWS	OTT_DEF	OTT_DWS
Métier names	Otter trawl, demersal fish	Otter trawl, deep-water fish	Midwater trawl, demersal fish	Twin trawl for deep-water fish
GFB landings (kg) (1)	8196	13 899	2645	62
GFB discards (kg) (1)	1516	3617	57	0
GFB landings (t) (2)	142	128	0	
GFB raised discards (t) (3)	24	27	4	0

Subarea VII

DCF MÉTIER	GTR_DEF	OTB_CRU	OTB_DEF	OTT_CRU	OTT_DEF
Métier names	Trammelnet for demersal species	Otter trawl, nephrops	Otter trawl demersal fish	Twin trawl, nephrops	Twin trawl, demersal fish
GFB landings(kg) (1)	0	59	62	4975	2332
GFB discards (kg) (1)	0	271	120	4265	1385
GFB landings (t) (2)	0	2	11	4	7
GFB raised discards (t) (3)	0	7	4	74	16

Subarea VIII

DCF MÉTIER	GNS-DEF	GTR_DEF	OTB_DEF	OTT_CRU	OTT_DEF
Métier names	Gillnet, demersal fish	Trammelnet, demersal fish	Otter trawl, demersal fish	Twin trawl, nephrops	Twin trawl for demersal fish
GFB landings(kg) (1)	0	0	6	160	332
GFB discards (kg) (1)	0	0	82	739	552
GFB landings (t) (2)	0	0	8	6	9
GFB raised discards (t) (3)	0	0	13	45	25

(1) from on-board observations; (2) from landings statistics; (3) observed discards raised to total landings.

3.2.2 Biological data

The members of the WKDEEP agreed that the biology of the species is poorly known. In general most of biological data are not reliable or not available (e.g. age composition, maturity, growth, natural mortality…). In this sense the spawning areas and seasonality are also not well (or at all) identified. Only the historical series of length frequencies from Porcupine survey were available (Figure 1).

Survey data demonstrates the existence of an ontogenic migration with juveniles and especially age group 1 occurring on the shelf and larger/older fish on the upper slope (Figures 1–10). The very clear peak, in length distribution from surveys, at 15–20 cm depending on the time of surveys allow for the recruitment-at-age 1 to be separated from the rest of the population. Survey data also allows identifying some nurseries such as the Celtic Sea, south of Ireland (Figures 5, 6 and 9).

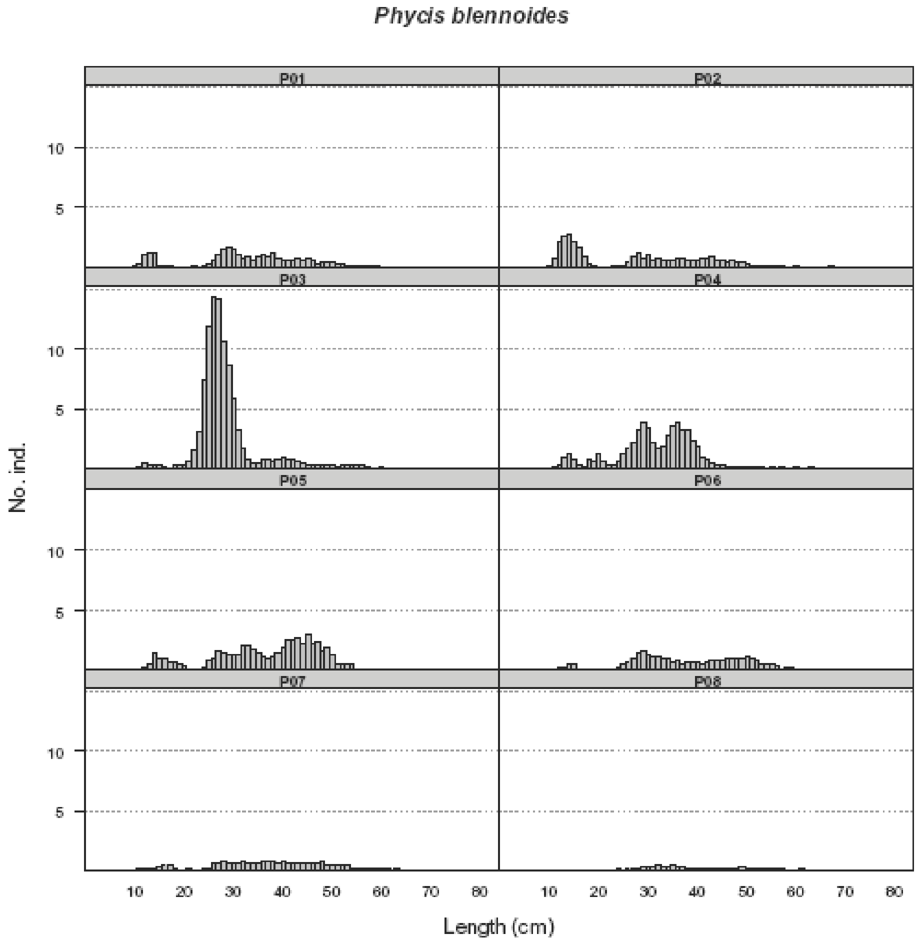

Figure 1. Mean stratified length distributions of greater forkbeard (*Phycis blennoides)* in Porcupine surveys (2001–2008).

In the Tables 3 and 4 a compilation of biological available data is demonstrate. (WGDEEP 2001 (ICES C.M. 2001/ACFM: 23; Lorance 2010).

Table 3. Life-history characteristics of Greater forkbeard (from WGDEEP 2001 (ICES C.M. 2001/ACFM: 23; Lorance 2010).

LHC	Sex	Estimate	Area (month)	Reference
Maximum observed length (TL, cm)	Combined	50	VIIIc and IXa	Sanchez *et al*., 1995
	Female	84	VIIIc and IXa	Casas and Piñeiro, 2000
	male	44	VIIIc and IXa	Casas and Piñeiro, 2000
Maximum observed age (year)	Female	14	VIIIc and IXa	Casas and Piñeiro, 2000
	male	6	VIIIc and IXa	Casas and Piñeiro, 2000
	combined	20	Atlantic	Cohen *et al*., 1990
	Female	9	NE Atlantic	Kelly, 1997
	male	7		
	combined	15	NE Atlantic	EC FAIR, 1999, Sub-t. 5.12, Doc.55
Length at 50% maturity (PAFL, cm)	Female	33 cm	NE Atlantic and Med.	Cohen *et al*., 1990(1,2)
	Male	18 cm		Cohen *et al*., 1990(1,2)
	Female	32 cm	NE Atlantic and Med.	Kelly, 1997
	Male	31 cm	NE Atlantic	
Age at 50% maturity (year)	Combined	3–4 yrs	Mediterranean sea	Muus and Nielsen, 1999
Length of smallest individuals caught (TL)	Combined	6 cm	VIIIc and IXa	Casas and Piñeiro, 2000
		8cm	VIIIa,b,d (Oct.–Nov.)	Data from French western IBTS
		8 cm	VIIg–k (Oct.–Nov.)	Data from French western IBTS
Age of youngest individuals caught (year)	Combined	< 1yr	VIIIc and Ixa	Casas and Piñeiro, 2000
Length of the first mode of the length distribution	Combined	13.9 cm	VIIIc, IXa (April)	Casas and Piñeiro, 2000
		16.9 cm	VIIIc, IXa (Sept.)	Casas and Piñeiro, 2000
		17.4 cm	VIIIc, IXa (Oct.)	Casas and Piñeiro, 2000
		16 cm	VIIIa,b,d (Oct.–Nov.)	Data from French western IBTS
		16 cm	VIIg–k(Oct.–Nov.)	Data from French western IBTS

Unclear whether it is mean length at first maturity or length of smallest mature individual.

Table 4. Growth parameters of greater forkbeard. (from WGDEEP 2001 (ICES C.M. 2001/ACFM: 23; Lorance 2010).

Sex	L∞	K	T0	Area	Reference
Male	41.7	0.208	N/A	Gulf of Lions (Med.)	Nony, 1983 (from Fishbase)
Female	51.2	0.258	N/A	Gulf of Lions (Med.)	Nony, 1983 (from Fishbase)
Combined	57.7	0.168	-0.66	Aegean sea (Med.)	Papaconstantinou *et al*., 1993
Male	54.9	0.217	-0.663	VIIIc and IXa	Casas and Piñeiro, 2000
Female	113.3	0.0886	-0.556	VIIIc and IXa	Casas and Piñeiro, 2000

3.2.3 Survey data

Data of abundance of *P. blennoides* and area covered by hauls from the Spanish Porcupine survey (ICES Divisions VIIc and VIIk) from 2001 to 2008 has been used in the assessment. Biomass of this species in the historical series of survey was estimated according to the likelihood-based geostatistics method (Roa-Ureta and Niklitschek, 2007) (Figure 2).

The method estimate the biomass parameter in function of the total area covered by the survey, the numbers of hauls with positive catches and the area covered in each haul of *P. blennoides* (Velasco *et al*., 2009, and Velasco, pers. com.) (Table 5).

The number of hauls, area covered, and mean of hauls with positive success remained very constant along the period 2001-2008. The biomass estimation by the likelihood-based geostatistics method demonstrated two maximum in 2003 and 2005 (11 108 and 11 510 tonne respectively). Minimum biomass (3248 tonne) occurred in 2008 (Table 5).

The historical series of length frequencies of this survey were not used in the model due to time constraints during the WKDEEP. No more information from other surveys was available for this Stock Assessment Unit.

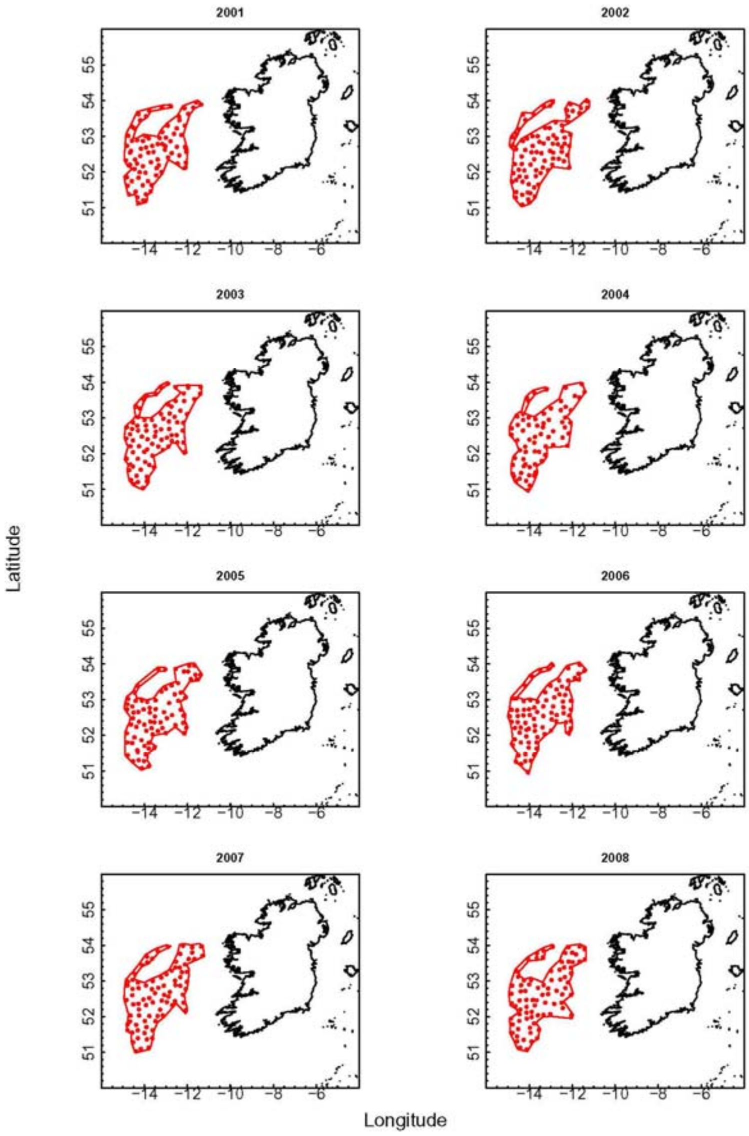

Figure 2. Area covered for the Spanish Porcupine survey from 2001 to 2008 and hauls location.

Table 5. Biomass estimation of *P. blennoides* by year from the Spanish Porcupine survey.

YEAR	START DATE	END DATE	Nº HAULS	AREA (KM2)	PS	PS S.DEV	MPD (TONNE/KM2)	MPD (TONNE/KM2) S.DEV	BIOMASS (TONNE)	BIOMASS (TONNE) S.DEV
2001	8/31/2001	10/02/2001	83	36548	0.90361	0.03239	0.14348	0.01856	4739	1125
2002	8/22/2002	9/22/2002	86	37201	0.90697	0.03182	0.10993	0.01538	3709	8954
2003	09/04/2003	10/04/2003	81	37803	0.90123	0.03279	0.32603	0.03434	11108	2520
2004	09/05/2004	10/07/2004	70	37736	0.90000	0.03527	0.24360	0.03292	8273	2057
2005	09/03/2005	10/03/2005	78	37197	0.91025	0.03341	0.33992	0.04598	11510	2787
2006	09/03/2006	10/03/2006	85	37829	0.84705	0.03201	0.21774	0.02974	6977	1755
2007	09/08/2007	10/06/2007	85	39750	0.87058	0.03201	0.17236	0.02477	5965	1496
2008	08/08/2008	10/08/2008	83	40251	0.86746	0.03239	0.09302	0.01222	3248	798

PS: Proportion of landings with success in *P. blennoides* catch

MPD: Mean (tonne/km2) of hauls with positive success in *P. blennoides* catch

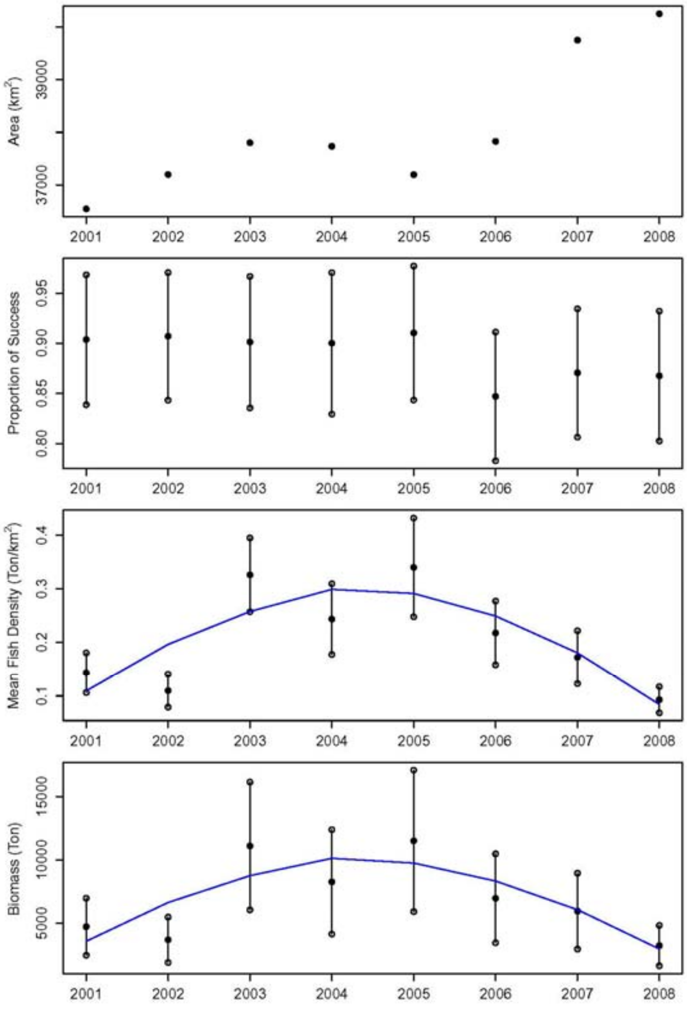

Figure 3. Historical series of area covered, biomass estimation, proportion of hauls success, and *P. blennoides* density from Spanish Porcupine survey.

Survey indicators were calculated from the Spanish IBTS in the Cantabrian sea (Division VIIIb), French western IBTS survey (EVHOE) in the Bay of Biscay (VIIIab and

Celtic Sea (VIIf,g,h,j), Spanish survey on the Porcupine Bank, Irish bottom-trawl survey and Scottish IBTS in VIa. The Indicators for the French and Spanish Porcupine surveys available from survey data analysis based upon the survey design, for the other survey, catch data were extracted from the DATRAS database and processed at the Workshop. In this case, only the mean length per 100 m depth strata was computed, as survey design were not extracted.

In some surveys the confidence intervals of greater forkbeard indicators were large due to small numbers caught. Overall, the indicators displayed no trends over the available time-series (Figures 4–16). On the Porcupine Bank, the indicators suggest a strong recruitment in 2003, which increased the abundance in the same year then increased the biomass in the two following years.

Based upon these indicators, population diagnostic can be made from combinations of two or more indicators. The simpler approach is a combination of abundance and mean size (Rochet *et al*., 2005). Diagnostic may be refined by taking into account 25 and 75 percentile of the length distribution; Trenkel *et al*., 2007) proposed a framework were log abundance, mean length, and recruitment abundance are taken into account. Because greater forkbeard is a bycatch species with significant discards in a number of shelf and upper slope fisheries data are scattered and poorly reliable. The species is of secondary or minor interest in all fisheries where it is caught. For some shelf fisheries there are discards only. Therefore, population indicators from surveys could be the most reliable information in the few next years.

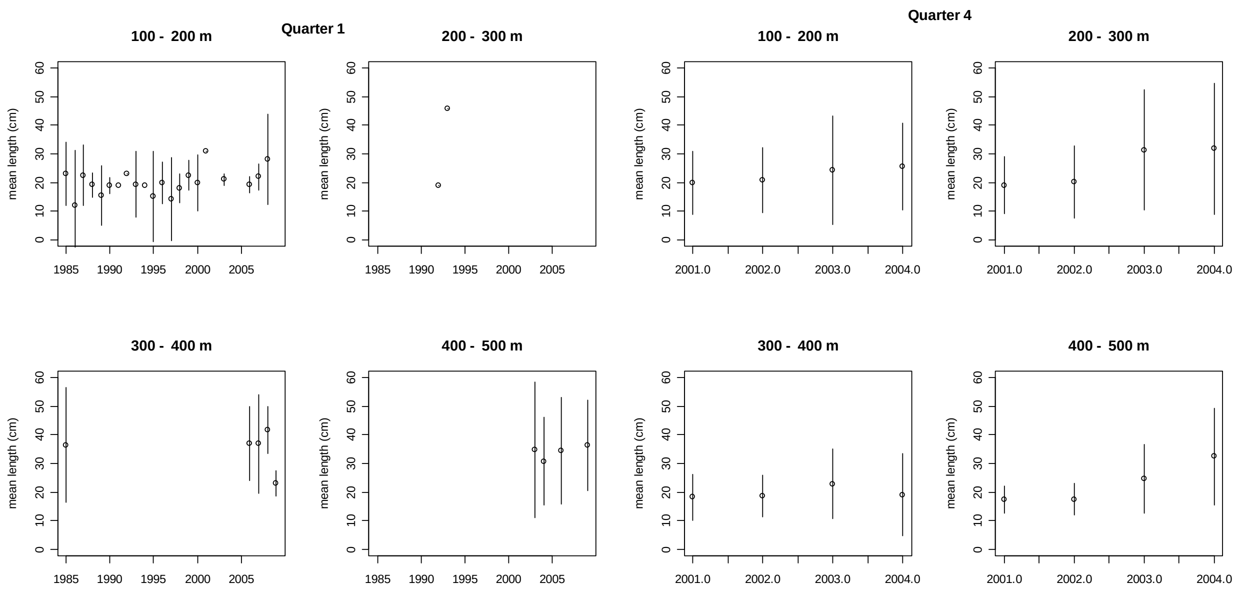

Figure 4. Greater forkbeard (*Phycis blennoides*). Mean length per depth strata in the Cantabrian Sea (Bay of Biscay, Division VIIIc, Spanish survey), quarter 1 (left) and 4 right).

In the Bay of Biscay and Celtic Sea, the French western IBTS survey (EVHOE) is stratified as in Figure 5. There are 5 Geographical strata (Gs and Gn for Bay of Biscay South and North) and Cs, Cc and Cn for Celtic Sea South, Central and North. In every geographical strata depth strata are numbered from 1 (corresponding to depths 15–30 m) down to 7 (400–600 m).

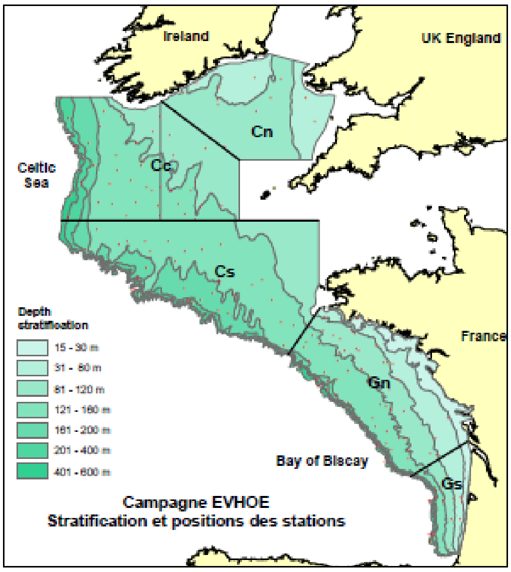

Figure 5. Survey design of the French western IBTS (also known as EVHOE) survey.

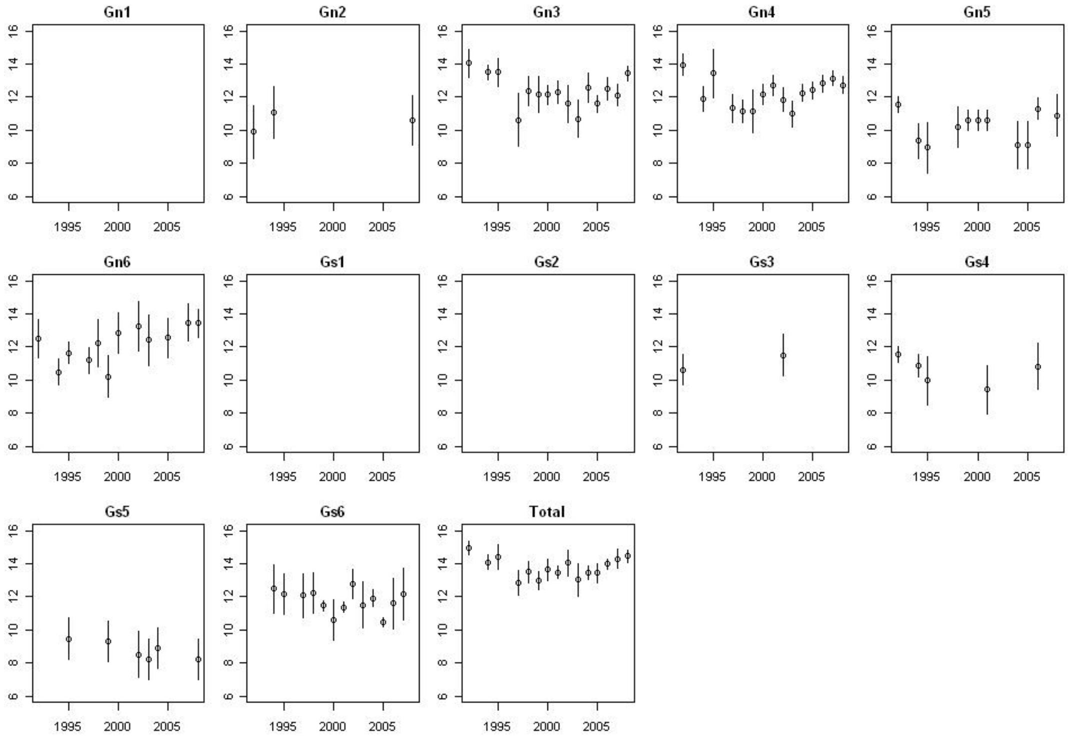

Figure 6. Greater forkbeard (*Phycis blennoides*). Raised abundance (swept-area method, Log scale) per strata in the Bay of Biscay (Divisions VIIIa,b) from the French western IBTS (see Figure 5 for strata code).

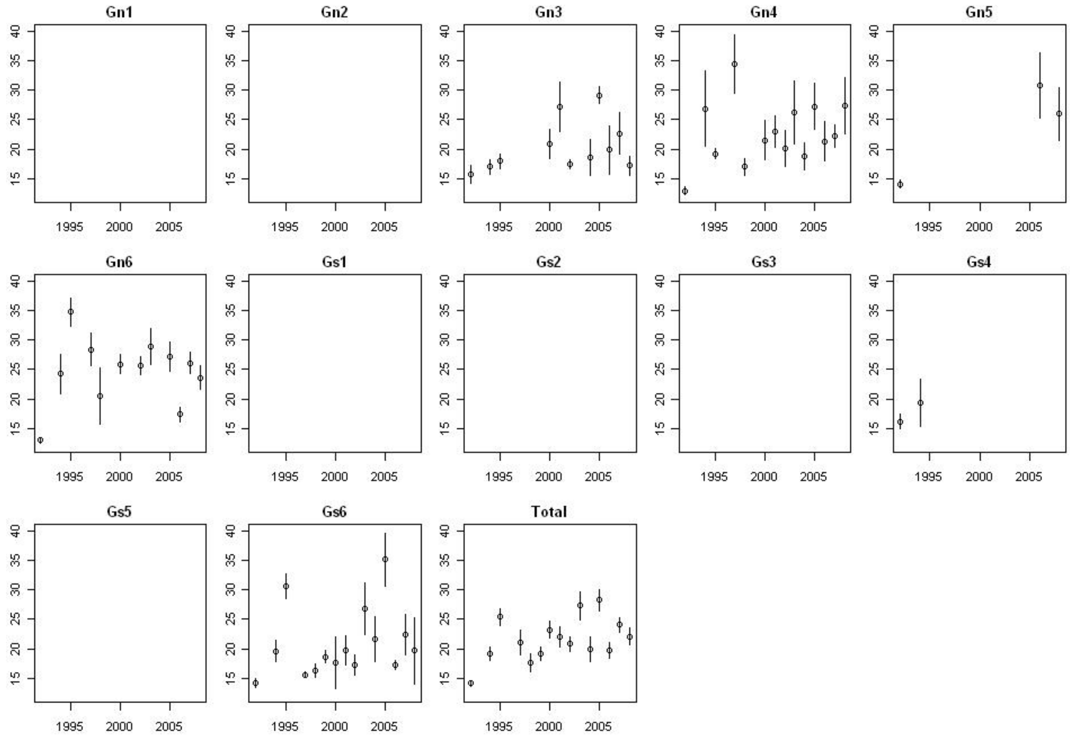

Figure 7. Greater forkbeard (*Phycis blennoides*). Mean length per strata in the Bay of Biscay (Division VIIIa,b) from the French western IBTS (see Figure 5 for strata code).

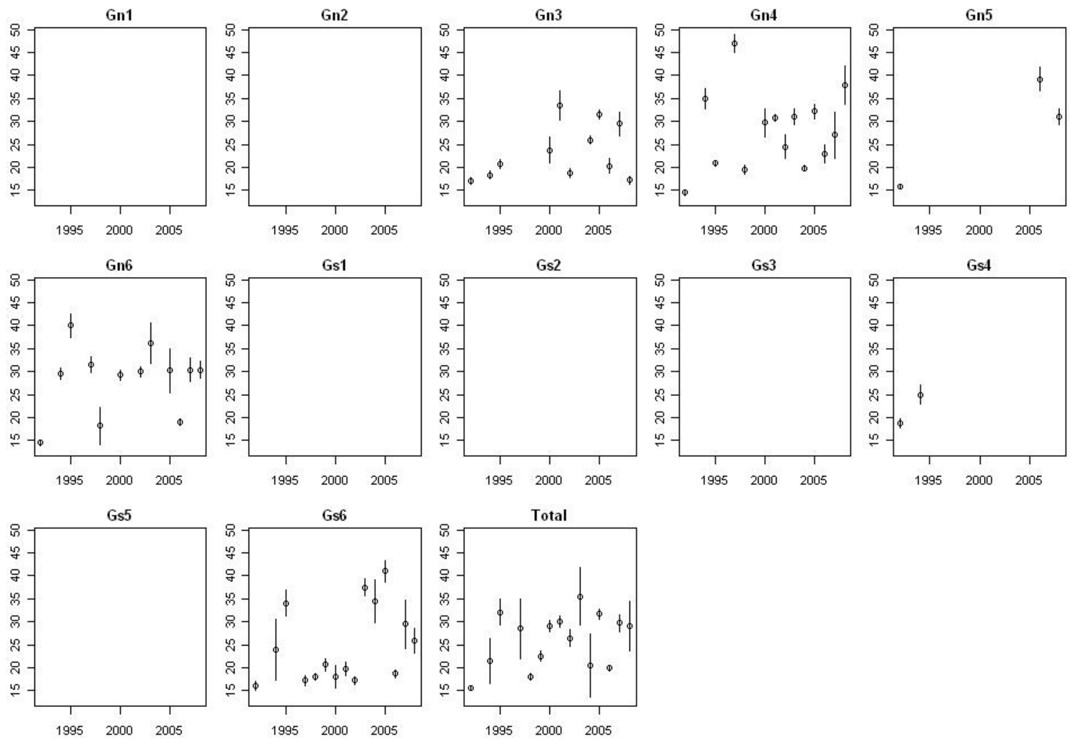

Figure 8. Greater forkbeard (*Phycis blennoides*). Length of the upper quartile (0.75) per strata in the Bay of Biscay (division VIIIa,b) from the French western IBTS (see Figure 5 for strata code).

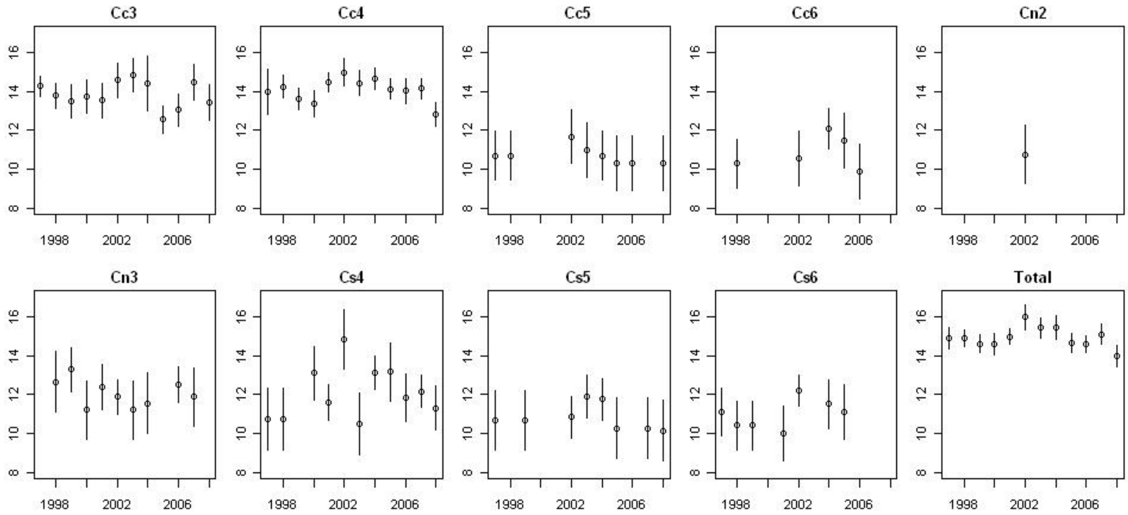

Figure 9. Greater forkbeard (*Phycis blennoides*). Raised abundance (swept-area method, Log scale) per strata in the Celtic Sea (Log scale) from the French western IBTS (see Figure 5 for strata code).

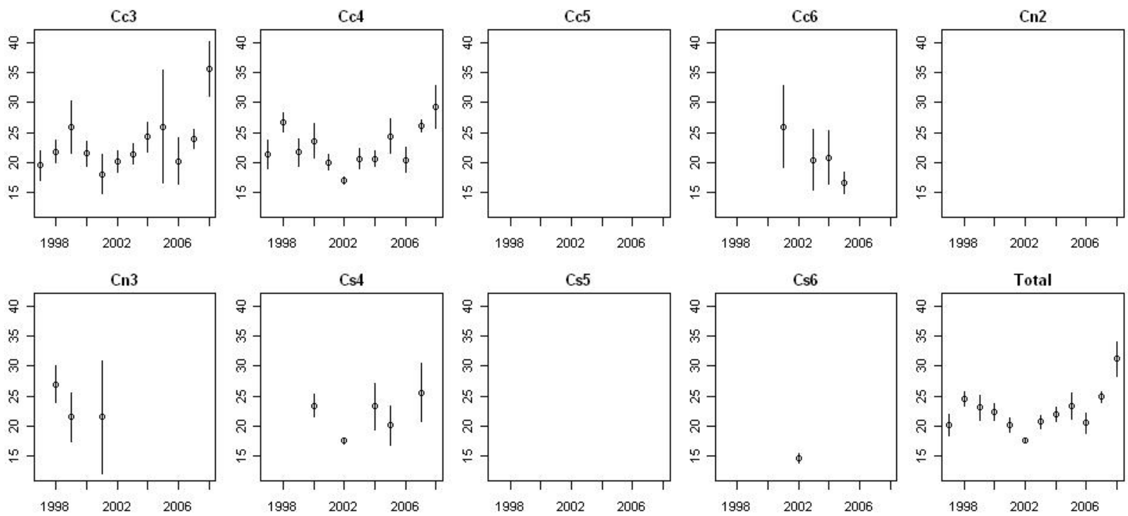

Figure 10. Greater forkbeard (*Phycis blennoides*). Mean length per strata in the Celtic Sea (Subarea VII) from the French western IBTS (see Figure 5 for strata code).

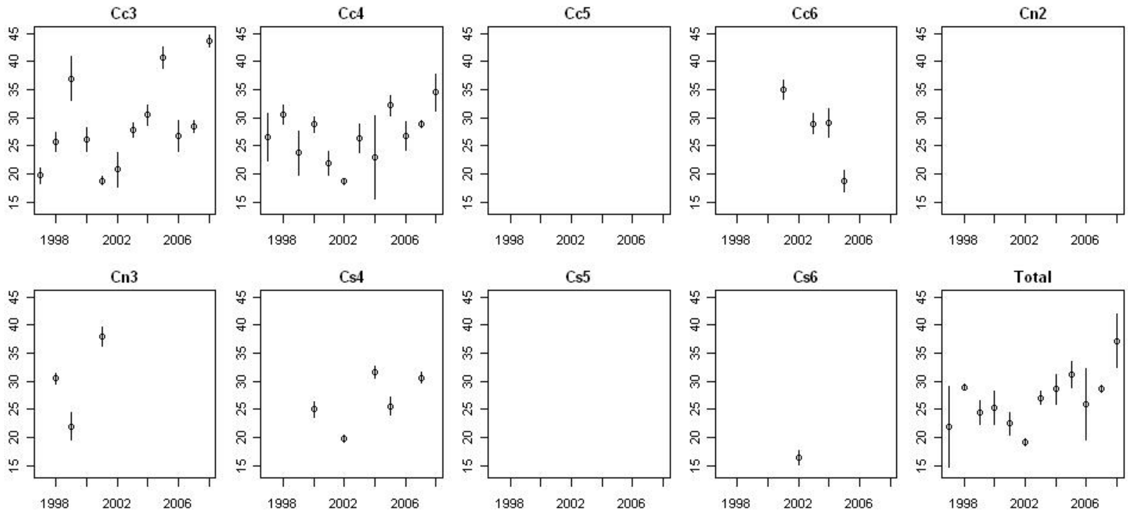

Figure 11. Greater forkbeard (*Phycis blennoides*). Length of the upper quartile (0.75) per strata in the Celtic Sea (Subarea VII) from the French western IBTS (see Figure 5 for strata code).

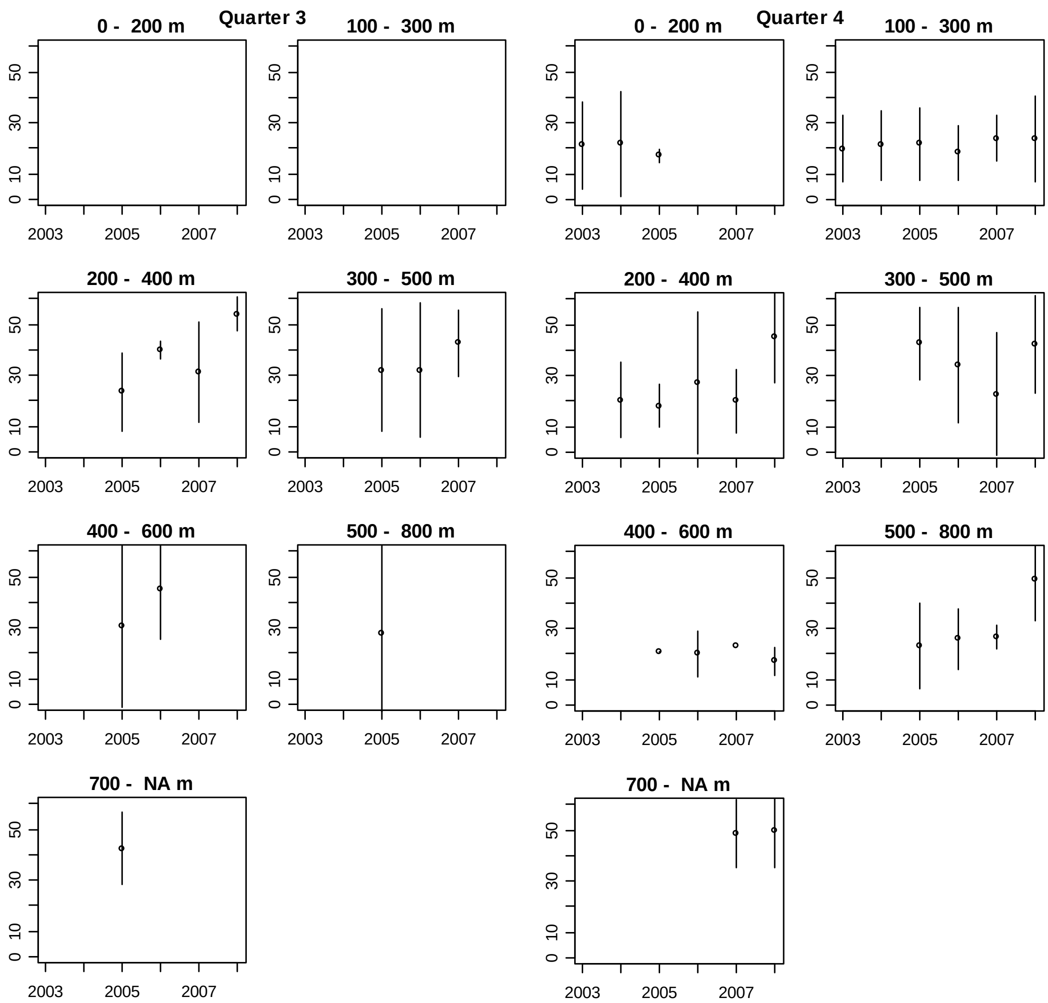

Figure 12. Greater forkbeard (*Phycis blennoides*). Mean length per depth strata in the ICES Subarea VII, Irish survey quarter 3(left) and 4 (right).

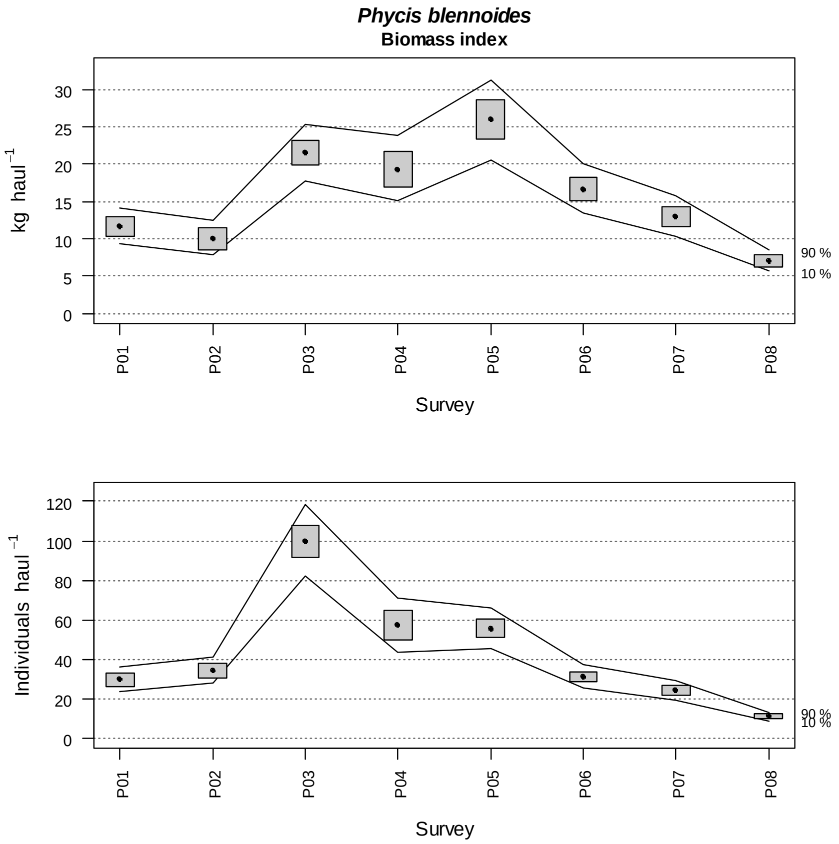

Figure 13. Variations in *Phycis blennoides* biomass and abundance indices during Porcupine Survey time-series (2001–2008). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (a = 0.80, bootstrap iterations = 1000).

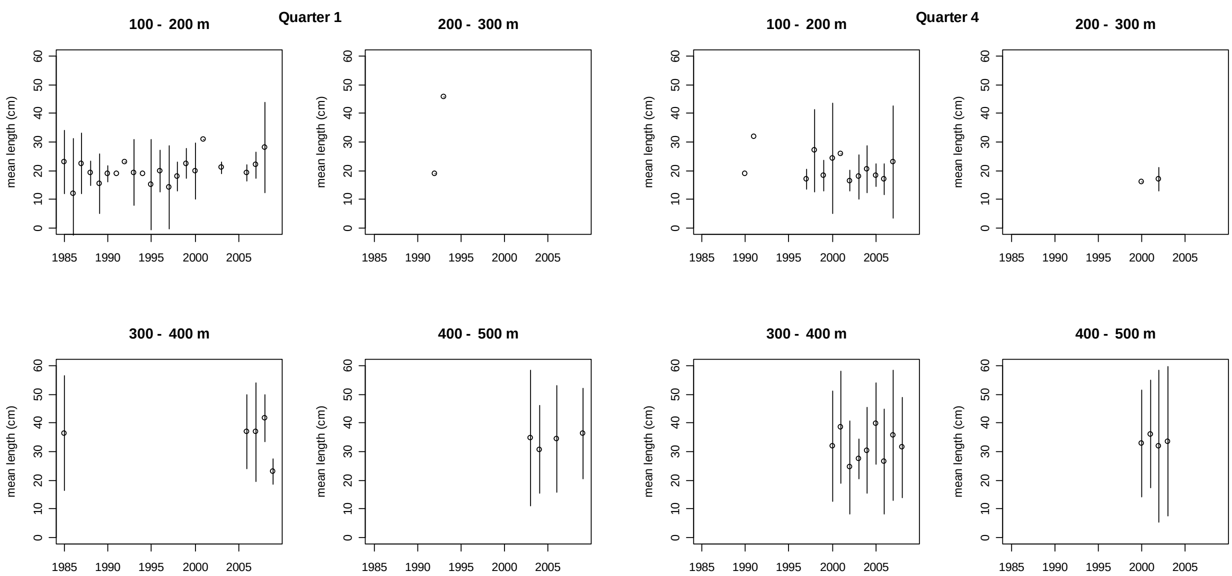

Figure 14. Greater forkbeard (*Phycis blennoides*). Mean length per depth strata in the ICES Subarea VI, Scottish IBTS, quarter 1 (left) and quarter 4 (right).

In the Bay of Biscay and Celtic Sea, the French western IBTS survey (EVHOE) is stratified as in Figure 5. There are 5 Geographical strata (Gs and Gn for Bay of Biscay

South and North) and Cs, Cc and Cn for Celtic Sea South, Central and North. In every geographical stratum depth strata are numbered from 1 (corresponding to depths 15–30 m) down to 7 (400–600 m).

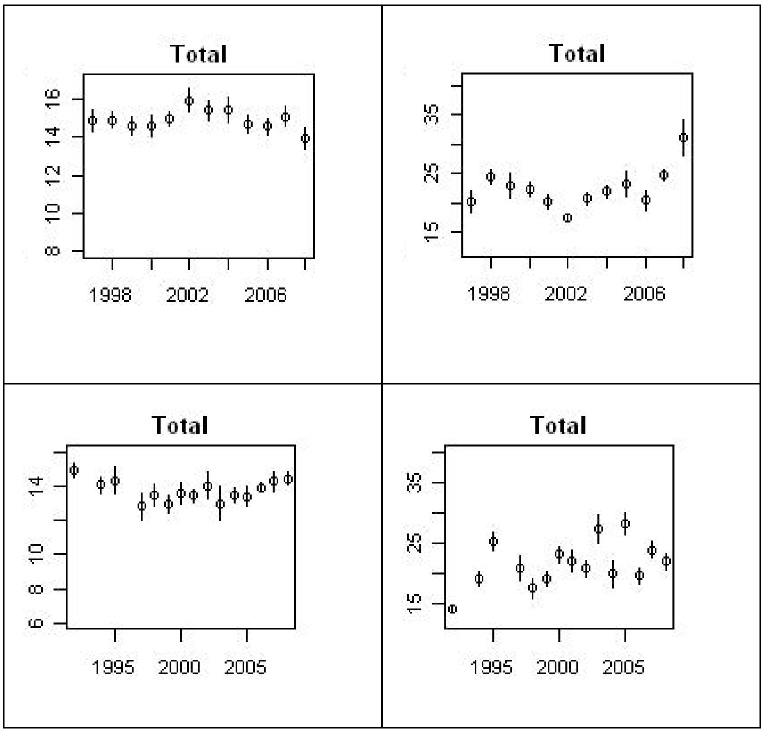

Figure 15. Greater forkbeard (*Phycis blennoides*). Raised abundance (swept-area method, Log scale) and mean length in the Celtic Sea (top) and Bay of Biscay (bottom). From the French western IBTS.

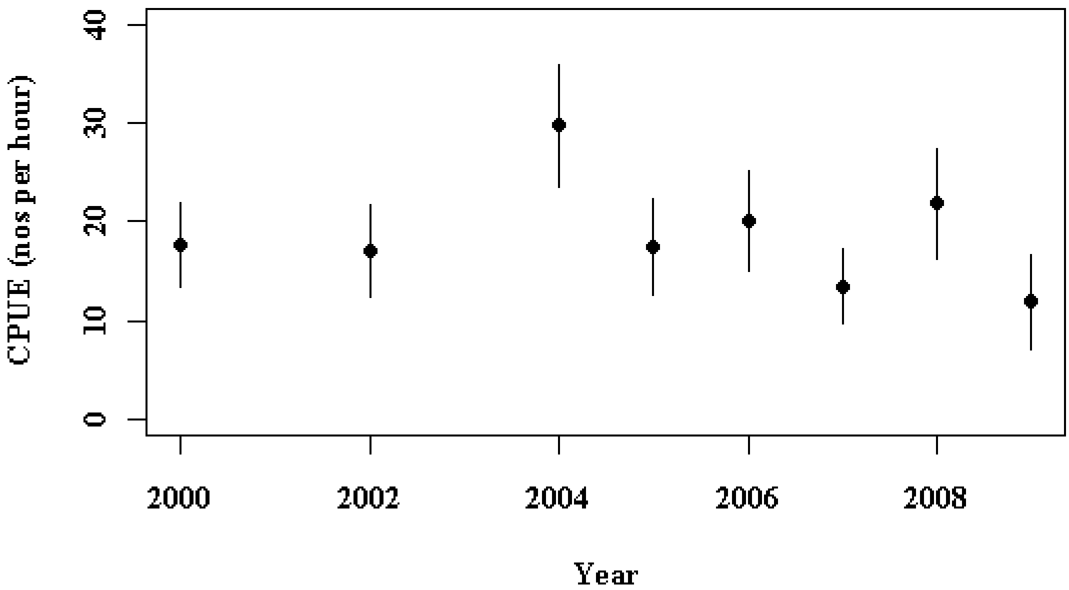

Figure 16. Greater forkbeard (*Phycis blennoides*). Cpues (nº/hour) from the Scottish IBTS survey in Division VIa since 2000.

3.2.4 Commercial tuning data

Not available.

3.2.5 Industry/stakeholder data inputs

No industry data were presented at WKDEEP.

3.3 Stock identity and migration issues

The WKDEEP members wanted to highlight that due to the availability of data the Single Assessment Unit (VI, VII and VIII) selected to develop an exploratory assessment with the SDM, has no indication on a stock definition for greater forkbeard.

3.4 Spatial changes in the fishery and stock distribution

According to the landings trend described in the ICES WGDEEP Report 2009 no significant changes has been reported in relation to the spatial location of the fishery and stock distribution. According this last report the Subareas VI and VII are historically the most important in landings. The trend in these subareas demonstrates a peak in landings in 2000 (4967 t) but since 2001 a continuous and notable decrease is observed and in 2008 only 1281 t are recorded. The landings come mainly from Spanish, French and UK fleet.

3.5 Environmental drivers of stock dynamics

There is a complete description of the Environmental drivers of Subareas VI, VII and VIII in the ICES Advice published in 2008, (Books 5 and 7) mentioned in the reference sections.

3.6 Role of multispecies interactions

3.6.1 Trophic interactions

The only evidence in the interaction of this species with other deep-water communities is the greater forkbeard could be a prey of deep-water sharks.

3.6.2 Fishery interactions

In the Report of WGDEEP in 2009 is a description of fishing interaction of different Spanish fleets fishing greater forkbeard in Subareas VI, VII, VIII, IX, XII, and XIV. Table 12.1 of this Report demonstrates that historically main landings come from bottom-trawler and longliner fleets (41% and 21% respectively) operating in Subareas VII and VIII. Minor landings of gillnetters and "other" fishing gears are also observed.

3.7 Impacts on the ecosystem

No ecosystem data were presented at WKDEEP. Greater forkbeard is mainly bycatch species in mixed fisheries. Therefore the impact on the ecosystem is consequence of the activity of mixed fisheries having bycatches of greater forkbeard.

3.8 Stock assessment methods

3.8.1 Models

WKDEEP proposed as exploratory assessment method for Greater forkbeard stocks a new version of the Stock Depletion Model (SDM) developed by Roa-Ureta and based on the model described by Roa-Ureta and Arkhipkin (2007).

The Leslie and Davies (1939) and Chapman (1974) stock depletion model for catch in numbers is

$$(1)\quad C_t = C(E_t, N_t) = q\,E_t\,N_t\,e^{-M/2} = q\,E_t\left(N_0 e^{-Mt} - e^{-M/2}\sum_{j=0}^{t-1} C_j e^{-(t-j-1)M}\right)e^{-M/2}$$

where *t* is an appropriate time-step, *q* is the catchability coefficient, *N*0 is initial number abundance, *M* is the natural mortality, *Ct* is the catch in numbers –the response variable–, *Et* is the effort –a predictor variable–, and *Nt* is number abundance –a second, unobserved, predictor variable–. Number abundance is expanded in such a way that it includes natural change for each time-step during the depletion period, in this case natural mortality only. The form of the expansion accounts for the fact that in backcalculating initial abundance it is necessary to discount the individuals that would have died because of natural mortality had they not been caught during the fishing process. The exp(-*M*) term quantifies the natural change as the probability of individual survival during one time-step, *Nt*/*Nt*-1, and the exp(- M/2) is the natural change during an additional half time-step, assuming that the catch occurs instantaneously at half the time-step.

In this model, catch is the effect of effort and abundance, assuming that every additional unit of effort and every additional unit of abundance produce each a proportional increase in catch, with a linear coefficient equal to *qe*-*M*/2. The model ignores two realistic processes where effort and abundance affect the catch non-linearly. They have not been formally named although their complementary aspects were described by Hilborn and Walters (1992), and Harley *et al*. (2001) for abundance, and by Bannerot and Austin (1983) and Quinn and Deriso (1999) for effort. We call them effort and abundance 'hyperresponse'. The complementary aspects of effort hyper-response are effort saturability, whereby the gear becomes saturated such that additional units of effort result in lesser net incremental catch, and effort synergy, whereby additional units of effort result in greater incremental catch. On the other hand, the complementary aspects of abundance hyper-response are hyper-stability and hyper-depletion. The former occurs when catch declines with negative acceleration while abundance declines whereas the latter happens when catch declines with positive acceleration as abundance declines.

Following Bannerot and Austin (1983), Hilborn and Walters (1992), Quinn and Deriso (1999), and Harley *et al*. (2001), a generalized Leslie-Davies-Chapman depletion model relates catch to effort and abundance by power functions,

$$(2)\quad C_t = q\,E_t^{\alpha}\,N_t^{\beta}\,e^{-M/2}$$

where α is the effort hyper-response parameter and β is the abundance hyper-response parameter. A generalized Leslie-Davies-Chapman depletion stock assessment model is thus,

$$(3)\quad \begin{aligned} C_t &= q\,E_t^{\alpha}\left(N_0 e^{-Mt} - e^{-M/2}\sum_{j=0}^{t-1} C_j e^{-(t-j-1)M}\right)^{\beta} e^{-M/2} \\ X_t &= C_t + \varepsilon_t, \qquad \varepsilon \sim \mathrm{Normal}(0, \sigma^2) \end{aligned}$$

where the four parameters of interest q, N0, α and β, are potentially subject to estimation, under the stochastic representation in the second formula of (3), with σ2 a nuisance parameter profiled out and with M fixed using some bioanalogical relation (Roa-Ureta and Arkhipkin, 2007) such as that available with natural longevity (Hewitt and Hoenig, 2005). The model in eq. (3) corresponds to observations of catch in numbers. Usually, however, the catch is directly recorded as biomass, so that it is necessary to have a sample of the length or body mass distribution in the catch to estimate the catch in numbers. In some very data-poor situations a biological sample of the catch is not available. For those situations it would be convenient to formulate the model with the catch in biomass units. To accomplish the natural change of biomass at every time-step need consider body growth as well as individual survival, while the catchability coefficient of eq. (3) changes units accordingly. So in this case the natural change in one time-step is

$$(4)\quad \frac{B_t}{B_{t-1}}=\frac{w_t N_t}{w_{t-1} N_{t-1}}$$

where w is individual body mass. Usually a good approximation to model growth of fish is von Bertalanffy's equation,

$$(5)\quad w_a=w_\infty(1-\lambda e^{-Ka})^3,\qquad \lambda=(1-l_0/l_\infty)\approx 1 \;\text{ for }\; l_0 \ll l_\infty$$

where a=t-t0 is age, t0 is the birth date, w∞ is asymptotic body mass, l0 is a linear measure of body size at birth, and K is a growth rate constant. Let

$$(6)\quad g(K)_{t-t_0}=\left(\frac{1-e^{-K(t-t_0)}}{1-e^{-K(t-t_0-1)}}\right)^3$$

be the natural change in body growth in one time. Then the model for catch in biomass units is

$$(6)\quad \begin{aligned} C_{t,a} &= q E_t^{\alpha}\left(B_0 g(K)_a e^{-Mt} - g(K)_{a-1/2} e^{-M/2}\sum_{j=0}^{t-1} C_j g(K)_{a-j-1} e^{-(t-j-1)M}\right)^{\beta} g(K)_{a-1/2} e^{-M/2} \\ X_t &= C_t+\varepsilon_t, \qquad \varepsilon \sim \mathrm{Normal}(0,\sigma^2) \end{aligned}$$

This model is more complex than eq. (3) because is an age-distributed representation (it is distributed over the birth date distribution of the fish being depleted) and it includes the additional parameter *K*. Because the model is intended to be applied to data-poor cases, it would be convenient to eliminate the need to know *K* and the birth date distribution. First, a basic knowledge of stock longevity and age of entry to the fishery can be used to replace the distributed formulation by a single representative value of age, namely the geometric mean within the range of age of entry and natural longevity, $\bar{a}$ It will be assumed that $\bar{a}$ is the representative age at the start of the depletion period. Second, life-history theory demonstrates that *K* and *M* are related in fish by a constant, *K*≈(2/3)*M* (Jensen, 1996). With these simplifications the generalized depletion model for catch in biomass becomes,

$$C_{t,a} = q E_t^{\alpha} \left(B_0 g(M)_{t,a} e^{-Mt} - g(M)_{t,a-1/2} e^{-M/2} \sum_{j=0}^{t-1} C_j g(M)_{t,a-j-1} e^{-(t-j-1)M} \right)^{\beta} g(M)_{t,a-1/2} e^{-M/2}$$

$$g(M)_{t,a} = \left(\frac{1-e^{-(2/3)M(t+a)}}{1-e^{-(2/3)M(t+\tilde{a}-1)}} \right)^3, \quad g(M)_{t,a-1/2} = \left(\frac{1-e^{-(2/3)M(t+a-1/2)}}{1-e^{-(2/3)M(t+\tilde{a}-1)}} \right)^3,$$

$$g(M)_{t,a-j-1} = \left(\frac{1-e^{-(2/3)M(t+a-j-3/2)}}{1-e^{-(2/3)M(t+\tilde{a}-j-2)}} \right)^3, \quad \tilde{a} = \exp\left(\frac{\sum_{a=a_r}^{A} \log(a)}{A-a_r} \right)$$

$$X_t = C_t + \varepsilon_t, \quad \varepsilon \sim \mathrm{Normal}(0, \sigma^2)$$

where A is longevity and ar is age-at-recruitment, both counted in discrete steps of length equal to the chosen time-step.

The model was written in R.

3.9 Stock assessment

The data used in the SDM were the historical series of landings and effort of the Basque Country trawlers operating in Subareas VI, VII and VIII from 2001 to 2008.

The assessment model has to be considered as exploratory. Preliminary runs of the model included changes in the specifications of the model suggested by the members of the WKDEEP. The first analyses were simulated with three different maximum ages (15, 20 and 25), several effort units (nº of hauls, nº of fishing days, nº of days at sea) and considering two different Assessment Stock Units separately (VI, VII and VIII) or only one (VI, VII, VIII Subareas together). Finally, WKDEEP agreed to run the SDM with a maximum age of 20 (Cohen *et al*., 1990) and one Assessment Stock Unit.

There was no apparent depletions observable in the actual data presented to the Group and used for the subsequent analyses. This issue was addressed via the model allowing for a non-linear relationship between catch, effort and biomass. Such a relationship requires extensive variation in all three variables to be able to identify the various parameters in an unbiased and accurate fashion and no such variation in biomass was seemingly observable making the estimates of the beta parameter essentially spurious.

- The analysis considered each year as essentially independent from all the others – no interrelationships between years in key parameters in the crucial catch, effort and biomass relationship were assumed. At the very least a hierarchical analysis (via random effects or a fully Bayesian approach) should be considered to address this problem.
- There was little if any consistency between the parameter estimates of catchability and the alpha and beta parameters in the catch, effort and biomass relationship across years. One can look at this in two ways: (1) given the assumed independence of years in the analysis there were no constraints to ameliorate such a problem, and (2) there is clearly no consistent information in the data and the estimation model is simply taking advantage of the significant freedom afforded to it via the over-parameterized model to fit each year of data practically independently.
- The surveys seem to indicate the various populations of greater forkbeard appear to undergo reasonably large recruitment variations with trend. Given the age-aggregated biomass model assumed in the DPM it would seem that not just when recruitment happens but its interannual variation

need addressing - the latter issue cannot be addressed by the DPM without further complex modelling techniques such as random effects.

3.9.1 Model settings

The time unit to estimate the outputs of the model is given in weeks. The 1st week in which the model starts to analyse the variables is different for each year and is set according to the period in which the fleet get the first catches in this year. The unit of effort selected was the number of total trips. Catches of fleet by year came from the data basis of logbooks. Data of discards are official estimation for the Basque Country trawler fleet (ICES 2009) (Table 5).

Table 5. Settings of the Stock Depletion Model.

Year	1st Week	Last Week	Effort	Effort Unit	Catch (tonne)	Discards (tonne)
2001	14	51	174.2	N. Trips	155.9	NA
2002	18	46	126.8	N. Trips	104.8	NA
2003	22	51	74.7	N. Trips	60.7	0.42
2004	23	50	62.2	N. Trips	48.2	0
2005	19	50	37.97	N. Trips	30.7	0
2006	NA	NA	NA	NA	NA	7.05
2007	18	32	40.01	NA	19.6	0.11
2008	14	38	54.3	NA	19.7	371.9

3.9.2 Biological assumptions

The Stock Depletion Model assumes no recruitment or migrations. Biological assumptions of the SDM are presented in Table 6.

Table 6. Biological assumptions of the Stock Depletion Model.

MAXIMUM AGE REPORTED IN BIBLIOGRAPHY	20 YEARS (COHEN *ET AL.*, 1990)
Natural longevity	25 years
Natural mortality	0.003694 1/week, constant along the depletion period c
Growth constant (K)	0.002463 1/week
b length-weight relationship	3
Age of recruitment to the fishing gear	208 weeks
Average age of the stock exploited	678 weeks
Recruitment	No recruitment during the depletion period
Migration	No migration happens during the depletion period
Growth	von Bertalanffy

3.9.3 Results

Results of the Stock Depletion Model are presented in Table 7. Due to difficulties in the model fittings, the results for the year 2006 could not be presented.

Table 7. The estimations of de SD Model for the Assessment Stock Unit (Subareas VI, VII and VIII) for greater forkbeard. Results for the year 2006 are not presented.

YEAR	INIT. BIOMASS (TONNE)	S.E. INIT BIOMASS (TONNE)	CATCHABILITY	S.E. CATCHABILITY	EFFORT HYPER-RESPONSE	S.E. EFFORT HYPER-RESPONSE
2001	14 886.7	11668.7	0.01227	0.00280	1.145	0.0928
2002	18 700.2	30390.7	0.01461	0.00958	0.878	0.1925
2003	20 896.1	32664.5	0.04083	0.05280	0.971	0.1006
2004	13 198.9	19971.7	0.50271	5.16196	0.992	0.2166
2005	7980.6	NA	0.09347	0.18796	1.036	0.1527
2006	NA	NA	NA	NA	NA	NA
2007	11 757.7	NA	0.09056	NA	1.23	NA
2008	9349.9	NA	0.01332	NA	0.814	NA

Table 7. cont.

Year	Abundance Hyper-Response	S.E. Abundace Hyper-Response	Biomass Last Week (tonne)	Total Catch VI-VII-VIII (tonne)	Exploitation Rate	Biomass Left (tonne)
2001	0.417	0.0462	14 715.8	1746	0.1172	12 969.8
2002	0.434	0.1044	18 560.6	1423	0.0760	17 137.6
2003	0.304	0.1410	20 795.6	1417	0.0678	19 378.6
2004	0.047	1.0837	13 127.0	1516	0.1148	11 611.0
2005	0.244	0.2194	7933.8	1233	0.1544	6700.8
2006	NA	NA	NA	1260	NA	NA
2007	0.152	NA	11 714.5	1325	0.1126	10 389.5
2008	0.385	NA	9311.1	315	0.0337	8996.1

3.10 Recruitment estimation

Not available.

3.11 Short-term and medium-term forecasts

No short-term and medium-term forecasts were performed.

3.12 Biological reference points

No suggestions for biological reference points were presented at the meeting.

3.13 Recommended modifications to the Stock Annex

No modifications to the Stock Annex are suggested as there was no annex in existence before this meeting.

3.14 Recommendations on the procedure for assessment updates

- As this species is considered a bycatch in the trawling mixed fishery, a comparative study of the proportion of effort devoted to *P. blennoides* and to the rest of species should be useful in order to refine the effort used in the model.
- To include the catch and effort data of Basque longliners in the area.
- To estimate the biomass (likelihood-based geostatistics method) from the Porcupine survey stratifying the analysis in relation to the proportion and distribution of mature and immature individuals in the area.

Survey based population indicators of greater forkbeard should be calculated from relevant surveys and commercial lpue series and provided to WGDEEP. The recommended indicators are: abundance, log abundance, mean length, quantiles of mean length, biomass, per strata and for the whole survey. Interpretation of trends by survey and strata should be used to define the overall trend for "stocks" of greater forkbeard.

3.15 Industry supplied data

No data were provided from the industry.

3.16 References

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Stock Annex: Greater forkbeard in the Northeast Atlantic

Stock	Greater forkbeard in the Northeast Atlantic
Working Group	WKDEEP
Date	February 2010 (WKDEEP)
Revised by	Guzman Diez (gdiez@azti.es), Ruben Roa (rroa@azti.es) and Pascal Lorance (Pascal.Lorance@ifremer.fr)

A. General

A.1. Stock definition

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

Unfortunately very little is known about stock structure of the species. Currently ICES considered greater forkbeard as a single stock for all the ICES area – greater forkbeard in the Northeast Atlantic. Probably the stocks structure is more complex, but further studies needs to be implemented to allow a scientific basis for the stock structure.

A.2. Fishery

Greater forkbeard may be considered as a bycatch species in the traditional demersal trawl and longline mixed fisheries targeting species such as hake, megrim, monkfish, ling, and blue ling. Since 1988, around 80% of landings came from the Subareas VI and VII. Spanish, French and UK trawlers and longliners are the main fleets involved in this fishery. But also the Irish deep-water fishery around Porcupine Bank is based on the flat grounds and targets orange roughy, black scabbard, roundnose grenadier and deep-water siki sharks has landed historically important quantities of this species. The Russian fishery in the North-East Atlantic targeting roundnose grenadier, tusk and ling fish small quantities of greater forkbeard as bycatch of the trawler fleet in Hatton and Rockall Banks. The rest of landings in that period (11%), come from Subareas VIII and IX (mainly from VIII) by the trawler and longliner Spanish and French fleet. In Subarea IX since 2001 small amounts of *Phycis* spp (probably *P. phycis*) are landed in ports of Strait of Gibraltar by the longliner fleet targeting scabbardfish in Algeciras, Barbate and Conil.

Minor quantities of *P. blennoides* from X Subdivision and Vb Subarea are landed by Portuguese and Norwegian vessels respectively. The Azores deep-water fishery is a multispecies and multigear fishery dominated by the main target species *Pagellus bogaraveo*. Target species can change seasonally according to abundance and market prices, but landings of Phycis blennoides representing less than 0.6% of total deep-water landings in last two years, and can be considered as bycatch.

Catches data for greater forkbeard in 2006 and 2007 aggregated at the level of statistical rectangle were provided to the Working Group by Basque Country (Spain) France, Ireland, the UK (England and Wales and Scotland) and Iceland.

A.3. Ecosystem aspects

For greater forkbeard can be applied the same ecosystem considerations of other deep-water fisheries in the areas defined for the stocks. Fishing is a major disturbance factor of the continental shelf communities of the regions. As the fishery of Greater forkbeard is mainly a bycatch of trawler fishery in all ecoregions the main affections on the ecosystem is the impact on the sediment compound.

B. Data

B.1. Commercial catch

Commercial landings are available from the Basque Country trawler fleet (OTB and PTB) operating in Subareas VI, VII and VIII from 2001 to 2008. . Owing to the bycatch status of the species, they may be unreliable and significant discards occur in some fisheries, in particular on the shelf where juvenile greater forkbeard occur.

B.2. Biological

The biology of the species is poorly known. In general most of biological data are not reliable or not available (e.g. age composition, maturity, growth, natural mortality…). In Tables 3 and 4 a compilation of biological available data are shown. (WGDEEP 2001 (ICES C.M. 2001/ACFM: 23; Lorance 2010)). The spawning areas and seasonality are also not well (or at all) identified. Only historical series of length frequencies from surveys were available.

Table 3. Life-history characteristics of Greater forkbeard (from WGDEEP 2001 (ICES C.M. 2001/ACFM: 23; Lorance, 2010).

LHC	Sex	Estimate	Area (month)	Reference
Maximum observed length (TL, cm)	Combined	50	VIIIc and IXa	Sanchez *et al*., 1995
	Female	84	VIIIc and IXa	Casas and Piñeiro, 2000
	male	44	VIIIc and IXa	Casas and Piñeiro, 2000
Maximum observed age (year)	Female	14	VIIIc and IXa	Casas and Piñeiro, 2000
	male	6	VIIIc and IXa	Casas and Piñeiro, 2000
	combined	20	Atlantic	Cohen *et al*., 1990
	Female	9	NE Atlantic	Kelly, 1997
	male	7		
	combined	15	NE Atlantic	EC FAIR, 1999, Sub-t. 5.12, Doc.55
Length at 50% maturity (PAFL, cm)	Female	33 cm	NE Atlantic and Med.	Cohen *et al*., 1990(1,2)
	Male	18 cm		Cohen *et al*., 1990(1,2)
	Female	32 cm	NE Atlantic and Med.	Kelly, 1997
	Male	31 cm	NE Atlantic	
Age at 50% maturity (year)	Combined	3-4 yrs	Mediterranean sea	Muus and Nielsen, 1999
Length of smallest individuals caught (TL)	Combined	6 cm	VIIIc and IXa	Casas and Piñeiro, 2000
		8cm	VIIIa,b,d (Oct.–Nov.)	Data from French western IBTS
		8 cm	VIIg-k (Oct.–Nov.)	Data from French western IBTS
Age of youngest individuals caught (year)	Combined	< 1yr	VIIIc and IXa	Casas and Piñeiro, 2000
Length of the first mode of the length distribution	Combined	13.9 cm	VIIIc, IXa (April)	Casas and Piñeiro, 2000
		16.9 cm	VIIIc, IXa (Sept.)	Casas and Piñeiro, 2000
		17.4 cm	VIIIc, IXa (Oct.)	Casas and Piñeiro, 2000
		16 cm	VIIIa,b,d (Oct.–Nov.)	Data from French western IBTS
		16 cm	VIIg-k(Oct.–Nov.)	Data from French western IBTS

Unclear whether it is mean length at first maturity or length of smallest mature individual.

