19 Stock Annexes

19.1 Alfonsinos/Golden eye perch

Stock:	Alfonsinos/Golden eye perch (*Beryx* Spp.)
Working Group:	WGDEEP
Date:	March 2011

A. General

A.1. Stock definition

The alfonsinos *Beryx spp*. are deep-water species that occur throughout the world's tropical and temperate waters, in depths from 25 to 1300 meters. The 2004 WGDEEP Report made reference to preliminary genetic results for *B. splendens* suggesting that significant genetic differentiation may occur between populations of the species within the North Atlantic, which may have some implications for future management of the fisheries. No further information is available. Because very little is known about stock structure of these species, the WG has assumed single-stocks of both *B. splendens* and *B. decadactylus* in the North Atlantic.

A.2. Fishery

Alfonsinos, *Beryx splendens* and *Beryx decadactylus*, are generally considered as bycatch species in the demersal trawl and longline mixed fisheries targeting deep-water species. For most of the fisheries, the catches of alfonsinos are reported under a single category, as *Beryx spp*. Historica- time-series by species is only available from the Azores fishery.

From 1988 to 1993 almost only the Azores (Subdivision Xa) was involved on the fishery (representing 94% of the landings). The Azores deep-water fishery is a multispecies (up to 20 or more) and multigear fishery dominated by the main target species *Pagellus bogaraveo*. This fishery has continued throughout the period from 1994 onwards.

During 1994 to 2000, Russian pelagic trawlers were responsible for high catches in Subdivision Xb (a seamount fishery on Mid-Atlantic Ridge).

Other ICES Subareas with important catches from the mixed demersal and deep-water fisheries (mainly trawlers and longliners) are VI and VII, with an average contribution of around 10–20% of the total reported catch to ICES during 1996 to 2007 and Areas VIII and IX, which landings averaged around 30% of the total from 1997 to 2007.

A.3. Ecosystem aspects

The Azores (Division Xa) are considered a "seamount ecosystem area" because of its high seamount density. The deep-water fishery in the Azores is mostly a seamount fishery where only bottom longlines and handlines are used.

B. Data

B.1. Commercial catch

For this species data are available from commercial fisheries reported to ICES for the different ICES Sub areas from 1988 to present. Landings data are usual aggregated by species. More detailed data by species is available from the Azores (Division Xa). Azorean data from commercial fisheries include landings (auction data) and some effort data from longliners inquires (since 1990), logbooks and observers (from large longliners and for recent years; WD Pereira, 2006a; 2010a).

Discards from this fishery have been increased in the recent years, due to quota restrictions. Information on discarding in the Azores has been made available to the WG since 2007 (ICES, 2006; 2010).

B.2. Biological

Length compositions and biological information including (ageing, weights, sex ratio and maturity) by species have been collected since 2002, analysed and reported to ICES (WD Pereira, 2006b; 2010b).

Considerable general information is available on the life-history characteristics of this species.

B.3. Surveys

Annually survey (ARQDAÇO) data are available from the Azores, since 1995. The survey was conducted annually each spring (usually from April to June) since 1995, with exception of the years 1998, 2006 and 2009. The survey followed a stratified design (six statistical areas and twelve depth strata) and covered the Azores archipelago around the islands, and major seamounts). The survey is design for abundance estimation of red (blackspot) sea bream, covering the depth strata from 50 to 600 m. During 2004 this depth was extended to 800 m in order to cover the depth range of the species. Additionally depth from 800 to 1200 m is covered in one transect by statistical area for ecological studies. Details of the survey design can be found Menezes *et al.* (2006) and a resume of the survey design can be found in the ICES WGNEACS 2010 report.

Abundance index time-series (computed for the depth range 50–600 m) is available by species. Length composition, and several biological data (sex, weight, otoliths and maturity) have been also collected and reported to ICES.

B.4. Commercial cpue

Standardized cpue was presented to ICES in 2006. Since then only nominal cpue has been available (WD Pereira, 2006c; WD Pereira and Pinho, 2010). Standardized series will be computed and made available from 2012.

B.5. Other relevant data

C. Assessment: data and method

\Landings and trends in abundance indices

Model used:

Software used:

Model Options chosen:

Input data types and characteristics:

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:

5) Weight-at-age in the stock:

6) Weight-at-age in the catch:

7) Exploitation pattern:

8) Intermediate year assumptions:

9) Stock–recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

No biological reference points have been defined.

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

ICES. 2006. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources. ICES CM 2006/ACFM:28.

ICES. 210. Working Group for Northeast Atlantic Continental Slope Survey. ICES CM 2010/SSGESST:16, REF. SCICOM, ACOM.

ICES. 2010. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources. ICES CM 2010/ACOM:17. 10/SSGESST:16, REF. SCICOM, ACOM.

Meneses, G. M., M. F. Sigler, H. M. Silva, and M. R. Pinho. 2006. Structure and zonation of demersal and deep-water fish assemblages off the Azores Archipelago (mid-Atlantic). Marine Ecology Progress Series, 324:241–260.

Pereira. 2006a. Statistical data on selected deep-sea species from the Azores fishery. WD WGDEEP 2006.

Pereira. 2006b. Statistics and biological data on the Alfonsinos, *Beryx decadactylus and Beryx splendens* from the Azores. WD WGDEEP 2006.

Pereira. 2006c. Standardized cpue for the Alfonsino *Beryx splendens* from ICES area X. WD WGDEEP 2006.

Pereira. 2010a. Statistical data on selected deep-sea species from the Azores fishery. WD WGDEEP10.

Pereira. 2010b. Updated statistics and biological data on the Alfonsinos, *Beryx decadactylus and Beryx splendens* from the Azores

19.2 Black scabbardfish in Vb, XIIb and VI, VII

Stock: Black scabbard fish in Subareas Vb and XIIb and Divisions VI and VII

Working Group: WGDEEP

Date: March 2011

A. General

A.1. Stock definition

The species is distributed on both sides of the North Atlantic and on seamounts and ridges south to about 30ºN. It occurs only sporadically north of the Scotland–Iceland–Greenland ridges. Juveniles are mesopelagic and adults are bentho-pelagic. It is admitted that the species' life cycle is not completed in just one area and also that either small or large-scale migrations occur seasonally. It has been postulated that fish caught to the west of the British Isles are pre-adults that migrate further south (possi-bly down to Madeira) as they reach maturity.

The stock structure is uncertain. Three management units are considered:

i) Northern (Divisions Vb and XIIb and Subareas VI and VII);

ii) Southern (Subareas VIII and IX);

iii) Other areas (Divisions IIIa and Va Subareas I, II, IV, X, and XIV).

A.2. Fishery

The Faroese fisheries take mostly place in Subarea Vb with a minor activity in Subarea VI. The Faroese deep-sea trawl fishery started in the late 1970s as a mixed redfish, blue ling, grenadier and black scabbardfish fishery; a more directed black scabbard fishery began in the late 1980s (1988) as a result of improvements of the gear and handling of the fish. And from 1993 onwards some of the otter board trawlers have targeted black scabbardfish either seasonally or throughout the year. The main fishing grounds for the species are located on the bank area southwest of the Faroes Islands. The fleet of otter board trawlers (the so called deep-sea trawlers) consist of 13 vessels >1000 HP, but only 1–3 trawlers > 2000 HP are targeting black scabbardfish. Landings are mostly derived from Division Vb and the values (about 1400 t) were registered in 2001 and 2002.

In ICES Subarea VI a Scottish mixed deep-water trawl fishery included some catches of black scabbard fish between 1999–2005. This fishery has decreased since the introduction of TACs in 2003.

Following the decline of target orange roughy Irish trawl fishery, landings of black scabbardfish derived from ICES Suabreas VI and VII reached about 1000 t in 2002. In the recent years (2008–2010) Irish landings have been null.

The French deep-water fishery operates mainly in Subareas VI and VII targeting roundnose grenadier, black scabbardfish, blue ling and deep-water sharks. Over recent years, the landings of black scabbardfish have declined but landings of other deep-water species (roundnose grenadier, orange roughy, deep-water sharks) have declined in a larger proportion.

The Spanish fishery in Hatton Bank started in 1996, triggered by the decline in catches in traditional fishing grounds. Durán Muñoz and Román Marcote (2001) described the beginning of this fishery and the fleet operating in Hatton. In all 48 vessels have logged in fishing days at Hatton for the period 2002–2009, but the maximum number of vessels in the fishing grounds in any given month is 16. Most often, and on average, vessels stayed in Division VIb less than two weeks per month, but stayed in Division XII between three and four weeks.

The Northern component comprises fish exploited mainly by trawl fisheries.

Total landings from the ICES Subareas Vb and Divisions VI, VII and XII show a markedly increasing trend from 1999 to 2002 followed by a decreasing trend till 2005. There was a peak in 2006 then there was a decrease mainly due continuous decreases of landings from ICES Divisions VI and VII.

A.3. Ecosystem aspects

A large proportion of deep-water trawl catches (upwards of 50%) can consist of unpalatable species and numerous small species, including juveniles of the target species, which are usually discarded (Allain *et al*., 2003). The main species in the discards of the trawl fishery in by far the Baird's smoothhead (*Alepocephalus bairdii*) however, a large number of other non marketable bentho-pelagic species are discarded. The survival of these discards is unknown, but believed to be virtually zero because of fragility of these species and the effects of pressure changes during retrieval (Gordon, 2001). Therefore such fisheries tend to deplete the whole fish community biomass. Depletion of dominant species can induce major changes to fish communities through removing key predatory or forage species.

A study of the impacts of deep-water fishing to the West of Britain using historical survey data found some evidence of changes in size spectra and a decline in species diversity between pre- and post-exploitation data, but the scarce and unbalanced nature of the time-series hampered firm conclusions (Basson *et al*., 2001).

The effects of fishing on the benthic habitat relates to the physical disturbance by the gear used. This includes the removal of physical features, reduction in complexity of habitat structure and resuspension of sediment. More attention has been paid to biogenic habitat that occurs along the slope, mainly the cold-water coral. The main reef building species is *L. pertusa*. Any long-lived sessile organisms that stand proud of the seabed will be highly vulnerable to destruction by towed demersal fishing gear. There are a number of documented reports of damage to Lophelia reefs in various parts of the Northeast Atlantic by trawl gear where trawl scars and coral rubble have been observed (e.g. Hall-Spencer *et al*., 2002). Damage can also be caused on a smaller scale by static gears such as gillnets and longlines (Grehan *et al*., 2003).

In Divisions VI, VII and XIIb there are a number of known areas of cold-water corals. These include the shelf break to the west and north of Scotland, Rockall Bank, Hatton Bank and the Porcupine Bank. The best known site is the Darwin Mounds, located at

1000 m to the south of the Wyville Thompson Ridge. Some of these areas have been heavily impacted by deep-water trawling activities (Hall-Spencer, 2002; Grehan *et al*., 2003).

B. Data

B.1. Commercial catch

The landings from Spanish trawling fleet operating on the Northern and Western Hatton Bank (Divisions VIb1 and XIIb) are available in a routine way since 2004.

Landings from other fleets are available from 1988.

Discard – Discard data from Spanish bottom otter trawl métiers operating Hatton Bank are available from the `Spanish observer Programme' carried out by the IEO since 1996. Trip was the sampling unit, being raised to fleet level using using fishing effort as auxiliary variable.

No data are available on discarding from other fisheries.

B.2. Biological

Since 2003 French length data of back scabbardfish by depth are available based on data from on-board observations of French trawlers.

French length distributions of back scabbardfish by depth have been provided (Figure 19.2.1). Data were derived from on-board observations of French trawlers.

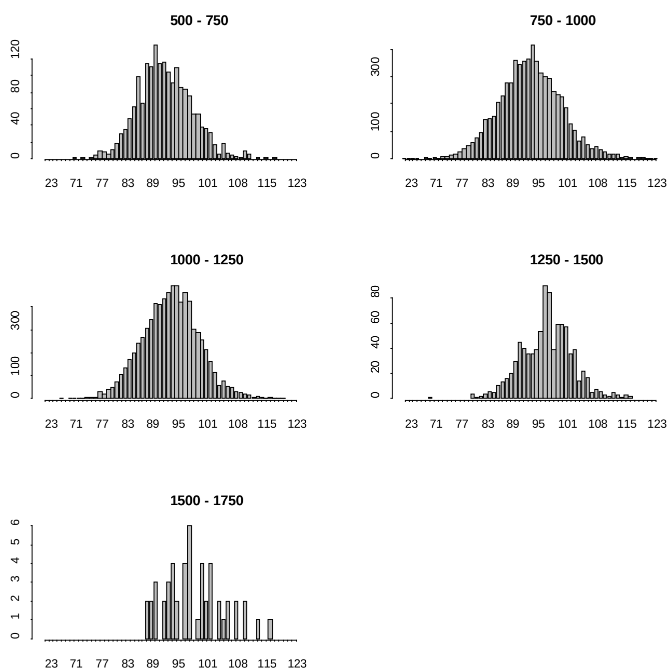
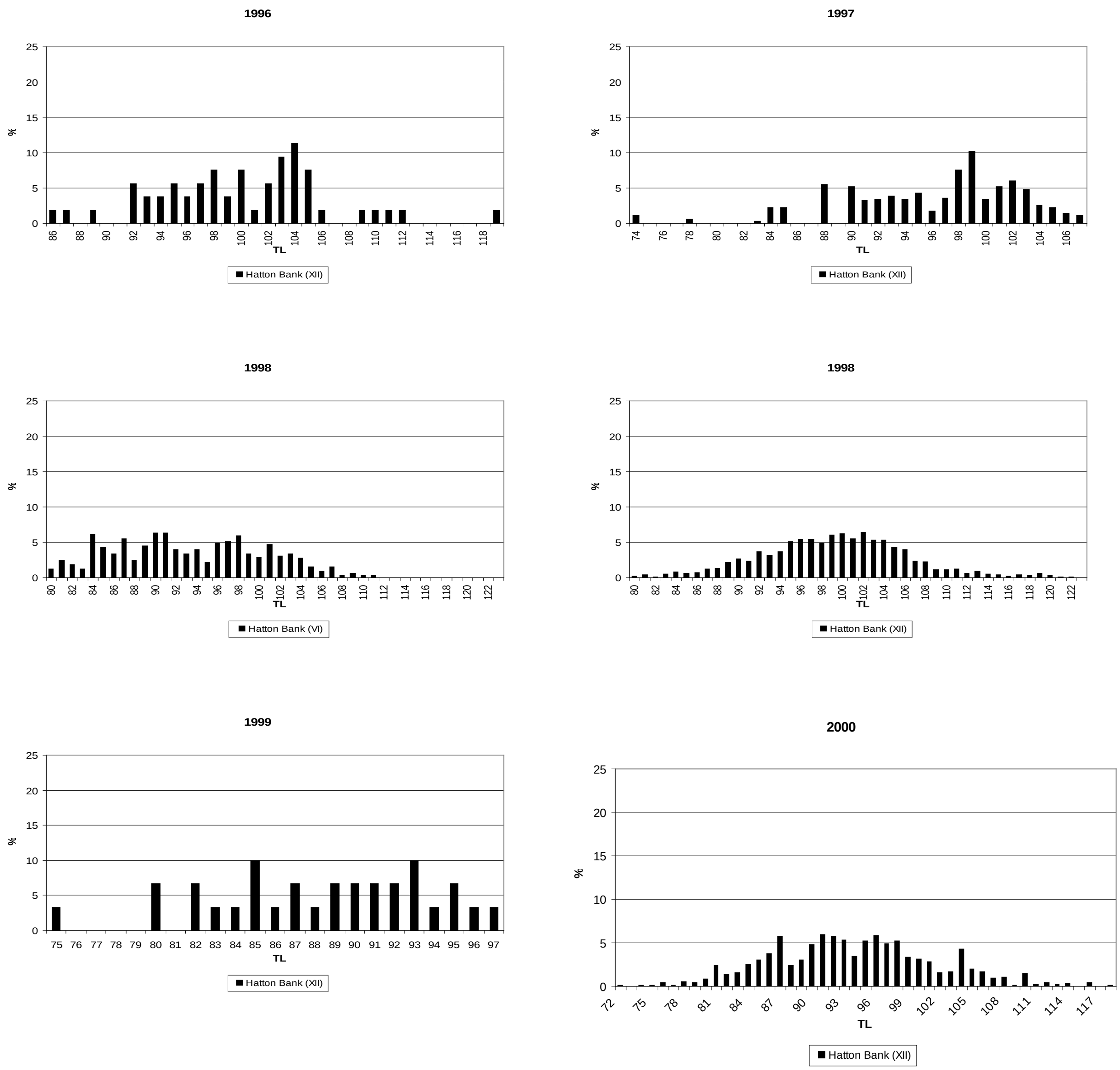


Figure 19.2.1. Black scabbard fish Length distribution by depth from on-board observations of French trawlers in subarea VI. Numbers were raised to total numbers in haul where black scabbardfish was measured. 2003–2005 combined data.

Length frequency distributions for the period 1996–2001 (Figure 19.2.2) have been provided from observers on board Spanish trawling fleet operating on the Northern and Western Hatton Bank (Divisions VIb1 and XIIb).



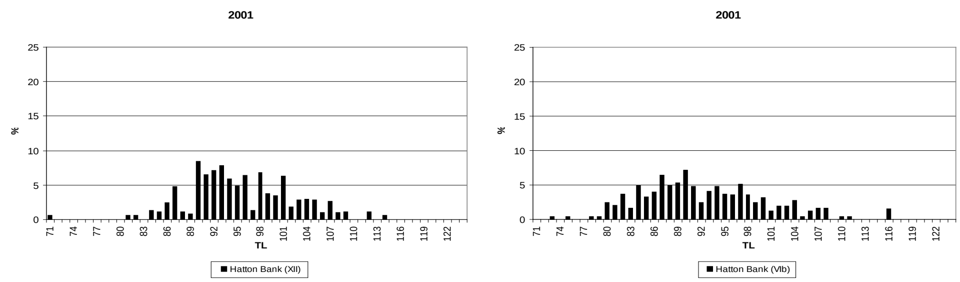


Figure 19.2.2. Black scabbard fish length frequency distribution by year from on-board observations of Spanish trawlers.

Length on data from Soviet exploratory fishing surveys at late 1970s at Lauzy Bank, Anthon-Dorn Bank and Anthon-Dorn Bank and the Hatton-Rockall Plateau showed that the size range of the species (70–130 cm with higher frequencies at lengths varying between 96–110 cm) do not greatly differ among areas (Vinnichenko *et al*., 2003).

LHC	Best estimate	Derived from?	Other estimates
Maximum observed length	1510 mm	Figueiredo *et al*., 2003	
Maximum observed age	32 y	Kelly *et al*., 1998	15 y (Anon., 2000)
Length at 50% maturity	1028 mm (females)	Figueiredo *et al*., 2003	1095 mm (males) and 1144 mm (females; Pajuelo *et al*., 2008).
Growth parameters: (von Bertalanffy parameters: B0,T0, L infinity, for example)	(Madeira) Females: Linf = 142 cm; k = 0.260 y-1; t0 = -2.079 y. Males: Linf = 155.3 cm; k = 0.155 y-1; t0 = -3.265 y.	Morales-Nin and Sena-Carvalho, 1996	Males: Linf = 1410 mm; k = 0.263 y-1; t0 = -3.507 y. Females: Linf = 1483 mm; k = 0.196 y-1; t0 = -4.467 y. All: Linf = 1477 mm; k = 0.200 y-1; t0 = -4.58 y. (Canary Islands, Pajuelo *et al*., 2008)
Fecundity, egg size, etc	73–373 oocytes g-1 female (Madeira). Vitellogenic oocytes ranged from 0.60 to 1.50 mm.	Neves et al. (2009)	

B.3. Surveys

Survey data on the species are available both from Scottish and Irish surveys. The former is conducted by the Marine Scotland - Science [formerly Fisheries Research Services, (FRS)] along the continental shelf/slope to the northwest of Scotland. The survey was initiated in 1996 with strictly comparable data available between 1998 and 2008. The core area is surveyed between 55–59°N, with trawling undertaken at depths ranging from 300 to 1900 m with most of the hauls being conducted at fixed stations, at depths of around 500 m, 1000 m, 1500 m and 1800 m. Further hauls have been made on seamounts in the area, and on the slope around Rockall Bank, but these are exploratory, irregular and not included in the survey dataset.

The Irish deep-water trawl survey sampled the fish community of the continental shelf slope to west and northwest of Ireland since 2006. Methodology and trawl gear is standardized in accordance with the Scottish deep-water survey with trawling at fixed stations around 500 m, 1000 m, 1500 m and 1800 m.

Length data from Scottish and Irish deep-water surveys were analysed. Mean length by depth stratum show that smaller length classes are preferentially distributed at depths shallower than 1000 m deep (Figure 19.2.3).

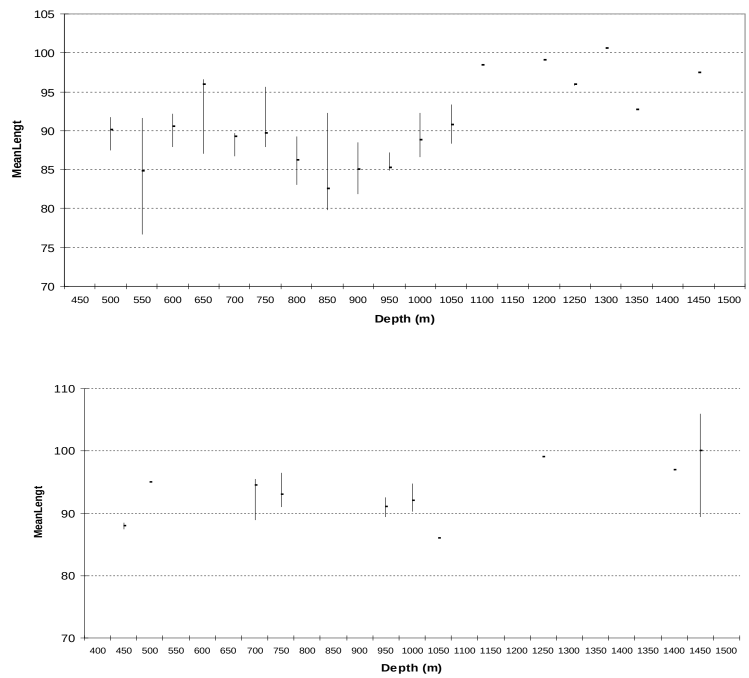


Figure 19.2.3. Black scabbard fish mean length per depth stratum from Scottish (upper) and Irish(lower) deep-water surveys.

Annual mean catch rates (kg/h) at depths shallower than 1000 m using on Scottish survey data are presented in Figure 19.2.4. The analysis of this suggests the existence of pulses of entrance of smaller specimens. This aspect should be further explored using appropriate statistical tools that enter into consideration the spatial correlation aspects.

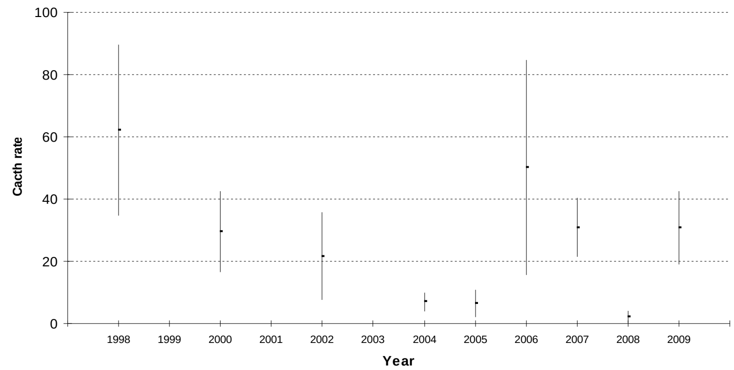


Figure 19.2.4. Black scabbard fish average catch rates +/- standard error along years based on Scottish survey data for fishing held at depth shallower than 1000 m.

B.4. Commercial cpue

A lpue series for black scabbardfish was presented based upon the French tallybooks (Pawlowski *et al.*, WD 2009). The tallybook (from skipper own logbooks) database provided by the French industry (PROMA/PMA a producers organization and EURONOR a ship owner), has the advantage in relation to logbook of having the records on a haul by haul resolution and on having fishing depth available (Pawlowski *et al.*, WD 2009).

Lpues estimated for areas to west of the British Isles as defined by Biseau, 2006WD and for the all ICES rectangles are presented in Figures 19.2.5 and 19.2.6. Estimates show rather wide confidence intervals with no clear trends during the 2000s.

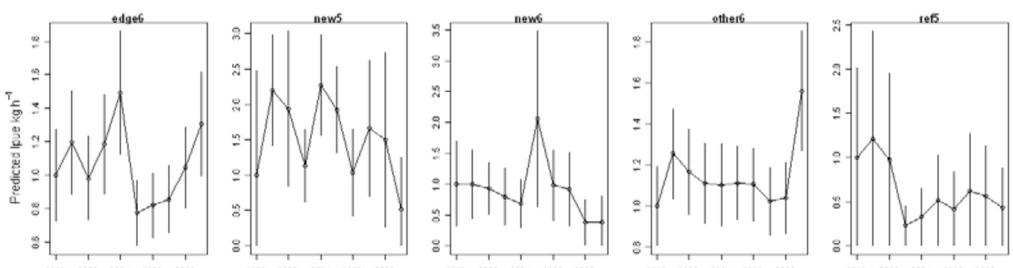


Figure 19.2.5. Lpue of French trawlers in 5 areas (labeled according to Biseau, 2006 WD) from tows targeting black scabbardfish (defined as tows where the total catch include >10% of black scabbardfish). Absolute levels should not be compared over areas as the predictions were carried out for one particular rectangle.

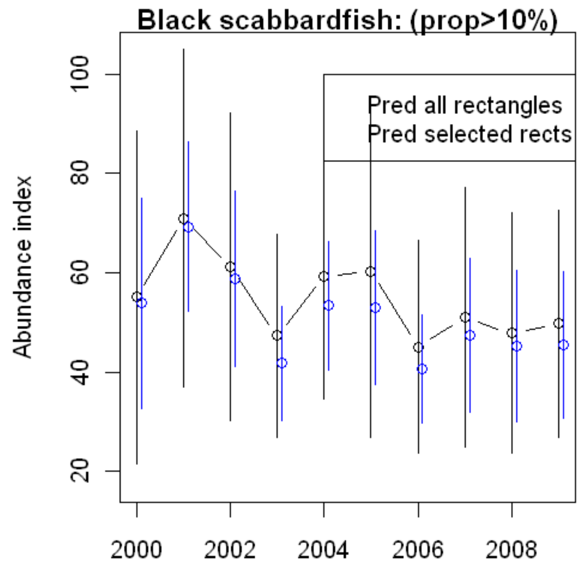


Figure 19.2.6. Lpue of French trawlers for the overall rectangles.

Unstandardized cpue series were determined for the Spanish trawlers operating Hatton Bank using the available data on annual catch and nominal effort (number fishing days). Figure 19.2.7. Cpue estimates were presented for Subdivisions VIb1 and XIIb separately, as well as, for the two combined.

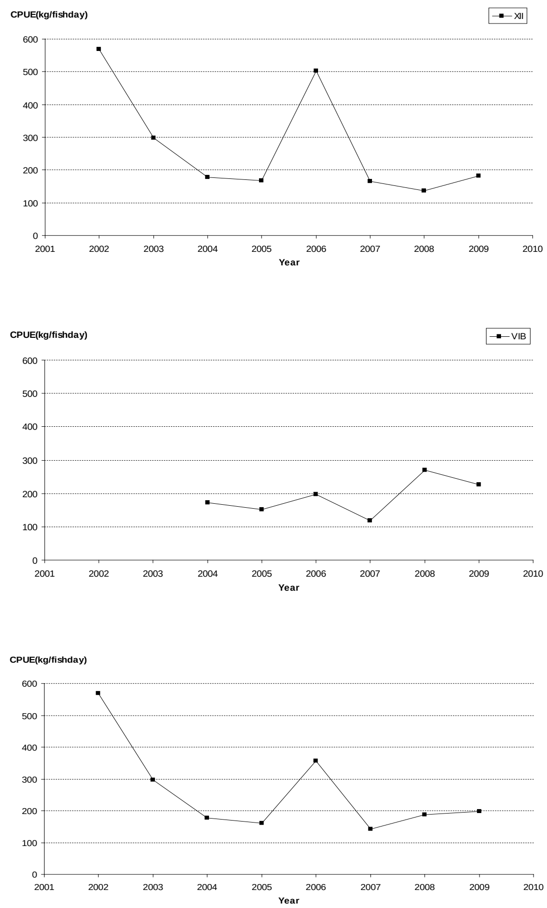


Figure 19.2.7. Black scabbard fish cpue (kg/fishing days) in VIb (upper left). XIb (upper right) and the two subareas combined (center) from Spanish trawlers.

B.5. Other relevant data

Information available for ICES Subareas Vb, VI, VII and XII consistently points out to the predominance of small and absence of mature specimens.

C. Assessment: data and method

Model used:

The stock is evaluated based on cpue trends.

Lpues for black scabbardfish are estimated based upon French skippers' tallybooks. The lpue estimates based on tallybooks demonstrate rather wide confidence intervals and do not indicate significant trends during the 2000s. Both the Spanish and the Faroese cpue series were not standardized and both covered a small time range of years.

Software used:

Model Options chosen:

Input data types and characteristics:

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:

9) Stock recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

The previous assessment trials were done taking into consideration a unique stock in NE Atlantic. However due to the different nature of fisheries in the northern and southern areas and lack of information on migration, the stock has traditionally been divided into northern and southern components for management purposes.

Year	Assessment type[3]	Assessment method(s) used	Assessment package/program used	Reference
1998	Exploratory	Scheafer Production model	CEDA	WGDEEP, 1998
2006	Exploratory	Dynamic Production model	ASPIC	WGDEEP, 2006
2006	Exploratory	Bayesian approach to Production model	Winbugs	WGDEEP, 2006

[3] Exploratory, Benchmark (to identify best practise), Update (repeat of previous years' assessment using same method and settings but with the addition of data for another year).

19.3 Black scabbardfish in Subareas VIII, IX

Stock:	Black scabbard fish in Subareas VIII, IX
Working Group:	WGDEEP
Date:	March 2011

A. General

A.1. Stock definition

The species is distributed on both sides of the North Atlantic and on seamounts and ridges south to about 30ºN. It occurs only sporadically north of the Scotland–Iceland–Greenland ridges. Juveniles are mesopelagic and adults are bentho-pelagic. It is admitted that the species' life cycle is not completed in just one area and also that either small or large-scale migrations occur seasonally. It has been postulated that fish caught to the west of the British Isles are pre-adults that migrate further south (possibly down to Madeira) as they reach maturity.

The stock structure is uncertain. Three management units are considered:

i) Northern (Divisions Vb and XIIb and Subareas VI and VII);

ii) Southern (Subareas VIII and IX);

iii) Other areas (Divisions IIIa and Va Subareas I, II, IV, X, and XIV).

A.2. Fishery

The main fishery taking place in these Subareas is derived from the Portuguese longliners.

In the early 1980s, an artisanal longline fishery targeting this species initiated in Portuguese continental waters. The fishery takes at grounds around Sesimbra port (south of Lisboa; latitude 38º 20' N), following a series of exploratory surveys conducted by the Portuguese Fisheries Research Institute (former IPIMAR) in close collaboration with professionals from the fisheries sector some of them from Madeira. These surveys were oriented towards the search of new fishing grounds for the species, the environmental characterization of the ocean layer where black scabbardfish occurrs, the experimentation of longline fishing gears and preliminary studies on the biology of the species. For this venture, fishers from Madeira with large experience in deep-sea longline fishing have greatly contributed. The number of vessels involved in this fishery has rapidly increased, with the fleet comprising altogether 15 longline vessels in 1984.

