Stock Annex: Portuguese dogfish (*Centroscymnus coelolepis*, *Centrophorus squamosus*) in subareas 1–10, 12 and 14 (the Northeast Atlantic and adjacent waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Portuguese dogfish
Working Group:	Working Group on Elasmobranch Fishes (WGEF)
Created:	
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Last updated:	17-24 February 2010
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A. General

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

A.1. Stock definition

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

A.2. Fishery

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

Country by country accounts are presented as follows:

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

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

Germany–At the early 2000s Two German vessels conducted a deep-water gillnet fishery (Hareide *et al.*, 2004). The main fishing area were Southern part of area 7 (Porcupine Seabight and around Rockall. (Area 6 and 12). The deep-water sharks were landed in Spain as 'various sharks'. This fishery ceased in 2006 as result of the EU ban on fishing with gillnets in depths greater than 600 m.

France–C*. squamosus* and *C. coelolepis* and lately, *Centroscyllium fabricii*, are caught by the French trawl fishery for mixed deep-water species. Initially this fishery was conducted in ICES Subareas 6.a, 7.c, 7.k but in 2001 when the Irish deep-water trawl fishery started to operate in Subarea 7 most of the French fishing fleet moved to Subarea 6.a).

In Subarea 12 there have been some French landings of deep-water sharks, but it is not possible to detect any trends from the available data.

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

Several large newer trawlers have targeted deep-water species in Subareas 6 and 7. There is a directed fishery for orange roughy in Subarea 7, with a low a bycatch which includes *C. coelolepis* and *C. squamosus* as well as a more extensive fishery on the continental slopes of Subareas 6 and 7 for mixed deep-water species including *C. coelolepis* and *C. squamosus*.

UK–Between the mid-1980s and 2006, UK registered longliners and gillnetters operated a directed fishery for deep-water sharks in Subareas 6, 7 and 12. The fleet was mostly composed of vessels based in Spain but registered in the UK, Germany and other countries outside the EU such as Panama.

C. squamosus and *C. coelolepis* are caught by a Scottish deep-water mixed-species trawl fishery operating mainly in Subarea 6. Since the introduction of TACs for a number of deep-water species in 2003, effort in this fishery has been at low level.

Spain–A fleet of around 24 large freezer trawlers conducts a mixed deep-water fishery in international waters of the Hatton Bank, mainly in ICES Subarea 12 and partially in Division 6.b, however, few of these vessels worked full-time in this fishery (two in 2000 and four in 2001). The main commercial fish species are smoothheads, roundnose grenadier, blue ling and *C. coelolepis*.

The Basque "baka" trawl fishery operates in Subareas 6 and 7 and Divisions 7.a-b, 7.d but deep-water species including sharks are only important in Subarea 6. In the period 1997–2002, a small longline fishery targeting deep-water sharks landed annually in Basque ports about 150 t in "trunk" weight (i.e. gutted and without head, skin and fins) of deep-water sharks (Lucio *et al*., 2004).

Portugal–At Sesimbra (Division 9.a), the longline fishery targeting black scabbardfish *Aphanopus carbo* takes a bycatch of deep-water sharks. The most important shark species caught by this fishery are the Portuguese dogfish and leafscale gulper sharks. Deep-water sharks are also caught by the Portuguese deep-water bottom-trawl fishery that targets the rose shrimp *Parapenaeus longirostris* and *Nephrops* mainly south and southwest of the Portuguese mainland. Deep-water shark species caught in this fishery are: birdbeak dogfish, blackmouth catshark, gulper shark, kitefin shark, leafscale gulper shark, smooth lanternshark *Etmopterus pusillus* and velvet belly.

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

A.3. Ecosystem aspects

Centroscymnus coelolepis

C. coelolepis is found in the Northwest Atlantic (from the Grand Banks to off Delaware Bay, and Cuba), Northeast Atlantic (Iceland to Sierra Leone, including the western Mediterranean, Azores and Madeira), South-East Atlantic (Namibia and South Africa) and western Pacific (Japan, New Zealand and Australia, and possibly in the South China Sea) (Compagno, 2004). Based on commercial landings and research vessel surveys, *C. coelolepis* is widely distributed in the ICES area, including off Norway (ICES Divisions 3.a and 4.a), Faroes Islands (5.b), Iceland (5.a), west of the British Isles (6, 7.b–c, 7.j–k), Bay of Biscay and Cantabrian Sea (8), Portugal (9), Azores (10) and off Madeira.