Table 4. Growth parameters of greater forkbeard. (From WGDEEP 2001 (ICES C.M. 2001/ACFM: 23; Lorance, 2010)).

Sex	L∞	K	T0	Area	Reference
Male	41.7	0.208	N/A	Gulf of Lions (Med.)	Nony, 1983 (from Fishbase)
Female	51.2	0.258	N/A	Gulf of Lions (Med.)	Nony, 1983 (from Fishbase)
Combined	57.7	0.168	-0.66	Aegean sea (Med.)	Papaconstantinou *et al*., 1993
Male	54.9	0.217	-0.663	VIIIc and IXa	Casas and Piñeiro, 2000
Female	113.3	0.0886	-0.556	VIIIc and IXa	Casas and Piñeiro, 2000

B.3. Surveys

Data of abundance, length frequencies of *P. blennoides* and area covered by hauls from the of Spanish survey in Porcupine and data of length frequencies from Spanish Cantabrian sea and French western and Scottish IBTS and Irish surveys has been used in the assessment.

Data from surveys are available in the DATRAS database and at national level. Most survey do not cover the deeper part of the depth distribution of the species.

B.4. Commercial effort

Commercial effort (number of total trips) is available from the Basque Country trawler fleet (OTB and PTB) operating in Subareas VI, VII and VIII from 2001 to 2008.

C. Historical stock development

Survey based population indicators of greater forkbeard should be calculated from all relevant survey and provided to WGDEEP. The recommended indicators are: abundance, log abundance, mean length, quantiles of mean length, biomass, per strata and for the whole survey. Interpretation of trends by survey and strata should be used to define the overall trend of greater forkbeard in areas where it is caught.

D. Short-term projection

No short-term forecasts were performed for greater forkbeard in the Northeast Atlantic.

E. Medium-term projections

No medium-term forecasts were performed for greater forkbeard in the Northeast Atlantic.

F. Long-term projections

No long-term forecasts were performed for greater forkbeard in the Northeast Atlantic.

G. Biological reference points

No reference points have been set for stocks of greater forkbeard in the Northeast Atlantic.

H. Other issues

Landings and effort data in XIIb should be included into the assessment if they become reliable. Landings and discards from all areas and fisheries were greater forkbeard occur should be compiled. Because greater forkbeard is a bycatch in shelf and slope fisheries and is subject to discards data on total catch are essential to assess the stock (s).

Greater forkbeard is caught in a number of surveys that are likely to provide reliable trends in either total abundance, recruitment of both. It is recommended that survey data are used to assess stocks trends.

Stock identity knowledge is lacking for greater forkbeard in the Northeast Atlantic.

I. References

Cohen, D.M., T. Inada, T. Iwamoto and N. Scialabba. 1990. FAO species catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fish. Synop. 10 (125). 442 p.

4 Tusk in Division Va and XIV

4.1 Current stock status and assessment issues

Tusk in Va is primarily a bycatch in the longline fishery, conducted in order of importance by Icelandic, Faroes and Norwegian boats. The Icelandic longline fleet mainly targets cod, haddock and other demersal species. In some years there are direct fishery for tusk along the south and southwest coast of Iceland. In recent years, over 550–590 Icelandic vessels have been reporting catches of tusk, from less than 0.1 t to over 330 t per year. Most of the landings from Va (over 95%) come from longliners, but only partly from aimed fisheries. 50% of the Icelandic ling catches in 2007 were taken within the depth range of 100–300 m, with 80% of the catches taken at depth less than 400 m.

Annual catches of tusk in XIV are small compared with catches in Va or less than 1%. Data from surveys conducted in XIV were available at the meeting but no data apart from landings data were available from the commercial fleet. As landings are low and surveys indicate low biomass of tusk in XIV assessment was only conducted on the Va data and landings.

The state of the stocks remains uncertain, but there are indications that both the adult stock (> 55 cm) and the fishable stock (> 40 cm) has started to recover from its record low level in 2001, and the recruitment signs indicate a possible increase in harvestable biomass in future.

No analytical assessment has been used as a basis for advice by ICES in the past. Advice has been based on trends in surveys and landings. Reference points have been suggested for tusk in Va based on survey indices (U) are:

U_{lim}= 0.2* U_{max},
U_{pa}= 0.5* U_{max},

However, as available indices do not go back to the start of the fishery, these are not considered appropriate as reference points. In the WGDEEP-2008 Report the Working Group (ICES, 2008) therefore recommended that direct effort should be kept low in order to further rebuild the adult stock.

At the 2009 WGDEEP meeting a Gadget model for tusk in Va was presented and the Group considered it to be a promising approach that might be further developed (ICES, 2009). Therefore WGDEEP proposed that Tusk be put forward as a candidate for a benchmark meeting.

It should be noted that the gadget tusk assessment model was partly developed to avoid the reliance on age-based data. However the tusk model is a new, complex, and significantly different approach from the ones used previously to give advice on tusk in Va and XIV. It is therefore likely that refinements and updates will be required over the coming years to the model and further consideration given to the data used. The panel considers that ICES should be flexible in allowing model improvements during the Assessment Working Groups and on an intersessional basis. ICES should therefore ensure that resources are in place to evaluate these improvements.

Issues considered in this benchmark relate to:

1) New ageing of tusk otoliths from 1995 and 2009 suggest that tusk grows considerably faster than previously assumed. The new age-readings are considered more plausible than the older estimates as they results in more

similar estimates of growth of tusk in Va as has been reported in other management units.

2) The new assessment model is a length-based approach using the Gadget model. This approach allows the direct use of length structured data. It provides an assessment of the stock, and provides a simulation tool for investigating the growth and biology of the stock.
3) The Gadget model for tusk in Va needs considerably more work and analysis for it to be used as a full-blown assessment model. However the current setup is close to being acceptable as 'indicative of trends' in biomass, SSB, etc.

4.2 Compilation of available data

4.2.1 Catch and landings data

Icelandic tusk catch in tonnes by month, area and gear are obtained from Statistics Iceland and Directorate of Fisheries. Catches are only landed in authorized ports where all catches are weighed and recorded. The distribution of catches is obtained from logbooks, available since 1991, where location of each haul, effort, depth of trawling and total catch of tusk is given. Landings of Norwegian and Faroese vessels are given by the Icelandic Coast Guard and reported to the Directorate of Fisheries. Discard is banned in the Icelandic demersal fishery and there is no information available on possible discard of tusk.

4.2.2 Biological data

Biological data from the commercial longline catch are collected from landings by scientists and technicians of the Marine Research Institute (MRI) in Iceland. The biological data collected are length (to the nearest cm), sex and maturity stage (if possible because most tusk is landed gutted), and otoliths for age reading. Most of the fish that otoliths were collected from were also weighted (to the nearest gramme). Biological sampling is also collected directly on board on the commercial vessels during trips by personnel of the Directorate of Fisheries in Iceland or from landings (at harbour). These are only length samples.

Age reading of tusk caught in Va either in commercial catches or in surveys has not been done on a routine basis since 1998. For this benchmark meeting ageing of tusk otoliths from 2009 were conducted. Comparisons of mean length-at-age between the 1990s and 2009 demonstrated great differences. Because of this ageing of tusk otoliths from 1995 were conducted (Figure **CompAge**). It appears that false age-rings were being counted as true age-rings in the past. The revised age readings appear to be closer to estimates of tusk growth from other regions (Figure **SurComp)**. Because of this all previous ageing was discarded from the 2009 gadget run and only the ageing from 1995 and 2009 are used (Figure **CatchOto, SurveyOto**).

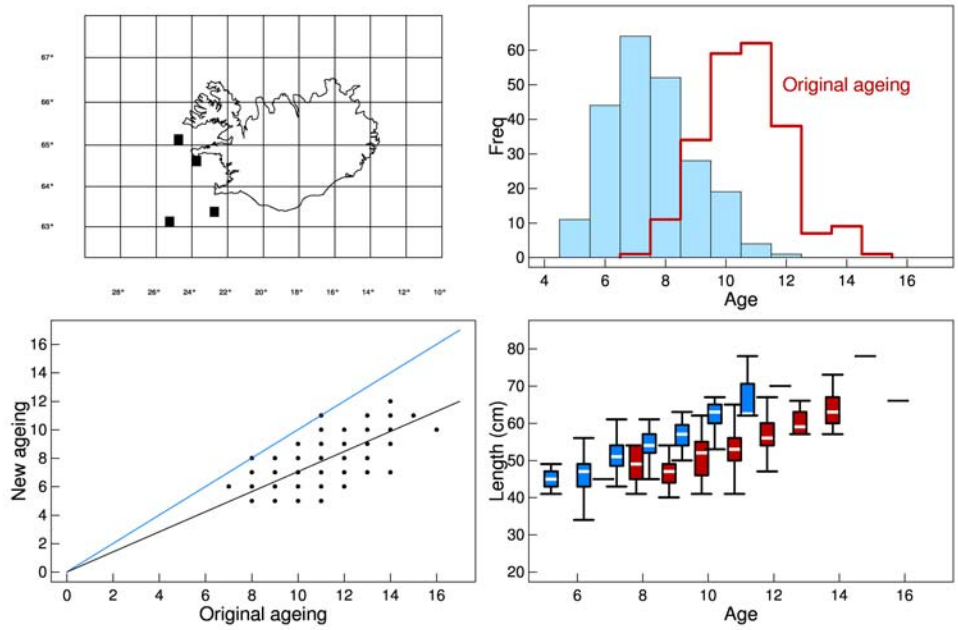

Figure CompAge. Tusk in Va. Two independent age-readings of four Tusk otolith samples from commercial catches in 1995. From top left to bottom right. Location of samples (TL). Frequency of age readings (TR). Relationship between original and new age-readings (BL) and age vs. length (BR). Blue represents new age readings and red original readings.

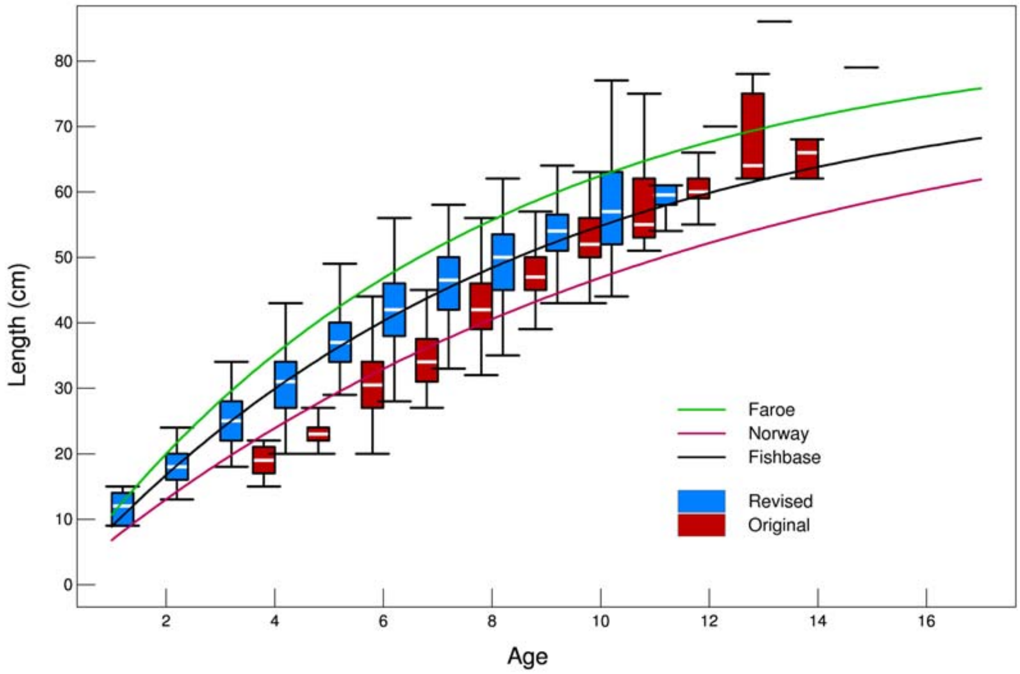

Figure SurComp. Tusk in Va. Growth of tusk in Va (boxplots) from revised age-readings (blue) and previous age-readings (red). Superimposed lines are predictions using von Bertalanffy parameter estimates from fishbase.org (green-, pink- and black-lines).

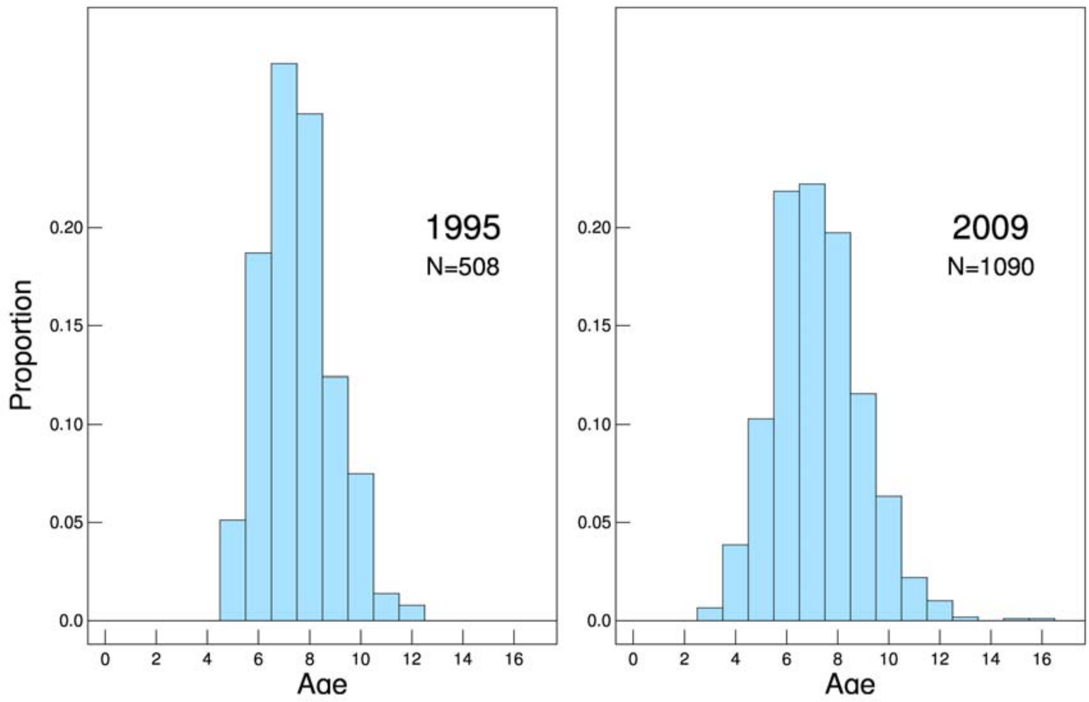

Figure CatchOto. Proportional age distribution of Tusk in Va as observed in commercial catches in 1995 and 2009.

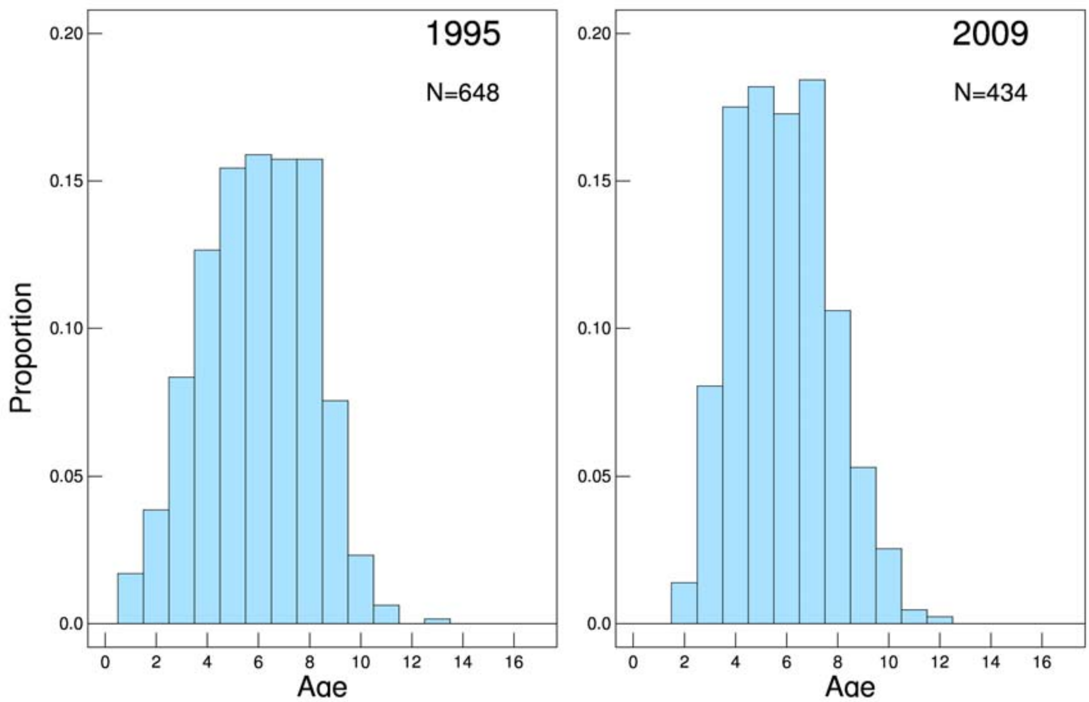

Figure SurveyOto. Proportional age distribution of Tusk in Va as observed in Spring Surveys in 1995 and 2009.

Earlier observations indicates that tusk becomes mature-at-age of about 8–10 years or at around the length of 56 cm. The mean length-at-maturity is close to the mean length of tusk in the commercial catches. This means that a large proportion of the tusk is caught as immature.

No estimates of natural mortality are available for tusk in Va and XIV. In the Gadget model (see below) natural mortality is assumed to be 0.2 $year^{-1}$.

4.2.3 Survey data

Two bottom-trawl surveys, conducted by the Marine Research Institute in Va, are considered representative for tusk, namely the Icelandic Groundfish Survey (IGS or the Spring Survey) and the Autumn Groundfish Survey (AGS or the Autumn Survey). The Spring Survey has been conducted annually in March since 1985 on the continental shelf at depths shallower than 500 m and has a relatively dense station-net (approx. 550 stations). The Autumn Survey has been conducted in October since 1996 and covers larger area than the Spring Survey. It is conducted on the continental shelf and slopes and extends to depths down to 1500 m. The number of stations is about 380 so the distance between stations is often larger. The main target species in the Autumn Survey are Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*).

A detailed description of the two surveys and data sampling is given in the stock annex for tusk in Va.

4.2.4 Commercial tuning data

No commercial fleet tuning data were proposed for use in the gadget model. This decision is supported by the availability of tuning data from the survey fleets and the limited degree to which commercial cpue data can be standardized over time.

4.2.5 Input from stakeholders/industry

No input from stakeholders in Va or XIV was presented to the Working Group.

4.3 Stock identity and migration issues

In 2007, WGDEEP examined the available evidence of stock discrimination in this species. Based mainly on genetic investigations, the group suggested the following stock units:

- Tusk in Va and XIV;
- Tusk on the Mid Atlantic Ridge;
- Tusk on Rockall (VIb);
- Tusk in I,II.

All other Areas (IVa,Vb, VIa, VII,…) are assessed as one combined stock.

Contrasting results exist regarding the mobility of tusk. Cosewic (2003 and references therein) ascribe a sedentary behaviour to this species while Lumankov *et al*. (1985) suggest a migrating behaviour between feeding and spawning grounds. No tagging studies are available that demonstrate large-scale movements of tusk between stock units.

4.4 Spatial changes in the fishery and stock distribution

The tusk fishery in Icelandic waters is largely limited to the southeast, southern and western shores of Iceland, with catches in Bormicon Areas 1, 9, and 10 dominating the annual catches since 1991 (Figure **AreaChange**). With time, the share of the catches taken in the southeast (Bormicon Areas 8–9, very little fishery is in Bormicon Area 7, the Iceland-Faroe Ridge) has decreased relative to that obtained in the south and southwest (Bormicon Areas 1 and 10).

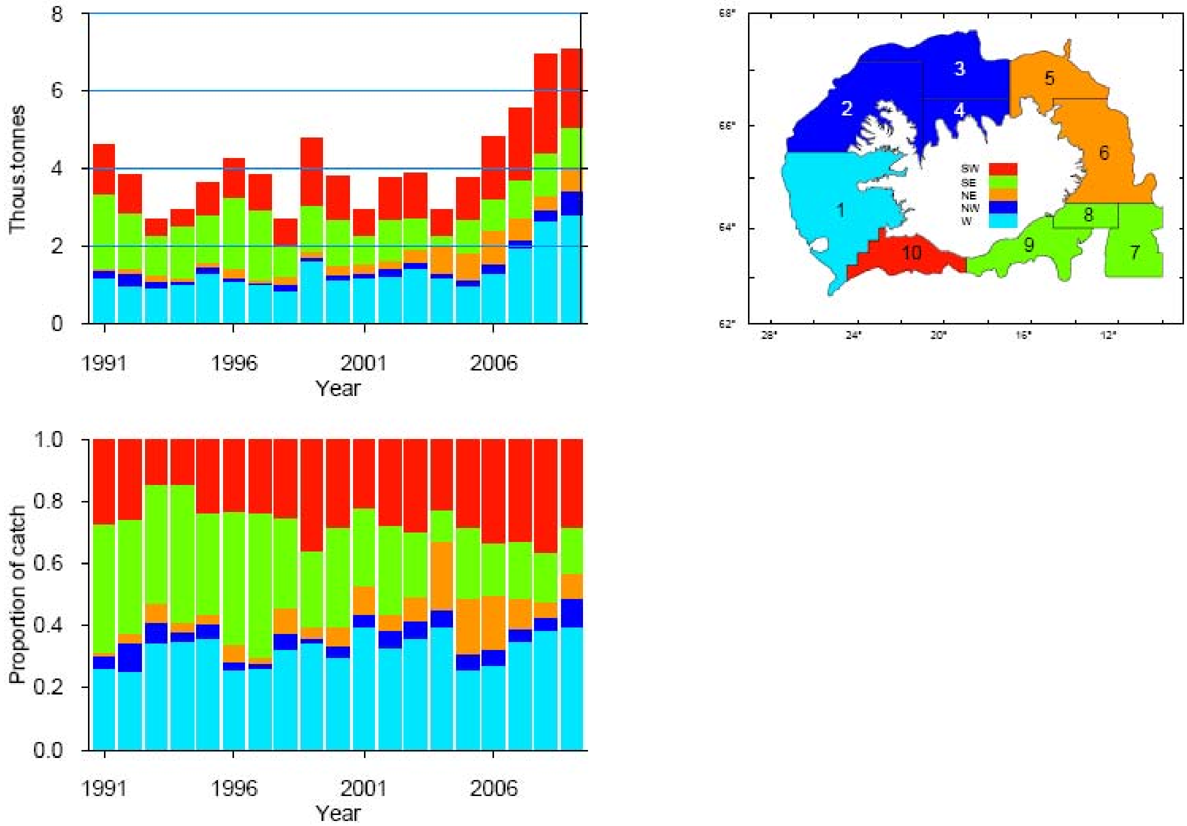

Figure AreaChange. Tusk in Va. Annual catch and proportional catches by Bormicon areas in 1991–2009.

Tusk is mainly caught at depths between 0 and 300 m (Figure **DepthDist**). In recent years, the proportion of tusk caught at depths greater than 600 m (usually between 600–750 m) has increased. The tusk fishery takes place more or less continuously throughout the whole year, although catches in April to June tend to be higher in recent years.

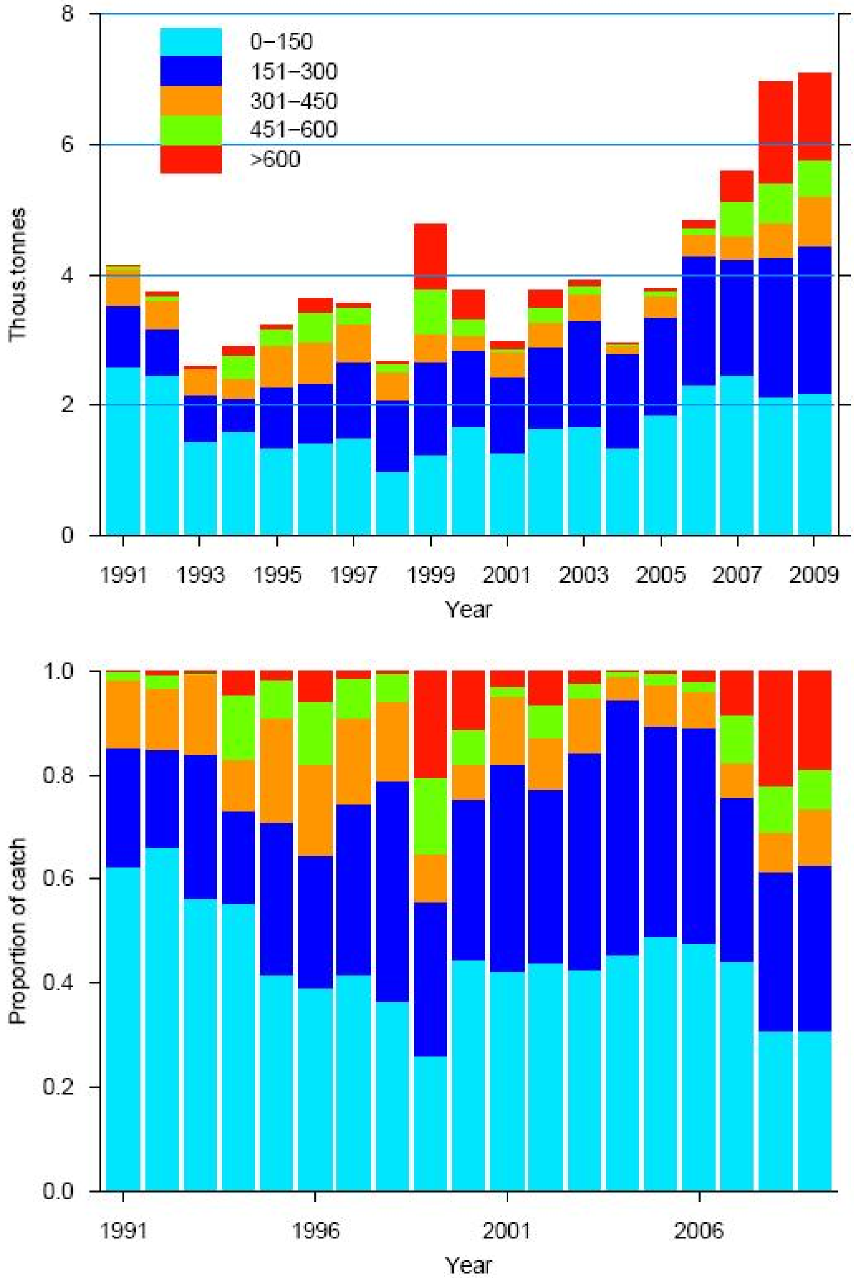

Figure DepthDist. Tusk in Va. Annual catch and proportional catches by depth in 1991–2009 based on logbooks.

4.5 Environmental drivers of stock dynamics

No evidence of environmental drivers was presented at this benchmark meeting. Such patterns should be considered in future.

4.6 Role of multispecies interactions

4.6.1 Trophic interactions

No data on trophic interactions was presented at the meeting and trophic interactions were not considered during the WKDEEP-meeting.

4.6.2 Fishery interactions

No data on fisheries interactions were presented at the meeting.

4.7 Impacts on the ecosystem

No ecosystem impacts were directly examined.

4.8 Stock assessment methods

4.8.1 Models

The Gadget assessment model (Begley and Howell, 2004; Frøysa *et al*. 2002) was selected for use in this assessment. This model is currently used for assessments of tiger prawns in Mozambique, and southern hake, redfish (experimental) and cod (auxiliary model) within ICES. Gadget is written in C++, running in UNIX, and is freely available for download (together with source code and full documentation) from http://www.hafro.is/gadget. This website is hosted by the Marine Research Institute of Iceland, and expected to remain online in the long term. Gadget is a tool for producing forward simulation age and size-based models, possibly including multispecies, multifleet or multi-area structure. Gadget has been designed to use a wide variety of assessment data structured by length and/or age. For this assessment length-structured data were used and the limited revised age estimations available from 1995 and 2009.

The model version used for this assessment is 2.1.06. Features of the model configuration included:

1) Quarterly time-steps.
2) One fishing fleet (longlineres)
3) Length disaggregated survey indices (10 cm increments) from the Icelandic groundfish survey in March 1985–2009.
4) Length distribution from the Icelandic commercial catch since 1979. The sampling effort was though relatively limited until the 1990s.
5) Landings data divided into four month periods per year (quarters).
6) Age–length keys and mean length-at-age from the Icelandic commercial fishery and surveys (1995 and 2009).
7) The annual recruitments are estimated for each year. No reliable spawner–recruit relationship exists, and no attempt was made to close the life cycle within the model. Instead the number of recruits was estimated within the model as the recruitment that produced the population that best fit the overall data.
8) Initial population by numbers was estimated for the initial population.
9) The growth was modelled as a von Bertanlanffy process.
10) The reported landings for the fleet were taken as exact and the model was set to match these catch sizes.
11) The selectivity pattern for the fishing fleet was calculated from the "Exponential L50" selectivity pattern within Gadget. This assumes an asymptotic selectivity, with all fish above a certain size being fully selected.
12) The survey is modelled as a fleet with constant effort and a nonparametric selection pattern that is estimated for each length group.
13) All catchabilities were assumed to be constant through time.

4.8.2 Sensitivity analysis

Due to time constrains no sensitivity analysis was done on the model setup but the following analysis will be conducted before WGDEEP 2010.

Likelihood profiling/sensitivity analysis: A sensitivity test on the optimized parameter set to examine if the model has reached an optimum. Each parameter is varied in turn by up to ±50%, with all other parameters remaining constant. The resulting sensitivity curves represent slices through the likelihood surface around the solution. This analysis provides evidence that the model has reached an optimum (although there is of course no guarantee that it has reached the global optimum).

Selectivity pattern: The choice of selectivity pattern for the commercial fleet may have large effects on the modelled population of tusk in Va. The sensitivity may arise because there is few data on large fish (>70 cm) in the population. Setting dome shaped selectivities for the commercial fishing may generate arbitrarily large populations of large old fish, because these would then never be caught in the fleet or the survey,

Natural mortality: In the gadget model presented at the WGDEEP meeting in 2009 M was set at 0.1. The Working Group thought that this value might be to low given the life history of the species. In light of these concerns and the age overestimation based on the otolith studies M was set at 0.2. Sensitivity testing on different values of M should be conducted.

Weighting of datasets: Assigning weights to the different datasets in the present run was done in an *ad hoc* manner. However more formal ways exists and have been used for the gadget model of southern hake. This should also be done for the tusk model.

4.8.3 Retrospective patterns

Retrospective patterns were not estimated due to time constrains. Each retrospective run requires re-optimization of the model.

4.8.4 Evaluation of the model

There appears to be considerable patterns in the residuals from the current model setup. These patterns are of concern and need to be addressed in future evaluations. Based on the limited evaluations of the model presented to the panel, the panel concluded that the model setup was a promising approach and after addressing the various points in Section 4.8.2 may be considered indicative of trends when giving advice on tusk in Va.

4.9 Stock assessment

The stock assessment in the current gadget setup is very uncertain due to the various reasons listed in previous sections. The assessment presented below should therefore not be taken at a face value but it may be indicative of trends. Due to lack of data estimates at the beginning of the time-series are highly uncertain.

The total biomass is estimated to have dropped by approximately 50% from the late sixties to the mid nineties (Figure **GadRes**). Since 2000 the stock biomass has increased to around 75% of the levels estimated in the late sixties. Harvestable biomass (the part of the stock available to the fishery given the selection curve estimated by gadget) follows a similar trajectory. Estimates of SSB (using a fixed length based maturity ogive) are similar to estimates of total- and harvestable biomass in the sense that SSB decreased more or less continuously since the late sixties, early seventies to the mid nineties. However the SSB has not increased at the same rate as the two other stock proxies and SSB is now estimated to be around 50% of the late sixties estimates (Figure **GadRes**). Estimates of fishing mortality indicate that fishing mortality has for most of the time-series been at around 2–3 times the assumed natural mortality of 0.2.

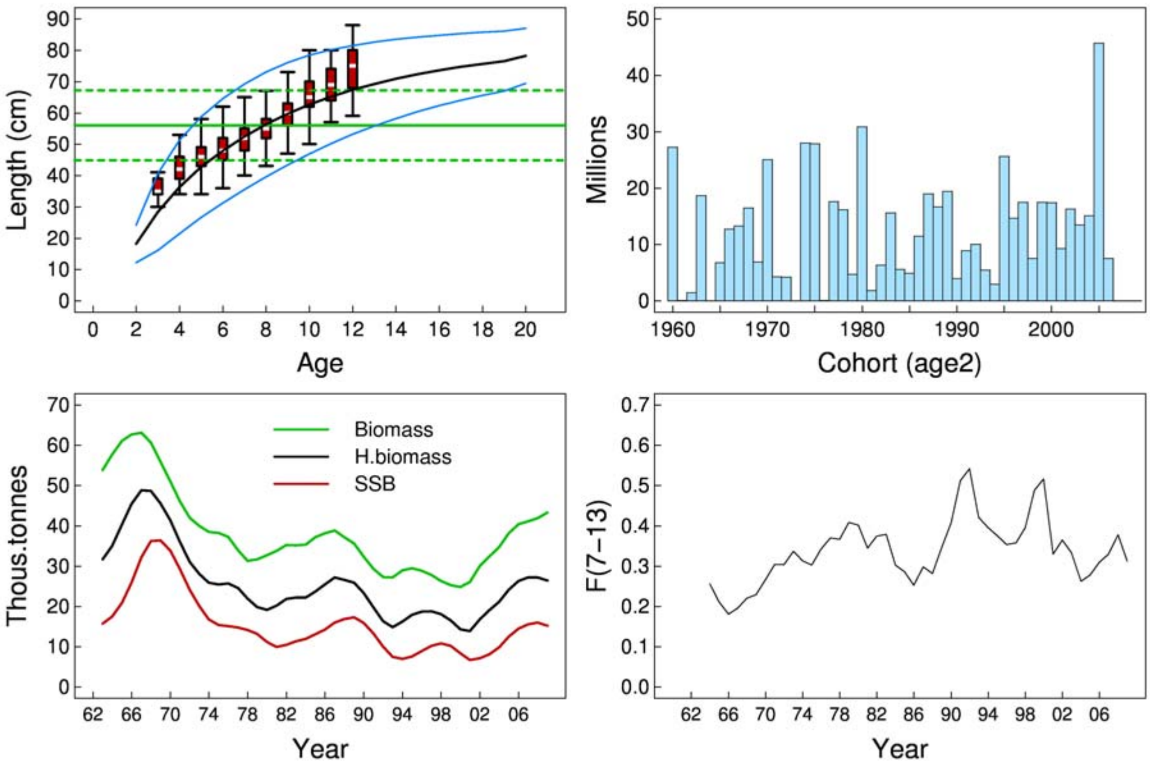

Figure GadRes. Results from gadget model for Tusk in Va. Top left: Estimated mean length-at-age from commercial catches (black line) and ± 2 x SE (blue lines). Boxplots are data from commercial catches in 1995 and 2009 with the maturity by length ogive as green lines (50% solid line, 25% and 75% as dotted lines). Top right: Recruitment-at-age 2. Bottom left: Trends in biomass, harvestable biomass and spawning-stock-biomass (SSB). Bottom right: Trends in fishing mortality (*$F_{7\text{-}13}$*).

4.10 Recruitment estimation

The yearly recruitment time-series is shown in Figure **GadRes**. Fluctuations appear to be without substantial trend until recent years, when several good recruitment years are modelled to have occurred.

4.11 Short-term and medium-term forecasts

Short and medium-term forecasts can be done using the current setup of the gadget model. The input parameters for the short forecast are described in the Stock Annex. However due to the fact that the model setup is not finalized at the Benchmark meeting, WKDEEP recommend that short-term forecast should further only be performed after further development of the assessment methodology. WKDEEP strongly recommend that those developments be performed in a near future in order to allow a future meeting to check assessment developments and run the short-term forecast.

4.12 Biological reference points

No suggestions for biological reference points were presented at the meeting.

4.13 Recommended modifications to the Stock Annex

No modifications on the Stock Annex are suggested as there was no annex in existence before this meeting.

4.14 Recommendations on the procedure for assessment updates

The procedure carried out within the Benchmark and described in the Stock Annex is considered to represent a promising approach to conducting update assessments for tusk in Va.

Because this is a new assessment using software that is new to the ICES arena, the current model configuration should be open to adjustment in subsequent assessment updates.

Adjustments that should be considered may include: introduction of some degree of time-varying selectivity to better account for trends in some remaining residual patterns and to consider appropriate weighting on the different datasets.

More substantial changes that could be considered would include more explicit treatment of the spatial pattern of the stock, fishery and surveys. Another possibility would be a disaggregation of the existing commercial fleet. Neither of these lists is meant to be prescriptive, development of the model should follow issues arising during research and assessment on this stock.

4.15 Industry supplied data

No data were supplied from the industry on tusk in Va.

4.16 References

Frøysa, K. G., Bogstad, B., and Skagen, D. W. 2002. Fleksibest-an age–length structured fish stock assessment tool with application to Northeast Arctic cod (*Gadus morhua* L.). Fisheries Research, 55: 87–101.

Stock Annex: Tusk in ICES Division Va and XIV

Stock	Tusk (Division Va)
Working Group	WKDEEP
Date	February 2010
Revised by	Kristjan Kristinsson, Gudmundur Thordarson

A. General

A.1. Stock definition

Tusk in Icelandic and Greenland waters (ICES Divisions Va and XIV respectively) is considered as one stock unit and is separated from the tusk found on the mid-Atlantic Ridge, on Rockall (VIb), and in Divisions I and II. This stock discrimination is based on genetic investigation (Knutsen *et al*., 2009) and was reviewed at the WGDEEP meeting in 2007.

A.2. Fishery

The tusk in ICES Division Va is mainly caught by Iceland (75—85% of the total annual catches in recent years), but the Faroe Islands and Norway also important fishing nations. Foreign catches of tusk in Va, mainly conducted by the Faroese fleet, has always been considerable but have decreased since 1990, whereas the Icelandic catches have increased.

Over 95% of the Icelandic tusk catch in Va comes from longliners and mainly caught as either bycatch in other fisheries or in mixed fishery. The Icelandic longline fleet mainly targets cod and haddock where tusk is often caught as bycatch. The directed fishery for tusk has traditionally been little but has increased in recent years. Tusk is then often caught with ling and blue ling along the south and southwest coast of Iceland.

In recent years between 150–250 longliners have annually reported tusk catches, whereof 80–85% have been caught by about 20–25 vessels (annual catch of each vessel from about 50 tonnes up to 800 tonnes).

Since 1991, 60–80% of the catches have been taken within the depth range of 100–300 m, with 80–95% of the catches taken at depth less than 400 m. In some years, about 20% of the annual tusk catch has been taken at depths between 600–700 m.

The longline fleet in Icelandic waters is composed of both small boats (<10 GRT) operating in shallow waters as well as much larger vessels operating in deeper waters. Cod and haddock are the main target species of this fleet but tusk, ling and blue ling are also caught, sometimes in directed fisheries. The 10 longline vessels that fish about 65% of the total tusk catch in Va are vessels between 300–600 GRT.

Tusk fishery in ICES Division XIV has traditionally been very little, with less than 100 t caught annually. The tusk is caught as bycatch in other fisheries.

A.3. Ecosystem aspects

Tusk in Icelandic waters is mainly found on the continental shelf and slopes of southeast, south, and west of Iceland at depths of 0–1000 m, but mainly at depths between 100–500 m.

A.4. Management

The Ministry of Fisheries is responsible for management of the Icelandic fisheries and implementation of the legislation. The Ministry issues regulations for commercial fishing for each fishing year, including an allocation of the TAC for each of the stocks subject to such limitations. Below is a short account of the main feature of the management system and where applicable emphasis will be put on tusk.

A system of transferable boat quotas was introduced in 1984. The agreed quotas were based on the Marine Research Institute's TAC recommendations, taking some socio-economic effects into account, as a rule to increase the quotas. Until 1990, the quota year corresponded to the calendar year but since then the quota, or fishing year, starts on September 1 and ends on August 31 the following year. This was done to meet the needs of the fishing industry. In 1990, an individual transferable quota (ITQ) system was established for the fisheries and they were subject to vessel catch quotas. The ITQ system allows free transferability of quota between boats. This transferability can either be on a temporary (one year leasing) or a permanent (permanent selling) basis. This system has resulted in boats having quite diverse species portfolios, with companies often concentrating/specializing on particular group of species. The system allows for some but limited flexibility with regards converting a quota share of one species into another within a boat, allowance of landings of fish under a certain size without it counting fully in weight to the quota, and allowance of transfer of unfished quota between management years. The objective of these measures is to minimize discarding, which is effectively banned. Since 2006/2007 fishing season, all boats operate under the TAC system.

At the beginning, only few commercial exploited fish species were included in the ITQ system, but many other species have gradually been included. Tusk was included into the ITQ system in the 2001/2002 quota year.

Landings in Iceland are restricted to particular licensed landing sites, with information being collected on a daily basis time by the Directorate of Fisheries in Iceland (the enforcement body). All fish landed has to be weighted, either at harbour or inside the fish processing factory. The information on each landing is stored in a centralized database maintained by the Directorate and is available in real time on the Internet (www.fiskistofa.is). The accuracy of the landings statistics are considered reasonable.

All boats operating in Icelandic waters have to maintain a logbook record of catches in each haul/set. The records are available to the staff of the Directorate for inspection purposes as well as to the stock assessors at the Marine Research Institute.

With some minor exceptions it is required by law to land all catches. Consequently, no minimum landing size is in force. To prevent fishing of small fish various measures such as mesh size regulation and closure of fishing areas are in place.

A system of instant area closure is in place for many species, including tusk. The aim of the system is to minimize fishing on juveniles. For tusk, an area is closed temporarily (for 2 weeks) for fishing if on-board inspections (not 100% coverage) reveal that more than 25% of the catch is composed of fish less than 55 cm in length. Because tusk is often bycatch in other fisheries, this rule does only apply when the tusk catch is more than 30% of the total catch in a set/haul. Because of repeated instant area closures off the south and southeast coast of Iceland in 2003, four areas were closed permanently for longline fishery in order to protect juvenile tusk (Figure 1).

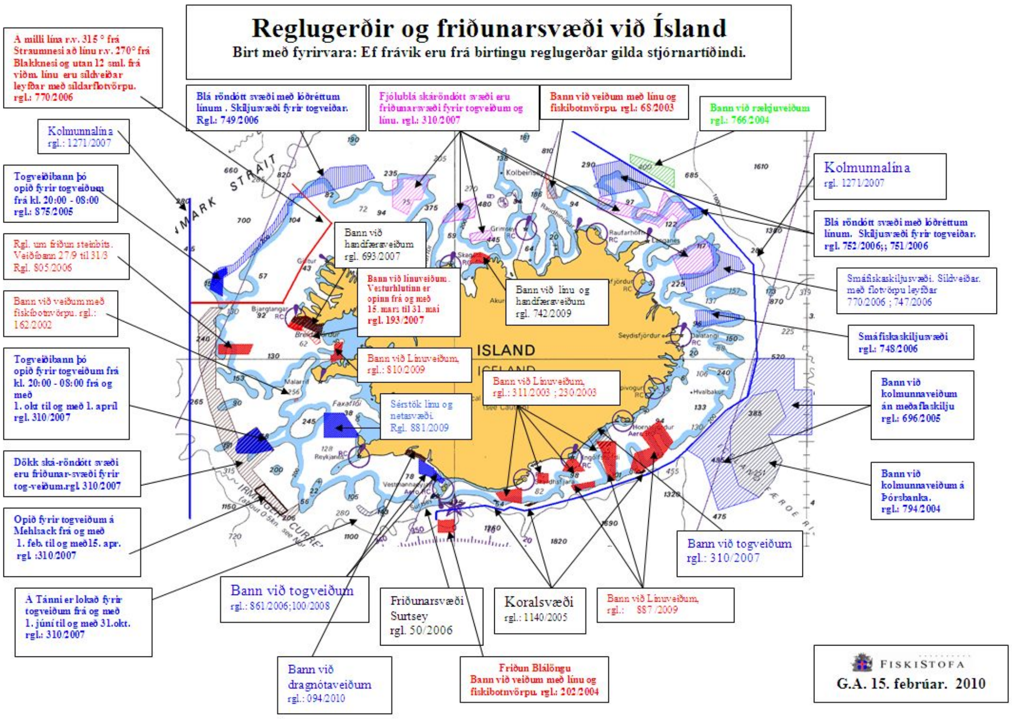

Figure 1. Marine protected areas in Icelandic waters. These areas are closed for various types of fisheries and may be closed permanently (all year around) or temporarily (closed part of the years. Four areas marked red south and southeast of Iceland (reference to the box *Bann við Línu-veiðum, rgl: 311/2003; 230/2003*) are areas permanently closed for longline fisheries in order to protect juvenile tusk. Trawling does not occur within these areas. Figure provided by Directorate of Fisheries in Iceland.

B. Data

B.1. Commercial catch

Landings and discards

The text Table below shows which data from landings is supplied from ICES Division Va.

ICES Division Va	Kind of data				
Country	Caton (Catch in weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition in catch
Iceland	x	Two years	Two years		x
The Faroe Islands	x				x
Norway	x				

Icelandic tusk catch in tonnes by month, area and gear are obtained from Statistical Iceland and Directorate of Fisheries. Catches are only landed in authorized ports where all catches are weighed and recorded. The distribution of catches is obtained from logbook statistic where location of each haul, effort, depth of trawling and total catch of tusk is given. Logbook statistics are available since 1991. Landings of Norwegian and Faroese vessels are given by the Icelandic Coast Guard and reported to the Directorate of Fisheries.

Discard is banned in the Icelandic demersal fishery and there is no information available on possible discard of tusk.

B.2. Biological

Biological data from the commercial longline catch are collected from landings by scientists and technicians of the Marine Research Institute (MRI) in Iceland. The biological data collected are length (to the nearest cm), sex and maturity stage (if possible because most tusk is landed gutted), and otoliths for age reading. Most of the fish that otoliths were collected from were also weighted (to the nearest gramme). Biological sampling is also collected directly on board on the commercial vessels during trips by personnel of the Directorate of Fisheries in Iceland or from landings (at harbour). These are only length samples.

The general process of the sampling strategy is to take one sample of tusk for every 180 tonnes landed. This means that between 30–40 samples are taken from the commercial longline catch each year. Each sample consists of 150 fish. Otoliths are extracted from 50 fish which are also length measured and weighed gutted. In most cases the tusk is landed gutted so it not possible to determine sex and maturity. If tusk is landed un-gutted, the un-gutted weight is measured and the fish is sex and maturity determined. The remaining 100 in the sample are only length measured.

Age reading of tusk from the commercial catch is not done on regular basis and otoliths from only two years have been age read.

Earlier observations indicates that tusk becomes mature-at-age of about 8–10 years or at around the length of 56 cm. However, new ageing of tusk otoliths from 1995 and 2009 suggest that tusk grows considerably faster than previously assumed. The new age-readings are considered more plausible than the older estimates as they results in more similar estimates of growth of tusk in Va as has been reported in other management units.

The mean length-at-maturity is close to the mean length of tusk in the commercial catches. This means that a large proportion of the tusk is caught as immature.

No estimates of natural mortality are available for tusk in Va and XIV. In the Gadget model (see below) natural mortality is assumed to be 0.2 year^{-1}.

The biological data from the fishery is stored in a database at the Marine Research Institute. The data are used for description of the fishery and as input data for the GADGET model.

B.3. Surveys

Iceland

Two bottom-trawl surveys, conducted by the Marine Research Institute in Va, are considered representative for tusk are the Icelandic Groundfish Survey (IGS or the Spring Survey) and the Autumn Groundfish Survey (AGS or the Autumn Survey) The Spring Survey has been conducted annually in March since 1985 on the continental shelf at depths shallower than 500 m and has a relatively dense station-net (approx. 550 stations). The Autumn Survey has been conducted in October since 1996 and covers larger area than the Spring Survey. It is conducted on the continental shelf and slopes and extends to depths down to 1500 m. The number of stations is about 380 so the distance between stations is often greater. The main target species in the Autumn Survey are Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*).

The text in the following description of the surveys is mostly a translation from Björnsson *et al*. (2007). Where applicable the emphasis has been put on tusk.

B.3.1. Spring survey in Va

From the commencing of the Spring Survey the stated aim has been to estimate abundance of demersal fish stocks, particularly the cod stock with increased accuracy and thereby strengthening the scientific basis of fisheries management. That is, to get fisheries independent estimates of abundance that would result in increased accuracy in stock assessment relative to the period before the Spring Survey. Another aim was to start and maintain dialogue with fishermen and other stakeholders.

To help in the planning, experienced captains were asked to map out and describe the various fishing grounds around Iceland then they were asked to choose half of the tow-stations taken in the survey. The other half was chosen randomly.

B.3.1.1. Timing, area covered and tow location

It was decided that the optimal time of the year to conduct the survey would be in March, or during the spawning of cod in Icelandic waters. During this time of the year, cod is most easily available to the survey gear as diurnal vertical migrations are at minimum in March (Pálsson, 1984). Previous survey attempts had taken place in March and for possible comparison with that data it made sense to conduct the survey in March.

The total number of stations was decided to be 600 (Figure 2). The reason of having so many stations was to decrease variance in indices but was inside the constraints of what was feasible in terms of survey vessels and workforce available. With 500–600 tow-stations the expected CV of the survey would be around 13%.

The survey covers the Icelandic continental shelf down to 500 m and to the EEZ-line between Iceland and Faroe Islands. Allocation of stations and data collection is based on a division between Northern and Southern areas. The Northern area is the colder part of Icelandic waters where the main nursery grounds of cod are located, whereas the main spawning grounds are found in the warmer Southern area. It was assumed that 25–30% of the cod stock (in abundance) would be in the southern area at the survey time but 70–75% in the north. Because of this, 425 stations were allocated in the colder northern area and 175 stations were allocated in the southern area. The two areas were then divided into ten strata, four in the south and six in the north.

Stratification in the survey and the allocation of stations was based on pre-estimated cod density patterns in different "statistical squares" (Palsson *et al*., 1989). The statistical squares were grouped into ten strata depending on cod density. The number of stations allocated to each stratum was in proportion to the product of the area of the stratum and cod density. Finally the number of stations within each stratum was allocated to each statistical square in proportion to the size of the square. Within statistical squares, stations were divided equally between fishermen and fishery scientist at the MRI for decisions of location. The scientist selected random position for their stations, whereas the fishermen selected their stations from their fishing experience. Up to 16 stations are in each statistical square in the Northern area and up to seven in the Southern are. The captains were asked to decide the towing direction for all the stations.

B.3.1.2. Vessels, fishing gear and fishing method

In the early stages of the planning it was apparent that consistency in conducting the survey on both spatial and temporal scale was of paramount importance. It was decided to rent commercial stern trawlers built in Japan in 1972–1973 to conduct the survey. Each year, up to five trawlers have participated in the survey each in a dedicated area (NW, N, E, S, SW). The ten Japan-built trawlers were all build on the same plan and were considered identical for all practical purposes. The trawlers were thought to be in service at least until the year 2000. This has been the case and most of these trawlers still fish in Icelandic waters but have had some modifications since the start of the survey, most of them in 1986–1988.

The survey gear is based on the trawl that was the most commonly used by the commercial trawling fleet in 1984–1985. It has relatively small vertical opening of 2–3 m. The headline is 105 feet, fishing line is 63 feet, footrope 180 feet and the trawl weight 4200 kg (1900 kg submerged).

Length of each tow was set 4 nautical miles and towing speed at approx. 3.8 nautical miles per hour. Minimum towing distance so that the tow is considered valid for index calculation is 2 nautical miles. Towing is stopped if wind is more than 17–21 m/sec, (8 on Beaufort scale).

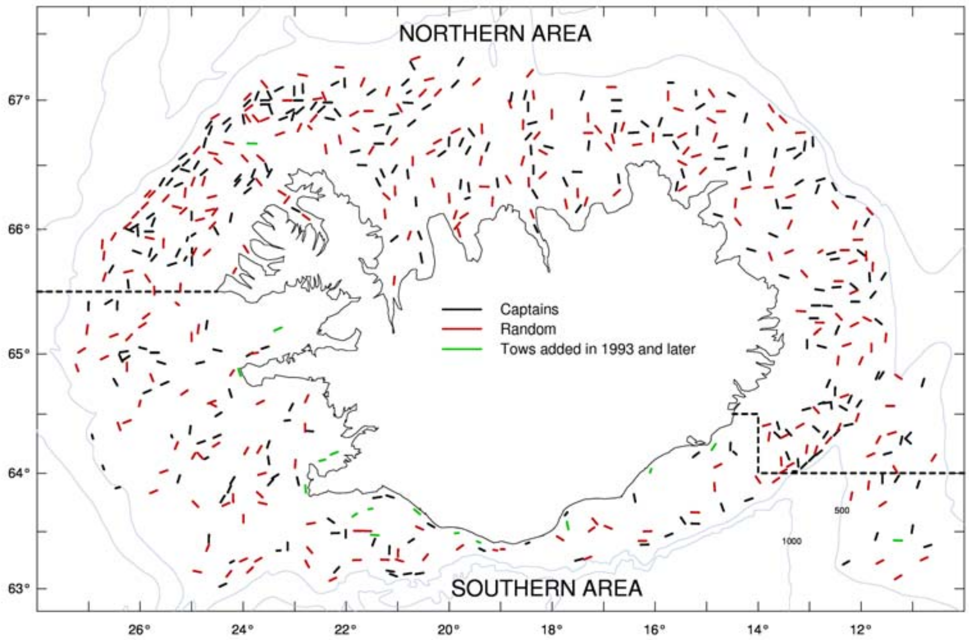

Figure 2. Stations in the Spring Survey in March. Black lines indicate the tow-stations selected by captains of commercial trawlers, red lines are the tow-stations selected randomly, and green lines are the tow-stations that were added in 1993 or later. The broken black lines indicate the original division of the study area into Northern and Southern area. The 500 and 1000 m depth contours are shown.

B.3.1.3. Later changes in vessels and fishing gear

The trawlers used in the survey have been changed somewhat since the beginning of the survey. The changes include alteration of hull shape (bulbous bow), the hull extended by several meters, larger engines, and some other minor alterations. These alterations have most likely changed the qualities of the ships but it is very difficult to quantify these changes.

The trawlers are now considered old and it is likely that they will soon disappear from the Icelandic fleet. Some search for replacements is ongoing. In recent years, the

MRI research vessels have taken part in the Spring Survey after elaborate comparison studies. The RV Bjarni Sæmundsson has surveyed the NW-region since 2007 and RV Árni Friðriksson has surveyed the Faroe-Iceland ridge in recent years and will in 2010 survey the SW-area.

The trawl has not changed since the start of the survey. The weight of the otter-boards has increased from 1720–1830 kg to 1880–1970 kg. The increase in the weight of the otter-boards may have increased the horizontal opening of the trawl and hence decreased the vertical opening. However, these changes should be relatively small as the size (area) and shape of the otter-boards is unchanged.

B.3.1.4. Later changes in trawl-stations

Initially, the numbers of trawl stations surveyed was expected to be 600 (Figure 2). However, this number was not covered until 1995. The first year 593 stations were surveyed but in 1988 the stations had been decreased down to 545 mainly due to bottom topography (rough bottom that was impossible to tow), but also due to drift ice that year. In 1989–1992, between 567 and 574 stations were surveyed annually. In 1993, 30 stations were added in shallower waters as an answer to fishermen's critique.

In short, until 1995 between 596 and 600 stations were surveyed annually. In 1996 14 stations that were added in 1993 were omitted. Since 1991 additional tows have been taken at the edge of the survey area if the amount of cod has been high at the outermost stations.

In 1996, the whole survey design was evaluated with the aim of reduce cost. The number of stations was decreased to 532 stations. The main change was to omit all of the 24 stations from the Iceland-Faroe Ridge. This was the state of affairs until 2004 when in response to increased abundance of cod on the Faroe-Iceland ridge 9 stations were added. Since 2005 all of the 24 stations omitted in 1996 have been surveyed each year.

In the early 1990s there was a change from Loran C positioning system to GPS. This may have slightly changed the positioning of the stations as the Loran C system was not as accurate as the GPS.

B.3.2. Autumn survey in Va

The Icelandic Autumn Survey has been conducted annually since 1996 by the MRI. The objective is to gather fishery-independent information on biology, distribution and biomass of demersal fish species in Icelandic waters, with particular emphasis on Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*). This is because the Spring Survey does not cover the distribution of these deep-water species. Secondary aim of the survey is to have another fishery-independent estimate on abundance, biomass and biology of demersal species, such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and golden redfish (*Sebastes marinus*), in order to improve the precision of stock assessment.

B.3.2.1. Timing, area covered and tow location

The Autumn Survey is conducted in October as it is considered the most a suitable month in relation to diurnal vertical migration, distribution and availability of Greenland halibut and deep-sea redfish. The research area is the Icelandic continental shelf and slopes within the Icelandic Exclusive Economic Zone to depths down to 1500 m. The research area is divided into a shallow-water area (0–400 m) and a deep-water area (400–1500 m). The shallow-water area is the same area covered in the

Spring Survey. The deep-water area is directed at the distribution of Greenland halibut, mainly found at depths from 800–1400 m west, north and east of Iceland, and deep-water redfish, mainly found at 500–1200 m depths southeast, south and southwest of Iceland and on the Reykjanes Ridge.

B.3.2.2. Preparation and later alterations to the survey

Initially, in all 430 stations were divided between the two areas. Of them, 150 stations were allocated to the shallow-water area and randomly selected from the Spring Survey station list. In the deep-water area, half of the 280 stations were randomly positioned in the area. The other half were randomly chosen from logbooks of the commercial bottom-trawl fleet fishing for Greenland halibut and deep-water redfish in 1991–1995. The locations of those stations were, therefore, based on distribution and pre-estimated density of the species.

Because MRI was not able to finance a project in order of this magnitude, it was decided to focus the deep-water part of the survey on the Greenland halibut main distributional area. For this reason, important deep-water redfish areas south and west of Iceland were omitted. The number and location of stations in the shallow-water area were unchanged.

The number of stations in the deep-water area was therefore reduced to 150. In all 100 stations were randomly positioned in the area. The remaining stations were located on important Greenland halibut fishing grounds west, north and east of Iceland and randomly selected from a logbook database of the bottom-trawl fleet fishing for Greenland halibut 1991–1995. The number of stations in each area was partly based on total commercial catch.

In 2000, with the arrival of a new research vessel, MRI was able finance the project according to the original plan. Stations were added to cover the distribution of deep-water redfish and the location of the stations selected in a similar manner as for Greenland halibut. In all 30 stations were randomly assigned to the distribution area of deep-water redfish and 30 stations were randomly assigned to the main deep-water redfish fishing grounds based on logbooks of the bottom-trawl fleet 1996–1999.

In addition, 14 stations were randomly added in the deep-water area in areas where great variation had been observed in 1996–1999. However, because of rough bottom which made it impossible to tow, five stations have been omitted. Finally, 12 stations were added in 1999 in the shallow-water area, making total stations in the shallow-water area 162. Total number of stations taken since 2000 has been around 381 (Figure 3).

The RV "Bjarni Sæmundsson" has been used in the shallow-water area from the beginning of the survey. For the deep-water area MRI rented one commercial trawler 1996–1999, but in 2000 the commercial trawler was replaced by the RV "Árni Friðriksson".

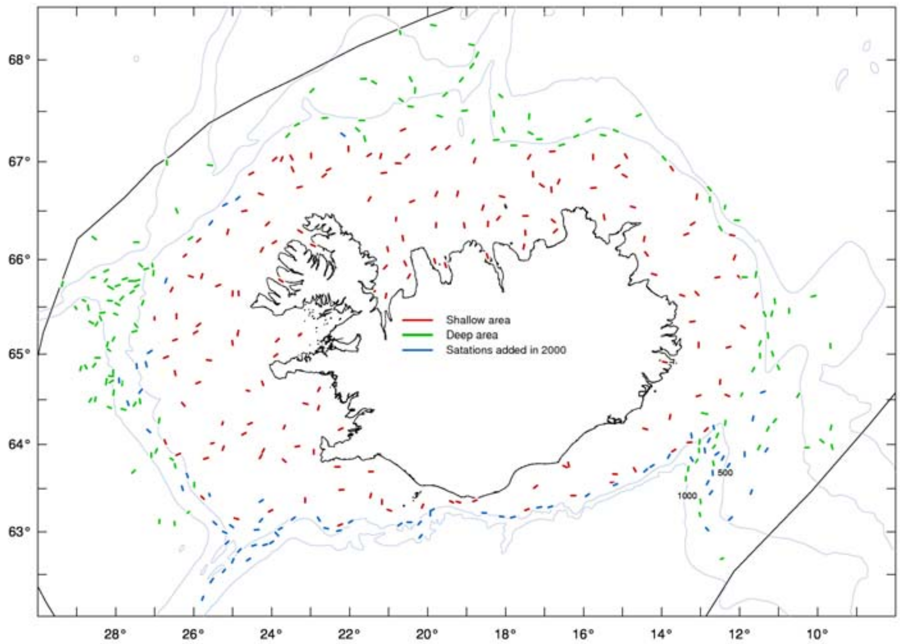

Figure 3. Stations in the Autumn Groundfish Survey (AGS). RV "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and RV "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

B.3.2.3. Fishing gear

Two types of the bottom survey trawl "Gulltoppur" are used for sampling: "Gulltoppur" is used in the shallow water and "Gulltoppur 66.6m" is used in deep waters. The trawls were common among the Icelandic bottom-trawl fleet in the mid 1990s and are well suited for fisheries on cod, Greenland halibut and redfish.

"Gulltoppur", the bottom trawl used in the shallow water, has a headline of 31.0 m, and the fishing line is 19.6 m. The deep-water trawl, "Gulltoppur 66.6m" has a headline of 35.6 m and the fishing line is 22.6 m.

The towing speed is 3.8 knots over the bottom. The trawling distance is 3.0 nautical miles calculated with GPS when the trawl touches the bottom until the hauling begins (i.e. excluding setting and hauling of the trawl).

B.3.3. Data sampling

The data sampling in the Spring and Autumn surveys is quite similar. In short there is more emphasis on stomach content analysis in the Autumn Survey than the Spring Survey. For tusk, the sampling procedure is the same in both surveys except tusk is weighed un-gutted and stomach content analysed in the Autumn survey.

B.3.3.1. Length measurements and counting

All fish species are measured for length. For the majority of species including tusk, total length is measured to the nearest cm from the tip of the snout to the tip of the longer lobe of the caudal fin. At each station, the general rule, which also applies to tusk, is to measure at least 4 times the length interval of a given species. Example: If the continuous length distribution of tusk at a given station is between 15 and 45 cm, the length interval is 30 cm and the number of measurements needed is 120. If the catch of tusk at this station exceeds 120 individuals, the rest is counted.

Care is taken to ensure that the length measurement sampling is random so that the fish measured reflect the length distribution of the haul in question.

B.3.3.2. Recording of weight, sex and maturity stages

Sex and maturity data has been sampled for tusk from the start of both surveys. Tusk is weighted as un-gutted in the Autumn Survey.

B.3.3.3. Otolith sampling

For tusk a minimum of one otolith in the Spring and Autumn Surveys is collected and a maximum of 25. Otoliths are sampled at a four fish interval so that if in total 40 tusks are caught in a single haul, 10 otoliths are sampled.

B.3.3.4. Stomach sampling and analysis

Stomach samples of tusk are routinely sampled in the Autumn Survey.

B.3.3.5. Information on tow, gear and environmental factors

At each station/haul relevant information on the haul and environmental factors, are filled out by the captain and the first officer in cooperation with the cruise leader.

Tow information

- **General:** Year, Station, Vessel registry no., Cruise ID, Day/month, Statist. Square, Sub-square, Tow number, Gear type no., Mesh size, Briddles length (m).
- **Start of haul:** Pos. N, Pos. W, Time (hour:min), Tow direction in degrees, Bottom depth (m), Towing depth (m), Vert. opening (m), Horizontal opening (m).
- **End of haul:** Pos. N, Pos. W, Time (hour:min), Warp length (fm), Bottom depth (m), Tow length (naut. miles), Tow time (min) , Tow speed (knots).
- **Environmental factors:** Wind direction, Air temperature °C, Wind speed, Bottom temperature °C, Sea surface, Surface temperature °C, Towing depth temperature °C, Cloud cover, Air pressure, Drift ice.

Greenland

Two research vessel series from Greenland waters are conducted annually, but very little tusk is caught.

B.3.2.4. Data processing

B.3.2.4.1. Abundance and biomass estimates at a given station

As described above the normal procedure is to measure at least 4 times the length interval of a given species. The number of fish caught of the length interval L_1 to L_2 is given by:

$$P = \frac{n_{measured}}{n_{counted} + n_{measured}}$$

$$n_{L_1 - L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i}{P}$$

Where $n_{measured}$ is the number of fished measured and $n_{counted}$ is the number of fish counted.

Biomass of a given species at a given station is calculated as:

$$B_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i \alpha L_i^{\beta}}{P}$$

Where Li is length and alpha and beta are coefficients of the length–weight relationship.

B.3.2.4.2. Index calculation

For calculation of indices the Cochran method is used (Cochran, 1977). The survey area is split into subareas or strata and an index for each subarea is calculated as the mean number in a standardized tow, divided by the area covered multiplied with the size of the subarea. The total index is then a summed up estimates from the subareas.

A 'tow-mile' is assumed to be 0.00918 square nautical mile. That is the width of the area covered is assumed to be 17 m (17/1852=0.00918). The following equations are a mathematical representation of the procedure used to calculate the indices:

$$I_{strata} = \frac{\sum_{strata} Z_i}{N_{strata}}$$

$$\sigma^2_{strata} = \frac{\sum_{strata} (Z_i - I_{strata})^2}{N_{strata} - 1}$$

$$I_{region} = \sum_{region} I_{strata}$$

$$\sigma^2_{strata} = \sum_{region} \sigma^2_{strata}$$

$$CV_{region} = \frac{\sigma_{region}}{I_{region}}$$

Where *strata* refers to the subareas used for calculation of indices which are the smallest components used in the estimation, *I* refers to the stations in each subarea and region is an area composed of 2 or more subareas. *Zi* is the quantity of the index (abundance or biomass) in a given subarea. *I* is the index and sigma is the standard deviation of the index. CV refers to the coefficient of variation.

The subareas or strata used in the Icelandic groundfish surveys (same strata division in both surveys) are shown in Figure 3. The division into strata is based on the so-called BORMICON areas and the 100, 200, 400, 500, 600, 800 and 1000 m depth contours.

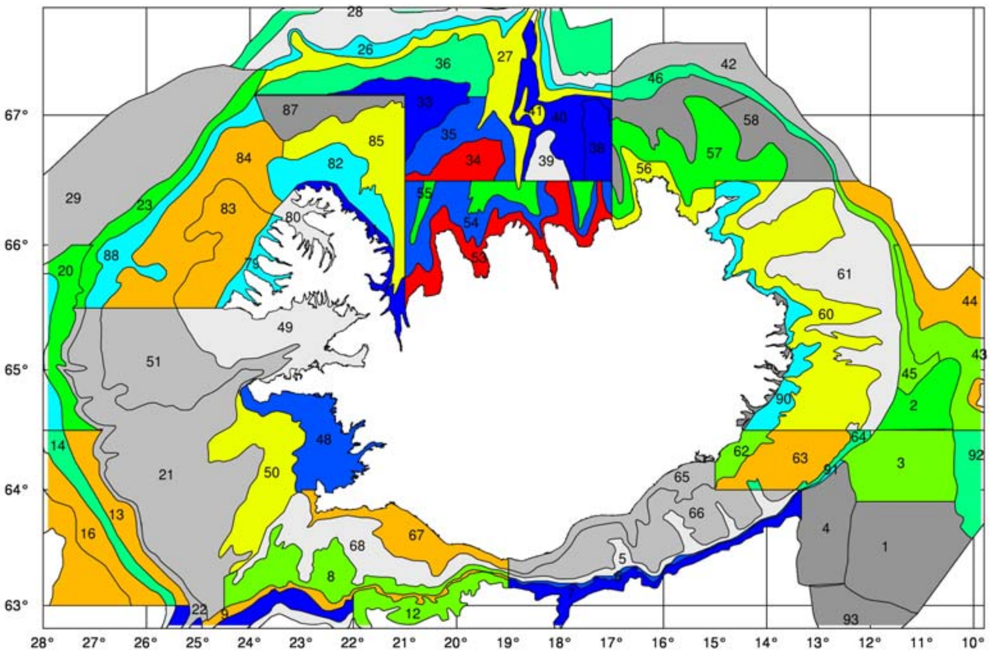

Figure 3. Subareas or strata used for calculation of survey indices in Icelandic waters.

B.4. Commercial cpue

Data used to estimate cpue for tusk in Division Va since 1991 were obtained from logbooks of the Icelandic longline fleet. Only sets were used where catches of tusk was registered, but also for sets where tusk constituted tom more than 10% and 30% of the catch.

Non-standardized cpue and effort is calculated for each year which is simply the sum of all catch divided by the sum of number of hooks.

B.5. Other relevant data

No other relevant data available.

C. Historical stock development

C.1. Description of gadget

Gadget is shorthand for the "Globally applicable Area Disaggregated General Ecosystem Toolbox", which is a statistical model of marine ecosystems. Gadget (previously known as BORMICON and Fleksibest). Gadget is an age–length structured forward-simulation model, coupled with an extensive set of data comparison and optimization routines. Processes are generally modelled as dependent on length, but age is tracked in the models, and data can be compared on either a length and/or age scale. The model is designed as a multi-area, multi-area, multifleet model, capable of including predation and mixed fisheries issues; however it can also be used on a single species basis. Gadget models can be both very data- and computationally intensive, with optimization in particular taking a large amount of time. Worked examples, a detailed manual and further information on Gadget can be found on www.hafro.is/gadget. In addition the structure of the model is described in Björnsson and Sigurdsson (2004), Begley and Howell (2004), and a formal mathematical description is given in Frøysa *et al*. (2002).