The fishing method and gear presented by the black scabbardfish longline fleet have developed soon after the initial fishing trials off the Sesimbra coast by fishers from Madeira. Gear design has been modified from the one initially used (similar to the Madeira traditional longline fishing gears) to catch the species in continental waters to a different configuration; setting horizontal bottom longline, where alternating floats and sinkers occur at constant intervals on the main line. This rearrangement aims to match the intricate vertical distribution exhibited by the species in the slopes and to prevent gear loss on the hard grounds (Henriques, 1997).

At the beginning of the fishery, the fleet was composed by small artisanal vessels, having an average LOA around 11 m and an average tonnage of ca. 16 GRT. In 1988, vessels showed there was a slight increase in both size and engine's power of vessels. However, from 1992 to 1995, average LOA and engine's power characteristics registered the highest raise in relation to 1988; about 30%. In 2000, the fleet experienced again technological improvements, indicated by the increase of engine's power, tonnage and LOA average values. Such improvements were experienced by a limited number of vessels (four), fact also reflected by the increase in standard deviation estimates.

The number of fleet vessels registered its highest value in 1986, but decreased from 1995 to 2004, when the fleet presented the same number of vessels exhibited twenty years before. In the period 1995–2004, the number of new vessels that entered the fleet attained its maximum in 1997 before an equal number of vessels left the fleet in 1998. During the same period, the number of vessels that remained in the fleet has decreased from 17 to 14.

The number of hooks by fishing gear varied since the beginning of the fishery till present days. In the first years of the fishery, gears used 3600 to 4000 hooks (Martins *et al*., 1989), while, in 1996, its number ranged from 4800 to 5400 (Henriques, 1997). More recently in 2004, the number of hooks by gear varied between 4000 and 10 000. The No. 5 Hook has been commonly used in fishing gears since the beginning of the fishery. The most common bait of the gear is sardine (*Sardina pilchardus*), however, chub mackerel (*Scomber japonicus*) can also be used when sardine is less available or its market price increases. The process of gear preparation, including disentangling, baiting and coiling of the main line into the tubs is carried out ashore by people hired for these tasks and by crewmen when they are not at sea (Henriques, 1997). All the work is performed by hand and is very intensive and laboriously.

Fishing operations usually start at dusk following a well-defined pattern: vessels leave the port early in the night, carrying a previously equipped longline gear, and navigate offshore for a period that varies between one to almost six hours (depending on the vessel and location of the fishing ground). When the vessel is at the fishing ground, two fishing operations generally occur: 1) the longline gear is deployed into the sea and set, 2) another longline gear previously set in the last 24–48 hours (average around 38 hours) is recovered with the aid of a hauling winch installed on board. The occasional presence of cetaceans, whose species and numbers are still to be confirmed, can result in a great economic loss for the fishers as these marine mammals are attracted by the catch when it reaches the surface and feed on the fish captured.

Fishing takes place on hard bottoms along the slopes of canyons at depths normally ranging from 800 to 1200 m and may attain 1450 m.

The French bottom trawlers operating in Subareas mainly VI and VII have a small marginal activity in Subarea VIII.

A.3. Ecosystem aspects

The Bay of Biscay and Iberian Coast region is situated in temperate latitudes with a climate that is strongly influenced by the inflow of oceanic water from the Atlantic Ocean and by the large-scale westerly air circulation which frequently contains low pressure system. The bottom topography of region is highly variable, from continental shelf to abyssal plain. Some remarkable topographic features such as seamounts, banks and submarine canyons can be found. The coastline is also highly diversified with estuaries, rias and wetlands, which all support extremely productive ecosystems.

In Subarea VIII there are historical records of impacts on deep-water ecosystems, in particular corals (Joubin, 1922).

In Division IXa some sporadic information available suggests the existence of coral and sponges. The topography of the region reveals the existence of seamount and canyons usually considered as VME´s.

B. Data

B.1. Commercial catch

Landing data from Subareas VIII and IX are available to WGDEEP. Almost all landing are derived from the Portuguese longline fishery that takes place in Subarea IXa.

The artisanal segment of the commercial fishing fleet of mainland Portugal is responsible for the largest landings' quantities of deep-water species. The on-board discard sampling for longline Portuguese commercial fleet started in mid-2005 and is integrated in the Portuguese Discard Sampling programme, included in the EU DCR/NP. On-board sampling in longline commercial vessels is carried out in a monthly basis to get discards and trip information.

B.2. Biological

Length data - In the scope of the National Minimum Landings Sampling Programme, length frequency and biological samples from Portuguese landing port at Sesimbra were collected on a monthly basis along years.

Ageing - Sectioned otoliths were considered more appropriate to age assignment because growth increments are more evident and ageing of larger specimens is easier than in whole otoliths. In addition although vertebrae are not the most appropriate structure for age assignment, this structure may be useful in the absence of otoliths. The growth parameter estimates of the von Bertalanffy model for Portugal Mainland (ICES Subarea IXa) and Madeira, as well as, for sex separated (Vieira *et al.*, 2009) are shown in table 19.3.1

in parenthesis.

Area	Sex	L_∞ (mm)	k (year^{-1})	T_0 (year)	r
Mainland	females	1354 (42.68)	0.170 (0.022)	–2.040 (0.378)	0.952
	males	1240 (28.99)	0.208 (0.021)	–1.654 (0.284)	0.941
Madeira	females	1586 (41.37)	0.119 (0.009)	–2.282 (0.224)	0.971
	males	1461 (12.78)	0.146 (0.004)	–1.441 (0.065)	0.965

Table 19.3.1. Von Bertalanffy growth model estimates for Aphanopus carbo caught off mainland Portugal and Madeira. Standard deviation in parentheses (Vieira *et al.*, 2009).

Females, particularly those from Madeiran waters, presented a lower growth rate than those from Mainland (ICES Subarea IXa). This reduction in the growth rate seems to be related to the reproductive effort. The differential growth pattern between the females from mainland Portugal (non-reproductive females) and Madeira (reproductive females) may reflect the optimization of the energetic balances (Vieira *et al*., 2009).

Maturity - In ICES Subarea IXa only immature and early developing specimens have been observed (Figueiredo, 2009 WD). Mature individuals only occurred in Madeira (Figueiredo *et al*., 2003) and, in Canary Islands (Pajuelo *et al*., 2008) and the northwest coast of Africa although it is possible that two species may occur in these areas.

In Madeira the spawning season takes place from September to December, and females had a GSI peak in November while males achieved theirs a month early. Such high GSI values are typical of synchronous spawners which, according to Tyler and Sumpter (1996) usually present GSI values ranging between 18 and 25 in mature female.

An increase in the relative weight of the liver just before the increase in weight of gonads in females was very conspicuous in Madeira, but it could also be perceived in mainland females. Such strategy is typical of thin fish in which the majority of the energy necessary to maturity is stored in the liver and, after the maturation is reached, the HSI present a sharp decrease. In males, the HSI did not follow the same conspicuous pattern shown in females since the energy needed for their reproduction has lower energy costs than females.

The HSI revealed a correlation with GSI in females but not in males and no relation of the Fulton's condition factor with the reproduction in both sexes was perceived.

Length of first maturity - The length at first maturity was estimated as 1078 mm for females and 1062 mm for males. This estimative was larger than the one presented by Figueiredo *et al*. (2003) in Madeira waters (1028 mm) but lower to the one found by Pajuelo *et al*. (2008) in Canary Islands (1095 mm for males and 1144 mm for females). It is probable that individuals from Canary Islands mature at larger sizes than those in Madeira, influenced by the fact that in the former archipelago they are distributed deeper and that they are subjected to different exploitation levels and regional oceanographic conditions (Morales-Nin *et al*., 2002).

Fecundity - Black scabbardfish has a determinate fecundity strategy the relative fecundity estimates ranged from 73 to 373 oocytes/female weight(g). Skipped spawning was also considered to occur in this species; the percentages of non-reproductive females between 21% and 37% (Vieira *et al*., 2009).

B.3. Surveys

No independent fishery data are available for this stock.

B.4. Commercial cpue

The commercial daily landings from Portugues longline vessels have been used to derive black scabbardfish monthly lpue values. Data has been provided by the Portuguese General Directorate of Fisheries and Aquaculture.

Monthly lpue are calculated for each vessel as the *ratio* total landed weight (kg)/number of fishing trips. Only vessels having total monthly landings >= 1000 kg and a monthly number of fishing trips >= five were considered in the analysis.

Although there is no information on the number of hooks used per trip, it is known from interviews with the fishers that each vessel uses the same number of hooks on each trip (Bordalo-Machado and Figueiredo, 2008). Hence, the effect of the number of hooks on the effort estimates is extracted from the model when we extract the effect of the vessel.

Standardized monthly effort of the fleet are estimated based on the adjustment of GLM model. Factors considered are YEAR, MONTH and VESSEL and the model is expressed as:

$$g(LPUE_{ijkl}) = \alpha_i YEAR_i + \beta_j MONTH_j + \lambda_k VESSEL_k + \varepsilon_{ijkl,} \quad (1)$$

where α_i (i = 1995,…, lastyear), β_j (j = 1,…,12) and λ_k (k = 1,…,33) are coefficients to be determined. The most appropriate distribution the expected or a function of the expected response variable was chosen among the exponential family group of distributions. The quality of the model adjustment was evaluated by quantile residuals analysis.

B.5. Other relevant data

Weight–length relationship - The weight (total weight W)–length (Total length TL) relationship for the species (Morales-Nin and Carvalho, 1996) estimated for the species has the following expression:

males W= 0.000154 TL 3.4519, r^2 = 0.95

females W= 0.000201 TL 3.3906, r^2 = 0.95

Seasonal effect on abundance - Monthly standardized black scabbardfish lpue from the longline fleet operating in Subarea IXa were estimated for the period 1995–2009 (Figueiredo and Farias, 2010 WD). The monthly lpue estimates and the corresponding confidence intervals are shown in Figure 19.3.1.

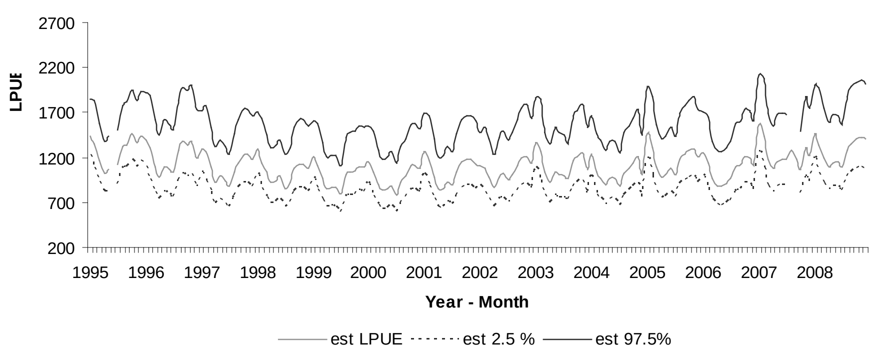


Figure 19.3.1. Monthly lpue estimates for ICES Subarea IXa with 95% confidence intervals from the adjusted GLM model (Figueiredo and Farias, WD 2010).

The monthly lpue estimates did not show any marked long-term trend and seem to follow a seasonal pattern along the period in analysis.

C. Assessment: data and method

Model used:

The stock is evaluated based on cpue trends.

The lpue estimate, as well as, other information on the species for the southern component and other components will be analysed under DEEPFISHMAN Project aiming to the development of new approaches that take into consideration spatial stock dynamics.

Software used:

Model Options chosen:

Input data types and characteristics:

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:

3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

The previous assessment trials were done taking into consideration a unique stock in NE Atlantic. However due to the different nature of fisheries in the northern and southern areas and lack of information on migration, the stock has traditionally been divided into northern and southern components for management purposes.

Year	Assessment type[3]	Assessment method(s) used	Assessment package/ program used	Reference
1998	Exploratory	Scheafer Production model	CEDA	WGDEEP, 1998
2006	Exploratory	Dynamic Production model	ASPIC	WGDEEP, 2006
2006	Exploratory	Bayesian approach to Production model	Winbugs	WGDEEP, 2006

I. References

Bordalo-Machado, P. and Figueiredo. 2009. Fishery for black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the Portuguese continental slope. Rev. Fish Biol. Fish., 19: 49–67.

Figueiredo, I., P. Bordalo-Machado, S. Reis, D. Sena-Carvalho, T. Blasdale, A. Newton and L.S. Gordo. 2003. Observations on the reproductive cycle of the black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the NE Atlantic. ICES J. Mar. Sci., 60(4): 774–779.

Henriques, V. 1997. Final report of Sub-task 1.3: description of Portuguese deep-water fisheries. Final Report of European Commission FAIR Contract CT95- 655 Developing deep-water fisheries: data for the assessment of their interaction with and impact on a fragile environment, 9 pp.

Martins, M. R., M. M. Martins and F. Cardador. 1989. Portuguese fishery of Black scabbard fish (*Aphanopus carbo* Lowe, 1839) off Sesimbra waters. ICES Demersal Fish committee CM1989/G:38, 29 pp.

Morales-Nin, B, A. Canha, M. Casas, I. Figuereido, L.S. Gordo, J. Gordon, E. Gouveia, C.G. Pineiro, S. Reis, A. Reis and S.C. Swan. 2002. Intercalibration of age readings of deep-water black scabbardfish, *Aphanopus carbo* (Lowe, 1839). ICES J. Mar. Sci., 59(2):352–364.

Pajuelo, J.G., J.A. González, J.I Santana, J.M. Lorenzo, A. García-Mederos and V. Tuset. 2008. Biological parameters of the bathyal fish black scabbardfish (*Aphanopus carbo* Lowe, 1839) off the Canary Islands, Central-east Atlantic. Fish. Res., 92(2–3): 140–147.

Tyler, C.R. and J.P. Sumpter. 1996. Oocyte growth and development in teleosts. Rev. Fish Biol. Fish., 6(3): 287–318.

Vieira, A.R.Farias, I. Figueiredo, I., Neves, A. Morareles-Nnin, B., Sequeirara, V., Martins, R. ang Gordo, L.S. 2009. Age and growth of black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the southern NE Atlantic Scientia Marina 73Ss.

[3] Exploratory, Benchmark (to identify best practise), Update (repeat of previous years' assessment using same method and settings but with the addition of data for another year).

19.4 Black scabbardfish in other areas

Stock	Black scabbard fish other Areas (I, II, IIIa, IV, X, Va, XIV).
Working Group:	WGDEEP
Date:	March 2011

A. General

A.1. Stock definition

The species is distributed on both sides of the North Atlantic and on seamounts and ridges south to about 30ºN. It occurs only sporadically north of the Scotland–Iceland–Greenland ridges. Juveniles are mesopelagic and adults are bentho-pelagic. It is admitted that the species life cycle is not completed in just one area and also that either small or large-scale migrations occur seasonally. It has been postulated that fish caught to the west of the British Isles are pre-adults that migrate further south (possi-bly down to Madeira) as they reach maturity.

The stock structure is uncertain. Three management units are considered:

i) Northern (Divisions Vb and XIIb and Subareas VI and VII);

ii) Southern (Subareas VIII and IX);

iii) Other areas (Divisions IIIa and Va Subareas I, II, IV, X, and XIV).

A.2. Fishery

The fisheries in the other areas have been taken place in different ICES subareas and different years.

In ICES Division IXa2 (Azorean EEZ) black scabbardfish fishery in the Azores has received sporadic experimental activity despite previous indications that a potential for a fishery exists (Vinnichenko, 1998; Hareide and Garnes, 2001). The absence of a local market and the complexity of the gear and labour requirements for its operation have thus far limited the development of the fishery. The commercial value of the species is, however, well-established in other regions

A Faroese exploratory trawl fishery took place in 2008 in the Mid-Atlantic Ridge area. This fishery was mainly targeting at orange roughy and black scabbard fish, and was undertaken in the period 13 February to 9 March 2008 in ICES Areas X and XII according to a resolution adopted at the 26th Annual Meeting of NEAFC on management measures for orange roughy. The fishery was performed with one trawler (M/S Ran TG0752) with many years participation in the Faroese orange roughy fishery. The gear used was a bottom trawl. Locations of catches of black scabbardfish are shown in Figure 19.4.1.

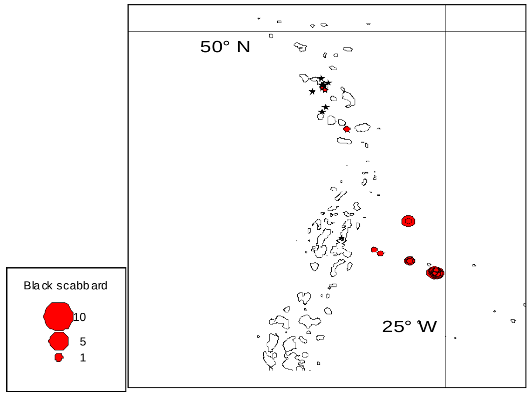


Figure 19.4.1. Faroese exploratory survey total catches of black scabbardfish (tonnes).

Total landings in "other areas" were quite variable along the years under analysis. Such variability seems to clearly reflect the ICES subarea where fisheries took place.

Landings from 1989 to 1992 were mainly derived from French trawlers operating at ICES Subarea IV (this may be misreported). In Faroese landings derived from ICES Subarea X (370 t) had significantly contributed for the maximum observed.

Landings from 1998 to 2000 were mainly derived from Portuguese longliners operating in ICES Subarea X. From 2004 onwards landings were mainly derived from Faroese trawlers both operating in ICES Subarea X. In 2009 the Faoese landings attained nearly 160 t.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Landing data are available from 1989 to present but these are derived from experimental fisheries that have been taken place in different ICES subareas and different years.

In Subareas II, IV and XIV reported landings are considered to be misreported although the extent of this is unknown.

Two species of Trichiuridae occur in the Azores, *Aphanopus. carbo* and *Aphanopus intermedius.* Landings in Subarea X may contain a mixture of these two species.

B.2. Biological

Considerable general information is available on the life-history characteristics of this species.

Recent genetic studies have shown that two species two species of Trichiuridae occurred in the Azores—*A. carbo* and *Aphanopus intermedius* and that in Pico *A. intermedius* dominated, characterized by smaller fish (Stefanni and Knutsen, 2007).

Length - Length frequency distribution based on data collected at 2008 Faroese exploratory survey for the all hauls pooled is shown in Figure 14.4.2. This distribution mainly reflects the length composition of the species from western seamounts of ICES Subarea Xb.

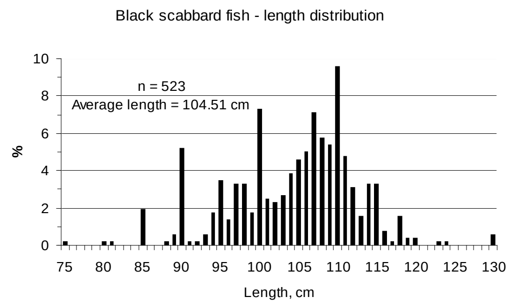


Figure 19.4.2. Faroese exploratory survey in Subarea X, 2009. Black scabbardfish. Total length distribution in all hauls.

Reproduction - ICES Subarea X - In Azorean waters females in spawning condition (GSI > 3 up to 9) with total lengths between 108 and 137 cm occurred predominantly in October and in November (J. Pereira, pers comm.). The length 108 cm corresponds to the estimate of first maturity determined for Madeira specimens. Spawners were observed around the Azores from November to April (Vinnichenko, 2002).

B.3. Surveys

No surveys are available for this stock.

B.4. Commercial cpue

No data are available for this stock.

B.5. Other relevant data

The spatial coverage of the EC TAC management units for this species does not correspond to the assessment units considered by ICES (Figure 19.4.3).

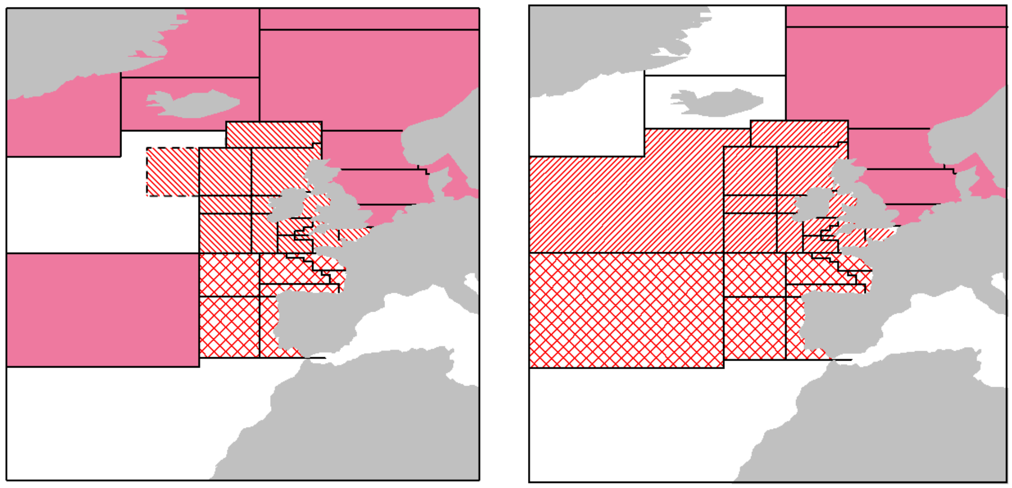


Figure 19.4.3. Black scabbardfish in other areas. ICES assessment units (left; solid pink I, II, III, IV, Va, X, XIV; diagonal lines Vb, VI, VII, XIIb; cross-hatched VIII, IX). Management areas for EU TAC, excluding CECAF areas, are shown to the right (solid pink I, II, III, IV; diagonal lines V, VI, VII, XII; cross-hatched VII, XI, X).

C. Assessment: data and method

Model used:

Only landings data available.

Software used:

Model Options chosen:

Input data types and characteristics

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

Hareide N. R., Garnes G. 2001. The distribution and catch rates of deep-water fish along the Mid-Atlantic Ridge from 43 to 61°N. Fisheries Research;51:297–310.

Vinnichenko V. I.ICES Document CM 1998/O: 18. 1998. Russian investigations and fishery on seamounts in the Azores area; p. 19.

Stefanni S., Knutsen H. 2007. Phylogeography and demographic history of the deep-sea fish, *Aphanopus carbo*, in the NE Atlantic: vicariance followed by secondary contact or speciation? Molecular Phylogeny and Evolution; 42:38–46.

Vinnichenko. 2002.

Reinert. 2010. WD

19.5 Blue ling in Va, XIV

Stock:	Blue ling in Va and XIV
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Gudmundur Thordarson

A. General

A.1. Stock definition

Biological investigations in the early 1980s suggested that at least two adult stock components were found within the Area, a northern stock in Subarea XIV and Division Va with a small component in Vb, and a southern stock in Subarea VI and adjacent waters in Division Vb. However, the observations of spawning aggregations in each of these areas and elsewhere suggest further stock separation. This is supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larval data from early studies also suggest the existence of many spawning grounds. The conclusion is that stock structure is uncertain within the areas under consideration.

However, as in previous years, on the basis of similar trends in the cpue series from Division Vb and Subareas VI and VII, blue ling from these areas has been treated for assessment purposes as a single southern stock. Blue ling in Va and XIV has been treated as a single northern stock. All remaining areas are grouped together as “other areas”.

A.2. Fishery

The change in geographical distribution of the Icelandic blue ling fisheries from 1996 indicates that there has been an expansion of the fishery of blue ling to northwestern waters. This increase is likely to be the result of increased availability of blue ling in the northwestern area, rather than being the result of an increase in effort or reporting.

The fishery for blue ling in Va changed substantially in nature and extent in the early 1980s. At the start of this period catches were high, in part because of fisheries on spawning aggregations. These aggregations diminished relatively quickly and since the mid-1980s blue ling has largely been a bycatch in the redfish and Greenland halibut fishery. In 1993, the Icelandic fleet fished on aggregations of spawning blue ling in a small area on the Reykjanes ridge at the border between Subareas Va and XIV. This was a transient fishery that declined rapidly in the years thereafter.

Before 2008 the majority of the catches of blue ling in Va were caught by trawlers, as by-catch where the main target species are cod, haddock and other demersal species. 50% of the bottom-trawl catches in 2007 were taken within the depth range of 300–700 m and 50% of the longline catches was taken at depths greater than 400 m. After 2008 there has been a substantial change in the fishery for blue ling in Va as longliners started targeting blue ling.

The gross fluctuation in catches in the late seventies, early eighties and again in the early nineties is most likely a reflection transient fisheries on spawning grounds. As a result of depletion of fish on spawning grounds, total international landings in Va declined from around 8500 t in 1980 to a level of between 2000 and 3000 t in the late 1980s. Landings were at a historical low in the late 1990s, but have increased in recent years.

Historically the fisheries in Subarea XIV have been relatively small.

A.3. Ecosystem aspects

Blue ling in Icelandic waters is mainly found on the continental shelf and slopes of south-east, south, and west of Iceland at depths of 0–1000 m, but mainly but is mainly caught in the fisheries at depths greater than 500 meters. 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 blue ling in Va.

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 blue ling.

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. Blue ling in Va is one of the few species in the Icelandic fisheries that is not included in the ITQ-system and as such not subjected to annual TAC.

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. The aim of the system is to minimize fishing on juveniles. An area is closed temporarily (for two weeks) for fishing if on-board inspections (not 100% coverage) reveal that more than a certain percentage of the catch is composed of fish less than the defined minimum length. The only restrictions on the Icelandic fleet regarding the blue ling fishery was the introduction of closed areas in 2003 to protect known spawning locations of blue ling, which are in effect during the spawning period of blue ling in Va 15th of February until 30th of April.

B. Data

B.1. Commercial catch

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)	Mat_{prop} (proportion mature-by-age)	Length composition in catch
Iceland	x				x
The Faroe Islands	x				
Norway	x				

Icelandic blue ling 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 blue ling 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 blue ling. Being a relatively valuable species and not subjected to TAC constraints nor minimum landing size there should be little incentive to discard blue ling in Va.

B.2. Biological

Biological data from the commercial longline and trawl fleet catches 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 since most blue ling 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 blue ling for every 180 tonnes landed. Each sample consists of 150 fish. Otoliths are extracted from 50 fish which are also length measured and weighed gutted. In most cases blue ling is landed gutted so it not possible to determine sex and maturity. If blue ling is landed ungutted, the ungutted weight is measured and the fish is sex and maturity determined. The remaining 100 in the sample are only length measured. Age reading of blue ling from commercial catches ended in 1998. The reason was great uncertainty in ageing and cost saving.

Earlier observations indicates that blue ling becomes mature-at-age of about 8–13 years or at around the length of 90 cm. The mean length-at-maturity is close to the mean length of blue ling in the commercial catches. This means that a large proportion of the blue ling is caught as immature.

No estimates of natural mortality are available for blue ling in Va and XIV.

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.

B.3. Surveys

For detailed description of the surveys relevant to blue ling in Va, please refer to the stock annex for tusk in Va and XIV.

The Icelandic Spring survey (March) commenced in 1985 and covers the Icelandic shelf down to 500 meters. As such the survey is not considered descriptive of biomass trends. However smaller blue ling is found at shallower depths and therefore the Spring Survey may contain valuable information on smaller and younger blue ling. This has at present not been explored.

The Icelandic Autumn survey (October) commences in 1996 and after its expansion in 2000 the survey is considered to cover the distributional range of blue ling in Va and therefore to be representative of stock biomass.

B.4. Commercial cpue

Data used to estimate cpue for blue ling in Division Va since 1991 are obtained from logbooks of the Icelandic trawl and longline fleet. 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

NA.

C. Assessment: data and method

Blue ling in Va and XIV is assessed based on trends in survey indices from the Icelandic autumn survey. Supplementary information includes relevant information from the fishery such as length distributions, maturity data, effort, cpue and analysis of changes in spatial and temporal distribution. Indices from the Icelandic spring survey may also be indicative of biomass of smaller blue ling. No data, other than landings, is available from XIV.

D. Short-term projection

No short-term predictions are performed.

E. Medium-term projections

No medium-term predictions are performed.

F. Long-term projections

No long-term predictions are performed.

G. Biological reference points

No biological reference points are defined for blue ling in Va and XIV.

H. Other issues

H.1. Historical overview of previous assessment methods

At WGDEEP-2004, exploratory runs of Delury, surplus production and stock reduction models were carried out using total international catch data for Division Va and Subareas XIV combined (1966–2003) and cpue data from Icelandic spring groundfish trawl survey (1985–2003). Although the survey data are fisheries independent and are considered to be a better indicator of changes in stock abundance than longline and trawl data from Icelandic commercial vessels, the fits from the models were generally poor reflecting a high variability of the survey-series, particularly in the early years.

I. References

19.6 Blue ling in Vb, VI, VII

Stock:	Blue ling (*Molva dypterygia*) in ICES Division Vb and Su bareas VI and VI.
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Pascal Lorance

A. General

A.1. Stock definition

Biological found within the Area, a northern stock in Subarea XIV and Division Va with a small component in Vb, and a southern stock in Subarea VI and adjacent waters in Division Vb. However, the observations of spawning aggregations in each of these areas and elsewhere suggest further stock separation. This is supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larval data from early studies also suggest the existence of many spawning grounds. The conclusion is that stock structure is uncertain within the areas under consideration.

However, as in previous years, on the basis of similar trends in the cpue series from Division Vb and Subareas VI and VII, blue ling from these areas has been treated for assessment purposes as a single southern stock. Blue ling in Va and XIV has been treated as a single northern stock. All remaining areas are grouped together as "other areas.

The assessment unit was defined as ICES division Vb and Subareas VI and VII. In Subareas VI and VII, only adults fish occur, juveniles are not caught to any significant level in. The situation is slightly different in Division Vb where some small fish occur and could be used for age and growth estimation purposes (Magnussen, 2007) but the numbers previously reported from Faroese trawl surveys do not seem significant to the size of the exploited adult stock.

Similarly, in the neighbouring ICES division, from where landings are currently a few hundred tonnes per year but have been higher in the past, only adult fish are known to be caught and these should probably be considered as the same stock as blue ling in Vb, VI and VII.

Spawning areas

Blue ling is known to concentrate of spawning aggregation. From 1970 to 1990, the bulk of the fishery for blue ling was seasonal fisheries targeting these aggregations, which are subject to sequential depletion. Known spawning aggregations are shown in Figure 19.6.1. In Iceland, the depletion of the spawning aggregation in a few years was documented (Magnússon and Magnússon, 1995) and blue ling is an aggregating species at spawning time. To prevent depletion of adult populations temporal closures have been set both in the Icelandic and EU EEZs.

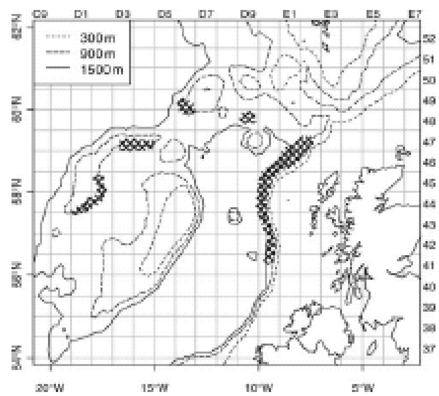


Figure 19.6.1. Known spawning areas of blue ling to the West of Scotland (from Large *et al.*, 2010).