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

B. Data

B.1. Commercial catch

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

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

In the second stage, the landings data in the "siki sharks" data table were split according to the proportions observed in various sampling schemes and surveys, etc. to give estimates of species-specific landings. The data sources used in this splitting

are listed in Table 2. A considerable number of assumptions have been made in order to split catches from areas, years and fisheries from which no data were available. For instance, data from trawl fisheries were used to split landings from UK gillnetters. This will be improved should better data become available in future e.g. it is expected that species-specific landings for UK gillnetters will be provided by the RACs.

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

LANDING CATEGORY	COUNTRY	ICES SUBAREAS/DIVISIONS	YEARS
cartilaginous fish NEI data	No landing in this category were considered to be deep-water sharks		
various sharks NEI	UK-England and Wales	5, 6 and 7.c,	1990 to 2002
	UK-Scotland	All	1989 to 2001
	Portugal	8.c	1990 to 2000
	Poland	6.b	2002 and 2003
	Estonia	6.b	2002 and 2003
	Lithuania	12	2001 and 2003
dogfish sharks NEI	France*	6, 7, 12	1989 to 2003
	Germany	5, 6, 7, 12	1995 to 2003
Landing identified by species but identification considered unreliable	Faroes	All	All
	France*	All	All
	Ireland (records of Portuguese dogfish probably contain unknown quantities of leafscale gulper shark)	7	2001-2006
	Scotland (Portuguese dogfish probably contain unknown quantities of leafscale gulper shark. Records of Leafscale gulper shark are considered to be correct)	6	1997–2005
	Lithuania (*C. coelolepis* landings probably contain *C. squamosus*)	All	All
Data supplied to WGEF but identification considered unreliable	UK-England and Wales**	All	2001–2004
	UK-Scotland	All	2001–2004

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

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

Table 2 Data sources to split "siki sharks".

Source	ICES area	Years	Gear	Type	Available information
French Landing	6.a	1999–2001	Trawl	Fishery Landing sampling	Ratios not by depth Note: 12 boats/year
French Landing	6.a	2002–2008	Trawl	Fishery	French landings statistics; vessels from one fish owning company reported the species separately using an appropriate protocol to identify species Note: Represent 50% of landings
French trawler(auction market)	6.a	2009	Trawl	Fishery	Proportion of the two species by depth
SAMS	6.a	2000–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: very small numbers caught
IRISH s	6.a & 7.c	2006–2009	Trawl	Survey	Data by species in weight and number at fishing haul Note: depth strata are not the same between surveys
DEEPNET Report	6 & 7		Gillnet	Fishery	Ratios in weight Note: data from 1 recovered net
Cefas	5.a-b 7.j-k	2004 2005	Gillnet	Fishery	Observer data
Cefas	6.a	2005; 2006	Longline	Fishery	Observer data
Spanish fishery	6.b and 12 Hatton Bank	2005–2008	Trawl	Fishery	Observer data Ratios per depth and by ICES subarea
IEO	7.b, 7.k	2001–2009	Trawl	Survey	Information by haul

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

B.2. Biological

Centroscymnus coelolepis

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

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

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

B.3. Surveys

FRS has conducted deep-water surveys (depth range 300–1900 m) in Division 6.a since 1996. Since 1998 the survey has been reasonably consistent about survey design, gear deployed and area covered (Jones *et al*., 2005). The survey uses a large commercial trawl (made by Jackson) and is towed for a period of 1.5–2 hours at speeds of 3–3.5 knots. Initially, the survey was carried out on a biennial basis, but since 2004 has been carried out annually.