Gadget is distinguished from many stock assessment models used within ICES (such as XSA) in that Gadget is a forward simulation model, and is structured be both age and length. It therefore requires direct modelling of growth within the model. An important consequence of using a forward simulation model is that the plus groups (in both age and length) should be chosen to be large enough that they contain few fish, and the exact choice of plus group does not have a significant impact on the model.

Setup of a Gadget run

There is a separation of model and data within Gadget. The simulation model runs with defined functional forms and parameter values, and produces a modelled population, with modelled surveys and catches. These surveys and catches are compared with the available data to produce a weighted likelihood score. Optimisation routines then attempt to find the best set of parameter values. Growth is modelled by calculating the mean growth for fish in each length group for each time-step, using a parametric growth function. In the tusk model a von Bertanlanffy function has been employed to calculate this mean growth. The actual growth of fish in a given length cell is then modelled by imposing a beta-binomial distribution around this mean growth. This allows for the fish to grow by varying amounts, while preserving the calculated mean. The beta-binomial is described in Stefansson (2001). The beta-binomial distribution is constrained by the mean (which comes from the calculated mean growth), the maximum number of length cells a fish can grow in a given time-step (which is set based on expert judgement about the maximum plausible growth), and a parameter β, which is estimated within the model. In addition to the spread of growth from the beta-binomial distribution, there is a minimum to this spread due by discretization of the length distribution.

Catches

All catches within the model are calculated on length, with the fleets having size-based catchability. This imposes a size-based mortality, which can affect mean weight and length-at-age in the population (Kvamme, 2005). A fleet (or other preditor) is modelled so that either the total catch in each area and time interval is specified, or the catch per time-step is estimated. In the hake assessment described here the commercial catch and the discards are set (in kg per quarter), and the surveys are modelled as fleets with small total landings. The total catch for each fleet for each quarter is then allocated among the different length categories of the stock according to their abundance and the catchability of that size class in that fleet.

Likelihood data

A significant advantage of using an age–length structured model is that the modelled output can be compared directly with a wide variety of different data sources. It is not necessary to convert length into age data before comparisons. Gadget can use various types of data that can be included in the objective function. Length distributions, age–length keys, survey indices by length or age, cpue data, mean length and/or weight-at-age, tagging data and stomach content data can all be used. Importantly this ability to handle length date directly means that the model can be used for stocks such as hake where age data are sparse or considered unreliable. Length data can be used directly for model comparison. The model is able to combine a wide selection of the available data by using a maximum likelihood approach to find the best fit to a weighted sum of the datasets.

Optimisation

The model has two alternative optimizing algorithms linked to it, a wide area search simulated annealing Corona *et al*. (1987) and a local search Hooke and Jeeves algorithm HookeJeeves1961. Simulated annealing is more robust than Hooke and Jeeves and can find a global optima where there are multiple optima but needs about 2–3 times the order of magnitude number of iterations than the Hooke and Jeeves algorithm. The model is able to use both in a single run optimization, attempting to utilize the strengths of both. Simulated annealing is used first to attempt to reach the general area of a solution, followed by Hooke and Jeeves to rapidly home in on the local solution. This procedure is repeated several times to attempt to avoid converging to a local optimum. The algorithms are not gradient based, and there is therefore no requirement on the likelihood surface being smooth. Consequently neither of the two algorithms returns estimates of the Hessian.

Likelihood weighting

The total objective function to be minimized is a weighted sum of the different components. Selection of the weights is based on expert knowledge of the quality of the data and the space-time coverage of each dataset.

Finding these weights is a lengthy procedure, but it does not generally need to be repeated for each assessment. Rather, the current weights can be used for several years. The weighted contribution of the datasets in a new assessment should be computed, and compared with the previous year. Provided the relative contributions are similar then the model results should be comparable between years.

C.2. Settings for the tusk assessment

Population is defined by 10 cm length groups, from 20–110 cm and the year is divided into four quarters. The age range is 2 to 20 years, with the oldest age treated as a plus group. Recruitment happens in the first and was set at age 2. The length-at-recruitment is estimated and mean growth is assumed to follow the von Bertalanffy growth function estimated by the model.

Weight Length relationship is obtained from spring survey data.

Natural mortality was assumed to be 0.2 $year^{-1}$. However different values of M are tested (0.1 and 0.3)

The commercial landings are modelled as one fleet (1980–2009) with a selection pattern described by a logistic function and the total catch in tonnes specified for each quarter. The survey (1985–2009), on the other hand is modelled as one fleet with constant effort and a nonparametric selection pattern that is estimated for each length group (one 10 cm length group).

Data used for the assessment are described below

- Length disaggregated survey indices (10 cm increments) from the Icelandic groundfish survey in March 1985–2009.
- Length distribution from the Icelandic commercial catch since 1979. The sampling effort was though relatively limited until the 1990s.
- Landings data divided into 4 month periods per year (quarters).
- Age–length keys and mean length-at-age from the Icelandic commercial fishery.

Description	period	by quarter	area	Likelihood component
Length distribution of landings	1981–1989, 1991–2009	YES	Iceland	ldist.catch
Length distribution of Icelandic GFS	1985–2010+	-	Iceland	ldist.survey
Abundace index of Icelandic GFS of 20–110 cm individuals	1985–2010+	-	Iceland	si20110
Age–length key of the landings	1995, 2009	YES	Iceland	alkeys.catch
Age–length key of the Icelandic GFS	1995, 2009	1st quarter	Iceland	alkeys.survey
Mean length by age of landings	1995, 2009	YES	Iceland	meanl.catch

Description of the likelihood components weighting procedure

Component	Description	Quarters	Weight	Type
Bounds	Keeps estimates inside bounds	All	10	8
Understocking	Makes sure there is enough biomass	All	10e-6	2
Si2029	Survey Index 20–29 cm	1	50	1
Si3039	Survey Index 30–39 cm	1	50	1
Si4049	Survey Index 40–49 cm	1	20	1
Si5059	Survey Index 50–59 cm	1	20	1
Si60110	Survey Index 70–100 cm	1	5	1
Si2080-2	Survey Index (To get a smoothed estimate of the survey selection curve	1	0.1	1
Ldist.catch	Length distribution commercial catches (Longlines)	All	0.1	3
Ldist.survey	Length distribution from the spring survey	1	0.1	3
Alkeys.catch	Age–length data (1995, 2009) from commercial catches	All	5	3
Meanl.catch	Mean length-at-age from commercial catches	All	0.01	4
Alkeys.survey	Age–length data (1995, 2009) from the spring survey	1	5	3

The parameters estimated are:

- The number of fish by age when simulation starts (ages 3 to 5) - 3 parameters. Older ages are assumed to be a fraction of age 5;
- Recruitment each year (1980 and onwards);
- Parameters in the growth equation; Linf is constant at 120 cm and K is estimated;
- Parameter β that models the transition from one length class to the next;
- Length-at-recruitment (mean length and SD);
- The selection pattern of:
    - The commercial catches (1980 and onwards - 2 params.

- Icelandic Spring survey - 1 parameter as the slope is kept constant.

40 parameters in total

The estimation can be difficult because of some or groups of parameters are correlated and therefore the possibility of multiple optima cannot be excluded. The optimization was started with simulated anneling to make the results less sensitive to the initial (starting) values then the optimization was changed to Hooke and Jeeves when the 'optimum' was approached. The model run presented at WGDEEP-2010 was started using the initial values and bounds below:

Initial parameter values used and the bounds assigned.

Switch	Value	Lower	Upper	Optimise
Linf	120	50	200	0
K	90	0.1	1000	1
Bbeta	0.1	0.001	15	1
Ic03	4	0.001	15	1
Ic04	3	0.001	15	1
Ic05	2	0.001	15	1
Recl	15	5	40	1
Recsdev	4	0.01	15	1
Rec1980	2	0.01	15	1
Rec1981	2	0.01	15	1
Rec1982	2	0.01	15	1
Rec1983	2	0.01	15	1
Rec1984	2	0.01	15	1
Rec1985	2	0.01	15	1
Rec1986	2	0.01	15	1
Rec1987	2	0.01	15	1
Rec1988	2	0.01	15	1
Rec1989	2	0.01	15	1
Rec1990	2	0.01	15	1
Rec1991	2	0.01	15	1
Rec1992	2	0.01	15	1
Rec1993	2	0.01	15	1
Rec1994	2	0.01	15	1
Rec1995	2	0.01	15	1
Rec1996	2	0.01	15	1
Rec1997	2	0.01	15	1
Rec1998	2	0.01	15	1
Rec1999	2	0.01	15	1
Rec2000	2	0.01	15	1
Rec2001	2	0.01	15	1
Rec2002	2	0.01	15	1
Rec2003	2	0.01	15	1
Rec2004	2	0.01	15	1
Rec2005	2	0.01	15	1
Rec2006	2	0.01	15	1
Rec2007	2	0.01	15	1
Rec2008	2	0.01	15	1
Alphacomm	0.9	0.03	10	1
L50comm	40	20	50	1
L50sur	15	5	100	1

However multiple optimization cycles were conducted to ensure that the model had converged to an optimum, and to provide opportunities to escape convergence to a local optimum.

The **diagnostics** run to analyse the model are:

- Likelihood profiles plot. To analyze convergence and problematic parameters.
- Plot comparing observed and modelled proportions in fleets (catches). To analyze how estimated population abundance and exploitation pattern fits observed proportions.
- Plot for residuals in catchability models. To analyse precision and bias in abundance trends.
- Retrospective analysis. To analyse how additional data affects historical predictions of the model.

D. Short-term projection

Short and medium-term forecasts for tusk in Va and XIV can be done in gadget using the settings described below. However the model setup was not finalized at the Benchmark meeting (WKDEEP-2010). The Benchmark meeting concluded that the setup presented at the meeting as indicative of trends and suggested further improvements. If assessment improvements are address properly, WKDEEP agrees with the following parameters as input for short-term forecast.

Model used: Age–length forward projection

Software used: GADGET (script: run.sh)

Initial stock size: abundance-at-age and mean length for ages 0 to 20+

Maturity: Fixed maturity ogive

F and M before spawning: NA

Weight-at-age in the stock: modelled in GADGET with VB parameters and length–weight relationship

Weight-at-age in the catch: modelled in GADGET with VB parameters and length–weight relationship

Exploitation pattern:

Landings: logistic selection parameters estimated by GADGET.

Intermediate year assumptions: F = last assessment year F

Stock recruitment model used: geometric mean of years 1989–2007

Procedures used for splitting projected catches: driven by selection functions and provide by GADGET.

E. Medium-term projections (NA)

F. Long-term projections

Model used: Age–length forward projection

Software used: GADGET

Initial stock size: 1 year class of 1 million individuals

Maturity: Fixed maturity ogive

F and M before spawning: NA

Weight-at-age in the stock: modelled in GADGET with VB parameters and length–weight relationship

Weight-at-age in the catch: modelled in GADGET with VB parameters and length–weight relationship

Exploitation pattern:

Landings: logistic selection parameters estimated by GADGET.

Procedures used for splitting projected catches:

Driven by selection functions and provided by GADGET.

Yield-per-recruit is calculated by following one year class of million fish for 29 years through the fisheries calculating total yield from the year class as function of fishing mortality of fully recruited fish. In the model, the selection of the fisheries is length based so only the largest individuals of recruiting year classes are caught reducing mean weight of the survivors, more as fishing mortality is increased. This is to be contrasted to age based yield-per-recruit where the same weights-at-age are assumed in the landings independent of the fishing mortality even when the catch weights are much higher as the mean weight in the stock.

G. Biological reference points

There are no reference points defined for this stock.

H. Other issues

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5 Deep-water sharks

Stock 1-Portuguese dogfish (*Centroscymnus coelolepis*)

A number of species of deep-water sharks are exploited in the ICES area but the two main species are leafscale gulper shark *Centrophorus squamosus* and Portuguese dogfish *Centroscymnus coelolepis*. Both species are considered separately under ICES WGEF.

In some of European fisheries the term "siki" is used to describe the combination of leafscale gulper shark and Portuguese dogfish. Although these species have different biological traits, ICES WGEF has combined them for assessment purposes. This is because landings data for both species were combined for some of the countries for most of the time since the beginning of the fishery.

In ICES' latest advice (2008) it was considered that was insufficient information to separate the landings of Portuguese dogfish *Centroscymnus coelolepis* and leafscale gulper shark *Centrophorus squamosus*. Total international landings of the combined species have steadily increased to around 11 000 t in 2003 and have rapidly declined after 2003 to the lowest levels since the fishery started. Substantial declines in cpue series for the two species in Subareas V, VI, and VII suggest that both species are severely depleted and that they have been exploited at unsustainable levels. In Division IXa, lpue series are stable for leafscale gulper shark and slightly declining for Portuguese dogfish.

5.1 Current stock status and assessment issues

The rates of exploitation and stock sizes of two main deep-water sharks have not been quantified, however due to their very low productivity; both are considered to can only sustain very low rates of exploitation.

At present, there is insufficient information to determine stock identity. In the absence of such information, they are considered as single stocks for assessment purposes although smaller units may be appropriate to management.

5.2 Compilation of available data

5.2.1 Catch and landings data

Landing data on deep-water shark remain very problematical. For many countries, data are only available for combined deep-water sharks. Many countries continue to report landings in generic categories such as various sharks nei. Retrospective splitting of the data into species categories could result in inconsistencies. Nevertheless an approach has been tried during the Benchmark.

5.2.2 Biological data

Studies on the reproductive strategy of *C. coelolepis* based on specimens from ICES Subarea IXa indicate that ovarian and uterine fecundities estimates for this species were 13.68 ± 4.88 and 11.31 ± 3.93 respectively. Furthermore the analysis demonstrated the existence of two periods during which ovulation is maximal. Late mature females, with high levels of GSI and maximal values of OGWI occurred in March/April and in October/November (Figueiredo *et al*., 2008).

Length of first maturity for males is estimated at 85.1 cm, while in females is about 101.2 cm. The median length of pregnant females was estimated at 100.4 cm. Embryos sex ratio was estimated as 1:1 and was based on a total of 1724 embryos (784 females and 766 males; the sex of the remaining 174 embryos was unidentified).

For other ICES areas there are data on size-at-maturity, fecundity and gestation are available from Icelandic waters (Magnússon and Magnússon, 1999), west of the British Isles (Gordon, 2001; Clarke *et al.*, 2002; Girard, 2000). The size-at-maturity for females has been estimated as 93–94 cm off Iceland (Magnússon, 1999), 102 cm west of the British Isles (Clarke *et al.*, 2002; Girard, 2000). Males mature at a smaller size (85–86 cm) (Clarke *et al.*, 2002; Girard 2000).

5.2.3 Survey tuning data

Although fishery-independent data are available for Irish, Scottish and Spanish trawl surveys, these surveys cover only a small area and a short time-series. Thus their used for assessment purposes will be restricted.

Scottish surveys are being conducted by FRS in Division VIa at depth ranging from 300 to 1900 m since 1996. However since 1998 the survey has been reasonably consistent about survey design, gear deployed and area covered (Jones *et al.*, 2005). The survey uses a large commercial trawl (made by Jackson) and is towed for a period of 1.5–2 hours at speeds of 3–3.5 knots. Initially, the survey was carried out on a biennial basis, but since 2004 has been carried out annually.

Ireland carried out a deep-water survey each year in Areas VI and VII from 2006 and 2009, concentrating on NW Ireland–west of Scotland, and the Porcupine area to the west of Ireland. Fishing takes place at 500 m, 1000 m, 1500 m and 1800 m. The survey is coordinated with the Scottish deep-water survey, through the Planning Group on North East Atlantic Continental Slope Surveys (PGNEACS). Parallel tows are carried out in the northernmost area for inter-calibration purposes. The survey took place in September from 2006–2008.

Surveys conducted by the Scottish Association for Marine Science were analysed using the proportions of hauls with zero catches are analysed, to explore whether there have been changes in the proportions over time. Only hauls in depths between 375 and 1374 m were used in the analysis. Within the SAMS cruises, the two gear types used in the cpue analyses were retained, because it was admitted that gear effects were less serious for presence/absence data than for actual catch per unit of effort. Sensitivity of results to the inclusion of a gear effect was nonetheless explored.

The two deep-water shark species, and the group of squalid sharks (which includes both the Portuguese dogfish and the leafscale gulper shark), had significant time-trends in the proportion of non-zero hauls from surveys.

The implications of the model fitted to the data for Portuguese dogfish are that in 1975, about 70% of hauls contained one or more of these dogfish, whereas in the 1990s this is below 30% (Table 1).

Table 1. Estimated proportions of non-zero hauls from SAMS data in depths 375–1374 m, based on presence/absence data. Estimated proportion of non-zero hauls.

YEAR	*C.COELOLEPIS*	*C.SQUAMOSUS*
1975	0.72	0.30
1976	0.69	0.26
1977	0.66	0.23
1978	0.64	0.20
1979	0.61	0.17
1983	0.48	0.08
1984	0.45	0.07
1985	0.42	0.06
1987	0.36	0.04
1990	0.28	0.02
1992	0.24	0.016
1999	0.12	0.004

There are, however, two concerns with regard to this analysis for the deep-water sharks. First, depth effect is not accounted for, and second, according to Gordon *et al*. (1996) the Granton gear type is more likely to catch mobile, supposedly fast swimming sharks than a semi-balloon trawl. A further concern is that the use of artificial lights on some trawls during the 1985 cruise may have affected (increased) the catchability of some species, including *C. coelolepis*.

5.2.4 Commercial tuning data

The *C. coelolepis* data used as an input on the Bayesian demographic model approach conducted during the Benchmark was based only on the Portuguese longline fleet targeting black scabbardfish. The data available included individual daily landings per species and per fishing vessel from 1990 to 2008.

During the Benchmark, new data were made available to update the splitting ratio estimates made during WGEF 2006 using more consistent data is presented in Table 1. Despite the data being provided from different sources and ICES areas, it was agreed to use the ones assigned to source French landing to split the trawl landing data.

In relation to deep-water UK fishery of gillnetters and longliners in VIa and VIIc the data available were considered insufficient to estimate the splitting ratio. Based on that it was decided to use as a proxy the same splitting ratios adopted for the trawl fishery.

Source	ICES area	Years	Gear	Type	Available information
French Landing	VIa	1999–2001	Trawl	Fishery Landing sampling	Ratios not by depth Note: 12 boats/year
French Landing	VIa	2002–2008	Trawl	Fishery	French landings statistics; vessels from one fish owning company reported the species separately using an appropriate protocol to identify species Note: Represent 50% of landings
French trawler(on-board observer)	VIa	2009	Trawl	Fishery	Proportion of the two species by depth
SAMS	VIa	2000–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: very small numbers caught
IRISH	VIa &VIIc	2006–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: depth strata are not the same between surveys
DEEPNET Report	VI & VII		Gillnet	Fishery	Ratios in weight Note: data from 1 recovered net
Cefas	Va,Vb VIIj,k	2004 2005	Gillnet	Fishery	Observer data
Cefas	VIa	2005; 2006	Longline	Fishery	Observer data
Spanish fishery	VIb and XII Hatton Bank	2005–2008	Trawl	Fishery	Observer data Ratios per depth & by ICES subarea
IEO	VIIb,k	2001–2009	Trawl	Survey	Information by haul

Ifremer has provided a new dataseries of landing data for the two species combined, *C. coelolepis* and *C. squamosus*, and fishing effort in fishing days and in Kw by fishing day for the time period 1985 to 2008. Since 2002 and for a fraction of the landing there is also information of landings by species. The data refers only to fishing trips where deep-water sharks represent at least 10% of the total landed way.

5.2.5 Industry/stakeholder data inputs

An observer from the Long Distance Fleet Regional Advisory Council (LDRAC) attended the Benchmark meeting. The observer contacted the LDRAC headquarters to investigate the possibility of having UK gillnetter and longliner fisheries data available long before the next WGEF that will be held in June 2010. Haul by haul data from the French industry tally book scheme is expected to be available for WGDEEP and WGEF in 2010.

This French cpue series will be further developed using data derived from haul-by-haul data provided by the French industry based upon tallybooks from volunteer vessels. Lpues will be estimated using GAMs with depth, vessel, statistical rectangle and zone by year as explanatory variables. Owing to their statistical distribution, landings will be modelled by a Tweedie distribution, which allows handling data with many zeros. In order to investigate how to reliably track stock trends, lpues will be estimated in five regions where previous analysis of EU-logbook (Biseau, WD2006) data from the French fleet demonstrated different trends.

The approach has been applied to roundnose during benchmark will be intersectionally applied to *C. coelolepis*.

5.3 Stock identity and migration issues

Portuguese dogfish is widely distributed in the Northeast Atlantic. Stock structure and its dynamics are poorly understood. The same size range and maturity stages exist in both the northern and southern ICES continental slopes. This information may suggest that this species is not so highly migratory, though it is widely distributed.

Preliminary genetic work (Moura *et al*., 2008 WD) did not reject the null hypothesis that there was no significant difference between the northern and southern areas. In the absence of more clear information on stock identity, a single assessment unit of the Northeast Atlantic has been adopted.

5.4 Spatial changes in the fishery and stock distribution

French data presented to the WGEF 2006 demonstrated that in 2001 new fishing grounds on ICES Subareas V and VI were exploited (Biseau, 2006 WD).

In 2006 there was a ban on gillnetting in EC and international waters at depths greater than 600 m in Subareas VI and VII. This has probably diverted effort to other gears, depths, and areas however due to the TAC restrictions recently introduced this might not be a major issue.

5.5 Environmental drivers of stock dynamics

Given the particularly reproductive strategy and low reproductive capacity of these stocks, recruitment is more dependent on female stock size than on environmental drivers.

Apart from that no data on environmental drivers were presented at the meeting.

5.6 Role of multispecies interactions

5.6.1 Trophic interactions

No data on trophic interactions was presented at the meeting.

5.6.2 Fishery interactions

No data on fisheries interactions were presented at the meeting.

Although lost and discarded gillnets may lead to ghostfishing, recent retrieval studies have indicated that ghost fishing in previous shark gillnet fisheries west of the British Isles was less of a problem than other gillnet fisheries (e.g. anglerfish).

From the Cefas and Irish surveys in 2006 should be interpreted with caution, because the EC introduced a temporary ban on gillnetting at depths .200 m in Divisions VIa,b and VIIb,c,j,k on 1 January 2006 [EC Regulation 51/2005; note that this was extended to 600 m on 1 January 2007 (EC Regulation 41/2006) and remains in force], and this may have impacted the results from these surveys. Notwithstanding, the results from the four surveys, particularly when considered in terms of lost fleets rather than gill-net panels, suggest that the scale of lost and abandoned gillnets and the related incidence of ghost fishing, particularly of fish species, may have been low in the deep-water shark fishery, but higher in the deep-water anglerfish fishery around Ireland and the British Isles. However, no firm conclusions can be drawn until the efficiency of the Norwegian retrieval gear is evaluated and more extensive surveys and mitigation exercises are carried out (Large *et al.*, 2009).

5.7 Impacts on the ecosystem

No ecosystem impacts were directly examined.

5.8 Stock assessment methods

5.8.1 Model

An exploratory model was presented. Due to uncertainties on data from others ICES subareas namely VI and VII was applied to only one .portion of the region adopted by ICES as assessment unit.

The demographic model proposed is a state-space model that divides the population system dynamics into two processes running in parallel: an unobserved process that describes the female shark's population abundance in number, and an observational model, annual catches, that allows establishing the connection between the unknown states. As outputs of the model are estimates of the population abundance in number along the time range, as well as the posterior estimates of some vital parameters of the species and of the fishery. In the approach made during the Benchmark only the females population abundance was considered.

The state of the population at each successive time-steps, $\{n_t, t=0,1, \ldots, T\}$ is described by unobserved vectors denoting the annual female shark's population abundance in number in January of year t. The state vectors are constituted by four components, two of those representing the females that have survived to fishing, further subdivided into two Length groups-juveniles (length< 101.2 cm) and adults (length 101.2 cm).

The population dynamics is modelled by further subdividing the population state process into subprocesses that consecutively succeed in time, each of which only depending on the subprocess immediately before. The subprocesses happen in successive time periods with the same order each year, corresponding to the following matrices: S, survival to natural death, C, population class transition, B, birth, and F, survival to death due to fishing. The corresponding stochastic formulation is done in terms of conditional expected values of the state process and it is assumed to be a first order Markov process: $E[n_t/n_{t-1}] = FBCSn_{t-1}$. The process is completely defined if the state process distribution at a certain time t conditionally on the process t-1 time is known $n_t \overset{d}{=} H_t[n_{t-1}]$, which is further decomposed according to the various subprocesses distributions as:

$$u_t^S \overset{d}{=} H_t^S[n_{t-1}] \qquad u_t^C \overset{d}{=} H_t^C[u_t^S] \qquad u_t^B \overset{d}{=} H_t^B[u_t^C] \qquad n_t = u_t^F \overset{d}{=} H_t^F[u_t^B]$$

where, for each time t, u_t^S represents a realization of the state vector after the subprocess of survival to death due to natural causes, u_t^C represents a realization after the subprocess of class transition, u_t^B after the subprocess of breeding and $u_t^F = n_t$ after the subprocess of survival to fishing.

For the subprocess surviving to the natural mortality $\phi_{S_{ja}} = e^{-S_{ja}}$ represents the probability of surviving from natural death and S_{ja} represents the mortality rate by natural causes. The distribution of the number of females that remain is each class is binomial

$$u_t^S \sim H_t^S(n_{t-1}) : \begin{pmatrix} u_{j,t}^S \sim Bi\left(n_{j,t}(\bar{F}), \phi_{S_{ja}}\right) \\ u_{a,t}^S \sim Bi\left(n_{a,t}(\bar{F}), \phi_{S_{ja}}\right) \end{pmatrix}$$

For the subprocess Class transition C_j represents the probability of a juvenile remaining a juvenile. Distribution of the number of juveniles that remain in the same class is binomial and the class of adults is composed by the adults that did not die due to natural causes plus the juveniles that have become adults

$$u_t^C \sim H_t^C(u_t^S) : \begin{pmatrix} u_{j,t}^C \sim Bi\left(u_{j,t}^C, C_j\right) \\ u_{a,t}^C = u_{a,t}^S + \left(u_{j,t}^S - u_{j,t}^C\right) \end{pmatrix}$$

In the Birth subprocess, a binomial distribution was chosen for each female with parameters equal to (f; pB), for the number of newly born female offspring that survive

$$u_t^B \sim H_t^B(u_t^C) : \begin{pmatrix} u_{j,t}^B = u_{j,t}^C + X\left[u_{a,t}^C\right] \qquad X\left[u_{a,t}^C\right] \sim Bi\left(fu_{a,t}^C, p_B\right) \\ u_{a,t}^B = u_{a,t}^C \end{pmatrix}$$

For the fishing subprocess it is assumed that ϕ_t is the probability of a juvenile or adult be fished in year t , which is related to the mortality rate due to fishing in that year (denoted by F_t) , through $\phi_t = e^{-F_t}$. It was considered that the distribution of the number of survivors of juveniles or of adults to fishing is binomial,

$$n_t = u_t^F \sim H_t^F\left(u_t^B\right): \begin{pmatrix} n_{j,t}\left(\overline{F}\right) \sim Bi\left(u_{j,t}^B .1-\phi_t\right) \\ n_{a,t}\left(\overline{F}\right) \sim Bi\left(u_{a,t}^B .1-\phi_t\right) \\ n_{j,t}\left(F\right) = u_{j,t}^B - n_{j,t}\left(\overline{F}\right) \\ n_{a,t}\left(F\right) = u_{a,t}^B - n_{a,t}\left(\overline{F}\right) \end{pmatrix}$$

The observational process of the population is a stochastic function of the unknown states denoted by {y_t, t=0,1, …, T}. The total number of fished sharks at year t, is assumed to be caught at a time period that occurs after all the subprocesses took place, and is supposed to be observed with an error.

The observations are estimates of the total catch per year and follow a normal distribution with conditional mean $E[y_t / n_t] = n_{j,t}(F) + n_{a,t}(F)$ and standard deviation proportional to the mean:

$$y_t \sim N\left(n_{j,t}(F) + n_{a,,t}(F), \psi^2\left(n_{j,t}(F) + n_{a,,t}(F)\right)\right)$$

The corresponding state-space model representing the parallel evolution of the state and observational processes are described by the following set of probability density functions

$$g_0\left(n_0, \Theta\right); \qquad g_t\left(n_t / n_{t-1}, \Theta\right); \qquad f_t\left(y_t / n_t, \Theta\right)$$

with parameters o $\Theta = \left(\phi_{S_{ja}}, C_j, \phi, \Psi\right)$ and

$$g_t\left(n_t / n_{t-1}; \Theta\right) = \int_{u_t^B} \int_{u_t^C} \int_{u_t^S} g^S\left(u_t^S / n_{t-1}, \Theta\right) \; g^C\left(u_t^C / u_t^S, \Theta\right) \; g^B\left(u_t^B / u_t^C, \Theta\right) \; g^F\left(n_t / u_t^B, \Theta\right) du_t^S \, du_t^C \, du_t^B$$

The estimation is done via the Bayesian paradigm, implying non-trivial integration of several probability density functions, accomplished through sequential importance sampling methods.

5.9 Stock assessment

The model was applied only to Portuguese data and the input data were Total catch in number and standardized fishing effort in number of fishing days.

YEAR	TOTAL LANDINGS	STANDARDIZED EFFORT FISHDAY
1992	40 531	10 794
1993	43 083	12 857
1994	37 791	16 016
1995	35 861	8636
1996	50 430	19 039
1997	48 375	15 413
1998	57 714	15 389
1999	53 418	13 584
2000	35 363	9394
2001	39 348	13 555
2002	39 908	12 702
2002	36 484	11 191
2003	30 822	12 206
2004	42 960	12 190
2005	33 587	13 814
2006	24 116	11 281
2007	15 297	7178
2008	22 598	7606

The priors adopted were constructed using as much as possible the information and knowledge available for the species. The natural mortality parameter was estimated using life-history (or meta-) analysis (Pauly, 1980). The estimate adopted for the growth parameter, Linf = 128:4cm as 0.95 of the maximum observed length. The growth parameter k was determined following Holden (1974) method, which models post-partum growth using the following information t0 = -2.17 (~ 26 month of gestation time) and a length of birth of 31 cm. The probability of transition was determined based on the expected length change or growth increment for an individual, over one year considering that individual growth following the VBGF with the parameter estimated before. The expected number of new females born for each adult female in the population was estimated based on its mean, weighted by the fraction of female embryos for pregnant females, the inverse of the gestation period t0 and the fraction of pregnancy in mature females each year. Fishing mortality by year (Ft) was estimated for juvenile and adult groups using the annual standardized fishing effort (Et) as auxiliary information through a full recruitment model.

In order to initialize the population state vector,

$$n_0' = \left(n_{j,0}\left(\bar{F}\right) \quad n_{a,0}\left(\bar{F}\right) \quad n_{j,0}\left(F\right) \quad n_{a,0}\left(F\right) \right)$$

the catch of the first year, y0, as used as the number of fished sharks. The total number of juvenile sharks plus the total number of adult sharks weighted by the corresponding fishing probabilities at year 0 is then equal to this number:

$$N_a\phi_0 + N_j\phi_0 = N_a e^{-qE_0} + N_j e^{-qE_0} = y_0$$

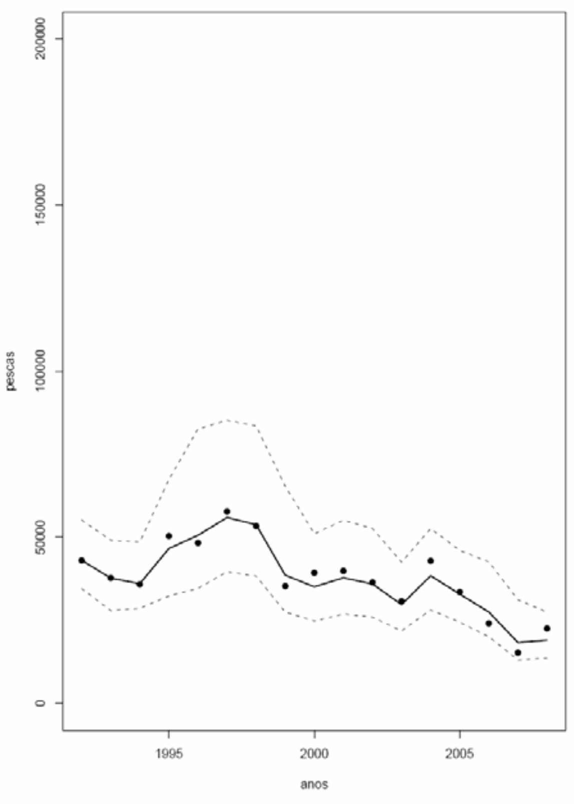
The proportion of adults in the population, p_a, was derived using information from length sampling data and thus $N_a = p_a N$ and $N_j = \left(1 - p_a\right) N$

$$N p_a \phi_0 + N(1-p_a)\phi_0 = y_0 \Leftrightarrow N = \frac{y_0}{p_a \phi_0 + (1-p_a)\phi_0}$$

Or

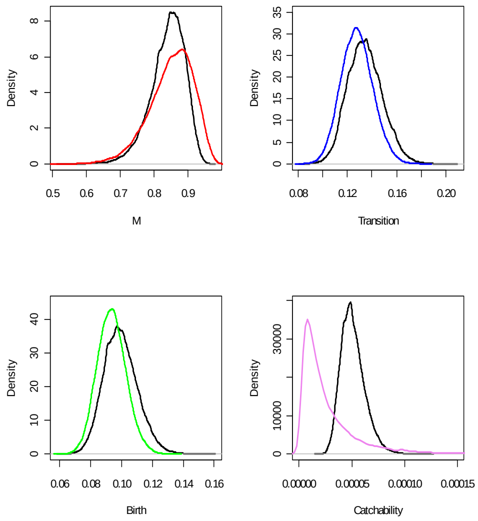
$$\begin{cases} n_{j,0} = (1-p_a)\left(\frac{y_0}{p_a \phi_0 + (1-p_a)\phi_0} - y_0\right) \\ n_{a,0} = p_a\left(\frac{y_0}{p_a \phi_0 + (1-p_a)\phi_0} - y_0\right) \\ n_{j,0} = (1-p_a)y_0 \\ n_{a,0} = p_a y_0 \end{cases}$$

The fit of the model is presented below; points correspond to the observed catches while the full line is the median of the *posteriori* estimate of catch and the dotted lines the 95% credible interval.

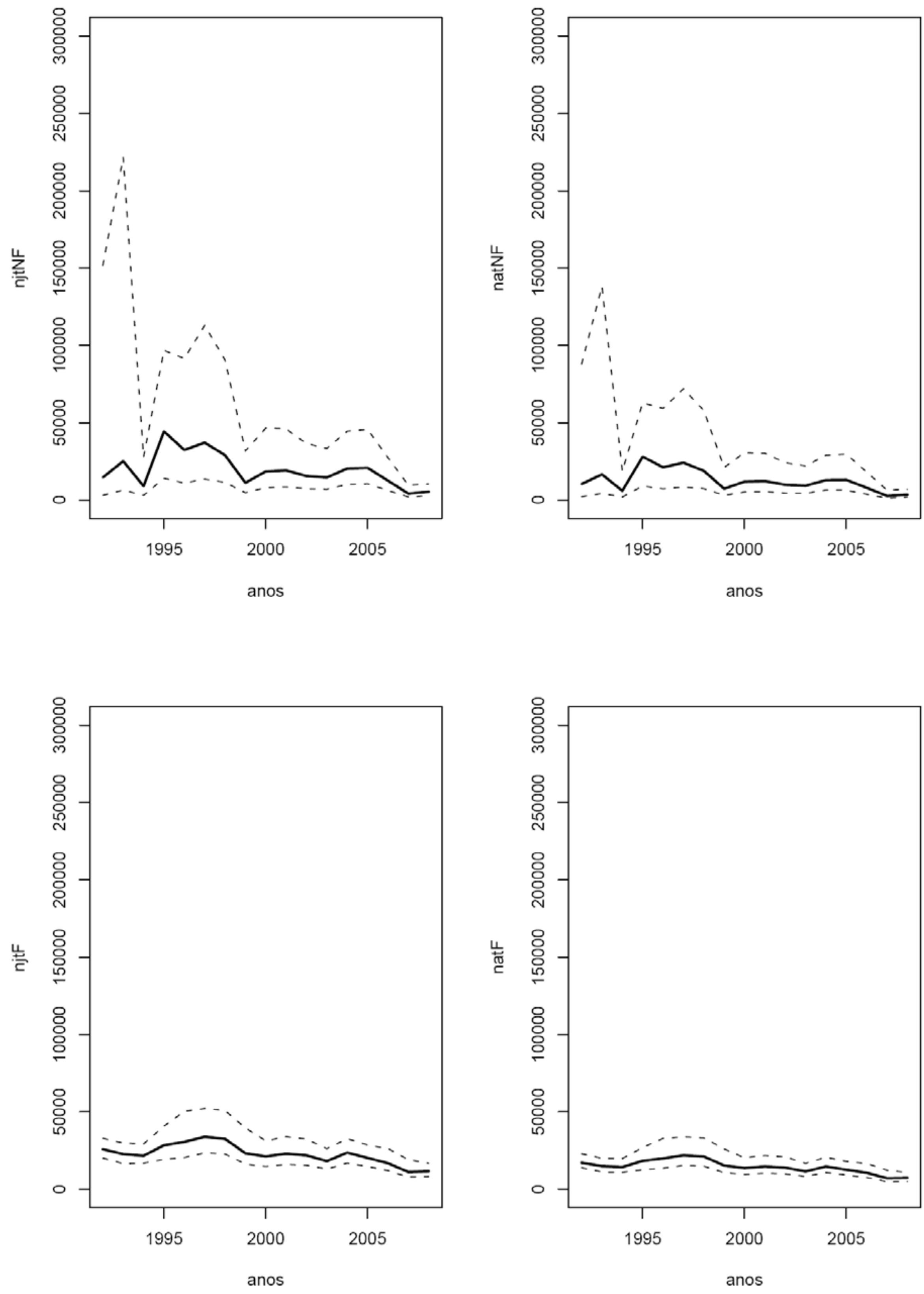


Following graph present the *priori* (coloured) and *posterior* (black) distribution of the main parameters.

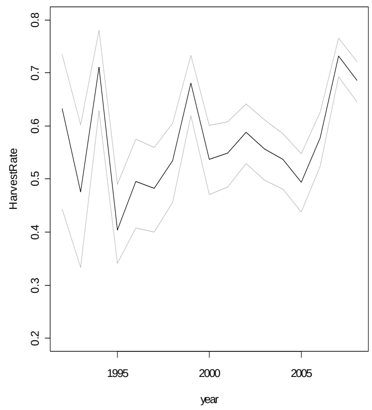
It was evident that the posterior distribution of q was strongly updated by the information contained in the data.



Posterior estimates of four states are presented (full line corresponds to median and dotted lines the 95% credible interval.



Posterior estimates for the Harvest rates by year and in grey lines the 95% credible interval.



5.10 Short-term and medium-term forecasts

Short and medium-term forecasts can be done using the current model.

5.11 Biological reference points

Using the present approach MSY reference point will be derived, using the estimate of intrinsic growth rate from the posterior distribution of the Projection Matrix.

5.12 Recommendations on the procedure for assessment updates

It was recommended to run the above model in WGEF for the dataset presented for the fisheries taken in the northern areas as an exploratory assessment.

It was further recommended to adapt in order to accommodate the male population in the state vectors for the next WGEF meeting.

5.13 Industry supplied data

No data were supplied from the industry.

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Stock 2-Leafscale gulper shark (*Centrophorus squamosus*)

5.15 Current stock status and assessment issues

The rates of exploitation and stock sizes of two main deep-water sharks have not been quantified, however due to their very low productivity; both are considered to can only sustain very low rates of exploitation.

At present, there is insufficient information to determine stock identity. In the absence of such information, they are considered as single stocks for assessment purposes although smaller units may be appropriate to management.

5.16 Compilation of available data

5.16.1 Catch and landings data

Landing data on deep-water shark remain very problematical. For many countries, data are only available for combined deep-water sharks. Many countries continue to report landings in generic categories such as various sharks nei. Retrospective splitting of the data into species categories could result in inconsistencies. Nevertheless an approach has been tried during the Benchmark.

5.16.2 Biological data

The size at first sexual maturity for fish caught off the western British Isles has been recorded as 98 and 106 cm for males and females respectively (Girard and Du Buit 1999). Clarke *et al*. (2002) estimated that males and females matured at lengths of 102 and 128 cm respectively. In Portugal mainland, males and females mature at 99.1 and 126.3 cm, respectively, and median length-at-pregnancy was estimated at 123.8 cm (Figueiredo *et al*., 2008).

Females from the western British Isles produce 7–11 oocytes, and a mean of five oocytes per ovary (Girard and Du Buit, 1999). However, it was recently suggested that ovarian fecundity is correlated with the female total length in this species (Figueiredo *et al*., 2008).

Available information reveals that pregnant females and pups are found in Portugal, mainly in Madeira and with punctual occurrences in the mainland (Moura *et al*., 2008 WD) whereas only pre-pregnant and spent females are found in the northern areas (Garnes, pers. comm.).

In Portugal mainland and despite the scarcity on mature females, the gonad index increased in the second quarter and the greatest values of mean follicle diameter and of oviducal gland width (which are supposed to occur prior to ovulation) were also found in the second quarter of the year. These facts, although not conclusive, may lead to the hypothesis of the existence of a reproductive season (Figueiredo *et al*., 2008).

Clarke *et al*. (2002) estimated ages of 21–70 years for *C. squamosus* caught off the western British Isles, although the absence of smaller specimens in the study area restricted the fitting of growth model.

5.16.3 Survey tuning data

Surveys conducted by the Scottish Association for Marine Science were analysed using the proportions of hauls with zero catches are analysed, to explore whether there have been changes in the proportions over time. Only hauls in depths between 375 and 1374 m were used in the analysis. Within the SAMS cruises, the two gear types used in the cpue analyses were retained, because it was admitted that gear effects were less serious for presence/absence data than for actual catch per unit of effort. Sensitivity of results to the inclusion of a gear effect is nonetheless explored.

The two deep-water shark species, and the group of squalid sharks (which includes both the Portuguese dogfish and the leafscale gulper shark), had significant time-trends in the proportion of non-zero hauls from surveys.

The implications of the model fitted to the data for Portuguese dogfish are that in 1975, about 70% of hauls contained one or more of these dogfish, whereas in the 1990s this is below 30% (Table 1). The occurrence of leafscale gulper sharks in hauls was only around 30% at the start of the period, either indicating lesser abundance, lower catchability or different distribution compared with the Portuguese dogfish. Nonetheless, this proportion is also estimated to have declined, to below 3% in the 1990s (Table 1).

Table 1. Estimated proportions of non-zero hauls from SAMS data in depths 375–1374 m, based on presence/absence data. Estimated proportion of non-zero hauls.

YEAR	*C.COELOLEPIS*	*C.SQUAMOSUS*
1975	0.72	0.30
1976	0.69	0.26
1977	0.66	0.23
1978	0.64	0.20
1979	0.61	0.17
1983	0.48	0.08
1984	0.45	0.07
1985	0.42	0.06
1987	0.36	0.04
1990	0.28	0.02
1992	0.24	0.016
1999	0.12	0.004

There are, however, two concerns with regard to this analysis for the deep-water sharks. First, depth effect is not accounted for, and second, according to Gordon *et al*. (1996) the Granton gear type is more likely to catch mobile, supposedly fast swimming sharks than a semi-balloon trawl. A further concern is that the use of artificial lights on some trawls during the 1985 cruise may have affected (increased) the catchability of some species, including *C. coelolepis*.

Because there are so few non-zero hauls for leafscale gulper shark, it is not sensible to do the same analysis as for the Portuguese dogfish. It is, however, worth noting that a similar analysis for depth bands 3 and 4, but including the Granton trawl gear (i.e. SAM and SAS gear types) demonstrates that there is no strong indication of a change in probability of non-zero hauls over time. The apparent low catchability, or low presence of this species in catches means that much larger sample sizes (more hauls) would be required to detect any changes over time.

5.16.4 Commercial tuning data

See the same Section for *C. coelolepis*.

5.16.5 Industry/stakeholder data inputs

See the same Section for *C. coelolepis*.

5.17 Stock identity and migration issues

Leafscale gulper shark has a wide distribution in the NE Atlantic. The species can live as a demersal shark on the continental slopes (depths between 230–2400 m) or have a more pelagic behaviour, occurring in the upper 1250 m of oceanic water in areas with depths around 4000 m (Compagno and Niem, 1998). Available evidence suggests that this species is highly migratory (Clarke *et al*., 2001; 2002). Available information reveals that pregnant females and pups are found in Portugal, both the mainland (Moura *et al*., 2008 WD) and Madeira, whereas only pre-pregnant and spent females are found in the northern areas (Garnes, pers. comm.). In the absence of more clear information on stock identity, a single assessment unit of the Northeast Atlantic has been adopted.

5.18 Spatial changes in the fishery and stock distribution

See the same Section of *C. coelolepis*.

5.19 Stock assessment

Giving the uncertainties on stock structure and its spatial dynamics as well as the deficient quality of data available assessment will be based on indicators.

5.20 Industry supplied data

No data were supplied from the industry.

5.21 Recommendations on the procedure for assessment updates

In face of the foreseen availability of cpue series from French trawl and new estimates of the landing data, e.g. Pella-Tomlinson production biomass-dynamic model for the exploitable stock biomass, may be considered as a candidate for exploratory assessment to be used at the next WGEF meeting.

5.22 References

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Stock Annex: Portuguese dogfish (*Centroscymnus coeloepis*)

Stock	Portuguese dogfish (*Centroscymnus coelolepis*)
Working Group	WKDEEP
Date	17.02.2010–24.02.2010
Revised by	Ivone Figueiredo and Tom Blasdale

A. General

Portuguese dogfish (*Centroscymnus coelolepis*) is widely distributed in the Northeast Atlantic. Specimens below 70 cm have been very rarely recorded in the NE Atlantic. There is a lack of knowledge of migrations, though it is known that females move to shallower waters for parturition and vertical migration seems to occur (Clarke *et al.*, 2001). The same size range and maturity stages exist in both the northern and southern ICES continental slopes. This information may suggest that, contrary to leafscale gulper shark, this species is not so highly migratory, though it is widely distributed.

A.1. Stock definition

There is insufficient information to differentiate stocks in the Northeast Atlantic and consequently ICES has adopted the assumption of single stocks for each of these species in the ICES area.

A.2. Fishery

Several species of deep-water sharks have been commercially exploited in the ICES area, however the most important are *C. squamosus* and *C. coelolepis*. These two species are both mainly taken in several mixed trawl fisheries in the Northeast Atlantic and in mixed and directed longline fisheries. Directed gillnet fisheries formerly operated in some areas.

Country by country accounts are presented as follows:

Norway–Norwegian longliners target blue ling (*Molva dypterigia*), Mora (*Mora moro*) and leafscale gulper shark (*Centrophorus squamosus*) on the continental slope between 800 and 1100 metres. In 2000 and 2001, a longline fishery for Greenland Halibut with a bycatch of Portuguese dogfish operated on Hatton Bank between 1300 and 1600 metres.

Faroes–A directed longline fishery on deep-water sharks was carried out in the southern and western slopes of Faroes Island from 1995 to 1999. No detailed information on this fishery is available although anecdotal information suggests that fishing was developed at depths between 800 and 1200 meters in the slopes west of the Wyville Thompson Ridge and south of the Faroe Bank Plateau.

Germany–At the early 2000s Two German vessels conducted a deep-water gillnet fishery (Hareide *et al.*, 2004). The main fishing area were Southern part of area VII (Porcupine Seabight and around Rockall. (Area VI and XII). The deep-water sharks were landed in Spain as 'various sharks'. This fishery ceased in 2006 as result of the EU ban on fishing with gillnets in depths greater than 600 m.

France–C. *squamosus* and *C. coelolepis* and lately, *Centroscyllium fabricii*, are caught by the French trawl fishery for mixed deep-water species. Initially this fishery was conducted in ICES Subareas VIa, VIIc,k but in 2001 when the Irish deep-water trawl fishery started to operate in Subarea VII most of the French fishing fleet moved to Subarea VIa).

In Subarea XII there have been some French landings of deep-water sharks, but it is not possible to detect any trends from the available data.

Ireland–An Irish longline fishery targeting ling and tusk in the upper slope and deep-water sharks started in 2000 and ceased in 2003. Mainly two species of deep-water sharks, *C. coelolepis* and *C. squamosus* were marketed but there were some landings of birdbeak dogfish and longnose velvet dogfish.

Several large newer trawlers have targeted deep-water species in Subareas VI and VII. There is a directed fishery for orange roughy in Subarea VII, with a low a bycatch which includes *C. coelolepis* and *C. squamosus* as well as a more extensive fishery on the continental slopes of Sub-areas VI and VII for mixed deep-water species including *C. coelolepis* and *C. squamosus*.

UK–Between the mid 1980s and 2006, UK registered longliners and gillnetters operated a directed fishery for deep-water sharks in Subareas VI, VII and XII. The fleet was mostly composed of vessels based in Spain but registered in the UK, Germany and other countries outside the EU such as Panama.

C. squamosus and *C. coelolepis* are caught by a Scottish deep-water mixed-species trawl fishery operating mainly in Subarea VI. Since the introduction of TACs for a number of deep-water species in 2003, effort in this fishery has been at low level.

Spain–A fleet of around 24 large freezer trawlers conducts a mixed deep-water fishery in international waters of the Hatton Bank, mainly in ICES Subarea XII and partially in Division VIb, however, few of these vessels worked full-time in this fishery (two in 2000 and four in 2001). The main commercial fish species are smoothheads, roundnose grenadier, blue ling and *C. coelolepis*.

The Basque "baka" trawl fishery operates in Subareas VI and VII and Divisions VIIa,b,d but deep-water species including sharks are only important in Subarea VI. In the period 1997–2002, a small longline fishery targeting deep-water sharks landed annually in Basque ports about 150 t in "trunk" weight (i.e. gutted and without head, skin and fins) of deep-water sharks (Lucio *et al*., 2004).

Portugal–At Sesimbra (Division IXa), the longline fishery targeting black scabbardfish *Aphanopus carbo* takes a bycatch of deep-water sharks. The most important shark species caught by this fishery are the Portuguese dogfish and leafscale gulper sharks. Deep-water sharks are also caught by the Portuguese deep-water bottom-trawl fishery that targets the rose shrimp *Parapenaeus longirostris* and *Nephrops* mainly south and southwest of the Portuguese mainland. Deep-water shark species caught in this fishery are: birdbeak dogfish, blackmouth catshark, gulper shark, kitefin shark, leafscale gulper shark, smooth lanternshark *Etmopterus pusillus* and velvet belly.

From 1983 till 2001 there was directed longline fishery for deep-water sharks, based at Viana do Castelo in northern Portugal. Landings from this fishery predominantly consisted of gulper shark. However, other deep-water species are caught in relatively small quantities. These include the leafscale gulper shark, Portuguese dogfish, blackspot sea bream (*Pagellus bogaraveo*), greater fork-beard (*Phycis blennoides*), European conger (*Conger conger*) and the black scabbardfish. In the early years of the fishery only the livers of the sharks were of commercial value.

A.3. Ecosystem aspects

Centroscymnus coelolepis

C. coelolepis is found in the Northwest Atlantic (from the Grand Banks to off Delaware Bay, and Cuba), Northeast Atlantic (Iceland to Sierra Leone, including the western Mediterranean, Azores and Madeira), South-East Atlantic (Namibia and South Africa) and western Pacific (Japan, New Zealand and Australia, and possibly in the South China Sea) (Compagno, 2004). Based on commercial landings and research vessel surveys, *C. coelolepis* is widely distributed in the ICES area, including off Norway (ICES Divisions IIIa and IVa), Faroes Islands (Vb), Iceland (Va), west of the British Isles (VI, VIIb–c, j–k), Bay of Biscay and Cantabrian Sea (VIII), Portugal (IX), Azores (X) and off Madeira.

C. coelolepis lives near the bottom from 270–3675 m depth (Compagno, 2004). In the Northeast Atlantic it is known from 1400–1900 m on the Reykjanes Ridge (Hareide and Garnes 2000), 1169 m off Iceland (Magnússon *et al.*, 2000); on the Hatton Bank 600–1200 m (Duran Muñoz *et al.*, 2000) and down to 1950 m (Hareide and Garnes, Appendix 8); 667–1750 m in the Rockall Trough (Gordon, 1999a), 750–2050 m in the Porcupine Seabight (Merret *et al.*, 1991) and 800–1500 m off Portugal (Veríssimo *et al.*, 2003).

B. Data

B.1. Commercial catch

In Portuguese and some Spanish fisheries, deep-water shark species have always been recorded separately in landings data. However, in other fisheries, it has been common practice until recently to record landings of all species collectively under generalized categories such as "various sharks not elsewhere identified", "siki sharks", "dogfish sharks not elsewhere identified," etc. This has made it very difficult to quantify landings of deep-water sharks, particularly as the same categories are often used to report other species such as pelagic sharks or spurdog.

Historical catches have been reconstructed according to a two stage procedure. First, landings data recorded under the various grouped categories were examined using expert knowledge of the fisheries operating in particular areas and time periods to determine which were likely to be deep-water sharks. These were included in the Working Group's estimate of "siki shark", i.e. mixed deep-water species comprising mainly *C. squamosus* and *C, coelolepis.* The data which were identified by WGDEEP 2005 as referring to deep-water shark species (included in the "siki sharks" data table) are listed in Table 1. All other records under mixed categories are believed to be other species.

In the second stage, the landings data in the "siki sharks" data table were split according to the proportions observed in various sampling schemes and surveys, etc to give estimates of species-specific landings. The data sources used in this splitting are listed in Table 2. A considerable number of assumptions have been made in order to split catches from areas, years and fisheries from which no data were available. For instance, data from trawl fisheries were used to split landings from UK gillnetters. This will be improved should better data become available in future e.g. it is expected that species-specific landings for UK gillnetters will be provided by the RACs.

Table 1 Landings recorded in combined categories considered by WGEF to be "siki" sharks; i.e. mixed deep-water species comprising mainly *C. squamosus* and *C, coelolepis*.

LANDING CATEGORY	COUNTRY	ICES SUBAREAS/DIVISIONS	YEARS
cartilaginous fish NEI data	No landing in this category were considered to be deep-water sharks		
various sharks NEI	UK-England and Wales	V, VI and VIIc,	1990 to 2002
	UK-Scotland	All	1989 to 2001
	Portugal	VIIIc	1990 to 2000
	Poland	VIb	2002 and 2003
	Estonia	VIb	2002 and 2003
	Lithuania	XII	2001 and 2003
dogfish sharks NEI	France*	VI, VII, XII	1989 to 2003
	Germany	V, VI, VII, XII	1995 to 2003
Landing identified by species but identification considered unreliable	Faroes	All	All
	France*	All	All
	Ireland (records of Portuguese dogfish probably contain unknown quantities of leafscale gulper shark)	VII	2001-2006
	Scotland (Portuguese dogfish probably contain unknown quantities of leafscale gulper shark. Records of Leafscale gulper shark are considered to be correct)	VI	1997–2005
	Lithuania (*C. coelolepis* landings probably contain *C. squamosus*)	All	All
Data supplied to WGEF but identification considered unreliable	UK-England and Wales**	All	2001–2004
	UK-Scotland	All	2001–2004

*** all data in FISHSTAT was replaced by more reliable data provided to WGDEEP 2002**

**** Data from 2003 and 2004 replaced with data from Cefas**

Table 2 Data sources to split "siki sharks".

Source	ICES area	Years	Gear	Type	Available information
French Landing	VIa	1999–2001	Trawl	Fishery Landing sampling	Ratios not by depth Note: 12 boats/year
French Landing	VIa	2002–2008	Trawl	Fishery	French landings statistics; vessels from one fish owning company reported the species separately using an appropriate protocol to identify species Note: Represent 50% of landings
French trawler(auction market)	VIa	2009	Trawl	Fishery	Proportion of the two species by depth
SAMS	VIa	2000–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: very small numbers caught
IRISH s	VIa &VIIc	2006–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: depth strata are not the same between surveys
DEEPNET Report	VI & VII		Gillnet	Fishery	Ratios in weight Note: data from 1 recovered net
Cefas	Va,Vb VIIj,k	2004 2005	Gillnet	Fishery	Observer data
Cefas	VIa	2005; 2006	Longline	Fishery	Observer data
Spanish fishery	VIb and XII Hatton Bank	2005–2008	Trawl	Fishery	Observer data Ratios per depth & by ICES subarea
IEO	VIIb,k	2001–2009	Trawl	Survey	Information by haul

Any future method developed to split the historical UK (E+W) landings data by species is not to be used for advice until it is benchmarked.

B.2. Biological

Centroscymnus coelolepis

Some data on size-at-maturity, fecundity and gestation are available from Icelandic waters (Magnússon *et al.*, 2000), west of the British Isles (Gordon, 1999a; Clarke *et al.*, 2002; Girard, 2000) and Portuguese mainland (Veríssimo *et al.*, 2003; Figueiredo *et al.*, 2008). The size-at-maturity for females has been estimated as 93–94 cm off Iceland (Magnússon, 1999), 102 cm west of the British Isles (Clarke *et al.*, 2002; Girard, 2000), and 100 cm off Portugal (Veríssimo *et al.*, 2003). Males mature at a smaller size (85–86 cm) (Clarke *et al.*, 2002; Girard, 2000; Figueiredo *et al.*, 2008).

Estimates of ovarian (number of oocytes in the ovary) and uterine (number of embryos developing) fecundities are available for two areas. West of the British Isles, both ovarian and uterine fecundity are 13 (Clarke *et al.*, 2002), whereas off Portugal, ovarian and uterine fecundity were 13 and 10–11 respectively (Veríssimo *et al.*, 2003; (Figueiredo *et al.*, 2008). No clear trend between the number of developed follicles and embryos, and the total length was observed (Figueiredo *et al.*, 2008).The gestation period is still unknown in this species, although it is expected to last more than one year (Figueiredo *et al.*, 2008). Estimates of the size at birth range from 26.8 cm (Veríssimo *et al.*, 2003) to 30.7 cm (Clarke *et al.*, 2002).

Analysis of reproductive data demonstrated the existence of two periods during which ovulation is maximal. Late mature females, with high levels of gonad index and maximal values of oviducal gland index occurred in March and April and in October and November. The high variability of reproductive indices from females in these two periods suggested that individuals in different stages of the maturation process coexist and this stage might have a long duration (Figueiredo *et al.*, 2008).

B.3. Surveys

FRS has conducted deep-water surveys (depth range 300–1900 m) in Division VIa since 1996. Since 1998 the survey has been reasonably consistent about survey design, gear deployed and area covered (Jones *et al.*, 2005). The survey uses a large commercial trawl (made by Jackson) and is towed for a period of 1.5–2 hours at speeds of 3–3.5 knots. Initially, the survey was carried out on a biennial basis, but since 2004 has been carried out annually.

B.4. Commercial cpue

Portuguese longline fisheries

In the 2008 meeting of WGEF, standardized lpue from Portuguese longliners data were presented (Figueriedo *et al.*, 2008WD). This working document presented the results of an exploratory analysis of daily landings data from Portuguese vessels with deep-water licences to operate in the Portuguese continental slope. These vessels target black scabbardfish but have bycatch of Portuguese dogfish and leafscale gulper shark.

The underlying assumption "*at small spatial scales, catch is proportional to the fishing effort and density*" followed when evaluating catch rates as an index of abundance, may be not adequate for deep-water sharks due to the mixed nature of this fishery that catches them.

Data used

- Individual daily landings per species and per fishing vessel were available for the period 1995–2006.
- For the period 2000–2004, VMS records exhibited time intervals of 10 min which allows the identification of fishing locations. Afterwards and with cross analysis with the daily landings data it was possible to infer the catch data, because in this fishery discards are almost null (WD).
- Following point 2 of article 8 from EC Regulation no. 2244/2003 of 18 December and due to operational constraints associated with data handling in Portuguese VMS monitoring centre, requests of this type of data from 2005 onwards have been provided with a polling frequency of 2 hours, which make their use for the fishing location purpose not viable.

In the analysis of the longer dataseries, several attempts were made to incorporate into the hurdle model factors other than fishing locations as a way to circumvent the lack of that information for the remaining time period. Due to the low level of adjustment, particularly for Portuguese dogfish, the analysis proceeded by estimating the mean landed weight by daily landing per year as well as its variance. To avoid the use of almost null catches of each deep-water shark landings it was decided not to consider landings in which the weight of each of these species represented less than 10% of landed weight of black scabbardfish.

Lpue from French fisheries in Subarea Vb, VI and VII

Time-series for lpue has been available in past years for a number of species exploited by French deep-water fisheries including deep-water sharks. Because sharks are not separated by species in landings data, this series is for combined species "siki" sharks. Lpues were calculated for a reference fleet of similar size vessels belonging to one French port and divided into six areas to account for changes in distribution of fishing effort (Figure 1). It is now impossible to further extend this time-series as all but one of the reference fleet has been decommissioned.

In one French port, landings of deep-water sharks are split by species. It is believed that vessels from this port are typical of the fishery as a whole so ratios derived from these landings can be used to split French landings of "siki" and thus calculate an unstandardized commercial lpue series for Portuguese dogfish and leafscale gulper shark individually. These series, when it is available, will be used in preference to the combined "sikis" lpue in assessments. Until then, the combined index will be used for historical trends but must be interpreted to take account of the different life histories of the two species and possible implications for sensitivity to fishing.

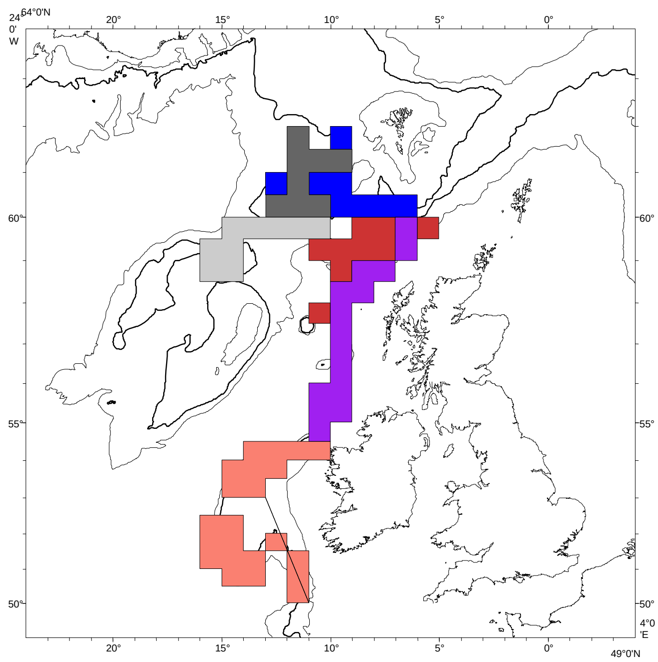

Figure 1. Areas used to compute lpue of French vessels (black: New grounds in V; blue, Reference area in V; Grey: new grounds in VI; Purple reference area in VI-edge; Red: Reference area in the VI - other; pink reference area in VII.

Industry data

An observer from the Long Distance Fleet Regional Advisory Council (LDRAC) attended the Benchmark meeting. The observer contacted the LDRAC headquarters to investigate the possibility of having UK gillnetter and longliner fisheries data available long before the next WGEF that will be held in June 2010.

B.5. Other relevant data

Centroscymnus coelolepis

Biological studies on the species held in the NE Atlantic and in the Pacific oceans, gave evidences for the species spatial segregation by sex and by maturity stage (Girard and Du Buit, 1999; Clarke *et al*., 2001; Yano and Tanaka, 1988). In the NE Atlantic females of Portuguese dogfish in all maturity stages can be caught in all different commercially exploited areas. Such distribution pattern may suggest the existence of small-scale populations of Portuguese dogfish in those different areas within which individuals are able to complete the entire life cycle (Verissimo *et al*., 2003), fact that was already pointed by ICES (2007).

C. Historical stock development

The first preliminary assessment on *C. coelolepis* and *C. squamosus* combined was attempted by SGDEEP (ICES, 2000) using the available series of catch and effort from French reference fleet trawlers as inputs. The series of cpue data presented in WGDEEP (ICES 2002b, Table 17.2) formed the basis of attempted assessments. In all cases, however, these assessments were considered to be too unreliable to be included in the Report of that Working Group.

Further analyses of stock status were presented in Basson *et al.* (2002) describes the results from the SGDEEP assessments of deep-water sharks using Schaefer and Delury analyses and from presence/absence analyses of long-term RV time-series data. This study demonstrated that it is evident that the relative importance of larger size females increased in recent years. In addition the percentages of non-zero hauls in Scottish research trawl surveys demonstrate a decline in percentage of hauls with *C. coelolepis* declined between 1975 and 2000.

A second attempt was made during DELASS. The French cpue data for Subareas V, VI and VII for *C. coelolepis* and *C.squamosus* together were used as inputs. The combined cpue for these Subareas was calculated from the total catch and effort data presented in the WGDEEP Report (ICES, 2002b). These data did not display as marked an upward trend as demonstrated in the WGDEEP Report (ICES, 2002b). Both cpue datasets were used as inputs. The time-series for Subarea VI, where most effort took place, both displayed downward trends until 1998. The WGDEEP 2002 series did not display the high peak in the SGDEEP 2000 series for 1991. However, the value for 2001 is the highest since 1994. There is no similar upward trend for the other subareas, and it is unclear what the reasons for this trend are. The series for the Subareas combined displayed the same trend, indicating the importance of effort in Subarea VI on these sharks. However, there is no anecdotal evidence from the fishery to suggest that there is an upward trend in abundance in 2000 or 2001.In addition, Norway (autoline) and Ireland (autoline and trawl) survey abundance indices in Subarea VI did not mirror the upward trend in cpue from the French commercial fishery. Furthermore, the pooled species data, from autoline surveys displayed a downward trend from 1997 to 2000. In Subareas VII and XII there is some evidence of a decline in survey cpue throughout the 1990s.

In the second attempt the cpue data for siki representing non-directed effort as input to Schaeffer Production Model, using the CEDA package (Holden *et al.*, 1995). This model and package were chosen to allow for comparisons to be made with the previous assessment attempted for these stocks. 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 that the time-series of catch and cpue were too short to explore the effect of recruitment over range of years. It was assumed, therefore, that growth rather than recruitment was the main contributor to biomass production. The available time-series data of cpue data demonstrate a gradual decline across most of the time period. 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. A value of the ratio of initial stock to virgin stock was chosen as 0.7, based on sensitivity analysis. The fit of the Schaeffer production model was very poor when all years were included. It was considered reasonable to exclude years 1991 and 1993 because the 42|ICES WGEF Report 2005 fishery was not fully developed then. The directed cpue series (ICES, 2000) displayed a peak in 1991. However non-directed cpue did not display a first peak until 1993, which probably reflected the targeting of the orange roughy fishery in Subarea VI at that time. The years 2000 and 2001 were excluded because there was no supporting evidence of an upward trend in stock abundance in these years. Subsequent runs of the Schaeffer model gave a better model fit than when all years were included. Two additional scenarios were considered, using the WGDEEP 2002 cpue and the cpue recalculated in DELASS from the raw catch and effort data. The model was considered to fit the downward trend on abundance quite well, for the years considered.

Many of the output parameters from the Schaeffer production model are poorly estimated (Intrinsic rate of population increase (r) and maximum sustainable yield) and should not be used to assess the developments in these stocks. Carrying capacity and catchability seemed to be estimated with narrower confidence intervals. It was emphasized that because the estimates of carrying capacity are sensitive to the catch data used, the absence of species-specific data are a cause for concern. Given that Portuguese dogfish has a deeper bathymetric distribution than the leafscale gulper shark, the combined series may mask important trends in their respective abundance. Further refinement of species-specific catch and effort data, perhaps considering other reference fleets should be carried out. Such work would be particularly valuable for the fisheries that have taken place for the longest duration (French trawl and Portuguese longline fisheries). The stock of Portuguese dogfish certainly has not stabilized during the 1990s. Estimates of maximum sustainable yield (MSY) and intrinsic population growth rate (r) derived from stock production models cannot be usefully applied with the current model fits.

Advice given for these stocks in 2008 was based on trends in cpue and landings for the two species combined in French trawl fisheries and for separate species in Portuguese longline fisheries.

Benchmarked assessment methodology

Portuguese dogfish is assessed using trends in;

- Standardised cpue indices from Portuguese commercial fisheries;
- Presence/absence in Scottish and Irish surveys disaggregated by depth;
- French lpue indices; species-specific indices will be used when they become available. Until then, the combined "sikis" index may be used with caution to provide historical trends in combined lpue.

G. Biological reference points

No appropriate biological reference points have been identified for these stocks.

H. Other issues

None.

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Stock Annex: Leafscale gulper shark (*Centrophorus squamosus*)

Stock	Leafscale gulper shark (*Centrophorus squamosus*)
Working Group	WKDEEP
Date:	17.02.2010–24.02.2010
Revised by	Ivone Figueiredo and Tom Blasdale

A. General

Leafscale gulper shark (*Centrophorus squamosus*) has a wide distribution in the North East Atlantic from Iceland and Atlantic slope south to Senegal, Madeira and the Canary Islands and the mid-Atlantic slope as far south as the Azores. On the Mid-Atlantic Ridge it is distributed from Iceland to Azores (Hareide and Garnes, 2001) The species can live as a demersal shark on the continental slopes (depths between 230 and 2400 m) or present a more pelagic behaviour, occurring in the upper 1250 m of oceanic water in areas with depths around 4000 m (Compagno and Niem, 1998). Available evidence suggests that this species is highly migratory (Clarke *et al.*, 2001, 2002). Available information demonstrates that pregnant females and pups are found in Portugal, both the mainland (Moura *et al.*, 2006) and Madeira, while only pre-pregnant and spent females are found in the northern areas (Garnes, Pers. Comm.).