A.2. Fishery

The main fisheries are those by Faroese trawlers in Vb and French trawlers in VI and, to a lesser extent, Vb. Total international landings from Subarea VII are small bycatch in other fisheries. In Subarea Vb and Division VI, other fisheries landings blue ling are the Norwegian longline fishery for ling and tusk where blue ling is a bycatch and Scottish trawlers. Landings from these fleets have been small since the 2000s but where high in the 1960s and 1970s for some fleet. Landings from Subareas VIII and IX previously reported as blue ling are now ascribed to the closely related Spanish ling (*Molva dypterygia*) and blue ling is not known to occur to any significant level in these Subareas. The area of distribution of the stock is limited to somewhere between 50 and 55°N along the Porcupine Bank slope (Bridger, 1978; Ehrich, 1983, Lorance *et al.*, 2009).

Landings by Faroese trawlers are mostly taken in the spawning season. Historically, this was also the case for French trawlers fishing in Vb and VI. However, in recent years blue ling has been taken mainly as a bycatch in French trawl fisheries for roundnose grenadier, black scabbardfish and deep-water sharks.

The rapid increase in the size of this fishery in the early 1970s is considered to be related to the expansion of national fisheries limits to 200 nautical miles and the resultant displacement of fishing effort and the associated development of markets.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

B. 1.1. Landings and discards

In 2008, the landings time-series from the southern blue ling stock was extended back to 1966 based upon Northwestern Working Group reports from 1989–1991 and data in Moguedet, (1988). Landings data in the 1980s for French freezer trawlers may be underestimated in some years but were included in 2011 for years 1988–2000.

Large French catches were reported as ling at the start of the fishery in 1973–1975. In order to derive a best estimate of blue ling landings, the average ling landings in the years preceding the start of the French blue ling fishery were subtracted from estimates of blue ling and ling combined.

Landings data by ICES statistical rectangles have been provided by France, (UK) Scotland, UK (England and Wales) and Ireland and have been aggregated by quarter and plotted to display the geographical distribution of the fishery by year starting from 2005.

Blue ling is not discarded to any significant level because no small blue ling are caught in the fishery.

In 2008, the landings time-series from the southern blue ling stock was extended back to 1966 based upon Northwestern Working Group reports from 1989–1991 and data in Moguedet, (1988). Landings data in the 1980s for French freezer trawlers may be underestimated in some years.

Large French catches were reported as ling at the start of the fishery in 1973–1975. In order to derive a best estimate of blue ling landings, the average ling landings in the years preceding the start of the French blue ling fishery were subtracted from estimates of blue ling and ling combined.

B.2. Biological

Available growth parameter in length and weight for blue ling are summarized in Tables 19.6.1 and 19.6.2 and maturity parameters in Table 3.

Table 19.6.1. Growth parameters of blue ling.

L∞ (cm)	K (year-1)	t0	Number of fish	Age range	Sex	Maximum observed size	Area	Reference
160	0.11	N/A	79	3–17	Combined		Faroe Bank	Magnussen, 2007
165.8	0.084	-0.138	N/A	?–20	Female	147 (1)	ICES VIa	Moguedet, (1985, 1988)
112.2	0.158	0.318	N/A	? –19	Male	110	ICES VIa	(1)
125	0.152	1.559	2619	5-25 (2,3)	Combined	136 (3)	Vb VIa,b	
145.2	0.155	1.281	1412		Female		Vb VIa,b	Ehrich and Reinsch, 1985
109.7	0.199	1.833	1391		Males		Vb VIa,b	(4)
116.25	0.17	0.57	590	5–20+	Female	130	Faroe Islands (5)	
104.2	0.197	0.57	331	5–20+	Male	107	Faroe Islands (5)	
137.37	0.13	0.46	117	6–18+	Female	139	Shetland Islands (5)	Thomas, 1987
108.31	0.185	0.57	227	5–20+	Male	109	Shetland Islands (5)	
			563	20 +	Female	138.5 (7)	Icelandic slope	
			431	17	Male	115 (7)	Icelandic slope	
			1492	20+ (6)	Combined	137.86 (7)	Icelandic slope	
			?	?	Combined	145-150 (8)	Iceland and RR (9)	Magnússon and Magnússon, 1995
			?	?	Female	140	Spawning aggreg. RR (9)	
			?	?	Male	124	Spawning aggreg. RR (9)	
			1399		Combined	130–135 (10)	West of the British Isles	Bridger, 1978
					Female	Ca. 145 (11)	West of the British Isles	Ehrich, 1983
					Males	Ca. 112 (11)	West of the British Isles	
			240 (♂+♀)		Female	150–155 (12)	West of the British Isles	Gordon and Hunter, 1994
			240 (♂+♀)		Male	110–115 (12)	West of the British Isles	Gordon and Hunter, 1994
			197		Combined	140	Norwegian Deep	Bergstad, 1991

(1) from sampling in 1984–1985; Female>= 130cm were 3% of total female numbers; (2) the bulk in age groups 7–20;(3) from length distribution of German landings 1980 and 1982; (4) estimates based upon length and age data from sampling of German blue ling landings (Ehrich and Reinsch, 1985). (5) based upon sampling in 1977 and 1979 (Shetland Islands) and 1977 and 1978 (Faroe Islands); areas are defined according to Thomas, (1987). (6) Magnússon and Magnússon (1995) reported mean length by age for the years 1978–1982. In their sample (n=1492), there was 7 fish of the age group 20+. (7) from age estimation sample; mean length of the oldest age group: 6 individuals for females, 1 for males, 7 combined; (8) visually from length distribution plots; few fish above 130 cm; (9) RR: Reykjanes Ridge; (10) from a plot of length distribution by 5 cm length classes. Largest length class was 130–135 cm. It included 1–2% of total number of fish measured, they modal size class was 95–99 cm; (11) from plot, modal size by 120 cm for females and 95 cm for males. (12) From SAMS surveys (unpublished data), from histogram by 5 cm size classes. Modal sizes of 95–100 cm for males and 105–110 for females, n=240 (sex combined).

Table 19.6.2a. Growth parameters in weight.

W∞ (g)	K	t0	Number of fish aged	Length range (TL, cm)	Age range (y)	Sex	Reference	Area
19 688	0.094		79	NA	3–17	Combined	Magnussen, 2007	Faroe Islands
5191						Male	Ehrich and Reinsch, 1985	
13 166						Female	Ehrich and Reinsch, 1985	

Table 19.6.2b. Maturity parameters, A50: age at 50% maturity; m: rate at which the population attains maturity (Magnussen, 2007); L50 length at 50% maturity; M50 weight at 50% maturity.

Sex	Area	A50	m	L50 (cm)	M50 (g)	Reference
Combined	Faroe Bank	6.2	1.66	79	1696	Magnussen, 2007
Female	Iceland	11	N/A	88	N/A	Magnússon and Magnússon, 1995
Male	Iceland	9	N/A	75	N/A	Magnússon and Magnússon, 1995
Female	Faroe Islands	8.1	N/A	N/A	N/A	Thomas, 1987 (1)
Male	Faroe Islands	6.4	N/A	N/A	N/A	Thomas, 1987 (1)
Female	South and West of the Faroe Islands	7	N/A	85		Magnússon *et al*., 1997
Male	South and West of the Faroe Islands	6	N/A	80		Magnússon *et al*., 1997
Combined	ICES IIa	N/A	M/A	75		Joenes, 1961

(1) The author specified that not too much significance should be given do the result because very few immature fish were caught and stated "it might be sufficient to know that the fish mature at an age between 6 and 8 years".

B. 2.1. Length composition

Length composition of the landings have been available from Faroese trawlers in Division Vb since 1996 and French trawlers in Division VIa since 1984. Mean length of blue ling from the Norwegian reference fleet in Divisions Vb, VIa, VIb are also provided.

Age estimation of blue was carried out in the past and was disrupted because of poor consistency between readers. Nevertheless, there is a general agreement that blue ling recruits to this stock at a size of 70–80 cm have an age of 6–8 years. Otoliths readings of blue ling sampled from the French landings were resumed in 2009 in application of DCF. Age readings of blue ling seem relatively straightforward and the reading scheme do not significantly differ for that of most gadoid species although the number of growth increments to count is higher. Nevertheless, age estimation for this species are unvalidated.

B.2.3. Weight-at-age

No time-series but overall weight-at-age are derived from age–length keys and length–weight relationships.

B 2.4. Maturity and natural mortality

Natural mortality (M). was estimated using the relationship (Annala, J. H., Sullivan, K. J., 1996):

$$M = \ln(100)/\text{maximum age}$$

In this relationship, the maximum age should be set at the age where 1% of a year class is still alive. Based on Faroese and French age readings, it is reasonable to assume the maximum age for blue ling is around 30 years. Given this and the relationship above, M may be in the order of 0.15.

Juvenile blue ling are not known to occur on the fishing nor in Subareas Vb, VI and VII to any significant level. Fish recruit to this area and to the spawning–stock at an age of 6 to 8 years. All blue ling occurring in Vb, VI and VI can be considered as mature fish.

B.3. Surveys

Weight and number per hour trawling in the Faroese spring survey since 1994 have been provided. Number have been provided for small (<80 cm) and large (>80 cm) fish. However, it was stressed that these surveys are limited to depth shallower than 500 m. These number have been small are have not been taken into account in assessment in any way. There is however a need to analyse these data to assess their representativity of variation of blue ling abundance in Vb.

An index of abundance in number per hour was available from a Scottish deep-water survey to the west of Scotland for years 1998–2009. The fish community of the continental shelf slope to the northwest of Scotland has been surveyed by Marine Scotland-Science since 1996, with strictly comparable data available between 1998 and 2008. This has focused on a core area between 55–59°N, with trawling undertaken at depths ranging from 300 to 1900 m with most of the hauls being conducted at fixed stations, at depths of around 500 m, 1000 m, 1500 m and 1800 m. Further hauls have been made on seamounts in the area, and on the slope around Rockall Bank, but these are exploratory, irregular and are not taken into account in the index of abundance.

This survey was conducted biennially, in September, until 2004, and annually in 2004–2009. Locations of trawl sites between depths of 500–1500 m are shown in Figure 19.6.2. From 1998 to 2008 the bottom trawl was rigged with 21″ rock-hopper groundgear, however in 2009, a switch was made to lighter groundgear, with 16″ bobbins.

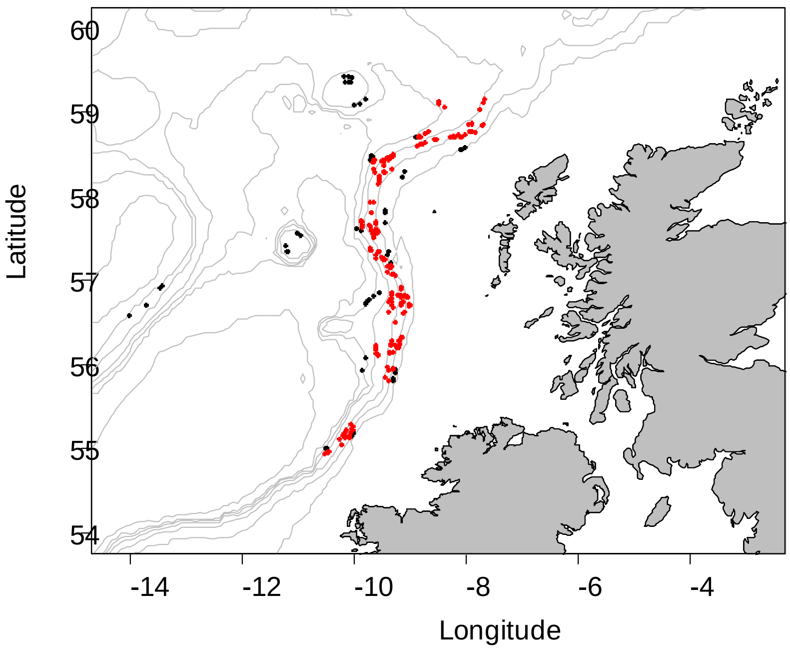


Figure 19.6.2. Sites of valid hauls in the 500–1500 m depth band in the Scottish Deep-water Survey dataset, 1998–2009 (in red). Valid hauls at other depths are shown in black.

An index of abundance was available from an Irish deep-water trawl survey of the fish community of the continental shelf slope to west and northwest of Ireland carried out from 2006 to 2009. The sampling protocol of this survey was standardized in accordance with the Scottish deep-water survey with trawling at fixed stations around 500 m, 1000 m, 1500 m and 1800 m. The gear used throughout the survey-series was the same as that used by Scotland in 2009. To be consistent across the years the haul data used for the index calculation only includes the areas that are covered in all four years and the depth bands (500–1500 m) that are covered in all four years. In total, the dataset comprised 42 valid hauls.

B.4. Commercial cpue

A French deep-water tallybook database (based on fishers' own records) developed by the French industry is use to compute landings per unit of effort (lpue) indices starting from year 2000 (Lorance *et al.*, 2010). The database includes more years back to 1992 with landings of blue ling back to 1993. However, there is not enough data one blue ling before 2000 because of different components of deep-water vessels being included and small catch of blue ling from vessel contributing to the data in 1993–1999. The abundance index is standardized using a GAM model.

To represent the spatial aspect in the model, five small areas where the fleet has caught blue ling were defined as cluster of ICES rectangles (Figure 19.6.3). Fishing area definition was based on ICES (2006), in which reference fishing grounds, exploited since the 1990s (ref5, ref6) and new fishing grounds, i.e. not fished by French trawlers for fresh fish before 200 (new5 and new6) were defined in ICES Division Vb and Subareas VI respectively. Area ref6 was further split between statistical rectangles from the slope to the west of Scotland, along the Rockall Trough, referred to as edge6, and other rectangles, referred to as other6 (Figure 19.6.3).

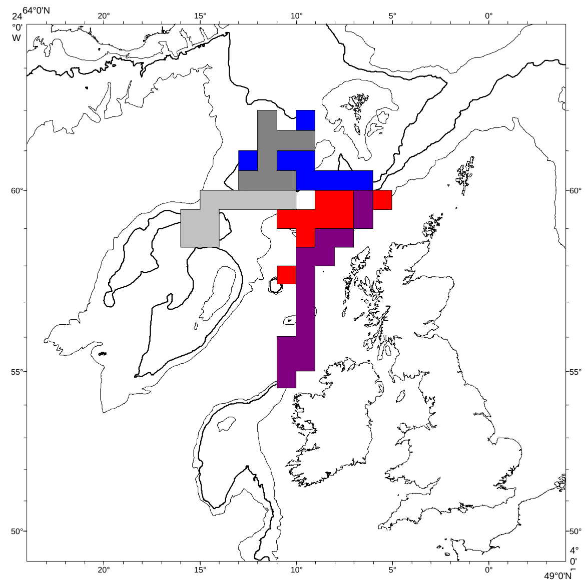


Figure 19.6.3. Areas (clusters of statistical rectangles) used to calculate French lpue for blue ling. Dark grey, new grounds in ICES Division Vb (new5); light grey, new grounds in Subarea VI (new6); red, others in Subarea VI (other6); purple, edge in VI (edge6); blue, reference in Division Vb (ref5).

The GAM models has the form:

log(E[landings]) = s(haul duration) + s(depth) + month + vessel.id+ rectangle + year :Area

where E[] denotes expected value, s() indicates a smooth non-linear function (cubic regression spline), vessel.id the vessel identity and year:area an interaction term. The dependent variable was landings and not lpue, which allows including haul duration as explanatory variable and have a non-proportional relationship between landings and fishing time. The fit was done assuming a Tweedie distribution of the dependent variable with a log-link function using the mgcv package in R (Wood, 2006).

The Tweedie distribution has mean μ and variance $\phi\mu^p$, where ϕ is a dispersion parameter and p is called the index. As a Poisson-Gamma compound distribution was used, $1<p<2$, the index p could not be estimated simultaneously with the model parameters. In 2010, a detailed study was carried out and p=1.7 provided the best fit. A model with a gamma distribution fit to haul where roundnose grenadier made up >= 10% of the total catch gave similar results.

The model fit was restricted to haul durations from 60 to 300 minutes and depth 700–1500 m covering the species depth range and excluding too short and long hauls for which there is a few data.

This lpue standardization method allowed estimating lpue time-trends for the five small areas. In order to derive standardized lpue for the whole area, lpue were predicted for all rectangles in the five small areas (using average haul depth in each rectangle and five hours haul duration) and averaged.

B.5. Other relevant data

No other relevant data.

C. Assessment: data and method

There is no benchmark assessment method for this stock. All assessments described below are exploratory.

Model used: SRA.

Stock reduction analysis (SRA) is a developed form of delay-difference model (Quinn and Deriso, 1999). The method uses biological parameters and information for time delays due to growth and recruitment to predict the basic biomass dynamics of age structured populations without requiring information on age structure. Thus, it can be considered to be a conceptual hybrid between dynamic surplus production and full age based models (Hilborn and Walters, 1992). A full description of the general approach can be found in Kimura and Tagart (1982), Kimura *et al*. (1984) and Kimura (1985 and 1988); (Large, unpublished 2002).

Software used: *FLaspm*

FLaspm is a package for the statistical computing environment R (R Development Core Team, 2010). The package is open source and is currently hosted at GoogleCode (the source code is freely available at http://code.google.com/p/deepfishman/. *FLaspm* is part of the FLR project (Kell *et al*., 2007) and requires that the package *FLCore* is also installed (v > 2.3). The stock reduction model used in this analysis implements the model described in Francis (1992) and is capable of fitting multiple indices simultaneously. The method requires time-series data of annual catches, one or more abundance index and a range of biological parameters. The effect of these biological parameters on results is investigated using sensitivity analysis. A Beverton–Holt stock–recruitment relationship with a steepness of 0.75 is used throughout.

Input data:

Total international landings from 1966 should be used for this assessment. Three tuning indices were available: French abundance index derived from skipper tallybook data (2000 to 2009), Marine Scotland's FRV SCOTIA deep-water survey (1998 to 2009) and Irish (2006 to 2009).

Other stock indicators

Change in mean length in the landings, catch curve to estimate total mortality Z are used to track trends in the stock.

Model Options chosen:

Input data types and characteristics:

Parameter	Symbol	Value
Maximum age	Amax	30
Natural mortality	M	0.15
Steepness of Beverton–Holt stock–recruitment relationship	h	0.75
Age of first selectivity	Asel	7
Age of maturity	Amat	7

Parameter	Symbol	Value
von Bertalanffy growth parameters	$L\infty$	125 cm
	k	0.152
	t0	1.552
Length–weight parameters	a	2e-6
	b	3.15

D. Short-term projection

No short-term predictions are carried out for this stock.

E. Medium-term projections

None.

F. Long-term projections

None.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

The stock identity is an issue for blue ling. The only area were juvenile are known to occur in large numbers in the Icelandic shelf. No juvenile are known to occur in Subareas VI and VII and number observed in the Faroese survey (about one fish smaller than 80 cm per hour) and for blue ling size up to 80 cm cover age up to 6–7 years.

H.1. Historical overview of previous assessment methods

Exploratory assessment carried out far are summarized below (synthesis carried out as part of the DEEPFISHMAN project).

Year	Assessment type[3]	Method	Assessment package/ program used	Used for advice?	If not, what was latest scientific advice based on?
1998	Exploratory	Schaefer & DeLury depletion model	CEDA ([1])	No	French OTB and Faroese longline lpue
2000	Exploratory	Schaefer & DeLury depletion model	CEDA ([1])	No	French OTB unstandardized lpue

[3] Exploratory, Benchmark (to identify best practise), Update (repeat of previous years' assessment using same method and settings but with the addition of data for another year).

2004	Exploratory	Schaefer, Pella-Tomlinson and Fox production models & DeLury depletion model	CEDA ([1])	No	Trend in French commercial otter trawl lpue
	Exploratory	Stock reduction	PMOD	No	Trend in French commercial otter trawl lpue
2006	Exploratory	Catch Survey analysis	CSA (Mesnil, 2003)	No	Trend in French commercial otter trawl lpue

([1]) MRAG (UK) software.

Summary of data ranges used in recent assessments:

Data	2007 assessment	2008 assessment	2009 assessment	2010 assessment
Landings	Years: 1988–2006	Years: 1988-2007	Years: 1966–2008	Years: 1966–2009
Quarterly length dist. of French landings	Years: 1989–2006	Years: 1984–2007	Years: 1984–2008	Years: 1984–2010
Quarterly length dist. of Faroese landings	Years: 1995–2006	Years: 1995–2007	Years: 1995–2008	Years: 1995–2009
Quartely age dist.				Year: 2009
Survey: Scottish deep-water			Years: 1998–2008 N° per hour	Years: 1998–2009 N° per hour
Survey: Irish				Years: 2006–2009 N° per hour
Survey: spring and autumn Faroese				Years: 1994–2009 N° per hour Size
Haul-by-haul lpues from French trawlers	Not used	Not used	Years: 2000–2008	Years: 2000–2009
Aggregated unstandardized French lpue	Years: 1989–2006	Years: 1989–2007	Years: 1989–2008	Not used

I. References

Annala, J. H., and Sullivan, K. J. 1996. Report from the Fishery assessment plenary, April-May 1996: stock assessments and yield estimates. 308 pp.

Bridger, J. P. 1978. New deep-water trawling grounds to the West of Britain. Laboratory Leaflet, Ministry of Agriculture Fisheries and Food (MAFF), Directorate of Fisheries Research, Lowestoft, United Kingdom.

Ehrich, S. 1983. On the occurrence of some fish species at the slopes of the Rockall Trough. Archiv für Fischereiwissenschaft, 33: 105–150.

Hilborn, R., and Walters, C.J. 1992. Quantitative Fisheries Stock Assessment – Choice, Dynamics and Uncertainty. New York & London. Chapman & Hall.

Kell, L. T., Mosqueira,I,. Grosjean, P., Fromentin,J., Garcia,D., Hillary,R., Jardim,E., Mardle,S., Pastoors,M. A., Poos,J. J., Scott,F. and Scott,R. D. 2007. *FLR: An open-source framework for the evaluation and development of management strategies,* ICES Journal of Marine Science, 64(4), 640–646.

Kimura, D.K., and Tagart, J.V. 1982. Stock reduction analysis, another solution to the catch equations. Canadian Journal of Fisheries and Aquatic Sciences, vol. 3 no. 11, pp 1467–1472.

Kimura, D.K., Balsiger, J.W., Ito, D.H. 1984. Generalised stock reduction analysis. Canadian Journal of Fisheries and Aquatic Sciences, vol. 41, no. 9, pp 1325–1333.

Kimura, D.K. 1985. Changes to stock reduction analysis indicated by Schnute's general theory. Canadian Journal of Fisheries and Aquatic Sciences, vol. 42, no. 12, pp 2059–2060.

Kimura, D.K. Stock–recruitment curves as used in the stock reduction analysis model. 1988. J. CONS. CIEM., vol. 44, no. 3, pp 253–258.

Large, P.A. 2002. The use of stock reduction analysis to assess deep-water species in the ICES area – an initial investigation (WD to ICES WGEEP, 2002).

Large, P. A., Diez, G., Drewery, J., Laurans, M., Pilling, G. M., Reid, D. G., Reinert, J., South, A. B., and Vinnichenko, V. I. 2010. Spatial and temporal distribution of spawning aggregations of blue ling (*Molva dypterygia*) west and northwest of the British Isles. ICES Journal of Marine Science, 67: 494–501.

Lorance, P., Pawlowski, L., and Trenkel, V. M. 2009. Deriving blue ling abundance indices from industry haul by haul data (communication ecrite). ICES Annual Science Conference, Berlin, 21–25 September 2009, ICES CM 2009/L:12, 25 pp.

Lorance, P., Pawlowski, L., and Trenkel, V. M. 2010. Standardizing blue ling landings per unit effort from industry haul-by-haul data using generalized additive models. ICES Journal of Marine Science, 67: 1650–1658.

Magnussen, E. 2007. Interpopulation comparison of growth patterns of 14 fish species on Faroe Bank: are all fishes on the bank fast-growing? Journal of Fish Biology, 71: 453–475.

Magnússon, J. V., and Magnússon, J. 1995. The distribution, relative abundance, and biology of the deep-sea fishes of the Icelandic slope and Reykjanes Ridge. *In:* Hopper, A. G., Deep-water fisheries of the North Atlantic oceanic slope. Kluwer Academic Publishers, Dordrecht/Boston/London, 161–199.

Mesnil, B. 2003. The Catch-Survey Analysis (CSA) method of fish stock assessment: an evaluation using simulated data. Fisheries Research (Amsterdam), 63: 193–212.

Quinn T.J. and Deriso R.B. 1999. *Quantitative Fish Dynamics*. Oxford University Press. New York. 1999. 542p.

R Development Core Team. 2010. *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria.

Wood, S. N. 2006. Generalized additive models. An introduction with R. Chapman and Hall/CRC, Boca Raton.

19.7 Blue ling other areas

Stock:	Blue ling in Subareas I, II, III, IV, VIII, IX, X and XII.
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Pascal Lorence

A. General

A.1. Stock definition

Biological investigations in the early 1980s suggested that at least two adult stock components were found within the Area, a northern stock in Subarea XIV and Division Va with a small component in Vb, and a southern stock in Subarea VI and adjacent waters in Division Vb. However, the observations of spawning aggregations in each of these areas and elsewhere suggest further stock separation. This is supported by differences in length and age structures between areas as well as in growth and maturity. Egg and larval data from early studies also suggest the existence of many spawning grounds. The conclusion is that stock structure is uncertain within the areas under consideration.

However, as in previous years, on the basis of similar trends in the cpue series from Division Vb and Subareas VI and VII, blue ling from these areas has been treated for assessment purposes as a single southern stock. Blue ling in Va and XIV has been treated as a single northern stock. All remaining areas are grouped together as "other areas.

A.2. Fishery

Blue ling has been an important bycatch in trawl fisheries for mixed deep-water species on Hatton Bank (Division XIIb) although historically there have been directed fisheries on spawning aggregations in that area. Historiclly there was a directed fishery on spawning aggregations in Subarea II but now this species is now only taken as bycatch in Norwegian longline fisheries in this area. In other areas blue ling is taken in small quantities. Small reported landings in Subareas VIII, IX and X probably refer to *Molva macropthalma*.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Full landings data are available from 1988 to present but it is thought that fisheries in some of these areas pre-date the time-series. Incomplete landings data are available from Norwegian longline fisheries from 1889 onwards. Additional landings data from other areas may be available from 1950 onwards.

There is limited data on discarding from Spanish observers in Subarea XII. Discard data for other areas is unavailable but it is thought the discarding of this species is insignificant.

B.2. Biological

No data available.

Considerable general information is available on the life-history characteristics of this species.

B.3. Surveys

No data available.

B.4. Commercial cpue

No data available.

B.5. Other relevant data

C. Assessment: data and method

Model used: Landing trends (total landings split on area and countries).

Software used:

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Split on areas and countries Yes/No	Variable from year to year Yes/No
Caton	Catch in tonnes	1988–2010	Yes	No

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

19.8 Greater forkbeard in all areas

Stock:	Greater forkbeard in all ecoregions
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Guzman Diez

A. General

A.1. Stock definition

The greater forkbeard is a gadoid fish which is widely distributed in the northeastern 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 stock 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 19.8.3 and 19.8.4 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 not at all) identified. Only historical series of length frequencies from surveys were available.

Table 19.8.3. 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	2	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	Cohen *et al.*, 1990(1,2)
	male	18 cm	Mediterranean	Cohen *et al.*, 1990(1,2)
	female	32 cm	NE Atlantic	Kelly, 1997
	male	31 cm	Mediterranean	
Age at 50% maturity Combined (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
		8 cm	VIIIa,b,d (Oct.–Nov.)	Data from French western IBTS
		8 cm	VIIg-k (Oct.–Nov.)	Data from French western IBTS

LHC	SEX	ESTIMATE	AREA (month)	REFERENCE
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

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

Table 19.8.4. 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 cpue

Commercial effort (number of total trips) and lpue (kg/day) is available from the Basque Country trawler fleet (OTB and PTB) operating in Subareas VI, VII and VIII from 2001 to 2010.

B.5. Other relevant data

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. 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.

C. Assessment: data and method

Model used:

Not applicable

Software used: Not applicable

Model Options chosen: Not applicable

Input data types and characteristics

D. Short-term projection

Not applicable

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Not applicable

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

Not applicable

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

19.9 Greater silver smelt in 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 19.9.1 and Table 19.9.1).

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.

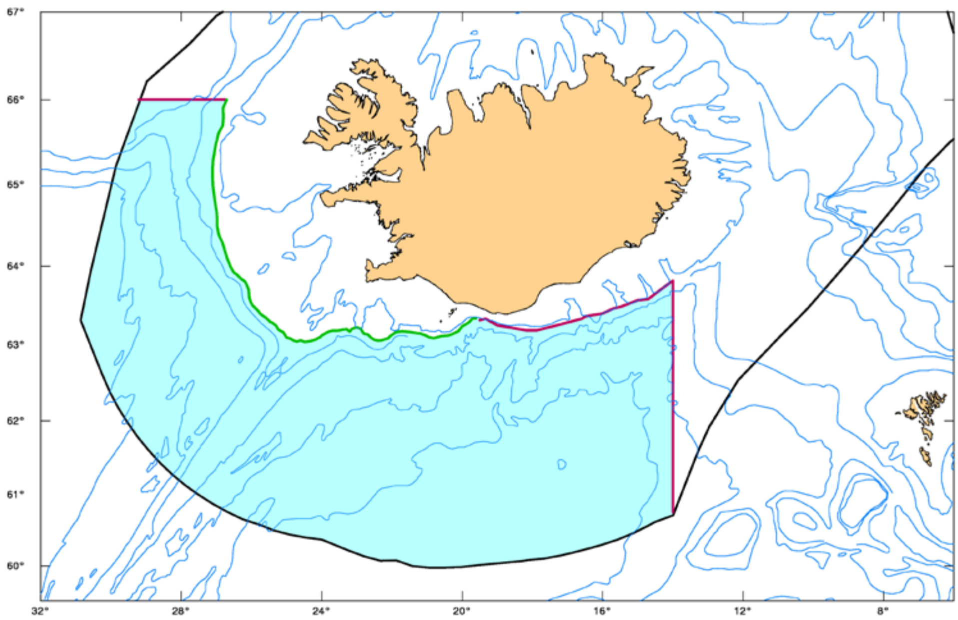


Figure 19.9.1. Area open to commercial fishing of Greater Silver Smelt in Va according to regulation nr 717, 6th of October 2000 with amendments 1138/2005 from the Ministry of Fisheries (the shaded blue area). The red-line off the south coast drawn according to Table 19.9.1 and the green line is an approximation of the 400 m depth contour.

A.3. Ecosystem aspects

Warming of sea temperature has 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 ungutted 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, a total of 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. Altogether 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. Altogether 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 since 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 19.9.2).

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".

