Stock Annex: Icelandic slope beaked redfish (*Sebastes mentella*) in Divisions Va and XIVb

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Icelandic slope beaked redfish (*Sebastes mentella*) in Divsions Va and XIVb
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A. General

A.1. Stock definition

The "Workshop on Redfish Stock Structure" (WKREDS, 22-23 January 2009, Copenhagen, Denmark; ICES 2009) reviewed the stock structure of beaked redfish (*Sebastes mentella*) in the Irminger Sea and adjacent waters. ACOM concluded, based on the outcome of the WKREDS meeting, that there are three biological stocks of beaked redfish in the Irminger Sea and adjacent waters:

- a 'Deep Pelagic' stock (NAFO 1–2, ICES V, XII, XIV >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faeroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1–2, ICES V, XII, XIV <500 m) – extends to ICES I and II, but primarily pelagic habitats, and includes demersal habitats east of the Faeroe Islands;
- an 'Icelandic Slope' stock (ICES Va, XIVb) – primarily demersal habitats.

This conclusion is primarily based on genetic information, i.e. microsatellite information, and supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns.

The adult redfish on the Greenland shelf has traditionally been attributed to several stocks, and there remains the need to investigate the affinity of adult beaked redfish in this region. The East-Greenland shelf is most likely a common nursery area for the three biological stocks.

The Icelandic slope beaked redfish is treated as a separate management unit.

A.2. Fishery

Annual landings and spatial and temporal distribution of catches

The fishery of Icelandic slope beaked redfish started in the early 1950s (Figure A.2.1). The annual catch 1950-1977 was on average 33,000 t. Annual landings gradually decreased from a record high of 57 000 t in 1994 to 17 000 t in 2001 t. Landings in 2003 increased to 28 500 t but have since then fluctuated between 16 000 t and 21 000 t.

The fishery for beaked redfish in Icelandic waters is predominantly conducted by the Icelandic bottom trawl fleet directed towards the species. Prior to 2000, between 10-40% of the total landings were taken by pelagic trawl. In general, the pelagic fishery has mainly been in the same areas as the bottom trawl fishery, but usually in later months of the year. In 2001-2010, no pelagic fishery occurred or it was negligible, except in 2003 and 2007.

The catch pattern was different in 2003 and in 2007 than in other years. The catches peaked in July in 2003 and in June 2007, which was unusual. This pattern is associated with the deep pelagic beaked redfish stock fishery within the Icelandic EEZ. The deep pelagic beaked redfish fishery has in some years moved further north, and in 2003 and 2007 it merged with the Icelandic slope beaked redfish fishery on the redfish line (a line defined by Icelandic authorities in 1993 to separate catches of pelagic and Icelandic slope beaked redfish) in July. When the deep pelagic beaked redfish crossed the redfish line to the east, it was recorded as Icelandic slope beaked redfish and caught either with pelagic or bottom trawls. This explains the pelagic catches of Icelandic slope beaked redfish in those two years.

The most important fishing grounds are southwest, west, and north-west (close to the Iceland-Greenland midline EEZ) of Iceland at depths from 450 to 800 m. A historically important fishing ground for the Icelandic slope beaked redfish stock is south-east of Iceland along the slope of the Iceland-Faroe Islands Ridge. Fishing in this area has gradually decreased since 2000 and in recent years there has not been a directed fishery for Icelandic slope beaked redfish.

Although no direct measurements are available on discards, it is believed that there are no significant discards of Icelandic slope beaked redfish.

Fleet composition

The fishing fleet operating in Icelandic waters consists of diverse boat types and sizes, operating various types of gear. The majority of the Icelandic slope beaked redfish catches are taken by trawlers larger than 40 BRT using bottom trawls. The remainder of the catch comes from vessels targeting Greenland halibut (*Reinhardtius hippoglossoides*) and in recent years greater silver smelt (*Argentina silus*). Most of the vessels that target Icelandic slope beaked redfish are the same vessels that fish the pelagic beaked redfish stocks and the majority of the golden redfish (*S. marinus*) catch.

Management

The Ministry of Fisheries and Agriculture is responsible for management of all Icelandic fisheries, including the Icelandic slope beaked redfish fishery, and for the implementation of the legislation in the Icelandic Exclusive Economic Zone (EEZ). There is, however, no explicit management plan for Icelandic slope beaked redfish.

The Ministry issues regulations for commercial fishing for each fishing year (from September 1st to August 31st), including 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 with emphasis on Icelandic slope beaked redfish when applicable. Further and detailed information on the management and regulations can be found at http://www.fisheries.is/.

A system of transferable boat quotas was introduced in 1984, but was changed to an individual transferable quota (ITQ) system in 1990. The fisheries are subjected to vessel catch quotas. The quotas represent shares in the national total allowable catch (TAC).