A.1. Stock definition

There is insufficient information to differentiate stocks of in the Northeast Atlantic and consequently ICES has adopted the assumption of single stocks for each of these species in the ICES area.

A.2. Fishery

Several species of deep-water sharks have been commercially exploited in the ICES area, however the most important are *C. squamosus* and *C. coelolepis*. These two species are both mainly taken in several mixed trawl fisheries in the Northeast Atlantic and in mixed and directed longline fisheries. Directed gillnet fisheries formerly operated in some areas.

Country by country accounts are presented as follows:

Norway–Norwegian longliners target blue ling (*Molva dypterigia*), Mora (*Mora moro*) and leafscale gulper shark (*Centrophorus squamosus*) on the continental slope between 800 and 1100 metres. In 2000 and 2001, a longline fishery for Greenland Halibut with a bycatch of Portuguese dogfish operated on Hatton Bank between 1300 and 1600 metres.

Faroes–A directed longline fishery on deep-water sharks was carried out in the southern and western slopes of Faroes Island from 1995 to 1999. No detailed information on this fishery is available although anecdotal information suggests that fishing was developed at depths between 800 and 1200 meters in the slopes west of the Wyville Thompson Ridge and south of the Faroe Bank Plateau.

Germany–In the early 2000s two German vessels conducted a deep-water gillnet fishery (Hareide *et al.*, 2004). The main fishing area was the southern part of Area VII (Porcupine Seabight and around Rockall. (Area VI and XII). The deep-water sharks were landed in Spain as 'various sharks'. This fishery ceased in 2006 as a result of the EU ban on fishing with gillnets in depths greater than 600 m.

France–C. *squamosus* and *C. coelolepis* and lately, *Centroscyllium fabricii*, are caught by the French trawl fishery for mixed deep-water species. Initially this fishery was conducted in ICES Subareas VIa, VIIc,k but in 2001 when the Irish deep-water trawl fishery started to operate in Subarea VII most of the French fishing fleet moved to Subarea VIa).

In Subarea XII there have been some French landings of deep-water sharks, but it is not possible to detect any trends from the available data.

Ireland–An Irish longline fishery targeting ling and tusk in the upper slope and deep-water sharks started in 2000 and ceased in 2003. Mainly two species of deep-water sharks, *C. coelolepis* and *C. squamosus* were marketed but there were some landings of birdbeak dogfish and longnose velvet dogfish.

Several large newer trawlers have targeted deep-water species in Subareas VI and VII. There is a directed fishery for orange roughy in Subarea VII, with a low a bycatch which includes *C. coelolepis* and *C. squamosus* as well as a more extensive fishery on the continental slopes of Sub-areas VI and VII for mixed deep-water species including *C. coelolepis* and *C. squamosus*.

UK–Between the mid 1980s and 2006, UK registered longliners and gillnetters operating a directed fishery for deep-water sharks in Subareas VI, VII and XII. The fleet was mostly composed of vessels based in Spain but registered in the UK, Germany and other countries outside the EU such as Panama.

C. squamosus and *C. coelolepis* are caught by a Scottish deep-water mixed-species trawl fishery operating mainly in Subarea VI. Since the introduction of TACs for a number of deep-water species in 2003, effort in this fishery has been at low level.

Spain–A fleet of around 24 large freezer trawlers conducts a mixed deep-water fishery in international waters of the Hatton Bank, mainly in ICES Subarea XII and partially in Division VIb, however, few of these vessels worked full-time in this fishery (two in 2000 and four in 2001). The main commercial fish species are smoothheads, roundnose grenadier, blue ling and *C. coelolepis*.

The Basque "baka" trawl fishery operates in Subareas VI and VII and Divisions VIIa,b,d but deep-water species including sharks are only important in Subarea VI. In the period 1997–2002, a small longline fishery targeting deep-water sharks landed annually in Basque ports about 150 t in "trunk" weight (i.e. gutted and without head, skin and fins) of deep-water sharks (Lucio *et al*., 2004).

Portugal–At Sesimbra (Division IXa), the longline fishery targeting black scabbardfish *Aphanopus carbo* takes a bycatch of deep-water sharks. The most important shark species caught by this fishery are the Portuguese dogfish and leafscale gulper sharks. Deep-water sharks are also caught by the Portuguese deep-water bottom-trawl fishery that targets the rose shrimp *Parapenaeus longirostris* and *Nephrops* mainly south and southwest of the Portuguese mainland. Deep-water shark species caught in this fishery are: birdbeak dogfish, blackmouth catshark, gulper shark, kitefin shark, leafscale gulper shark, smooth lanternshark *Etmopterus pusillus* and velvet belly.

From 1983 till 2001 there was directed longline fishery for deep-water sharks, based at Viana do Castelo in northern Portugal. Landings from this fishery predominantly consisted of gulper shark. However, other deep-water species are caught in relatively small quantities. These include the leafscale gulper shark, Portuguese dogfish, blackspot sea bream (*Pagellus bogaraveo*), greater fork-beard (*Phycis blennoides*), European conger (*Conger conger*) and the black scabbardfish. In the early years of the fishery only the livers of the sharks were of commercial value.

A.3. Ecosystem aspects

Centrophorus squamosus

C. squamosus is found in the eastern Atlantic (from Iceland to Senegal and off Namibia and South Africa), western Indian Ocean (off South Africa and Madagascar) and western Pacific (Japan, Philippines, southeastern Australia and New Zealand) (Compagno, 2004). In the ICES area, *C. squamosus* is widely distributed in deeper waters off Iceland (ICES Divisions Va–b) the western British Isles (VIa–b, VIIb–c, j–k), Bay of Biscay and Cantabrian Sea (VIII), off Portugal (IX) and the Azores (X).

This species lives near the bottom of the continental slope from 230–2400 m depth (Compagno *et al.*, 2004). Recorded depth ranges in the Northeast Atlantic are 933 m off Iceland (Magnússon *et al.*, 2000); 1400–1900 m along the Reykjanes Ridge, west of Norway (Hareide and Garnes, 2000); on the Hatton Bank 600–1200 m (Duran Muñoz *et al.*, 2000) and down to 1950 m; 458–1019 m in the Rockall Trough (Gordon, 1999); 600–1400 m west of Ireland (Girard, 2000); 750–1500 m in the Porcupine Seabight (Merret *et al.*, 1991) and 800–1500 m off Portugal (Veríssimo *et al.*, *2003*).

B. Data

B.1. Commercial catch

In Portuguese and some Spanish fisheries, deep-water shark species have always been recorded separately in landings data. However, in other fisheries, it has been common practice until recently to record landings of all species collectively under generalized categories such as "various sharks not elsewhere identified", "siki sharks", "dogfish sharks not elsewhere identified," etc. This has made it very difficult to quantify landings of deep-water sharks, particularly as the same categories are often used to report other species such as pelagic sharks or spurdog.

Historical catches have been reconstructed according to a two stage procedure. First, landings data recorded under the various grouped categories were examined using expert knowledge of the fisheries operating in particular areas and time periods to determine which were likely to be deep-water sharks. These were included in the Working Group's estimates of "siki shark", i.e. mixed deep-water species comprising mainly *C. squamosus* and *C, coelolepis.* The data which were identified by WGDEEP 2005 as referring to deep-water shark species (included in the "siki sharks" data table) are listed in Table 1. All other records under mixed categories are believed to be other species.

In the second stage, the landings data in the "siki sharks" data table were split according to the proportions observed in various sampling schemes and surveys, etc to give estimates of species-specific landings. The data sources used in this splitting are listed in Table 2. A considerable number of assumptions have been made in order to split catches from areas, years and fisheries from which no data were available. For instance, data from trawl fisheries were used to split landings from UK gillnetters. This will be improved should better data become available in future e.g. it is expected that species-specific landings for UK gillnetters will be provided by the RACs.

Table 1. Landings recorded in combined categories considered by WGEF to be "siki" sharks; i.e. mixed deep-water species comprising mainly *C. squamosus* and *C, coelolepis*.

LANDING CATEGORY	COUNTRY	ICES SUBAREAS/DIVISIONS	YEARS
cartilaginous fish NEI data	No landing in this category were considered to be deep-water sharks		
various sharks NEI	UK-England and Wales	V, VI and VIIc,	1990 to 2002
	UK-Scotland	All	1989 to 2001
	Portugal	VIIIc	1990 to 2000
	Poland	VIb	2002 and 2003
	Estonia	VIb	2002 and 2003
	Lithuania	XII	2001 and 2003
dogfish sharks NEI	France*	VI, VII, XII	1989 to 2003
	Germany	V, VI, VII, XII	1995 to 2003
Landing identified by species but identification considered unreliable	Faroes	All	All
	France*	All	All
	Ireland (records of Portuguese dogfish probably contain unknown quantities of leafscale gulper shark)	VII	2001–2006
	Scotland (Portuguese dogfish probably contain unknown quantities of leafscale gulper shark. Records of Leafscale gulper shark are considered to be correct)	VI	1997–2005
	Lithuania (*C. coelolepis* landings probably contain *C. squamosus*)	All	All
Data supplied to WGEF but identification considered unreliable	UK-England and Wales**	All	2001–2004
	UK-Scotland	All	2001–2004

*** all data in FISHSTAT was replaced by more reliable data provided to WGDEEP 2002.**

**** Data from 2003 and 2004 replaced with data from Cefas.**

Table 2.

Source	ICES area	Years	Gear	Type	Available information
French Landing	VIa	1999–2001	Trawl	Fishery Landing sampling	Ratios not by depth Note: 12 boats/year
French Landing	VIa	2002–2008	Trawl	Fishery	French landings statistics; vessels from one fish owning company reported the species separately using an appropriate protocol to identify species Note: Represent 50% of landings
French trawler(auction market)	VIa	2009	Trawl	Fishery	Proportion of the two species by depth
SAMS	VIa	2000–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: very small numbers caught
IRISH s	VIa &VIIc	2006–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: depth strata are not the same between surveys
DEEPNET Report	VI & VII		Gillnet	Fishery	Ratios in weight Note: data from 1 recovered net
Cefas	Va,Vb VIIj,k	2004 2005	Gillnet	Fishery	Observer data
Cefas	VIa	2005; 2006	Longline	Fishery	Observer data
Spanish fishery	VIb and XII Hatton Bank	2005–2008	Trawl	Fishery	Observer data Ratios per depth & by ICES subarea
IEO	VIIb,k	2001–2009	Trawl	Survey	Information by haul

Any future method developed to split the historical UK (E+W) landings data by species cannot be used for advice until it is benchmarked.

B.2. Biological

Centrophorus squamosus

There is little information regarding reproductive biology in this species, although there are some data on the size-at-maturity and fecundity for fish caught west of the British Isles (Gordon, 1999; Girard, 2000) and Portugal (Figueiredo *et al*., 2008). The size at first sexual maturity for fish caught off the western British Isles has been recorded as 98 and 106 cm for males and females respectively (Girard and Du Buit, 1999). Clarke *et al*. (2002) estimated that males and females matured at lengths of 102 and 128 cm respectively. In Portugal mainland, males and females mature at 99.1 and

126.3 cm, respectively, and median length at pregnancy was estimated as 123.8 cm (Figueiredo *et al*., 2008) Females from the western British Isles produce 7–11 oocytes, and a mean of five oocytes per ovary (Girard and Du Buit, 1999). However, it was recently suggested that ovarian fecundity is correlated with the female total length in this species (Figueiredo *et al*., 2008).

Available information reveals that pregnant females and pups are found in Portugal, mainly in Madeira and with sporadic occurrences in the mainland (Moura *et al*., 2006 WD) whereas only pre-pregnant and spent females are found in the northern areas (Garnes, pers. comm.).

In Portugal mainland and despite the scarcity of mature females, the gonad index increased in the second quarter and the greatest values of mean follicle diameter and of oviducal gland width (which are supposed to occur prior to ovulation) were also found in the second quarter of the year. These facts, although not conclusive, may lead to the hypothesis of the existence of a reproductive season (Figueiredo *et al*., 2008).

Clarke *et al*. (2002) estimated ages of 21–70 years for *C. squamosus* caught off the western British Isles, although the absence of smaller specimens in the study area restricted the fitting of growth models with meaningful confidence limits.

B.3. Surveys

FRS has conducted deep-water surveys (depth range 300–1900 m) in Division VIa since 1996. Since 1998 the survey has been reasonably consistent about survey design, gear deployed and area covered (Jones *et al*., 2005). The survey uses a large commercial trawl (made by Jackson) and is towed for a period of 1.5–2 hours at speeds of 3–3.5 knots. Initially, the survey was carried out on a biennial basis, but since 2004 has been carried out annually.

B.4. Commercial cpue

Portuguese longline fisheries

In the 2008 meeting of WGEF, standardized lpue from Portuguese longliners data were presented (Figueriedo *et al*., 2008WD). This Working Document presented the results of an exploratory analysis of daily landings data from Portuguese vessels with deep-water licences to operate in the Portuguese continental slope. These vessels target black scabbardfish but have bycatch of Portuguese dogfish and leafscale gulper shark.

The underlying assumption "*at small spatial scales, catch is proportional to the fishing effort and density*" followed when evaluating catch rates as an index of abundance, may be not adequate for deep-water sharks due to the mixed nature of this fishery that catches them.

Data used

- Individual daily landings per species and per fishing vessel were available for the period 1995–2006;
- For the period 2000–2004, VMS records exhibited time intervals of 10 minutes which allows the identification of fishing locations. Afterwards and with cross analysis with the daily landings data it was possible to infer the catch data, because in this fishery discards are almost null (WD);

- Following point 2 of article 8 from EC Regulation no. 2244/2003 of 18 December and due to operational constraints associated with data handling in Portuguese VMS monitoring centre, requests of this type of data from 2005 onwards have been provided with a polling frequency of 2 hours, which make their use for the fishing location purpose not viable.

In the analysis of the longer dataseries, several attempts were made to incorporate into the hurdle model factors other than fishing locations as a way to circumvent the lack of that information for the remaining time period. Due to the low level of adjustment, particularly for Portuguese dogfish, the analysis proceeded by estimating the mean landed weight by daily landing per year as well as its variance. To avoid the use of almost null catches of each deep-water shark landings it was decided not to consider landings in which the weight of each of these species represented less than 10% of landed weight of black scabbardfish.

Lpue from French fisheries in Subarea Vb, VI and VII

Time-series for lpue has been available in past years for a number of species exploited by French deep-water fisheries including deep-water sharks. Because sharks are not separated by species in landings data, this series is for combined species “siki” sharks. Lpues were calculated for a reference fleet of similar size vessels belonging to one French port and divided into six areas to account for changes in distribution of fishing effort (Figure 1). It is now impossible to further extend this time-series as all but one of the reference fleet has been decommissioned.

In one French port, landings of deep-water sharks are split by species. It is believed that vessels from this port are typical of the fishery as a whole so ratios derived from these landings can be used to split French landings of “siki” and thus calculate an unstandardized commercial lpue series for Portuguese dogfish and leafscale gulper shark individually. These series, when it is available, will be used in preference to the combined “sikis” lpue in assessments. Until then, the combined index will be used for historical trends but must be interpreted to take account of the different life histories of the two species and possible implications for sensitivity to fishing.

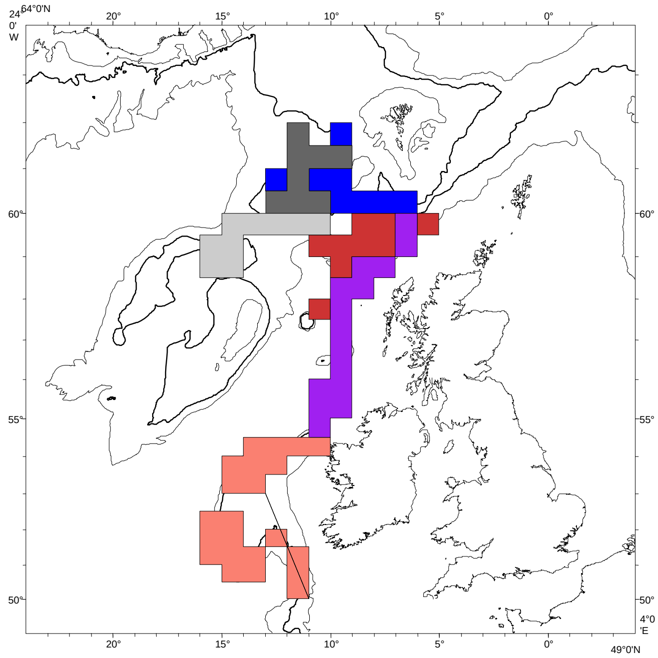

Figure 1. Areas used to compute lpue of French vessels (black: New grounds in V; blue, Reference area in V; Grey: new grounds in VI; Purple reference area in VI-edge; Red: Reference area in the VI - other; pink reference area in VII.

Industry data

An observer from the Long Distance Fleet Regional Advisory Council (LDRAC) attended the Benchmark meeting. The observer contacted the LDRAC Headquarters to investigate the possibility of having UK gillnetter and longliner fisheries data available long before the next WGEF that will be held in June 2010.

B.5. Other relevant data

C. Historical stock development

The first preliminary assessment on *C. coelolepis* and *C. squamosus* combined was attempted by SGDEEP (ICES, 2000) using the available series of catch and effort from French reference fleet trawlers as inputs. The series of cpue data presented in WGDEEP (ICES 2002b, Table 17.2) formed the basis of attempted assessments. In all cases, however, these assessments were considered to be too unreliable to be included in the Report of that Working Group.

Further analyses of stock status were presented in Basson *et al.* (2002) describes the results from the SGDEEP assessments of deep-water sharks using Schaefer and Delury analyses and from presence/absence analyses of long-term RV time-series data. This study demonstrated that it is evident that the relative importance of larger size females increased in recent years. In addition the percentages of non-zero hauls in Scottish research trawl surveys demonstrate a decline in percentage of hauls with *C. coelolepis* declined between 1975 and 2000.

A second attempt was made during DELASS. The French cpue data for Subareas V, VI and VII for *C. coelolepis* and *C.squamosus* together were used as inputs. The combined cpue for these Subareas was calculated from the total catch and effort data presented in the WGDEEP Report (ICES, 2002b). These data did not display as marked an upward trend as demonstrated in the WGDEEP Report (ICES, 2002b). Both cpue datasets were used as inputs. The time-series for Subarea VI, where most effort took place, both displayed downward trends until 1998. The WGDEEP 2002 series did not display the high peak in the SGDEEP 2000 series for 1991. However, the value for 2001 is the highest since 1994. There is no similar upward trend for the other subareas, and it is unclear what the reasons for this trend are. The series for the Subareas combined displayed the same trend, indicating the importance of effort in Subarea VI on these sharks. However, there is no anecdotal evidence from the fishery to suggest that there is an upward trend in abundance in 2000 or 2001.In addition, Norway (autoline) and Ireland (autoline and trawl) survey abundance indices in Subarea VI did not mirror the upward trend in cpue from the French commercial fishery. Furthermore, the pooled species data, from autoline surveys displayed a downward trend from 1997 to 2000. In Subareas VII and XII there is some evidence of a decline in survey cpue throughout the 1990s.

In the second attempt the cpue data for siki representing non-directed effort as input to Schaeffer Production Model, using the CEDA package (Holden *et al.*, 1995). This model and package were chosen to allow for comparisons to be made with the previous assessment attempted for these stocks. 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 that the time-series of catch and cpue were too short to explore the effect of recruitment over range of years. It was assumed, therefore, that growth rather than recruitment was the main contributor to biomass production. The available time-series data of cpue data demonstrate a gradual decline across most of the time period. 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. A value of the ratio of initial stock to virgin stock was chosen as 0.7, based on sensitivity analysis. The fit of the Schaeffer production model was very poor when all years were included. It was considered reasonable to exclude years 1991 and 1993 because the 42|ICES WGEF Report 2005 fishery was not fully developed then. The directed cpue series (ICES, 2000) displayed a peak in 1991. However non-directed cpue did not display a first peak until 1993, which probably reflected the targeting of the orange roughy fishery in Subarea VI at that time. The years 2000 and 2001 were excluded because there was no supporting evidence of an upward trend in stock abundance in these years. Subsequent runs of the Schaeffer model gave a better model fit than when all years were included. Two additional scenarios were considered, using the WGDEEP 2002 cpue and the cpue recalculated in DELASS from the raw catch and effort data. The model was considered to fit the downward trend on abundance quite well, for the years considered.

Many of the output parameters from the Schaeffer production model are poorly estimated (Intrinsic rate of population increase (r) and maximum sustainable yield) and should not be used to assess the developments in these stocks. Carrying capacity and catchability seemed to be estimated with narrower confidence intervals. It was emphasized that because the estimates of carrying capacity are sensitive to the catch data used, the absence of species-specific data are a cause for concern. Given that Portuguese dogfish has a deeper bathymetric distribution than the leafscale gulper shark, the combined series may mask important trends in their respective abundance. Further refinement of species-specific catch and effort data, perhaps considering other reference fleets should be carried out. Such work would be particularly valuable for the fisheries that have taken place for the longest duration (French trawl and Portuguese longline fisheries). The stock of Portuguese dogfish certainly has not stabilized during the 1990s. Estimates of maximum sustainable yield (MSY) and intrinsic population growth rate (r) derived from stock production models cannot be usefully applied with the current model fits.

Advice given for these stocks in 2008 was based on trends in cpue and landings for the two species combined in French trawl fisheries and for separate species in Portuguese longline fisheries.

Benchmarked assessment methodology

Leafscale gulper shark is assessed using trends in;

- Standardised cpue indices from Portuguese commercial fisheries;
- Presence/absence in Scottish and Irish surveys disaggregated by depth;
- French lpue indices; species-specific indices will be used when they become available. Until then, the combined "sikis" index may be used with caution to provide historical trends in combined lpue.

G. Biological reference points

No appropriate biological reference points have been identified for these stocks.

H. Other issues

None.

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6 Red (blackspot) sea bream in Subarea X (*Pagellus bogaraveo*)

6.1 Current stock status and assessment issues

ICES considered a single stock of red (blackspot) sea bream for the all ICES area. However, recognize three different management/assessment units, based on genetics and tagging information:

- Areas VI, VII, and VIII;
- Area IX; and
- Area X (Azores region).

The status of the red blackspot sea bream in Subarea X is uncertain but there are signs of increases in indices of abundance from surveys and stable cpue from the fishery.

Last assessment was performed during the 2006 WGDEEP meeting exploring the following common assessment methods: separable VPA, Laurec-Shepherd *ad hoc* VPA and the XSA. Results demonstrate imprecise estimations on recruitment and a lack of convergence on the population estimates and recruitment back on time. No formal assessment was carrying out thereafter, because similar trends where observed. Data are available for this species but results from exploratory analysis from the Expert Group have been demonstrated that they do not catch the dynamic of this fishery (highly spatially disaggregated) and species (sex change dynamic).

6.2 Compilation of available data

6.2.1 Catch and landings data

Complete official landings are available since 1982; however detailed landing by vessel is only available since 1990. An incomplete time-series from 1948 is available to be used for illustrative development of the fishery.

Available data for this species:

Biological data

Length composition from the fishery (1990–2008) and surveys (1995–2008).

Age–length keys from the fishery (period 2002–2008) and surveys (1995–2008).

Maturity data from the fishery (periods 1982/1986; 1991 and 2002/2008).

Sex-ratio from the fishery (periods 1982/1986; 1991 and 2002/2008) and from surveys (1995–2008).

Fecundity information is available, estimated from fishery data for period 1984/1986.

Survey tuning data

Annual Azorean longline survey relative abundance is available for the period 1995–2008. Survey abundance indices present a high interannual variability with an increase pattern along time. There is not a full explanation for this variability which may result from several sources (small to large-scale environmental effects, year effects on catchability, etc).

Commercial tuning data

Standardized fishery catch rates are available for the period 1990–2008. The fishery catch rates presented a relatively stable trend along time.

Industry/stakeholder data inputs

No data for red (black spot) sea bream were present by the industry at WKDEEP.

6.3 Stock identity and migration issues

The red (black spot) sea bream of Subarea X have been considered as a separate management unit. The Azores is a remote oceanic area, far from the other continental components, and the essential fishing habitat available for the species on Subarea X occurs only around the Azores EEZ. Genetic information demonstrates that there are no genetic differences between populations from different ecosystems within the Azores region (East, Central and West group of Islands, and Princesa Alice bank) but there are genetic differences between Azores (ICES Subdivision Xa2) and mainland Portugal (ICES Division IXa) (Stockley *et al.*, 2005). Tagging data (unpublished information) suggests there are no significant large-scale movements. About 5150 red (black spot) sea breams where tagged until now with a recapture of about 4%. The average time at liberty was 1 year and the maximum time recorded was 8 years. Ontogenic migrations toward the deeper strata and from islands to seamounts are hypothesized. Preliminary acoustic tagging data seems to demonstrate fish residency pattern within some areas, suggesting possible different behaviours within the population.

6.4 Spatial changes in the fishery and stock distribution

Technical management measures related with spatial planning of the demersal/deep-water fleets have been implementing in the Subdivision Xa2 by the Autonomous Regional Government of Azores. Longline gear are almost only permitted on the seamounts areas consequently the larger vessels (>24 m) expanded the operational area to the limits of the EEZ or even outside the EEZ. Inside the 3 miles of the coastal areas only handlines are permitted (inside the 1 mile box only handlines and vessels less than 12 m). The effect of these measures on the stocks was not yet assessed, because data are not available with the necessary area/vessel/gear detail.

6.5 Environmental drivers of stock dynamics

Stock dynamics of *Pagellus bogaraveo* seems to be highly affected by environmental variability at several scales. This is a bentho-pelagic species, feeding mainly in the water column, and so, changes on the water mass structure or on the distribution of the preferential prey species may introduce severe catchability problems.

6.6 Role of multispecies interactions

The Azores fishery presented a high level of technological interactions (several species are caught at the same time with the same gear) (Menezes *et al.,* 2006). Although some degree of targeting is possible for some species, red (blackspot) sea bream included, data are available by trip, which include several sets using different gears. Landings with positive catches of red (blackspot) sea bream demonstrate high correlations of co-occurrence with other demersal/deep-water species from the different depth assemblages. The assessment of the impacts on the more vulnerable species are difficult and management to address this problem have been based on technical measures to reduce the fishing effort on the more coastal areas, corresponding to the distribution area of the more vulnerable species.

During the last two years some interactions between the handlines fishery (particularly the fishery targeting squids) and dolphins have been documented and are under research.

6.6.1 Trophic interactions

No important trophic interactions have been document between the demersal/deep-water species.

6.6.2 Fishery interactions

This fishery is a multispecies, multigear, multifleet one where technological interactions occur. Fisheries interactions where observed between handlines and longliners (gear interaction for space). To minimize this effect a spatial fleet zonation was implemented, moving away longliners from coastal areas, grading the distance from the coast according the gear, TAB and vessel size (Portaria Regional nº 101/2002 de 24 de Outubro). Demersal/deep-water fisheries where also classified as demersal (<400 m), deep (400–700 m) and very deep (>700 m), limiting the proportion of certain species that each component can land.

Some degree of fisheries interaction have been also reported between the larger longliners and the European swordfish fishery operating between the 100 miles and 200 miles of the Azorean EEZ, and even outside the EEZ areas. This is mainly a space problem, particularly on the seamounts where both fisheries tend to concentrated.

6.7 Impacts on the ecosystem

The Azores area is considered a "clean" area because there are no significant sources of pollution like industry, urban waste, etc. Fisheries are considered, along with the commercial traffic of marine transport and the tourism, the main source of man impact in the ocean. However, the hook and lines have been considered the gears with less impact in the marine environment, and observations until know in the Azores ecosystem does not demonstrate any significant gear effects on the seabeds. Trawl is forbidden in a significant EEZ area (trawl ban box) (EC Reg. 1568/2005) and other European vessels than the Azorean have no access to the 100 miles area of the Azorean EEZ (100 miles box).

6.8 Stock assessment methods

Annual survey and fishery abundance index from ICES Subarea Xa2 demonstrates relatively stability trend along time (Figure 1). As a complement to this information WKDEEP suggests to analyse survey and fishery data in order to derive other possible indicators to assess the stock status. Mean length and abundance for different components of the population, like immature and mature component of the stock were used here as possible indicators for illustration.

Annual survey and fishery length composition where used for this exercise. Annual mean length was computed for both sources of data and the trend analysed.

For the survey data indices of abundance (cpue weighted by the area size) by length classes were computed. These annual data were then disaggregated by sexes assuming a sex change dynamic proposed by Krug (1990; 1998). Sexes categories considered were: females, males, hermaphrodites and undifferentiated. Undifferentiated correspond to individuals that sex was not possible to identified (usually correspond to very immature individuals in which sex is difficult to observe macroscopically during the sampling). Females correspond to individuals in which only the gonad is present or hermaphrodites females in which female gonad and male testes are present but the individual was classified, during the sampling, as female because gonad was in a more developed stage and so was assumed to be as functional female. The opposite was assumed for males i.e. males include gonochoric males and hermaphrodites males classified as functional males. Hermaphrodites correspond to individuals with both sexes present but none was classified as functional active (or it was difficult during the sampling to classify it without doubts). So, these hermaphrodites may include immature and mature individuals.

To split the annual length composition by sex the following equations were used to describe the sex-ratio of each sex:

$$P = \frac{1}{1 + e^{(6.56 - 0.1816 * LF)}} \quad \text{Females}$$

$$P = \frac{1}{1 + e^{(-5.180 + 0.227 * LF)}} \quad \text{Males}$$

$$P = 0.388 * (-23.688 + LF) e^{[-0.225 * (-23.688 + LF)]} \quad \text{Hermaphrodites}$$

$$P = e^{(16.68 - 0.71 * LF)} \quad Undifferen\ tiated$$

Female's sex-ratio covers the period 1982/1986, because no significant statistical differences were found between periods. For the others sexes was adopted the estimates from the year 1991, because it is the most recent estimates available. Equations for males and females describe the sex ratio as a logistic function (ascendant for females and descendent for males), dome shape for the hermaphrodites and descent exponential for the Undifferentiated.

To split these annual length compositions by mature and immature length compositions the following maturity ogives for males and females were adopted:

$$P = \frac{1}{1 + e^{(-21.43 + 0.66 * LF)}} \quad \text{Females}$$

$$P = \frac{1}{1 + e^{(-13.46 + 0.476 * LF)}} \quad \text{Males}$$

Abundance was estimated first for each sex type summing along length the abundance of mature males and females (the matrix result from the multiplication of length, sex-ratio and maturity). Hermaphrodite's abundance corresponded to males and females but no mature or immature individuals were separated. Undifferentiated correspond to the abundance of sex combined of juveniles. Immatures were not completely separated with this method.

In a second step, a knife edge was adopted to separate mature from immature fish by sex type. For this purpose the following lengths of first maturity were used for males and females, or adopted arbitrary for the hermaphrodites (on the assumption that individuals larger than 28 cm are in sex transition from male to female and so are already mature fish):

SEX	MATURE	IMMATURE
Males	> 32 cm	< 32 cm
Females	> 28 cm	< 28 cm
Hermaphrodites	> 30 cm	< 30 cm
Undifferentiated	-	All

Total annual abundance for mature was then estimated as the sum of considered mature males, females and hermaphrodites and the immature as the sum of considered immature males, females, hermaphrodites and Undifferentiated.

For each of these sexes the mean length was estimated.

This analysis was run for all survey area. The analysis was not run for disaggregated area because there was no time during the Benchmark meeting to perform it. Concerns were also express if data by area on this discontinued ecosystem are representative, because the Azorean longline survey is not design for abundance estimate of a particular area (ex. Individual Seamount or island). Seamounts in particular, are structures of different sizes, shapes, elevation, heights, depth summit, etc, where only part of the essential habitat for the species distribution is available. In this sense the sampling effort for this analysis may be not representative or may be affected by uncounted factors like local and temporally depletion due to fishing before sampling. Conclusions from these results should be interpreted with caution.

Following the same procedure mean length by statistical area was computed.

The input data for this exercise are resumed in Figures 2–5. The dynamic of sex change, maturity and sex-ratio were assumed constant along time (Figures 2–4). Abundance of the longline survey length composition presented annual variability with a mode on 25–30 cm (Figure 5).

Abundance estimates by sex are presented on Figure 6. It follows the same trend of variability of the total abundance and the same stability of the abundance along time is observed. Annual mean length by sex is also stable along time (Figure 7).

Annual abundance and mean length of mature and immature individuals, estimated by adopting a knife edge hypothesis is presented on Figures 8–10. The same stability trend is observed on abundance and mean length. Abundance of mature and immature individuals follows also the same annual variability of the total abundance.

Annual mean length from the survey and fishery presented a similar trend of annual variability (Figure 11).

Additionally annual information on mean length by area for the total population is presented in Figure 12. It is observed that larger individuals are present in the banks areas (mean length 35 cm) and smaller individuals in the coastal areas (28 cm). However, West islands groups presented the similar mean lengths that those from the banks. The overall trend seems to be stable along years and areas. These results may suggest different fishing mortalities from these two major areas (coastal areas and banks/seamounts).

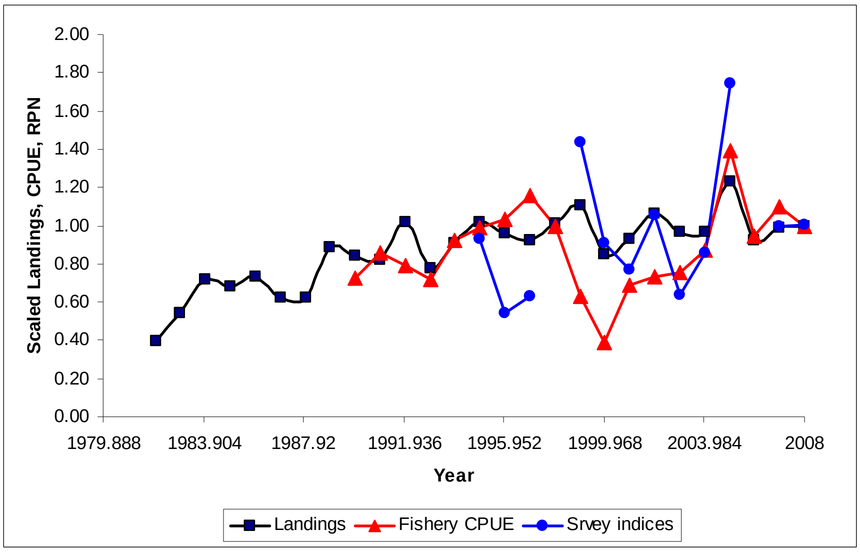

Figure 1. Fishery and survey abundance indices of Red (Blackspot) sea bream Subarea Xa2. Historical landings are also presented on the graph. The information is scaled to the mean of each dataset.

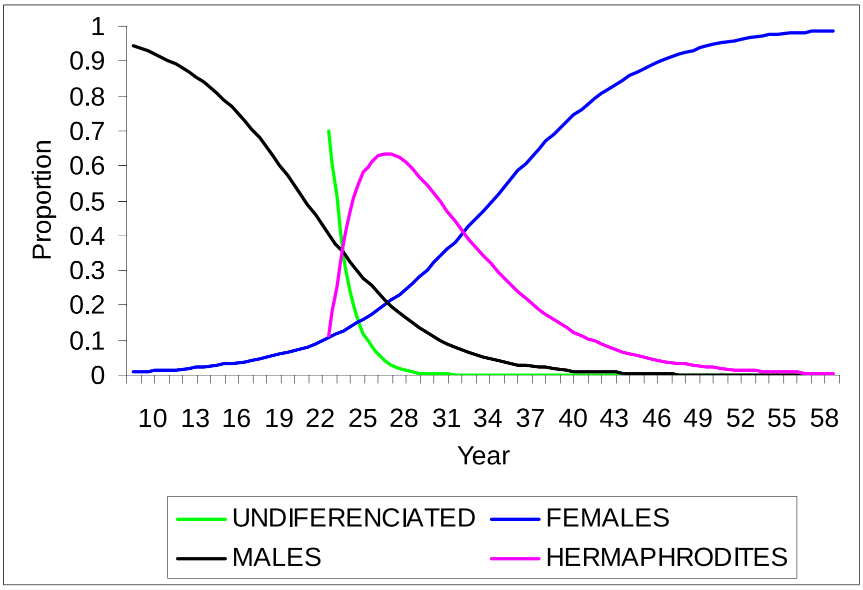

Figure 2. Sex-ratio dynamic adopted for the stock.

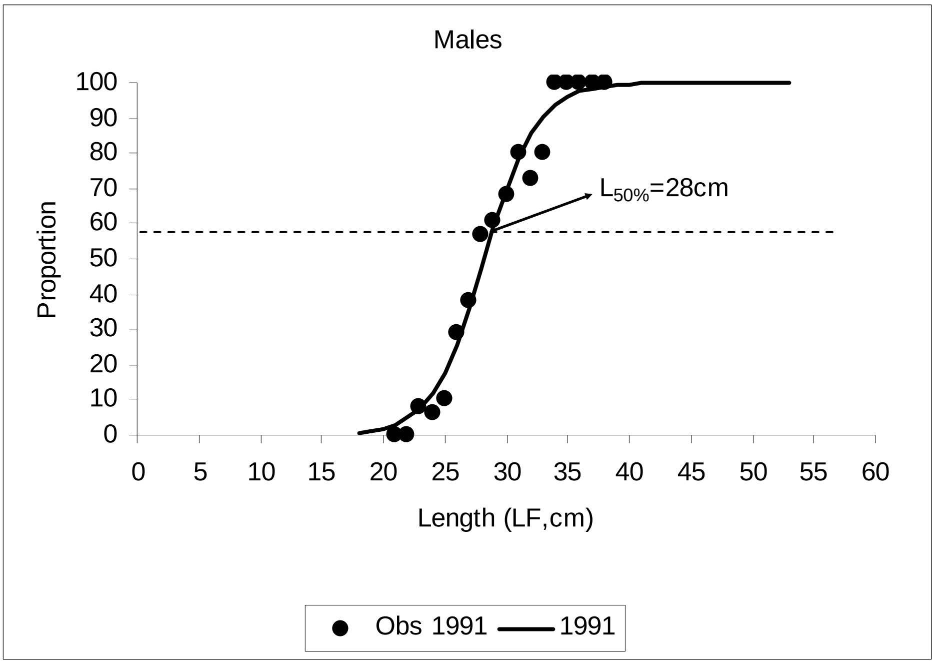

Figure 3. Maturity ogive adopted for males.

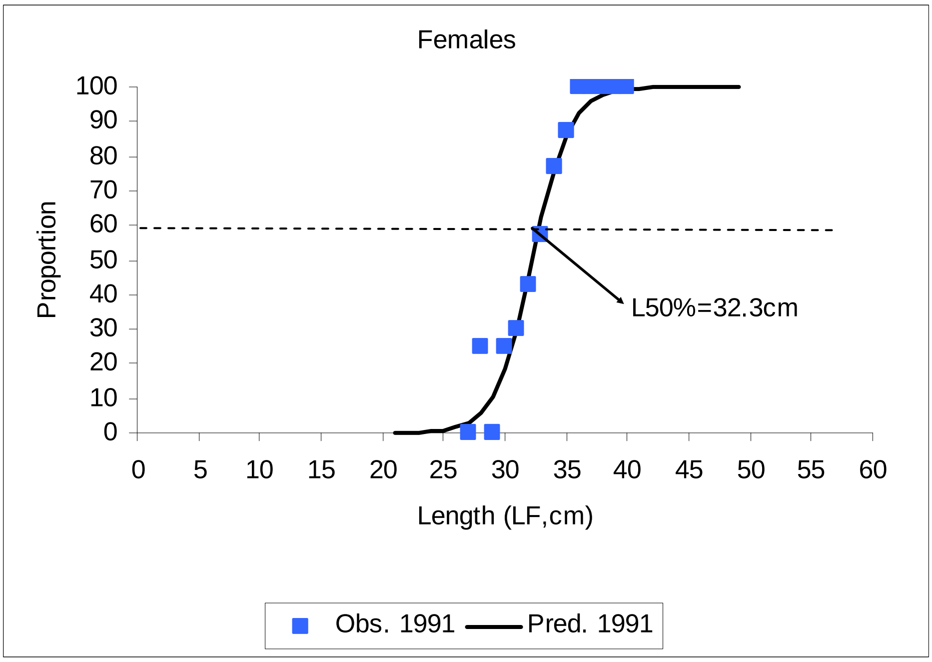

Figure 4. Maturity ogive adopted for females.

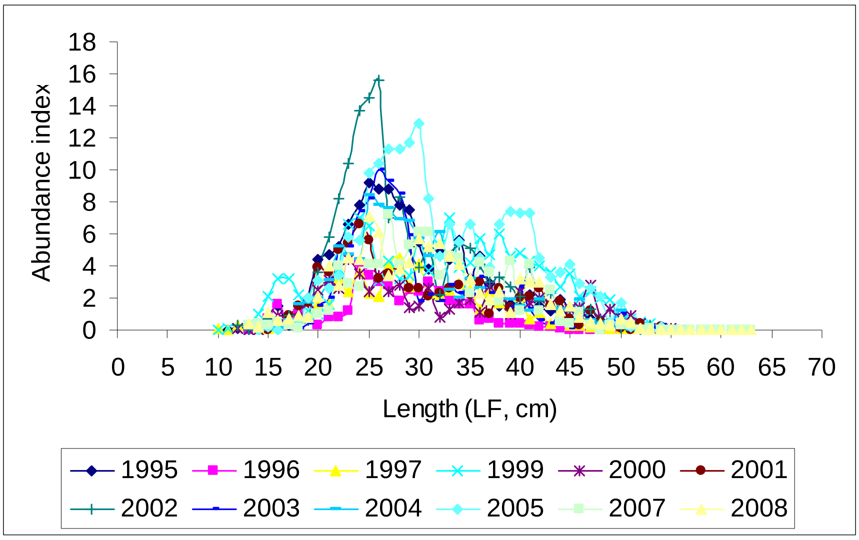

Figure 5. Azorean (ICES Subarea Xa2) survey length compositions from 1995 to 2008.

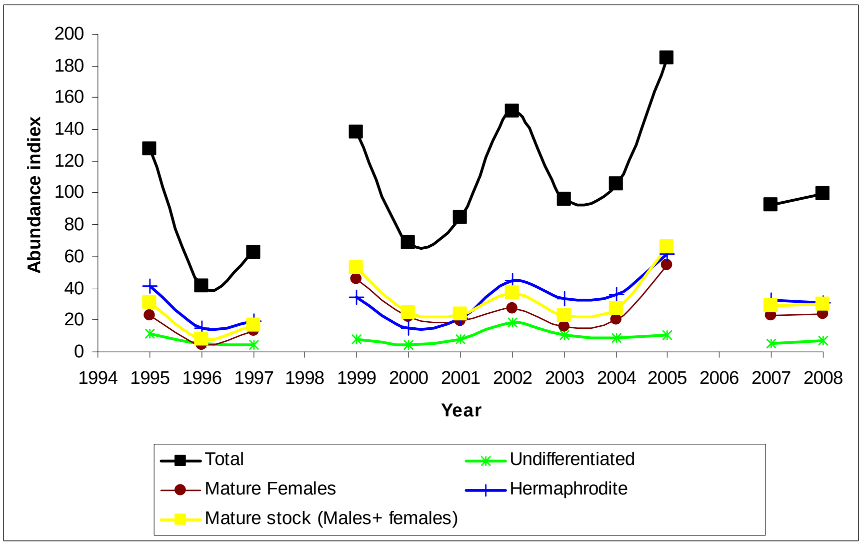

Figure 6. Annual abundance by sex (immature individuals were not separated).

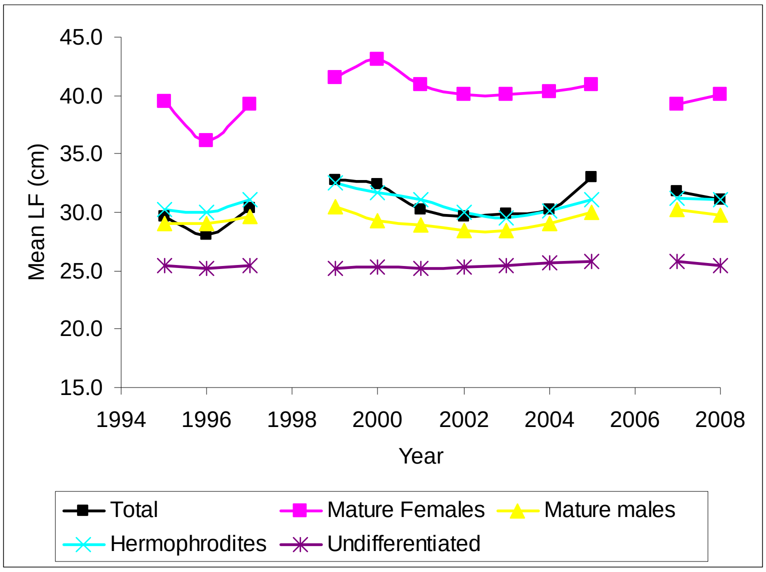

Figure 7. Annual survey mean length by sex.

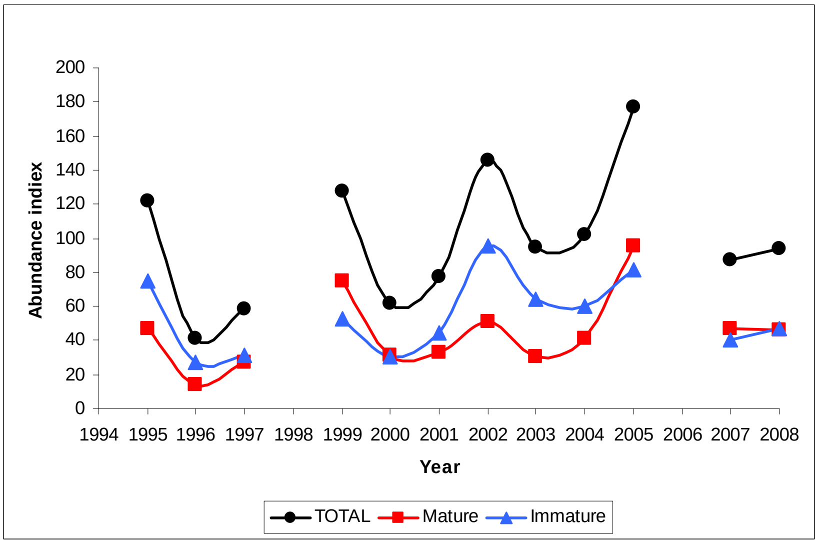

Figure 8. Annual abundance estimates of total population, mature and immature individuals estimated under the knife edge hypothesis.

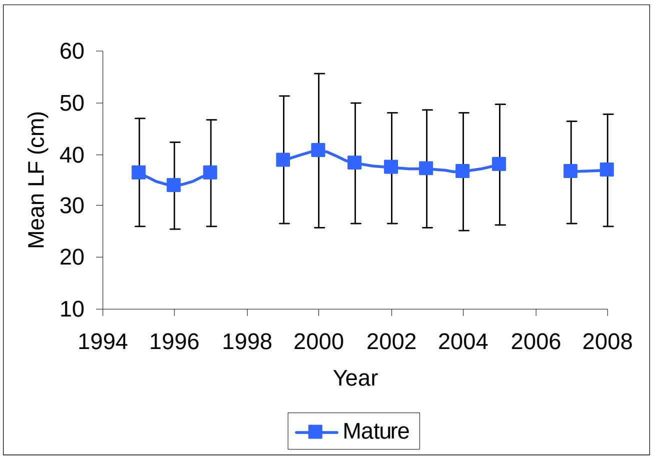

Figure 9. Annual mean length of mature individuals from the Azorean longline survey.

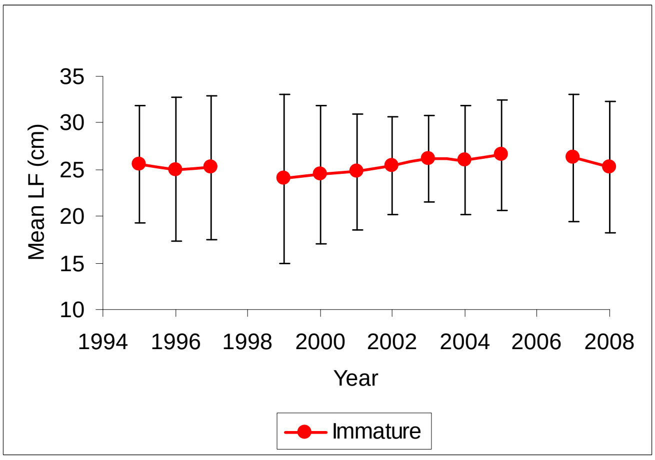

Figure 10. Annual mean length of immature individuals from the Azorean longline survey.

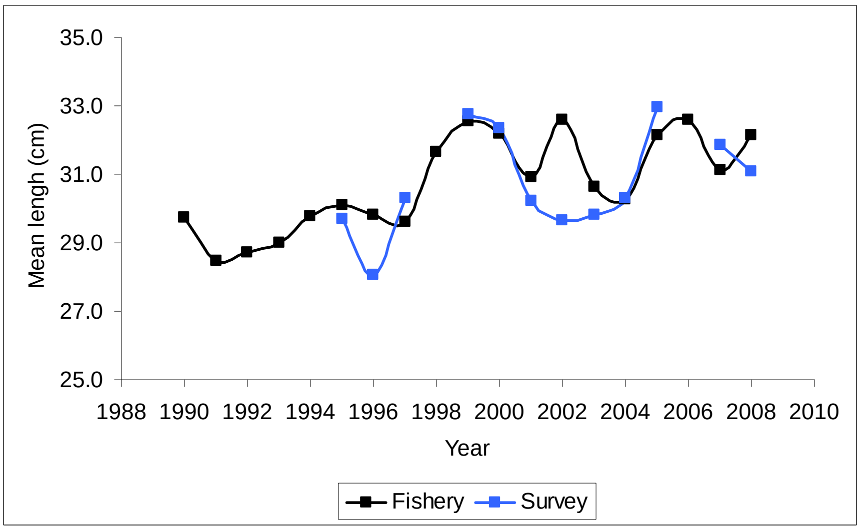

Figure 11. Annual mean length from the fishery and survey from the Azores.

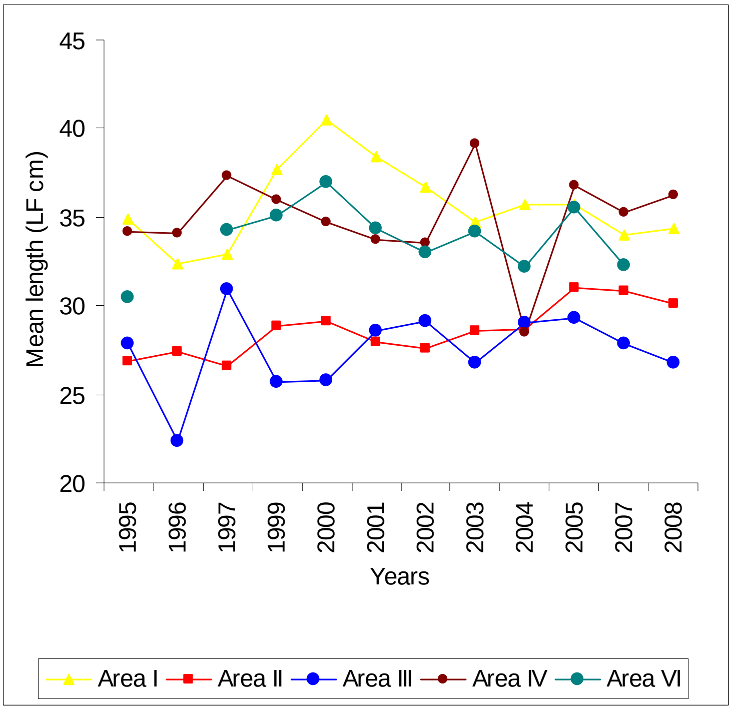

Figure 12. Annual survey mean length by statistical areas. I-Princesa Alice bank, II-Coastal of central islands group, III- Costal of Est island groups, IV- Mar da Prata bank, VI-West island groups.

6.8.1 Models

No assessment model were presented to WKDEEP.

6.9 Biological reference points

No biological reference points were proposed for red (blackspot) sea bream in Subarea X at WKDEEP.

6.10 Recommended modifications to the stock annex

No modifications on the stock annex are suggested as there was no annex in existence before this meeting.

6.11 Recommendations on the procedure for assessment updates

For this species annual fishery and survey abundance index trends and biological indicators derived from the length compositions should be explored and used to assed the stock status. Annual data disaggregated as much as possible (by year, area and strata) must be prepared and biological indicators like recruitment index, mature and immature abundance and mean lengths computed. It would be highly desirable to have annual fishery abundance data split by area (at least aggregated by coastal areas and bank/seamounts) and gears.

6.12 Industry supplied data

No data were sullied by the industry.

6.13 References

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Stock Annex: Red (Blackspot) sea bream (*Pagellus bogaraveo*) in Subarea X

Stock	Red (Blackspot) sea bream (*Pagellus bogaraveo*) in Subarea X
Working Group	WKDEEP
Date	February, 2010 WKDEEP 2010
Revised by	Mario Pinho

A. General

A.1. Stock definition

"Stock limits are generally determined not only by biological considerations but also by agreed boundaries and coordinates. ICES considered three different components for this species: a) Areas VI, VII, and VIII; b) Area IX, and c) Area X (Azores region). This separation does not pre-suppose that there are three different stocks of red (blackspot) sea bream, but it offers a better way of recording the available information" (ICES, 2007).

In fact, the interrelationships of the red (blackspot) sea bream (*Pagellus bogaraveo*) from Subareas VI, VII, and VIII, and the northern part of Division IXa, and their migratory movements within these sea areas have been confirmed by tagging results (Gueguen, 1974). Possible links between red (blackspot) sea bream from the Azores region (Subarea X) with the others areas are not yet fully studied. However, recent studies demonstrate that there are no genetic differences between populations from different ecosystems within the Azores region (East, Central and West group of Islands, and Princesa Alice bank) but there are genetic differences between Azores (ICES Subarea X) and mainland Portugal (ICES Division IXa) (Stockley *et al.*, 2005). These results, combined with the known distribution of the species by depth and tagging information, suggest that Subarea X component of this stock can be considered as a separate management unit.

A.2. Fishery

Blackspot sea bream has been exploited in the Azores (Subdivision Xa2), at least, since the XVI century, as part of the demersal fishery (Silva and Pinho, 2007).

The Azorean fishery is a multispecies (Figure 1) and multigear/fleet one (demersal mixed hook and lines) (Figure 2). About 104 species belonging to 49 families were caught and identified during the spring demersal longline surveys from 1995–2006 (Menezes *et al.*, 2006). This demersal community is structured by assemblages according depth (Pinho and Menezes, 2005; Menezes *et al.*, 2006). Three main assemblages can be defined according depth: Shallow (<200 m), Intermediate (200–700 m) and Deep (>700 m). The key species of this fishery is black spot sea bream (*Pagellus bogaraveo*) and bluemouth (*Helicolenus dactylopterus*), distributing from shallow (<50 m) to deep depth strata (1000 m). The fishery is also considered as small-scale because the largest proportion (about 80%) of small vessels (<12 m).

The directed fishery is a mixed hook and line fishery where two components of the fleet can be defined: the artisanal (handlines) and the longliners. The artisanal fleet is composed of small open (sometimes closed) deck boats (<12 m) that operate on local areas near the coast of the islands using several types of handlines and covering depth until 800 m. Longliners are closed deck boats (>12 m) that operate in all areas (except on the 3 miles of island coasts), including banks and seamounts (Pinho and Menezes, 2005; Silva and Pinho, 2007; Pinho and Menezes, 2009) (Figure 3). In the past, the tuna fishery has also caught juveniles (age 0) of blackspot sea bream for use as live bait, in a seasonal and irregular way, depending on tuna abundance and on the occurrence of other preferred bait species, like *Trachurus picturactus* (Pinho *et al*., 1995). This practice has been reduced significantly during the last decade, particularly since the introduction of the TACs.

The operational regime of each vessel type varies considerably. Small open-deck vessels usually operate in areas near the coast, using mainly handlines. They make daily trips and target mainly shallow (<200 m) and intermediate (200–700 m) depth species (see Pinho and Menezes, 2005). On average this component make between 70 to 150 fishing days per year, depending on the based island of the vessel. Some open-deck vessels (9–12 m) based in St Miguel Island operates in a larger area including banks near the coast (to 50 nm). These vessels make about 200 fishing days per year. Small closed-deck vessels (<14 m) are considered the main component of the fleet targeting deep-water species and cover almost all areas and depth strata. They use mainly deep longlines and handlines, operating in coastal areas of the islands and in the main banks and seamounts. These vessels operate in all strata but preferentially target species from 200–800 m strata, making on average between three and seven fishing days per trip, with one set a day, though occasionally more, using from six to ten thousands hooks by set. On average they make about 200 fishing days per year. Industrial vessels operate mainly on banks and seamounts, inside or outside the EEZ, including the ICES and CECAF areas, using deep longlines. They usually fish in the intermediate (200–700 m) and deep-water strata (>700 m). These vessels make trips, on average of seven days, with one (or more) sets a day of about 14 000 hooks a set. They make on average 250 fishing days per year. However, the fleet presents a very high level of absenteeism (many vessels operate on a non regular basis and with many interruptions on landings along time), particularly on the small vessel size component, probably related with the subsistence characteristic of this component where the fishers are also farmers.

Although the predominant gears are the demersal longline and handlines, the fleet, particularly the local open (or close) deck component, is very plastic and can operate opportunistically and on seasonal way to other species like crustaceans (using traps) or small pelagic (using nets), squids or tunas (live and bait) in function of the abundance and price (Pinho and Menezes, 2009). Each vessel has usually permits to use different gears.

A.3. Ecosystem aspects

The red blackspot sea bream is found in the Northeast Atlantic, from south of Norway to Cape Blanc, in the Mediterranean Sea, and in the Azores, Madeira, and Canary Archipelagos (Desbrosses, 1938; Pinho and Menezes, 2005**)**. Hareide (2002) reported also occasional occurrence of this species along the Mid-Atlantic Ridge (north and south of the Azores). The Azores region (Subdivision Xa2) is considered a management unit based on genetic studies and tagging data (ICES, 2007).

Blackspot sea bream is a bentho-pelagic species that inhabits various types of bottom (rock, sand, and mud) down to a depth of 900 m. The vertical distribution of this species varies according to individual size, and season of the year. In the Azores, this species is found in all habitats (coastal areas of islands, banks, and seamounts) down to 900 m depth (Figure 4). Local distribution is directly correlated with depth with juveniles inhabiting littoral and shallow waters (0–30 m), young immature individuals inhabiting depths less than 300 m, and large adults inhabiting areas between 300–700 m depth (Menezes *et al*., 2005).

Blackspot sea bream undertakes a vertical spawning migration, with the adults moving from deeper to shallower waters during the spawning season (December–March) and forming aggregations (Krug, 1990; 1998). The dynamic of the spatial distribution in the Azores region is not yet very well understood. Data from the survey demonstrates that juveniles (age 0–1 years) are almost absent from the main seamounts, but are found in the coastal areas throughout the year, suggesting areas interactions (Pinho, 2003).

The Azores is an oceanic region where deep-water ecosystem is predominant. The major topography feature is the mid-Atlantic Ridge (MAR) that follows a sinuous course southwards from Iceland to the Azores. Islands and seamounts are other prominent topographic features, which are characterized by very specific circulation patterns and play an important role in ocean biological system (Bashmachnikov *et al*., 2005; 2009a; 2009b; Silva and Pinho, 2007, Morato *et al*., 2008). This ecosystem is poorly known and important dynamics of the *Pagellus bogaraveo* population are dependent of environmental dynamics at different scales.

The essential fishing habitat of *Pagellus bogaraveo* comprises littoral and deep-water areas. The distribution of this habitat around the Azores is much discontinued.

B. Data

For this species data are available from commercial fisheries and from surveys reported to ICES (Table 1). Data from commercial fisheries include landings (auction data) and biological port sampling. There are also inquires and logbooks and observers (from large longliners) available to compute fishing effort.

Annual landings are computed from the diary sales of fresh fish on the auctions. Landing information does not include discards. Biological sampling is made on the most important fisheries ports, which usually incorporate an inquiry to the captain. From these data are computed the annual fishery length composition and the fishing effort. Standardized catch rates, exploring several explanatory variables (year, port, season and vessel type), have been estimated since 2006.

Biological fishery data, including aging and maturity, is available and is collected annually since 2002, under the EU data collection regulation, and since 2009, under the EU data collection framework.

Demersal longline survey data are available since 1995 (Pinho, 2003; Menezes *et al*., 2006). Annual abundance index and biological data (length composition, sex, age and maturity) from the survey is available and the time-series have been presented to the ICES WGDEEP.

Data is supplied from databases maintained by Department of Oceanography and Fisheries (DOP/UAç). An informatics routine to compute these basic output data specific for the WGDEEP is under development.

The data used in the assessments are considered as the best available data at the Working Group time of the year.

B.1. Commercial catch

Landings data (in weight and value) from the Azores have been reported to ICES. Landings are collected directly from the first sale of fresh fish on the auctions. Information on discards has been collect in recent years, but it is not relevant to Red (Blackspot) sea bream because the species almost is not rejected.

Complete official landings are available since 1982; however detailed landing by vessel is only available since 1990. An incomplete time-series from 1948 is available to be used for illustrative development of the fishery (Figure 5).

Landing data disaggregated by gear type, area and depth is lacking or is incomplete.

B.2. Biological

The information available for *Pagellus bogaraveo*, Azores ICES Subdivision Xa2, is resumed in Table 1.

Annual length composition from the fishery (1990–2008) and survey (1995–2008) are available. In general length composition covers amplitude of lengths from 10 to 57 cm with a mode around 30 cm.

Pagellus bogaraveo is a protandric hermaphrodite species changing from males to females (Figure 6). Sexing and staging this species may be sometimes problematic because macroscopic scales are not validated with microscopic observations.

Spawning in SubdivisionXa2 occurs from December to March, with a mode on January/March (Figure 7).

Maturity information is only available for some periods (1982-1986, 1991 and 2002–2008).

Red (blackspot) sea bream is considered a slow growing species. Gueguen (1969) reported a maximum age of 20 years, Ramos and Cendero (1967) and Coupé (1954) reported 12 years, Sanchez (1983) reported 10 years, Ana *et al* (2006) reported 9 years and Gil and Sobrino (2002) reported 8 years. In the Azores a maximum age of 15 years was observed in a 56 cm length fish (Krug, 1994). However, no age validation was obtained by examining structures from known age fish (e.g. from mark-recapture studies with conventional tags or tetracycline method).

Ageing data are available from the fishery and from the surveys. Annual ALK are available for the survey (1996–2008) and fishery (2002–2008). Growth parameters have been estimated for sex combined (Pinho *et al.,* 2006).

B.3. Surveys

Survey data available from the Azores for *Pagellus bogaraveo* is resumed in Table 1.

The Azorean longline survey was conducted annually each spring (usually from April to June) from 1995 to 2008, with exception of the years 1998 and 2009. The survey followed a stratified design (6 statistical areas and 12 depth strata) and covered the Azores archipelago around the islands, banks, and major seamounts (Figure 8). The survey is design for abundance estimation of red (blackspot) sea bream, covering the depth strata from 50 to 600 m. Depth coverage was extending to 800 m since 2004. Additionally depth from 800 to 1200 m is covered in one transept by statistical area for ecological studies. Details of the survey design can be found in Pinho (2003) and Menezes *et al.* (2006).

The catch per hook value (cpue) was calculated for each species, area, and station stratum, and an index of relative abundance in number (RPN) (or weight-RPW) was obtained by multiplying each of these cpue values by the corresponding area size. The average RPN value for each area and stratum was then calculated. The abundance values for each area and for the Azores were computed by summing the abundance index values across strata and across areas, respectively.

Length data were collected for all survey years, following a random stratified design. Length samples were stratified by station, statistical area and depth strata, then weighted by the area-stratum size. The resultant length distributions were averaged within each area-stratum and summed across strata and areas to estimate total length frequency.

B.4. Commercial cpue

Nominal commercial catch rates are estimated by trip from the fishery landing enquiries data, collected by interviews to the fishermen during the landings. So, the catch data for each trip correspond to the landings information collect by the auction market. The effort data are recorded by shore based samplers that inquire the fishing masters collecting detailed information on fishing operations, including the number of hooks per set, number of sets per trip, gear characteristics, etc. Each record also includes information on date, geographical area of the catch and catch in weight for each species landed. The total fishing effort per trip is usually estimated as the product of the mean number of hooks per set times the number of sets per trip. Nominal catch rates were estimated as the kg of blackspot sea bream caught per 1000 hooks.

This catch rates are affected by the abundance but also by other factors, like season, gear configuration, boat type and fishing target species. The effects of the different factors in the catch rates have been estimated, using GLM - generalized linear models, since 2006 (Pereira, 2006). This standardized cpue covered the considered “fully exploited phase” of the fishery (since 1990) and presented a relatively stable trend. There is no information available for the ancient times of the fishery.

B.5. Other relevant data

C. Historical stock development

The first attempted to assess the resource was performed during 1996 SGDEEP meeting using the SVPA and Laurec-Shepherd on the matrix of catch-at-age from the period 1982–1993 and the Azorean effort fleet. Concerns related to the annual age compositions, maturity ogives and lack of convergence were expressed and the assessment was not validated (ICES, 1996). A new attempted was made during the 2006 WGDEEP meeting using SeparableVPA, Ad hoc VPA tuning and XSA) (ICES, 2006). The results from the exploratory assessment performed in 2006 were considered unreliable.

Agreed data and assessment at the Benchmark (WKDEEP, 2010).

Annual landing data from 1990 and onwards and standardized cpue from 1990 and onwards. Standardized fishery cpue derived by applying the GLM delta lognormal model distribution to inquiry data (landing and effort data by trip and vessel).

Azorean longline survey abundance indices from 1995–onwards.

Annual survey length compositions abundance by area from 1995–onwards.

This assessment unit is assessed based on i) trends in the mean length of mature and immature from longline survey using the entire survey area and individual survey statistical areas; ii) trend in abundance in survey and standardize commercial cpue series.

For the survey data indices of abundance (cpue weighted by the area size) by length classes were computed. These annual data were then disaggregated by sexes assuming a sex change dynamic proposed by Krug (1990; 1998). The sexes include: Females, males, hermaphrodites and undifferentiated.

To split the annual length composition by sex the following equations were used to describe the sex-ratio of each sex:

$$P = \frac{1}{1 + e^{(6.56 - 0.1816 * LF)}} \quad \text{Females}$$

$$P = \frac{1}{1 + e^{(-5.180 + 0.227 * LF)}} \quad \text{Males}$$

$$P = 0.388 * (-23.688 + LF) e^{[-0.225 * (-23.688 + LF)]} \quad \text{Hermaphrodites}$$

$$P = e^{(16.68 - 0.71 * LF)} \quad Undifferen\ tiated$$

Where P is the proportion of each sex category and LF is the fork length.

To split these annual length compositions by mature and immature length compositions the following maturity ogives for males and females were adopted:

$$P = \frac{1}{1 + e^{(-21.43 + 0.66 * LF)}} \quad \text{Females}$$

$$P = \frac{1}{1 + e^{(-13.46 + 0.476 * LF)}} \quad \text{Males}$$

Where P is the proportion of mature of each sex and LF fork length.

L50% derived from ogives given above were 28 cm for males and 32 cm for females. A midpoint between these two values was assumed for hermaphrodites. A knife edge was adopted to separate mature from immature fish by sex type see Table below).

Sex	Mature	Immature
Males	> 28 cm	< 28 cm
Females	> 32 cm	< 32 cm
Hermaphrodites	> 30 cm	< 30 cm
Undifferentiated	-	All

This analysis should be carried out for the entire survey area and survey statistical areas.

D. Short-term projection

No short-term projection is conducted for this stock.

E. Medium-term projection

No medium-term projection is conducted for this stock.

F. Long-term projection

No long-term projection is conducted for this stock.

G. Biological reference points

No reference points were defined for this stock.

H. Other issues

None.

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Table 1. Time-series from fishery and survey available for the assessment of *Pagellus bogaraveo*, ICES, Area X. Data in brackets refers to a period.