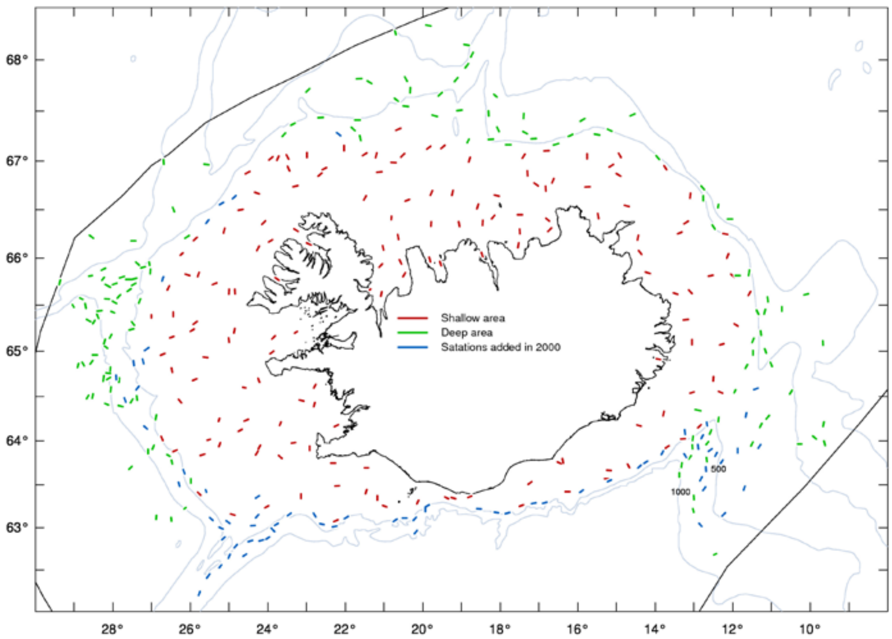


Figure 19.9.2. Stations in the Autumn Groundfish Survey (AGS). RV "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and RV "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

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 four 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 one 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, ten 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, Windspeed, 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". 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 four 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 two 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 19.9.3. 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.

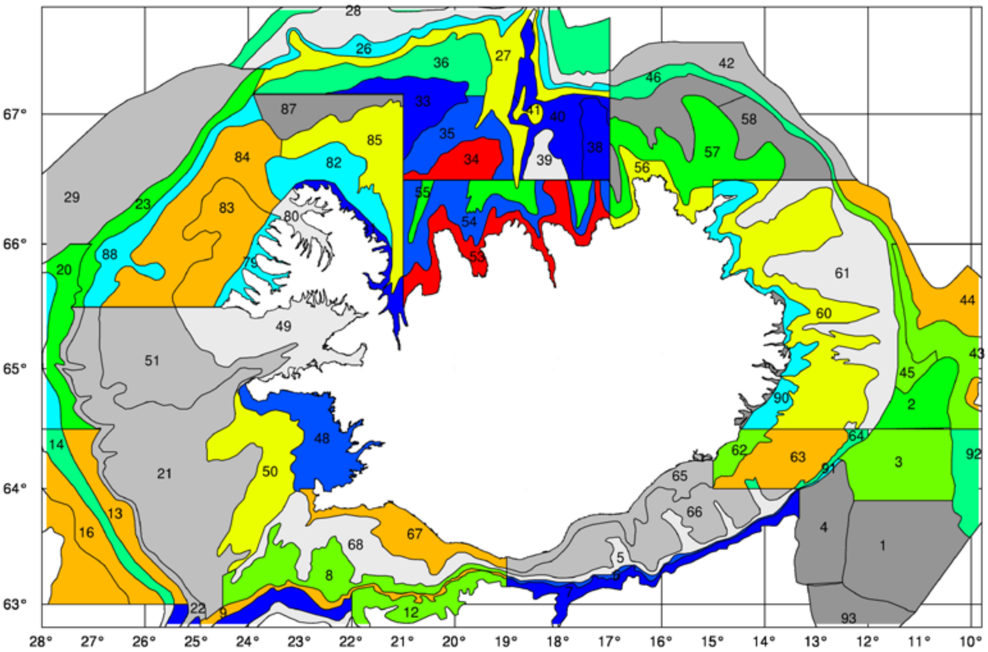


Figure 19.9.3. Subareas or strata used for calculation of survey indices in Icelandic waters.

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 19.9.1 and Figure 19.9.4).

Table 19.9.1. 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

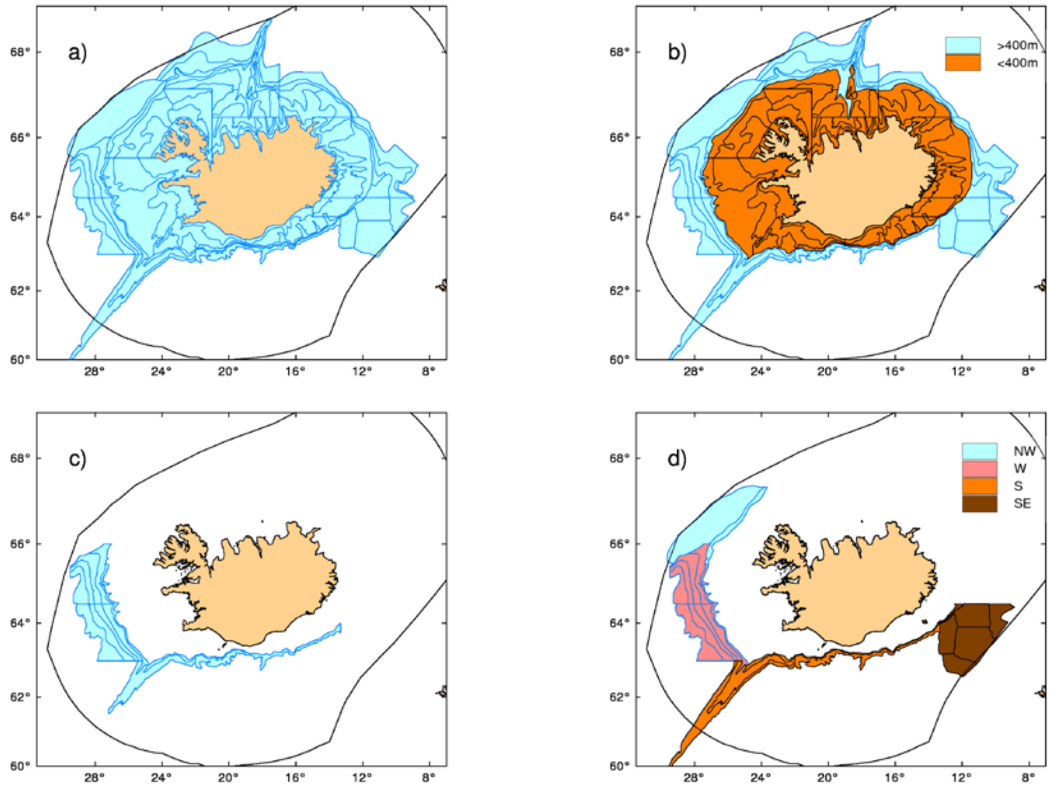


Figure 19.9.4. Divisions used in calculation of indices for greater silver smelt in Va. a) Total area. b) Division at 400 m depth contour. c) Greater silver smelt fishing area. d) Subdivisions of the main distributional area of greater silver smelt.

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 numbers 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 needed. 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.

19.10 Ling in I and II

Stock:	Ling in Subareas I and II
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Kristin Helle

A. General

A.1. Stock definition

WGDEEP 2006 indicated: '*There is currently no evidence of genetically distinct populations within the ICES area. However, ling at widely separated fishing grounds may still be sufficiently isolated to be considered management units, i.e. stocks, between which exchange of individuals is limited and has little effect on the structure and dynamics of each unit. It was suggested that Iceland (Va), the Norwegian Coast (II), and the Faroes and Faroe Bank (Vb) have separate stocks, but that the existence of distinguishable stocks along the continental shelf west and north of the British Isles and the northern North Sea (Subareas IV, VI, VII and VIII) is less probable. Ling is one of the species included in a recently initiated Norwegian population structure study using molecular genetics, and new data may thus be expected in future*'

A.2. Fishery

Ling has been fished in these Subareas for centuries, and the historical development is described in, e.g. Bergstad and Hareide (1996). In particular, the post-World War II increase in catch, because of a series of technical advances, is well documented. Currently the major fisheries in Subareas I and II are the Norwegian longline and gillnet fisheries, but there are also bycatches taken by other gears, i.e. trawls and handlines. Around 50% of the Norwegian landings are taken by longlines and 45% by gillnets, partly in the directed ling fisheries and partly as bycatch in fisheries for other groundfish. Other nations catch ling as bycatch in their trawl fisheries.

During the period 2000–2005 the landings varied between 6000 and 7000 tonnes, which are about the same catches as in the preceding decade. In 2007 and 2008 the landings increased to over 10 000 tonnes.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Full landings data are available from 1988 to present but it is thought that fisheries in some of these areas pre-date the time-series. Incomplete landings data are available from Norwegian longline fisheries from 1889 onwards. Additional landings data from other areas may be available from 1950 onwards.

B.2. Biological

Length data for the Norwegian reference fleet in Subarea IIa have been routinely collected since 2002.

Considerable general information is available on the life-history characteristics of this species.

B.3. Surveys

No data available.

B.4. Commercial cpue

Norway started in 2003 to collect and enter data from official logbooks into an electronic database and data are now available for the period 2000–2009. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding eight tonnes in a given year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. Cpue were calculated as the average total catch of ling per vessel (*C*), and the average number of hooks per set and per vessel (*N*) associated with these catches. Then, for each year and catch category, the estimated cpue for the entire fleet was determined as *C*/*N*. Thus the estimated cpue for each year and subarea was the mean catch in kg per hook for the entire fleet.

The boats that provided logbooks are the primary sampling units, and *C* and *N* are both random variables. It follows that this is a ratio-type estimator, therefore the standard errors of the cpue estimates could be calculated as described in Cochran (1977, page 32). This cpue estimator is a weighted average, that is the more hooks a boat sets, the more influence it has on the estimate (Cochran, 1977). For comparison, an unweighted cpue series was also constructed (i.e. the average cpue per boat).

A standardized series will be developed in preparation for WGDEEP 2012.

B.5. Other relevant data

C. Assessment: data and method

Model used: The stock is assessed using trends in catch and cpue.

Software used:

Model Options chosen:

Input data types and characteristics

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

19.11 Ling in Va

Stock:	Ling in Va
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Gudmundur Thordarson

A. General

A.1. Stock definition

WGDEEP 2006 indicated: '*There is currently no evidence of genetically distinct populations within the ICES area. However, ling at widely separated fishing grounds may still be sufficiently isolated to be considered management units, i.e. stocks, between which exchange of individuals is limited and has little effect on the structure and dynamics of each unit. It was suggested that Iceland (Va), the Norwegian Coast (II), and the Faroes and Faroe Bank (Vb) have separate stocks, but that the existence of distinguishable stocks along the continental shelf west and north of the British Isles and the northern North Sea (Subareas IV, VI, VII and VIII) is less probable. Ling is one of the species included in a recently initiated Norwegian population structure study using molecular genetics, and new data may thus be expected in future*'.

WGDEEP 2007 examined available evidence on stock discrimination and concluded that available information is not sufficient to suggest changes to current ICES interpretation of stock structure.

A.2. Fishery

The fishery for ling in Va has not changed substantially in recent years. Around 150 longliners annually report catches of ling, around 70 gillnetters and a similar number of trawlers. Most of ling in Va is caught on longlines and the proportion caught by that gear has increased since 2000 to around 65% in 2010. At the same time the proportion caught by gillnets has decreased from 20–30% in 2000–2001 to 4–8% in 2008–2010. Catches in trawls have varied less and have been at around 20%.

Most of the ling caught in Va by Icelandic longliners is caught at depths less than 300 meters and less than 500 meters by trawlers. The main fishing grounds for ling in Va as observed from logbooks are on the south, southwestern and western part of the Icelandic shelf.

In the 1950s until 1970 the total landings of Ling in Va amounted to 10 000 to 16 000 tonnes annually of which more than half was usually caught by foreign fleets. This changed with the extension of the Icelandic EEZ in the early 1970s when total landings fell to 4000–8000 tonnes of which the Icelandic fleet caught the main share. Between 1980 and 2000 catches varied between 3200 to 5800 tonnes.

A.3. Ecosystem aspects

Ling 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 but is mainly caught in the fisheries at depths around than 200–500 meters. 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 ling in Va.

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 ling.

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 commercially exploited fish species were included in the ITQ system, but many other species have gradually been included. Ling in Va was included in 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. The aim of the system is to minimize fishing on juveniles. An area is closed temporarily (for two weeks) for fishing if on-board inspections (not 100% coverage) reveal that more than a certain percentage of the catch is composed of fish less than the defined minimum length.

B. Data

B.1. Commercial catch

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)	Mat_{prop} (proportion mature-by-age)	Length composition in catch
Iceland	x				x
The Faroe Islands	x				
Norway	x				

Icelandic B_{ling} 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 ling 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. Based on limited data discard rates in the Icelandic longline fishery for ling are estimated very low (<1% in either numbers or weight; WGDEEP-2011, WD02). Measures in the management system such as converting quota share from one species to another are used by the fleet to a large extend and this is thought to discourage discards in mixed fisheries.

B.2. Biological

Biological data from the commercial longline and trawl fleet catches 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 since most ling 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 ling for every 180 tonnes landed. Each sample consists of 150 fish. Otoliths are extracted from 50 fish which are also length measured and weighed gutted. In most cases ling is landed gutted so it not possible to determine sex and maturity. If ling is landed ungutted, the ungutted weight is measured and the fish is sexed and maturity determined. The remaining 100 in the sample are only length measured. Age reading of ling from commercial catches ended in 1998. The reason was uncertainty in ageing and cost saving.

At 60 cm around 10% of ling in Va is mature, at 75 cm 50% of ling is mature and at 100 cm more or less every ling is mature. Ling is a relatively slow growing species; mean length in catch is around 80 cm which according to available ageing means that it is approximately eight years old.

No information is available on natural mortality of ling in Va.

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.

B.3. Surveys

For detailed description of the surveys relevant to ling in Va, please refer to the stock annex for tusk in Va and XIV.

The Icelandic spring survey (March) commenced in 1985 and covers the Icelandic shelf down to 500 meters. The survey is considered descriptive of biomass trends. The Icelandic autumn survey (October) commences in 1996 and was expanded in 2000 the survey is considered to cover the distributional range of ling in Va and therefore to be representative of stock biomass, it is however a shorter time-series and has fewer stations that the spring survey.

B.4. Commercial cpue

Data used to estimate cpue for ling in Division Va since 1991 are obtained from logbooks of the Icelandic trawl and longline fleet. 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

NA.

C. Assessment: data and method

Ling in Va and XIV is assessed based on trends in survey indices from the Icelandic spring and autumn survey. Supplementary information includes relevant information from the fishery such as length distributions, maturity data, effort, cpue and analysis of changes in spatial and temporal distribution.

D. Short-term projection

No short-term predictions are performed.

E. Medium-term projections

No medium-term predictions are performed.

F. Long-term projections

No long-term predictions are performed.

G. Biological reference points

No biological reference points are defined for ling in Va.

H. Other issues

I. References

19.12 Ling in other areas

Stock:	Ling (*Molva Molva*) in areas (IIIa, IV, VI, VII, VIII, IX, X, XII, XIV)
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Kristin Helle

A. General

A.1. Stock definition

WGDEEP 2006 indicated: '*There is currently no evidence of genetically distinct populations within the ICES area. However, ling at widely separated fishing grounds may still be sufficiently isolated to be considered management units, i.e. stocks, between which exchange of individuals is limited and has little effect on the structure and dynamics of each unit. It was suggested that Iceland (Va), the Norwegian Coast (II), and the Faroes and Faroe Bank (Vb) have separate stocks, but that the existence of distinguishable stocks along the continental shelf west and north of the British Isles and the northern North Sea (Subareas IV, VI, VII and VIII) is less probable. Ling is one of the species included in a recently initiated Norwegian population structure study using molecular genetics, and new data may thus be expected in future*'

A.2. Fishery

Significant fisheries for ling have been conducted in Subarea III and IV at least since the 1870s, pioneered by Swedish longliners. Since the mid-1900s and currently, the major targeted ling fishery in IVa is by Norwegian longliners conducted around Shetland and in the Norwegian Deep. There is little activity in IIIa. Of the total Norwegian 2010 landings, 83% were taken by longlines, 8% by gillnets, and the remainder by trawls. The bulk of the landings from other countries were taken by trawls as bycatches in other fisheries, and the landings from the UK (Scotland) are the most substantial. The comparatively low landings from the central and southern North Sea (IVb,c), are only bycatches from various other fisheries.

The major directed ling fishery in VI is the Norwegian longline fishery. Trawl fisheries by the UK (Scotland) and France primarily take ling as bycatch.

When Areas III–IV and VI–Xiv are pooled over the period 1988–2010, 40% of the landings were in Area IV, 29% in Area VI, and 26% in Area VI.

In Subarea VII the Divisions b, c, and g–k provide most of the landings of ling. Norwegian landings, and some of Irish and Spanish landings are from targeted longline fisheries, whereas other landings are primarily bycatches in trawl fisheries. Data split by gear type were not available for all countries, but the bulk of the total landings (at least 60–70%) were taken by trawls in these areas.

In Subareas VIII and IX, XII and XIV all landings are bycatches in various fisheries.

There was a decline in landings from 1988 to 2003, thereafter the landings have been stable (Figure 19.12.1). When Areas III–IV are pooled, the total landings averaged 32 thousand tons in 1988–1998 then declined to an average of 15 thousand tons in 2003–2010. The decline has been simultaneous in the main Areas IV, VI and VII, but Area VII has had a greater reduction in landings than in Areas IV and VI (Figure 19.12.2).

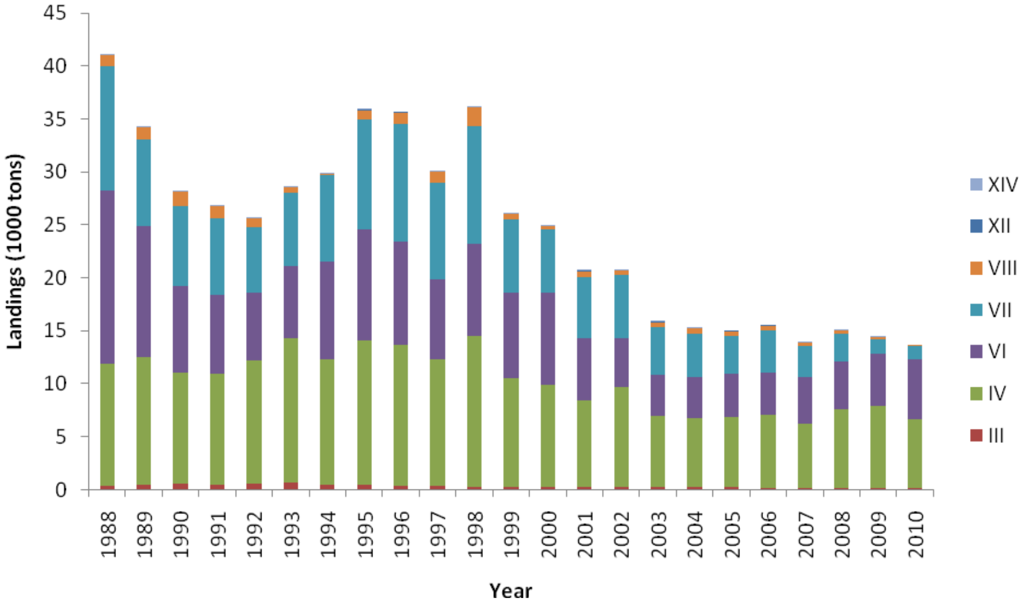


Figure 19.12.1 international landings. Ling in other areas

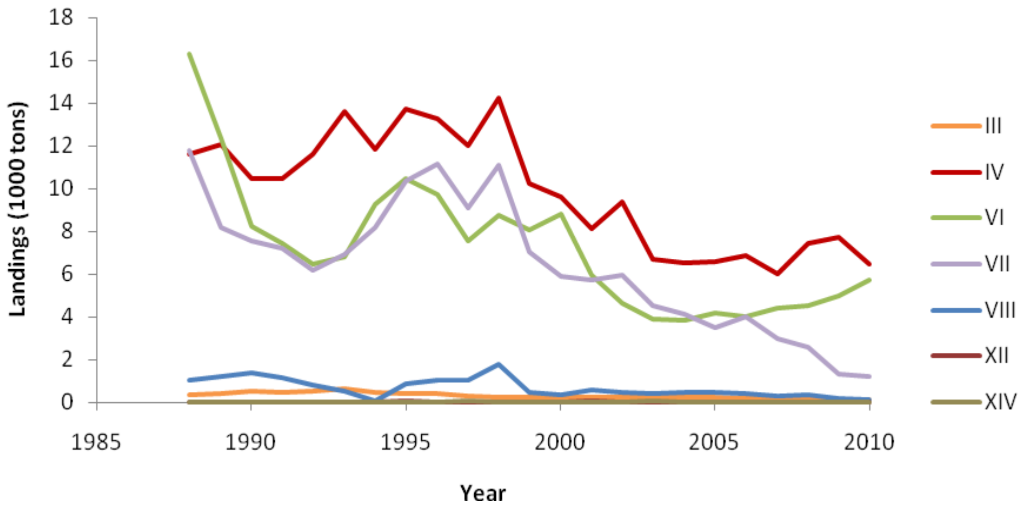


Figure 19.12.2. international landings. Ling in other areas

In Division IVa the total landings have varied between 10 000 and 13 000 t until 1998, then declined until 2003 to about half previous level, and have since remained stable.

In Division VIa the statistics are incomplete for the period 1989–1993. In the period 1994–2008, when the data are complete, they demonstrate a declining trend towards a level less than half that in the 1990s. The Norwegian landings declined substantially since the mid-1990s compared with earlier years. In Division VIb landings decreased in the late 1990s and reached a minimum in 2002, after which a gradual increase has occurred. In 2010 the landings were above the mean annual landings for the period 1988–1995.

In Subarea VII landings were around 10 000 t in the period 1995–1998. After this there was a gradual decrease, and the preliminary estimate of catch for 2010 is only 1233 t.

In Subarea VIII annual ling landings have totaled only a few hundred tons since 1999, and in Subareas IX, XII, and XIV the landings have remained minor.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Full landings data are available from 1988 to present but it is thought that fisheries in some of these areas pre-date the time-series. Incomplete landings data are available from Norwegian longline fisheries from 1889 onwards. Additional landings data from other areas may be available from 1950 onwards.

B.2. Biological

Length data for the Norwegian reference fleet in other areas have been routinely collected since 2002.

Considerable general information is available on the life-history characteristics of this species.

B.3. Surveys

B.4. Commercial cpue

Norway started in 2003 to collect and enter data from official logbooks into an electronic database and data are now available for the period 2000–2009. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding eight tonnes in a given year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. Cpue were calculated as the average total catch of ling per vessel (C), and the average number of hooks per set and per vessel (N) associated with these catches. Then, for each year and catch category, the estimated cpue for the entire fleet was determined as C/N. Thus the estimated cpue for each year and Subarea was the mean catch in kg per hook for the entire fleet.

The boats that provided logbooks are the primary sampling units, and C and N are both random variables. It follows that this is a ratio-type estimator, therefore the standard errors of the cpue estimates could be calculated as described in Cochran (1977, page 32). This cpue estimator is a weighted average, that is the more hooks a boat sets, the more influence it has on the estimate (Cochran, 1977). For comparison, an unweighted cpue series was also constructed (i.e. the average cpue per boat).

A standardized series will be developed in preparation for WGDEEP 2012.

B.5. Other relevant data

C. Assessment: data and method

Model used: The stock is assessed using trends in catch and cpue.

Software used:

Model Options chosen:

Input data types and characteristics

D. Short-term projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other Issues

H.1. Historical overview of previous assessment methods

I. References

19.13 Orange roughy in all areas

Stock:	Orange roughy (*Hoplostethus atlanticus*) in I, II, IIIa, IV, V, VI, VII, VIII, IX, X, XII, XIV
Working Group:	WGDEEP
Date:	March 2011

A. General

A.1. Stock definition

The current practice is to assume three assessment units;

- Subarea VI;
- Subarea VII;
- Orange roughy in all other areas.

Orange Roughy is an aggregating species and the spatial scale of current management units would not prevent sequential depletion of local aggregations. ICES recommended that where the small-scale distribution is known, this be used to define smaller and more meaningful management units.

A.2. Fishery

The main fishery for orange roughy was conducted in Areas VI and VII on the peak fisheries. Small fisheries have existed in Subareas Va, Vb, VIII, X and XII.

In VI, there was a French target fishery, centred on spawning aggregations around the Hebrides Terrace Seamount. Irish vessels fished there for two years starting in 2001, but they have now abandoned it. The fishery began in 1989 with landings peaking at 3500 t in 1991, and 5300 t were removed from the stock by the end of 1993 (Figure 19.13.1). It is not clear if over-reporting was a feature of the fishery in this area in the years preceding the introduction of TACs. Reported landings since 2003 have been decreasing to very low levels.

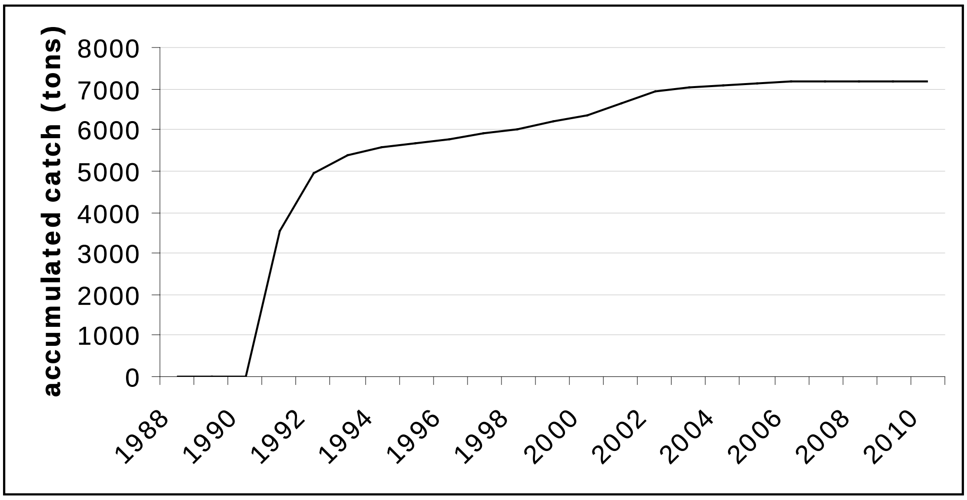


Figure 19.13.1. Accumulated catches of orange roughy in ICES Area VI.

After the collapse of the VI fishery, the main fishery for orange roughy in the northern hemisphere moved to Subarea VII. French vessels used to prosecute this fishery alone, but in 2001, new Irish vessels became heavily involved in this fishery for a short number of years. Orange roughy aggregations are mainly associated with seamounts, but they are also found close to other features and on the flat grounds of the continental slope. Initially, trawlers targeted orange roughy at the base of seamounts, but from 2000 onwards, there was a shift to fishing down the slopes of seamounts. Before the fishery closure, new features were found to replace them, as catch rates declined. Large (~50 m) high-sea French trawlers targeted orange roughy in Subarea VII up to 2001. These large trawlers have reduced their activity in VII. There were two fisheries for Orange Roughy in the area. A single targeted peak fishery that has been occurring on distinct topographical features and a mixed trawl flat fishery that occurs along the continental slope and has Orange Roughy as a bycatch. In recent years some targeted fishing from a few or even one single 20–24 m trawlers was carried out until 2008. Since 2010, the TAC has been set at zero.

When the French fishery in VII developed in 1991, landings peaked at over 3000 t in 1992. By the end of 2000 the French fleet had removed over 13 500 t of orange roughy from Subarea VII (Figure 19.13.2). An Irish fishery commenced in 2001, and since then the combined Irish and French accumulated landings have amounted to a further 10 800 t (Figure 19.13.2). Historical landings data suggest several pulses in landings (Figures 19.13.3). The first occurred in 1992 when over 3000 t were landed. Landings declined until 1995, but then increased again to the highest in the series in 2002. The total accumulated catch in Area VII is close to 25 thousand tons. A restrictive quota was introduced in 2003 and resulted in a decrease in declared landings since then. Since 2010, the TAC has been set at zero.

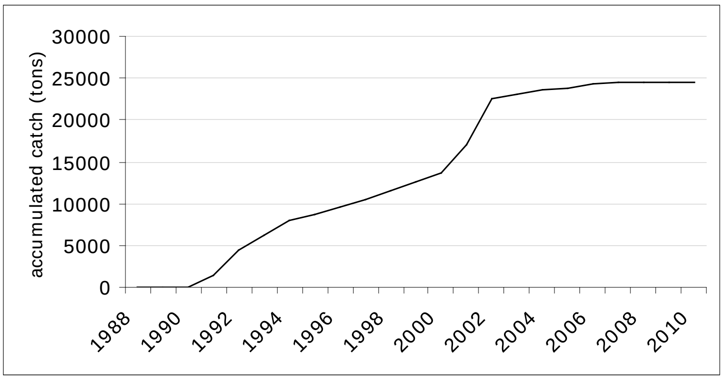


Figure 19.13.2. Accumulated catches of orange roughy in ICES Area VII.

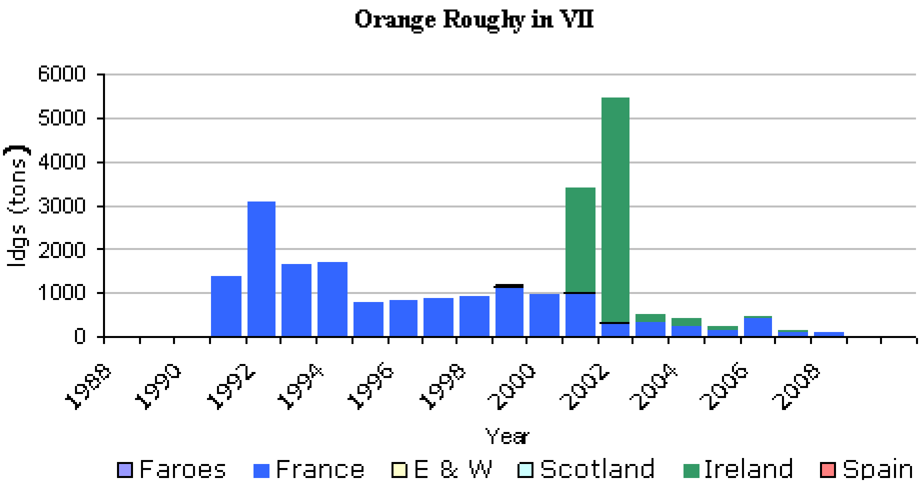


Figure 19.13.3. Time-series of Orange Roughy landings by country in ICES Subarea VII.

In Division Va, the fishery peaked with landings of over 700 t in 1993, and landings have declined to very low levels by 2002. In Division Vb, landings were highest in 1995, at 420 t, but since 1997 they have been trivial except for 2000.

In Subarea VIII, there have been small landings by France since the early 1990s. In Subareas VIII and IX, Spain has recorded small landings in some years.

In Subarea X, there are fluctuating Faroese landings, and in 2000, there was an experimental fishery by the Azores (Portugal).

In Subarea XII, the Faroes dominated the fishery throughout the 1990s, with small landings by France. New Zealand and Ireland have targeted orange roughy in this area for single years. There are many areas of the Mid-Atlantic Ridge where aggregations of this species occur, but the terrain is very difficult for trawlers.

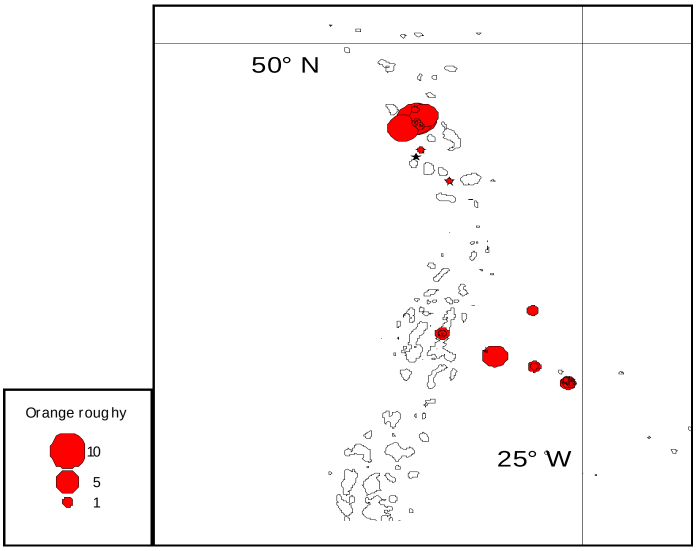


Figure 19.13.4. Total catches of orange roughy (tonnes) during the Faroese exploratory orange roughy fishery on the Mid-Atlantic Ridge (X and XII) in 2008.