B.4. Commercial cpue

Portuguese longline fisheries

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

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

Data used

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

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

Lpue from French fisheries in Subarea 5.b, 6 and 7

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

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

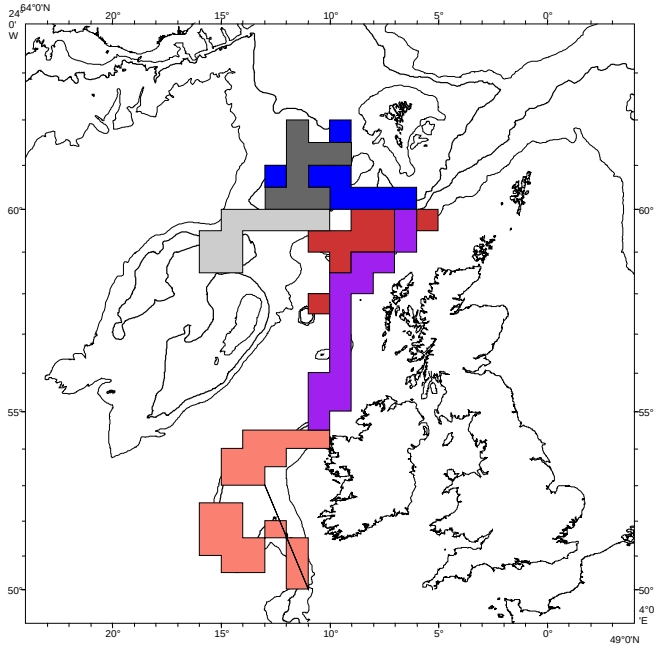

Figure 1. Areas used to compute lpue of French vessels (black: New grounds in 5; blue, Reference area in 5; Grey: new grounds in 6; Purple reference area in 6-edge; Red: Reference area in the 6 - other; pink reference area in 7.

Industry data

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

B.5. Other relevant data

Centroscymnus coelolepis

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

C. Historical stock development

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

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

A second attempt was made during DELASS. The French cpue data for Subareas 5, 6 and 7 for *C. coelolepis* and *C.squamosus* together were used as inputs. The combined cpue for these Subareas was calculated from the total catch and effort data presented in the WGDEEP Report (ICES, 2002b). These data did not display as marked an upward trend as demonstrated in the WGDEEP Report (ICES, 2002b). Both cpue datasets were used as inputs. The time-series for Subarea 6, where most effort took place, both displayed downward trends until 1998. The WGDEEP 2002 series did not display the high peak in the SGDEEP 2000 series for 1991. However, the value for 2001 is the highest since 1994. There is no similar upward trend for the other subareas, and it is unclear what the reasons for this trend are. The series for the Subareas combined displayed the same trend, indicating the importance of effort in Subarea 6 on these sharks. However, there is no anecdotal evidence from the fishery to suggest that there is an upward trend in abundance in 2000 or 2001.In addition, Norway (autoline) and Ireland (autoline and trawl) survey abundance indices in Subarea 6 did not mirror the upward trend in cpue from the French commercial fishery. Furthermore, the pooled species data, from autoline surveys displayed a downward trend from 1997 to 2000. In

Subareas 7 and 12 there is some evidence of a decline in survey cpue throughout the 1990s.

In the second attempt the cpue data for siki representing non-directed effort as input to Schaeffer Production Model, using the CEDA package (Holden *et al.*, 1995). This model and package were chosen to allow for comparisons to be made with the previous assessment attempted for these stocks. A sensitivity analysis was used to evaluate the effect of error models and ratio of initial to virgin biomass. A time-lag of zero was used because that the time-series of catch and cpue were too short to explore the effect of recruitment over range of years. It was assumed, therefore, that growth rather than recruitment was the main contributor to biomass production. The available time-series data of cpue data demonstrate a gradual decline across most of the time period. Given this sort of pattern, caution is needed because of the one-way trip. (Hilborn and Walters, 1992) resulting in highly unreliable estimates of the parameters of this model. A value of the ratio of initial stock to virgin stock was chosen as 0.7, based on sensitivity analysis. The fit of the Schaeffer production model was very poor when all years were included. It was considered reasonable to exclude years 1991 and 1993 because the 42|ICES WGEF Report 2005 fishery was not fully developed then. The directed cpue series (ICES, 2000) displayed a peak in 1991. However non-directed cpue did not display a first peak until 1993, which probably reflected the targeting of the orange roughy fishery in Subarea 6 at that time. The years 2000 and 2001 were excluded because there was no supporting evidence of an upward trend in stock abundance in these years. Subsequent runs of the Schaeffer model gave a better model fit than when all years were included. Two additional scenarios were considered, using the WGDEEP 2002 cpue and the cpue recalculated in DELASS from the raw catch and effort data. The model was considered to fit the downward trend on abundance quite well, for the years considered.

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

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

Benchmarked assessment methodology

Portuguese dogfish is assessed using trends in;

- Standardised cpue indices from Portuguese commercial fisheries;
- Presence/absence in Scottish and Irish surveys disaggregated by depth;

- French lpue indices; species-specific indices will be used when they become available. Until then, the combined "sikis" index may be used with caution to provide historical trends in combined lpue.

G. Biological reference points

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

H. Other issues

I. References

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