DATA	FIHERY	SURVEY
Length composition (sex combined)	1990–2008	1995–2008
ALK (otholits)	(2002–2008)	1995–2008
Maturity ogives	(1982–1986); 1991; (2002–2008)	-
Sex-ratio	Same as maturity ogives	1995–2008
Abundance index	1990–2008	1995–2008
Landings (weight)	1980–2008	-

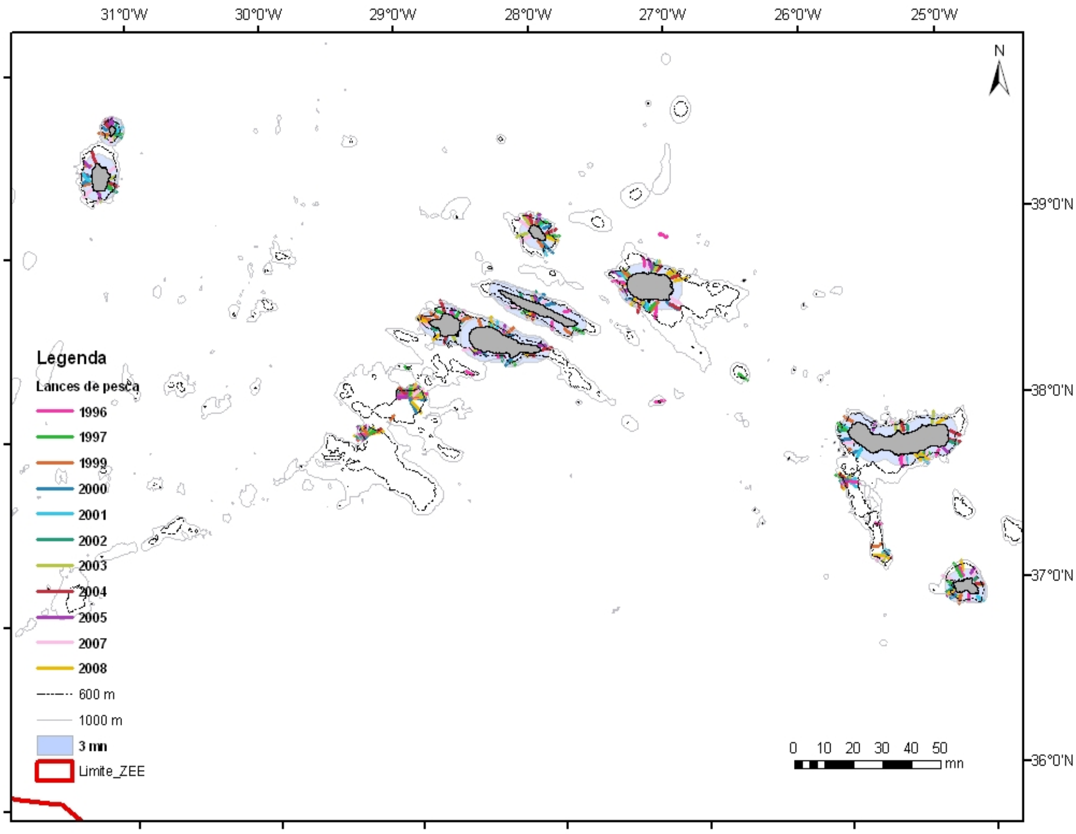

Figure 8. Statistical areas covered by the Azorean Spring Demersal Longline Survey. Annual transepts are represented on the graph for illustration. The 3 miles (shadow) island coast box area and the 600 m and 1000 m contour are also shown. Adapted from Rosa (1999).

7 Greater silver smelt (*Argentina silus*) in the Northeast Atlantic

7.1 Stock identity and migration issues

The current ICES structure for greater silver smelt is that ICES Subareas I, II, IV, VI,VII, VIII, IX, X, XII and XIV and Divisions IIIa and Vb, are treated as a single assessment unit. Only the greater argentine around Iceland (Division Va) is treated as a separate assessment unit.

The limited and hypothetical information on possible stocks was reported in the 1998 Study Group Report (CM 1998/ACFM:12), quote:

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

For the purpose of an exploratory assessment, WGDEEP in 2009 made an assumption that greater silver smelt around the Faroe Islands could be treated as a separate assessment unit, although available information was not sufficient to suggest changes to the ICES interpretation of stock structure.

During the WKDEEP2010 meeting, new data and analyses were presented on growth curves (age, length data), maturity ogives (age at first maturity, gonad stage), and distribution and timing of spawning. These analyses generally grouped data into the three main fisheries areas: Iceland, Faroe Islands, and Norway.

7.1.1 Growth curves

Available age–length data were used to generate von Bertalanffy curves for the three main fishing areas separately. Although there was considerable variability of individual fish length-at-age, the resultant curves for the areas showed marked differences (Table 7.1.1, Figure 7.1.1). No age calibration exercises as been performed to check the agreement between age readers of the different institutes. Ageing of greater silver smelt is considered relatively easy at least up to age 20 and this might relax the importance of the lack of calibration, although conducting such calibration is encouraged.

Table 7.1.1. Parameters estimated in von Bertalanffy growth curve for combined sexes, females, and males for age 0–19.

	Both sexes		Females		Males	
	Estimate	Std.	Estimate	Std.	Estimate	Std.
ICELAND						
Linf	47.9	0.294	49.6	0.441	45.8	0.369
K	0.17	0.004	0.16	0.005	0.19	0.005
t0	-2.14	0.058	-2.30	0.089	-2.01	0.074
NORWAY						
Linf	39.5	0.273	41.7	0.388	36.9	0.29
K	0.19	0.007	0.19	0.008	0.22	0.01
t0	-2.13	0.136	-1.85	0.169	-2.02	0.173
FAROE ISLANDS						
Linf	42.4	0.231	43.9	0.311	40.3	0.288
K	0.22	0.004	0.22	0.005	0.24	0.007
t0	-1.12	0.043	-1.08	0.050	-1.11	0.067

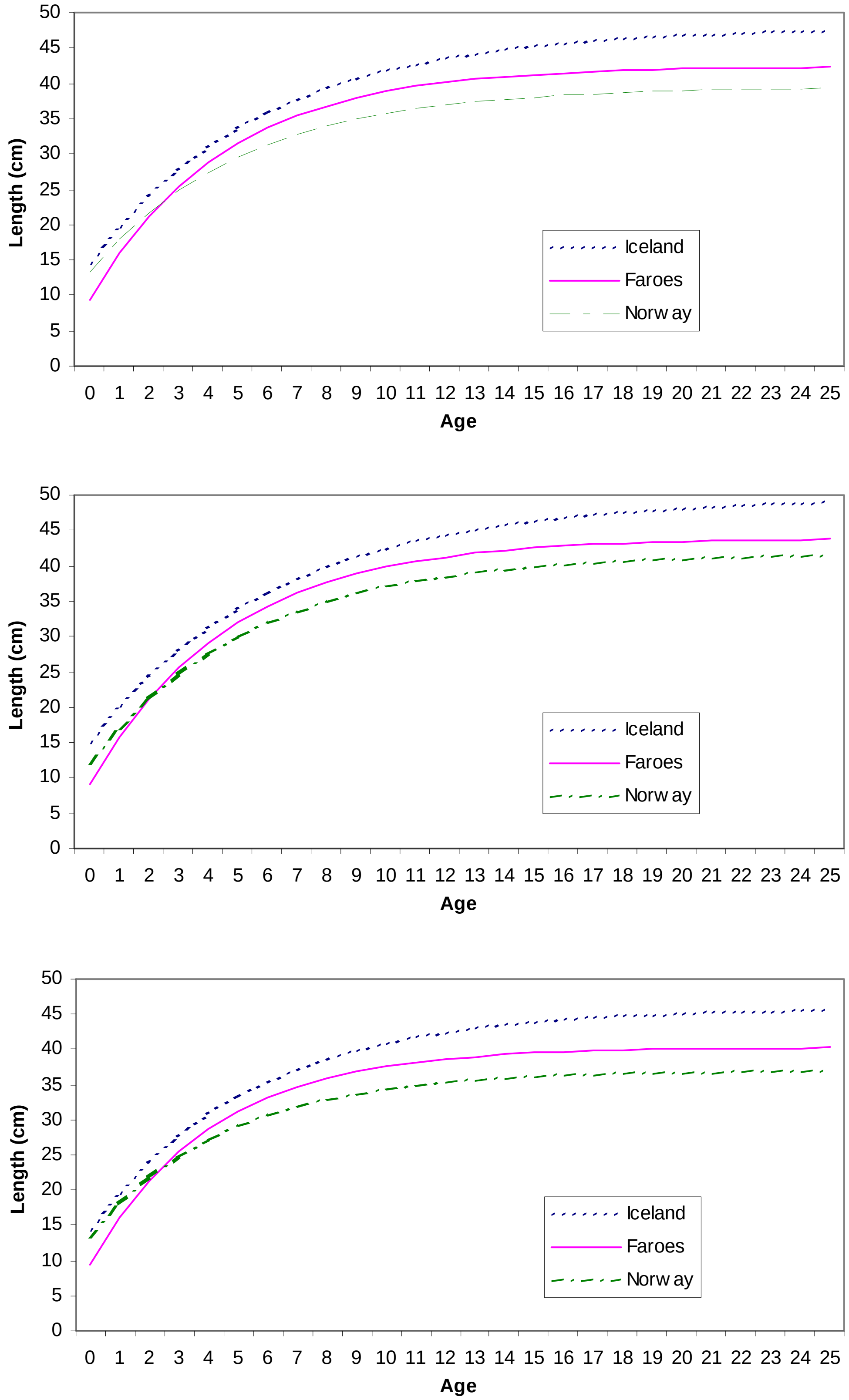

Figure 7.1.1. Growth curves for greater silver smelt by area (combined sexes (top), female (middle), male (bottom).

It was unclear whether these differences could be clear patterns in regional growth, or whether they indicated wider-scale variability. A single comparison was then done dividing the Icelandic dataset into two: a western set, and data from south of Iceland. The latter demonstrated differences which in some cases were as large as the differences between the three larger regions (Figure 7.1.2).

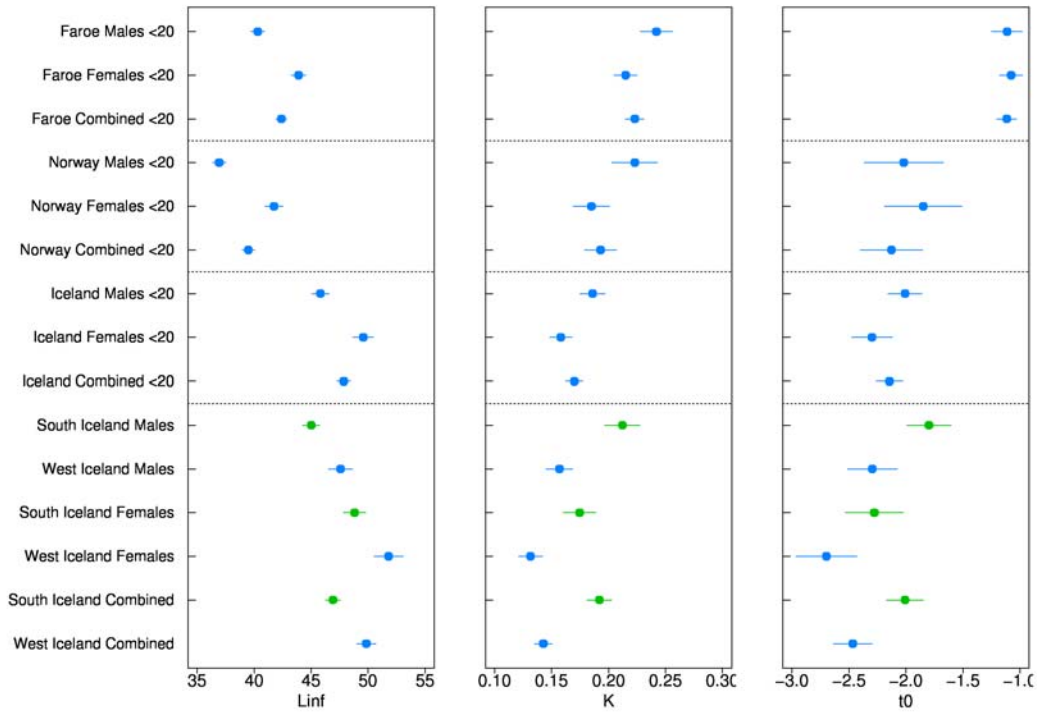

Figure 7.1.2. Comparison of von Bertalannfy parameters between areas off Iceland (2), and Faroese and Norway.

7.1.2 Maturity ogives

Maturity ogives also demonstrated strong differences between the three areas (Table 7.1.1.2, Figure 7.1.3). The Faroese maturity ogive is based upon data from February–October for 2006–2008 (Ofstad, WKDEEP, WD GSS-07). The Norwegian data are from Norwegian surveys in spring 2007, 2008 and 2009 (see Hallfredsson WD WKDEEP 2010, GSS-9).

Table 7.1.2. Summary of maturity ogive parameters for greater silver smelt by area.

PARAMETER	ICELAND		FAROE ISLANDS		NORWAY	
	Female	Male	Female	Male	Female	Male
a	-2.64	-4.43	-6.78	-7.30	-3.35	-2.26
b	0.40	0.79	1.16	0.96	0.79	0.44
A50	6.54	5.61	5.84	7.60	4.23	5.12

Trends in these parameters vary between areas, but also between sexes. It was noted there was some uncertainty in the direct equivalence of some of the gonad-staging between areas.

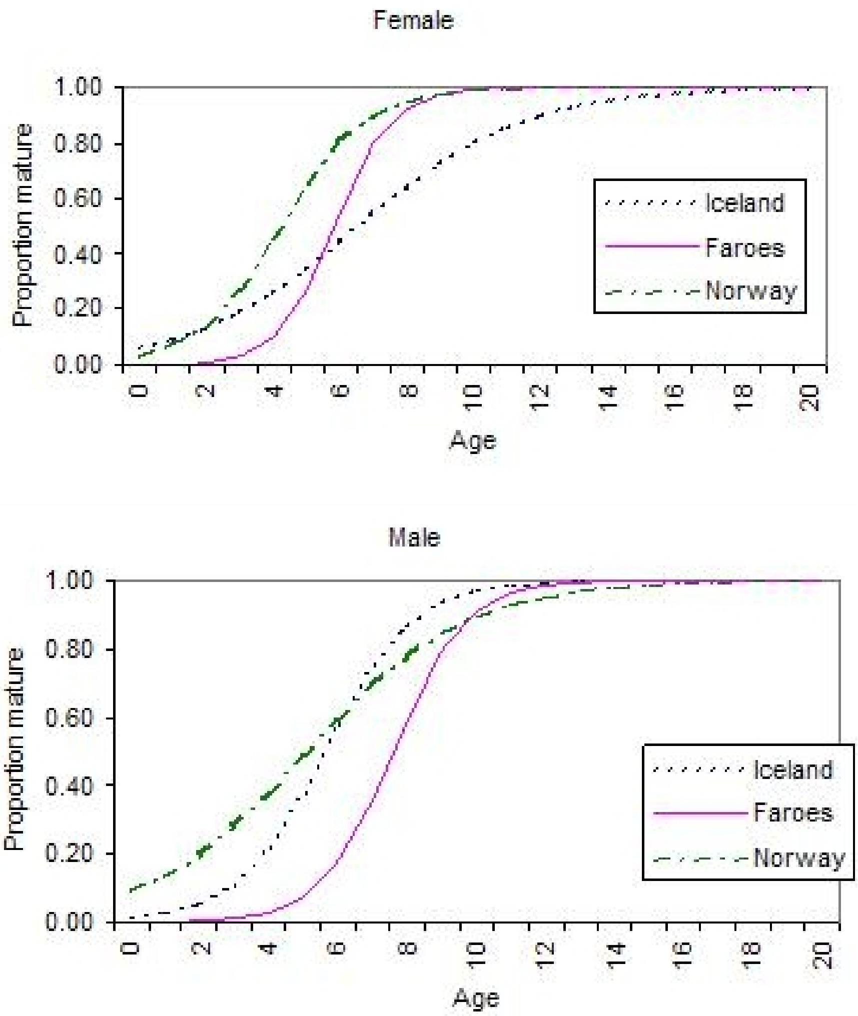

Figure 7.1.3. Maturity ogive plots for female (top) and male (bottom) greater silver smelt by area.

7.1.3 Spawning locations and timing

Plots were examined of the distribution of spawning fish around Iceland (Thordarson, WKDEEP 2010, GSS-04) and the Faroe Islands (Ofstad, WKDEEP 2010, GSS-07). In both areas there appeared to be multiple spawning sites. Timing of spawning appeared to extend over several months, and there was not a clear temporal or spatial pattern that was felt to inform decisions on stock identity.

7.1.4 Conclusions about stock structure

It was concluded that the new data presented did not change the existing basis for ICES advice on stock structure. Differences in growth and maturity curves between the main fishing grounds were regarded by the group as indicating there could be differences in the growth rates and maturity of greater silver smelt between regions, but was not necessarily suggestive of different stocks. Varying oceanographic conditions and differing exploitation patterns between the areas could cause changes in growth rates between populations within a larger stock area. No new information was available for greater silver smelt in VI, VII, IIIa and IVa and the relationship between these areas and others is unknown.

Nevertheless, it was also noted that differences in growth and maturity were potentially important considerations for stock assessment and fisheries management. They imply that the response of the species may differ between fisheries (e.g. greater silver smelt are faster growing off Iceland than in Norwegian waters), and this would be reflected in potentially different parameters of productivity in fisheries models.

No data were presented to support the original decision to separate Division Va around Iceland from other areas of the North Atlantic. However, it was noted that such a split, if based on life-history parameters as reported, could be subject to the same variability noted in comparisons of the age, growth, and maturity aspects during WKDEEP 2010.

7.1.5 Further work

Stock identity is recognized as a key issue for this species. Although the Norwegian fishing grounds are somewhat distant from the other two, the fisheries off Iceland and the Faroe Islands are close, and linked bathymetrically by the Faroe-Iceland Ridge. Given that the fisheries are large by volume, and research surveys demonstrate similar patterns in biomass indices and length, it is very important for future stock assessment that resources are put into attempting to resolve stock structure in the general region, including VI and VII and IIa and IVa.

There are a large number of methods that can be applied to identify stock structure. No single technique has proven suitable across a wide range of fisheries, and the general intention in most stock structure studies now is to apply a holistic approach, and use several approaches. These include aspects of oceanography, morphometrics and meristics (including biological information of aspects such as age, growth, and reproduction), distributional information, tagging, and genetics.

For greater silver smelt several aspects were recommended for further appraisal:

- Oceanographic conditions (e.g. current flows, both surface and seabed) between Iceland, Faroes, Norway, west of Scotland and Ireland, Skagerrak and northern North Sea.
- Genetic characteristics. These methods would focus on nuclear and mitochondrial DNA, but sampling considerations were important. Samples need to be taken in the different regions over several time periods. They should also span a wide size range of the fish.
- Morphometric and meristic characters. Studies on shape, size, and numerical characteristics of body parts etc can be done reasonably quickly and cheaply. This could also include exploratory analysis of otolith shape.

7.2 Greater silver smelt (*Argentina silus*) in DivisionVa

7.2.1 Current stock status and assessment issues

Greater silver smelt is mostly fished along the south and southwest coast of Iceland, at depths between 500 and 800 m. Greater silver smelt has been caught in bottom trawls for years as bycatch in the redfish fishery. Only small amounts were reported prior to 1996 as most of the greater silver smelt was discarded. However the discarding is not considered as significant because of the relatively large mesh-size used in the redfish fishery. The greater silver smelt fishery is at present not managed by quotas but rather as an exploratory fishery subject to licensing since 1997. The main factor in the regulation of the fishery is that taking of greater silver smelt is banned at depths less than 400 meters. Regulations regarding the fishery are presented in the stock annex for greater silver smelt in Va.

Since 1997, direct fishery for greater silver melt has been ongoing and the landings have increased significantly. The fishery seems to be driven mainly by market factors such as price of greater silver smelt and oil. This along with quota shares of redfish and Greenland halibut seem to be the main drivers of the fishery. In 2001 landings were at their lowest since 1997 at 2700 tonnes but have increased year on year to over 11 000 tonnes in 2009. Since 1996, between 20 and 30 trawlers have reported catches of greater silver smelt.

Survey indices from the Autumn survey indicate an increase in biomass of greater silver smelt in Va. A preliminary glm-model using logbook data to estimate cpue gives very similar trends. Quite contrasting signal is seen in the data collected from the surveys and commercial catches where mean length from catches have decreased and mean age in the commercial catches has decreased by 6 yrs from 15.7 in 1997–1998 to 9.6 in 2008.

Issues considered in this Benchmark relate to:

1) Estimates of catch in numbers in 1997, 1998, 2002, 2006–2008 which indicate considerable shift in the age distribution in commercial catches;
2) Representative indices of greater silver smelt abundance/biomass trends in Va;
3) Suitability of formal analytical assessments on greater silver smelt in Va.

7.2.2 Compilation of available data

7.2.2.1 Catch and landings data

Icelandic commercial catches in tonnes by month and gear are provided by Statistics Iceland (hagstofa.is) and the Directorate of Fisheries. Data on catch in tonnes from other countries are taken from ICES official statistics (STATLAN) and/or from the Icelandic Coast Guard. Annual landings are available from 1985 or from the commencing of the targeted fishery. The fishing statistics are considered accurate. Discards are not considered to be of relevance and therefore not included in estimates of catches.

7.2.2.2 Biological data

Biological data from the greater silver smelt catch is collected on board of the fishing vessel, as it is mandatory to send at least one sample from each fishing trip. Each sample consists of randomly selected 100–200 specimens of greater silver smelt. In each sample, otoliths are extracted from 50 specimens. The biological data collected are length (to the nearest cm), sex and maturity stage, and ungutted weight (to the nearest gramme). The rest of the sample is only length measured.

Estimates of catch in numbers of Greater Silver Smelt in Va calculated from available data were presented at the meeting. The main obstacle for performing the calculations is the rather limited number of aged otoliths available (Table 7.2.1.). Ageing of Greater Silver Smelt is not considered difficult but has not been verified nor has there been any attempt to standardize it across the species distributional range.

Table 7.2.1. Greater silver smelt in Va. Number of samples (otoliths and length measurements) and number of aged otoliths and specimens measured used for estimating catch in numbers.

Year	No. Otolith samples	No. Otoliths aged	No. Length samples	No. Length measurements
1997	19	985	45	4863
1998	24	890	141	14 911
2002	4	127	20	2220
2006	10	465	29	4186
2007	8	272	14	2158
2008	31	1387	37	3378

Results from the calculations of catch in numbers indicate a great shift in the age distribution of greater silver smelt in Va. In 1997–1998 the mean age was around 15.7 and most of the greater silver smelt caught was older than 12 years. It should be noted that the 2002 estimates are based on limited data. In 2006–2009 the mean age from the catches has decreased to around 9.5 years and Greater Silver Smelt older than age 12 are now rare in the landings (Figure 7.2.1).

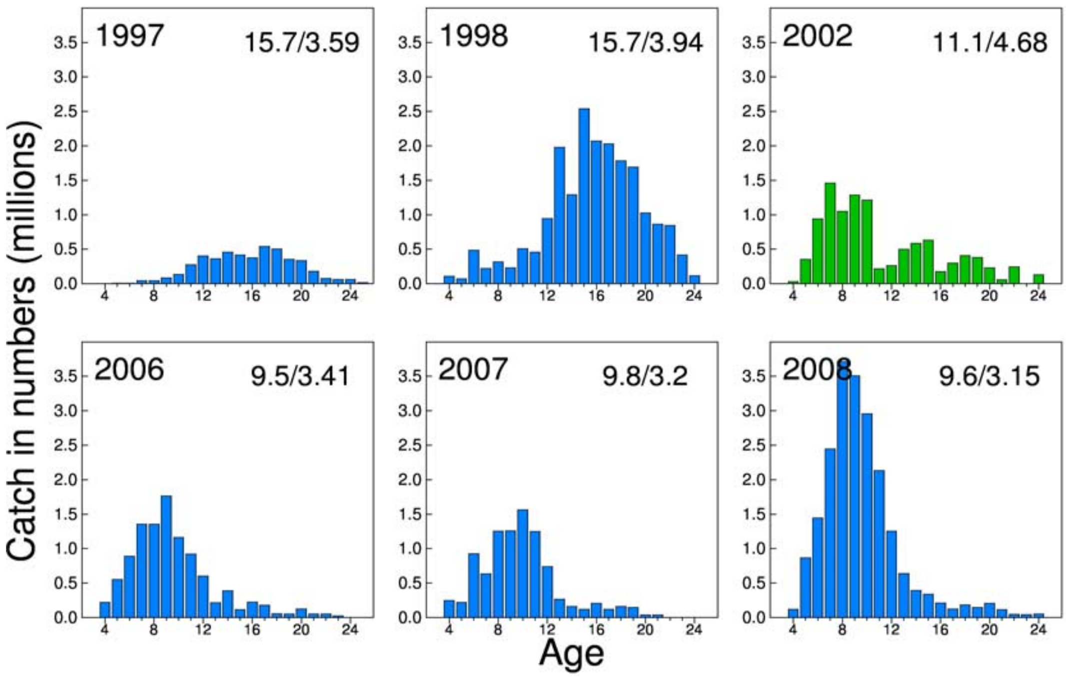

Figure 7.2.1. Greater Silver Smelt in Va. Estimates of catch in numbers 2002 estimates are highly uncertain because of limited data used for estimation of catch in numbers. Numbers in top right corner are mean age and its standard deviation.

The great shift in the age distribution from commercial catches of greater silver smelt are a cause for concern in regard to management of the stock. It is highly unlikely that the reason for the shift is because of inconsistent ageing as the otoliths of greater silver smelt do have clear age rings, difference in spatial distribution of samples both in relation to the fishery and time.

If a fixed age–length key is applied to the length–frequency data available from 1996–2008 the results indicate that the decrease in mean age has been continuous rather than a sudden drop. However using a fixed age–length key results in considerable bias in catch in numbers compared with the estimates obtained by using annual age–length keys.

7.2.2.3 Survey data

Two bottom-trawl surveys, conducted by in Va produce estimates of abundance of greater silver smelt, namely the Icelandic Groundfish Survey (IGS or the Spring Survey) and the Autumn Groundfish Survey (AGS or the Autumn Survey). The Spring Survey is not considered representative for the assessment unit in Va as it only goes down to 500 m. The indices calculated from the data collected in the surveys are stratified area-swept indices (Cochran, 1977).

The Autumn Survey has been conducted in October since 1996 and covers a larger area than the Spring Survey. It is conducted on the continental shelf and slopes and extends to depths down to 1500 m. The number of stations is about 380. The main target species in the Autumn Survey are Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*). A detailed description of the Autumn survey and data sampling is given in the stock annex for greater silver smelt in Va.

Greater Silver Smelt is a difficult species to get reliable information on from bottom-trawl surveys. This is in large part due to the fact that sometimes a few large hauls of Greater Silver Smelt are caught in the survey. This can result in very high indices with large variances particularly if the tow-station in question happens to be in large strata with relatively few tow-stations.

The standard calculations of regional survey indices which are designed with cod, haddock and such species in mind are not particularly applicable to greater silver smelt. Therefore the processing of the Autumn Survey data was presented at the meeting on a slightly different regional scale. In short the main distributional area of Greater Silver Smelt is off the Southeast, South and West coast of Iceland and in recent years also off the Northwest coast. Also fishing of greater silver smelt is banned at depths less than 400 meters. Therefore to get a proxy for 'fishable' survey indices a few regions are defined for depths greater than 400 m (Table 7.2.2).

Table 7.2.2. Greater silver smelt in Va. Survey regions used for calculations of indices from the Autumn survey.

REGION	NO. STRATA	AREA (KM2)	NO. STATIONS
Total	74	339 691	378
Gss fishing grounds	13	46 993	80
Depth > 400m	32	152 626	186
Depth < 400m	41	186 870	192
NW > 400m	2	20 081	16
W > 400m	9	31 613	60
S > 400m	6	26 715	24
SE > 400m	7	30 358	36

One of the main problems when calculating indices from surveys is how to treat large hauls. In some cases one or two hauls that happens to be inside a large stratum which can result in very marked increase in survey estimates. This is a problem for greater silver smelt, as for many other species. Not only can exceptionally large hauls increase survey estimates but also they greatly affect estimated CV of the index in question.

Winsorization is one way to deal with outliers (Sokal and Rohlf, 1995). A typical way to go when applying Winsorization is to set all outliers to a specified percentile of the data; for example, a 90% Winsorisation would see all data below the 5th percentile set to the 5th percentile, and data above the 95th percentile set to the 95th percentile. Winsorised estimators are usually more robust to outliers than their unwinsorised counterparts.

This strategy is applied to the greater silver smelt data from AGS. The number of GSS that are greater than the 95th percentile are set at the quantile. The same is done for the 5th precentile quantile; that is numbers that are lower than 5th percentile quantile ar set at the quantile. It should be noted that tow-stations that have no Greater Silver Smelt are excluded from the Winsorization.

In Table **WinsorSur** the winsorization is summed up and it can be seen that each year between 7 and 9 tow-stations are affected by the procedure.

Table 7.2.3. Greater silver smelt in Va. Number of stations affected by winsorization. The minimum (Min), maximum (Max) and median (Median) values changed and the 95% quantile the values are set at.

YEAR	NO.STATIONS	MIN	MAX	MEDIAN	Q95
2000	7	346	476	386	336
2001	9	334	1428	447	333
2002	8	312	1110	541	302
2003	8	372	1450	544	353
2004	8	561	1065	706	554
2005	8	652	1765	862	600
2006	8	646	1680	993	573
2007	9	434	1050	514	433
2008	8	734	1776	1158	695
2009	8	616	2075	774	581

Annual trends in total biomass indices for the different survey regions described in Table 7.2.3 are presented in Figure **7.2.2**. Normally the winsorized and unwinsorized indices demonstrate the same trend with the exception of 2009. 2009 is characterized by very high value in most regions and correspondingly a large standard error. This is vastly reduced in the winsorized indices.

The overall trend is that the indices are increasing during the Autumn Survey period. The main exceptions are the less than 400 m index (<400 m) and the northwestern region at depths greater than 400 m (NW>400 m). This is interesting as the shallow water is the main nursery grounds for Greater Silver Smelt and secondly the NW area has been increasingly targeted by the fleet as a supplementary to the Greenland halibut and redfish fishery in the area. The most important thing regarding Figure 7.2.2 is the region below 400 m (>400 m) and the 'Regulation area' but both indices demonstrate a minor increase in recent years.

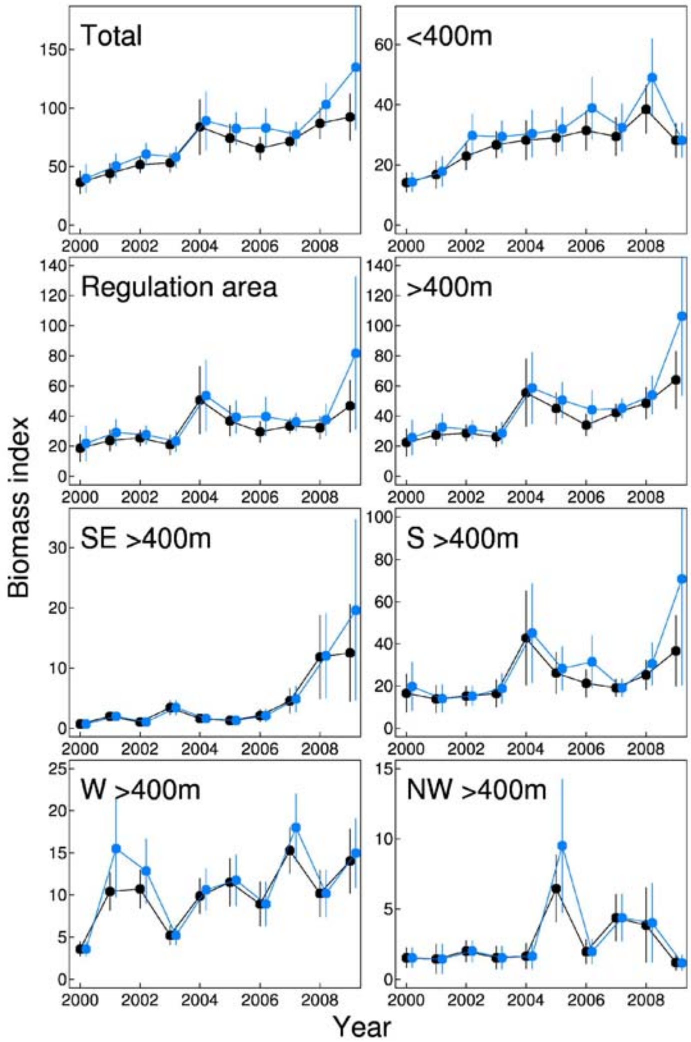

Figure 7.2.2. Biomass indices for Greater Silver Smelt in Va from the Autumn survey. Black lines are winsorized indices and blue un-winsorized indices. Vertical lines represent +/- 1 standard error.

In Figure **7.2.3** winsorized length disaggregated indices are presented for the 'Total' region which is then divided by the 400 m depth contour. The main thing to note is that hardly any silver smelt smaller than 30 cm is found at depths greater than 400 m. Very few Greater Silver Smelts longer than 45 cm are caught at depths above 400 m. In 2004 there is a spike at around 20 cm which could indicate a burst of good recruitment and a second spike in 2007. With some imagination it may be possible to see those spikes transgress to the left of the distribution.

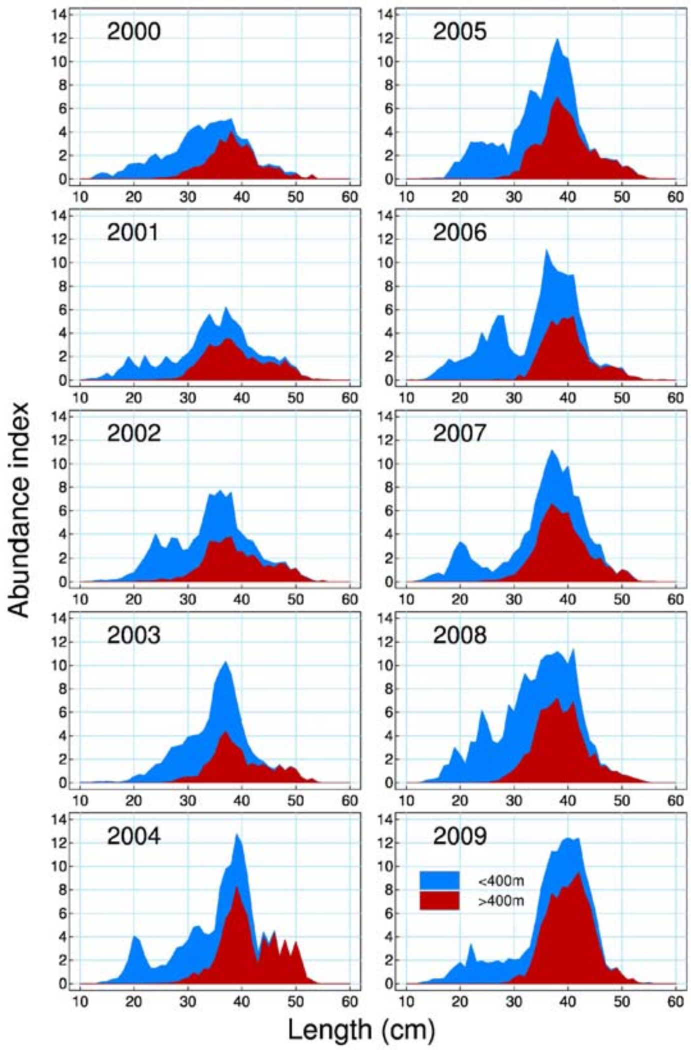

Figure 7.2.3. Winsorized length disaggregated indices for Greater Silver Smelt in Va from the Autumn Survey for regions '<400 m' blue, '>400 m' red and 'Total' red and blue combined.

7.2.2.4 Commercial tuning data

A glm-model that estimates cpue from the greater silver smelt was presented however the panel did not consider the results appropriate as a basis for advice. This decision is supported by the availability of data from the survey fleets and the limited degree to which commercial cpue data can be standardized over time and the nature of the fishery.

7.2.2.5 Input from stakeholders/industry

No input from stakeholders in Va on greater silver smelt was presented to the Working Group.

7.2.3 Stock identity and migration issues

See Section 7.1.

7.2.4 Spatial changes in the fishery and stock distribution

Spatial distribution of catches in 1996–2008 is presented in Figure **7.2.4**. With the exception of 1996 most of the catches have been from the southern edge of the Icelandic shelf. However in recent years there has been a gradual increase in the proportion caught in the western area.

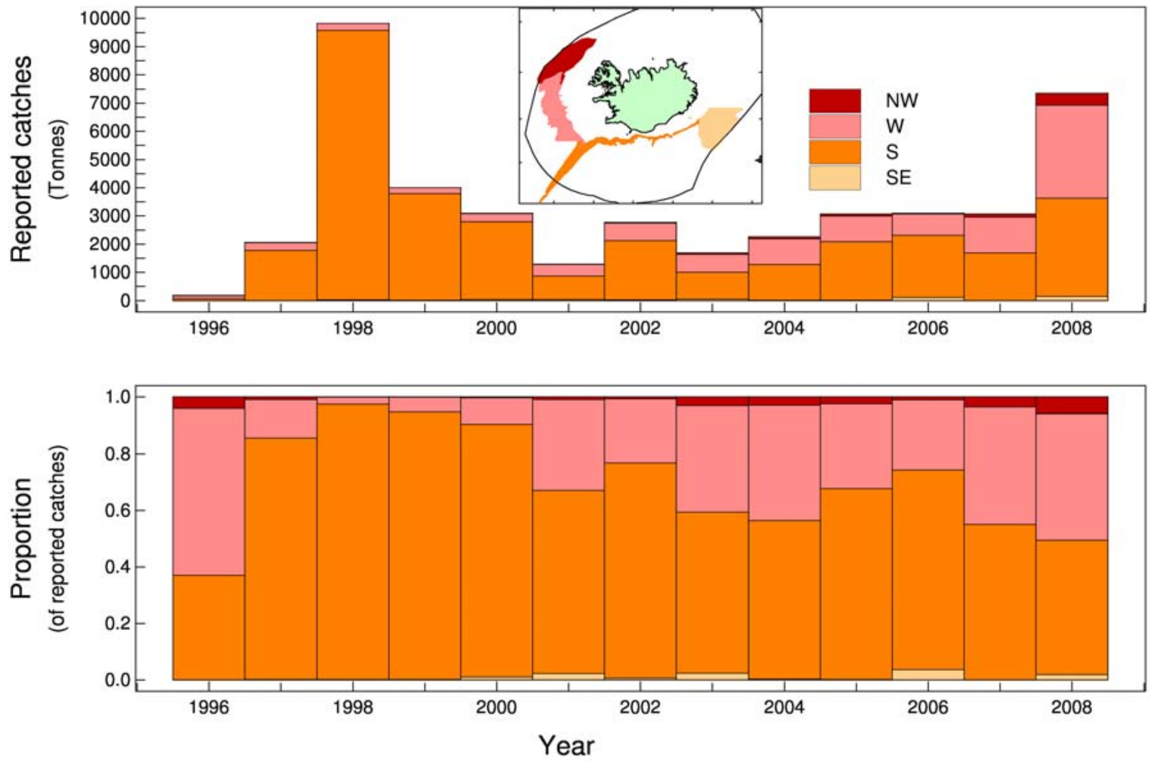

Figure 7.2.4. Greater Silver Smelt in Va. Catches divided by defined survey regions (See Table 7.2.3) by year. Above are the catches on absolute scale and below is in proportions.

According to the Autumn survey the biomass seems to have slightly decreased at depths less than 400 meters but increased at depths greater than 400 meters. The main change in proportional changes in biomass as estimated in the Autumn survey is the increase in 2005 and subsequent depletion in 2008 and 2009.

7.2.5 Environmental drivers of stock dynamics

No environmental drivers that could affect greater silver smelt in Va were presented at the meeting. Such patterns should be considered in future. They could be of considerable importance for greater silver smelt in Va as temperatures have increased along the south and west coast/shelf of Iceland. These changes in temperature have been related to increased abundance of more southerly species in Va such as anglerfish.

7.2.6 Role of multispecies interactions

7.2.6.1 Trophic interactions

No data on trophic interactions was presented at the meeting.

7.2.6.2 Fishery interactions

No data on fisheries interactions were presented at the meeting.

7.2.7 Impacts on the ecosystem

No ecosystem impacts were examined at the meeting.

7.2.8 Stock assessment methods

In an attempt to use formal analytical assessments on greater silver smelt in Va several modelling approaches were considered before the meeting. Among them Gadget, Schaefer biomass dynamic model and a variety of age- and length-based Coleraine models. Exploratory analysis led to the choice of a purely age-based Coleraine model (WKDEEP 2010, GSS-06).

7.2.8.1 Models

Coleraine (Hilborn *et al*., 2003) is a versatile environment for single-species statistical catch-at-age modelling. It can incorporate a combination of catch-at-age, catch-at-length, and abundance indices from different fisheries and surveys, allowing for missing years. Data and parameters can be sex- and gear-specific. Future projections can be used to evaluate a range of harvest policies. The model is implemented in AD Model Builder (ADMB Project 2008), supporting maximum likelihood or Bayesian estimation, using the delta method and/or Bayesian MCMC to analyse the uncertainty.

The model used in this assessment is a simple age-based Coleraine model. Due to the apparent low variability of recruitment, as well as the overall limited amount of data, annual recruitment is not estimated as free parameters, but deterministic Beverton–Holt predictions are used, based on spawning-stock-biomass and a steepness (Francis, 1992) of $h=0.6$. The stock is assumed to be in unfished condition in 1988, and landings are known without error. All parameters are assigned wide bounds that are used as flat priors in the Bayesian uncertainty analysis, where 1000 draws were saved out of 1 000 000 MCMC iterations.

7.2.8.2 Sensitivity analysis

No sensitivity analyses were done.

7.2.8.3 Retrospective patterns

No retrospective runs were done.

7.2.8.4 Evaluation of the model

The base case model presented at the meeting did not fit the upward trend in the autumn survey biomass index. Several attempts were made to find a model where the population grows fast enough to fit the survey index, but it was found that such a model would require two features. First, the population in 1988 would need to start in a heavily overfished condition, which goes against the documented history of this fishery. Secondly, the strong recruitment pulse needed for the population to grow this fast would show up clearly in age and length compositions, but the observed age compositions indicate no such pulse. In fact, the observed age compositions (Figures.7.2.5 and 7.2.6) show a distinct lack of variable cohort strengths.

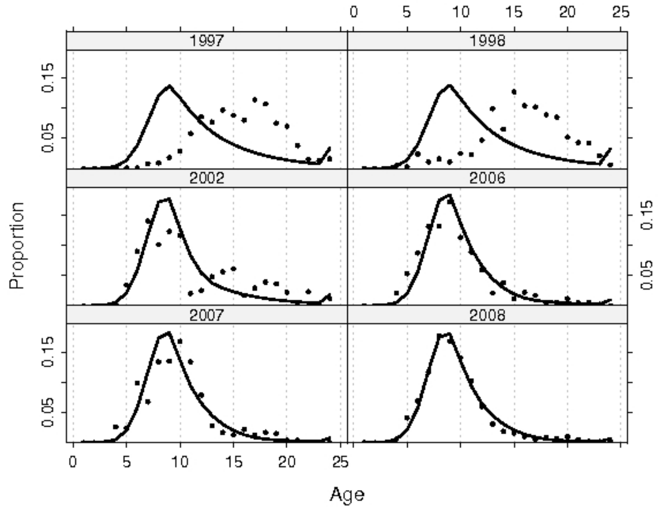

Figure 7.2.5. Model fit (line) to observed commercial catch-at-age data.

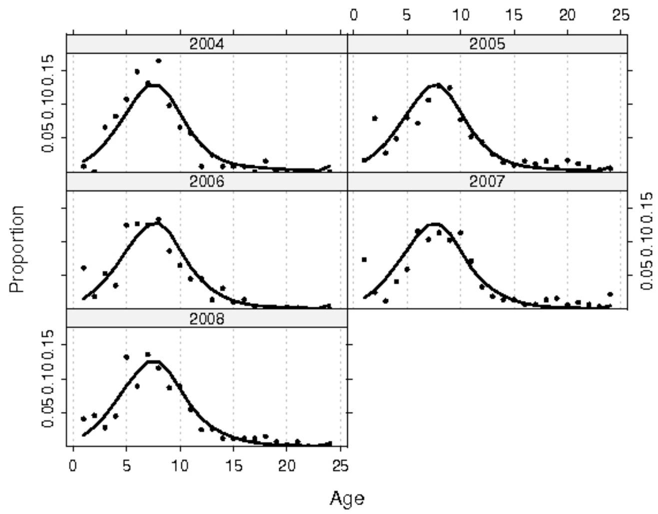

Figure 7.2.6. Model fit (line) to observed survey catch-at-age data.

The only model that can fit the fast biomass growth is a simplistic model using only landings and survey biomass index, ignoring all age and length compositions (Schaefer or Schaefer-like), starting at a very low level, but long-term biomass predictions of those models can exceed a billion tons. This is because the biomass index does not respond to years of relatively large catch removals.

The main conclusion after exploring the data with many variations of Coleraine models, including the base case run presented at the meeting, is that no model was found that can fit all the data components. The data seem to violate model assumptions (e.g. cohorts growing instead of decaying in the survey data), which severely undermines traditional statistical statements, required for managing the Icelandic greater silver smelt fishery.

7.2.9 Stock assessment

At the meeting the panel came to the conclusion that the dataseries presented was to contradictory and short for an analytical assessment to be able to accommodate the different data components. This is further supported by the uncertainty on stock structure of greater silver smelt and the large variance in the survey.

7.2.10 Recruitment estimation

No estimates of recruitment were presented at the meeting.

7.2.11 Short-term and medium-term forecasts

No forecasts were presented at the meeting.

7.2.12 Biological reference points

No suggestions for biological reference points were presented at the meeting.

7.2.13 Recommended modifications to the stock annex

No modifications on the stock annex are suggested as there was no annex in existence before this meeting.

7.2.14 Recommendations on the procedure for assessment updates

Update assessments should be based on survey indices from the Autumn survey as these are most likely to represent changes in biomass of greater silver smelt in Va of the dataseries available (Spring survey, cpue). Emphasis should be placed on following closely any further changes in the age distribution of greater silver smelt, both from surveys and commercial catches. Acoustic survey might in future be beneficial for assessing trends in the biomass of greater silver smelt in Va.

7.2.15 Industry supplied data

No data were supplied from the industry on greater silver smelt in Va.

7.2.16 References

Cochran,W.G. 1977. Sampling techniques, 3rd edition. New York: Wiley & Sons.

Francis, R. I. C. C. 1992. The use of risk analysis to assess fishery management strategies: a case study using orange roughy (*Hoplostethus atlanticus*) on the Chatham Rise, New Zealand. Canadian Journal of Fisheries and Aquatic Sciences, 49: 922–930. Hilborn *et al.*, 2003.

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7.3 Greater silver smelt (*Argentina silus*) in Subareas I, II, IV, VI, VII, VIII, IX, X, XII, and XIV, and Divisions IIIa and Vb (other areas)

7.3.1 Current stock status and assessment issues

This grouping is a combination of isolated fishing grounds and these areas are thus grouped due to their mutual lack of data. In order to evaluate the stock structure further, sampling for genetic studies from the whole distribution area of greater silver smelt is needed (see Section 7.1). Greater silver smelt is a bentho-pelagic deep-water species and lives in schools close to the bottom. Greater silver smelt is primarily fished in the depth range 100–700 m. Greater silver smelt is vulnerable to overexploitation due to its low productivity (although not as low as for example orange roughy (ICES, 2006, Section 8.2.2)). Greater silver smelt is particularly susceptible to rapid local depletion due to its highly aggregating behaviour.

7.3.2 Compilation of available data

7.3.2.1 Catch and landings data

The present targeted fisheries for greater silver smelt are conducted with pelagic trawl operated very close to or at the seabed and depend on localization of aggregations. In Subarea I and II the fishery for greater silver smelt is primarily prosecuted by licensed Norwegian trawlers that have this species as target. They operate specialised greater silver smelt "pelagic" trawls at the seabed (Hallfredsson and Svellingen, WD11 ICES WGDEEP 2009).

In the Skagerrak (Division IIIa), greater silver smelt has periodically been targeted by Norwegian, Danish and Swedish bottom trawlers. During the last 10 years it is primarily a few Danish vessels that have conducted targeted fisheries for roundnose grenadier and greater silver smelt. However, there is also a bycatch in the Norwegian and Danish small-mesh bottom-trawl fisheries along the Norwegian Deep (primarily in IVa) that land the catch for reduction. In Subarea IV the Norwegian landings have increased from 11 tonnes in 2005 to over 3000 tonnes in 2006 and 2007, but 1550 tonnes are registered in 2008.

In the Faroese (Division Vb) pairtrawlers have had a direct fishery for greater silver smelt, from spring to autumn, for more or less since 1994. There is a minor bycatch of greater silver smelt in the pelagic fishery for blue whiting in Subarea Vb.

Landings since 1988 are mainly reported in Subareas I–VII (Table 7.3.2.1.1), with landings elsewhere being either minor (VIII, XII and XIV) or none. There are currently three areas where direct fisheries are conducted, around Iceland (Va), around Faroe Islands (Vb) and west of mid Norway (IIa) (Figure 7.3.2.1.1). The direct fisheries are mainly by semi-pelagic trawls. In addition, the greater silver smelt is being exploited west of Ireland (VI, VII) by the Dutch fleet (and previously by other fleets), and historically in the Skagerrak (IIIa) by Norwegian, Danish and Swedish vessels.

Argentina silus can be a very significant discard of the trawl fisheries of the continental slope of Subareas VI and VII particularly at depths 300–700 m (Girard and Biseau, WD 2004). No new information was provided.

Table 7.3.2.1.1. Landings of greater silver smelt in all ICES areas (ICES 2009). ***Argentina sphyraena*** **may in some cases have been included in the landing figures (particularly in Subareas III and IV).**

YEAR	I + II	III + IV	VA	VB	VI + VII	VIII	XII	XIV	TOTAL
1988	11 351	2718	206	287	10 438				25 000
1989	8390	3786	8	227	25 559				37 970
1990	9120	2321	112	2888	7294			6	21 741
1991	7741	2554	247	60	5197				15 799
1992	8234	5319	657	1443	5906				21 559
1993	7913	3269	1255	1063	1577		6		15 083
1994	6807	1508	613	960	5707				15 595
1995	6775	1082	492	12286	6242				26 877
1996	6604	3300	808	9498	5863		1		26 074
1997	4463	2598	3367	8433	7300				26 161
1998	8261	3982	13387	17 570	5555				48 755
1999	7163	4320	6704	8214	8856		2		35 259
2000	6293	2471	5657	5209	13 866			217	33 713
2001	14 369	2925	3043	10 081	19 050			66	49 534
2002	7407	1811	4960	7471	15 985	191			37 825
2003	8917	1188	2683	6549	2451	37			21 825
2004	16 162	1157	3645	6451	5133	23	4		32 575
2005	17 093	791	4481	7009	3808	202	322		33 706
2006	21 685	4016	4775	12 559	1115	0	0		44 150
2007	13 273	3343	4227	14 093	4122				39 059
2008*	11 876	1629	8778	14 595	4035				40 913

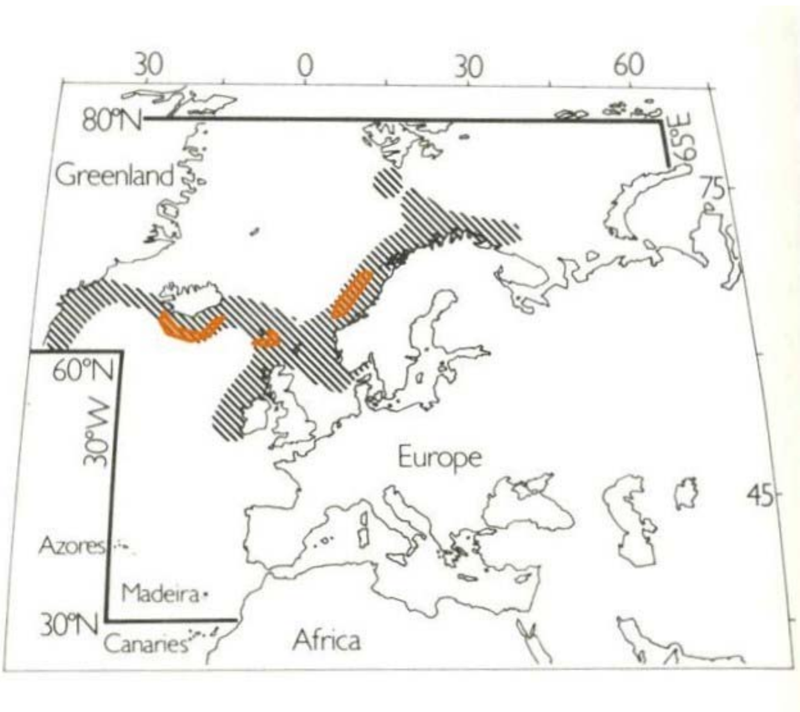

Figure 7.3.2.1. Distribution of greater silver smelt in the ICES area (Cohen, 1984). The locations of current direct fisheries are indicated in orange.

7.3.2.2 Biological data

Length compositions

Length distributions were presented from a Norwegian survey in 2008 on greater silver smelt and from surveys targeting Greenland halibut 2003–2005 and beaked red-fish 2008 in Subarea IIa (Figure 7.3.2.2.1) (Hallfredsson and Svellingen, WD11, 2009).

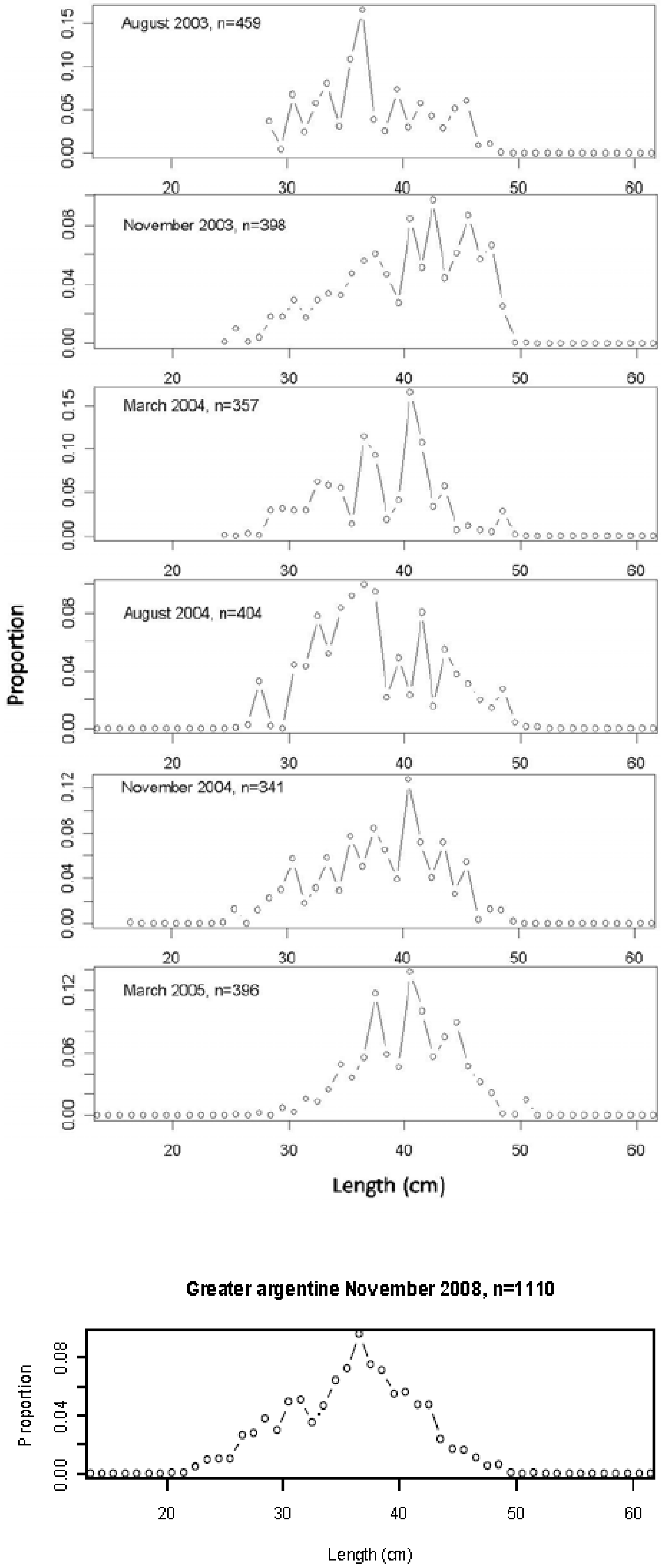

Figure 7.3.2.2.1. Length distribution for greater silver smelt in Greenland halibut surveys 2003–2005. (upper panels) and in beaked redfish survey in November 2008 (lower panel) in Subarea IIa.

The Greenland halibut surveys and the beaked redfish surveys cover the continental slope, but not the Norwegian continental shelf part of the distribution area and were conducted with commercial bottom trawl. According to these surveys the length distribution seems to be relatively stable the later years with mean length around 40 cm and no obvious seasonal variation.

The aimed survey in 2008 was carried out for examination of acoustical properties of greater silver smelt and the trawling was by specialised greater silver smelt trawl on registrations at the fishing grounds. Thus the length distributions from this survey were presented station vice and are closer to reflect lengths in the fisheries rather than being representative for the area (Figure 7.3.2.2.2).

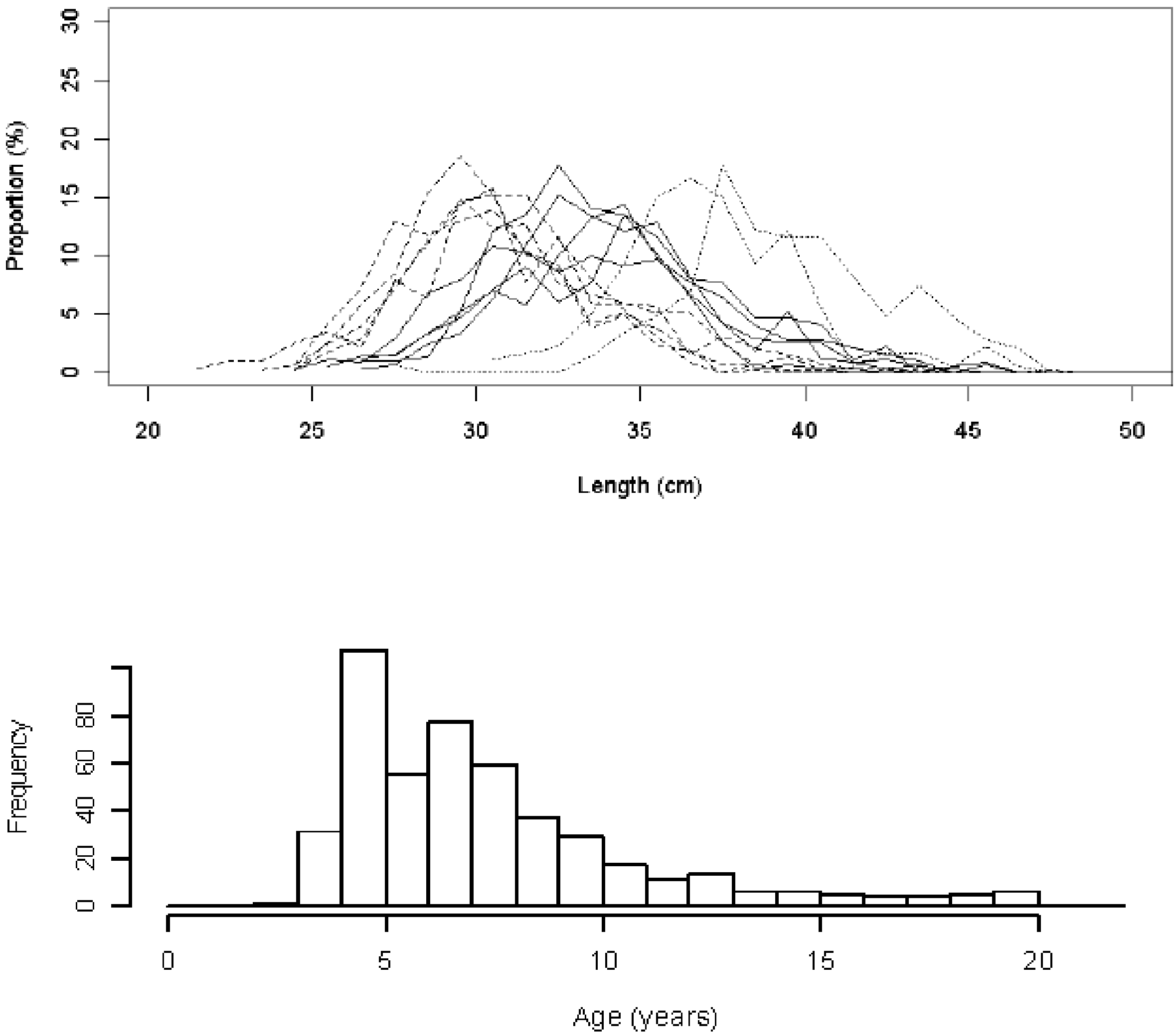

Figure 7.3.2.2.2. Size and age distributions of greater silver smelt based on a Norwegian survey conducted at the fishing grounds north of 62° N (ICES Division IIa) in 2008. Length distributions are from length samples at each station (greater silver smelt trawl). The distributions are approximately classified by weighted mean length; dashed lines 30.2–31.5 cm, solid lines 33.0–34.6 cm (station nr. 6, and dotted lines 37.2–39.6 cm. The age distribution is for all greater argentine sampled as the first 100 specimens in each sample in the same survey. Age-group 20 is a plus-group.

The mean length in the hauls was generally lower than the distributions in the bottom-trawl surveys indicate. The deeper strata in the survey are representative of the length classes exploited by the fisheries (see Figure 7.3.2.2.3).

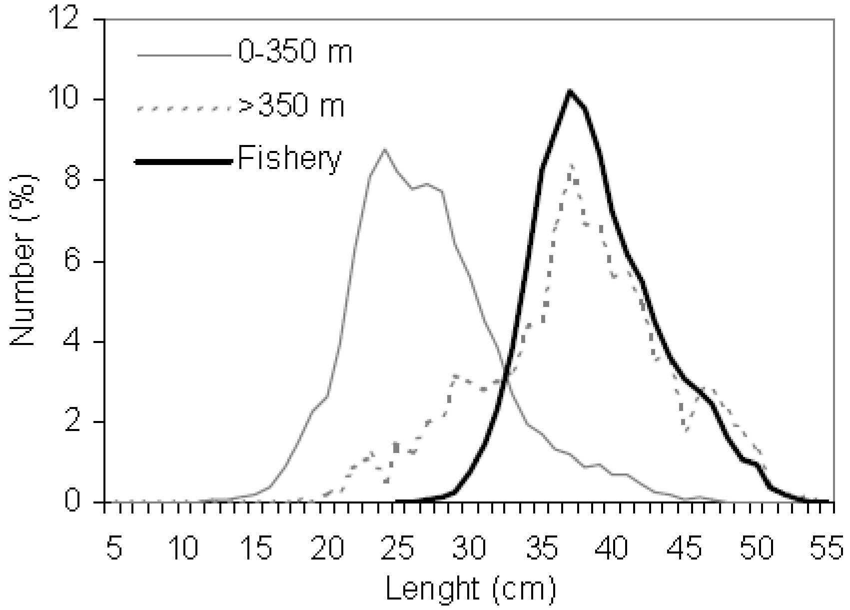

Figure 7.3.2.2.3. Greater silver smelt (Division Vb). Length distribution in depth interval 0–350 m and >350 m from surveys for cod, haddock and saithe and length distribution from all samples from landings.

The average length in Faroese commercial catches has decreased since 1994–2000 but seem to have stabilized since then (Figure 7.3.2.2.4.) (Ofstad, WD, ICES WKDEEP-GSS_8).

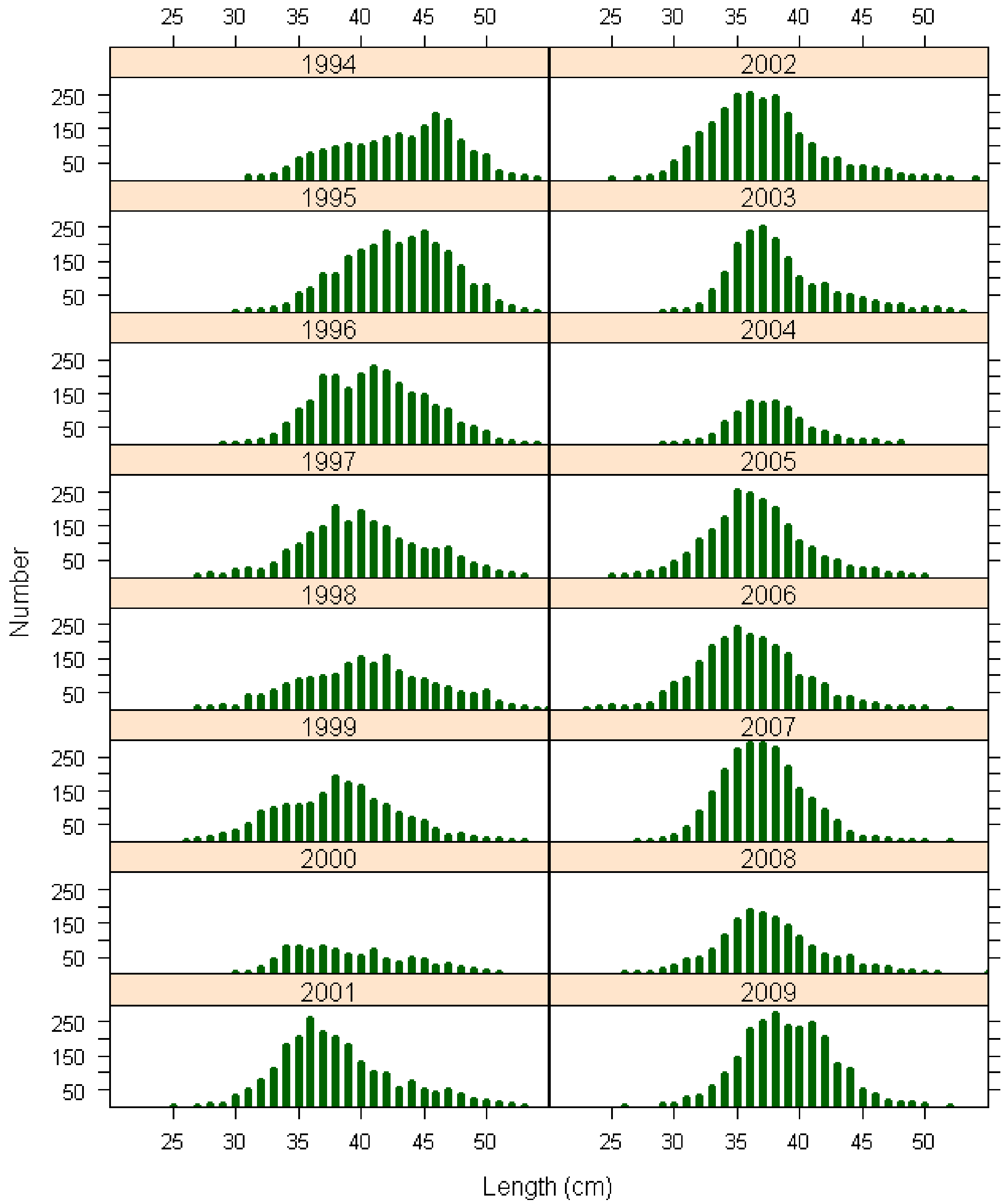

Figure 7.3.2.2.4. Length distributions of greater silver smelt in the Faroese landings 1994–2009.

This is probably a natural reaction as a consequence of new fishery. Length distributions were available for two Faroese surveys in Vb (1996 onwards). There was no obvious trend in either series (Ofstad, WKDEEP 2010, GSS-08). The bathymetric distribution of greater silver smelt from Faroese surveys is clearly size-related with larger individuals dominating in the deeper areas (Figure 7.3.2.2.5), as was the case for on Porcupine bank survey data presented in 2008 WGDEEP Report.

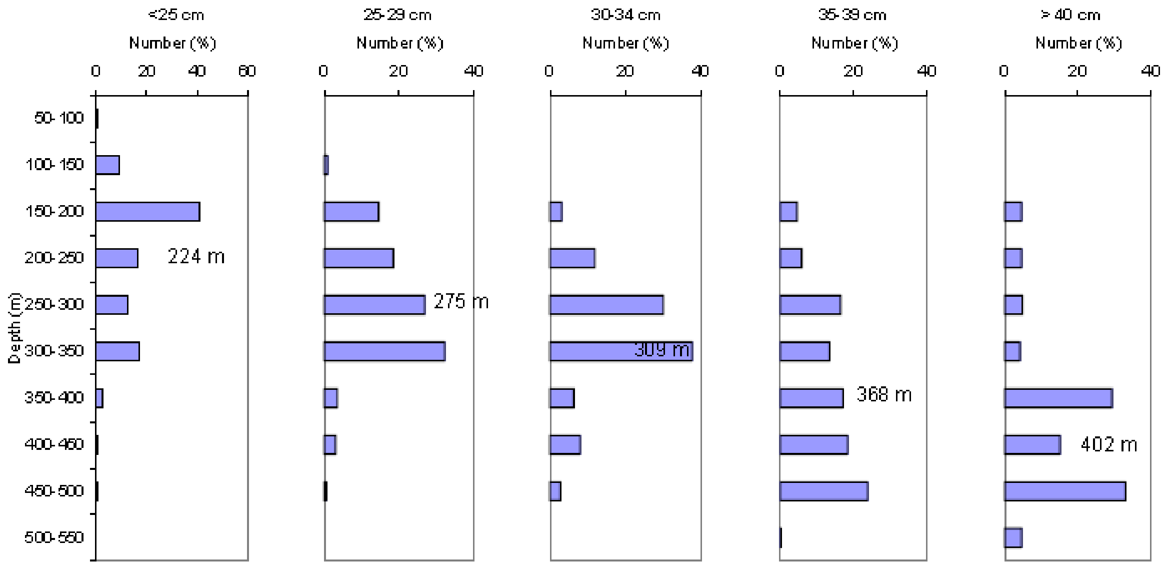

Figure 7.3.2.2.5. Greater silver smelt (Division Vb). Distribution of length groups in depth intervals from the Faroese surveys for cod, haddock and saithe. Number scaled against depth and number of hauls in the depth intervals. Mean depths for length groups are indicated.