A.2.1. Fleet

A.2.2. Regulations

In 2003 an EU TAC was introduced for orange roughy in VI and VII. For the other areas, an EU TAC was introduced in 2005. EU TACs have been decreasing in the last years and are now set to zero for all three management areas.

Table 19.13.1. Development of EU TAC for orange roughy in VI, VII and other areas since 2003.

Year	EU TAC (t) VI	EU TAC (t) VII	EU TAC (t) other
2003	88	1349	
2004	88	1349	
2005	88	1149	102
2006	88	1149	102
2007	51	193	44
2008	34	130	30
2009	17	65	15
2010	0	0	0
2011	0	0	0
2012	0	0	0

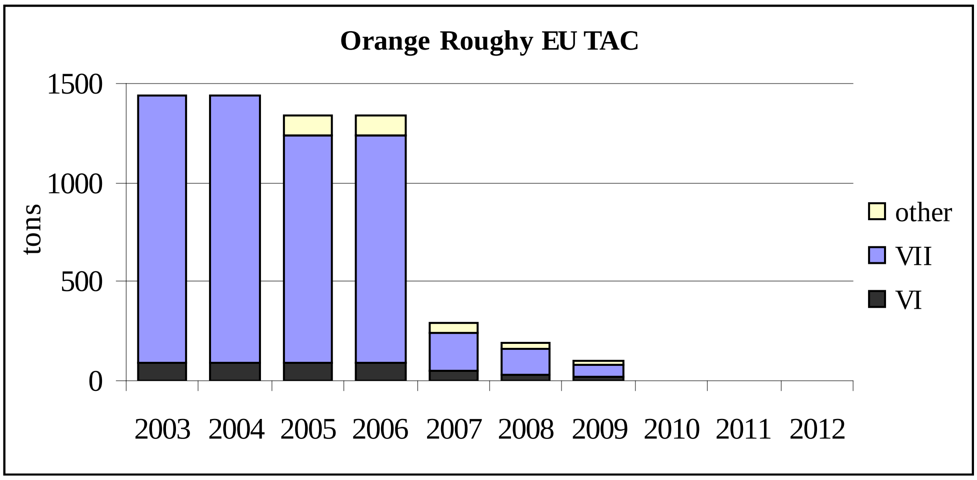


Figure 19.13.5. Total allowable catch for orange roughy in VI, VII and all other areas for EU vessels since 2003.

A.3. Ecosystem aspects

Directed trawl fisheries for orange roughy have been associated with seamounts and other bathymetric features. In ICES Divisions VI and VI there has been a spatial overlap of historical orange roughy fisheries with vulnerable habitats such as cold-water corals. The direct impact of this fishery on vulnerable habitats has not been evaluated. However, in other areas of the world, such fisheries have been demonstrated to have considerable impact. There are currently no directed fisheries targeting orange roughy in Subareas VI and VII. The spatial resolution of catch data for orange roughy in other areas currently available to the working group is not sufficient to assess the spatial overlap with vulnerable habitats. There are currently orange roughy fisheries occurring in ICES Subarea X and XII. The potential impact on vulnerable habitats should be evaluated. However, NEAFC have introduced precautionary closed areas to protect VMEs on the Mid-Atlantic Ridge.

B. Data

B.1. Commercial catch

Landings data are available for all fleets. On-board observations of the French deep-water fishery in Area Va, VI and VII are available and suggest that the bycatch of orange roughy might be minor on most fishing grounds. Irish discard information is available from three observer discard trips carried out in 2003 and 2004, covering targeted fishery on peaks and in canyons for orange roughy and fishing on flat grounds for a mixture of roundnose grenadier, black scabbard, blue ling, siki sharks and orange roughy. Discarding of orange roughy was zero in the peak fishery and <1% of landed orange roughy on the flat fishery.

B.2. Biological

Summary of life characteristics

Table 19.13.2. Summary of biological parameters for orange roughy in VI, VII.

LHC	Best estimate	Derived from?
Maximum observed length	70.6 cm SL	Nolan(ed) 2004
	60 cm SL	Shepard and Rogan 2004
Maximum observed age	>130	Thompson 1998
	169 years	Shepard and Rogan 2004
	187 years	Nolan(ed) 2004
Length at 50% maturity	34 -37 cm SL	Shepard and Rogan 2004
Age at 50% maturity	Approx 30 years	Shepard and Rogan 2004
	20-40 years	Nolan(ed) 2004
	27.5 years (37cm)	Minto and Nolan 2006
Length at recruitment	30-34 cm SL	Shepard and Rogan 2004
	Approx 35 cm	Nolan(ed) 2004
Age at recruitment	30-40 years	Shepard and Rogan 2004
	30-35 years	Nolan(ed) 2004
Growth parameters: (von Bertalanffy parameters: B_0,T_0, L infinity, for example)	$L\infty$=476 mm,	Shepard and Rogan 2004
	k=0.039 yr^{-1} and	
	t_0=2.61 years.	
Fecundity, egg size etc	22000 eggs per kg body weight. Diameter 2mm	Panchurts & Conroy 1987
	48,530 eggs per kg body mass	Gordon 1999
	33376 eggs	Minto and Nolan 2006
Natural mortality	M= 0.04	Annala (1993)
	M=0.025	WGDEEP, 2002
	M= 0.045	Large (2002) WD from WGDEEP 2002

Length compositions

There are a number of historical length frequencies available for Areas VI, VII and X and XII from observer programmes (Figures 19.13.6 to 19.13.8). Length frequencies from most of the commercial catches show a distribution between 45 and 65 cm. Survey data show that the length frequency distribution on bathymetric features is mainly between 38 and 55 cm (Figure 19.13.9). Survey length frequency information is available from the Irish and Scottish deep-water trawl surveys (Figure 1913.10) which sample the flat grounds along the continental slope in VI and VII. Survey data show that the length frequency on gentle slopes has several peaks between 7 and 23 cm with a further peak between 45 and 65 cm suggesting the presence of several juvenile cohorts.

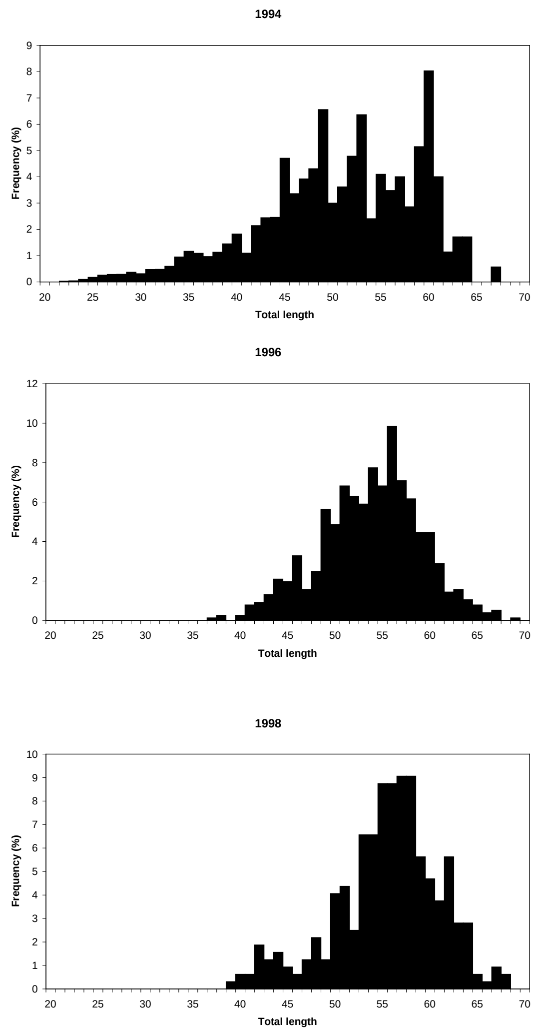


Figure 19.13.6. Length distribution of French landings of orange roughy from 1994 to 1998.

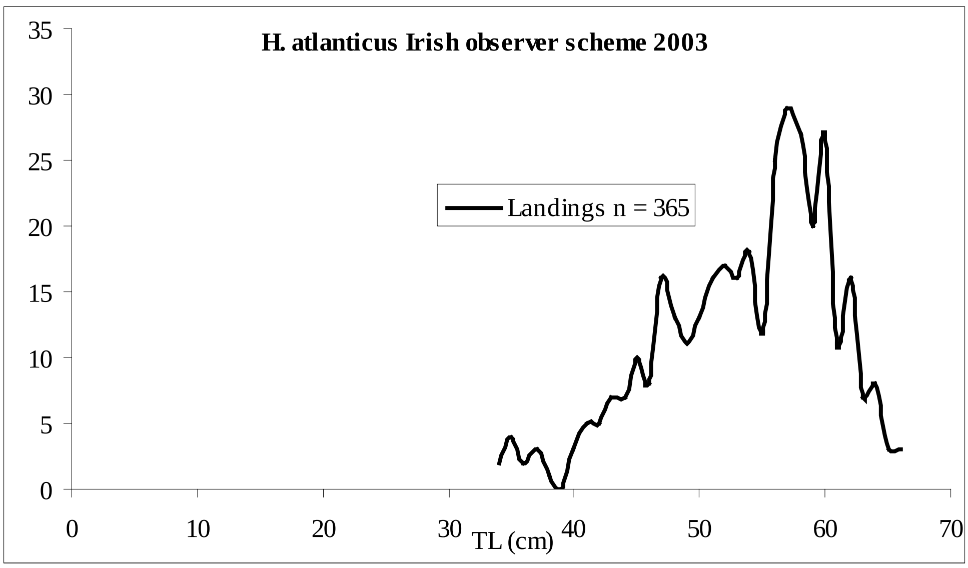


Figure 19.13.7. Length frequencies from Irish fishery in 2003 (VI and VII) from Irish Marine Institute observer scheme.

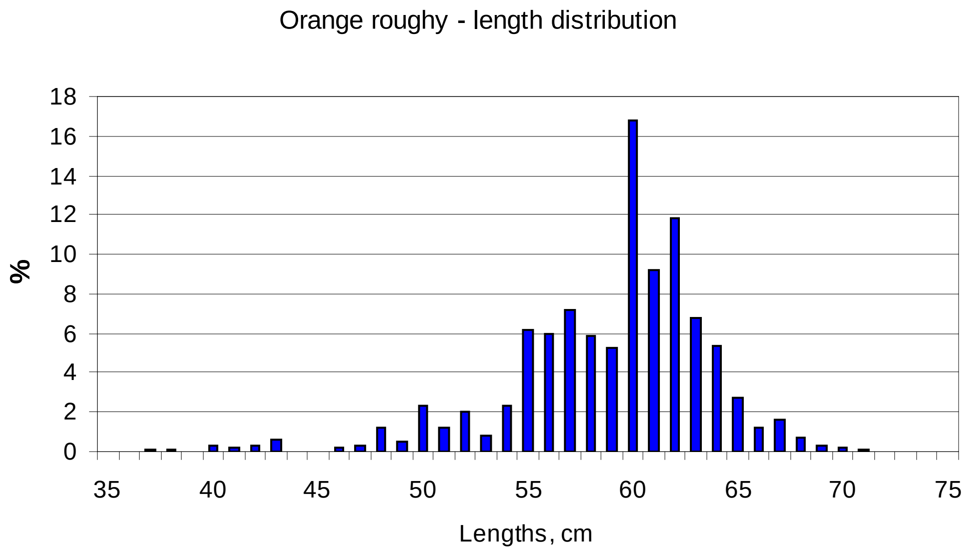


Figure 19.13.8. Orange roughy length frequencies from Faroese exploratory fishery in 2008 in the Mid-Atlantic Ridge (MAR_X and XII).

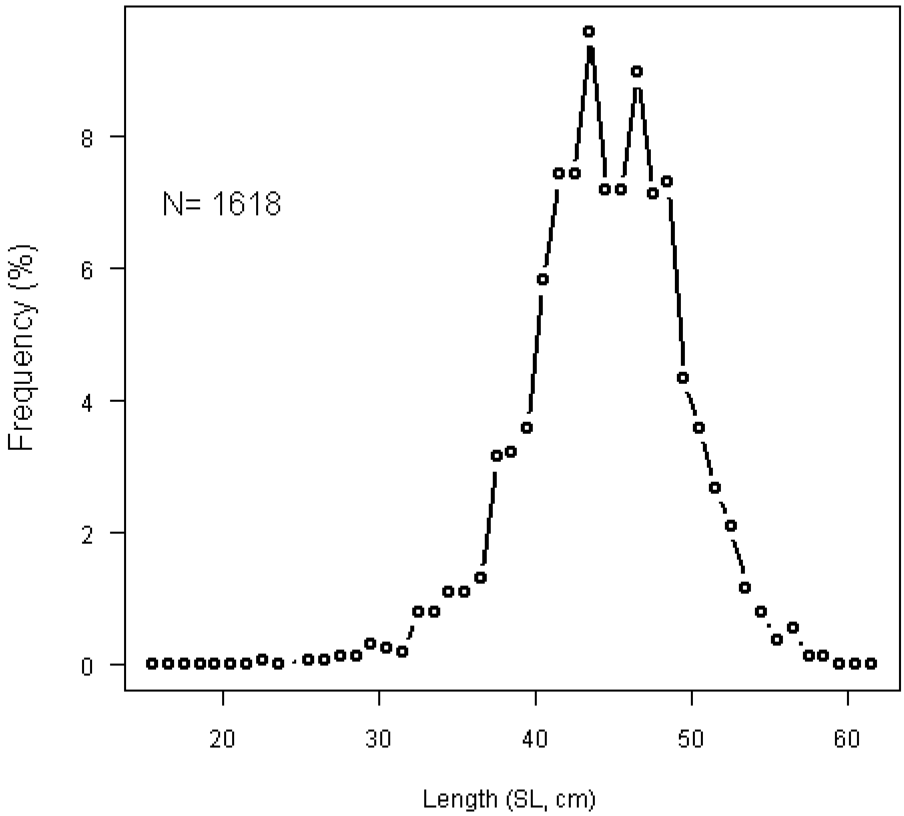
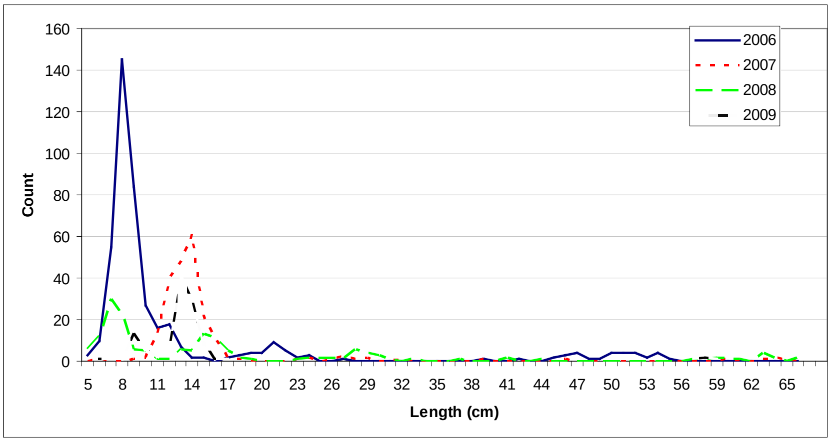


Figure 19.13.9. Length frequency from bathymetric feature trawl data sampled on the 2005 acoustic survey, VII.



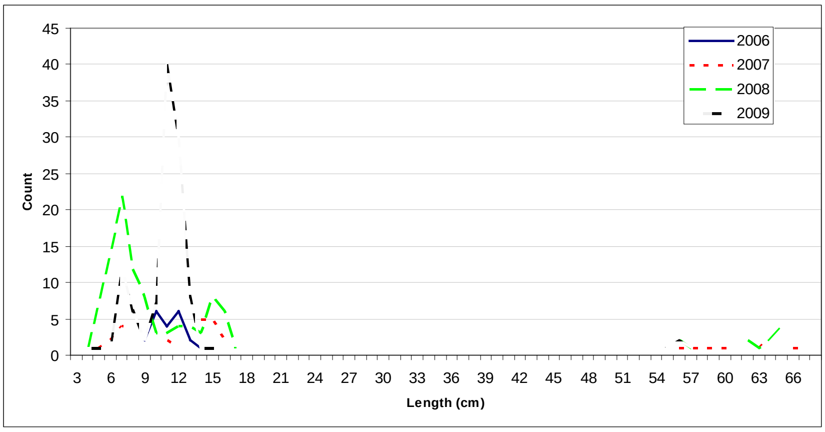


Figure 19.13.10. Length frequency of orange roughy caught at the Irish (upper panel) and Scottish (lower panel) deep-water survey 2006–2009.

Age compositions

Age data were available from sampling at-sea on commercial trawlers operating on the Porcupine Bank during September 2003–April 2004 and February 2005 (Sheppard and Rogan, 2006). Most otolith samples were of juvenile fish (< 30 cm SL). Otoliths were prepared and sectioned according to Tracey and Horn (1999). Age estimates (6–169 years) were obtained from in all 151 otoliths. The von Bertalanffy growth model was fitted to the data (R^2=0.92) (Figure 19.13.11). Estimated growth parameters were: L_∞=47.6 cm, k=0.039 yr^{-1} and t_0=2.61 years.

Age estimates were presented by Talman *et al.* (2002) based on samples taken from the Irish developmental fishery in 2001, in VI and VII (BIM, WD 2002). Age estimates from sectioned otoliths ranged from 20 to 187 years (Standard Lengths 30 to 68 cm). Empirical growth curves presented by Talman *et al*. (2002) suggest that growth slows and reaches an asymptote at about 55 cm SL and 37 years. This asymptote is far greater than estimate above and the cause of this is unknown (it possibly could be TL rather than SL). The orange roughy in the area west of Ireland appear to reach the greatest age of any populations so far examined.

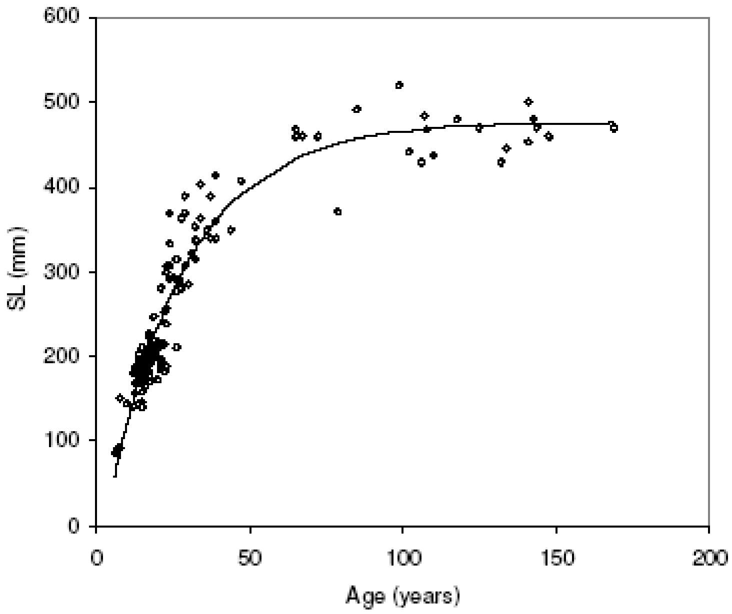


Figure 19.13.11. Age estimates and the estimated von Bertalanffy growth curve (Sheppard and Rogan, 2006). Note that the y-axis refers to standard length rather than total length as used elsewhere.

Weight-at-age

No data.

Maturity and natural mortality

Recently estimated maturity L50 was 34 cm SL for Orange Roughy collected from the flats fishery and 37 cm SL from hill aggregations on the Porcupine Bank (Sheppard and Rogan, 2006). This is similar to the estimate from the west of Ireland of 36 cm SL (Minto and Nolan, 2003). These are higher than that estimated for orange roughy in New Zealand and Australia.

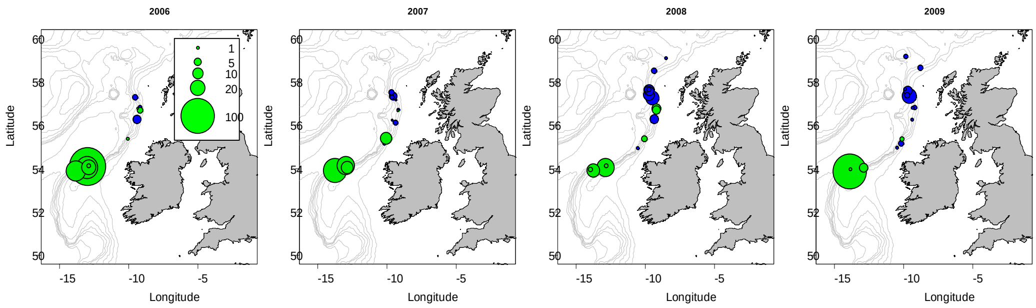
B.3. Surveys

In 2005 an acoustic survey was carried out on the slopes to the west and north of the Porcupine Bank. Estimates of biomass were considered to be unreliable due to concerns over target strength.

Biological samples and multibeam echosounder and a ROV were used on selected sea-mounds to map the orange roughy habitats (O'Donnell *et al.*, 2007).

Distribution of juvenile and adult cpues of orange roughy in VI and VII within the survey areas of the Scottish and Irish Deep-water survey are shown in Figure 19.13.12. Mean catch rates (number/hours) for orange roughy from the Irish deep-water trawl survey are shown in Figure 19.13.13 for individuals >23 cm (a.) and <23 cm (b.) caught in the 1000 m to 1500 m depth band between 2006–2009. Data are very variable, but do indicate the entry of juveniles into the population.

a.)



b.)

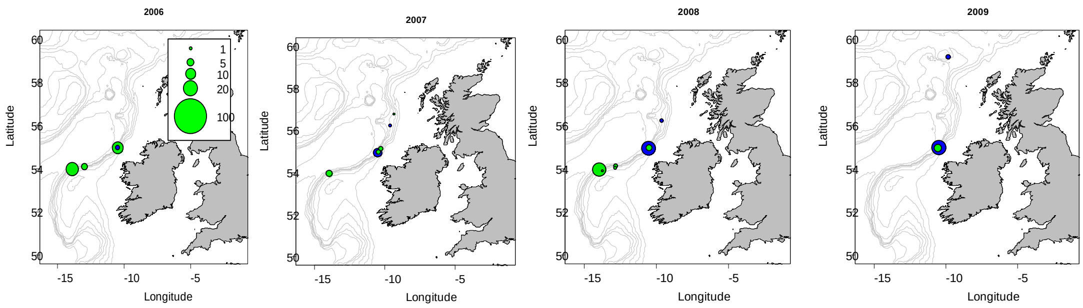


Figure 19.13.12. Cpue of a.) orange roughy (≤23 cm) and cpue of b.) orange roughy (>23 cm), 2006–2009. Combined Irish (green) and Scottish (blue) Deep-water survey data.

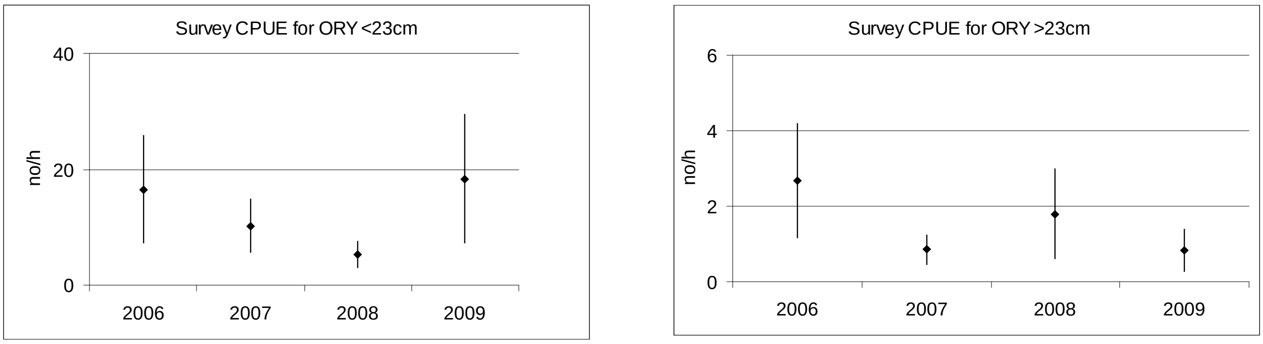


Figure 19.13.13. Mean catch rates (number/hours) for orange roughy >23 cm (a.) and < 23 cm (b.) caught at the Irish deep-water survey 2006–2009 in the 1000 m to 1500 m depth band (±1SE).

B.4. Commercial cpue

Historical French cpue series is shown in Figure 19.13.14 and 19.13.15 for Subarea VI and VII . No new data are available for this cpue from 2006 onwards, as the fishery has virtually ceased.

Standardized cpues for Irish deep-water trawlers targeting orange roughy are shown in Figure 19.13.16. These are based on personal logbooks and are calculated using the mean catch weight per haul per month for the period of January 2001 to December 2003, i.e. the main period when the Irish trawlers were participating in the fishery. In the peak fishery for orange roughy the trawl is often fast on the bottom or sometimes lifted over coral and rocks. Effective fishing time can be as short as 20 minutes.

Trawling time therefore does not give any good indication of effort and consequently, only catch per haul is used for the analysis. The cpue from fishery on flat ground was also worked up but the data were scarcer as it only developed as a regular fishery since the second half of 2002.

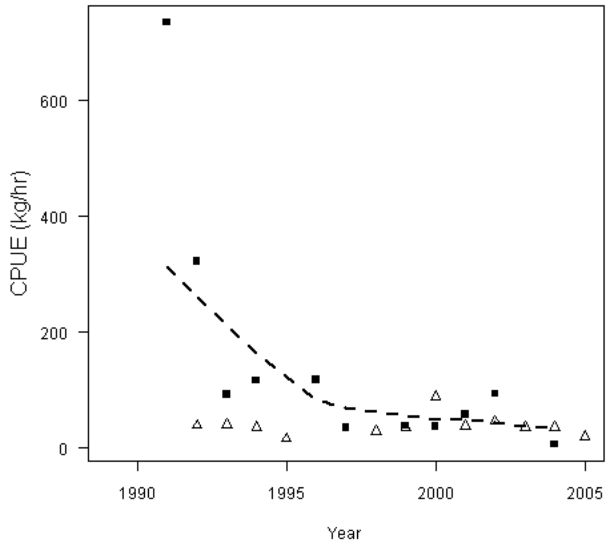


Figure 19.13.14. French 2006 cpue series (VIa) for 400–600 kw power vessels (open triangles) and for 1400–1600 kw vessels (solid squares). The line is a smooth curve through the latter series.

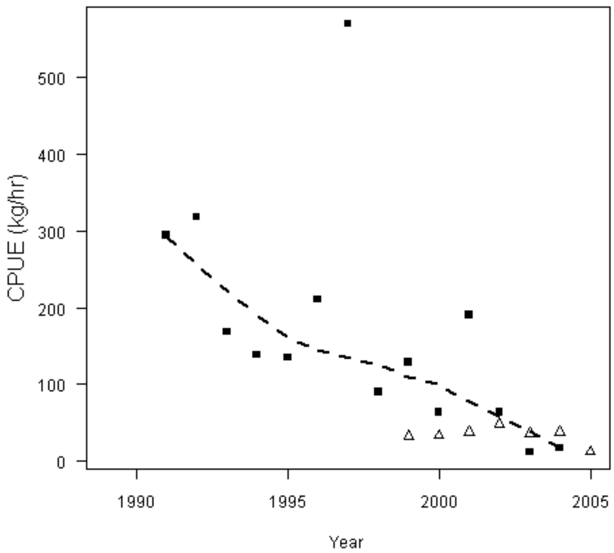


Figure 19.13.15. 2006 cpue series for 400–600 kw power vessels (open triangles) and for 1400–1600 kw vessels (solid squares). The line is a smooth curve through the latter series excluding the high 1997 point.

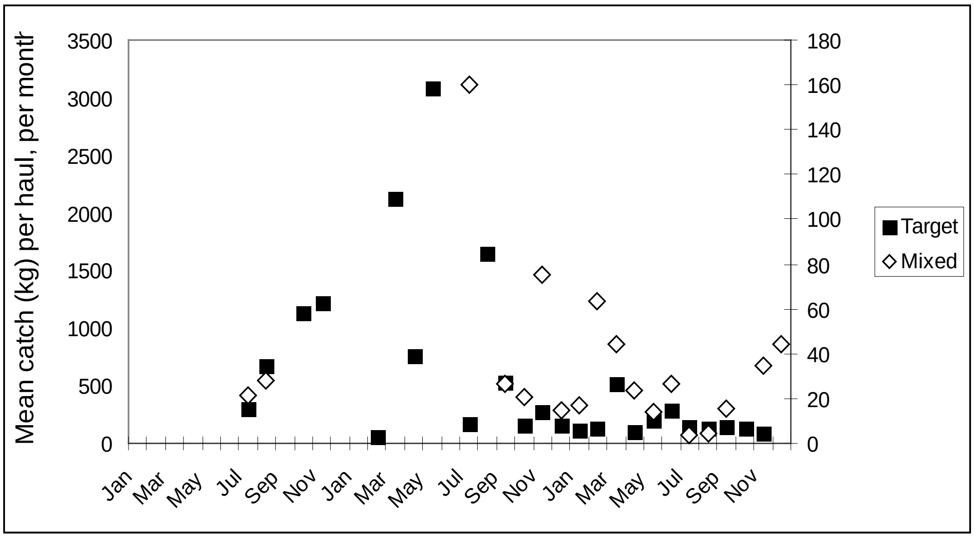


Figure 19.13.16. Cpue series for Irish deep-water trawlers targeting orange roughy with mean catch weight by haul per month between January 2001 and December 2003 for targeted (closed squares) and mixed fisheries hauls (open diamonds). Secondary axis corresponds to mixed fishery.

B.5. Other relevant data

C. Assessment: data and method

No assessment. Advice is based on historical landings and cpue trends.

Model used:

Software used:

Model Options chosen:

Input data types and characteristics

D. Short-term projection

NA.

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

E. Medium-term projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

F. Long-term projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

19.14Red sea bream in VI, VII, VII

Stock:	Red Sea bream (*Pagellus Bogaraveo*) in Subareas VI, VII, VII
Working Group:	WGDEEP
Date:	March 2011
Revised by	Guzman Diez

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) seabream, 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 DivisionIXa, 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 show 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

The fishery in Subareas VI, VII and VIII strongly declined in the mid-1970s, and the stock is seriously depleted. Since 1988 the landings from Subarea VIII represents the 67% and VI and VII the 23% of total accumulated landings. At present red sea bream catches in these areas are almost all bycatches of LLS and OTB fleets. Small artisanal and recreational landings from Bay of Biscay from are not reported to the Working Group.

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).

Red 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. Blackspot sea bream undertakes a vertical spawning migration, with the adults moving from deeper to shallower waters during the spawning season and forming aggregations.

B. Data

B.1. Commercial catch

Landing series were performed from two different sources. The first source has been updated from a table performed in WGDEEP 2004 (S1; Figure 19.14.1), and the second one come from several data sources compiled by Lorance (2010; S2; Figure 19.14.2). According the source S2 landings *of P. bogaraveo* in Areas VI–VIII were on the order of 10–30 thousand t/year during 1950–1980, and between 10–15 thousand t/year according the source S1. Despite the different level of landings showing both series, in the period in which the series coincides the historical trend is very similar, giving a clear perspective of the important decline of this fishery in Northeast Atlantic in last 30 years.

The information of observers in the Basque country fleet in Subareas VI, VII and VIII indicates that there was no discard for this species in the period 2003–2010.

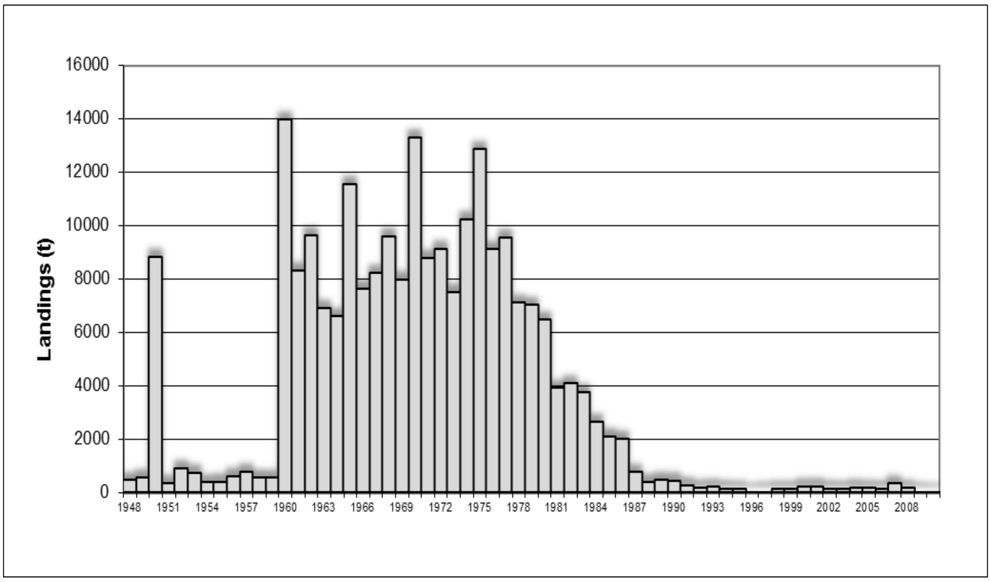


Figure 19.14.1. Historical series of Red Sea bream landings since 1900 in Northeast Atlantic (Subareas VI, VII and VIII).

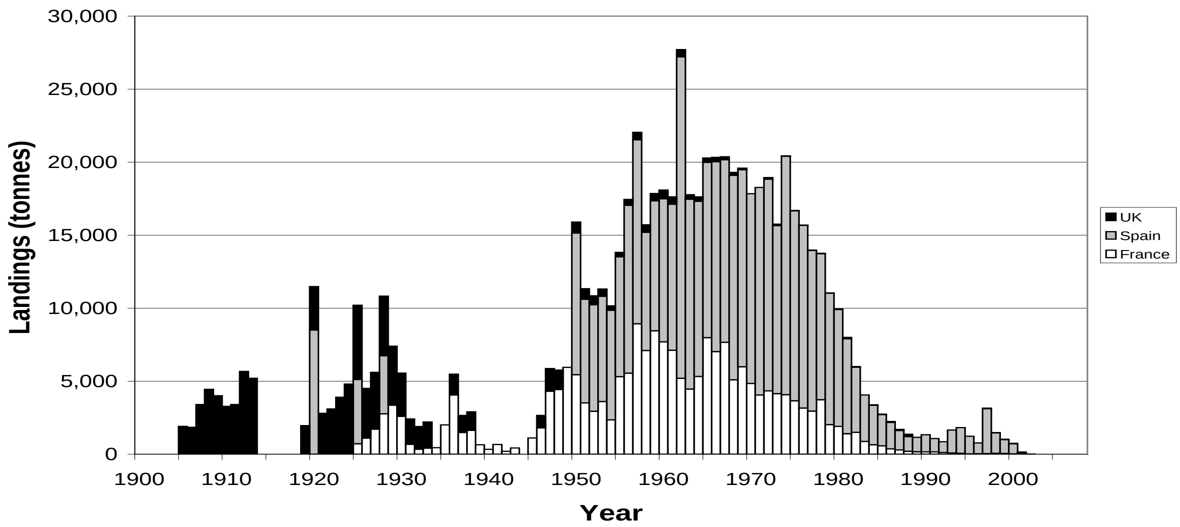


Figure 19.14.2. Reconstructed time-series of landings of red sea bream by country from the Bay of Biscay population (catch from ICES Subareas VI, VII and VIII). Lorance (2010).

B.2. Biological

Pagellus bogaraveo is a protandric hermaphrodite species changing from males to females. Sexing and staging this species may be sometimes problematic because macroscopic scales are not validated with microscopic observations. Red (blackspot) sea bream is considered a slow growing species. Gueguen (1969b) reported a maximum age of 20 years. Natural Mortality of 0.2 estimated by Lorance (2010) was derived from the presumed longevity in the population according the rule M ¼ 4.22/t max , where t is the maximum age in the population derived from data from many populations (Hewitt and Hoenig (2005)). According to this rule the 1% of the population survives to 23 years.

Table 19.14.1. Von Bertalanffy growth coefficient for *P. bogaraveo* for the Bay of Biscay. From Lorance, 2010.

K	L	To	N	ICES Area	
0.092	56.8	–2.92		VIII	Walford method from Guéguen (1969b)
0.162	48.3	–0.72	10186a	VIII	New fit using data from Guéguen (1969b)
0.137	51.4	–0.97	20b	VIII	New fit to mean length-at-ages from Guéguen (1969b)
0.209	51.56	–0.53	530	VIIIc	Sánchez (1983)
0.174	53.9	–0.66		VIIIc	Ramos and Cendrero (1967)
0.196	48.06	–0.47		VIIIc	Alcazar *et al*. (1987)
0.174	54.2	–0.66		VIIIB,c	Castro Uranga (1990)

[a] **Size-at-age derived from back calculation (Guéguen, 1969b).**

[b] **Number of age groups.**

B.3. Surveys

In the current Western IBTS time-series, only a few individuals (zero in some years) are caught which reflects that the stock remains at very low levels compared to historical abundance.

In two French surveys in 1973 and 1976, conducted with the same protocols as the current western IBTS survey in the Bay of Biscay, red sea bream was caught in significant numbers. In the current Western IBTS time-series, only a few individuals (zero in some years) are caught which reflects that the stock remains at very low levels compared to historical abundance.

B.4. Commercial cpue

No effort and commercial cpue data were available to the Working Group.

B.5. Other relevant data

C. Assessment: data and method

No assessment has been carried out before for this stock.

Model used: Not applicable

Software used: Not applicable

Model Options chosen: Not applicable

Input data types and characteristics

D. Short-term projection

Not applicable.

E. Medium-term projections

Not applicable.

F. Long-term projections

Not applicable.

G. Biological reference points

Not applicable.

H. Other issues

Its peculiar reproductive biology and aggregative distribution makes red sea bream especially vulnerable to fishing.

Because of the sex-changing in red sea bream only the old ages contribute significantly to the production of oocytes. Therefore if young fish that are sexually immature then males are exploited the proportion of fish reaching the female stage may become very low. It is therefore essential to avoid catching small fish (red sea bream forms shoals that can be targeted). This is the reason for the minimum landing size at 35 cm.

In the 1920s and 1930s, it was reported that juveniles were widely distributed on the coasts of Brittany and in the Western Chanel French and UK coasts.

19.15 Red sea bream in IX

Stock:	Red sea bream in ICES Subarea IX
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Juan Gil

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 sea bream, but it offers a better way of recording the available information" (ICES, 2007). The inter-relationships of the red sea bream from Areas VI, VII, and VIII, and the northern part of Area IXa, and their migratory movements within these areas have been observed by tagging methods (Gueguen, 1974). However, there is no evidence of movement to the southern part of IXa where the main fishery currently occurs. Tagging has been done also in the Strait of Gibraltar area, where the majority of the fishery currently occurs. No significant movements are reported, although local migrations are also observed: feeding grounds are distributed along the entire Strait of Gibraltar and the species seems to remain in this area as a resident population (Gil, 2006). In 2007, Piñera *et al*. suggests no significant genetic differences are present along Spanish coasts (Mediterranean and Atlantic areas).

Besides, in the case of the Strait of Gibraltar red sea bream also inhabit in Morocco waters. In fact recaptures of tagged fish were also notified by Moroccan fishers.

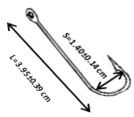
A.2. Fishery

Although *Pagellus bogaraveo* is caught by Spanish and Portuguese fleets in Subarea IX, only a more complete description of one of the fisheries has been provided to the Working Group, the corresponding to the Spanish fishery in the southern part of Subarea IX, close to the Strait of Gibraltar.

The majority of landings on deep-water species at mainland Portugal are conducted by the artisanal fleet, mainly longline fisheries. These operated in the Portuguese continental slope and located in ports as Peniche, Sesimbra and Sagres. Red sea bream landings reflect a seasonal activity probably related with a larger availability of the species or market demands that lead fishers to spend some time targeting this species (I. Figueiredo, pers. comm.).

In relation to the Spanish fishery in the southern ICES Subarea IXa, an updated description of it has been presented to the Working Group by Gil *et al*. (WD 2011), that complete the information offered in the previous WGs (Gil *et al*., 2000; 2003, 2005, 2006, 2007, 2008, 2009 and 2010; Gil and Sobrino, 2001, 2002 and 2004). This artisanal longline fishery targeted red sea bream has been developed along the Strait of Gibraltar area. Actually this fishery covers more than the 70% of the landings for the species in the Subarea IX. The base and landing ports are two: Algeciras and mainly Tarifa (Cádiz, SW Spain). The "*voracera*", a particular mechanized hook and line baited with sardine, is the gear used by the fleet (Table 19.15.1). The mean technical characteristics of this fleet by port are 8.95 and 6.52 meters length and 5.84 and 4.0 tons G.T.R. for Tarifa and Algeciras, respectively (Gil *et al.*, 2000). Currently around 100 boats are involved in the fishery. Fishing grounds are located at both sides of the Strait of Gibraltar and quite close to the main ports (Figure 19.15.1). Fishing is carried out taking advantage of the turnover of the tides in depths from 200 to 400 fathoms. Landings are distributed in categories due to the wide range of sizes and to market reasons (these categories have varied in time but from 2000 onwards still the same).

Table 19.15.1. Red sea bream Spanish fishery of the Strait of Gibraltar: Fleet and gear summary descriptive.

Fleet ID	Gear type	N° boats	Number of lines	Hook type and size	Mean soaktime	Effort (days at sea)
LHM_DEF	Vertical mechanized handline ("voracera")	±100	Maximum of 30 lines per day (each line attached a maximum of 100 hooks, usually ±70)	L=3.95±0.39 cm S=1.40±0.14 cm 	±30 min	Maximum 140 days

From 2002 onwards artisanal boats from other port, Conil, have began to direct its fishing activity to *P. bogaraveo* in different fishing grounds and with different fishing gear (longlines) than the "*voracera*" fleet boats. Nowadays, only around six boats are developing this fishery.

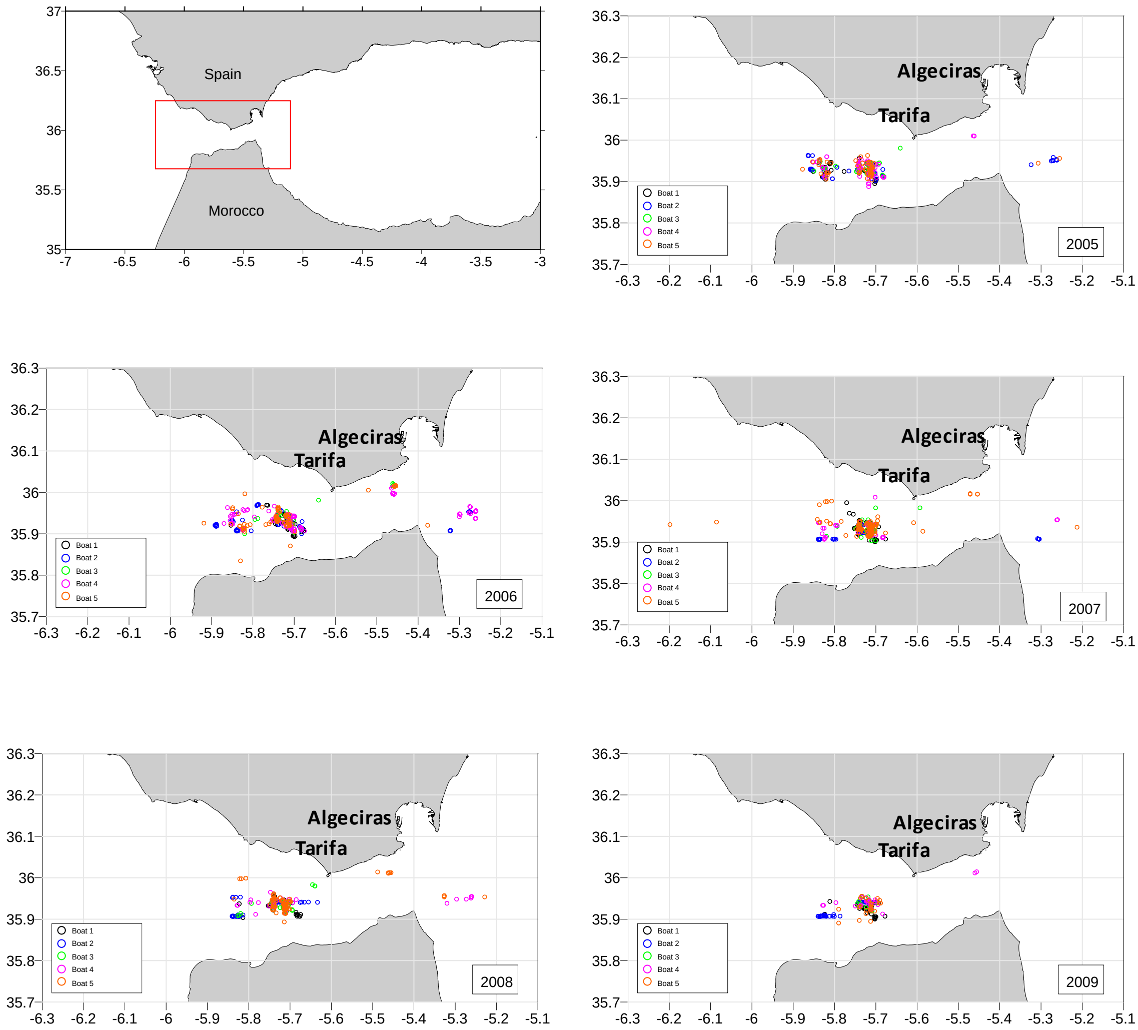


Figure 19.15.1. Red sea bream Spanish fishery of the Strait of Gibraltar: Yearly soaking positions footprints from observers on-board programme (from Gil *et al.*, WD 19).

A.3. Ecosystem aspects

Red sea bream is a bentho-pelagic species that inhabits various types of bottom (rock, sand, and mud) down to a depth of 900 m. It 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).

Feeding habit of this species has been little studied. Morato *et al*. (2001) describes the diet of *Pagellus bogaraveo* and *Pagellus acarne* in the Azores and Olaso and Pereda (1986) describe the diet of 22 demersal fish in the Cantabrian Sea including *Pagellus bogaraveo*. In the Strait of Gibraltar fishery, feeding studies presents the difficult of the use of bait (sardine), which should be ignored to describe the feeding habit of the species. Altogether 1106 red sea bream stomachs contents were analysed: 725 stomachs were empty and 381 were fullness. Vacuity index (VI) was 66%. The trophic spectrum is composed of 24 prey taxa, six orders, eleven families and 15 species and genera are represented. Despite the trophic spectrum diversity observed, the overall diet is not very diverse. Red sea bream in the Strait of Gibraltar has only a main prey, *Sergia robusta* (Polonio *et al*., in preparation).

Main red sea bream predators are unknown in the Strait of Gibraltar waters but maybe dolphins' predation should be taken into account (personal communication from Ceuta veterinary). Studies in Azores (Gomes *et al*., 1998) cite that *Conger conger, Raja clavata* and *Galeorhinus galeus* must be considered as potential predators (all three species are present in Strait of Gibraltar area).

Deep-sea coral ecosystems represent true biodiversity hot spots. OSPAR identified cold-water coral ecosystems as one of the most vulnerable ecosystems where action is required now to mitigate further loss of biodiversity. Figure 19.15.2 shows the deep-water coral occurrences in the Strait of Gibraltar.

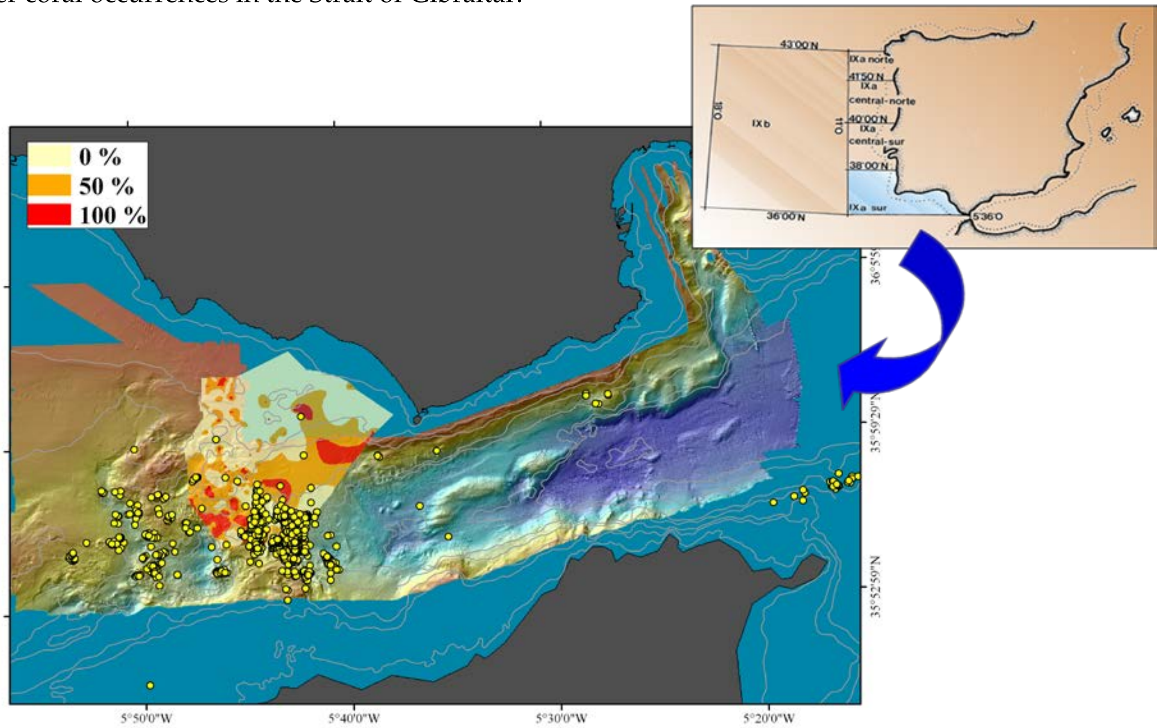


Figure 19.15.2. Coral distribution in the Strait of Gibraltar (adapted from Álvarez-Pérez *et al*. in Freiwald and Roberts, (eds.) 2005). Yellow points correspond to "*voracera*" fleet fishing grounds from observers on-board programme. Legend refers to percentage cover of coral.

B. Data

B.1. Commercial catch

In Subarea IX, catches -most of them taken by lines- correspond to Spain (72%) and Portugal (28%). Spanish landings data from this area are available from 1983 and Portuguese from 1988 onwards. The maximum catch in this period was obtained in 1993–1994 and 1997 (about 1000 t) and the minimum in 2002 (359 t). Catches in 2009 amount to 718 t, but decreases again (484 t) along the last year.

Almost all Spanish catches in this area are taken in waters close to the Gibraltar Strait. Until 2002 they were restricted to two ports (Tarifa and Algeciras), but from 2002 significant catches were obtained also by artisanal Spanish boats of a third port (Conil) in different fishing grounds of the same area. An increasing trend in landings was observed but since 2008 it only rates an average of 15 t, lower than in the early years.

In the Portuguese landings no clear tendency is observed. The maximum values took place in 1988 (370 t) and in 1998 (357 t) and the minimum one in 2000 (83 t). In 2010 landings was 105 t.

Length frequencies of landings are only available for the Spanish red sea bream fishery in the Strait of Gibraltar (1983–2010). There is a decrease of the mean size from 1995 to 1998. It is necessary to point out that the red sea bream may have a variable length distribution depending on its geographic and bathymetric distribution, as suggests the different mean length of landings measured in ports (Tarifa and Algeciras). The mean length of the landings increases steadily in both ports from 1999 onwards then decreased but has been increasing again between 2006 and 2009. The mean length from both landing ports declined in 2010. However the median value is lower than the mean since 1995, and very close to the minimum landing size in Algeciras.

A Kolmogorov–Smirnoff test reflects significant differences ($p<0.05$) between the length distributions from Spain and Morocco (Belcaid *et al.*, WD 20) and also within Spain (Gil *et al.*, WD 19). Differences among the sampling protocols may be the explanation to the observed difference. In Morocco and Spanish observers programme the sampling covers certain the boats (random sampling) while in the Spanish first sale fish market the sampling covers the 4 market categories (stratified sampling). So raising the random sampling weight to the total landings did not take into account the difference due to the variability of the length composition related to bathymetric distribution of the species and the stratified sampling seems to be more appropriate.

B.2. Biological

Red sea bream is a protandric hermaphrodite species changing from males to females. Red sea bream have a low productivity and they change sex as they age, starting as males and becoming females between ages 4 and 6. Measures to ensure balanced exploitation between younger fish (males) and older fish (females) are essential.

An annual reproductive cycle has been described for the species in this area (Gil, 2006). The spawning season seems to take place during the first quarter of the year. The smallest specimens are mainly males, maturing at a L_{50}=30.15 cm. At about 32.5 cm in total length, an important percentage of individuals change sex and became females, maturing at L_{50}=35.73 cm. Thus, from age 5 all individuals can be considered mature, whether they are males or females.

Red sea bream is considered a slow growing species. A combined ALK was obtained by three agreed readings from 1497 otoliths collected from 2003 to 2008 (Gil *et al.*, 2009). It comprises lengths from 24 to 54 cm and ages between 3 and 10, but it has not been validated yet. According to the available information the maximum age recorded in Subarea IX is ten years. However, the ages of older fish may be underestimated and it is possible that this species may be slower growing and longer-lived than current studies indicate. In fact, there was one recapture from tagging surveys notified more than ten years after its release (J. Gil, pers. comm.). Table 19.15.2 presents different estimates of von Bertalanffy Growth Function (VBGF) parameters available from otoliths readings or tag-recapture data.

Table 19.15.2. Red sea bream of the Strait of Gibraltar: VBGF parameter estimates.

Authors	Study Area	Methodology	t0	k	L∞
Sobrino and Gil, 2001	Strait of Gibraltar	Otholits reading	-0.67	0.169	58.00*
Gil *et al*., 2008	Strait of Gibraltar	Otholits reading	-1.23	0.169	62.00*
Gil *et al*., 2009	Strait of Gibraltar	Otholits reading	-0.34	0.162	62.00*
Gil *et al*., 2008	Strait of Gibraltar	Recaptures (1)		0.079	62.00*
Gil *et al*., 2008	Strait of Gibraltar	Recaptures (2)		0.098	62.00*
Gil *et al*., 2008	Strait of Gibraltar	Recaptures (3)		0.161	62.00*
Gil *et al*., 2008	Strait of Gibraltar	Recaptures (4)		0.080	62.00*

(1)Gulland y Holt, 1959 (2)Munro, 1982 (3)Fabens, 1965 (4)Appeldoorn, 1987.

***Fixed (from the largest observed sample).**

Padillo *et al*. (2011,WD17) present new information based on Discriminant Analysis of several of the samples used to make the ALK, combining morphometric and morphological variables to re-estimate red sea bream ages. The reclassification success percentage was 85.3%, well above from the 70% adopted by other authors (Palmer *et al*., 2004; Galley *et al*., 2006). Changes in otolith shape could be related to the growth rate and be also strongly influenced by environmental components. Therefore, future work should include the analysis of such factors throughout years and cohorts.

The natural mortality of *Pagellus bogaraveo* is uncertain because there is no data available to estimate M directly. A mortality rate of 0.2 year^{-1} has been adopted by several authors in several studies from other areas (Silva, 1987; Silva *et al*., 1994; Krug, 1994; Pinho *et al*., 1999; Pinho, 2003) and also by Gil (2006) for the Strait of Gibraltar.

B.3. Surveys

Only tagging surveys were carried out in the Strait of Gibraltar area. Since 1997, 7066 samples were tagged (juveniles + adults) and at the moment 396 recaptures were notified. Recaptures from tagged juveniles show significant displacements from South Mediterranean breeding areas toward the Strait of Gibraltar. However, recaptures from tagged adults did not reflect big displacements, which are limited to feeding movements between the different fishing grounds where the "*voracera*" fleet works (Gil, 2006).

B.4. Commercial cpue

It should be noted that the effort unit from the historical series, number of sales, may be inappropriate, as it fails to consider the missing effort from boats that have not caught enough fish to go to the market. Thus, in the years this missing effort has increased substantially (fishing vessels with no catches and no sale sheet to be recorded) and its lpue values may be overestimated.

Gil *et al*. (2011, WD19) presents a short series of cpue (2005–2009) from the observers on-board programme in the red sea bream fishery of the Strait of Gibraltar. Sampling level was five boats and three trips per month. Number and length measurements of caught species were recorded. Values vary around three red sea bream per ±70 hooks but the general trend seems to be slightly decreasing throughout the years. Further work should be done to standardize the cpue.

B.5. Other relevant data

C. Assessment: data and method

Model used: No model was adopted for the assessment yet. Till the moment the assessments attempts were no accepted and only several trends (landings and length distributions) were used for the scientific advice.

Software used: None

Model Options chosen: None

Input data types and characteristics

D. Short-term projection

NA.

E. Medium-term projections

NA.

F. Long-term projections

NA.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	N/A	
Approach	F_{MSY}	F0.1=	YpR Analysis
	B_{lim}	N/At	
Precautionary	B_{pa}	N/A	
Approach	F_{lim}	N/A	
	F_{pa}	N/A	

No biological reference points have been defined.

H. Other issues

H.1. Historical overview of previous assessment methods

Historical series of landings data available to the Working Group have been exploratory assess by the WGDEEP since 2006. No discard data were available to the Working Group, but for this species this could be considered minor. The landings data used in the assessment exercise of red sea bream in IX included Spanish and Portuguese landings from 1990 onwards.

New assessment exercises were presented to the Group in 2011. An Extended Survivors Analysis (XSA) attempt with the Strait of Gibraltar Spanish red sea bream fishery data is described by González and Gil (2011, WD18). Belcaid *et al*. (2011, WD20) presents the results obtained by a Yield-per-recruit analysis from 2005–2007 Spanish and Morocco landings length distribution available information from the Strait of Gibraltar area.

19.16 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 19.16.1):

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.

Fish in all maturity stages have been observed throughout the distribution area (Allain, 2001; Kelly *et al.*, 1996, 1997; Shibanov, 1997; Vinnichenko *et al.*, 2004), which would be consistent with the existence of several populations.

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.

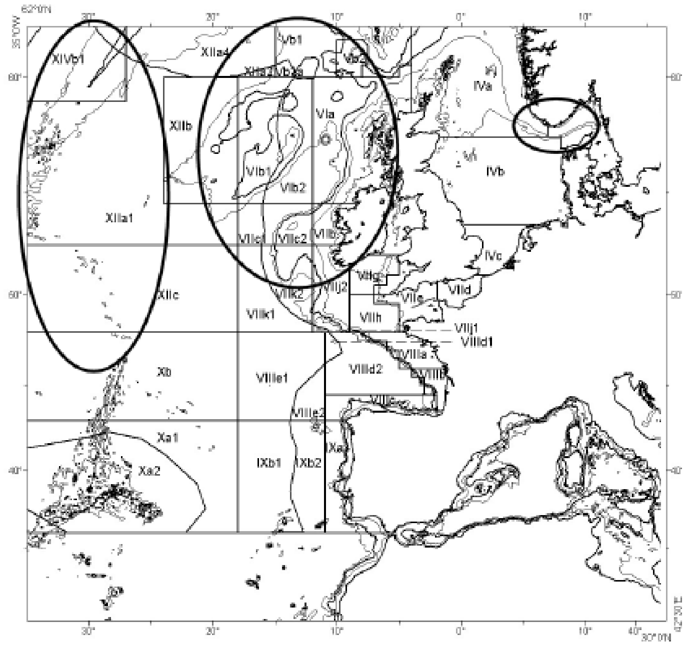


Figure 19.16.1. Areas of the main fisheries for roundnose grenadier, Skagerrak, west of the British Isles and mid-Atlantic Ridge. The isobaths displayed are 100, 200, 1000 and 2000 m (from Lorance *et al.*, 2008).

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. Historical length frequency series from sampling on board French trawlers by French and Scottish observer are presented in Figures 19.16.2 and 19.16.3.

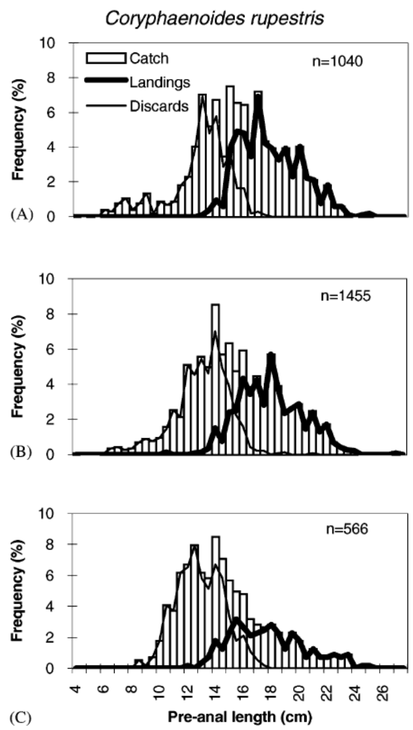


Figure 19.16.2. Length distribution of the discards and landings of roundnose grenadier in 1996–1997 by depth, A) 800–1000 m, B) 1000–1200 m, c) 1200–1400 m, sampled on board French vessels, (redrawn from Allain, 2003).

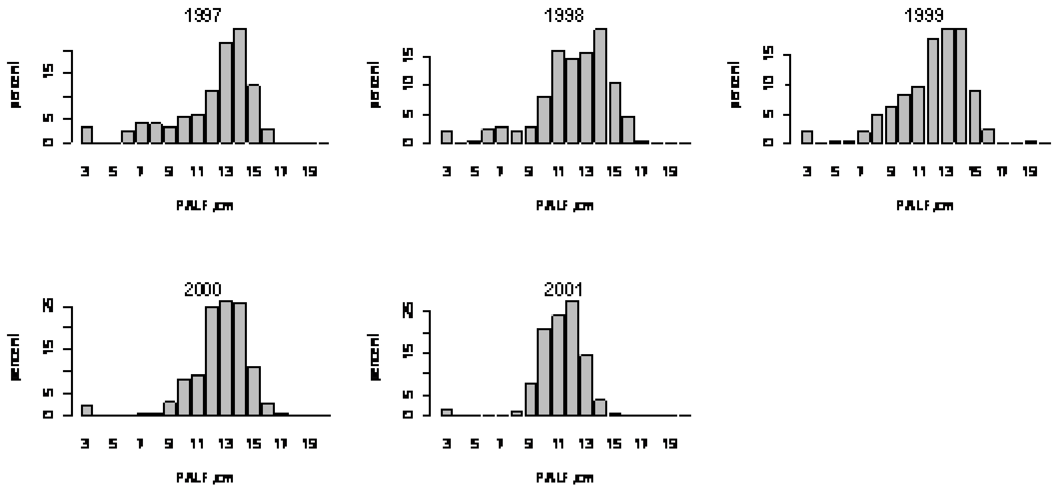


Figure 19.16.3. Length distribution of the discards of the French fleet, sampled on board French vessels by Scottish observers, 1997–2001.