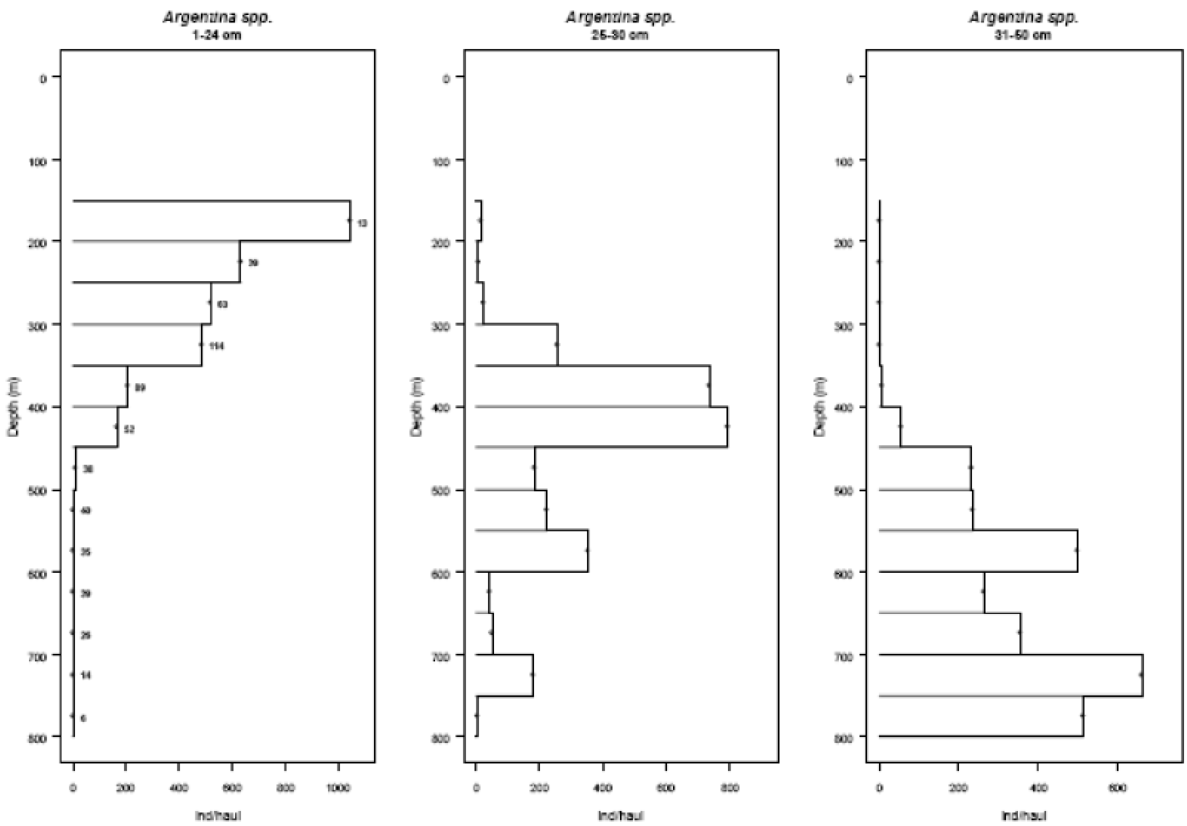

Figure 7.3.2.2.6. Bathymetric distribution of *Argentina silus* catches (ind./30 min haul) by size range in Porcupine surveys as a whole until 2007. Numbers to the right of each column in the first graph correspond to the number of hauls per depth intervals.

Figure 7.3.2.2.7 presents the comparison between length–frequency distributions from the 2001–2008 Spanish bottom-trawl surveys on the Porcupine bank (Subarea VII).

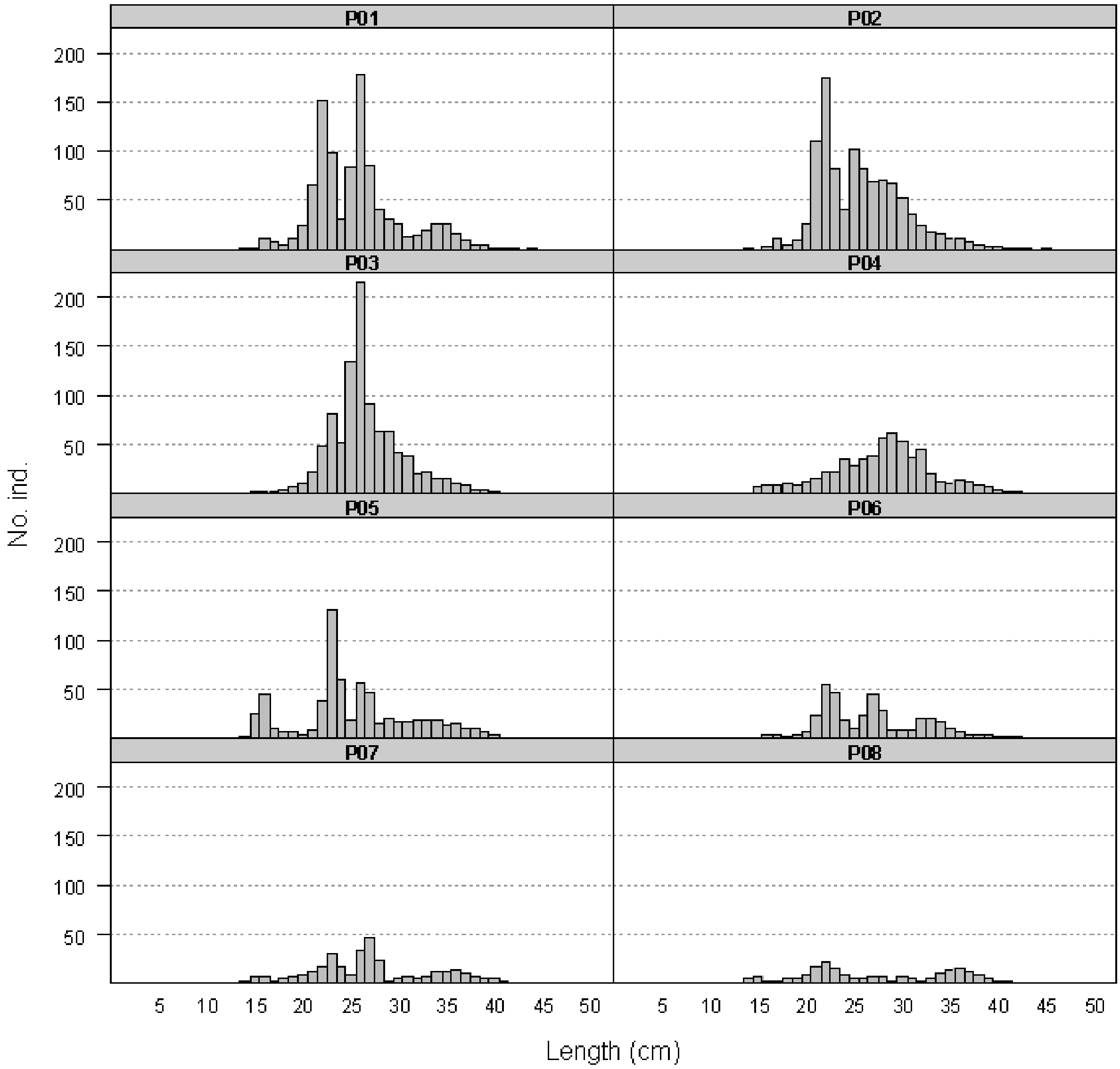

Figure 7.3.2.2.7. Mean stratified length distributions of *Argentina silus* in Porcupine surveys (2001–2008).

There seem to be two main modes at about 22–23 and 26–27 cm throughout the time-series, and there is a consistent decrease in numbers caught (Velasco *et al.*, WD7, 2009).

Age compositions

The age distribution of greater silver smelt in the landings in Division Vb demonstrate a decrease in mean age in 1994–2000 but seem to have stabilized since then (Figure 7.3.2.2.8).

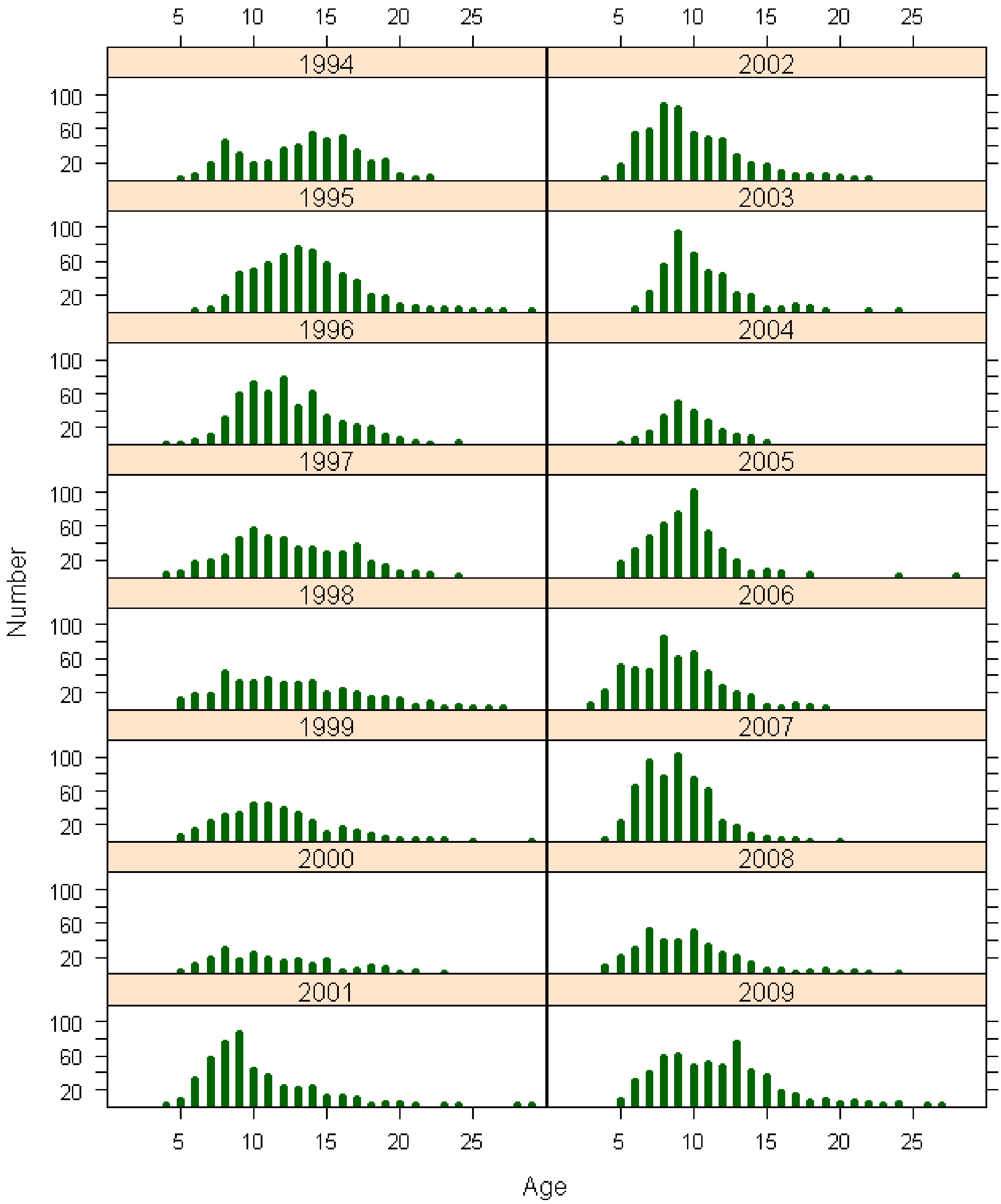

Figure 7.3.2.2.8. Age distribution of greater silver smelt in Faroese landings 1994–2009.

This could reflect a natural reaction to an introduced fishery, but a clearer analysis is needed to investigate this reduction for the sustainability of the fishery.

Age distribution from a Norwegian survey in 2007 on greater silver smelt was presented in Bergstad *et al.*, WD7, 2008). Compared with age-distributions in the same areas in the 1980s and early 1990s, the Subarea II demonstrated a marked decline in 20+ specimens (7% in 2007 compared with up to 26% in the 1980s) In the age distribution from the fishing grounds in the greater silver smelt survey in 2008 the same trend is observed with very few old individuals (Figure 7.3.2.2.1, see above) (Hallfredsson and Svellingen, WD11, 2009).

There is an additional time-series of age information available for Dutch landings from Subarea VI but these are not yet available to the Working Group. Age distribution for 2008 from these fisheries, are presented in Table 7.3.2.2.1 A and B.

Table 7.3.2.2.1 A and B. Age readings from the Netherland's fisheries in Area VIa 2008, by sex and time period.

			Q1			Q2	
		numbers	weight	length	numbers	weight	length
age	yearclass	('000)	(kg)	(cm)	('000)	(kg)	(cm)
0	2008						
1	2007						
2	2006						
3	2005						
4	2004				19.4	0.266	33.5
5	2003	69.3	0.245	33	58.1	0.276	34.17
6	2002	34.7	0.265	33.5	155	0.321	35.5
7	2001	138.6	0.305	34.75	251.9	0.308	35.35
8	2000	242.6	0.304	34.93	658.8	0.333	36.09
9	1999	173.3	0.335	36.1	465	0.346	36.25
10	1998	242.6	0.325	35.64	658.8	0.364	36.74
11	1997	138.6	0.325	35.25	213.1	0.4	38.14
12	1996	69.3	0.341	35.5	387.5	0.401	38.2
13	1995				38.8	0.383	38.5
14	1994				19.4	0.513	40.5
15 +	1993				96.9	0.479	40.5
Sample weight (kg)				17.1			126.3
Number of samples				2			22
Number of age readings				32			156

A. **Males**

		Q1			Q2		
		numbers	weight	length	numbers	weight	length
age	yearclass	('000)	(kg)	(cm)	('000)	(kg)	(cm)
0	2008						
1	2007						
2	2006						
3	2005						
4	2004						
5	2003				38.8	0.327	35.5
6	2002	34.7	0.337	35.5	135.6	0.345	36.21
7	2001	69.3	0.384	36	232.5	0.37	37
8	2000	69.3	0.439	37.5	542.5	0.397	37.75
9	1999	69.3	0.388	37	697.5	0.4	38.17
10	1998	242.6	0.397	37.21	736.3	0.433	38.87
11	1997	34.7	0.275	.34.50	426.3	0.432	38.73
12	1996	69.3	0.406	.37.5	155	0.479	40.38
13	1995	34.7	0.476	.39.5	77.5	0.518	41.5
14	1994				58.1	0.497	40.5
15 +	1993				135.6	0.564	42.21
Sample weight				17.1			126.3
Number of samples				2			22
Number of age readings				18			167

B. Females

Weight-at-age

Data for the Faroese pairtrawler fleet in Division Vb are presented in Table 7.3.2.2.2. Mean weights-at-age of greater silver smelt in the Faroese landings have varied since the introduction of the fishery, but there are no obvious trends neither increasing nor decreasing for age 4–13.

Table 7.3.2.2.2. Greater silver smelt (Division Vb). Catch weights-at-age (kg) from the Faroese pairtrawler fleet.

Table 2 Catch weights at age (kg)

YEAR	1995	1996	1997	1998
AGE				
4	.1900	.2020	.1610	.1900
5	.2360	.2240	.1980	.2570
6	.4550	.2600	.2740	.2680
7	.3380	.2940	.3400	.3080
8	.3630	.3590	.3630	.3980
9	.4320	.3730	.4000	.4160
10	.4690	.4300	.4530	.4700
11	.5430	.4850	.4790	.5170
12	.5920	.5020	.5230	.5290
13	.6800	.6240	.5790	.6280
+gp	.7220	.6590	.6890	.6360
0 SOPCOFAC	.9997	1.0002	1.0002	1.0001

YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
AGE										
4	.1900	.1900	.1870	.1460	.1900	.1900	.1900	.2100	.2210	.2020
5	.2120	.2880	.2200	.2180	.2360	.2180	.2150	.2450	.2800	.2540
6	.2340	.2860	.2610	.2540	.2490	.2760	.2710	.2980	.3190	.3010
7	.2910	.3450	.3140	.2960	.3240	.3040	.3080	.3350	.3670	.3560
8	.3240	.3660	.3520	.3530	.3520	.3740	.3170	.3500	.3800	.3670
9	.3710	.3770	.3990	.3760	.3620	.3740	.3830	.3750	.4110	.3710
10	.4190	.4590	.4260	.4060	.3860	.4100	.3910	.4180	.4850	.4280
11	.4460	.5170	.4970	.4540	.4560	.4550	.4430	.4890	.4890	.4720
12	.5050	.5730	.5310	.5060	.4840	.4970	.5130	.5130	.5390	.5360
13	.5320	.5980	.6180	.5480	.5400	.5630	.5360	.6030	.6300	.5790
+gp	.6020	.7050	.6520	.6390	.6680	.6260	.6390	.6450	.6680	.6340
0 SOPCOFAC	.9996	.9999	1.0003	1.0001	.9999	.9993	.9996	1.0103	.9999	1.0000

Growth, maturity and natural mortality

A Working Paper on growth and maturity of greater silver smelt at Vb was submitted to WKDEEP (Ofstad, WKDEEP 2010, WD: GSS-07) and the principle results are described here. Growth of greater silver smelt until maturation was around 4 cm per year (age 3 to 6) and around 1 cm per year after maturation. It seems like the female greater silver smelt grow a bit larger and reaches older ages than males (Table 7.3.2.2.3, Figure 7.3.2.2.9).

Table 7.3.2.2.3. Background data for greater silver smelt in VBF growth curve divided by sex in Area Vb.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Female	3	25	29	67	45	43	58	36	40	62	43	36	24	25	20
Male	1	13	22	39	31	51	98	55	39	41	23	28	26	17	19
Total	4	38	51	106	76	94	156	91	79	103	66	64	50	42	39

Age	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total
Female	17	13	13	5	8	8	2	7	1	3	1			2		556
Male	8	6	6	5	2	5	4	6	3	2	1		2	2	2	503
Total	25	19	19	10	10	13	6	13	4	5	2	0	2	4	2	1059

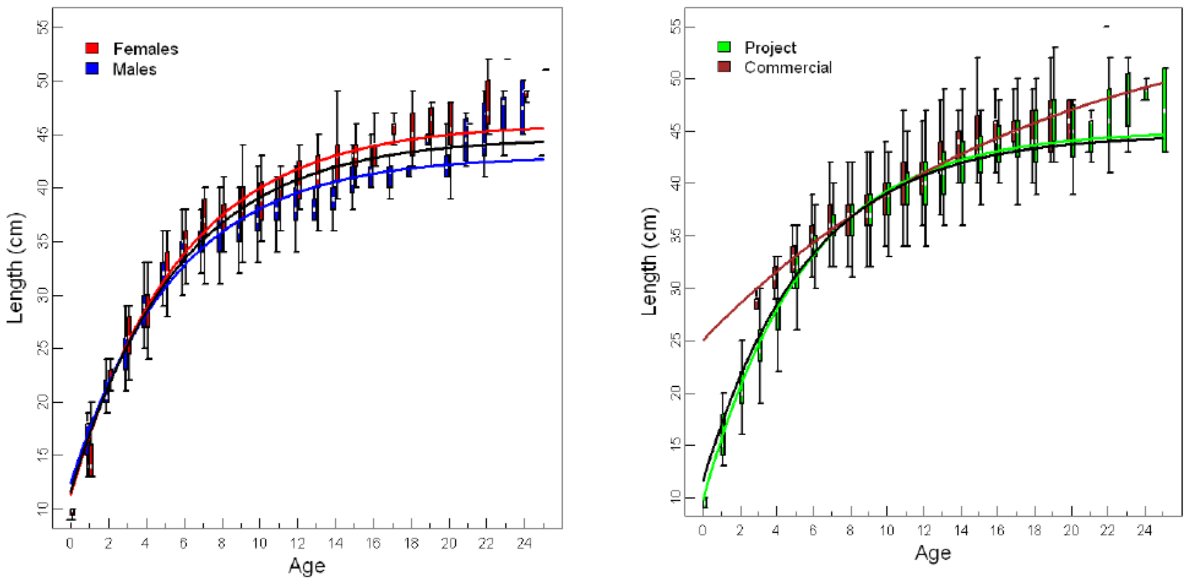

Figure 7.3.2.2.9. Median length-at-age and growth curve for female (red) and male (blue)(left figure) and from commercial samples (brown) and project results (green) (right figure).

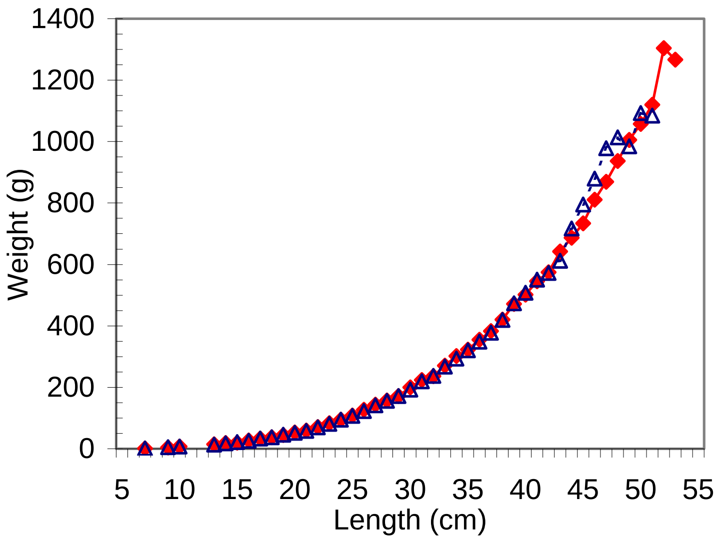

Figure 7.3.2.2.10. Length–weight relationship for females (red) and males (blue) ($W_{total} = 0.0033 * L^{3.2331}$).

Proportion of females analysed by length in landings data demonstrated that males were slightly more numerous in length less than 37 cm, and over 37 cm females were predominant (Figure 7.3.2.2.11).

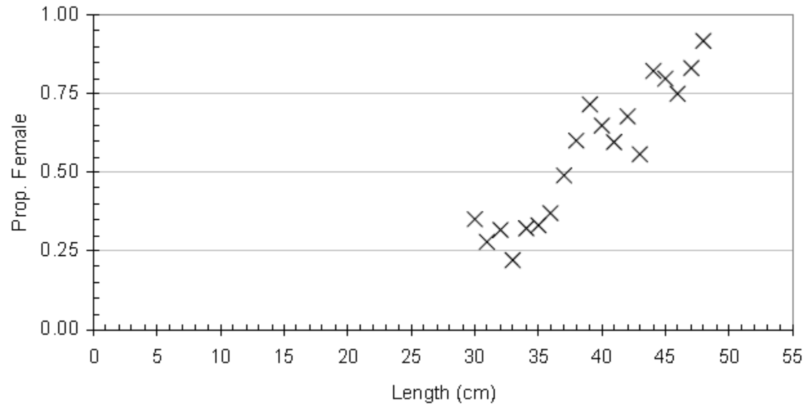

Figure 7.3.2.2.11. Proportion females per lengths from the landing data.

Length at first maturity (L50%) was calculated to be 34 cm for females and 36 cm for males. This corresponds to an age at maturity of around 6 years for females and 8 years for males (Tables 7.3.2.2.4. and 7.3.2.2.5, Figure 7.3.2.2.12).

Table 7.3.2.2.4. Maturity ogive estimates for age.

Coefficient	Female	SE	Male	SE	Total (F+M)	SE
a	-6.776	0.795	-7.296	0.772	-6.267	0.497
b	1.160	0.130	0.960	0.106	0.925	0.072
A50	5.84		7.60		6.78	

Table 7.3.2.2.5. Maturity ogive estimates for lengths.

Coefficient	Female	SE	Male	SE	Total (F+M)	SE
a	-24.297	1.863	-21.546	1.836	-22.753	1.273
b	0.716	0.054	0.607	0.052	0.654	0.036
L50	33.91		35.48		34.81	

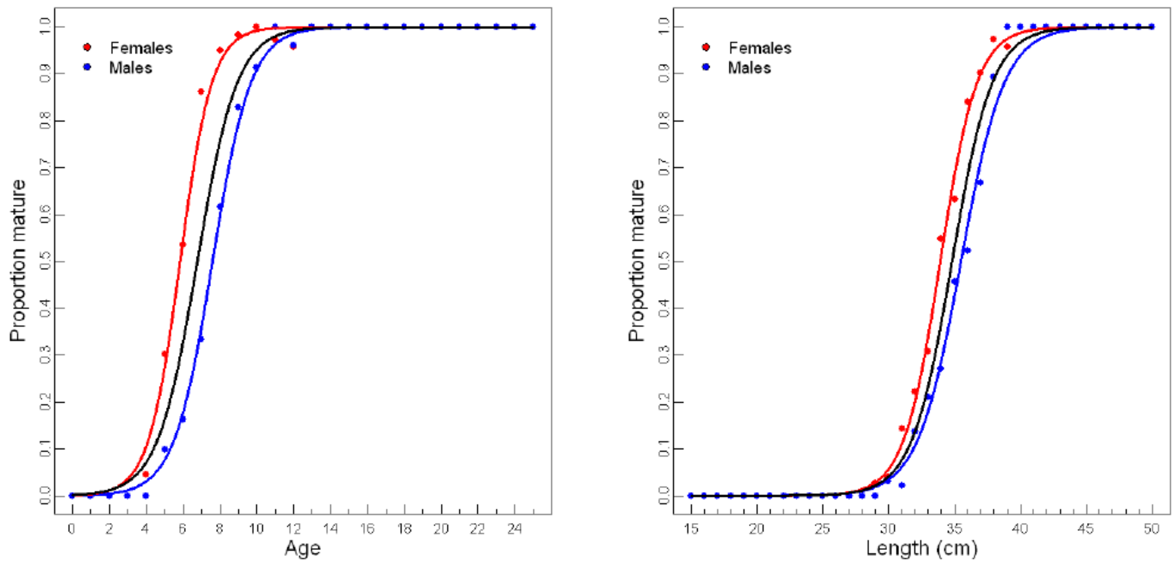

Figure 7.3.2.2.12. Maturity ogives for female and male greater silver smelt in Faroese waters as a function of age (left) and length (right).

Gonadosomatic index (GSI) values higher than 6% were taken to indicate signs of maturation and were found in females larger than 34 cm and male of about 31 cm (Figure 7.3.2.2.13). Based on observations of spawning greater silver smelt and GSI data, the spawning season is suggested to be March to July (Figure 7.3.2.2.14).

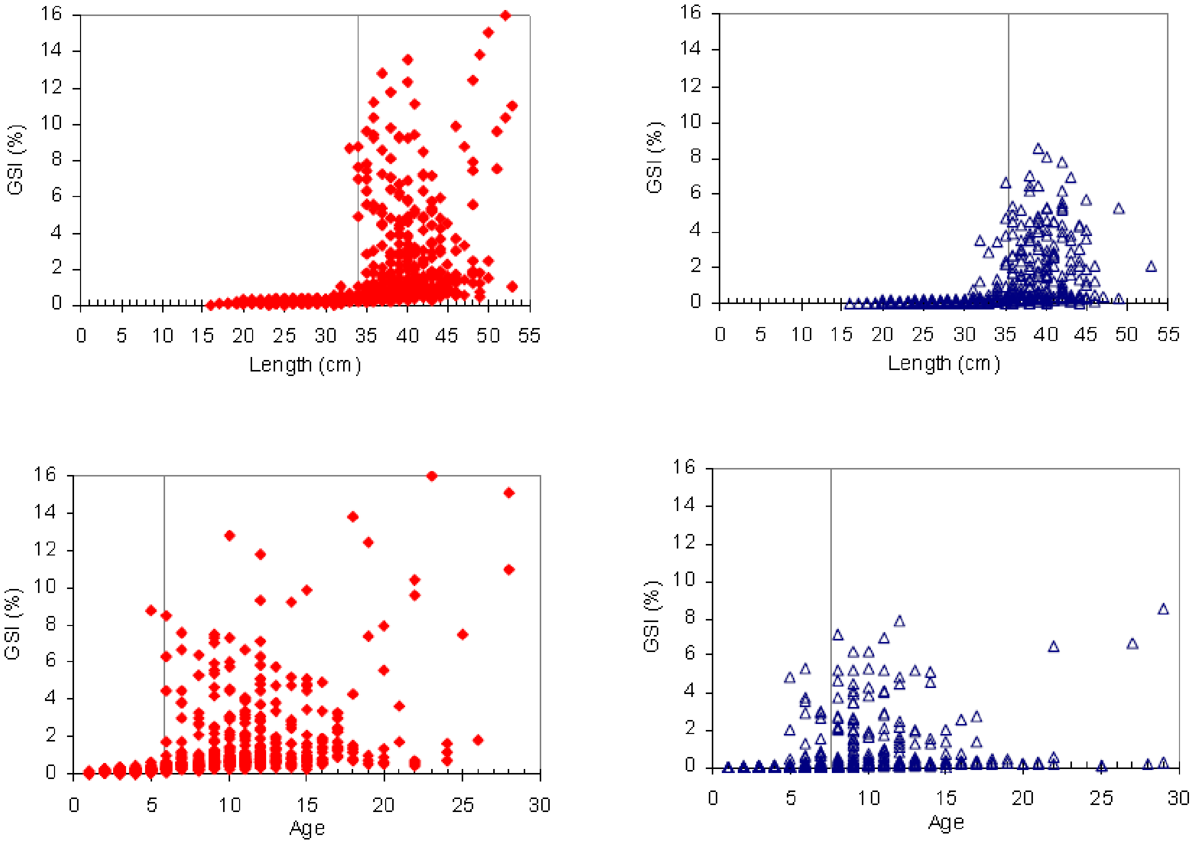

Figure 7.3.2.2.13. Greater silver smelt (Division Vb). Gonadosomatic index for female (left) and male (right) plotted against length (top), and age (bottom). Female L50=33.9 cm, A50= 5.8 year and male L50=35.5 cm, A50= 7.6 year (indicated as a line in the figures).

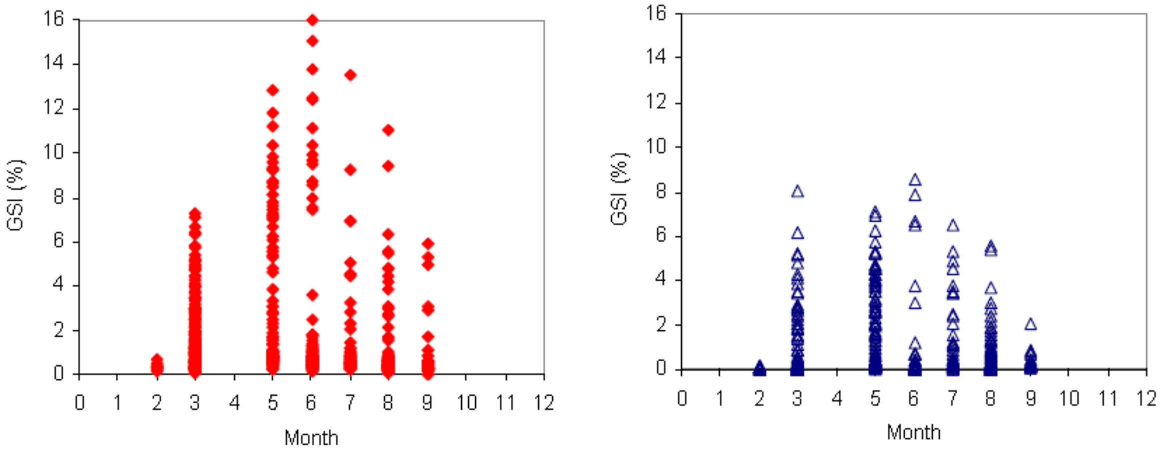

Figure 7.3.2.2.14. Gonadosomatic index per month for greater silver smelt (left- female, right- male).

Findings of pelagic greater silver smelt larvae, together with observations of spawning fish, suggest that there is spawning activity of greater silver smelt in Faroese waters (Figure 7.3.2.2.15).

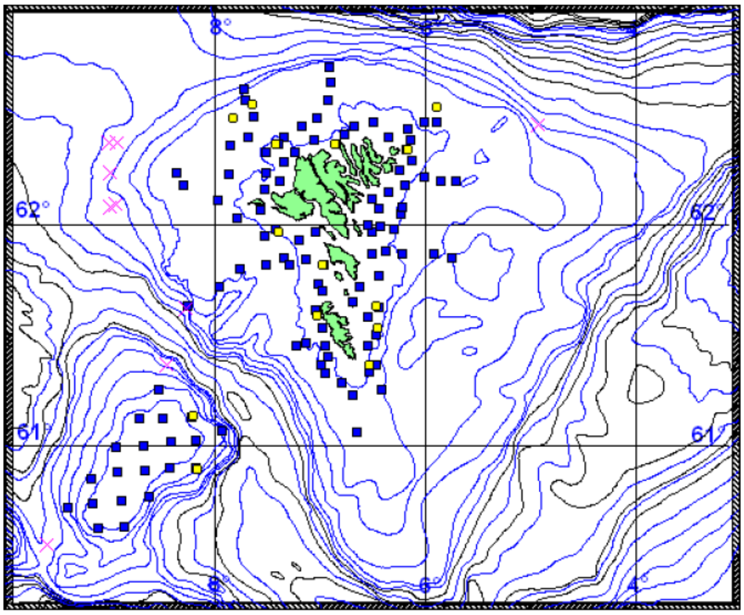

Figure 7.3.2.2.15. Observations of greater silver smelt larvae (n = 18) (yellow circles) from the pelagic 0-groupFaroese waters in June–July 1984–2009. The blue rectangles show positions of all stations in the 0-group survey and pink crosses are where spawning greater silver smelt is registered. Depth contours are per 100 m.

A Working Paper on growth and maturity of greater silver smelt off Norway was submitted to WKDEEP (Hallfredsson, 2010 WD: GSS-09) and the principle results are described here. The L_∞ parameter for the von Bertalanffy growth curve was lower for the males than for the females in the analysed data (Figures 7.3.2.2.16 and 7.3.2.2.17, Table 7.1.2.2.6). Fitting the curve with log-log transformation on the current data gave most marked different results for K and t0 for females (Table 2).

Table 7.1.2.2.6. Estimates of von Bertalanffy growth parameters of greater silvers smelt based on data from Norwegian surveys in 2007–2009. Only data for fish less than 20 years is used.

	Combined sexes		Females		Males	
Parameter	Value	Std.	Value	Std.	Value	Std.
L∞	40.121	0.290	42.689	0.444	37.088	0.272
K	0.178	0.007	0.163	0.009	0.220	0.011
t0	-2.490	0.189	-2.426	0.267	-2.100	0.208

Log-log fit

L∞	39.497	0.273	41.735	0.388	36.936	0.290
K	0.193	0.007	0.185	0.008	0.223	0.010
t0	-2.126	0.136	-1.848	0.169	-2.018	0.173

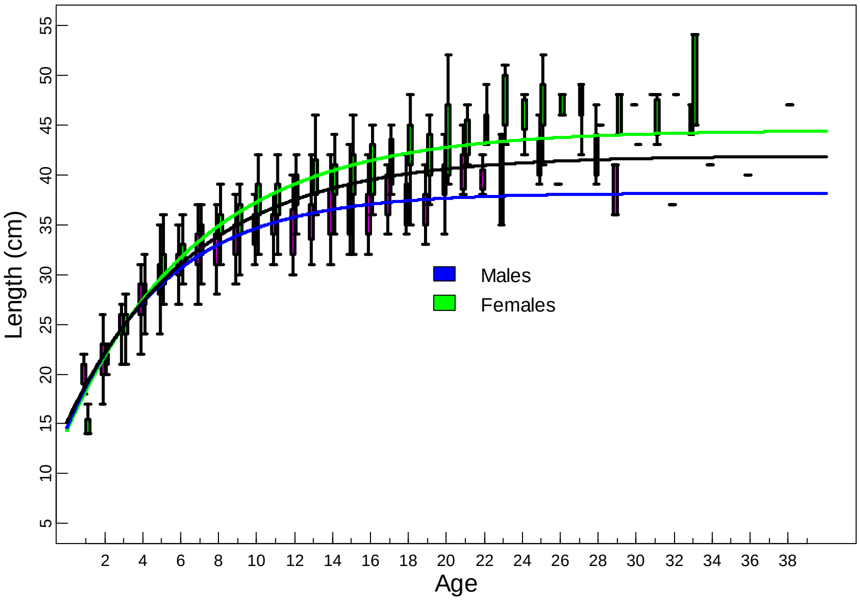

Figure 7.3.2.2.16. Length-at-age for grater silver smelt in Norwegian surveys in 2007–2009 divided by sex (boxplots). The lines are von Bertalanffy growth curves fitted to data, black line is estimated von Bertalanffy curve using the whole dataset.

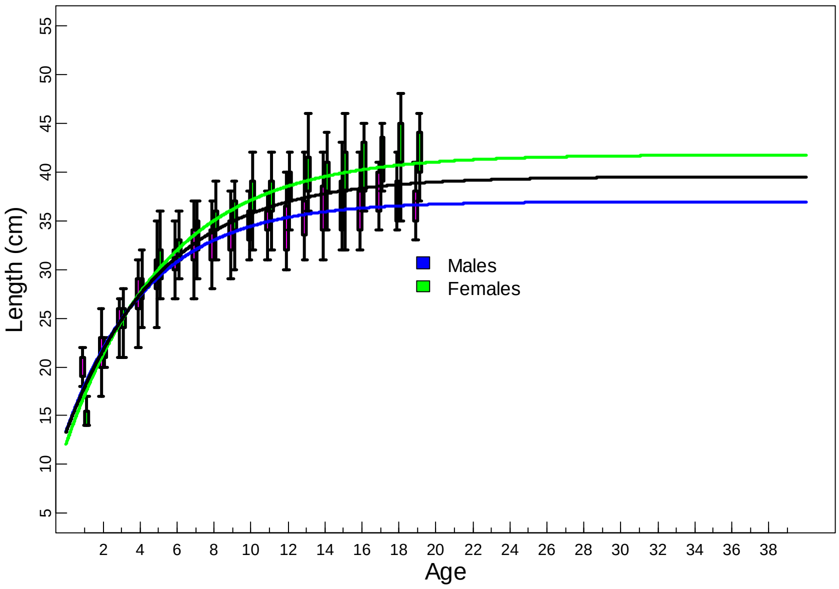

Figure 7.3.2.2.17. Length-at-age for grater silver smelt in Norwegian surveys in 2007–2009 divided by sex (boxplots). The lines are von Bertalanffy growth curves fitted to data, black line is estimated von Bertalanffy curve using the whole dataset. Only specimens aged less than twenty years are included.

The results for current data were quite similar for females compared with results from surveys in the North Sea and Skagerrak in 1985–1987 (Bergstad, 1993, Table 3), while the results for males were more different. Still, this might indicate that the change in growth pattern for greater silver smelt in Norwegian waters is minor.

Table 7.3.2.2.7. Estimates of von Bertalanffy growth parameters of greater silvers smelt based on data from summer and autumn surveys 1985–1987 in the North Sea (Norwegian deep) and Skagerrak (from Bergstad, 1993).

	Estimated length parameter for:		Estimated weight parameter for:	
Parameter	Females	Males	Females	Males
K	0.192	0.207	0.172	0.196
L_∞/W_∞	42.6	40.3	624.4	529.8
t_0	−1.95	−1.95	−2.12	−1.76
r^2	0.93	0.93	0.77	0.80

Age-at-maturity (A50) was estimated to 4.6 years, and was lower for females than males (Table 7.3.2.2.8, Figure 7.3.2.2.18). Length-at-maturity (L50) was estimated to 27.8 cm, and was lower for females than males (Table 7.3.2.2.9, Figure 7.3.2.2.19).

Table 7.3.2.2.8. Estimate of logistic regression coefficients and age at 50% maturity of greater silver smelt in Norwegian surveys in 2007–2008.

SURVEYS	COEFFICIENTS	COMBINED SEXES		FEMALES		MALES	
		Value	SE	Value	SE	Value	SE
Combined	a	-2.428	0.185	-3.347	0.406	-2.265	0.216
	b	0.527	0.030	0.792	0.074	0.442	0.033
	A50	4.605	0.138	4.226	0.176	5.124	0.191

Table 7.3.2.2.9. Estimate of logistic regression coefficients and length at 50% maturity of greater silver smelt in Norwegian surveys in 2007–2008.

SURVEYS	COEFFICIENTS	COMBINED SEXES		FEMALES		MALES	
		Value	SE	Value	SE	Value	SE
Combined	a	-8.460	0.513	-12.022	1.167	-6.859	0.585
	b	0.306	0.017	0.434	0.038	0.247	0.019
	L50	27.813	0.367	27.696	0.353	27.813	0.367

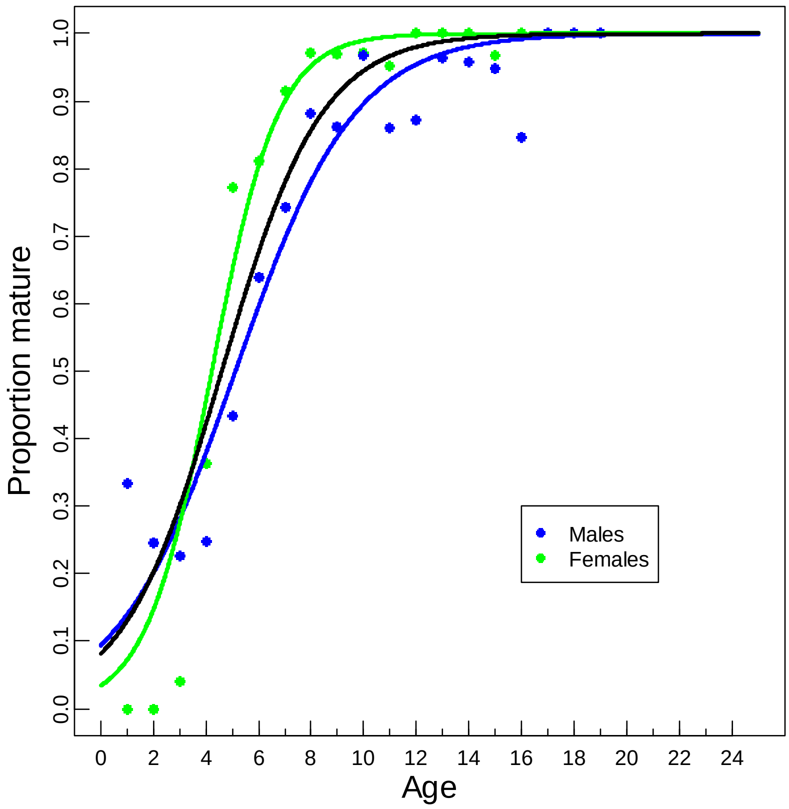

Figure 7.3.2.2.18. Proportion mature by age in Norwegian surveys in 2007–2009 combined. Lines are predictions of a logistic regression, black line both sexes combined.

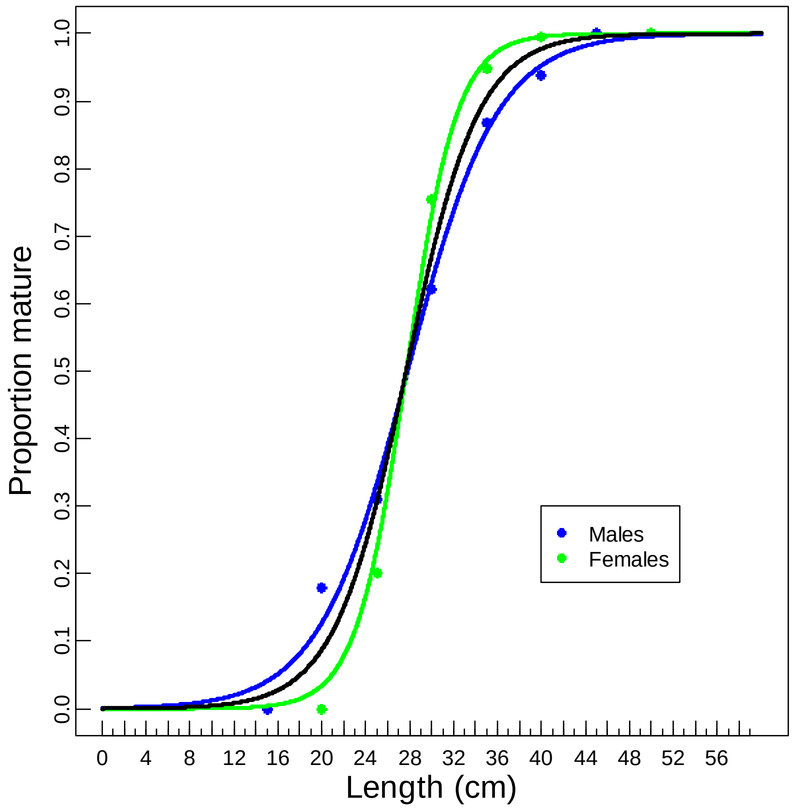

Figure 7.3.2.2.19. Proportion mature by length in Norwegian surveys in 2007–2009 combined. Lines are predictions of a logistic regression, black line both sexes combined.

No information is available on the natural mortality on greater silver smelt in these areas.

7.3.2.3 Survey tuning data

Survey information is available for greater silver smelt off Norway (acoustic survey), at the Faroese (trawl surveys) and on Porcupine bank (Division VII) (Spanish trawl survey).

Norwegian acoustic survey

A working paper on acoustical research of greater silver smelt off Norway was submitted to WKDEEP (Harbitz 2010, WD: GSS-01) and the principle results are described here. This species lives semi-pelagically as indicated in (Figure 7.3.2.3.1), has a swimbladder and is therefore suitable for abundance estimations by acoustics.

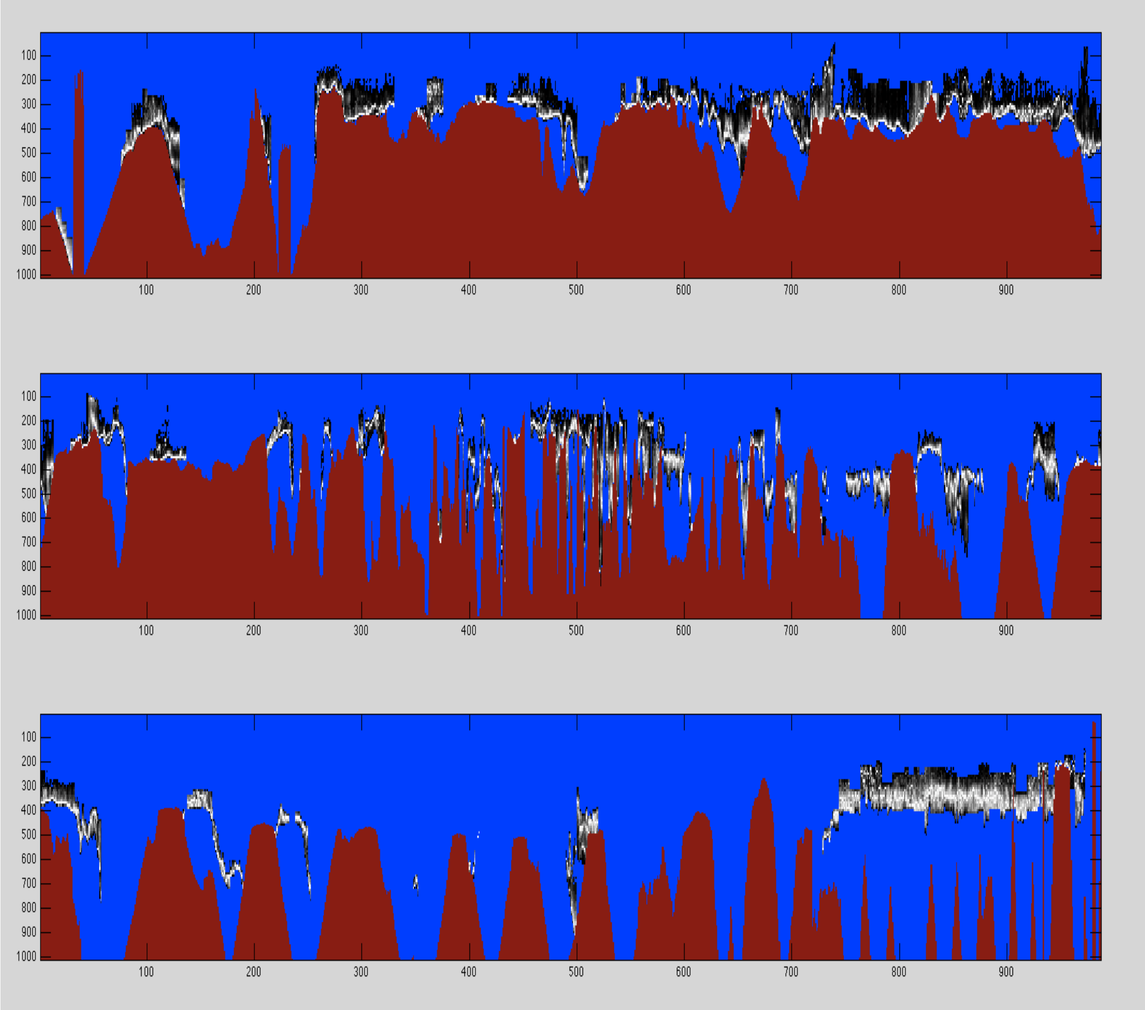

Figure 7.3.2.3.1. Observed S_A values allocated to greater silver smelt indicating the vertical distribution of greater silver smelt from acoustics along the entire survey track in Norwegian survey in 2009. Colouring of the observations is increasing density from black to white. Brown area is the bottom contour. On the x-axes the latitude is generally increasing from left in the uppermost panel to right in the lowermost panel. The Scale on the Y-axes is depth in meters with range from 0 m to 1000 m.

Estimates of abundance from acoustic surveys are available for the years 1989–1992. This survey was resumed in 2009 for redfish and greater silver smelt as focus species. An abundance estimate for greater silver smelt has been calculated using the target strength equation $TS = 20 \log_{10}L - 67.5$. Length frequency distributions were provided from 45 trawl hauls rather evenly distributed over the study area. To take account of the size dependence on latitude and depth, four different length distributions were calculated based on latitude of 68 deg N and a depth of 500 m as separation criteria. The study area was stratified by the depth in intervals with limits 1000 m, 700 m, 500 m, 450 m, 400 m, 350 m, 300 m and 250 m, limited to the latitude range south from 68 deg N. The abundance north of 68 deg N was negligible and this was omitted from the analysis. The result was an estimate of 390 kt. Estimates for the same area from Norwegian surveys in 1989–1992 is available (Monstad and Johannesen, 2003) (Table 7.3.2.3.1), and might indicate that the abundance is not less in 2009 than in these earlier findings. However this should not be considered as time-series until further evaluation of the earlier acoustic estimations. More detailed results for the

2009 estimates are shown in Table 7.3.2.3.2 below. The study area with the acoustic transect is shown in Figure 7.3.2.3.2.

Table 7.3.2.3.1. Comparison of acoustic biomass estimates for Greater Silver Smelt in Norwegian surveys in 1989–1992 and 2009 in biomass and numbers (N) in Area II. Also shown is catch of greater silver smelt in ICES Area I and II in biomass. The main fishing grounds are in Area II.

Year	Biomass estimate	N x 10^{-9}	Catch in I and II (kt)
1989[1]	67	0.2	8
1990[1]	168	0.7	9
1991[1]	180	0.5	8
1992[1]	161	0.6	8
2009[2]	390	1.1	12[3]

[1]TS = 20 log L – 67.4, see Monstad and Johannessen, 2003.

[2]TS = 20 log L – 67.5, Ronald Pedersen (pers. comm. 2010, he was the acoustical operator at this survey).

[3]TAC in 2009.

Table 7.3.2.3.2. Biomass of greater silver smelt by depth in the 2009 acoustic abundance estimate for Greater Silver Smelt.

Depth interval (m)	Area (nm^2)	Biomass	mean fish weight (g)
700–1000	6900	33 779	564
500–700	4387	94 065	564
450–500	1049	36 030	291
400–450	2390	77 432	291
350–400	6008	59 021	291
300–350	6745	54 111	291
250–300	8166	24 952	291
Total:	35 645	379 381	

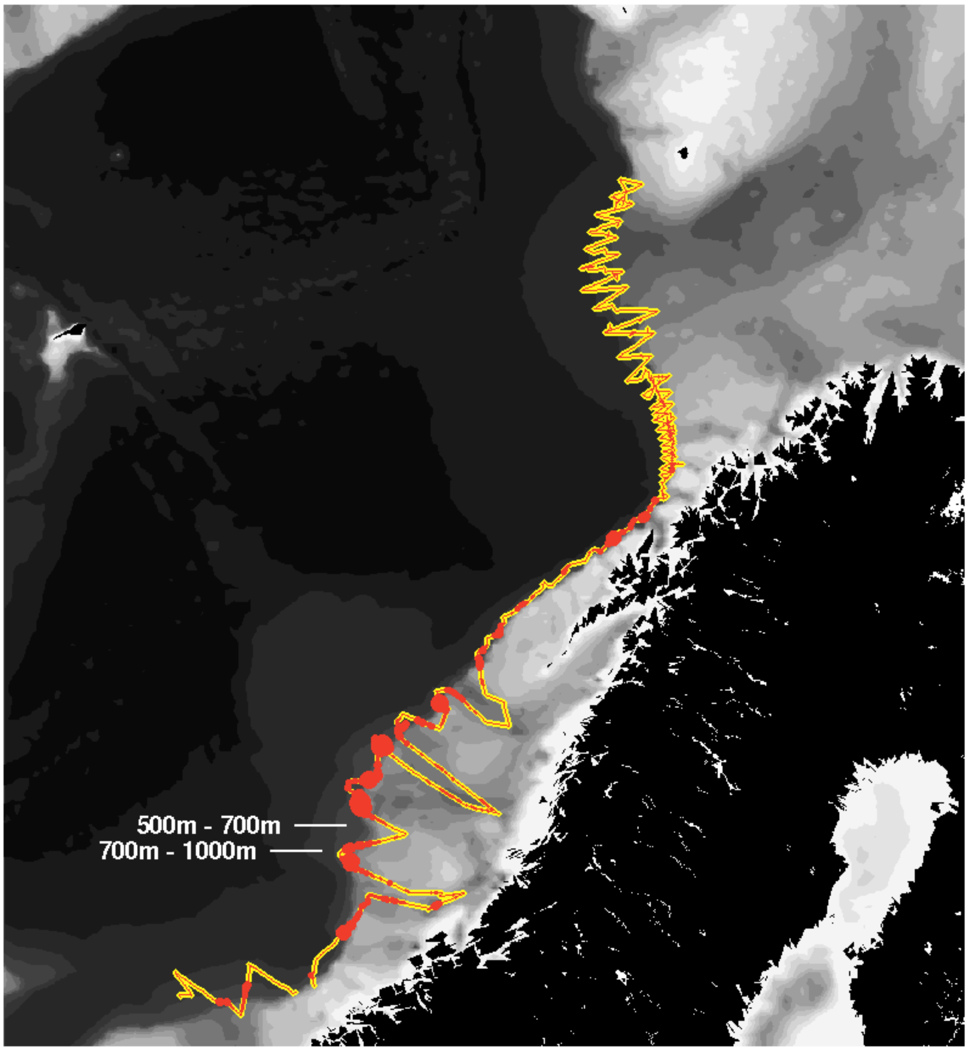

Figure 7.3.2.3.2. The acoustic transect for the 2009 survey from which greater silver smelt abundance is estimated. Yellow line shows the survey track. The Red circle areas are proportional to s_A values allocated to greater silver smelt. The smallest red dots are zero observations and the largest are S_A = 2288 m²/nm².

Faroese trawl surveys

Cpue indices for greater silver smelt were presented from two Faroese surveys for cod, haddock and saithe in Vb (1994 onwards, Figure 7.3.2.3.3). The two series do not demonstrate any significant trend. Although the greater silver smelt is not a target species in these surveys the 2010 WKDEEP regarded them as a useful indicator of trends in relative abundance.

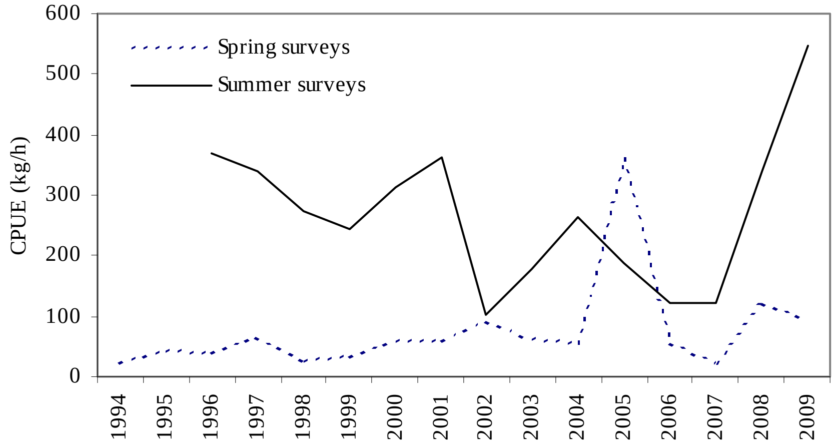

Figure 7.3.2.3.3. GSS area Vb. Stratified cpue from the spring and summer survey for cod, haddock and saithe.

Times-series data of mean length for greater silver smelt (immature <35 cm and mature 35–55 cm) in summer survey are shown in Figure 7.3.2.3.4 and Table 7.3.2.3.3.

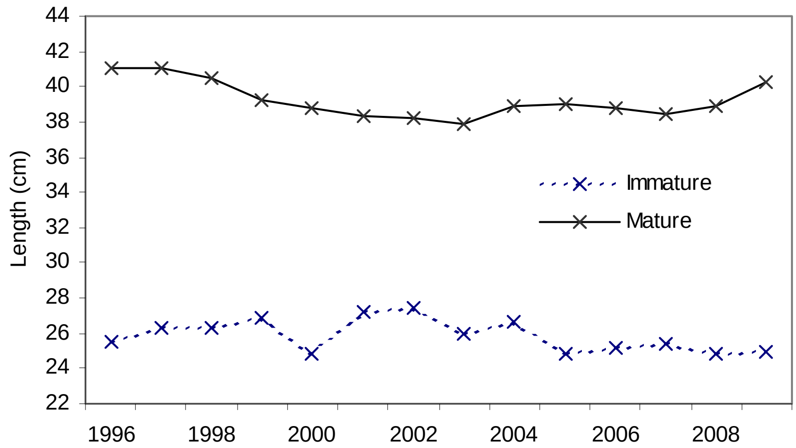

Figure 7.3.2.3.4. Mean length for greater silver smelt (immature <35 cm and mature 35–55 cm) in summer survey for cod, haddock and saithe.

Table 7.3.2.3.3. Mean length for greater silver smelt (immature <35 cm and mature 35–55 cm) in the Faroese summer survey.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Immature	25.6	26.4	26.3	26.9	24.8	27.2	27.4	26.0	26.7	24.9	25.2	25.4	24.8	24.9
Mature	41.0	41.1	40.5	39.2	38.8	38.4	38.2	37.9	38.9	39.1	38.7	38.5	38.9	40.3

The trends in mean length for immature greater silver smelt demonstrate that there is probably continuous recruitment and the mature greater silver smelt reveal no decrease.

At the meeting biomass for immature and mature greater silver smelt in the Faroese surveys was examined. The trends do not indicate decrease in amounts of greater silver smelt, however of the stations in this survey is at depths less than 400 m. The fisheries are mostly at depths more that 400 m.

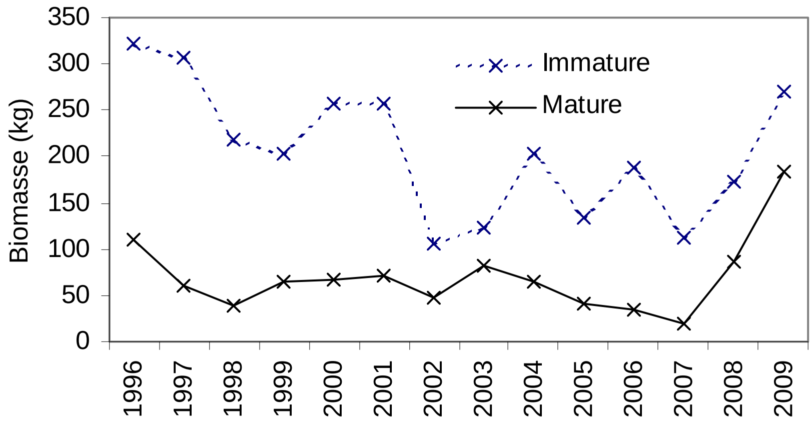

Figure 7.3.8.1. Biomass (kg) for greater silver smelt (immature <35 cm and mature 35–55 cm) in summer survey for cod, haddock and saithe (from standardized cpue data). NB! Most of the station is at depth less than 400 m!

Table 7.3.8.1. Biomass (kg) for greater silver smelt (immature <35 cm and mature 35–55 cm) in summer survey for cod, haddock and saithe (from standardized cpue data).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Immature	322.8	307.6	218.8	203.1	256.1	256.5	105.3	123.6	202.3	134.9	188.8	111.3	172.3	270.5
Mature	110.1	60.3	38.2	64.7	67.0	70.6	47.2	82.5	64.1	40.7	35.6	19.5	85.7	184.4

Spanish surveys on the Porcupine bank

Spanish research bottom-trawl surveys have been carried out in Subarea VII (Porcupine) since 2001. Figure 7.3.2.3.5 shows the catch rate of greater silver smelt and Figure 7.3.2.3.6 the geographical distribution. Blue whiting is the most abundant species in the survey area.

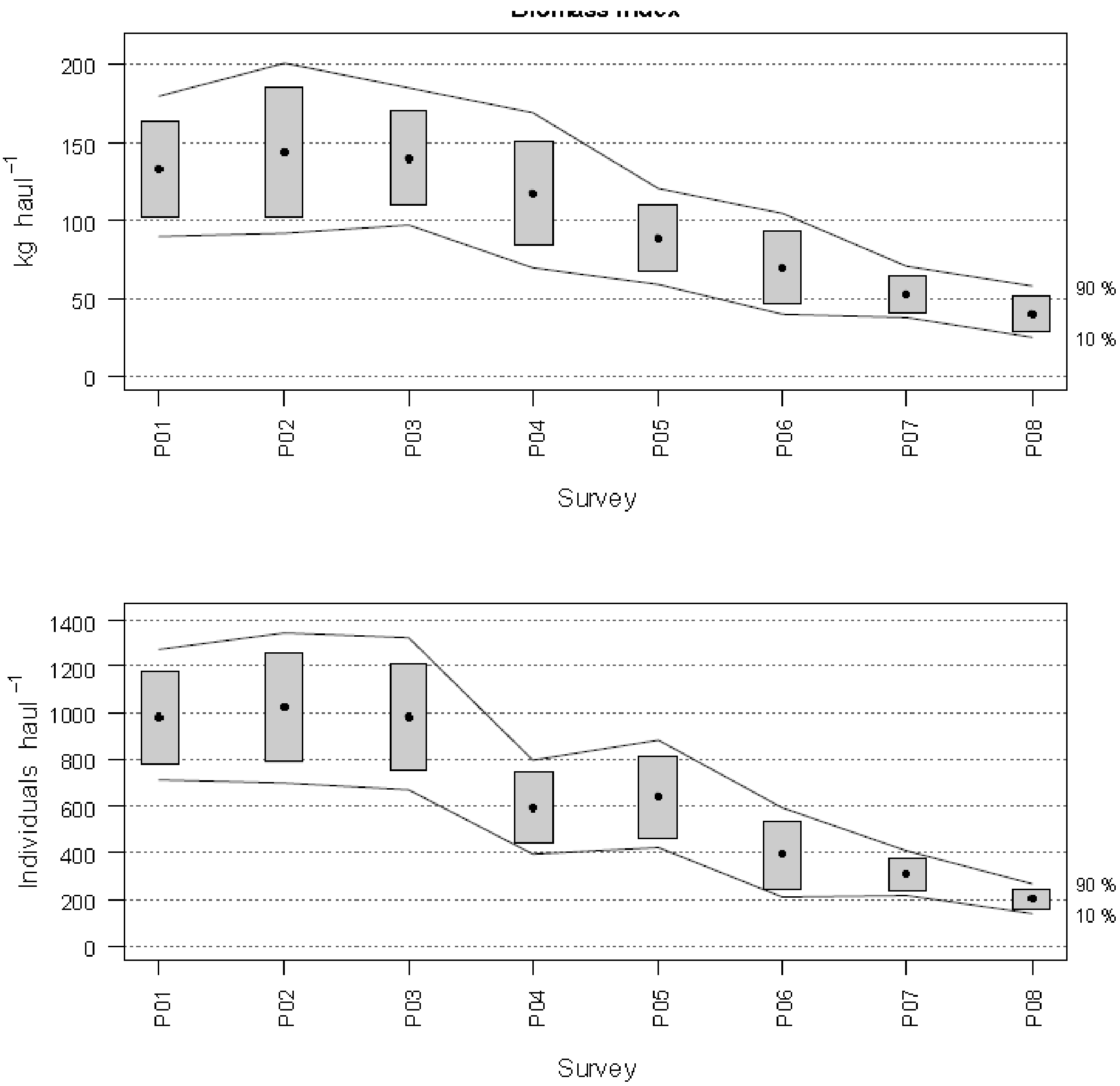

Figure 7.3.2.3.5. Changes in Argentina spp. biomass and abundance indices during Porcupine Survey time-series (2001–2008). Boxes mark parametric standard error of the stratified abundance index. Lines mark bootstrap confidence intervals (α = 0.80, bootstrap iterations = 1000).

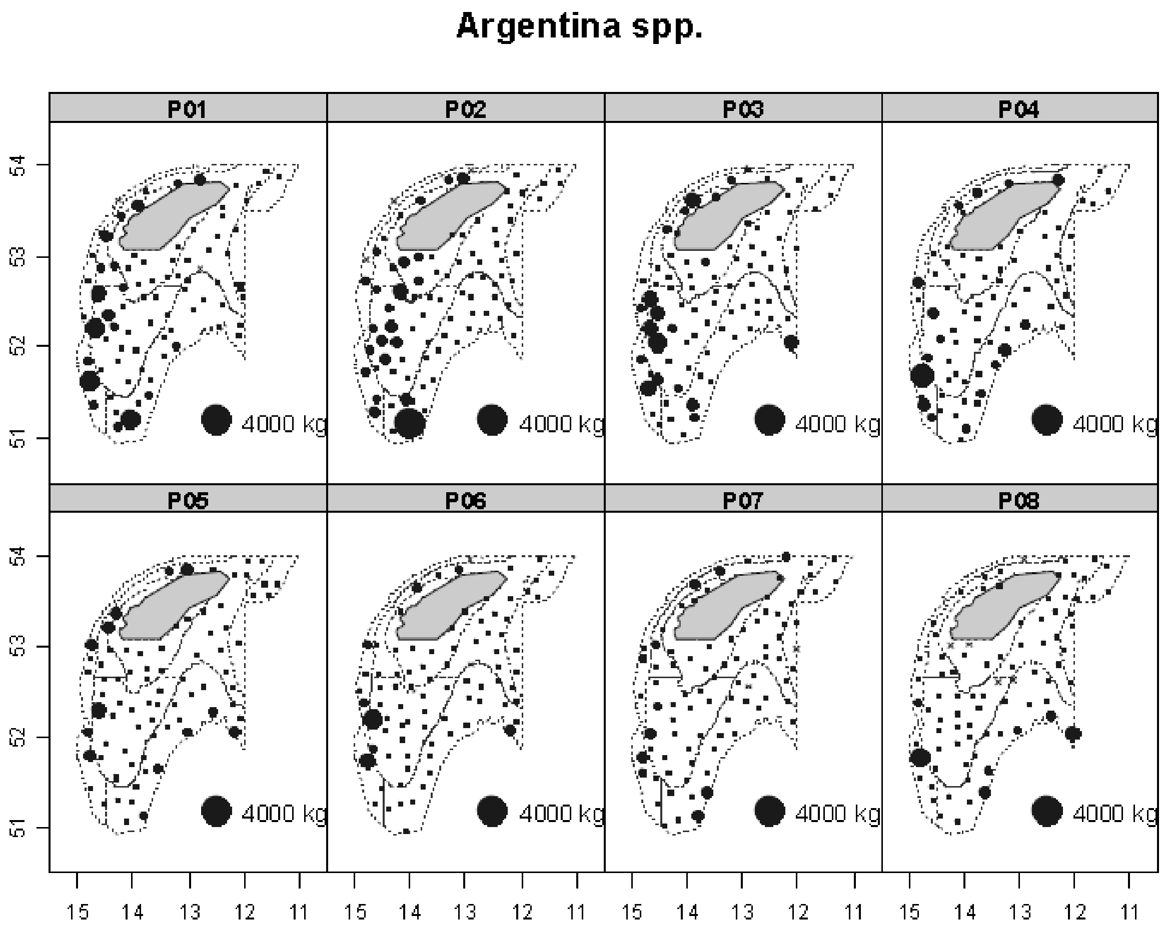

Figure 7.3.2.3.6. Geographic distribution of Argentina spp. catches (kg/30 min haul) in Porcupine surveys between 2001 and 2008.

7.3.2.4 Commercial tuning data

Logbook catch and corresponding effort data for the Danish fleet in Division IIIa are available for the period 1992–2006, but a closer evaluation is necessary before accepting these cpues as indicators (see Table 7.3.2.4.1, Figure 7.3.2.4.1).

Table 7.3.2.4.1. Danish cpue for *Argentina silus* in Division IIIa for 1992 to 2006. Data from log-books do not represent the entire landings.