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 databased upon French tallybooks are available from 2000 based upon a voluntary participation of fishers. 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 databased 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.

G. 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 depends 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.

I. References

Allain V. 2001. Reproductive strategies of three deep-water bentho-pelagic fishes from the Northeast Atlantic Ocean. Fisheries Research 51: 165–176.

Allain V, Biseau A, Kergoat B. 2003. Preliminary estimates of French deep-water fishery discards in the Northeast Atlantic ocean. Fisheries Research 60: 185–192.

Allain V, Lorance P. 2000. Age estimation and growth of some deep-sea fish from the Northeast Atlantic Ocean. Cybium 24: 7–16.

Andriyashev A. P. 1954. The North Sea's fish. Moscow. AN USSR:568 (in Russian).

Bergstad OA. 1990. Distribution, population structure, growth and reproduction of the roundnose grenadier *Coryphaenoides rupestris* (Pisces: Macrouridae) in the deep waters of the Skagerrak. Marine Biology 107: 25–39.

Bergstad OA, Gordon JDM. 1994. Deep-water ichthyoplankton of the Skagerrak with special reference to *Coryphaenoides rupestris* Gunnerus, 1765 (Pisces, Macrouridae) and *Argentina silus* (Ascanius, 1775; Pisces, Argentinidae). Sarsia 79: 33–43.

Charuau A., Dupouy H., Lorance P. 1995, French exploitation of the deep-water fisheries of the North Atlantic. In: Hopper A.G. (Ed.) Deep-water fisheries of the North Atlantic oceanic slope, Series E: Applied Sciences, Kluwer Academic Publishers, Dordrecht/Boston/London, 337–356.

Dushchenko V. V. 1989. On intraspecific structure of roundnose grenadier (*Coryphaenoides rupestris* G.) from the North Atlantic. Abstract of Biology science kandidat dissertation. M:22. (in Russian).

Eliassen J.E. 1983. Distribution and abundance of roundnose grenadier (*Coryphaenoides rupestris*, Gadiformes, Macrouridae) in northern and mid Norway//ICES CM1983/G:43:24.

Geistdoerfer P. 1977. Contribution a la biologie de *Coryphaenoides rupestris*. Repartition et reproduction dans l'Atlantique nord-est// ICES C.M. 1977/F:45:6.

Gordon JDM. 1978. Some notes of the biology of the Roundnose Grenadier *Coryphaenoides rupestris* to the west of Scotland// ICES C.M. 1978/G:40:13.

Gordon, JDM, Swan SC, Geffen AJ,Morales-Nin B. 2001. Otolith microchemistry as a means of identifying stocks of deep-water demersal fishes (OTOMIC). Northwest Atlantic Fisheries Organization (NAFO) Scientific Council Meeting, Varadero (Cuba), NAFO Scientific Council Research Document 01/100 Serial No. N4488.

ICES. 2006. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources. ICES CM2006/Assess:28.

ICES. 2007a. Report of the Workshop on Age Reading of Roundnose Grenadier (WKARRG), 4–7 September 2007, Boulogne-sur-mer, France. ICES CM 2007/ACFM:36. 50 pp.

ICES. 2007b, Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), 8–15 May 2007. International Council for the Exploration of the Sea. ICES CM 2008/ACOM 14. 471p.

ICES. 2008, Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), 3–10 March 2008. International Council for the Exploration of the Sea. ICES CM 2008/ACOM 14. 486p.

ICES. 2009, Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), 9–16 March 2009. International Council for the Exploration of the Sea. ICES CM 2008/ACOM 14. 504p.

Kelly CJ, Connolly PL, Bracken JJ. 1996. Maturity, oocyte dynamics and fecundity of the roundnose grenadier from the Rockall Trough. Journal of Fish Biology 49: 5–17.

Kelly CJ, Connolly PL, Bracken JJ. 1997. Age estimation, growth, maturity and distribution of the roundnose grenadier from the Rockall Trough. Journal of Fish Biology 50: 1–17.

Knutsen, H., Jorde, P. E., Albert, O. T., Hoelzel, A. R., Stenseth, N. C. 2007. Population genetic structure in the North Atlantic Greenland halibut (*Reinhardtius hippoglossoides*): influenced by oceanic current systems? Canadian Journal of Fisheries and Aquatic Sciences 64(6), 857–866.

Knutsen, H., Jorde, P. E., Sannaes, H., Hoelzel, A. R., Bergstad, O. A., Stefanni, S., Johansen, T., Stenseth, N. C. 2009. *Bathymetric barriers promoting genetic structure in the deep-water demersal fish tusk (Brosme* brosme). Molecular Ecology 18(15), 3151–3162.

Knutsen H., Jorde P.E., Skogen M., Stenseth N.C. 2009. Large-scale population structure in roundnose grenadier. ICES International Symposium, Issues confronting the deep oceans, Horta, Azores, 27–30 April 2009.

Leim AH, Scott WB. 1966. Fishes of the Atlantic coast of Canada. Ottawa: 220–221.

Logvinenko BM, Nefedov GN, Massal'skaya LM., Polyanskaya IB. 1983. A population analysis of rock grenadier based on the genetic polymorphism of non-specific esterases and myogenes. Can Trans Fish Aquat Sci No. 5406: 16pp.

Lorance P., Dupouy H., Allain V. 2001, Assessment of the roundnose grenadier (*Coryphaenoides rupestris*) stock in the Rockall Trough and neighbouring areas (ICES Subareas V–VII). Fisheries Research 51, 151–163.

Lorance P., Garren F., Vigneau J. 2003. Age estimation of roundnose grenadier (*Coryphaenoides rupestris*), effects of uncertainties on ages. Journal of Northwest Atlantic Fishery Science 31:387–399.

Lorance P., Large P.A., Bergstad O.A., Gordon J.D.M. 2008. Grenadiers of the Northeast Atlantic – Distribution, biology, fisheries, and their impacts, and developments in stock assessment and management. In: Grenadiers of the world oceans: biology, stock assessment and fisheries, Bethesda, MS, USA, American Fisheries Society Symposium 63, 365–397.

Lorance P., Pawlowski L., Trenkel V. 2009. Standardizing blue ling LPUE from industry haul by haul data using generalised additive models, Journal of Marine Science. *Submitted.*

Magnússon J, Magnússon JV, Jakobsdottir KB. 2000. Deep-sea fishes. Icelandic contributions to the deep-water research project, EC FAIR Project CT 95-0655, 1996–1999.

Neat F., Burns F. in press. Stable abundance, but changing size structure in grenadier fishes (*Macrouridae*) over a decade (1998–2008) in which deep-water fisheries became regulated. Deep-sea Research I.

Parin, NV, Neyma VG, Rudyakov YA. 1985. To the problem of waters biological productivity in the High Sea areas of underwater elevations. In: Biological grounds of the fishery development of the High Sea areas. Selected papers. Nauka. Moscow: 192–203 (in Russian).

Parr AE. 1946. The Macrouridae of the Western North Atlantic and Central American seas//Bull. of the Bingham Oceanogr. Collect. Yale Univers., - v. X, art. 1. p. 1–101.

Pawlowski L., Lorance P. 2009. Effect of discards on roundnose grenadier stock assessment in the Northeast Atlantic. *Aquat. Living Resour.* 22 (2009). DOI: 10.1051/alr/2009040.

Pshenichny, BP., Kotlyar AN, Glukhov AA, 1986. Fish resources of thalassobathyal Atlantic Ocean. In: Biological resources of the Atlantic Ocean. Moscow, Nauka:230–252 (in Russian).

Savvatimsky, PI. 1969. Roundnose grenadier of the North Atlantic. PINRO, Murmansk, 72 (in Russian).

Sauskan VI. 1988. Commercial fish of the Atlantic ocean. Agropromizdat, Moscow: 165–166 (in Russian).

Shibanov VN. 1997. Biological foundation of roundnose grenadier (*Coryphaenoides rupestris* Gunnerus, 1765) fishery in the North Atlantic. Candidate Dissertation in Biological Sciences. Murmansk, PINRO:156 (in Russian).

Shibanov VN, Vinnichenko VI. 2007. Biology and fishery of roundnose grenadier (*Coryphaenoides rupestris* Gunnerus 1765) in the North Atlantic/ *In press.*

Vinnichenko VI, Khlivnoy BN, Orlov AM. 2004. Biology and distribution of the deep-water fish on the Northeast Atlantic underwater elevations. Fishery economy. Water biological resources, their condition and use: Obzornaya informacjiya/ VNIERH. Moscow. 1:46 (in Russian).

Vinnichenko VI, Khlivnoy BN. 2007. New data on distribution of young roundnose grenadier (*Coryphaenoides rupestris*) in the North Atlantic. In press.WALTERS, C. 2003. Folly and fantasy in the analysis of spatial catch rate data. Canadian Journal of Fisheries and Aquatic Sciences, 60, 1433–1436.

Zilanov VK, Troyanovsky FM, Shepel LI. 1970. Some biology features, search and fishery characteristics of the roundnose grenadier in the North Atlantic. In: Materials of the Northern Basin. Murmansk. 16:3–21 (in Russian).

19.17 Roundnose grenadier in Xb, XIIc, Va1, XIIa1, XIVb1

Stock:	Roundnose grenadier (*Coryphaenoidesrupestris*) in Divisions Xb, XIIc and Subdivisions Va1, XIIa1, XIVb1
Working Group:	WGDEEP
Date:	8th March 2011
Revised by:	Vladimir Vinnichenko

A. General

A.1. Stock definition

ICES WGDEEP has in the past proposed four assessment units of roundnose grenadier in the NE Atlantic:

- Skagerrak, IIIa
- Celtic Sea and the Faroe–Hatton area, 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 of distribution 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. 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.

Recent genetic studies using different method and number of loci, provided different views of the population structure of roundnose grenadier but consistently showed that roundnose grenadier form the MAR is genetically different from Celtic Sea and the Faroe–Hatton area (Knutsen *et al*., 2010; White *et al*., 2010)

Studies have allowed observing fish in all maturity stages and/or larvae in all the distribution area (Allain, 2001; Kelly *et al*., 1996, 1997; Shibanov, 1997; Vinnichenko *et al*., 2004; Bergstad and Gordon, 2001), therefore allowing for distinct populations to exist.

A.2. Fishery

The fishery on the northern Mid-Atlantic Ridge (MAR) started in 1973, when dense concentrations of roundnose grenadier were discovered by USSR exploratory trawlers. Roundnose grenadier aggregations may have occurred on 70 seamounts between 46 and 62°N but only 30 of them were commercially important and subsequently exploited. The fishery is mainly conducted using pelagic trawls although on some seamounts it is possible to use bottom gear.

The greatest annual catch of roundnose grenadier (almost 30 000 t) on the MAR was taken by the Soviet Union in 1975, fluctuating in subsequent years between 2800 and 22 800 t. The fishery for grenadier declined after the dissolution of the Soviet Union in 1992. In the last 15 years, there has been a sporadic fishery by vessels from Russia (annual catch estimated at 200–3200 t), Poland (500–6700 t), Latvia (700–4300 t) and

Lithuania (data on catch are not available). Grenadier has also been taken as bycatch in the Faroese orange roughy fishery and Spanish blue ling and roughhead grenadier fishery. During the entire fishing period to 2010, the catch of roundnose grenadier from the northern MAR amounted to more than 232 000 t, mostly from ICES Subarea XII.

A.3. Ecosystem aspects

The depth in most of Divisions Xb, XIIc and Subdivisions Va1, XIIa1, XIVb1 is > ca. 4000 m and abyssal is not exploited by fisheries. The major topographic feature is the Northern part of the MAR, located between Iceland and the Azores. Numerous seamounts of variable heights occur all long this ridge along with isolated seamounts in other areas such as Altair and Antialtair. The physical structure of seamounts often amplify water currents and create unique hard substrata environments that are densely populated by filter-feeding epifauna such as sponges, bivalves, brittlestars, sea lilies and a variety of corals such as the reef-building cold-water coral *Lophelia pertusa*. This benthic habitat supports elevated levels of biomass in the form of aggregations of fish such as orange roughy and alfonsinos, and a number of seamounts have been targeted by commercial fleets. Such habitats are however highly susceptible to damage by mobile bottom fishing gear and the fish stocks can be rapidly depleted due to the life-history traits of the species which are slow growing and longer-living than non-seamount species.

The MAR is isolated from the continental slope except for the relatively continuous shallower connections via the Greenland and Scotland ridges, and some seamount chains, e.g. the New England seamounts. Along with much of the general biology, the intraspecific status of species inhabiting the MAR is unclear. Based on geographical patterns it is probable that MAR populations of both fish and benthic organisms are isolated from the others in the North Atlantic and endemism.

B. Data

B.1. Commercial catch

Landings time-series data per ICES subarea are available for whole fishery period. Landings by ICES division are available by countries. Landings data by ICES statistical rectangle are not available.

Catch in Subarea XII are allocated to MAR (Divisions XIIa,c) and western Hatton Bank (XIIb) according to knowledge of the fisheries from WG members.

There were no discards of roundnose grenadier on Russian trawlers where smallest fish and waste were used for fishmeal processing. There is no information on discards by other countries vessels.

B.2. Biological data

Size frequency data (total length distribution) for roundnose grenadier are available for Russian catches for 1972–1990 (Shibanov, 1997). Age estimates were available from Russia for 1974–1990 (Shibanov, 1997).

According to retrospective Russian data, maturation of roundnose grenadier starts when fish are at least 50 cm long total length. Mean length-at-maturity of males and females being 76 and 79 cm (TL) respectively (Savvatimsky, 1992). Some individuals mature at the age 6, though some fish may remain immature until the age 20 (Savvatimsky, 1969; Shibanov 1985). No new data on maturity has been collected in recent years.

No specific information is available from the Mid-Atlantic Ridge but natural mortality of 0.1 has been used for roundnose grenadier in Vb, VI, VII and XIIb since 2002. This is based on catch curves from pre-exploitation surveys.

B.3. Surveys

There have been number of investigations from the Soviet Union on the northern MAR in the 1972–1990 including trawl acoustic surveys and underwater observations (Shibanov *et al.*, 2002). In the 1990s no researches of roundnose grenadier were conducted in the area.

In recent years the MAR-ECO project yielded some biological data (length, age maturity) for roundnose grenadier on the northern MAR.

Trawl acoustic surveys on the MAR were resumed in 2003, when Russian RV *Atlantida* investigated area between 47° and 58°N (Gerber *et al.*, 2004). New data were obtained on grenadier biology, behaviour, distribution and living conditions. Acoustic estimates of the biomass of roundnose grenadier were carried out for several seamounts. Similar research was carried out again in 2010 in the area between 44° and 50°N (Shnar *et al.*, 2011).

B.4. Commercial cpue

Only nominal catch per fishing day are available from the Soviet/Russian official data from 1974 to 2010. There are gaps in the series due to the lack of catch statistics for 1973 and 1982, as well as absence or too limited of target fishery in 1994–1995 and 2006–2010. These data must be treated with caution because catch rates might be sensitive to several factors (distribution of pelagic concentrations, experience of vessel crew, environmental conditions, etc.) that could not be taken in account so far.

B.5. Other relevant data

No other source of data is used in the assessment.

C. Assessment: data and method

No analytical assessments are used.

D. Short-term projection

No projections are performed.

E. Medium-term projections

No projections are performed.

F. Long-term projections

No projections are performed.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

The current data are inappropriate to provide MSY estimates.

H. Other issues

Because of the particular environmental conditions on the MAR and roundnose grenadier occurring in large concentration, unlike in other areas where it is rather a dispersed species, it may remain impossible to assess the biomass reliably without extensive acoustic surveys.

I. References

Allain, V. 2001. Reproductive strategies of three deep-water bentho-pelagic fishes from the Northeast Atlantic Ocean. Fisheries Research, 51: 165–176.

Bergstad, O. A., and Gordon, J. D. M. 1994. Deep-water ichthyoplankton of the Skagerrak with special reference to *Coryphaenoides rupestris* Gunnerus, 1765 (Pisces, Macrouridae) and *Argentina silus* (Ascanius, 1775; Pisces, Argentinidae). Sarsia, 79: 33–43.

Gerber, E. M., S. N. Burykin, A. V. Zimin, A. V. Oleinik, and V. T. Soldat. 2004. Russian fishery researches in the Mid-Atlantic Ridge area in 2003. Working Document to the Working Group on theBiologyand Assessment of Deep-Sea Fisheries Resources, 18–24 February2004, Copenhagen, Denmark. ICES Headquarters, Copenhagen, Denmark.

Kelly, C. J., Connolly, P. L., and Bracken, J. J. 1996. Maturity, oocyte dynamics and fecundity of the roundnose grenadier from the Rockall Trough. Journal of Fish Biology, 49: 5–17.

Kelly, C. J., Connolly, P. L., and Bracken, J. J. 1997. Age estimation, growth, maturity and distribution of the roundnose grenadier from the Rockall Trough. Journal of Fish Biology, 50: 1–17.

Knutsen, H., Jorde, P. E., Skogen, M., and Bergstad, O. A. 2010. Population structure in the deep-sea fish, roundnose grenadier (*Coryphaenoides rupestris*), as revealed by microsatellite DNA. 12th International Deep-sea Biology Symposium, Reykjavik, Iceland, 7–11 June 2010.

Savvatimsky, P. I. 1992. Systematical position, biologyand fishery significance of the roundnose grenadier.In:Researches of the North Atlantic biological resources.Selected papers. PINRO, Murmansk: 251–264 (In Russian).

Shibanov, V. N. 1985. Peculiarities of the roundnose grenadier reproduction in the North Atlantic. Studying and conservation of the biological resources in the North Seas and the North Atlantic. In: Scientific conference of Russian scientists and specialists. Abstracts of papers. PINRO, Murmansk: 71 (In Russian).

Savvatimsky, P.I. 1969. Roundnose grenadier of the North Atlantic. PINRO, Murmansk, 72 (in Russian).

Shibanov V.N. 1997. Biological foundation of roundnose grenadier (*Coryphaenoidesrupestris-*Gunnerus, 1765) fishery in the North Atlantic. Candidate Dissertation in Biological Sciences. Murmansk, PINRO:156 (in Russian).

Shibanov VN, Vinnichenko VI. 2007. Biology and fishery of roundnose grenadier (*Coryphaenoidesrupestris*Gunnerus 1765) in the North Atlantic/ *In press.*

ShibanovV.N., V.I.Vinnichenko, A.P.Pedchenko. 2002. Russian investigations and fishing in the northern part of the Mid-Atlantic Rigde.ICES CM 2002/L: 35.

Shnar V.N., A.M.Safronov and A.P. Malyshko. 2011. Russian research of roundnose grenadier in the Mid-Atlantic Ridge area during 2010. Working Document to the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources, 2–8 March 2011, Copenhagen, Denmark. ICES Headquarters, Copenhagen, Denmark.

White, T. A., Stamford, J., and Hoelzel, A. R. 2010. Local selection and population structure in a deep-sea fish, the roundnose grenadier (*Coryphaenoides rupestris*). Molecular Ecology, 19: 216–226.

19.18 Roundnose grenadier in IIIa

Stock:	Roundnose grenadier (*Coryphaenoides rupestris*) in Division IIIa
Working Group:	WGDEEP
Date:	March 2011
Revised by:	WGDEEP

A. General

A.1. Stock definition

Roundnose grenadier (*Coryphaenoides rupestris*) in Division IIIa is treated as one stock separated from three other stocks within the distribution area in Northeast Atlantic.

The current perception is based on what is believed to be natural restrictions to the dispersal of all life stages. The stock in Skagerrak (Division IIIa) is thought to be separated from the other stocks through the Wyville–Thomson Sill.

In 2007, WGDEEP examined the available evidence of stock discrimination in this species but, on the available evidence, was not able to make further progress in discriminating stocks. On this basis WGDEEP concluded there was no basis on which to change current practice.

Recent genetic analyses have brought forward new information regarding the issue of stock discrimination in the roundnose grenadier. White *et al*. (2010), investigating a limited geographic area in the central and eastern North Atlantic, found evidence of population substructure and local adaptation to depth. An ongoing study, to be published soon (Knutsen *et al*., in prep), covers a larger geographic range and finds indication for population structure throughout the species' distribution range. More specifically, they found that stock structure is clearly evident in the outskirts of the distribution range (Canada and Norway) however, significant but weaker structure, is found among some pairwise samples in the central distribution areas like MAR, west of UK and Greenland (Oral presentation by Knutsen *et al*., 2010 ICELAND DSBS).

A.2. Fishery

For many years the grenadier was only taken as bycatch in bottom-trawl fisheries for *Pandalus borealis* and perhaps *Nephrops*, and it is uncertain if all catches were landed. The interest in marketing bycatches and developing targeted fisheries grew in the 1980s, probably stimulated by the new fisheries to the west of the British Isles and marketing opportunities in e.g. France. The potential for landing and marketing grenadier for human consumption was explored and exploratory surveys were conducted, but a major sustained fishery never developed in this area.

The stock of roundnose grenadier found in the deep parts of Skagerrak (IIIa) was then the basis for commercial exploitation by a few Danish vessels from the late 1980s until 2006, in some years mainly by a single vessel. This directed fishery began in 1987 as an exploratory fishery. Up to 2003 landings increased gradually, from around 1000 t to 4000 t with fluctuations. However, in 2004 and 2005 exceptionally high catches were reported. The catches were landed mainly for reduction. The fishery and catches were both mainly conducted in the Norwegian economic zone of Skagerrak. This directed fishery stopped in 2006 due to implementation of new agreed regulations between EU and Norway concerning this fishery (Bergstad, 2006). Roundnose grenadier is also taken as bycatch in the Danish fisheries for *Pandalus*, in IIIa. However, the landings of this bycatch (also for reduction) are generally insignificant.

Other countries' bycatches of roundnose grenadier in IIIa, from such as the Norwegian *Pandalus borealis* fishery, is minor due to an introduction of sorting grid in this fishery since the mid 1990s.

Only Denmark has contributed significantly to this fishery and since 2007 landings have been negligible.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Landings have been reported to WGDEEP since 1988. Prior to 1988 landings were small or at the level observed in the early 1990s. Danish landings were always dominant, and Norway and Sweden and all other nations reported very minor landings. Until 2000 the landings were mostly below 2500 tonnes per year. Subsequently, the Danish fishery expanded, and in 2005 the landings reported to WGDEEP reached almost 12 000 tonnes. The landings declined again in 2006 to very low levels and have since been stable reflecting only bycatches from other fisheries.

The total Danish landings of this species split in landings for H.C. and for reduction is shown in Table 19.18.1. These landings figures have been estimated on basis of reported logbook records combined with samples of the landed catches for reduction. They differ slightly from the logbook recorded catches, which generally overestimate the true landings. For the period 2001–2006 peak landings within a year were recorded in March–April.

Data are given on the geographical distribution of this fishery from 2006 (Figure 19.18.1). This fishery had a very small geographical distribution and landings were mainly from a very few rectangles in Norwegian zone of Skagerrak.

Table 19.18.1. Danish landings, 1996–2006 of roundnose grenadier split into H.C. landings and landings for reduction.

	Landings of roundnose grenadier (kg)		Total landings
year	H. C.	Reduction	(tons)
1996	6493	2 207 000	2213
1997		1 356 280	1356
1998	635	1 489 000	1490
1999		3 113 000	3113
2000	315	2 400 000	2400
2001	6401	3 061 000	3067
2002	4	4 195 738	4196
2003	7	4 301 661	4302
2004	3129	9 870 664	9874
2005	17 056	1 904 545	11 922
2006	2448	2 259 000	2261

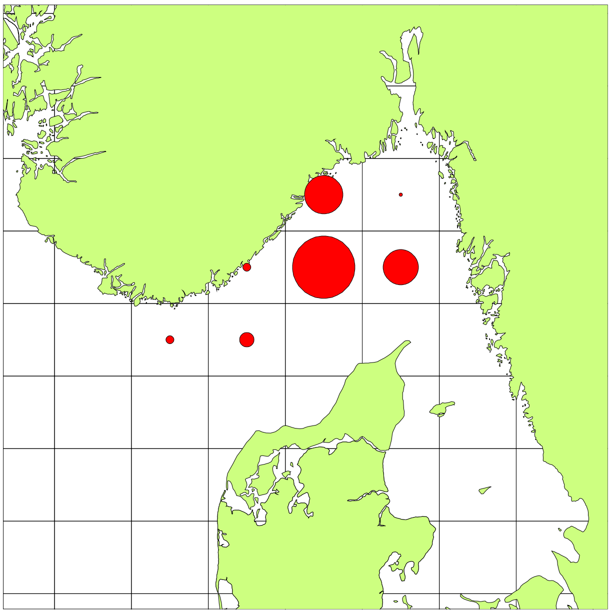
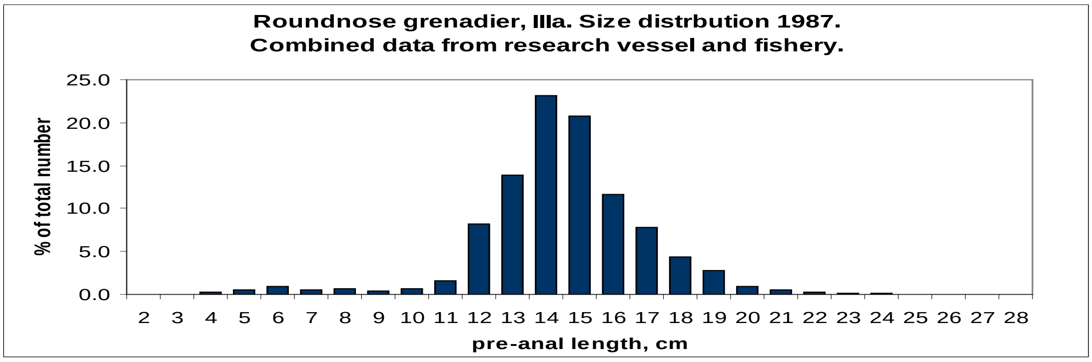
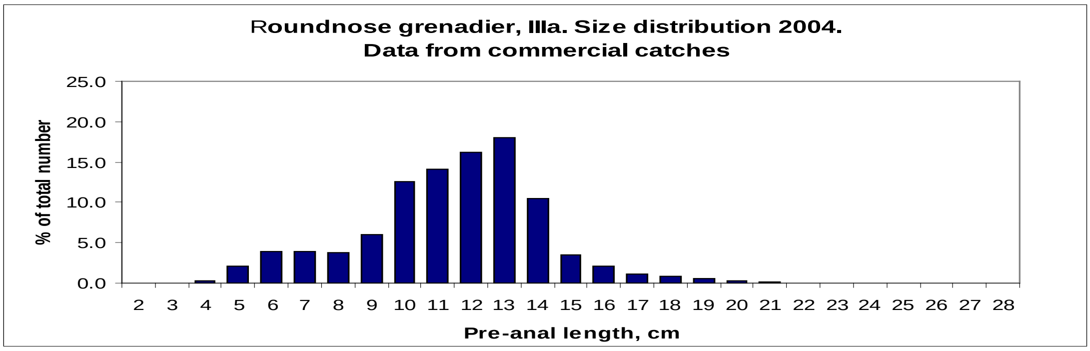


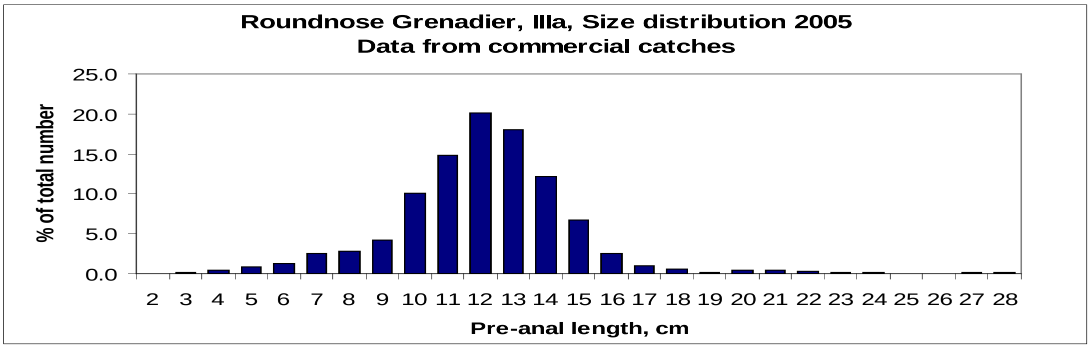
Figure 19.18.1. Geographical distribution of the fishery for roundnose grenadier in IIIa in 2006.

B.2. Biological

Length frequency data for roundnose grenadier in IIIa are available from a 1987 survey by the Danish research vessel and an experimental Danish fishery in the same year. Samples of the Danish landings 2004–2006 have provided information of the size composition in landings during the major expansion of the fishery, see Figure 19.18.2.







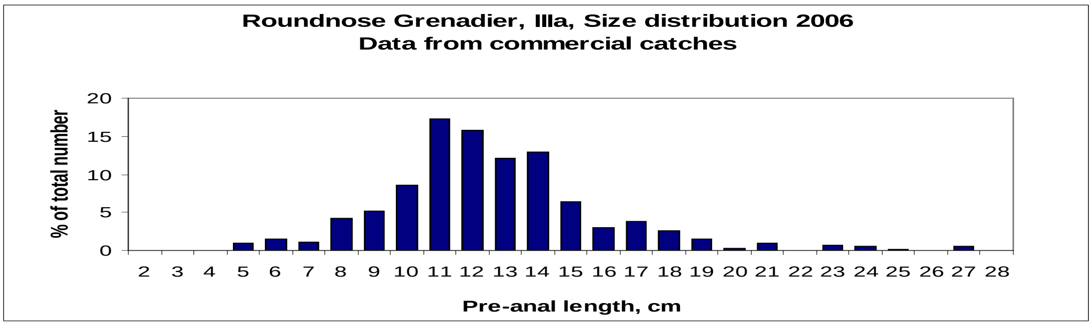


Figure 19.18.2. Size compositions from Danish commercial catches in 1987, 2004–2006.

B.3. Surveys

B.3.1. *Pandalus borealis* survey

An annual *Pandalus borealis* shrimp survey performed by the Institute of Marine Research have been conducted in the area since 1984. The survey is a depth stratified research survey with approximately 25% of the stations deeper than 300 m (depth range 110–520 m). The stations are placed at random within strata and subareas, and the same sites area sampled every year. The survey is thought to have a representative sampling for roundnose grenadier although the survey originally was designed primarilly for sampling shrimp. Although some changes occurred over the years, the overall standardization was maintained throughout the time-series (Bergstad *et al.*, 2009 and 2011, WD's to WGDEEP). At present, data from this survey is the only fishery-independent information on this stock from this area.

Biomass and abundance was calculated as mean of all stations at depths>300 m including the stations with zero catches. Percentage length distributions were standardized to catch size and trawling distance for all stations >300 m with positive catches.

B.3.2. Other survey data

Investigations by Bergstad (1990) based on data from 1987 in Skagerrak suggest very slow growth and consequently the age distributions in catches could span over 20–30 years.

B.4. Commercial cpue

The overall trends in logbook recorded catch, effort and cpue for the Danish directed fishery on this stock for the period 1996–2006 is showed in Table 19.18.2 A–C. A number of different mesh sizes were used in the fishery. The evaluation of the Danish cpue data is presented in ICES (2007) together with suggestive comments. Here it suffices to state, that these cpue figures (Tables 19.18.2 A–C) do not provide any clear indications of stock development and status for that period (Figure 19.18.3).

Table 19.18.2 A–C. The Danish fishery for roundnose grenadier in IIIa. Trends in catch, effort and cpue by major ICES rectangle, see text.

	Total catch (tons) by ICES rectangle					
year	44F8	44F9	45F8	45F9	46F9	Total
1996	80	40	25	709	98	951
1997	28	0	115	1088	163	1393
1998	238	235	180	1483	1112	3248
1999	0	25	61	704	1353	2143
2000	0	0	40	893	854	1787
2001	105	11	65	862	956	1999
2002	165	79	0	928	1531	2702
2003	0	120	545	1223	1769	3657
2004	1104	5786	215	1704	1721	10 529
2005	518	4073	682	4739	2823	12 834
2006	26	517	40	1067	487	2136
	Total effort (days) by ICES rectangle					
year	44F8	44F9	45F8	45F9	46F9	Total
1996	5	23	2	59	6	95
1997	3		7	67	5	82
1998	7	9	4	54	32	106
1999		2	4	43	65	114
2000		2	4	57	48	111
2001	5	8	3	49	65	130
2002	11	7		42	70	130
2003		5	17	70	96	188
2004	99	391	9	74	65	638
2005	47	178	9	107	77	418
2006	2	19	2	24	20	67
	Total cpue (tons/day) by ICES rectangle					
year	44F8	44F9	45F8	45F9	46F9	Average
1996	16.0	1.7	12.5	12.0	16.3	10.0
1997	9.2		16.4	16.2	32.5	17.0
1998	34.0	26.1	45.0	27.5	34.8	30.6
1999		12.5	15.3	16.4	20.8	18.8
2000		0.0	10.0	15.7	17.8	16.1
2001	21.0	1.4	21.7	17.6	14.7	15.4
2002	15.0	11.3		22.1	21.9	20.8
2003		24.0	32.1	17.5	18.4	19.5
2004	11.2	14.8	23.9	23.0	26.5	16.5
2005	11.0	22.9	75.7	44.3	36.7	30.7
2006	12.8	27.2	20.0	44.5	24.3	31.9

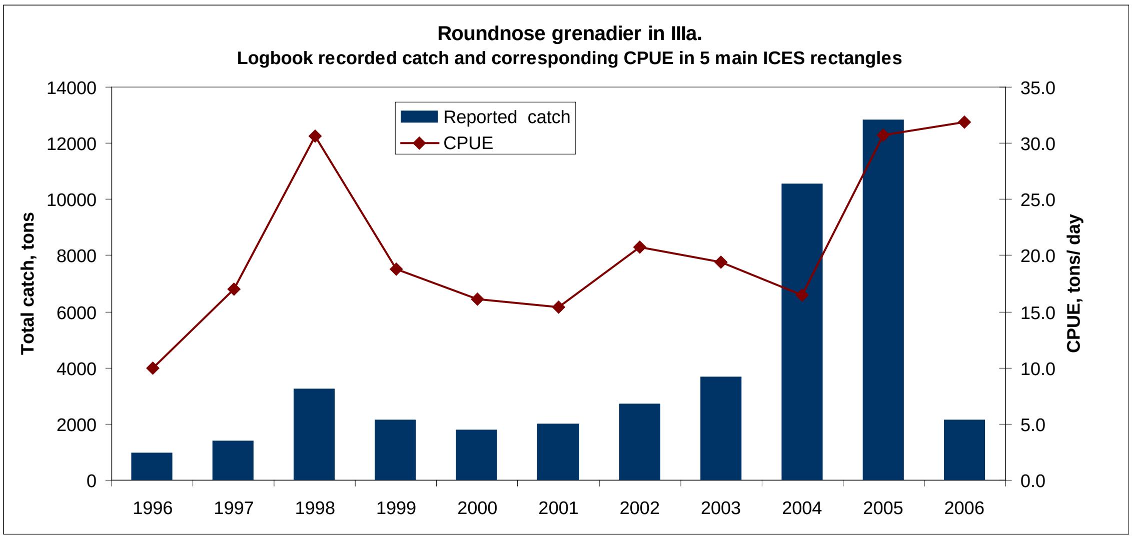


Figure 19.18.3. Danish catches and cpue by main ICES rectangle. Based on logbook records.

B.5. Other relevant data

C. Assessment: data and method

Model used: Survey trends, landings and size distribution from landings during directed fishery.

Software used:

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Split on countries	Variable from year to year Yes/No
Landings	Catches in tonnes	1988–2010	Yes	No
Danish cpue commercial catches	Tonnes/day	1996–2006	Danish only	No
Danish commercial length compositions	% of total number	1987 and 2004–2006	Danish only	Yes
Survey catch rate	Kg/hour	1984–2010	Norwegian only	No
Survey length compositions	% of total number	1984–2010	Norwegian only	No

D. Short-term projection

NA.

E. Medium-term projections

NA.

F. Long-term projections

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

No biological reference points have been set.

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

Bergstad, O.A., H.Ø. Hansen, and T. Jørgensen. 2009. Fisheries-independent information on temporal variation in abundance, size structure, recruitment and distribution of the roundnose grenadier *Coryphaenoides rupestris*, 1984-2009. Working Document for ICES WGDEEP, Copenhagen 2009.

Bergstad, O.A., H.Ø. Hansen and T. Jørgensen. 2011. Update on Norwegian fishery-independent information on roundnose grenadier (*Coryphaenoides rupestris*) in the Skagerrak and northeastern North Sea (ICES Division IIIa and Iva). Working Document 12 for ICES WGDEEP, Copenhagen 2010.

Bergstad, O.A. 1990a. Ecology of the fishes of the Norwegian Deeps: Distribution and species assemblages. *Netherlands Journal of Sea Research* 25(1/2): 237–266.

Bergstad, O.A. 2006. Exploitation and advice options for roundnose grenadier in the Skagerrak (IIIa). Working Document for ICES WGDEEP, Vigo, 2006. 8 p.

Bergstad, O.A. 1990b. Distribution, population structure, growth and reproduction of the roundnose grenadier *Coryphaenoides rupestris* (Pisces:Macrouridae) in the deep waters of the Skagerrak. *Marine Biology* 107: 25–39.

ICES. 2007. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). ICES CM 2007/ACOM:??.

Knutsen *et al*. 2010 ICELAND DSBS. Oral presentation.

White, T.A., J. Stamford, and A.R. Hoelzel, 2010. Local selection and population structure in a deep-seafish, the roundnose grenadier (*Coryphaenoides rupestris*). Molecular Ecology 19: 216–226.

19.19 Roundnose grenadier in other areas

Stock:	Roundnose grenadier (*Coryphaenoides rupestris*) in other areas (I, II, IV, Va2, VIII, IX, XIVa, XIVb2)
Working Group:	WGDEEP
Date:	8th March 2011
Revised by>	Vladimir Vinnichenko

A. General

A.1. Stock definition

See Annex “Roundnose grenadier in Vb, VI, VII and XIIb”.

A.2. Fishery

There have been no directed fisheries of roundnose grenadier, and this species was taken as bottom-trawl bycatch only in small amounts in a number of discrete areas. The total catch had permanent decrease tendency during recent years and amounted only 46 t in 2009 and 59 t in 2010.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

Landings data per ICES areas and by countries are available for 1989–2010. Catch in Division XIVb are allocated to MAR (Division XIVb1) and East Greenland (Division XIVb2) according to knowledge of the fisheries from WG members. There is no information on discards.

B.2. Biological data

There was only occasional sampling for roundnose grenadier in other areas in the previous years.

B.3. Surveys

There were no special surveys earlier for roundnose grenadier in other areas.

B.4. Commercial cpue

There is no information on cpue.

B.5. Other relevant data

No other relevant sources of data.

C. Assessment: data and method

No analytical assessments are used.

D. Short-term projection

No projections are performed.

E. Medium-term projections

No projections are performed.

F. Long-term projections

No projections are performed.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

No biological reference points have been defined.

H. Other issues

No comments.

I. References

No references.

19.20 Tusk in I and II

Stock:	Tusk (*Brosme Brosme*) in Subareas I and II
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Kristin Helle

A. General

A.1. Stock definition

In 2007, WGDEEP examined the available evidence of stock discrimination in this species. Based on the genetic investigation, the Group suggested that Tusk in I and II should be treated as one unit.

A.2. Fishery

Tusk has been caught, primarily as bycatch in the ling and cod fisheries, in these subareas for centuries, and the historical development is described by e.g. Bergstad and Hareide, 1996, including the post-World War II increase caused by a series of technical advances. Currently the major fisheries in Subareas I and II are the Norwegian longline and gillnet fisheries, but there are also bycatches by other gears, i.e. trawls and handlines. Of the Norwegian landings, usually around 85% is taken by longlines, 10% by gillnets and the remainder by a variety of other gears. Other nations catch tusk as a bycatch in trawl and longline fisheries.

Russian landings (107 tonnes) from Subdivisions IIa and IIb in 2010 were mainly taken as bycatch in longline fisheries. In Subarea I one tonne was caught (Vinnichenko *et al*., WD 2011).

A.3. Ecosystem aspects

B. Data

Full landings data are available from 1988 to present but it is thought that fisheries in some of these areas pre-date the time-series. Incomplete landings data are available from Norwegian longline fisheries from 1889 onwards. Additional landings data from other areas may be available from 1950 onwards.

B.2. Biological

Length data for the Norwegian reference fleet in Subarea IIa have been routinely collected since 2002.

Considerable general information is available on the life-history characteristics of this species.

B.3. Surveys

No data available.

B.4. Commercial cpue

Norway started in 2003 to collect and enter data from official logbooks into an electronic database and data are now available for the period 2000–2009. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding 8 tonnes in a given year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. Cpue were calculated as the average total catch of ling per vessel (*C*), and the average number of hooks per set and per vessel (*N*) associated with these catches. Then, for each year and catch category, the estimated cpue for the entire fleet was determined as *C*/*N*. Thus the estimated cpue for each year and Subarea was the mean catch in kg per hook for the entire fleet.

The boats that provided logbooks are the primary sampling units, and *C* and *N* are both random variables. It follows that this is a ratio-type estimator, therefore the standard errors of the cpue estimates could be calculated as described in Cochran (1977, page 32). This cpue estimator is a weighted average, that is the more hooks a boat sets, the more influence it has on the estimate (Cochran, 1977). For comparison, an unweighted cpue series was also constructed (i.e. the average cpue per boat).

A standardized series will be developed in preparation for WGDEEP 2012.

B.5. Other relevant data

C. Assessment: data and method

D. Short-term projection

E. Medium-term projections

F. Long-term projections

G. Biological Reference Points

No biological reference points have been defined.

H. Other Issues

I. References

No references.

19.21 Tusk MAR

Stock:	Tusk (*Brosme Brosme*) on the Mid-Atlantic Ridge (Subdivisions XIIa1 and XIVb1)
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Kristin Helle

A. General

A.1. Stock definition

In 2007, WGDEEP examined the available evidence of stock discrimination in this species. Based on the genetic investigation, the Group suggested that Tusk on the Mid Atlantic Ridge should be treated as one unit.

A.2. Fishery

Tusk is a bycatch species in the gillnet and longline fisheries in Subdivisions XIIa1 and XIVb1. Russia reported catches of tusk in 2005–2007 and 2009. No catches were reported for 2010. During the period 1996–1997 Norway also had a fishery in this area.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

B.2. Biological

B.3. Surveys

B.4. Commercial cpue

B.5. Other relevant data

C. Assessment: data and method

D. Short-term projection

E. Medium-term projections

F. Long-term projections

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other issues

I. References

No references.

19.22 Tusk in VIb

Stock:	Tusk (*Brosme Brosme*) in VIb
Working Group:	WGDEEP
Date:	March 2011
Revised by:	Kristin Helle

A. General

A.1. Stock definition

In 2007, WGDEEP examined the available evidence of stock discrimination in this species. Based on the genetic investigation, the Group suggested that Tusk in VIb should be treated as one unit.

A.2. Fishery

Tusk is a bycatch species in the trawl, gillnet and longline fisheries in Subarea VIb. Norway has traditionally landed the largest percentage of the total catch. Longliners catch about 90% of the Norwegian landings. Since the 12th of January 2007 parts of the Rockall bank has been closed to fishing with bottom trawls, gillnets and longlines. The areas closed are traditional areas fished by the Norwegian longline fleet.

In 2004 Russia started longline fishery of ling with bycatch of tusk in international waters of the Rockall Bank. Maximum catch (137 t) was taken in 2005. In recent years, intensity of Russian longline fishery decreased. Small bycatches of tusk were also taken in the area by trawlers on haddock fishery.

A.3. Ecosystem aspects

B. Data

Full landings data are available from 1988 to present but it is thought that fisheries in some of these areas pre-date the time-series. Incomplete landings data are available from Norwegian longline fisheries from 1889 onwards. Additional landings data from other areas may be available from 1950 onwards.

B.2. Biological

Length data for the Norwegian reference fleet in Subarea IIa have been routinely collected since 2002.

Considerable general information is available on the life-history characteristics of this species.

B.3. Surveys

No data available.

B.4. Commercial cpue

Norway started in 2003 to collect and enter data from official logbooks into an electronic database and data are now available for the period 2000–2009. Vessels were selected that had a total landed catch of ling, tusk and blue ling exceeding 8 tonnes in a given year. The logbooks contain records of the daily catch, date, position, and number of hooks used per day. Cpue were calculated as the average total catch of ling per vessel (*C*), and the average number of hooks per set and per vessel (*N*) associated with these catches. Then, for each year and catch category, the estimated cpue for the entire fleet was determined as *C*/*N*. Thus the estimated cpue for each year and subarea was the mean catch in kg per hook for the entire fleet.

The boats that provided logbooks are the primary sampling units, and *C* and *N* are both random variables. It follows that this is a ratio-type estimator, therefore the standard errors of the cpue estimates could be calculated as described in Cochran (1977, page 32). This cpue estimator is a weighted average, that is the more hooks a boat sets, the more influence it has on the estimate (Cochran, 1977). For comparison, an unweighted cpue series was also constructed (i.e. the average cpue per boat).

A standardized series will be developed in preparation for WGDEEP 2012.

B.5. Other relevant data

C. Assessment: data and method

D. Short-term projection

E. Medium-term projections

F. Long-term projections

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	Xxx	Explain
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

No biological reference points have been defined.

H. Other issues

H.1. Historical overview of previous assessment methods

I. References

There are no references.

19.23 Tusk in V and XIV

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

Likelihood weighting text added by WGDEEP 2011.

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 ten 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 socioeconomic 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 two 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. Since 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 19.23.1).

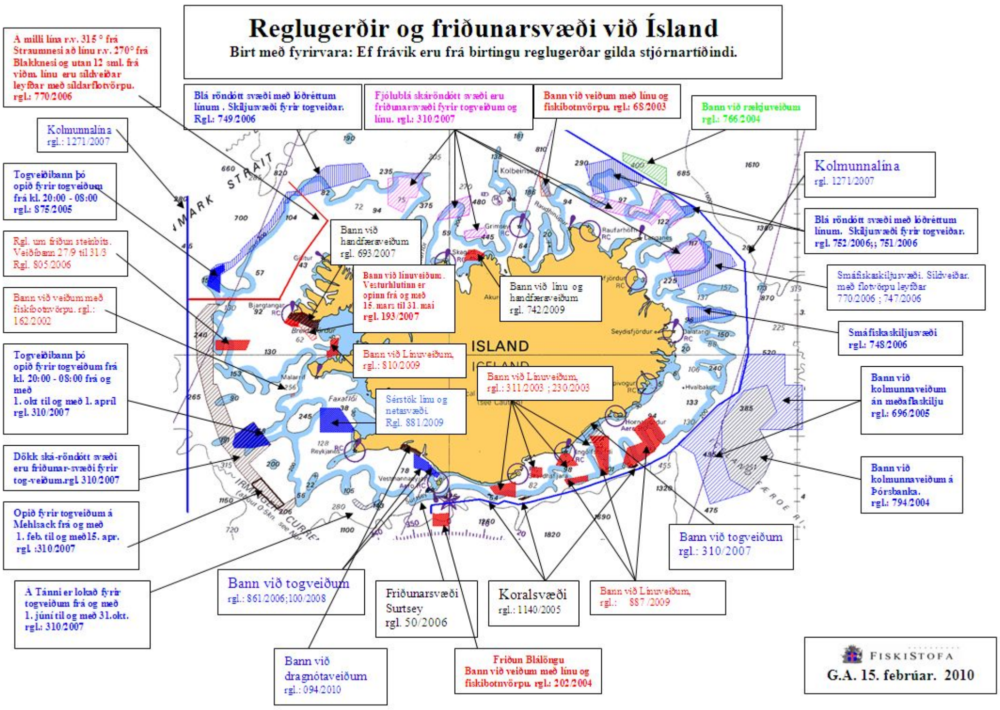


Figure 19.23.1. Marine protected areas in Icelandic waters. These areas are closed for various types of fisheries and may be closed permanently (all year around) or temporarily (closed part of the years. Four areas marked red south and southeast of Iceland (reference to the box *Bann við Línu-veiðum, 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

At 45 cm around 20% of tusk in Va is mature, at 58 cm 50% of tusk is mature and at 80 cm more or less every tusk is mature.

No information is available on natural mortality of tusk in Va. In the Gadget model it is assumed to be 0.2 but different variants of natural mortality are tested.

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 since 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 ungutted, the ungutted 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 (approximately 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 fishers 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 19.23.2). 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 fishers and fishery scientist at the MRI for decisions of location. The scientist selected random position for their stations, whereas the fishers 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 Japanese built trawlers were all built 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).

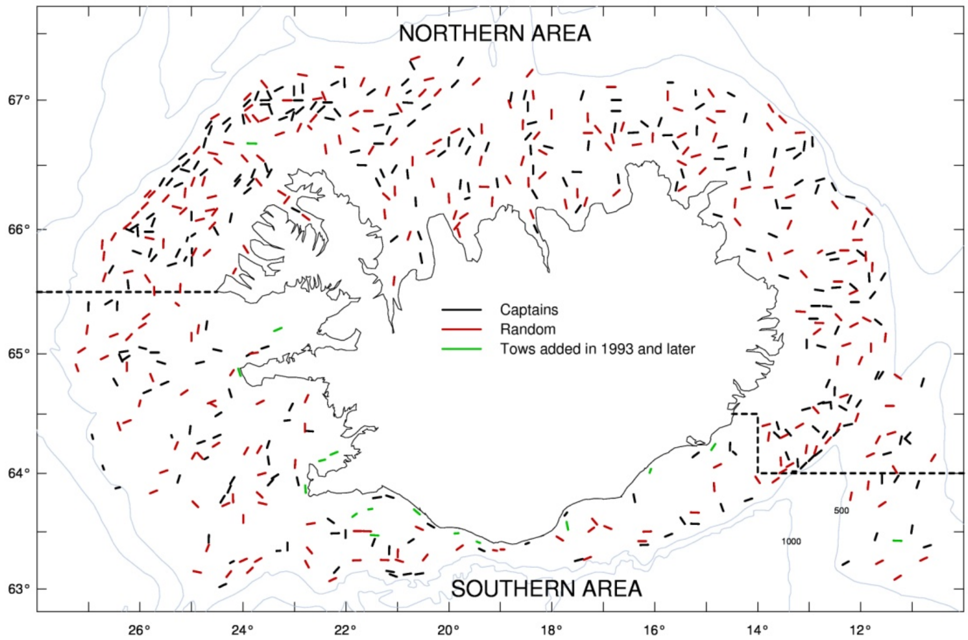


Figure 19.23.2. Stations in the spring survey in March. Black lines indicate the tow-stations selected by captains of commercial trawlers, red lines are the tow-stations selected randomly, and green lines are the tow-stations that were added in 1993 or later. The broken black lines indicate the original 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 19.23.2). 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 fishers' 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 nine 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, a total of 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. A total of 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. A total of 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 19.23.3).

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".

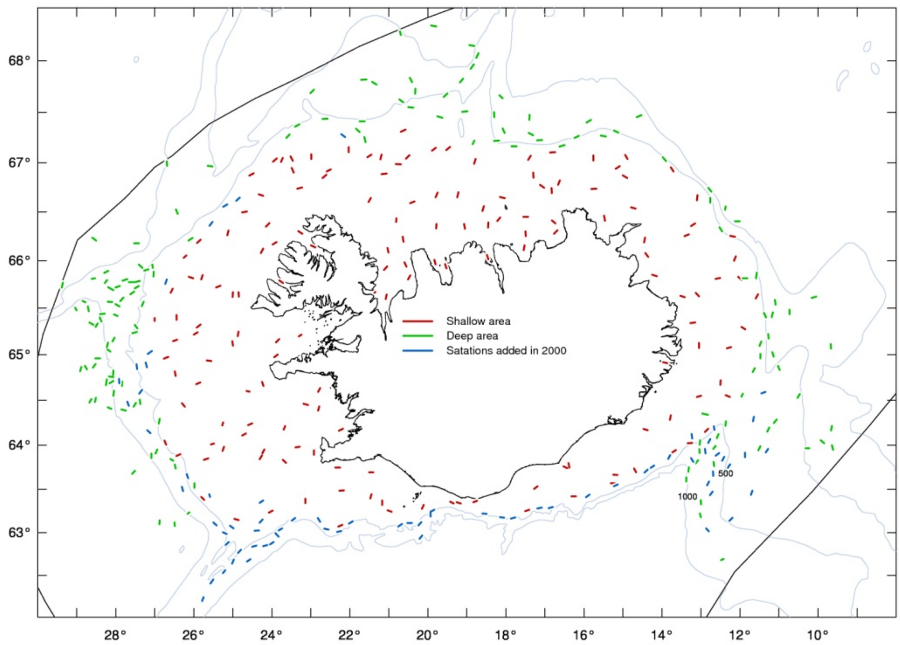


Figure 19.23.3. Stations in the Autumn Groundfish Survey (AGS). RV "Bjarni Sæmundsson" takes stations in the shallow-water area (red lines) and RV "Árni Friðriksson" takes stations in the deep-water areas (green lines), the blue lines are stations added in 2000.

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 ungutted 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 four 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 ungutted 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, ten 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, Windspeed, 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 four 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 two 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 19.23.4. 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.

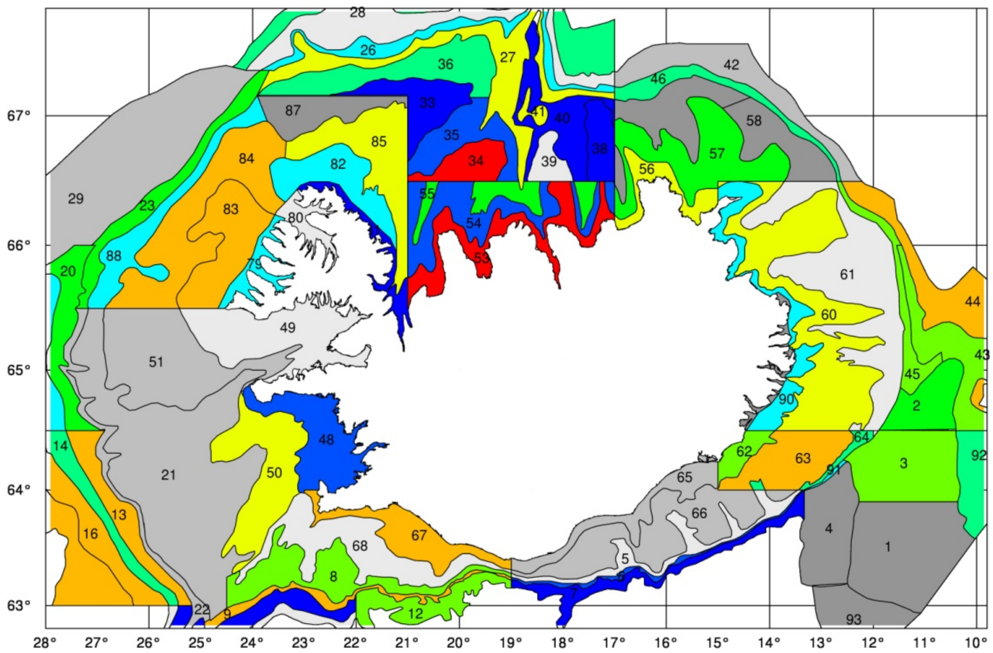


Figure 19.23.4. Subareas or strata used for calculation of survey indices in Icelandic waters.

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 against the available data to produce a weighted likelihood score. Optimization 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 that 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 against 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.

Optimization

The model has two alternative optimizing algorithims linked to it; a wide area search simulated annealing Corona *et al*. (1987) and a local search Hooke and Jeeves algorithim, 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 algorithim. 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 algorithims 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 estimated following the procedure laid out by Taylor *et al*. (2007) where an objective re-weighting scheme for likelihood components is described for Gadget models using cod as a case study. The iterative re-weighting heuristic tackles this problem by optimizing each component separately in order to determine the lowest possible value for each component. This is then used to determine the final weights. The iterative re-weighting procedure has now been implemented in the R statistical language as a part of the **rgadget** package which is written and maintained by B. Th. Elvarsson.

Conceptually the likelihood components can roughly be thought of as residual sums of squares (SS), and as such their variance can be estimated by dividing the SS by the degrees of freedom. Then the optimal weighting strategy is the inverse of the variance. The variances and hence the final weights are calculated according the following algorithm:

1) Calculate the initial SS given the initial parameterization. Assign the inverse SS as the initial weight for all likelihood components. With these initial weights the objective function will start off with value equal to the number of likelihood components.
2) For each likelihood component, do an optimization run with the initial score for that component set to 10 000. Then estimate the residual variance using the resulting SS of that component divided by the effective number of datapoints that is all non-zero data-points.
3) After the optimization set the final weight for that all components as the inverse of the estimated variance from step 3 (weight =(1/SS) * d.f.*).

The effective number of datapoints (d.f.*) in 3) is used as a proxy for the degrees of freedom determined from the number of non-zero datapoints. This is viewed as satisfactory proxy when the dataset is large, but for smaller datasets this could be a gross overestimate. In particular, if the survey indices are weighed on their own while the yearly recruitment is estimated they could be over-fitted. If there are two surveys within the year Taylor *et al*. (2007) suggest that the corresponding indices from each survey are weighed simultaneously in order to make sure that there are at least two measurements for each yearly recruit. In general problem such as those mentioned here could be solved with component grouping that is in step 2) above likelihood components that should behave similarly, such as survey indices, should be heavily weighted and optimized together.

Another approach for estimating the weights of each index component, in the case of a single survey fleet, would be to estimate the residual variances from a model of the form:

$$\log(I_{lt} = \mu + Y_t + \lambda_t + \varepsilon_{lt}$$

where *t* is denotes year, *l* length-group and the residual term, ε_{lt}, is independent normal with variance σ_s^2 where *s* denotes the likelihood component. The inverse of the estimated residual variance are then set as weights for the survey indices. In the RGadget routines this approach is termed **sIw** as opposed to **sIgroup** for the former approach.

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, starting in 1980 with a selection pattern described by a logistic function and the total catch in tonnes specified for each quarter. The survey (1985 onwards), 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 four 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+	YES	Iceland	ldist.catch
Length distribution of Icelandic GFS	1985+	-	Iceland	ldist.survey
Abundace index of Icelandic GFS of 20–39 cm individuals	1985+	-	Iceland	si2039
Abundace index of Icelandic GFS of 40-59 cm individuals	1985+	-	Iceland	si4059
Abundace index of Icelandic GFS of 60–110 cm individuals	1985+	-	Iceland	si60110
Age–length key of the landings	See stock section	YES	Iceland	alkeys.catch
Age–length key of the Icelandic GFS	See stock section	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	Type
Bounds	Keeps estimates inside bounds	All	8
Understocking	Makes sure there is enough biomass	All	2
Si2039	Survey Index 20–39 cm	1	1
Si4049	Survey Index 40–59 cm	1	1
Si60110	Survey Index 60–100 cm	1	1
Si2080-2	Survey Index (To get a smoothed estimate of the survey selection curve	1	1
Ldist.catch	Length distribution commercial catches (Longlines)	All	3

Component	Description	Quarters	Type
Ldist.survey	Length distribution from the spring survey	1	3
Alkeys.catch	Age–length data from commercial catches	All	3
Meanl.catch	Mean length-at-age from commercial catches	All	4
Alkeys.survey	Age–length data from the spring survey	1	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; two params.
  - Icelandic spring survey; one parameter as the slope is kept constant.

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 is 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 runs presented at WGDEEP-2010 was started using the initial values and bounds below:

Inital parameter values used and the bounds assigned.

Switch	Value	Lower	Upper	Optimize
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

Switch	Value	Lower	Upper	Optimize
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 analyse convergence and problematic parameters.
- Plot comparing observed and modelled proportions in fleets (catches). To analyse 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 were addressed properly, WKDEEP agreed with the following parameters as input for short-term forecast. The ADGDEEP and subsequently ACOM decided to base the ICES advice for 2010 for tusk in Va and XIV based on projections from Gadget.

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 one 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

I. References

Begley, J., and Howell, D. 2004. An overview of Gadget, the Globally applicable Area-Disaggregated General Ecosystem Toolbox. ICES C.M. 2004/FF:13, 15 pp.

Björnsson, H. and Sigurdsson, T. 2003. Assessment of golden redfish (*Sebastes marinus* L.) in Icelandic waters. Scientica Marina, 67 (Suppl. 1): 301:304.

Björnsson, Höskuldur, Jón Sólmundsson, Kristján Kristinsson, Björn Ævarr Steinarsson, Einar Hjörleifsson, Einar Jónsson, Jónbjörn Pálsson, Ólafur K. Pálsson, Valur Bogason and Þorsteinn Sigurðsson 2007. The Icelandic groundfish surveys in March 1985–2006 and in October 1996–2006 (*in Icelandic with English abstract*). Marine Research Institute, Report 131: 220 pp.

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.

ICES. 2008. Report of the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP), 3–10 March 2008, ICES Headquarters, Copenhagen. ICES CM 2008/ACOM:14. 531 pp.

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.

Knutsen, H., Jorde, P. E., Sannæs, H., Hoelzel, A. R., Bergstad, O. A., Stefanni, S., Johansen, T. and Stenseth, N. C. 2009. Bathymetric barriers promoting genetic structure in the deepwater demersal fish tusk (*Brosme brosme*). Molecular Ecology, 18: 3151–3162.

Pálsson, Ó. K. 1984. Studies on recruitment of cod and haddock in Icelandic waters. ICES CM 1984/G:6, 16p.

Pálsson, Ó. K., Jónsson, E. Schopka, S. A., and Stefánsson, G. 1989. Icelandic groundfish survey data used to improve precision in stock assessments. Journal of Northwest Atlantic Fishery Science, 9: 53–72.

Taylor, L., Begley, J., Kupca, V. and Stefánsson, G. 2007. A simple implementation of the statistical modelling framework Gadget for cod in Icelandic waters. African Journal of Marine Science, 29:223–245.