Year	Mesh size in trawl									
	70 - 100 mm			30 - 45 mm			<25 mm			All trawls
	Kg	days	CPUE	Kg	days	CPUE	Kg	days	CPUE	CPUE
1992	592430	62	9555				77601	10	7760	9306
1993	885880	71	12477	720000	36	20000	77200	4	19300	15163
1994	978300	78	12542	212000	7	30286				14004
1995	647140	67	9659	423848	98	4325	10000	1	10000	6512
1996	1303420	84	15517							15517
1997	808360	69	11715				136000	4	34000	12936
1998	703180	56	12557							12557
1999	885900	65	13629	907900	66	13756	22000	1	22000	13756
2000	767300	89	8621	169000	9	18778	27600	4	6900	9450
2001	788520	103	7656							7656
2002	791000	92	8598							8598
2003	182000	30	6067	669000	80	8363				7736
2004	100000	11	9091	830000	108	7685				7815
2005				454200	67	6779				6779
2006				324000	51	6353				6353

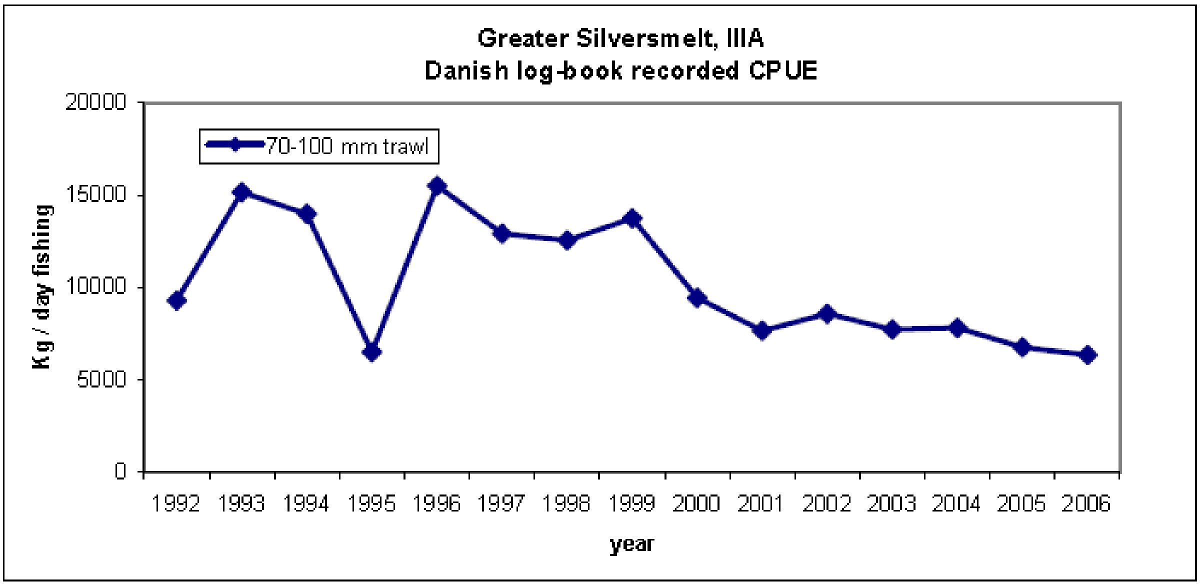

Figure 7.3.2.4.1. Cpue from Danish trawl fisheries in Division IIIa for 1992–2006.

Logbooks from three pairs of pairtrawlers (>1000 HP) fishing greater silver smelt in Faroese waters (Division Vb) are available (Ofstad and í Homrum, WGDEEP 2009, WD14). Figure 7.3.2.4.2 shows cpue where catches of greater silver smelt contribute with more than 50% of total catch in each haul for these series.

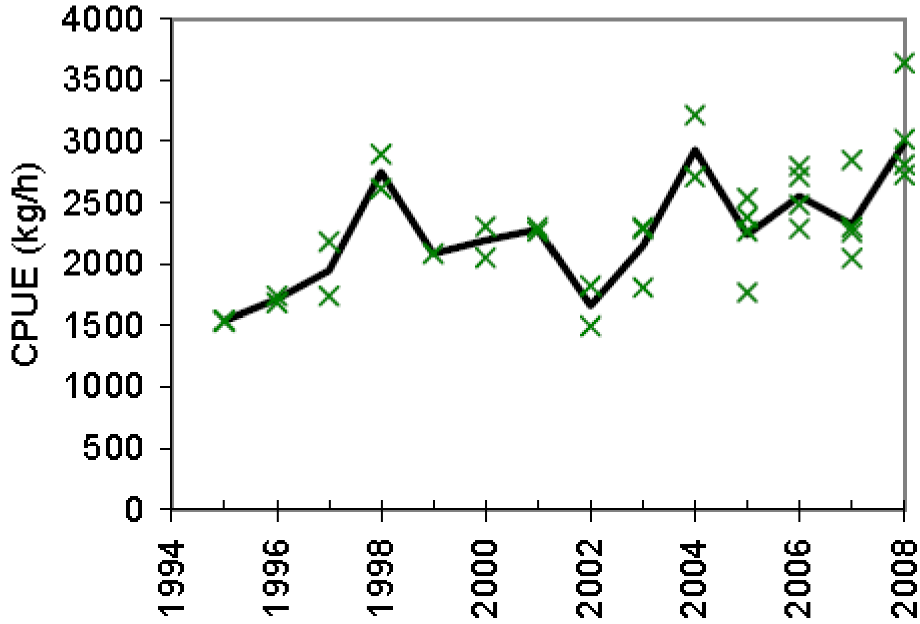

Figure 7.3.2.4.2. Catch per unit of effort (kg/h) for three pairs of Faroese pairtrawlers (Division Vb). Only hauls where greater silver smelt is more that 50% of the total catch are used.

Logbook data reveals that greater silver smelt is fished mostly in the area west of the Faroe Islands and on the continental slope north and northwest of the Faroe Bank, at depths around 300–700 meters. To some extent, there is also being trawled on the Bill Bailey Bank and Lousy Bank and north of the Faroes (Figure 7.3.2.4.3).

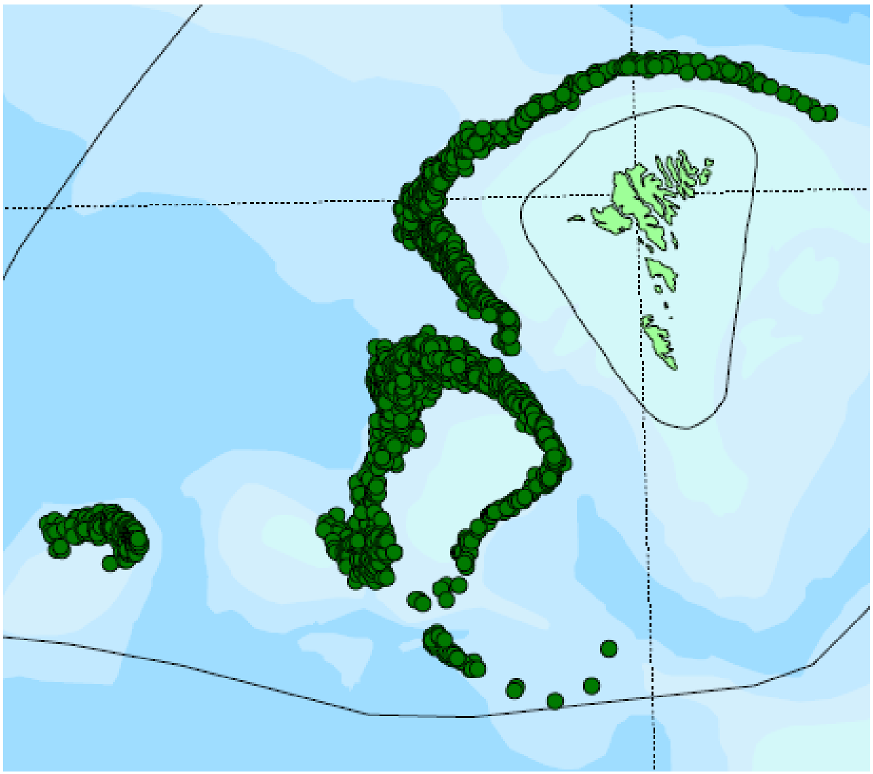

Figure 7.3.2.4.3. Greater silver smelt (Division Vb). Distribution of Faroese pairtrawler hauls with more than 50% greater silver smelt in the hauls (1995–2008).

7.3.2.5 Industry/stakeholder data inputs

No industry/stakeholder data were available to WKDEEP.

7.3.3 Stock identity and migration issues

See Section 7.1.

7.3.4 Spatial changes in the fishery and stock distribution

No information was available to WKDEEP on changes to distribution in the fisheries. Regarding stock distribution see Section 7.1.

7.3.5 Environmental drivers of stock dynamics

Greater silver smelt is considered to be mobile semi-pelagic species and its distribution is likely to be influenced by environmental parameters i.e. temperature. However no information is available to WKDEEP.

7.3.6 Role of multispecies interactions

No information was available to WKDEEP.

7.3.6.1 Trophic interactions

Little is known about trophic interaction for this species.

7.3.6.2 Fishery interactions

It is known that greater silver smelt can be taken as a bycatch in the blue whiting fisheries in some areas.

7.3.7 Impacts on the ecosystem

No information was available on impacts on the ecosystem of fishing for greater silver smelt.

7.3.8 Stock assessment methods

A working paper on an XSA based assessment of greater silver smelt in Vb was submitted to WKDEEP (Ofstad 2010, WD:WKDEEP GSS-08).The analysis is run on what is considered by ICES as a part of an assessment unit. As the stock structure is unclear (see Section 7.1) the use of single-stock model might be inappropriate. The XSA is calibrated with pairtrawlers as tuning series (Table 1.4.1). Several different settings were tried in XSA however the model did not converge largely because of the tuning fleet being composed of commercial data also used to create the catch-at-age.

7.3.8.1 Models

No models were presented to the WKDEEP meeting except for the exploratory XSA from the Faroese.

7.3.8.2 Sensitivity analysis

No sensitivity analysis was performed at WKDEEP 2010.

7.3.8.3 Retrospective patterns

No retrospective analysis was performed at WKDEEP 2010.

7.3.8.4 Evaluation of the models

A working paper on an XSA based assessment of greater silver smelt in Vb was submitted to WKDEEP (Ofstad 2010, WD:WKDEEP GSS-08).The analysis is run on what is considered by ICES as a part of an assessment unit. As the stock structure is unclear (see Section 7.1) the use of single-stock model might be inappropriate. The XSA is calibrated with pairtrawlers as tuning-series (Table 1.4.1). Several different settings were tried in XSA however the model did not converge largely because of the tuning fleet being composed of commercial data also used to create the catch-at-age.

7.3.9 Stock assessment

No analytical assessment were considered appropriate to asses greater silver smelt ICES Subareas I, II, IV, VI, VII, VIII, IX, X, XII and XIV and Divisions IIIa and Vb. Trends of biomass indices for greater silver smelt from Faroese summer survey for cod, haddock and saithe (only cpue trends and mean length trends for both surveys) in Division Vb, and Spanish surveys in the Porcupine bank are useful information that can give indications on the state of this assessment unit in these areas. It should be noticed that these greater silver smelt demonstrates an aggregation behaviour and catch trends and cpue in different areas are unlikely to reflect the level of abundance of this bentho-pelagic species (WGDEEP Report 2008).

Acoustical surveys have been conducted in Norwegian waters to estimate abundance of greater silver smelt. These studies are too few to serve as time-series. However, given properly standardized surveys the method is appropriate to achieve reliable time-series of trends in abundance for the species in a given area.

7.3.10 Recruitment estimation

Not available.

7.3.11 Short-term and medium-term forecasts

Due to the lack of an agreed analytical assessment no short-term and medium-term forecasts were performed.

7.3.12 Biological reference points

No biological reference points were proposed for greater silver smelt in ICES Subareas I, II, IV, VI, VII, VIII, IX, X, XII and XIV and Divisions IIIa and Vb at WKDEEP.

7.3.13 Recommended modifications to the stock annex

Stock Annex has not previously existed for this assessment unit.

7.3.14 Recommendations on the procedure for assessment updates

No recommendations were elaborated in relation with assessment procedure. The urgent need for these assessment units is to resolve stock identity issues (see Section 7.1–Further work).

7.3.15 Industry supplied data

No data were supplied from the industry.

7.3.16 References

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Stock Annex: Greater Silver Smelt in Division Va

Stock	Greater Silver Smelt in Division Va
Working Group	WKDEEP
Date	February 2010
Revised by	Gudmundur Thordarson

A. General

A.1. Stock definition

Greater Silver Smelt (*Argentina silus*) stock in Division Va (Icelandic waters) is treated as a separate assessment unit is from greater silver smelt in Subareas I, II, IV, VI, VII, VIII, IX, XII, XIV and Divisions IIIa and Vb.

A.2. Fishery

Greater silver smelt is mostly fished along the south, southwest, and west coast of Iceland, at depths between 500 and 800 m.

Greater silver smelt was caught in bottom trawls for years as bycatch in the redfish fishery. Only small amounts were reported prior to 1996 as most of the greater silver smelt was discarded. Since 1997, direct fishery for greater silver smelt has been ongoing and the landings have increased significantly. At the beginning, the fishery was mainly located along the slopes of the south and southwest coast, but in recent years the fishery has expanded and significant catches are taken along the slopes west of Iceland.

The greater silver smelt fishery is at present not managed by quotas but rather as an exploratory fishery subject to licensing (see A.2.1) since 1997. Greater silver smelt is now mainly taken both in a directed fishery with, but also as a bycatch in the redfish fishery.

A.2.1. Fleet

Greater silver smelt in Va is caught only in bottom trawls, often as a bycatch or in conjunction with redfish and Greenland halibut fishing. Between 20 and 30 trawlers have participated in the fishery since 1996. In recent years, the majority of the greater silver smelt landings have been taken in hauls were the species was 50% or more of the catch in the haul. The trawlers that target greater are mainly freezer trawlers that are between 1000 and 2000 GRT. The fleet uses a bottom trawl with small mesh size belly (80 mm) and codend (40 mm).

A.2.2. Regulations

The greater silver smelt fishery is subject to regulation nr 717, 6th of October 2000 with amendments 1138/2005 from the Ministry of Fisheries. In short the regulation states among others that:

1) All fishing of greater silver smelt is subject to licensing by the Directorate of Fisheries that has to be renewed each year.

2) Fishing for Greater silver smelt is only allowed south and west of Iceland. That is west of W19°30 and south of N66°00 at depths greater than 220

fathoms (approx 430 m). Between W19°30 and W14°30 taking of greater silver smelt is allowed south of given line (Figure 1 and Table 1).

3) It is mandatory to keep logbooks were the date, exact position of haul, catch and depth are recorded.

4) Samples shall be collected, at least one from each fishing trip. The sample shall consist of randomly selected 100–200 specimens of greater silver smelt. The sample is frozen on board and sent to the Marine Research Institute in Reykjavik for further investigation.

5) Minimum mesh size in the trawl is 80 mm but 40 mm in the codend.

A revised regulation will soon come into effect that expands the fishing area north to 67°N and east to 12°W.

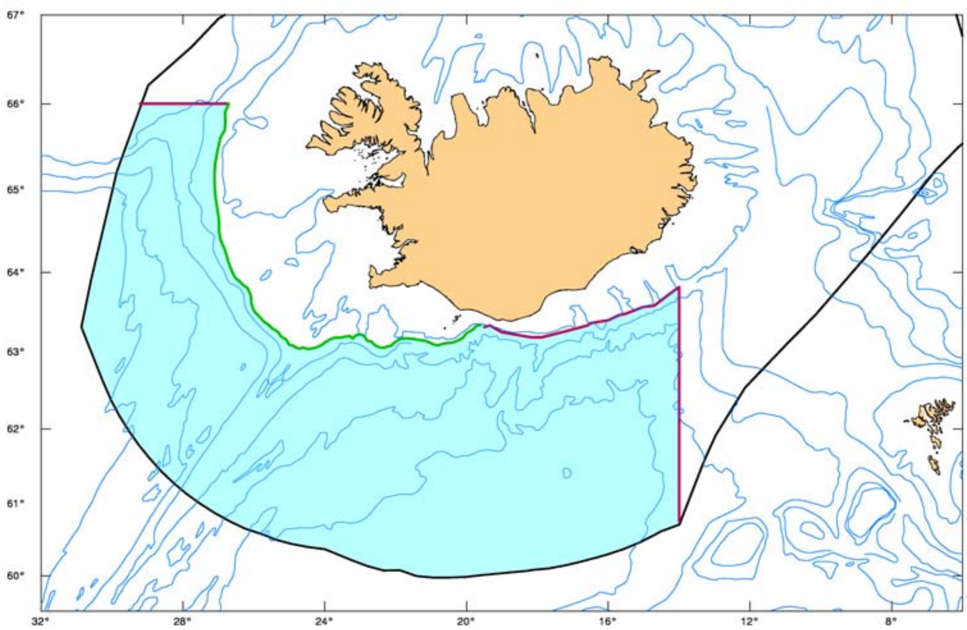

Figure 1. Area open to commercial fishing of Greater Silver Smelt in Va according to regulation nr 717, 6th of October 2000 with amendments 1138/2005 from the Ministry of Fisheries (the shaded blue area). The red-line off the south coast drawn according to Table 1 and the green line is an approximation of the 400 m depth contour.

A.3. Ecosystem aspects

Warming of sea temperature, have been documented in Va and an expansion of distributional area of warm-water species such as anglerfish. The significance and reliability of such metrics is considered at the moment insufficient for their consideration in the provision of management advice of greater silver smelt in Va.

B. Data

B.1. Commercial catches

Icelandic commercial catches in tonnes by month and gear are provided by Statistical Iceland and the Directorate of Fisheries. Data on catch in tonnes from other countries are taken from ICES official statistics (STATLAN) and/or from the Icelandic Coast Guard. Annual landings are available from 1985 or from the commencing of the targeted fishery. The fishing statistics are considered accurate. Discards are not considered to be of relevance and therefore not included in the assessment. There are limited measurements of discard from 2002 to 2009. The distribution of catches is obtained from logbook statistics where location of each haul, effort, depth of trawling and total catch of greater silver smelt is given. From the logbook catch per unit of effort and effort is estimated.

B.2. Biological

Biological data from the greater silver smelt catch is collected on board of the fishing vessel, as it is mandatory to send at least one sample from each fishing trip. The sample is sent to the Marine Research Institute and analysed by scientists and technicians. Each sample consists of randomly selected 100–200 specimens of greater silver smelt. In each sample, otoliths are extracted from 50 specimens. The biological data collected are length (to the nearest cm), sex and maturity stage, and un-gutted weight (to the nearest gramme). The rest of the sample is only length measured.

From 1987–1996, biological sampling from the catches were sporadic. Biological sampling of the catches has been generally considered sufficient since 1997. Age reading is considered accurate.

Greater silver smelt in Va reaches 50% maturity at around 36 cm or at around 6–8 years of age. The species enters the fishery at around 30 cm or 3–4 years of age. Only very few greater silver smelt have been measured 60 cm or larger.

B.3. Surveys

The annual Icelandic groundfish surveys give trends on fishable biomass of many exploited stocks on Icelandic fishing grounds. The main objective in the design of the surveys was to monitor the most important commercial stocks such as cod, haddock, saithe, and redfish. However the surveys are considered representative for many other exploited stocks of lesser economic importance.

B.3.1. The Icelandic groundfish survey in March

In the Icelandic groundfish survey which has been conducted annually in March since 1985 gives trends on fishable biomass of many exploited stocks on Icelandic fishing grounds. Total of more than 500 stations are taken annually in the survey at depths down to 500 meters. Therefore the survey area does not cover the most important distribution area of greater silver smelt and is not considered fully representative for greater silver smelt in Va.

B.3.2. The Icelandic groundfish survey in October (Autumn Survey)

The Icelandic Autumn Groundfish Survey (AGS) has been conducted annually since 1996 by the Marine Research Institute (MRI). The objective is to gather fishery-independent information on biology, distribution and biomass of demersal fish species in Icelandic waters, with particular emphasis on Greenland halibut (*Reinhardtius hippoglossoides*) and deep-water redfish (*Sebastes mentella*). This is because the Icelandic Groundfish Survey (IGS) conducted annually in March does not cover the distribution of these deep-water species. Secondary aim of the survey is to have another fisheries independent estimate on abundance, biomass and biology of demersal species, such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and golden redfish (*Sebastes marinus*), in order to improve the precision of stock assessment.

AGS is conducted in October as it is considered the most a suitable month in relation to diurnal vertical migration, distribution and availability of Greenland halibut and deep-sea redfish. The research area is the Icelandic continental shelf and slopes within the Icelandic Exclusive Economic Zone to depths down to 1500 m. The research area is divided into a shallow-water area (0–400 m) and a deep-water area (400–1500 m). The shallow-water area is the same area as covered by IGS. The deep-water area is directed at the distribution of Greenland halibut, mainly found at depths from 800–1400 m west, north and east of Iceland, and deep-water redfish, mainly found at 500–1200 m depths southeast, south and southwest of Iceland and on the Reykjanes Ridge.

Initially, in all 430 stations were divided between the two areas. Of them, 150 stations were allocated to the shallow-water area and randomly selected from the IGS station list. In the deep-water area, half of the 280 stations were randomly positioned in the area. The other half were randomly chosen from logbooks of the commercial bottom-trawl fleet fishing for Greenland halibut and deep-water redfish in 1991–1995. The locations of those stations were, therefore, based on distribution and pre-estimated density of the species.

Because MRI was not able to finance a project in order of this magnitude, it was decided to focus the deep-water part of the survey on the Greenland halibut main distributional area. For this reason, important deep-water redfish areas south and west of Iceland were omitted. The number and location of stations in the shallow-water area were unchanged.

The number of stations in the deep-water area was therefore reduced to 150. In all 100 stations were randomly positioned in the area. The remaining stations were located on important Greenland halibut fishing grounds west, north and east of Iceland and randomly selected from a logbook database of the bottom-trawl fleet fishing for Greenland halibut 1991–1995. The number of stations in each area was partly based on total commercial catch.

In 2000, with the arrival of a new research vessel, MRI was able finance the project according to the original plan. Stations were added to cover the distribution of deep-water redfish and the location of the stations selected in a similar manner as for Greenland halibut. In all 30 stations were randomly assigned to the distribution area of deep-water redfish and 30 stations were randomly assigned to the main deep-water redfish fishing grounds based on logbooks of the bottom-trawl fleet 1996–1999. The years 1996–1999 cannot be used for abundance and biomass estimates of greater silver smelt because the AGS in those years did not cover adequately the distribution of the species.

In addition, 14 stations were randomly added in the deep-water area in areas where great variation had been observed in 1996–1999. However, because of rough bottom which made it impossible to tow, five stations have been omitted. Finally, 12 stations were added in 1999 in the shallow-water area, making total stations in the shallow-water area 162. Total number of stations taken since 2000 has been around 381 (Figure 2).

The RV "Bjarni Sæmundsson" has been used in the shallow-water area from the beginning of the survey. For the deep-water area MRI rented one commercial trawler 1996–1999, but in 2000 the commercial trawler was replaced by the RV "Árni Friðriksson".

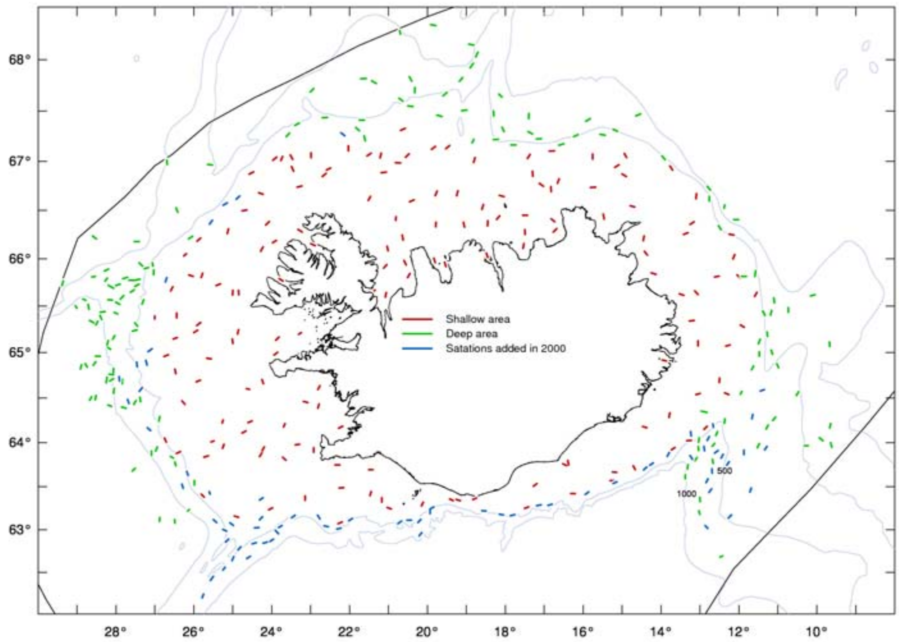

Figure 2. Stations in the Autumn Groundfish Survey (AGS). RV "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and RV "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

B.3.2.1. Data collection (biological sampling)

B.3.2.1.1. Length measurement, counting (subsampling)

All fish species are measured for length. For the majority of species including greater silver smelt, total length is measured to the nearest cm from the tip of the snout to the tip of the longer lobe of the caudal fin. At each station, the general rule, which also applies to greater silver smelt is to measure at least 4 times the length interval of a given species. Example: If the continuous length distribution of greater silver smelt at a given station is between 15 and 45 cm, the length interval is 30 cm and the number of measurements needed is 120. If the catch of greater silver smelt at this station exceeds 320 individuals, the rest is counted.

Care is taken to ensure that the length measurement sampling is random so that the fish measured reflect the length distribution of the haul in question.

B.3.2.1.2. Recording of weight, sex and maturity stages

Sex and maturity data has not been collected from greater silver smelt sampled in the autumn survey, nor has silver smelt been weighted. Collection of these data is supposed to commence in 2010.

B.3.2.1.3. Otolith sampling and weighing

For greater silver smelt a minimum of 1 and a maximum of 25 otoliths are collected from each haul. Otoliths are sampled at a 30 fish interval so that if in total 300 greater silver smelt are caught in a single haul, 10 otoliths are sampled.

B.3.2.2. Station information

At each station relevant information on the haul and environmental factors, are filled out by the captain and the first officer in cooperation with the cruise leader.

Tow information

- **General:** Year, Station, Vessel registry no., Cruise ID, Day./month, Statist. Square, Sub-square, Tow number, Gear type no., Mesh size, Briddles length (m).
- **Start of haul:** Pos. N, Pos. W, Time (hour:min), Tow direction in degrees, Bottom depth (m), Towing depth (m), Vert. opening (m), Horizontal opening (m).
- **End of haul:** Pos. N, Pos. W, Time (hour:min), Warp length (fm), Bottom depth (m), Tow length (naut. miles), Tow time (min) , Tow speed (knots).
- **Environmental factors:** Wind direction, Air temperature °C, Wind speed, Bottom temperature °C, Sea surface, Surface temperature °C, Towing depth temperature °C, Cloud cover, Air pressure, Drift ice.

B.3.2.3. Fishing gear

Two types of the bottom survey trawl "Gulltoppur" are used for sampling: "Gulltoppur" is used in the shallow water and "Gulltoppur 66.6 m" is used in deep waters. The trawls were common among the Icelandic bottom-trawl fleet in the mid-1990s and are well suited for fisheries on cod, Greenland halibut and redfish.

The bottom trawl used in the shallow water is called "Gulltoppur". The headline is 31.0 m, and the fishing line is 19.6 m. The trawl used in the deep-water area is "Gulltoppur 66.6 m" (Figures 6–9). The headline is 35.6 m and the fishing line is 22.6 m.

Towing speed and distance: The towing speed is 3.8 knots over the bottom. The trawling distance is 3.0 nautical miles calculated with GPS when the trawl touches the bottom until the hauling begins (i.e. excluding setting and hauling of the trawl).

B.3.2.4. Data processing

B.3.2.4.1. Abundance and biomass estimates at a given station

As described above the normal procedure is to measure at least 4 times the length interval of a given species. The number of fish caught of the length interval L_1 to L_2 is given by:

$$P = \frac{n_{measured}}{n_{counted} + n_{measured}}$$

$$n_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i}{P}$$

Where $n_{measured}$ is the number of fished measured and $n_{counted}$ is the number of fish counted.

Biomass of a given species at a given station is calculated as:

$$B_{L_1-L_2} = \sum_{i=L_1}^{i=L_2} \frac{n_i \alpha L_i^{\beta}}{P}$$

Where Li is length and alpha and beta are coefficients of the length–weight relationship.

B.3.2.4.2. Index calculation

For calculation of indices the Cochran method is used (Cochran, 1977). The survey area is split into subareas or strata and an index for each subarea is calculated as the mean number in a standardized tow, divided by the area covered multiplied with the size of the subarea. The total index is then a summed up estimates from the subareas.

A 'tow-mile' is assumed to be 0.00918 square nautical mile. That is the width of the area covered is assumed to be 17 m (17/1852=0.00918). The following equations are a mathematical representation of the procedure used to calculate the indices:

$$I_{strata} = \frac{\sum_{strata} Z_i}{N_{strata}}$$

$$\sigma^2_{strata} = \frac{\sum_{strata} (Z_i - I_{strata})^2}{N_{strata} - 1}$$

$$I_{region} = \sum_{region} I_{strata}$$

$$\sigma^2_{strata} = \sum_{region} \sigma^2_{strata}$$

$$CV_{region} = \frac{\sigma_{region}}{I_{region}}$$

Where *strata* refers to the subareas used for calculation of indices which are the smallest components used in the estimation, *I* refers to the stations in each subarea and region is an area composed of 2 or more subareas. *Zi* is the quantity of the index (abundance or biomass) in a given subarea. *I* is the index and sigma is the standard deviation of the index. CV refers to the coefficient of variation.

The subareas or strata used in the Icelandic groundfish surveys (same strata division in both surveys) are shown in Figure 3. The division into strata is based on the so-called BORMICON areas and the 100, 200, 400, 500, 600, 800 and 1000 m depth contours.

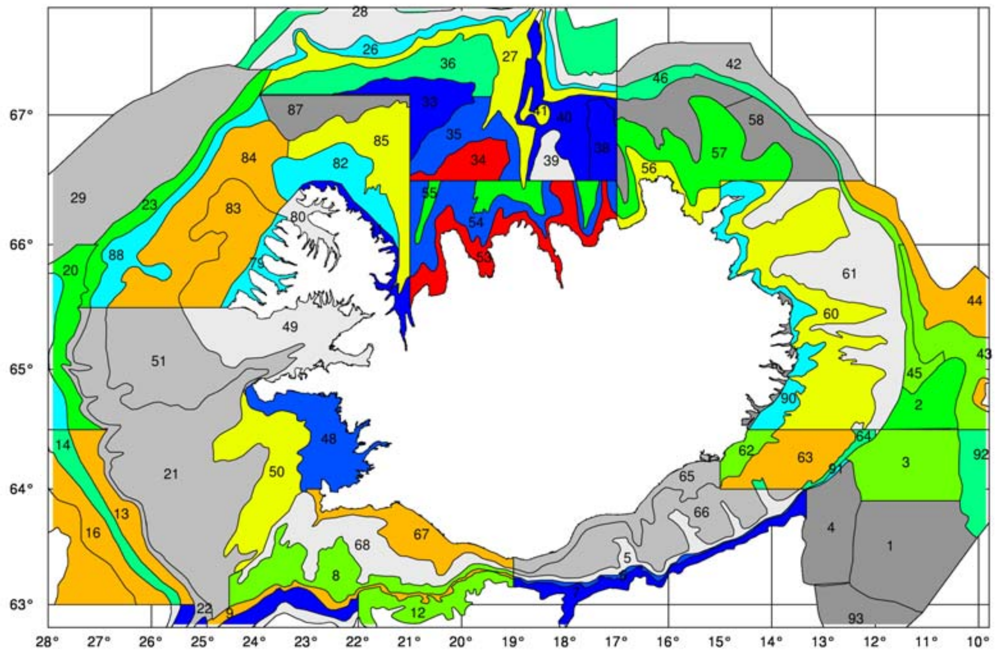

Figure 3. Subareas or strata used for calculation of survey indices in Icelandic waters.

B.3.2.4.3. Stratification for Greater Silver Smelt

The standard calculations of regional survey indices are not particularly applicable to greater silver smelt (originally designed for cod). Therefore, the processing of the Autumn Survey data is done at a slightly different regional scale. In short, the main distributional area of greater silver smelt off the southeast, south and west coast of Iceland, and in recent years also off the northwest coast. Also, fishing of greater silver smelt is banned at depths less than 220 fathoms (~400 m). To get a proxy for 'fishable' survey indices a few regions are defined for depths greater than 400 m (Table 1 and Figure 4).

Table 1. Survey regions used for calculation of various Autumn Groundfish Survey indices for greater silver smelt in Va.

Region	No. strata	Area (km2)	No. stations
Total	74	339 691	378
GSS fishing grounds	13	46 993	80
Depth >400 m	32	152 626	186
Depth <400 m	41	186 870	192
NW >400 m	2	20 081	16
W >400 m	9	31 613	60
S >400 m	6	26 715	24
SE >400 m	7	30 358	36

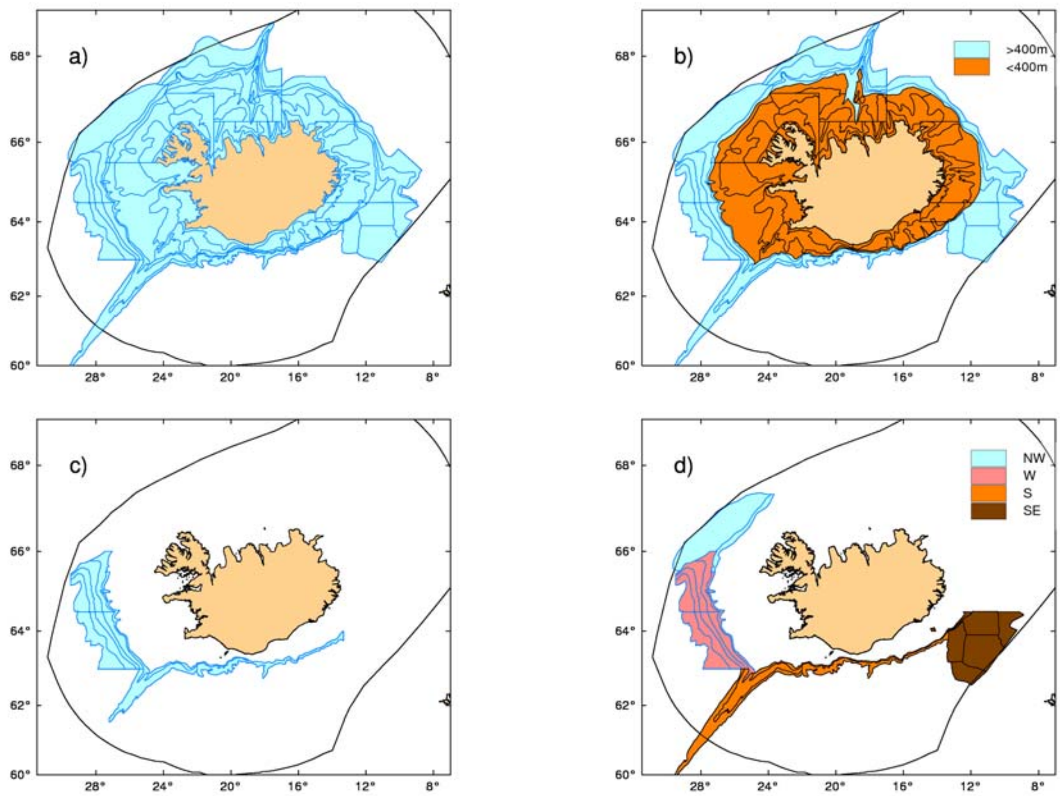

Figure 4. Divisions used in calculation of indices for greater silver smelt in Va. a) Total area. b) Division at 400 m depth contour. c) Greater silver smelt fishing area. d) Subdivisions of the main distributional area of greater silver smelt.

B.3.2.4.4. Winsorization of survey data

One of the main problems when calculating indices from tow surveys is how to treat few large hauls. In some cases, one or two hauls, that happens to be inside a large stratum, can result in very marked increase in survey estimates. This is a problem for greater silver smelt as for many other species. Not only can exceptionally large hauls increase survey estimates but also greatly affect estimated *CV* of the index in question.

Winsorization is one way to deal with outliers (Sokal and Rolf, 1995). A typical way to go when applying Winsorization is to set all outliers to a specified percentile of the data; for example, a 90% Winsorisation would set all data below the 5th percentile to the 5th percentile, and data above the 95th percentile set to the 95th percentile. Winsorised estimators are usually more robust to outliers than their un-winsorised counterparts.

This strategy is applied to the greater silver smelt data from Autumn Groundfish Survey. The number of greater silver smelt in a tow that are greater than the 95th percentile are set at the quantile. The same is done for the 5th percentile quantile, that is, numbers of greater silver smelt in a tow that are lower than 5th percentile quantile are set at the quantile. It should be noted that tow-stations that have no greater silver smelt are excluded from the Winsorization.

B.4. Commercial cpue

Catch per unit of effort (cpue) has been calculated using all data where catches of the greater silver smelt were more than 30%, 50% and 70% of the total reiterated catch in each haul. Estimates of Raw-cpue is simply the sum of all catch divided by the sum of the hours trawled. As the trawlers do not set out the trawl except when the captain is certain there is an aggregation of greater silver smelt and as the fishery is largely driven by markets and quota shares in other species (deep-water redfish and Greenland halibut) it is not certain how representative the cpue series is of stock trends.

C. Historical stock development

Greater silver smelt in Va is assessed based on trends in survey biomass indices (standard un-winsorized and winsorized) from the Icelandic Autumn survey and changes in age distributions from commercial catches and surveys. Supplementary data used includes relevant information from the fishery and surveys such as changes in spatial (geographical and depth range) and temporal distribution, length distributions and maturity ogives.

At present analytical assessments cannot be conducted because of contrasting signals in the available data and the relative shortness of the time-series available.

D. Short-term predictions

No short-term predictions are performed.

E. Medium-term predictions

No medium-term predictions are performed.

F. Long-term predictions

No long-term predictions are performed.

G. Biological reference points

No biological reference points are defined for greater silver smelt in Division Va.

H. Other issues

Stock identity of greater silver smelt in the Northeast Atlantic is unclear and further research is need. Strong recommendations are given in the 2010 WKDEEP Report on this issue (Section 7.1, WKDEEP 2010 Report).

I. References

Cochran,W.G. 1977. Sampling techniques, 3rd edition. New York: Wiley & Sons.

Sokal, R. R. and Rohlf, F. J. 1995. Biometry. W. H. Freeman and Company, 3rd edition.

Stock Annex: Greater Silver Smelt (Argentina silus) in Subareas I, II, IV, VI, VII, VIII, IX, X, XII and XIV, and Divisions IIIa and Vb

Stock	Greater Silver Smelt (*Argentina silus*) in Subareas I, II, IV, VI, VII, VIII, IX, X, XII and XIV, and Divisions IIIa and Vb (whole ICES Area except Division Va)
Working Group	WKDEEP
Date	24 March 2010
Revised by	Elvar H. Hallfredsson and Lise Helen Ofstad

A. General

A.1. Stock definition

Stock definitions for greater silver smelt is unclear and further research is needed. Within ICES greater silver smelt in Subareas I, II, IV, VI, VII, VIII, IX, XII, XIV and Divisions IIIa and Vb is one assessment unit, while greater silver smelt in Division Va is a separate assessment unit.

A.2. Fishery

Landings since 1988 are mainly reported in Subareas I–VII (Table 1), with landings elsewhere being either minor (VIII, XII and XIV) or none. There are currently three areas where direct fisheries are conducted; around Iceland (Va), around Faroe Islands (Vb) and west of mid Norway (IIa) (Figure 1). The direct fisheries are mainly by semi-pelagic trawls. In addition, the greater silver smelt is being exploited west of Ireland (VI, VII) by the Dutch fleet (and previously by other fleets), and historically in the Skagerrak (IIIa) by Norwegian, Danish and Swedish vessels.

Table 1. Landings of greater silver smelt in all ICES areas (ICES, 2009). ***Argentina sphyraena*** **may in some cases have been included in the landing figures (particularly in Subareas III and IV).**

YEAR	I + II	III + IV	VA	VB	VI + VII	VIII	XII	XIV	TOTAL
1988	11 351	2718	206	287	10 438				25 000
1989	8390	3786	8	227	25 559				37 970
1990	9120	2321	112	2888	7294			6	21 741
1991	7741	2554	247	60	5197				15 799
1992	8234	5319	657	1443	5906				21 559
1993	7913	3269	1255	1063	1577		6		15 083
1994	6807	1508	613	960	5707				15 595
1995	6775	1082	492	12 286	6242				26 877
1996	6604	3300	808	9498	5863		1		26 074
1997	4463	2598	3367	8433	7300				26 161
1998	8261	3982	13387	17 570	5555				48 755
1999	7163	4320	6704	8214	8856		2		35 259
2000	6293	2471	5657	5209	13 866			217	33 713
2001	14 369	2925	3043	10 081	19 050			66	49 534
2002	7407	1811	4960	7471	15 985	191			37 825
2003	8917	1188	2683	6549	2451	37			21 825
2004	16 162	1157	3645	6451	5133	23	4		32 575
2005	17093	791	4481	7009	3808	202	322		33 706
2006	21685	4016	4775	12559	1115	0	0		44 150
2007	13273	3343	4227	14093	4122				39 059
2008*	11876	1629	8778	14595	4035				40 913

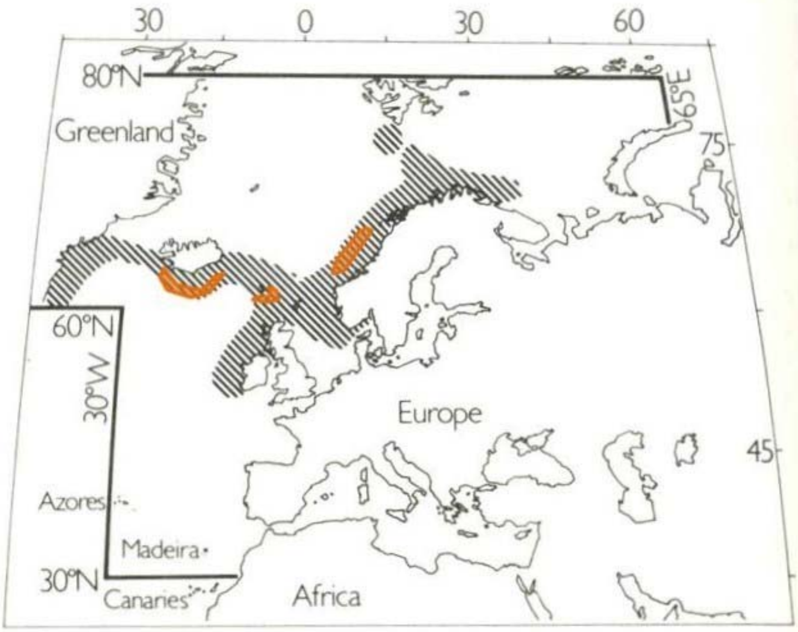

Figure 1. Distribution of greater silver smelt in the ICES area (Cohen, 1984). The locations of current direct fisheries are indicated in orange.

No analytical assessment is provided for the assessment unit by ICES.

Norwegian fisheries and management: Only selected trawlers are licensed to conduct aimed trawling for smelt in IIa, and area and season restrictions also apply in this area. For a period after 1983 a precautionary unilateral annual TAC applied, but the landings never exceeded the quota and this regulation was abandoned in 1992. Annual landings from this fishery were stable around 10000 t for a long period. However, in the 2004–2005 there was a sharp increase in the landings. The fleet expressed concern about declining catch rates and reduced abundance of large individuals in the catches, and the Norwegian authorities again implemented a precautionary TACs based on Norwegian scientific advice. The advice from IMR was to limit the landings to a level that had proven sustainable for the past 1–2 decades. For 2010 the TAC is 12 000 tonnes. Landings by Norway in Subareas III and IV varied between 1000 and almost 4500 t. The Danish quota (part of EU TAC) for 2003 onwards was 1388 t, and the annual landings are below this level. As a consequence of the introduction of the sorting grid to the shrimp fishery the bycatch of fish is very low in the Danish, Norwegian and Swedish fishery for *Pandalus borealis*. The Norwegian bycatch in the industrial fishery for Norway pout and blue whiting is very variable. Bycatch is now regulated in the Norwegian EEZ not to exceed 10% in total catches and in individual catches.

Faroese fisheries and management: There is no species-specific management of greater silver smelt in Vb, only minimum landing size (28 cm) and a licensing system. At present licences are issued to three pairs of pairtrawlers. The landings of *A. silus* in Division Vb increased considerably from 1994–1998 as a direct fishery for this species. After 1998 when 18 000 tonnes were landed, the landings were 6500 tonnes on average in 1999–2005. In 2006, 2007 and 2008 the landings have increased to 12 500, 14 100 and 14 600 tonnes respectively. The variations in the catches are largely as a consequence of market demands, and that a third pair of trawlers got licensed in 2007. Greater silver smelt is also taken as bycatch in the blue whiting fishery and in the deep-water fishery for e.g. red fish and blue ling. These bycatches are not recorded in the landings.

EU fisheries and management: The EU introduced TAC management in 2003, and for each year quotas were set for greater silver smelt. EU TACs as valid for community vessels fishing in community waters and waters not under the sovereignty or jurisdiction of third countries. There has been a considerable decline in the landings of *A. silus* from Subareas VI and VII from a peak in the late 1980s to the mid 1990s, with the exception of the years 2000–2002, when the landings were between 14 000 and 19 000 tonnes. A main fleet producing catches of greater silver smelt is Dutch freezer trawlers operating in Vb, VI and VII, west and northwest of the Hebrides, and west of Ireland (Porcupine Bank) where smelt is a minor bycatch in the fishery directed at blue whiting. The Dutch fleet apparently also operated in IIa in 2004. In 2004 the landings significantly exceeded the TAC for the Netherlands for V and VI. Irish landings were very high in the late 1980s when an exploratory fishery was developed by large pelagic trawlers. However by the early 1990s landings had declined to a few hundred tonnes and directed fishing had ceased by 1993. There was some directed fishing for the species in subsequent years. In 2000 larger Irish pelagic trawlers began to direct effort at this species on the shelf edge of Division VIa. Landings reached over 4700 t in 2000 and were estimated at around 7500 t in 2001 and 2002. Figures for 2003 demonstrated a very low landing of only 95 t. Because of a restrictive quota there was no Irish directed fishery for greater silver smelt. The landings by Scottish vessels also increased in 2000–2002 and between 65% and 75% of these landings were outside the UK. The Scottish landings also dropped abruptly to a very low level in 2003. In some of the years where landings are very high, there is possibly some misreporting but no documentation of quantities is available.

The Russian bycatch statistic of greater silver smelt in the commercial blue whiting fishery in Division Vb demonstrates considerable catch decline during recent years.

A 2. Ecosystem aspects

No information is available on impacts on the ecosystem of fishing for greater silver smelt.

B. Data

B.1. Commercial catches

Logbook catch and corresponding effort data for the Danish fleet in Division IIIa are available for the period 1992–2006 as demonstrated in the WGDEEP Report 2008. The Danish fisheries are reduced and insignificant in 2007 and 2008. Data from logbooks do not represent the entire landings (ICES, 2008, WGDEEP).

Logbooks from three pairs of pairtrawlers (>1000 HP) fishing greater silver smelt in Faroese waters (Area Vb) are available (Ofstad and í Homrum, 2009, WGDEEP, 2009 WD14). The longest of these series is from 1995 to 2003. Logbook data reveals that greater silver smelt is fished mostly in the area west of the Faroes and on the continental slope north and north-west of the Faroe Bank, at depths around 300–700 meters. To some extent, there is also being trawled on the Bill Bailey Bank and Lousy Bank and north of the Faroes.

Landings are available from other areas.

B.2. Biological

Analysis on growth as well as age and length-at-maturity were presented at the WKDEEP 2010.

Table 2 summarizes the von Bertalanffy growth parameters estimated by sex and for combined sexes. Greater silver smelt older than 19 years old were not include in the analysis. Table 3 summarizes the estimated maturity ogive parameters from Norway and Faroese data.

Although there was considerable variability of individual fish length-at-age, the resultant curves for the areas showed marked differences (Table 2). No age calibration exercises have been performed to check the agreement between age readers of the different institutes. Ageing of greater silver smelt is considered relatively easy at least up to age 20 and this might relax the importance of the lack of calibration, although conducting such calibration is encouraged.

Table 2. Parameters estimated in von Bertalanffy growth curve for combined sexes, females, and males for age 0–19.

	BOTH SEXES		FEMALES		MALES	
	Estimate	Std.	Estimate	Std.	Estimate	Std.
NORWAY						
Linf	39.5	0.273	41.7	0.388	36.9	0.29
K	0.19	0.007	0.19	0.008	0.22	0.01
t0	-2.13	0.136	-1.85	0.169	-2.02	0.173
FAROE ISLANDS						
Linf	42.4	0.231	43.9	0.311	40.3	0.288
K	0.22	0.004	0.22	0.005	0.24	0.007
t0	-1.12	0.043	-1.08	0.050	-1.11	0.067

Maturity ogives also demonstrated strong differences between the two areas (Table 3). Trends in these parameters vary between areas, but also between sexes. It was noted there was some uncertainty in the direct equivalence of some of the gonad-staging between areas.

Table 3. Summary of maturity ogive parameters for greater silver smelt by area.

PARAMETER	FAROE ISLANDS		NORWAY	
	Female	Male	Female	Male
a	-6.78	-7.30	-3.35	-2.26
b	1.16	0.96	0.79	0.44
A50	5.8	7.6	4.2	5.1

B.3. Surveys

Survey indices for greater silver smelt in Faroese area are available from an annual spring- (since 1994) and a summer- (since 1996) groundfish survey for cod, haddock and saithe. The survey covers the Faroe Plateau (depths less than 500 m) and the spring survey in February cover 100 stations while the summer survey in August has 200 stations. Although the greater silver smelt is not a target species in these surveys the 2010 WKDEEP regarded them as a useful indicator of trends in relative abundance in this area.

Spanish research bottom-trawl surveys have been carried out in Subarea VII (Porcupine) since 2001. Blue whiting is the most abundant species in the survey area.

It should be noticed that these greater silver smelt demonstrates an aggregation behaviour and catch trends and cpue in different areas are unlikely to reflect the level of abundance of this bentho-pelagic species (WGDEEP Report 2008).

Norwegian research vessel investigations 1980–1994 and 2007–2009, including acoustic survey estimates of biomass for the years 1989–1992 and 2009 (Hallfredsson, 2010 ICES WKDEEP-GSS-09). However lack of information on methodical standardization for the earlier surveys compared with the 2009 survey prohibits any direct comparison of biomass estimates.

C. Historical stock development

For Division Vb, trends in biomass were derived from the Faroese summer survey and mean length for the mature and immature greater silver smelt from the spring- and summer surveys for cod, haddock and saithe. For Subarea VII, biomass indices and length frequencies were derived for the greater silver smelt from the Spanish Porcupine survey.

Acoustic abundance estimates for greater silver smelt from Norwegian surveys in 1989–1992, 2007 and 2009 are available. The results might indicate that the abundance in IIa is not less in 2009 than in the earlier findings. However this should not be considered as time-series until further evaluation of the earlier acoustic estimations.

D. Short-term predictions

No short-term predictions are performed.

E. Medium-term predictions

No medium-term predictions are performed.

F. Long-term predictions

No long-term predictions are performed.

G. Biological reference points

No biological reference points are defined for Greater Silver Smelt in Subareas I, II, IV, VI, VII, VIII, IX, X, XII and XIV, and Divisions IIIa and Vb.

H. Other issues

WKDEEP 2010 strongly recommends the building of acoustical time-series for the purpose of assessment for greater silver smelt.

Emphasis should be placed on following closely any further changes in the age distribution of greater silver smelt, both from surveys and commercial catches.

Stock definitions for greater silver smelt are unclear and further research is needed. Strong recommendations are given in the 2010 WKDEEP Report on this issue.

I. References

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ICES, 2009. Report of the Working Group on the Biology and Assessment of Deep Sea Fisheries Resources (WGDEEP), 9–16 March 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:14. 511 pp.

8 Roundnose grenadier (*Coryphaenoides rupestris*) in Division Vb and Subareas VI, VII and XIIb

8.1 Current stock status and assessment issues

Roundnose grenadier presents major assessment challenges largely driven by: life-history characteristics: long-lived (~60 years old) and slow growing, changes in exploitation pattern resulting from changes in the geographical and depth distribution of trawl fisheries in relation to stock distribution, a lack of fisheries-independent survey data, and discontinuity in the availability of time-series discard data (fisheries on this stock generate high discards) and of age data.

Abundance indices based on French trawl catch and effort data are available but their use in assessments is problematic because of changes in spatial and depth distribution of fishing and also changes fleet composition/fishing power. Time-series length distribution data are available for French trawl landings. Time-series haul by haul data on catch and effort by French trawlers, collected in collaboration with the industry, is now available. Landings from XIIb have been considered uncertain because of unreported landings that may occur in international waters therefore this Division has been removed from the assessment until data are considered to be usable. Separable VPA has been used in exploratory assessments. Major issues are the short time-series of data against the high longevity of this species, the lack of information on discards and the reliability of aging.

The following documents were presented during the Workshop:

WKDEEP-2010-GNR-01 Quantifying the effects of uncertainties of the age–length key for Roundnose Grenadier; *Lionel Pawlowski*

WKDEEP-2010-GNR-02 Effect of discards on roundnose grenadier stock assessment in the Northeast Atlantic; *Lionel Pawlowski, Pascal Lorance*

WKDEEP-2010-GNR-03 Collection process and validation of haul by haul data : a partnership between science and industry – Blue ling and Roundnose grenadier; *Lionel Pawlowski, Pascal Lorance, Franck Evrat, Antoine Le Garrec, Julien Lamothe*

WKDEEP-2010-GNR-04 Analysis of haul by haul data for blue ling; *Pascal Lorance, Lionel Pawlowski, Verena M. Trenkel*

Two additional presentations were made: one from Verena Trenkel on "Estimating total mortality for roundnose grenadier: Random effects quasi-likelihood population dynamics models based on proportion-at-age and removal data" and one from Pascal Lorance on the use of Tweedie distribution to estimate lpues from the French Tallybooks for roundnose grenadier.

8.2 Compilation of available data

The stock is considered to be a data-poor stock due to the lack of information in the early days of the fishery; substantial gaps in time-series. This perception has not changed during the Benchmark meeting. However, more data have been or are being made available for the upcoming WGDEEP meeting from Spanish and Irish fleets. Known issues on data, apart from the issue with their availability, are the poor reliability and aggregation of the Age–Length Key used in the stock assessment model that has been previously used at WGDEEP, the lack of discard information in recent years and in the early days of the fishery which prevents estimates of international catch level at time and subsequent estimates of virgin stock biomass and reference points. Additional data include length distribution, age–length key, length–weight relationship, pre-anal fin length to total length relationship.

8.2.1 Catch and landings data

Landings

International landings have been available since 1988. In Vb, VI, VII, those data are available by most countries (or corrected according to Statland). The assessed area is actually Vb, VI, VII and XIIb. Uncertainties (missing data, potential misreporting) in XIIb has led the Group to exclude XIIb in the assessment although landings are substantial in that Division. This problem also relates to other stocks such as blue ling. No attempt has been made so far to compile time-series historical landings in XIIb and that may be difficult as historical data are not available by ICES rectangle. Furthermore, landings data reported after these new ICES areas were introduced are for some countries still only reported as XII.

New information on landings data in Division VIb and Subarea XII from the Spanish fisheries for the years 2005, 2007 and 2008 have been made available to the Group. These newly obtained data are from the freezer fleet operating mostly in those regions (Tables 8.1 and 8.2). Data from 2006 are incomplete and of no use for this meeting.

There are some landings reported in Division VIa and Subarea XIV in 2005 and 2008, respectively, but they only represent 9% and 4% of the total annual catch and will not be discussed here.

Table 8.1. Total annual Spanish landings of grenadier species per subarea/division.

TOTAL LANDINGS (tonnes)	VIA	VIB	XII	XIV	Total
Macrourus berglax		2515	2672		5187
2005		1480	2200		3680
2007		909	384		1294
2008		125	88		213
Trachyrincus trachyrincus		5842	2781		863
2005		1089	234		1323
2007		3307	1537		4844
2008		1447	1009		2456
Coryphaenoides rupestris	12	1056	11 357	5	12 430
2005	12	456	4194		4661
2007		120	4216	0.1	4336
2008		480	2948	5	3433
Total	12	9413	16 810	5	26 240

Table 8.2. Spanish landings of grenadier species per subarea/division, expressed as % of annual landings.

% OF LANDINGS					
(per sps & year)	VIA	VIB	XII	XIV	Total
Macrourus berglax	0.00%	48.49%	51.51%	0.00%	100.00%
2005	0.00%	40.23%	59.77%	0.00%	100.00%
2007	0.00%	70.30%	29.70%	0.00%	100.00%
2008	0.00%	58.82%	41.18%	0.00%	100.00%
Trachyrincus trachyrincus	0.00%	67.75%	32.25%	0.00%	100.00%
2005	0.00%	82.28%	17.72%	0.00%	100.00%
2007	0.00%	68.27%	31.73%	0.00%	100.00%
2008	0.00%	58.91%	41.09%	0.00%	100.00%
Coryphaenoides rupestris	0.09%	8.49%	91.37%	0.04%	100.00%
2005	0.25%	9.78%	89.97%	0.00%	100.00%
2007	0.00%	2.76%	97.24%	0.00%	100.00%
2008	0.00%	13.99%	85.86%	0.14%	100.00%
Total	0.04%	35.87%	64.06%	0.02%	100.00%

Misreporting

Misreporting is not known to be a strong issue in Division Vb, Subarea VI and VII. The level of misreporting in international waters in XIIb is unknown.

However, it was reported that the main problem associated to Spanish official landing data for roundnose grenadier is the uncertainty regarding their accuracy. The disagreement between observer catch data and official landings data suggests that catches of this species might be reported as corresponding to several species. Roughhead grenadier is mostly absent from observer data despite recorded annual catches above 1000 tonnes in 2005 and 2007. Similarly, roughsnout grenadier is absent from observer data although apparently between 1300 and 4800 tonnes where landed in the years 2005, 2007 and 2008. Gunther´s grenadier was recorded by the observers but not in the logbooks (Table 8.7).

Discards

Discards in recent years are available through observer programmes. Discards data previously used at WGDEEP were available from 1997–2001 and 2004–2006 from observers aboard French fishing vessels. New discards data are available from France in 2008 and 2009 but were not fully scrutinized before the workshop. Spain has made available discards from 2005 to 2008 in VIb and XII (Tables 8.3 and 8.4). From 2010, discarding of roundnose grenadier is not allowed in application of Council regulation (EC) No 1224/2009 of 20 November 2009, which specify that *"All catches of a stock […] subject to quota […] shall be charged against the quotas …"*, as there is no minimum landing size for roundnose grenadier in the EU, all catch should be landed.

Spanish discards data are available from observers and large variations occur not only between species, but also between observers and vessels. Therefore, an accurate analysis of their discards date would require information about i) about the expertise of the different observers, to maybe use only the data from the most experienced ones, and ii) if the vessels are the same year after year. As this problem is likely to occur in other countries, it is important to emphasize that only observers with some experience in the identification of species of grenadier should be involved in the observation of those fisheries.

Table 8.3 Total weight of discards (in kg) for the different grenadier species recorded by observers on board Spanish vessels during the period 2005–2008.

	2005				2006					2007		2008				
Observer*	11	21	31	41	11	31	41	42	43	21	31	11	31	41	42	51
VIb																
Nezumia aequalis				6												
Grenadier unid.						755										35
C. guenteri			80	412					437	1025						
Macrourus berglax						55	25							0		
T. trachyrincus	1305	0	1392	2300	267	15910	144	17	393	1055				70	5	40
C. rupestris	30 712	0	2365	3444	5522	16 370	190	95	696	425	22 690	27 565	297	190	250	740
Caelorhyncus occa				290		1350										
XII																
Nezumia aequalis				3												
Grenadier unid.														65	115	
C. guenteri			12	102			136		414	464						
Macrourus berglax							0						13	0		
T. trachyrincus		0	6823	668	18		413	49	430	452				519	1015	109
C. rupestris	7164	0	10 415	1084	1891	1130	462	764	547	385	145	900	510	4435	1975	1710
Caelorhyncus occa				235												

*** The observers vary from year to year although the code number is the same. The first figure indicates observer and the second, the vessel. Thus observer 4 worked on three different vessels in 2006.**

Table 8.4 Average percentage of discards estimated from total catch per species for the different grenadier species recorded by observers on board Spanish vessels during the period 2005–2008.

	2005				2006					2007		2008				
Observer*	11	21	31	41	11	31	41	42	43	21	31	11	31	41	42	51
VIb																
Nezumia aequalis				50												
Grenadier unid.						50										50
C. guenteri			50	50					50	49.4						
Macrourus berglax						50	7.1							0		
T. trachyrincus	50	0	50	50	50	49.3	50	50	50	50				50	50	50
C. rupestris	16.0	0	1.7	2.8	2.1	3.8	0.9	9.4	0.4	0.2	6.0	5.9	0.1	16.3	1	2.5
Caelorhyncus occa				50		49.7										
XII				50												
Nezumia aequalis														50	50	
Grenadier unid.			50	50			50		50	50						
C. guenteri							0						50	0		
Macrourus berglax		0	50	50	50		51	50	50	50				50	50	50
T. trachyrincus	19.8	0	2.4	0.5	3.6	4.8	0.6	11	0.4	0.3	3.7	6	0.1	10.6	2.4	0.7
C. rupestris				50												
Caelorhyncus occa				50												

*** The observers vary from year to year although the code number is the same. The first figure indicates observer and the second, the vessel. Thus Observer four worked on three different vessels in 2006.**

8.2.2 Biological data

Length distributions

Pre-anal fin length data are routinely collected on landings in the French harbour and have been used in the previous stock assessments. Additional distributions have been presented by Spain for Division XIIb. Length distribution for discards as well as length distribution per depth band are scarce through time and therefore attempts to rebuild catch or population structure in the early days of the fishery has been a difficult and uncertain exercise. In 2007, ICES WKARRG noted that uncertainty on measurement of PAFL is unknown. No investigation has been made so far on this issue.

No new information has been presented at the Benchmark except for Spain where biological data from catches are available from observers and include length measurements, sex and maturity stage. There is detailed information for each haul (coordinates, duration, depth). Below are shown some figures with length distribution disaggregated by sex and area (Figures 8.1–8.4).

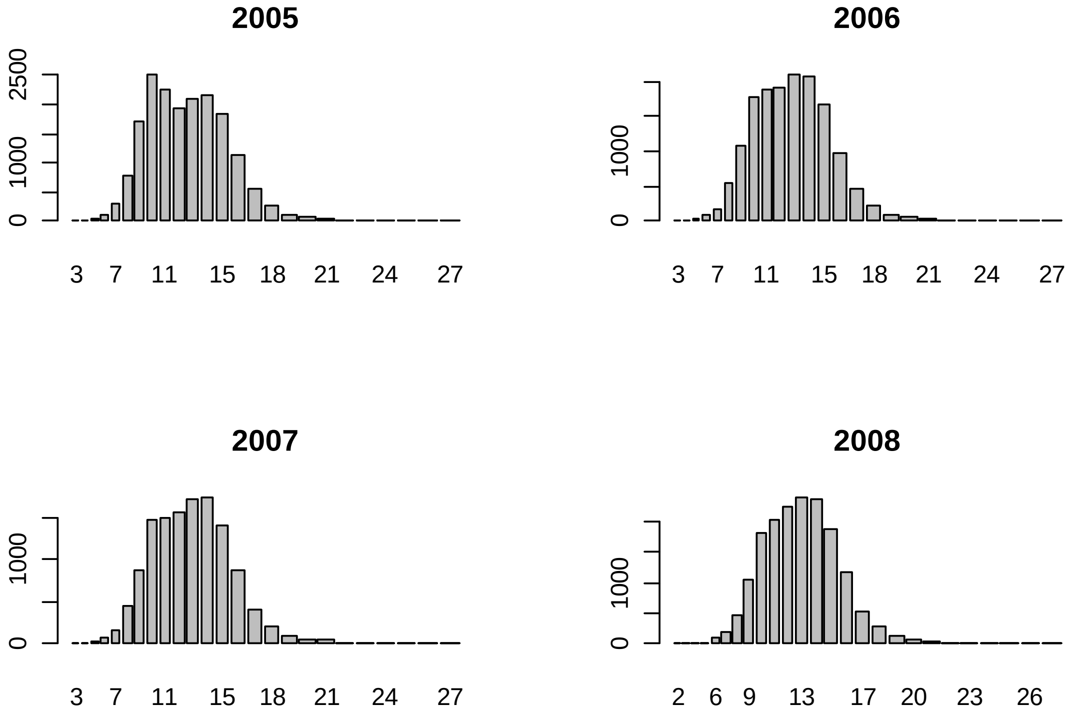

Figure 8.1. Length distribution of male RNG in Division VIb.

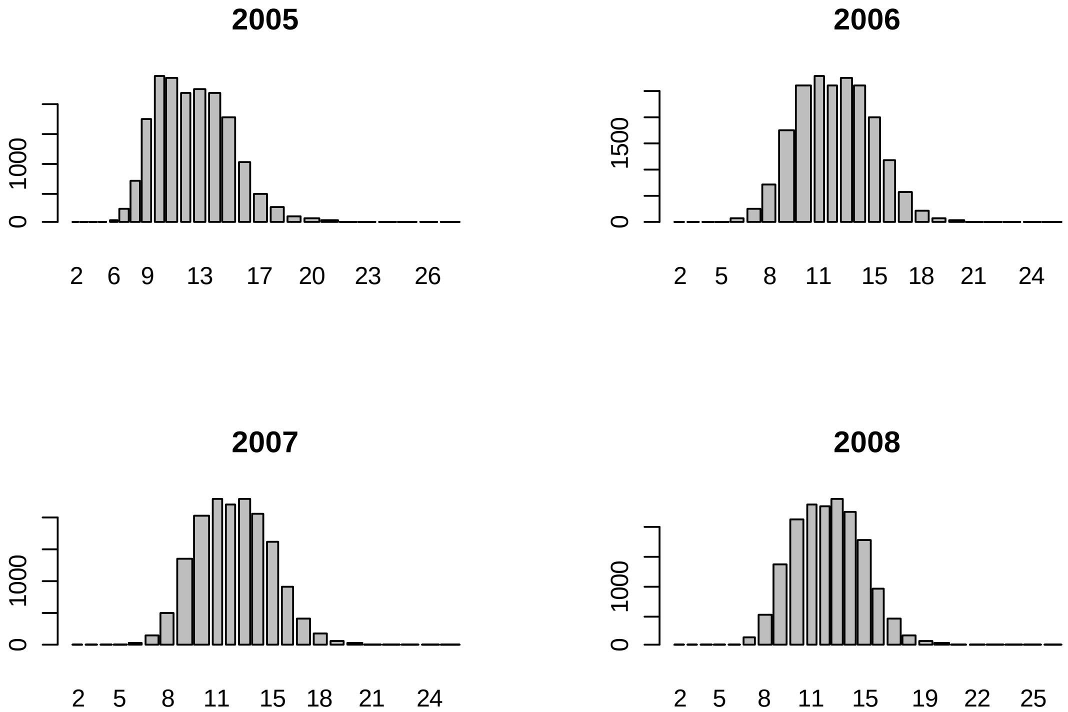

Figure 8.2. Length distribution of male RNG in Subarea XII (measured to nearest 0.5 cm).

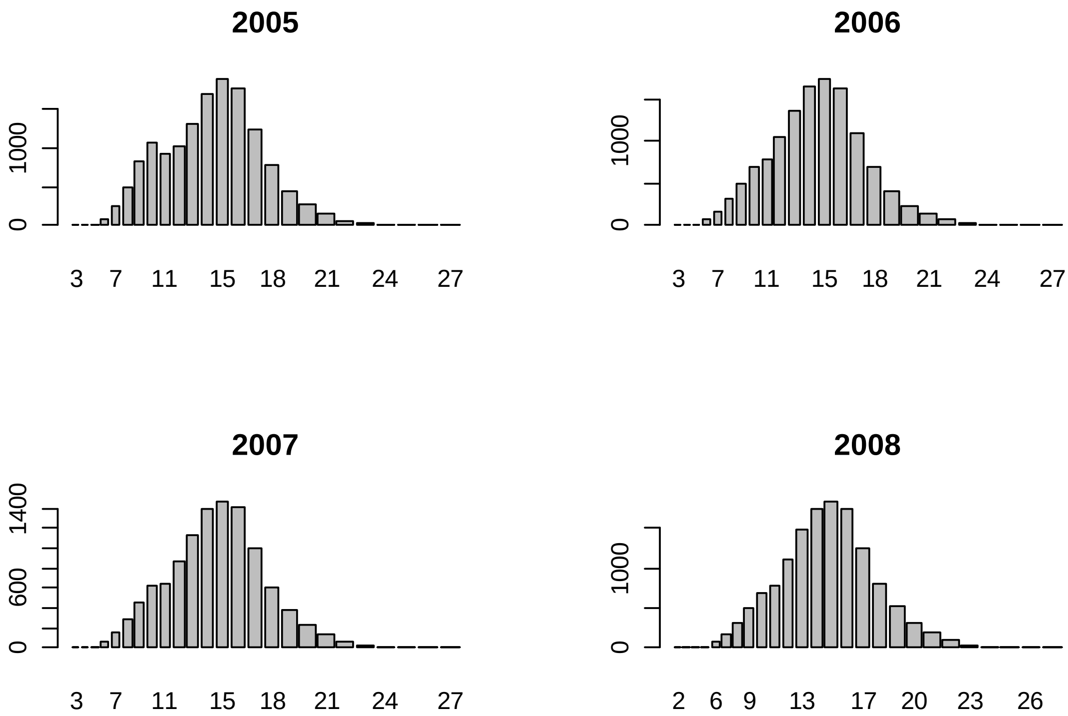

Figure 8.3. Length distribution of female RNG in Division VIb.

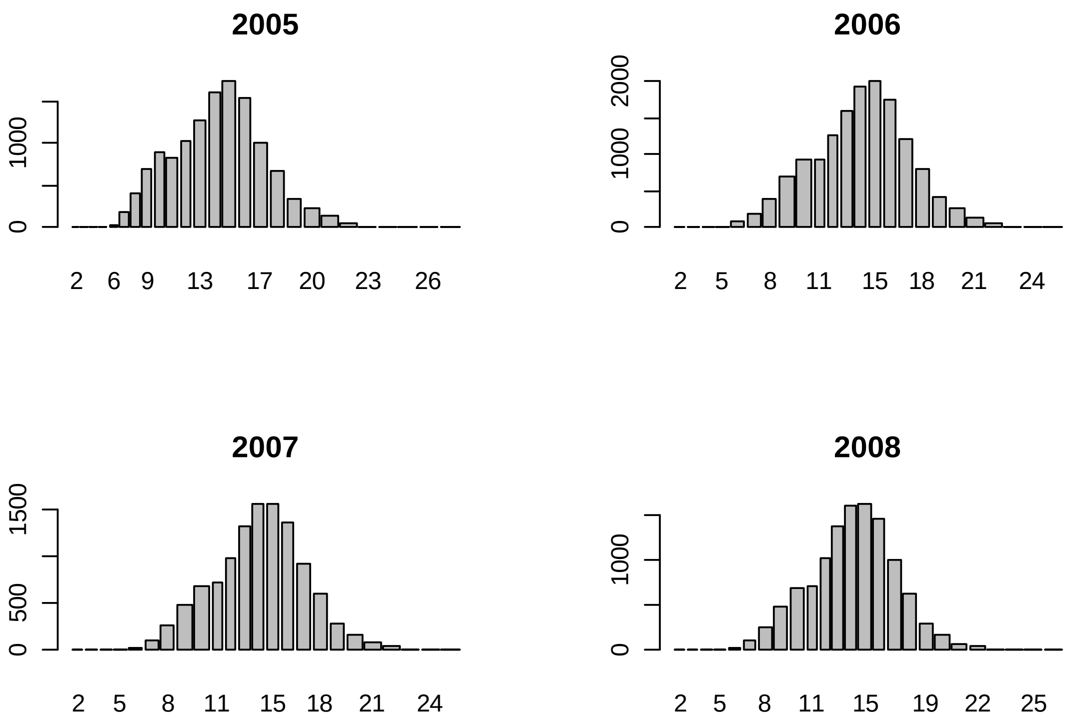

Figure 8.4. Length distribution of female RNG in Subarea XII.

Age–Length Key (ALK)

An ALK has been built from samples 1996, 1997, 2003, 2004 and aggregated for use at WGDEEP. Age reading on roundnose grenadier requires specific training. ICES WKARRG (ICES, 2007) demonstrated strong differences in age reading from one reader to another. This is a source of uncertainties about the reliability of the current ALK. At WGDEEP 2009, concerns have been raised about using a single combined ALK (containing more than 2700 samples) rather than yearly ALKs but the level of sampling is too low to split this combined ALK into yearly ones (WD WKDEEP 2010 GNR 01). Otoliths have been collected in France in 2007 and are being read. No collection has been done in 2008 and 2009. The whole process of age collection and reading is slowed down due to the lack of experienced personnel for this task in national laboratories.

Natural mortality

Based upon catch curved from the pre-exploitation period, a natural mortality of 0.1 was used by WGDEEP in the past for exploratory assessment purposes. New statistical modelling is underway as part of the EU Deepfishman project to develop multiyear catch curve analysis. Such modelling allows estimating the total mortality per year under some assumptions based upon the age distribution over time. Available length distributions of the landings go back in time to 1992, i.e. the presumed early time of the fishery in Vb, VI and VII. Therefore the total mortality estimated for the early years of the time-series corresponds to the natural mortality. Nevertheless, discards and unreported landings may have occurred before the 1990s so that the estimates derived from this model should be interpreted with caution.

Maturity

No new information has been presented at the Benchmark. Maturity data are collected in Spain as part of the on-board observation programme but were not available for scrutiny during the Benchmark meeting.

8.2.3 Survey tuning data

Survey data are very scarce and have been not used for tuning purposes.

An Irish survey is being carried out every year during fall since 2006. Data have not been scrutinized during the Benchmark and has not been long enough so far to be included into any assessment.

A deep-water survey has been carried to the West of Scotland by FRS since 1998. Abundance indices for roundnose grenadier were derived from this survey. The results suggest that the abundance was stable over recent years, although at a low level compared with historical level (Neat and Burns, 2010).

PGNEACS: In 2007 NEAFC put a special request to ICES WGDEEP to consider the coordination of existing deep-sea surveys (ICES 2007). The evaluation was also to include recommendations for the development of new surveys if it was considered to be appropriate. WGDEEP and WGDEC gave a summary of the existing deep-water surveys that were conducted at the time and WGDEEP proposed a number of coordinated deep-water water surveys as priority. In the response to the request, WGDEEP also included the recommendation that one or several ICES Planning Groups for international NEA Deepwater Surveys be formed to coordinate the prioritized surveys. PGNEACS was formed and met for the first time in 2008 with the overall TOR to review existing NEA deep-water & slope surveys in terms of sampling strategy, protocols and intercomparability and based on this review, suggest a plan for internationally coordinating annual or regular deep-water surveys in the Northeast Atlantic. Between 2008 and 2009 the Group drafted a proposal for three coordinated deep-water surveys in the Northeast Atlantic (ICES 2008 and ICES 2009).

The first survey proposal covers Nordic deep-water trawl surveys. There are several Nordic deep-water trawl surveys currently undertaken by Norway, Iceland, Faroe and Greenland which provide abundance indices for deep-water species in particular Greenland halibut to ICES AFWG and NWWG. These national surveys are established time-series, but they are similar in their scientific objectives and design and under PGNEACS they will undertake to enhance their coordination in terms of spatial and temporal coverage, data collection, management and analysis.

The second survey proposal by PGNEACS consists of a coordinated deep-water trawl survey along the Central European slope and associated banks and seamounts stretching from the Faroese Plateau (Vb) to the Goban Spur (VIII). There are currently a number existing survey programmes operating in the area (mainly Scotland and Ireland), however their spatial extent does not sufficiently cover the stock distribution and main fisheries of the deep-water species in the area. Hence a new survey proposal was presented in ICES 2009 which extends the spatial coverage to the main distributions of the deep-water fisheries with a proposed design that allows improved abundance and variance estimation (random stratified) while at the same time retaining elements of existing time-series. The implementation of this survey proposal depends on external funding and different survey alternatives are presented in ICES 2009 depending on resource allocation.

The third PGNEACS proposal covers surveys in the southern Area (IX and X). It covers an existing longline survey that is currently surveying the islands from the Azorean archipelago and three main seamounts survey in ICES Subarea Xa2 with a lower with a bathymetric limit of 800 m. It is proposed under PGNEACS to extend this survey to greater depths (down to 1200 m deep) including covering new seamounts. The southern survey proposal also highlights new survey requirements for deep-water fishery in the southern area (Iberian continental slope IXa and associated canyons).and proposes a longline survey in this area which would be coordinated with the existing Azorean longline survey. The proposed new survey extensions in the south would require additional funding to be implemented.

8.2.4 Commercial tuning data

France

Commercial tuning data are based from the analysis of the lpues through the partnership between Ifremer and two fishing organizations providing a deep-water haul by haul database (see Section 8.2.5).

Spain

Landings data for three different grenadier species, along with cpue data for those species estimated from both the landings and from the observer catch data (Table 3). At the moment, Spain does not possess information on a haul to haul basis from most of the commercial fishing trips, therefore the data presented during WKDEEP cannot be allocated to ICES statistic rectangles. Only efforts at the spatial scale of Subarea and Division can be estimated. However, observer data covering between 9% and 20% of the total number of fishing days are also available (Tables 3 and 4); coordinates are available for these hauls.

Given that only data from three years are presented here we will not discuss trends in catches, but it should be noted that cpue estimated from catches recorded by observers (expressed here in terms of kg day^{-1}) is much higher than the cpue estimated from landing data in most cases, and except for the case of Subarea XII in 2007, cpue estimated from observer data is between 1.6 and 43.5 times larger than cpue estimated from landing data.

Table 8.5. Fishing effort of the Spanish fleet (in days) and observer coverage (in days and %).

	DIVISION/SUBAREA	2005	2006	2007	2008
FLEET	VIB	1068	1073	915	781
	XII	1614	1274	1129	726
	XIVA	3	90	100	43
	XIVB	477	391	594	305
OBSERVERS (DAYS)	VIb	97	140	130	92
	XII	104	60	63	145
OBSERVERS (%)	VIb*	9.1	13.0	14.2	11.8
	XII*	6.4	4.7	5.6	20.0

*** Percentages.**

Table 8.6 Total Spanish fleet catch (tonnes).

	2005			2007				2008			
Sps	VIB	XII	Total	VIB	XII	XIV	Total	VIB	XII	XIV	Total
Roughhead grenadier*	1480	2200	3680	909	384	0	1294	125	88	0	213
Roughsnout grenadier**	1089	234	1323	3307	1537	0	4844	1447	1009	0	2456
Roundnose grenadier***	456	4194	4649	120	4216	0	4336	480	2948	5	3433
Total	3025	6628	9653	4336	6137	0	10 473	2052	4045	5	6102

**Macrourus berglax*

***Trachyrincus trachyrincus*

*** *Coryphaenoides rupestris*

Table 8.7. Cpue (KG/DAY) from the Spanish official landing data (fleet) and from the observers.

		2005		2007		2008	
	Sps	VIB	XII	VIB	XII	VIB	XII
FLEET	Roundnose grenadier***	426.7	2598.3	130.9	3734.1	615.2	4060.5
	Roughhead grenadier*	1386.2	1362.9	993.9	340.4	160.3	120.7
	Roughsnout grenadier**	1019.6	145.3	3613.8	1361.3	1852.6	1390.1
OBSERVERS	Roundnose grenadier***	8020.6	8545.6	5699.3	3295.2	7747.7	6496.1
	Roughhead grenadier*					4	27.5
	Gunther's grenadier****	5.1	1.1	8	7.4	0	0

Ireland

Haul by haul data from Irish deep-water observer scheme and commercial surveys at sea. Data is from 2003 to 2005. There is no new observer data since then. Those data have not been scrutinized during the Benchmark.

8.2.5 Industry/stakeholder data inputs

A partnership between Ifremer and two organizations involved in the deep-sea fishery, EURONOR and PROMA/PMA has led to the availability of a database from trawlers based in Boulogne-sur-Mer (Pas de Calais) and trawlers operating from Brittany (Lorient and Concarneau) where deep-water effort and catch data are recorded. The entire database was made of more than 26 000 hauls in 2008.

Historical data (before 2000) also comes from skippers' personal notes. Recent ones include few trips with observers on board whose observations have been captured in the fishing industry database. Recent information coming from trips with observers and special deep-sea fishing sheets are more complete, including environment data, discards estimations, and some sampling records. Information from fishing notebooks is limited to the essential data on fishing effort and commercial catches, included depth strata.

Both IDSF database and official data (national statistics based upon logbooks and available at Ifremer through the Fishery Information System) have been compared together in order to validate the industry datasets. Although those data come from the same boats and fishing trips, these datasets can be considered as independent as the data collection processes differ. Validation steps included comparing recorded locations of the fishing operations, total landings per trip, level of representation of the fleets in both database and additional analysis to understand if the activity recorded in the industry database could be considered representative of the whole French deep-water industry. Results have demonstrated a strong correlation between data coming from both independent database and no evidence was found that the recorded activities were different from those of fishing vessels not involved into the industry database. Therefore, the haul by haul database appears to be representative of the French deep-water fishing effort. Details on the database and validation can be found in WD WKDEEP2010 GNR 03.

8.3 Stock identity and migration issues

The current perception by ICES of the stock definition considers roundnose grenadier in Division Vb, XIIb, Subareas VI, VII as a single stock. More information on stock identity is available on the RNG stock annex (see Stock Annex to Section 8).

New genetic studies are likely to become available in the forthcoming months where, in absolute terms, the amount of genetic differentiation among roundnose grenadier samples was considerably higher than in other deep-sea fish, such as Greenland halibut (Knutsen *et al.*, 2007) and tusk (Knutsen *et al.*, submitted) over comparable distances. The gene flow appeared restricted also among relatively closely situated localities (less than 500 km) (Knutsen *et al.*, 2009).

If these preliminary results are confirmed, the current stock structure used for assessment may require revision towards a structuring at smaller spatial scale. It was discussed during the meeting how those new information could impact the stock assessment but as they were not formally available, the group was unable to review those data and make further recommendations for some changes in stock definition.

8.4 Spatial changes in the fishery and stock distribution

France

Over recent years, the spatial distribution of the French deep-water fishing effort as contracted to a smaller area mainly along the West of Scotland slope and southern Wyville Thomson Ridge.

Ireland

Data from official logbooks; Irish operations for catches of grenadier per statistical rectangle, whereby catches were aggregated by month will be available from 1995 to 2008, with subsequent data provided every year. Those data have not been scrutinized during the Benchmark because of their late availability during the Benchmark.

Métier based deep-water effort in fishing days whereby Irish deep-water métier was classified according to DCF criteria; NE Atlantic OBT deep-water and mixed demersal and deep-water métier-data can be provided every year, but the Irish deep-water fleet is not active anymore.

8.5 Environmental drivers of stock dynamics

No new information has been presented to the Benchmark. A Working Document at WGDEEP 2009 about roundnose grenadier in the Skagerrak has suggested recruitment can exhibit substantial variation. It is unknown how environmental changes affect the biology of roundnose grenadier and further work on that matter should be encouraged.

8.6 Role of multispecies interactions

8.6.1 Trophic interactions

No new information has been presented to the Benchmark.

8.6.2 Fishery interactions

No new information has been presented to the Benchmark. Roundnose grenadier is part of the French deep-water mixed trawler fishery and a case study of the EU Deep-fishman project. Assessing fishery interactions is part of the objectives of the Deep-fishman project. Future developments in the modelling of the interactions of this stock with other fisheries are therefore likely to be available in future.

8.7 Impacts on the ecosystem

No new information has been presented to the Benchmark.

8.8 Stock assessment methods

Over the years, there have been several attempts to carry out an assessment for this stock. Separable VPA has been carried out since 2006 at WGDEEP with several attempts to integrate discards and to rebuild catch data from the beginning of the fishery in 1990. Lastly, during the ICES Assessment Methods Working Group (WGMG) in 2009 (ICES, 2010), considering the uncertainty around the age–length key (ALK), bootstrap methods were used in conjunction of the SVPA to estimate the level of uncertainties resulting from the ALK.

In all cases, the members of WGDEEP considered those assessments as exploratory due to the lack of suitable datasets. Main issues were:

- A short time-series of data for a long-lived species.
- An unreliable landing in XIIb which has led to exclude this area from the assessment and a resulting mismatch between stock unit and assessed areas.
- Some substantial gaps in discards especially in the early days of the fisheries.
- The uncertainties and aggregation of the Age–Length Key as a result of a small number of samples and complexity of the age reading technique for this stock.
- The fact that no assessment has taken account of the change of fishing depth over time in regard of the vertical life cycle of this species.

The members of WGMG in 2009 concluded that age- or length-based methods are not suitable to assess this stock and suggested the development of a life-stage structured approach or a surplus production model. The members of WKDEEP also considered as a potential assessment method the use of this type of model.

Due to the lack of reference points, other indicators have been proposed to describe the status of the stock. The partnership between Ifremer and the French deep-water fisheries has led to some analysis of the lpues from the French tallybooks and during this Benchmark some analysis on mortality has been presented.

8.8.1 Models

Mortality estimates from catch-curve analysis

The mortality for roundnose grenadier was estimated using a random effects quasi-likelihood population dynamics models based on proportion-at-age and removal data.

Estimates of lpues

Lpues were derived from haul-by-haul data provided by the French industry based upon tallybooks from volunteer vessels. Lpues were estimated using GAMs with depth, vessel, statistical rectangle and zone by year as explanatory variables. Owing to their statistical distribution, landings were modelled by a Tweedie distribution, a family of distributions with the Poisson distribution as a special case and Poisson-Gamma mixtures as another. In the later case, it has a positive mass at zero and a continuous Gamma distribution for positive values. The Tweedie distribution allows handling data with many zeros.

In order to investigate how to reliably track stock trends, Lpues were estimated in five regions where previous analysis of EU-logbook data from the French fleet demonstrated different trends (Figure 8.8.1).

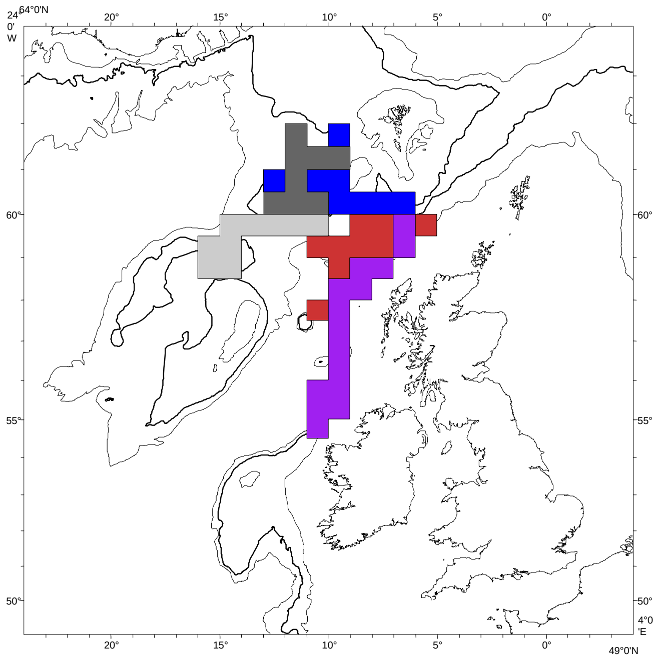

Figure 8.8.1. Areas for which lpues were estimated based upon tallybook data (purple: egde6, burgundy: other6, light grey: new6, dark grey: new5, blue: ref5).

Surplus production model

A surplus production model has been evaluated to assess the stock through a Bayesian implementation of the simplistic Pella Tomlinson biomass dynamic model for the exploitable stock biomass, *By*:

$$B_y = B_{y-1} + r \cdot B_{y-1} \cdot \left(1 - B_{y-1}^{m-1}\right) - \frac{C_{y-1}}{K}$$

where *r* is the intrinsic growth rate, *K* the carrying capacity, m a shape parameter and *Cy* the catch. This model is a function available from the FLR FLBayes package.

The overall decreasing lpue trend on this stock can be seen as a "one way trip" catch and effort data which cause problems in accurately estimating *r* and *K*. In the context of the Bayesian framework, a distribution of *r* is derived from age-at-maturity, natural mortality and the stock–recruit parameter steepness. Natural mortality was estimated from life-history methods, the first from Hewitt and Hoening (2005) based on the concept of maximum age and the second from Charnov (1990) based on a linear proportionality between expected female lifespan and age-at-maturity. For the end-user, this method requires the knowledge of fish longevity and age-at-maturity. From that point, estimates of *r* are available (e.g. in Figure 8.8.5).

For the assessment, it is necessary to know:

- Distribution of fish longevity and age-at-maturity;
- Catch or Landings (if catch data are not available);
- Cpues or lpues.

The final model estimates of *r, Q, K* along estimates of stock biomass provide some estimates of *Bmsy*, the sustainable stock size (K/2), *Cmsy*, the sustainable catch level (*Bmsy* x r/2) and *Hmsy*, the sustainable harvest rate (*r/2*). Being in the Bayesien framework, it is possible to estimate the probabilities of being above or under those indicators (Figure 8.8.6) for each year of the time-series.

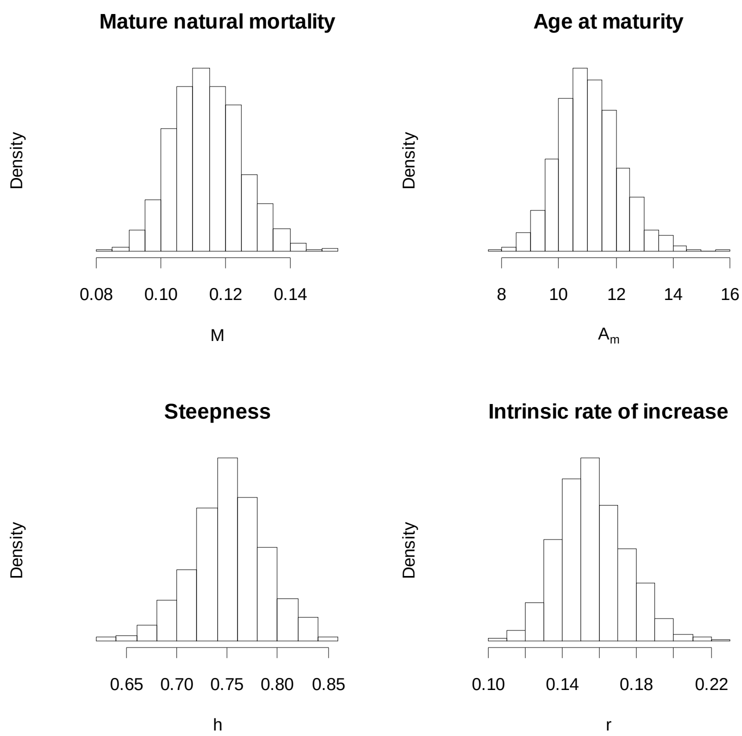

Figure 8.8.5. Example of an initial *r* distribution obtained from age at maturity and longevity distributions.

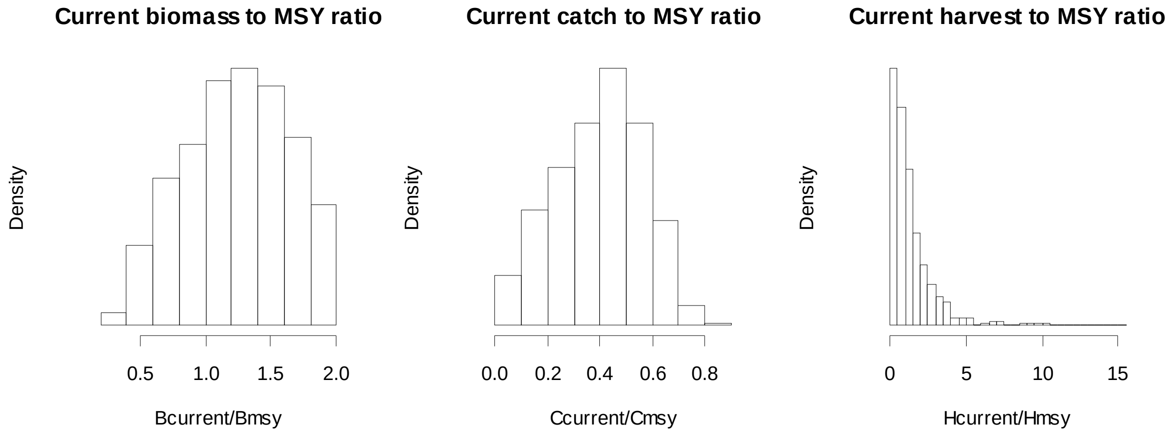

Figure 8.8.6. Example of probabilities of having the stock status being above or under sustainable levels.

8.8.2 Sensitivity analysis

Mortality estimates from catch-curve analysis

The Multiyear catch curve (MYCC) model was run, prior to the Workshop under two options for modelling the total mortality per year (Zt) modelled either as a random walk or a fixed year effect. The model was run for three datasets including (a) landings only; (b) landings and discards (estimated based upon on-board observations) and (c) total catch (landings+discards) age distribution estimated based upon the distribution of fishing effort by depth from the French tallybooks and the length distribution by depth from archive survey data (Mauchline and Gordon, 1984). The natural mortality was either fixed at M=0.1 or estimated by the model. The model estimates the total mortality for ages 25–46+ (fully recruited ages); F prior to the modelled period for dataset (c).

Results for all datasets and model options demonstrated a pattern in Z increasing until 2002 then decreasing sharply. Estimated population abundance decreased until recent years. When estimated, M was between 0.14 and 0.16 (for ages 25 and over). This value is high compared with previous assumption of M=0.1, but it apply only to ages 25–46+ and may reflect that the older fraction of the population undergo a higher natural mortality than the average mortality per year required for the species to have a longevity over 50 years. Confidence intervals were wide except for estimates of M. The catch curve analysis was from an exploited population therefore the estimates of Z are more robust. This model is still in its development stage and any estimate of M is uncertain.

Estimates of lpues

Lpues based upon the French tallybooks were estimated for a range of datasubsets including all tows or only tows where roundnose grenadier comprised a given proportion of the total catch. Two models were tried including either a vessel factor or the vessel power as explanatory variable and gave similar results, the model with the vessel factor was kept as it was believe to better integrate all variations between vessels than the vessel power only.

The results based upon all tows available in the tallybook (Figure 8.8.2.2) or only tows where roundnose grenadier comprises more than 10% of the catch (not shown) gave similar trends. In all areas lpues declined strongly in the early 2000s and stabilized to a low level in recent years.

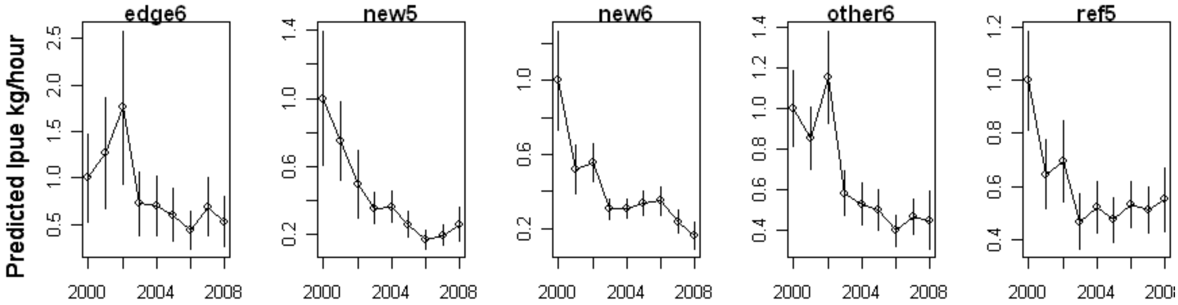

Figure 8.8.2.2. Predicted standardized roundnose grenadier lpue per area from figure 8.8.1. Predictions are made for one vessel in January, 5 hours fishing time and 1000 m depth.

Surplus production model

Three runs were performed to compare the effects of 1) using landings or catch data, 2) having a short (1996–2008) or a longer (1988–2008) time-series of landings. The run based on catches assumes the rate of discards has been constant from 1996 as observed. Landings are transformed into catch by an elevation using the discard rate. The following parameters and data were applied:

Table 8.8.2.1. Catch, landings and lpues used for the assessments.

		LANDINGS/CATCH		LPUES
Run name	Ref	Land88	Catch	
Year	Reference run	Landings back to 1988	landings+ discards	common to all runs
1988		33		
1989		2698		
1990		7279		
1991		10 104		
1992		12 155		
1993		11 802		
1994		8528		
1995		8990		
1996	8173	8173	9666	
1997	8182	8182	9854	
1998	8031	8031	10 018	
1999	8534	8534	11 692	
2000	11 606	11 606	15 322	1.000
2001	18 143	18 143	23 466	0.829
2002	13 627	13 627	18 180	0.822
2003	8717	8717	11 549	0.564
2004	8133	8133	11 140	0.560
2005	5777	5777	7952	0.556
2006	4283	4283	6052	0.498
2007	3526	3526	4968	0.636
2008*	2519	2519	3608	0.563

*** Provisional.**

Table 8.8.2.2. Initial parameters used for the assessments.

RUN NAME	REF	LAND88	CATCH
	Reference run	Landings back to 1988	landings+discards
Catch/landings	1996–2008	1988–2008	1996–2008
lpues	2000–2008	2000–2008	2000–2008
Longevity	50	50	50
Age-at-maturity	11	11	11
Longevity var	0.1	0.1	0.1
Age-at-maturity var	0.1	0.1	0.1

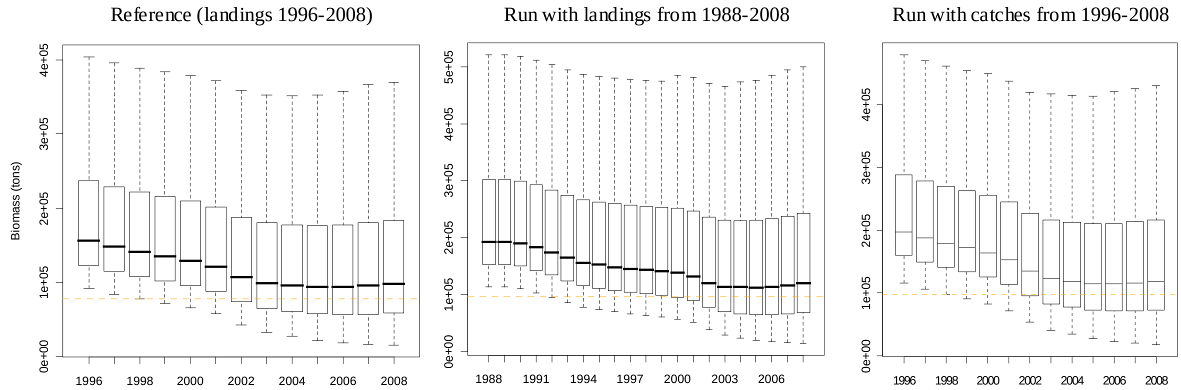

Figure 8.8.2.6. Estimated stock biomass level for the different runs. The orange line represents the estimated B_{msy} for each run.

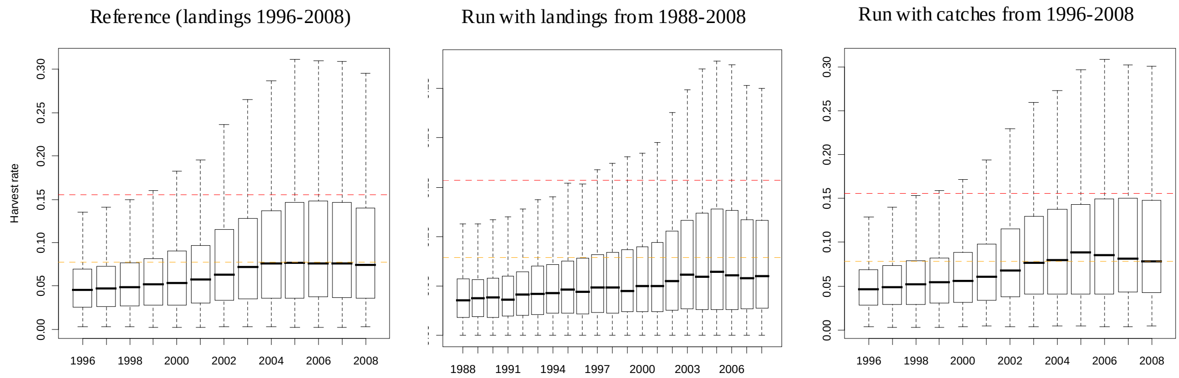

Figure 8.8.2.7. Estimated harvest rates for the different runs. Orange line represents the estimated H_{msy} for each run and red is the Hmax level.

Table 8.8.2.3. Summary of results for 2008.

	Reference	Landings back to 1988	Catch
Catch/landings (tons)	2519	2519	3608
B2008 median (tons)	101 012	101 877	120 729
B2008 mean (tons)	153 379	142 865	168 579
B2008 standard deviation	151 262	109 887	146 199
Harvest rate in 2008	0.06	0.07	0.07
H_{msy}	0.08	0.08	0.08
B_{msy} (tons)	80 228	88 943	99 067
C_{msy} (tons)	6165	6942	7694
H/H_{msy}	0.97	0.88	1.04
B/B_{msy}	0.97	1.14	1.19
C/C_{msy}	0.57	0.36	0.65

Overall, those carried assessments are very exploratory and may be considered as indicative of trends.

Qualitatively speaking, estimated biomasses and harvest rates (Figures 8.8.2.6 and 8.8.2.7) have all wide standard errors as a possible consequence of a short time-series of lpues. The trends are the same for all runs.

Table 8.8.2.3 summarizes some of the estimates for the last year (2008) of the run. The biomass estimate is higher for the run based on catches. Using landings back to 1988 does not substantially change the biomass estimate for the last year but reduces greatly the standard deviation. For all simulations, the estimated harvest rate tends to remain the same.

Estimates of sustainable biomass B_{msy} and catch C_{msy} are the lowest for the reference runs and the highest for the catch-based assessment. The assessment with the longer time-series of landings has intermediate results.

Taking account into the model of longer time-series and discards is likely to increase B_{msy} and C_{msy}, and reduce standard deviations of various estimates. Harvest rates are not very sensitive to those changes.

8.8.3 Retrospective patterns

No retrospective analysis has been carried out for the stock assessment due to the short length of the lpue time-series.

8.8.4 Evaluation of the models

The Surplus production model has been the only stock assessment model evaluated during the Benchmark. This type of model does not require any age and length based data. Those data were sources of uncertainties for the assessment of this stock using the Separable VPA. This model also comes with estimates of uncertainties, something unavailable from a standard SVPA. In addition, the surplus production model also provides some probabilities regarding MSY indicators. No reference points being defined for this stock, those estimates may be useful for giving management advices.

Additional information on landings and effort can be added almost directly. Taking account discards only requires the knowledge of the discard rates.

In addition, model diagnostics like the detection of local minima when parameters are fitted to the time-series are provided by FLBayes and during the trials of this model have proven to be useful to ensure the assessment was correctly performed by both the end-user and the software.

While this model suffers like the SVPA of the lack of data, it appears to be more informative although it requires less type of data to run.

8.9 Stock assessment

The Surplus production model (developed under FLBayes) appears to run properly despite the very short lpues data available. Longer time-series are likely to reduce uncertainties therefore it might be beneficial to use this model with the full-time-series of landing starting in 1988 and to seek ways to compile past lpues. Uncertainties in the various estimates are expected to decrease with the addition of past and future data points for landings and lpues. Adding discards is also recommended but the lack of information on discards level at the beginning of the fishery remains an unsolved problem for this stock.

8.10 Recruitment estimation

Not available.

8.11 Short-term and medium-term forecasts

Not available.

8.12 Biological reference points

The EU Project DEEPFISHMAN, which will develop a monitoring, assessment and management framework for deep-water stocks in the NE Atlantic, has a dedicated work package to develop suitable Biological Reference Points for deep-water species including roundnose grenadier. The project started in April 2009 and will complete by March 2012.

Biological indicators such as trends in mean length, ratio of mature/immature continue to provide a valuable insight of the state of the stocks.

With longer time-series, the Surplus Production Model could provide usable estimates of B_{msy}, C_{msy} and H_{msy}.

8.13 Recommended modifications to the Stock Annex

There was no Stock Annex prior to this meeting.

8.14 Recommendations on the procedure for assessment updates

Considering the data-poor nature of this stock and the performance of the surplus production model relying on the length of the time-series of data, effort should be focused on consolidating the available time-series of data. Any assessment update should also explore the possibility of adding new data (landings and cpues/lpues) during the WGDEEP meetings. This implies:

- evaluating the effects of including data (landings, cpues) from Division XIIb;
- integrating new cpue/lpue indices from other fleets;
- estimating past cpue/lpue indices to add more years to the time-series.

Further developments of the MYCC model on mortality estimates will be made as part of the EU Deepfishman project, especially to overcome some of the caveats in the present model namely (i) use a one single age–length key, (ii) absence of stock recruitment, (iii) discard rate not available for all the time-series back to the onset of the fishery.

The time-series of indicators from surveys and commercial fisheries including onboard observations should be used in addition to the dynamic population model.

There is a need for extensive survey coverage across the whole geographical area inhabited by the stock in Vb, VI, VII, XIIb. This is a common problem with other stocks. In that matter, PGNEACS proposed fully standardized (in terms of methodology) surveys in order to provide common abundance indices for deep-water species including roundnose grenadier.

Some study on how environmental changes affect the biology of roundnose grenadier (e.g. recruitment) should be encouraged.

8.15 Recommendations for Industry supplied data

Information on past practices on discards and commercial cpue are likely to improve the quality of the assessment. Haul by haul information such as those provided by the French deep-water fisheries would be useful. Information should contain location and depth.

8.16 References

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Stock Annex: Roundnose grenadier in Vb, VI, VII and XIIb

Stock	Roundnose grenadier (*Coryphaenoides rupestris*) in Division Vb and Subareas VI, VII and Division XIIb
Working Group	WKDEEP
Date	11th March 2010
Revised by	Lionel Pawlowski and Pascal Lorance

A. General

A.1. Stock definition

ICES WGDEEP has in the past proposed four assessment units of roundnose grenadier in the NE Atlantic (Figure A.1):

- Skagerrak (IIIa)The Faroe-Hatton area;
- Celtic sea (Divisions Vb and XIIb, Subareas VI, VII);
- the Mid-Atlantic Ridge 'MAR' (Divisions Xb, XIIc, Subdivisions Va1, XIIa1, XIVb1);
- All other areas (Subareas I, II, IV, VIII, IX, Division XIVa, Subdivisions Va2, XIVb2).

Roundnose grenadier is widely distributed in the North Atlantic. Its area stretches from Norway to northwest Africa in the east to the Canadian-Greenland coasts and the Gulf of Mexico in the west, and from Iceland in the north to the areas south of the Azores in the south (Parr, 1946; Andriyashev, 1954; Leim and Scott, 1966; Zilanov *et al*., 1970; Geistdoerfer, 1977; Gordon, 1978; Parin *et al*., 1985; Pshenichny *et al*., 1986; Sauskan, 1988; Eliassen, 1983). Aggregations of this species are found on the continental slope of Europe and Canada, on the MAR seamounts, in the Faroe-Hatton area (banks Hatton, Rockall, Louzy, Bill Baileys, etc.) and in the Skagerrak and Norwegian fjords.

Some studies have allowed observing fish in all maturity stages in all the distribution area (Allain, 2001; Kelly *et al*., 1996, 1997; Shibanov, 1997; Vinnichenko *et al*., 2004), therefore allowing for several populations to exist.

No genetic results are available to validate the hypothetical stock structure presented above. Several authors also consider that roundnose grenadier is a poor swimmer and is therefore unlikely to make extended migrations. No pattern in seasonal density variation has been observed from surveys or from fisheries. However, there are no data available to indicate whether or not individuals move around during their lifespan.

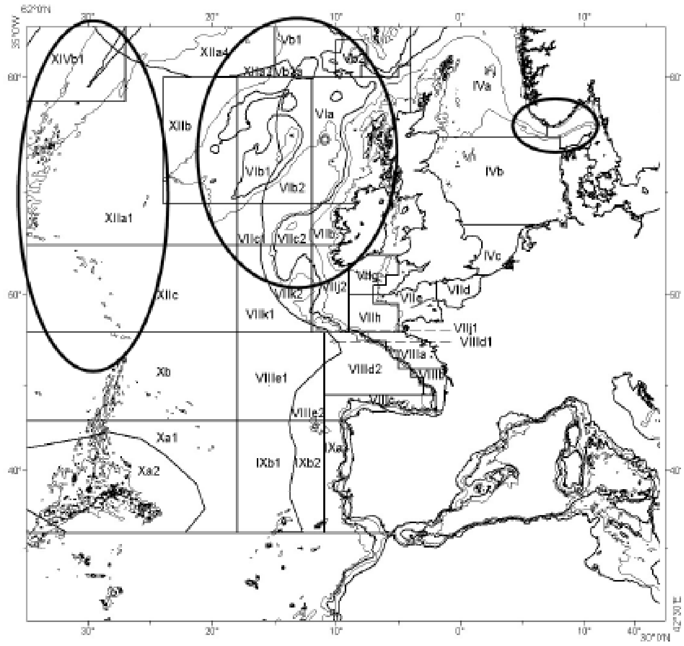

Figure A.1. Areas of the main fisheries for roundnose grenadier, Skagerrak, west of the British Isles and mid-Atlantic Ridge. The isobaths displayed are 100, 200, 1000 and 2000 m (from Lorance *et al.*, 2008).

The current perception is based on what is believed to be natural restrictions to the dispersal of all life stages. The Wyville Thomson Sill may separate populations further south on the banks and slopes off the British Isles and Europe from those distributed to the north along Norway and in the Skagerrak. Considering the general water circulation in the North Atlantic, populations from the Icelandic slope may be separated from those distributed to the west of the British Isles.

It has been postulated that a single population occurs in all the areas south of the Faroese slopes, including also the slopes around the Rockall Trough and the Rockall and Hatton Banks but the biological basis for this remains hypothetical.

Published results on length (11.5–12.5 cm pre-anal fin length, PAFL) and age (9–14 years) at first maturity of females to the West of British Isles and in the Skagerrak (Allain, 2001; Bergstad, 1990; Kelly *et al*., 1996; 1997) do not seem to clearly discriminate these two groups, although they are most likely to be demographically different unit.

Some studies have detected genetic differentiation in at least parts of the species range and indicating the presence of distinct populations within the species (Logvinenko *et al*., 1983; Duschenko, 1989).

In 2007, WGDEEP examined the available evidence of stock discrimination in this species based on length distribution, commercial catch, cpue, age, maturity, reproduction. Length distribution, catch and cpue data were considered too aggregated or too dependent on external factors (e.g. fleet dynamics, depth) to be usable to discriminate stocks. Analyses on age data on longevity were unable to conclude if the differences of longevity from one region to another were local changes or the effect of exploitation.

New genetic studies are likely to become available in the forthcoming months. Preliminary results were presented in the ICES symposium "Issues confronting the Deep Oceans" (Horta, Azores, 27–30 April 2009). Microsatellite DNA was used to characterize the large-scale population structure from samples spanning over the entire North Atlantic. Samples of *ca.* 800 individuals were analysed for eight microsatellite loci. Roundnose grenadier was found to display a trend of increasing genetic differentiation with distance among samples. In absolute terms the amount of genetic differentiation among roundnose grenadier samples was considerably higher than in other deep-sea fish species, such as Greenland halibut (Knutsen *et al.*, 2007) and tusk (Knutsen *et al.*, submitted) over comparable distances. The gene flow appeared restricted also among relatively closely situated localities (less than 500 km) (Knutsen *et al.*, 2009). If these preliminary results are confirmed, the current stock structure used for assessment and primarily based upon bathymetry and hydrology will need revision towards a structuring at smaller spatial scale.

A.2. Fishery

The majority of landings of roundnose grenadier from this area are taken by bottom trawlers. To the west of the British Isles, in Divisions Vb, VIa, VIb2 and Subareas VII, French trawlers catch roundnose grenadier in a multispecies deep-water fishery. The Spanish trawl fleet operates further offshore along the western slope of the Hatton Bank in ICES Divisions VIb1 and XIIb.

French trawlers began to land increasing amounts of roundnose grenadier, from the west of Scotland in 1987 (Charuau *et al.*, 1995). Landings of these species have been reported separately in French landings statistics since 1989 (Lorance *et al.*, 2001). The quantities landed in 1987 and 1988 are not known with accuracy but they are believed to be less compared with landings in the 1990s.

The activity of the Spanish fishery in international waters is poorly known. New information on landings data in Division VIb and Subarea XII from the Spanish fisheries for the years 2005, 2007 and 2008 have been made available. These newly obtained data are from the freezer fleet operating mostly in those regions. Data from 2006 are incomplete and of no use for stock assessment. The main problem associated to Spanish official landing data for roundnose grenadier is the uncertainty regarding their accuracy. The disagreement between observer catch data and official landings data suggests that catches of this species might be reported as corresponding to several species. Roughhead grenadier is mostly absent from observer data despite recorded annual catches above 1000 tonnes in 2005 and 2007. Similarly, roughsnout grenadier is absent from observer data although apparently between 1300 and 4800 tonnes where landed in the years 2005, 2007 and 2008. Gunther´s grenadier was recorded by the observers but not in the logbooks. The distribution of the catch and effort are poorly known. Effort directed at deep-water species increased from 1989 to 1996 (Lorance and Dupouy, 2001). In 1995 an effort regulation was introduced but was not a constraint to this fleet. TACs and a new effort regulation was introduced in 2003 (Council Regulation (EC) No 2347/2002 of 16 December 2002) and the fishery has reduced. Part of the fishing time of the licensed fleet is expended on the shelf mainly in the Celtic Sea.

A.3. Ecosystem aspects

Roundnose grenadier is a slow-moving species, which prefers grounds with slow currents. Vertical diurnal migrations are also observed, the pattern of which depends on feeding (Savvatimsky, 1969) and water circulation and meteorological processes (Shibanov and Vinnichenko, 2007).

There is no direct evidence of long distance migrations made by adult fish. The distribution and dispersal of the eggs and larval stages is poorly known, except in the Skagerrak (Bergstad and Gordon, 1994). Juveniles grenadier of 2–8 cm pre-anal length were caught in the midwater by 120–840 m over bottoms of 1200–3200 m along Greenland slope, on the Mid-Atlantic Ridge, Hatton bank, in the Irminger and Labrador seas suggesting that some passive migrations of juveniles in the open ocean occurs (Vinnichenko and Khlivnoy, 2007).

In the Skagerrak (ICES Division IIIa), available information indicates that roundnose grenadier spawn in the late autumn (Bergstad, 1990a). Eggs (diameter 2.4–2.6 mm), postlarvae and pelagic juveniles have been caught with plankton net from 150 to 550 m. The newly hatched larvae appear very primitive and the pelagic phase is extensive. The mean size of larvae, assumed to belong to the same cohort sampled repeatedly in the same year, increased from February to October, when they attained a demersal stage of life cycle (Bergstad and Gordon, 1994). To the west of the British Isles, females with maturing ovaries have been observed from February to December, but they were more abundant from May to October and spawning appears to extend at least from May to November (Kelly *et al.*, 1996; Allain, 2001). Studies in Icelandic waters indicate year-round spawning, with no obvious peaks (Magnússon *et al.*, 2000). There appear thus to be differences in the timing of spawning between areas, perhaps reflecting varying environmental conditions. Roundnose grenadier is a batch spawner with a fecundity of 4000–70 000 oocytes per batch (Allain, 2001).

There is a lack of knowledge of the distribution and dispersal of the eggs and larval stages, except in the Skagerrak (Bergstad and Gordon, 1994), and so the biological basis for the current hypothetical population structure must await the results from future studies of genetics and otolith microchemistry. To date, only a single study of whole otolith microchemistry of roundnose grenadier from a wide area of the Atlantic (Mid-Atlantic Ridge, Reykjanes Ridge, Hatton Bank, Porcupine Seabight, Rockall Trough, Skagerrak and two Norwegian fjords) has been carried out using solution-based, inductively coupled, plasma mass spectrometry (SO-ICPMS) (Gordon *et al.*, 2001). Discriminant analysis of eight elements separated samples from the Norwegian fjords and the Skagerrak from those from the NE Atlantic areas. Differences between samples from six areas of the Atlantic (Hatton Bank, Rockall Trough, Porcupine Seabight, Mid-Atlantic Ridge, and Reykjanes Ridge) were small, and elemental concentrations overlapped. Therefore, this study supports the view that populations in the NE Atlantic are separate from the Norwegian fjords and the Skagerrak, but does not demonstrate any difference in populations between the Mid-Atlantic Ridge and the remainder of the NE Atlantic.

B. Data

B.1. Commercial catch

Landings time-series data per ICES areas are available.

Landings data by ICES statistical rectangle are available from France, Norway and UK (England and Wales and Scotland). No other country provided data by rectangle. Landings by ICES division are available from other countries.

Catch in Subarea XII are allocated to Division XIIb (western Hatton Bank) or XIIa, c (Mid-Atlantic Ridge) according to knowledge of the fisheries from WG members. For each country, the time-series of landings are checked and revised if needed according to Statland data. Statland reports landings in Subarea XII consistently with what this Working Group did in the past.

Catch and discards by haul are available from observer programmes. From the French observer programme, total catch, landings and discards and catch, landings and discards of roundnose grenadier are available on a haul by haul basis for 2004–2006.

Discard data (quantities and length distribution) are also available from the on-board observation of the French fishery, 2004–ongoing, from French on-board observations on French vessels in 1997–1998 and from Scottish observers on board of French vessels, 1997–2001. The length distributions of discards from all these observations seem quite consistent.

Based on EU observer programme 2004–2005, about 30% by weight and 50% by number of the catch of roundnose grenadier is discarded, because of small size. This figure is higher than in previous sampling where the discarding rate in the French fisheries was estimated slightly above 20% from sampling in 1997-1998 (Allain *et al.*, 2003). The change may come from a combination of changes in the depth distribution of the fishing effort and a decrease in the abundance of larger fish as visible in the landings. The modal discarded length has remained constant.

The mode of the length distribution of the discards from the Spanish fleet in Divisions VIb and XIIb is slightly smaller, probably because of different sorting habits in relation to different markets. It is therefore important that length distribution of the landings and discards are provided to the working group by all fleets exploiting the stock. Larger variations in discards levels have been reported between species and between observers and vessels.

Misreporting or underreporting is not known to have been a problem in the French trawling fleet. Concerns have been repeatedly expressed that misreporting could occur in international waters (NEAFC regulatory area). There are also been regular complains from the French Industry that IUU fish was landed in France and was pulling the prices down. This seems to have disappeared in recent years. Misreporting is not an issue that scientists have the power to inquire and this should stay in hand on management and regulation authorities to monitor misreporting. No quantitative data on misreporting is available.

The landings data were however considered uncertain in Division XIIb, because unreported landings may occur in international waters. In addition to this, all national landings data were not reported by new ICES divisions and some landings were allocated to divisions according to knowledge of the fisheries from the Working Group. Lastly significant unallocated landings occurred in 2005. This has led the Working Group to remove in 2008, XIIb from the exploratory assessments although the stock definition consider the Faroe-Hatton area, Celtic sea catches (Divisions Vb and XIIb, Subareas VI, VII) belonging to the same stock.

B.2. Biological data

Size frequency data (and corresponding weight data) for roundnose grenadier are available for French catches for every year since 1990.

Age estimates were available from France. This dataset may be heterogeneous, because three different readers estimated the age over these different years and also because measuring the fish on board may lead to different age–length relationship than measuring the landed fish that may have lost water for some days in ice. Large discrepancies between readers were observed in a recent otolith reading exchange and workshop (ICES, 2007a).

Age composition of the French landings has been routinely estimated since 2001. Formerly age–length keys (ALK) were derived from a cruise in 1999 and from sampling on board of commercial trawler in 1996–1997 (Lorance *et al.*, 2001; 2003). Preliminary analysis of the length-at-age data demonstrated that ALK is very stable over years. ALK for years 1999 and 2001–2004 were very similar, the ALK for 2005 appeared different and the change was ascribed to a change of the reader.

These data are based upon ALK from age estimates in 1996, 1999 and 2002–2005. Otoliths from 1996 and 1999 were collected respectively on board of commercial trawlers and during a scientific cruise; otoliths for 2002–2005 were routinely sampled from the landings.

No new data on maturity and natural mortality has been collected in recent years. Natural mortality was previously estimated from catch curves and an estimated M=0.1 was used by the Working Group since 2002. It should be kept in mind than this estimate is based on limited data.

B.3. Surveys

Only one cruise relevant to roundnose grenadier is currently carried out on a yearly basis by FRS (Scotland). Stock indicators were derived from this survey (Neat and Burns, in press) but have not yet been formally integrated into stock assessment.

Another cruise has been carried out since 2006 on the RV Celtic explorer every year during autumn. The surveys aim to collect biological data on the main deep-water fish species and invertebrates along the continental slope in Subareas VI and VII north. Fishing tows were carried out at four depths, 500 m, 1000 m, 1500 m and 1800 m in three distinct areas. The effective fishing time, from when the net touched the bottom, was set at two hours. Tows were carried out along the depth contour. At each station the entire catch was sorted to species level and weighed. Full biological sampling, i.e. length, weight, sex, maturity, and age, was carried out on specific commercial species. Additional biological sampling, without age, was carried out on an *ad-hoc* basis on other species.

B.4. Commercial cpue

Time-series of French fishing effort are available based upon logbook data (1987–2009). Following their requirement under the Data Collection Regulation (DCF), VMS data (starting back from 2003) are made available from 2010. Lpues data based upon French tallybooks are available from 2000 based upon a voluntary participation of fishermen. These data are used in the Working Group as indicators of trends and also in the assessment.

Time-series of fishing effort of past years can be improved from tallybooks. In EU logbooks, fishing operations (individual tows and lines and net setting) carried out in the same day and rectangle are cumulated. For the French trawling fleet, tallybooks of haul by haul data were provided by the industry and allowed for better account of all factors in lpues (Lorance *et al.*, 2009). Applied to all fleets such data would allow effort to be properly handled. Electronic logbooks are under development on French vessels and data will be reported haul by haul including depth. It should be noted that this improvement is particular to deep-water fisheries where depth may vary a lot in a single statistical rectangle. Therefore haul by haul data and fishing depth are much more crucial in deep-water fisheries than in shelf fisheries were most of the depth information is conveyed by the statistical rectangle.

VMS data also allows for improvement of effort data as is allows for some particular uses such as estimating the fishery footprint and fine scale changes in effort distribution. Nevertheless, data such as tallybooks provided to Ifremer by the industry includes all the effort information (tow duration, depth, location) coupled with catch, while using VMS requires assumptions to identify fishing and steaming activities and coupling catch to VMS data is an unresolved issue.

Overall the knowledge of the fleet activity at sea is reliable in Division Vb and Subareas VI and VII, the situation is poorer in Divisions VIb and XIIb. Distribution of catch and effort at the resolution of ICES rectangle has been available, from France, Ireland and UK (ICES, 2006; ICES, 2007b).

The French fleet is known based upon the licensing scheme since 2003. Before this time, catch composition was used to identify which vessels were fishing in the deep water. Therefore, composition of the fleet, number of vessels can be considered available since the early 1980s.

B.5. Other relevant data

No other source of data is used in the assessment.

C. Historical stock development

Past assessments

Based upon what is believed to be natural restrictions to the dispersal of all life stages, the area of this stock is considered to include Division Vb and XIIb and Subareas VI and VII. Due to uncertainties in the catch in Division XIIb, assessment has been restrained to Vb, VI, VII. Therefore only a portion of the regions of this stock has been assessed in 2008 and 2009.

Given the lack of data, assessments have only been exploratory until 2009. Exploratory assessments focused on integrating discard data into the assessment (WGDEEP, 2008) and rebuilding catch at the beginning of the fishery (WGDEEP, 2009; Pawlowski and Lorance, 2009). The assessment model used was the Separable VPA. The main criticisms against the use of this model were the short time-series of available data and the uncertainties around the age- and length-based approach for this species.

The *Bayesian Surplus Production model*, *Multiyear Catch Curve model* and other *indicators* of trends are currently used for assessment until the next Benchmark Workshop.

Bayesian surplus production model

In 2010, WKDEEP considered the Bayesian Surplus Production Model as the most parsimonious short-term approach. Such an approach can be informative on relative trends such as changes in exploitation biomass and depletion. However, interpreting absolute levels are inappropriate with the current data.

Multiyear catch curve model

A Multi year catch curve (MYCC) model developed as part of the EU-DEEPFISHMAN project, returns realistic trends in total mortality Z per year. Absolute level may have to interpret with caution. Nevertheless, this model should be used further, to derive an indicator of total mortality and to explore the stock dynamic. Input data are age distribution of the landings or of the catch (landings and discards) per year. The model was run on age 25–46+ (fully recruited stock). The model requires some parameter to be fixed.

- M=0.1 (depending on model setting)
- Coefficient of variations of the recruitement (CVrec= 0.1)

- Coefficient of variations of the landings or catch (CVo=0.1 : CV of observations

Other indicators of trends

Biological indicators such as trends in mean length, ratio of mature/immature provide valuable insights of the state of stocks. Information from length distribution of landings and discards in addition to information on fishing depths are useful indicators of trends in the fishery and in the population structures.

Lpues data based upon French tallybooks are used as indicators of trends and also in the assessment. Catch rates from surveys are used to check the consistency of the analysis on the commercial cpues.

Stock assessment parameters

Assessment Model used: Surplus Production Model (based on Pella Tomlinson biomass dynamic model)

Software used: FLBayes package version 1.4, FLCore 1.99-91, R 2.9.2 (URL: http://code.google.com/p/wgdeep-rng/)

Model Options chosen:

Initial parameters

- Age-at-maturity: 11 (variance 0.1)
- Longevity: 50 (variance 0.1)
- Priors for Q (logQ.mean = 0, loqQ.var = 100)
- Priors for K (K.mean = log(100000) , K.var = 1)
- Priors for r (r.mean = mean(log(r.mc)), r.var = mean(var(r.mc)))
- sigma.shape = 2
- sigma.rate = 1

Input data types and characteristics:

- Landings data are used from 1988 in Vb, VI, VII and XIIb when available.
- Lpues from French tallybooks from 2000 (past lpues may be included when data will be available). Lpues are provided by region and are combined. The weight of each region is the proportion between the local and the total landings.

D. Short-term projection

No projections are performed.

E. Medium-term projections

No projections are performed.

F. Long-term projections

No projections are performed.

Biological reference points

The current data are inappropriate to provide MSY absolute estimates from the Bayesian Surplus Production model.

H. Other issues

Landings and effort data in Division XIIb should be included into the assessment if they become reliable. A separate assessment for Division XIIb should be carried out separately from the one for Division Vb, and Subareas VI, VII.

As the performance of this model is dependent on the length of the time-series, separate exploratory runs may be performed to evaluate the effects of new datasets or data points.

Because discarding is no longer allowed for this species (ref), all catch should be landed in the forthcoming years and will be integrated into the assessment.

New stock identity results are likely to become available in the next few years and should be considered to evaluate the assessment area.

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Annex 2: WKDEEP Terms of Reference 2010

2009/2/ACOM38 A **Benchmark Workshop on Deep Water Species (WKDEEP)** (Chaired by: Richard Hillary (Australia) and ICES coordinators: Tom Blasdale (UK) and Phil Large (UK) and two invited external experts) will be established and will meet in ICES HQ, Copenhagen, Denmark, 17–24 February 2010 to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of fishery-dependent, fishery-independent, and life-history data currently being collected for use in the current assessment work and the proposed assessment;

b) Agree and document preferred method for evaluating stock status and (where applicable) short-term outlook and update the assessment handbooks as appropriate;

c) Develop recommendations for future improving assessment methodology and data collection;

d) As part of the evaluation:

- i) conduct a one day data compilation workshop. Stakeholders shall be invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of the data compilation workshop consider the quality of data including discard and estimates of misreporting of landings;
- ii) consider the possible inclusion of environmental drivers for stock dynamics in the assessments and outlook;
- iii) evaluate the role of stock identity and migration;
- iv) evaluate the role of multispecies interactions on the assessments.

STOCK	ASSESSMENT LEAD
Roundnose grenadier in Division Vb and Subareas VI and VII	Lionel Pawlowski
Greater Silver smelt in all areas	Gudmundur Thordarson and Elvar Hallfredsson
Tusk in Division Va	Gudmundur Thordarson
Red (blackspot) sea bream in Subarea X	Mario Rui Pinho
Deep-water squaliform sharks in all areas	Ivone Figueiredo
Greater forkbeard	Guzmán Diez

The Benchmark Workshop will report for the attention of ACOM by 8 March 2010.

Supporting information

PRIORITY:	
Scientific justification and relation to action plan:	Roundnose grenadier in Division Vb and Subareas VI and VII: This species presents major assessment challenges largely driven by: life-history characteristics (long-lived (~60 years) and slow growing), changes in exploitation pattern resulting from changes in the geographical and depth distribution of trawl fisheries in relation to stock distribution, a lack of fisheries-independent survey data, and discontinuity in the availability of time-series discard data (fisheries on this stock generate high discards) and of age data. Abundance indices based on French trawl catch and effort data are available but their use in assessments is problematic because of changes in spatial and depth distribution of fishing and also changes fleet composition/fishing power. Time-series length distribution data are available for French trawl landings. Time series haul by haul data on catch and effort by French trawlers, collected in collaboration with the industry, is now available. Separable VPA was used for an exploratory assessment in 2009. Greater Silver smelt in all areas: This species is long-lived (~40 years) and slow growing but is bentho-pelagic and targeted largely by pelagic trawlers. Time-series length and age data are available for some areas. Exploratory assessment methodologies used include acoustic surveys (in IIa) and, in 2009, XSA (Vb). Tusk in Division Va: This is a gadoid species and as such is not particularly long-lived (20-30 years) or slow growing. It is caught largely as a bycatch in longline fisheries for other species. Age data are sparse but there are survey data. Length distribution data are available from surveys and commercial landings. Gadget was used for an exploratory assessment in 2009. Red (blackspot) sea bream in Sub-area X: This species is not particularly long-lived (15-20 years) or slow-growing but is a protandric hermaphrodite (changes sex as it grows). Fisheries are artisanal (longlines and handlines) and are mostly prosecuted on seamounts. Survey data are available as are length and age data. Separable VPA and XSA have been previously trialled; however, an exploratory assessment was not attempted in 2009. Deep-water squaliform sharks in all areas: These include the Portuguese dogfish and the leafscale gulper shark, and are mostly long-lived (up 60 years). Length and age data are not available and historical landings data are not available by species (although in recent years the quality of landings data has improved). Haul by haul data from French trawlers fishing in Vb,VI and VII by species back to the mid-1990s were made available in 2008. Directed fisheries for these species are currently not permitted but they are still taken as a small bycatch in other fisheries. Greater forkbeard: This is a gadoid species and is considered likely to exhibit typical gadoid life-history characteristics, although these are not known with any accuracy. Commercial landings are significant but this almost entirely a bycatch species taken in other fisheries. Exploratory assessments have not yet been attempted.
Resource requirements:	
Participants:	WGDEEP and WGEF members, ecosystem integration experts, data quality experts, stakeholders
Secretariat facilities:	None
Financial:	None required

Linkages to advisory committees:	ACOM
Linkages to other committees or groups:	WGDEEP, WGEF
Linkages to other organizations:	

Annex 3: Agenda

	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	MONDAY	TUESDAY	WEDNESDAY
	Feb 17 Day 1	18 Day 2	19 Day 3	20 Day 4	21 Day 5	22 Day 6	23 Day 7	24 Day 8
9 am		Greater silver smelt: background presentation including stock identity, data and preliminary results/proposed methods + brief discussion (Gudmundur and Elvar)	Plenary session - for each case study - detailed review of available data and development of agreed assessment methodologies to be trialed/further developed. (Richard)	Case Study leaders to carry out/develop assessments using agreed methods - with assistance of Chair, EEs and ICES co-chairs	Case Study leaders to carry out/develop assessments using agreed methods - with assistance of Chair, EEs and ICES co-chairs	Review of progress thus far and issues arising (Richard)	Report writing by Stock Leaders - (stock section and annex)+ plus general sections (Richard and EEs and ICES co-chairs)	Plenary session to review draft report sections and annexes
10 am	Opening (Richard) Practicalities (Helle) Round Table Adoption of the agenda (Richard) Timetable (Richard) ToRs (Richard)	Roundnose grenadier: background presentation including stock identity, data and preliminary results/proposed methods + brief discussion (Lionel)						
		Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11am	Coffee break	Plenary session -		Continue previous	Continue previous	ICES MSY	Continue previous	Continue previous

	MSY Framework (Cristina) PGCCDBS and feedback from data users (Cristina)	summing up and overview - Richard	Continue previous item	item	item	Framework	item	item
12 pm	Greater forkbeard: background presentation including stock identity, data and preliminary results/proposed methods + brief discussion (Guzman)							
1 pm	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
2 pm	Tusk in Va: background presentation including stock identity, data and preliminary results/proposed methods + brief discussion(Gudmundur)	Plenary session - for each case study - detailed review of available data and development of agreed assessment methodologies to be trialed/further developed	Case Study leaders to carry out/develop assessments using agreed methods - with assistance of Chair, EEs and ICES co-chairs	Continue previous item	Continue previous item	Case Study leaders to carry out/develop assessments using agreed methods - with assistance of Chair, EEs and ICES co-chairs	Continue previous item	Continue previous item
3 pm	Deep-water							Recommendations

	squaliform sharks in all areas: background presentation including stock identity, data and preliminary results/proposed methods + brief discussion (Ivone and Tom)							for data collecting and methodologies (Richard)
4 pm	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
	Red (blackspot) sea bream in Sub-area X: background presentation including stock identity, data and preliminary results/proposed methods + brief discussion (Mario)							AOB
5 pm		Continue previous item	Continue previous item	Continue previous item	Continue previous item	Continue previous item	Continue previous item	
	Reception							

Annex 4: Recommendations

Stock	Recommendation	For follow up by:
Greater silver smelt in the Northeast Atlantic	WKDEEP recommends that a large-scale study on greater silver smelt stock identity be implemented. More details about a this recommendation are available in Sections 3 and 7.1	National institutes involved in greater silver smelt fisheries.
All WKDEEP stocks	WKDEEP recommends that a workshop on stock identity issues relating to deep-water species be carried out. An integrated "holistic" approach is advised, which includes increasing the database on these multiple potential sources of information to significantly increase the ability of any such workshop to identify stock structure (See Section 3).	ACOM
All WKDEEP stocks	WKDEEP recommends to carry out age validation studies for all species assessed in WKDEEP. For some of the shorter-lived species (e.g. tusk, greater silver smelt, greater forkbeard) techniques such as marginal increment analysis or length-modal analysis may be appropriate, while for longer lived species radiometric techniques (e.g. lead-radium) that have been refined in recent years for species such as orange roughy, could be applied.	National institutes involved on deep-water species ageing.
Greater silver smelt	An age calibration exercise (otolith exchanges and workshops) is needed, between the national institutes that are reading greater silver smelt otoliths.	PGCCDBS
Red (backspot) sea bream	WKDEEP recommends a small-scale otolith exchange between the two institutes that are currently ageing this species (DOP- Portugal and EIO- Cadiz, Spain).	PGCCDBS
All WKDEEP stocks	Life time growth estimates could be greatly improved by ensuring adequate numbers of small and large (i.e. young and old) fish are sampled, which will improve definition of both ends of the age–length relationship. WKDEEP recommends that age sampling should covers all length range of the species.	RCMs and national institutes
All WKDEEP stocks	Due to the bad quality of fisheries dependent data, survey information is crucial to deep-water species assessment. Fishery-independent surveys are viewed as a cost-effective primary source of spatially explicit stock abundance and size data. In particular, consideration should be given to extending the depth range of several existing surveys down to greater depth (e.g. 1000 m) to cover the main depth range of the fisheries. However, in some areas there is a need for extensive survey coverage across the whole geographical area inhabited by stocks in Vb, VI, VII, and XIIb (e.g. roundnose grenadier, black scabbard fish, blue ling).	ACOM, national institutes, European Commission
All WKDEEP stocks	WKDEEP recommends that the spatial distribution of the main stocks for which the survey aims to provide abundance indicators is reviewed. Based on this review the design of the survey should be adjusted to ensure adequate stock coverage while at the same time making a realistic proposal in terms of costs and logistics.	PGNEACS, ACOM, national institutes, European Commission

STOCK	RECOMMENDATION	FOR FOLLOW UP BY:
All WKDEEP stocks	WKDEEP recommends that landings of WKDEEP species be fully reported within ICES areas. For some species this may require a change in focus from landings, as has been the basis of the historical database, to specific catches (i.e. landings plus discards). In addition, to the extent possible, future reporting should be explicitly spatially indexed. It is recommended that haul-by-haul data should be collected and reported for all trawl and longline fisheries.	National institutes
Future benchmarks	WKDEEP recommends that future benchmark meetings there should be a limit of three stocks to allow a more thorough evaluation of data, methods and synthesis.	ACOM, ICES Secretariat
Red (backspot) sea bream	WKDEEP recommends a Workshop on maturity staging of hermaphrodite species (or in red blakspot sea bream in particular).	PGCCDBS
Roundnose grenadier	WKDEEP recommends that roundnose grenadier effort data should be provided by all involved countries.	Each country involved in this fishery / fishing organizations involved, RCM-NA, RCM-NS&EA
Roundnose grenadier	*Coryphaenoides* sp. species, are frequently misidentified. WKDEEP recommends that only observers with an experience in the identification of species of grenadier should be sent aboard fishing vessels catching species of grenadier.	National observer programmes
Roundnose grenadier	The quality of pre-anal fin length measurement is unknown. WKDEEP recommends that some exercises should be made to evaluate between observers (or for the same person) the quality of pre-anal fin length measurement.	National institutes.
Roundnose grenadier	The length distribution of the stock per depth is poorly known. WKDEEP recommend that some trip should include full measurement of length of the catches and the depth of the haul should be reported.	National observer programmes
Deep waters sharks	Taxonomic problems on the identification of species include in the *Centrophoridae* family particularly those occurring at NE Atlantic (e.g. *C. granulosus*, *C. lusitanicus*). WKDEEP recommends studies to improve deep-water sharks identifications, namely by means of genetic approach.	RCM-NA, National institutes
Deep waters sharks	Some tentatives were already essayed to age *C. squamosus* and *C. coelolepis* and others are now being tried. Most of the approaches rely on dorsal spines analyses. WKDEEP recommends that a collaborative work between labs needs to be done to: i) critically revise the procedures adopted as well as the results data ii) propose a standardization of methods and methods to assigned ages.	National institutes

STOCK	RECOMMENDATION	FOR FOLLOW UP BY:
Greater forkbeard	There is a problem in the species-specific identification of landings. Landing tables could include significant landings of *Phycis* spp, *Urophycis* spp species. WKDEEP recommends the edition of a guide and training of observers in the identification of the most common *Phycis* species.	Countries involved in fisheries reporting specific composition of landings to WGDEEP
Greater forkbeard	Few countries supply discard data to the WG. WKDEEP recommends toncrease of number discard samplings (% of trips covered by observers) on commercial vessels.	RCM-NA and RCM-NS&EA

Annex 5: Working Documents presented at WKDEEP meeting

WKDEEP-2010-DWSHARKS-01: DEEPWATER SHARK - Modelling the dynamics of the population of the Portuguese dogfish *Centroscymnus coelolepis*, I. Figueiredo, L. Carvalho, I. Natario and T. Moura.

WKDEEP-2010-GFB-01: Options for assessment of greater forkbeard (*Phycis blennoides*), P. Lorance.

WKDEEP-2010-GNR-01: Quantifying the effects of uncertainties of the age–length key for roundnose grenadier, L. Pawlowski.

WKDEEP-2010-GNR-02: Effect of discards on roundnose grenadier stock assessment in the Northeast Atlantic, L. Pawlowski and P. Lorance.

WKDEEP-2010-GNR-03: Collection process and validation of haul by haul data : a partnership between science and industry – blue ling and roundnose grenadier, L. Pawlowski , P. Lorance, F. Evrat, A. Le Garrec, J. Lamothe.

WKDEEP-2010-GNR-04: Analysis of haul by haul data for blue ling, P. Lorance, L. Pawlowski, and V. M. Trenkel.

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