Since 2006/2007 fishing season, all boats operate under the TAC system. 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. The agreed quotas are based on the Marine Research Institute's TAC recommendations, taking some socio-economic effects into account.

Within this system, individual boat owners have substantial flexibility to exchange quota, both among vessels within an individual company and among different companies. The latter can be done via temporary or permanent quota transfer. In addition, some flexibility is allowed by individual boats with regard to transfer allowable catch of one species to another. These measures, which can be acted on more or less instantaneously, are likely to reduce initiative for discards (which is effectively banned by law) and misreporting than can be expected if individual boats are restricted by TAC measures alone. They may, however, result in fishing pressures of individual species to be different than intended under the single species TAC allocation.

Furthermore, a vessel can transfer some of its quota between fishing years. There is a requirement that the net transfer of quota between fishing years must not exceed 10% of a given species (was changed from 33% in the 2010/211 fishing year). This may result in higher catch in one fishing year than the set TAC and subsequently lower catches in the previous 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 (the native enforcement body). All fish landed has to be weighted, either at harbour or inside the fish processing factory. The information on landing is stored in a centralized database maintained by the Directorate and is available in real time on the internet (www.fiskistofa.is). Up to 10% of the amount of the Icelandic slope *S. mentella* caught annually in Icelandic waters is landed in foreign ports. The accuracy of the landings statistics are considered reasonable although some bias is likely.

All boats operating in Icelandic waters have to maintain a log-book record of catches in each haul. For the larger vessels (for example vessels using bottom and pelagic trawls) this has been mandatory since 1991. 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. No formal harvest control rule exists for this stock. The minimum allowable mesh size is 135 mm in the trawl fisheries, with the exception of targeted shrimp fisheries in waters north of the island.

Redfish (golden refish and Icelandic slope beaked redfish) has been within the ITQ system from the beginning. Icelandic authorities gave, however, until the 2010/2011 fishing year a joint quota for these two species. MRI has since 1994 provided a separate advice for the species. The separation of quotas was implemented in the fishing year that started September 1, 2010.

A.3. Ecosystem aspects

Beaked redfish is an ovoviviparous fish species, meaning that eggs are fertilized, develop and hatch internally. The male and female mate several months before the female extrudes the larvae. The females carry sperm and non-fecundated eggs for months before fertilisation takes place in winter. Females are thought to have a determinate fecundity. Beaked redfish produce many, small larvae (40-400 thousand larvae) that are extruded soon after they hatch from eggs and disperse widely as zooplankton zooplankton (Jónsson and Pálsson 2006). The extrusion of larvae may take place over several days or weeks in a number of batches. Knowledge on the biology, behaviour and dynamics of Icelandic slope beaked redfish reproduction is very scarce.

Little is known about the geographic location and timing of fertilization (mating grounds where copulation occurs) and extrusion of larvae (larval extrusion grounds) of Icelandic slope beaked redfish, but it is similar to those for the pelagic beaked redfish stocks (Magnusson and Magnusson 1995). It is known that mating and copulation takes place in the autumn (September-November), but the exact location of copulation is not known (most likely southwest and south of Iceland). The fertilization of eggs occurs in the winter (February-March). The extrusion of larvae occurs in the spring (April-June), but its exact location of the extrusion area is unknown. The extrusion areas of the pelagic beaked redfish stocks and the Icelandic stocks may merge to some extend, and they are in the open seas in the Irminger Sea, southwest of Iceland (Magnusson and Magnusson, 1995). The extrusion takes place mainly at 500-700 m depth in waters with temperature around 6°C.

Larvae drift to the continental shelf of East Greenland and to some extent to West Greenland, where they settle to the bottom. They are difficult to distinguish from their sibling species golden redfish (*S. marinus*), which has the same nursery areas.

Only the fishable stock of Icelandic slope beaked redfish is found in Icelandic waters, i.e. mainly fish larger than 30 cm. The East Greenland shelf is most likely the main nursery area for the Icelandic slope stock. The nursery areas of both pelagic and the stock found on the continental shelf of Iceland are believed to be on the continental shelf of East Greenland at depths of 200-400 m and reach the shelf off West-Greenland. The proportion of juveniles recruiting to each stock is not known.

Growth and maturity

Icelandic slope beaked redfish is like the pelagic beaked redfish and golden redfish are long lived, slow-growing and late-maturing fish species.

Diet

The food consists of dominant plankton crustaceans such as amphipods, copepods and euphausids. Small fish and cephalopods (small squids) can also be important food items in certain areas.

B. Data

B.1. Commercial catch

Sampling from the Icelandic fleet

	Kind of data				
Country/area	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 (Va)	X				X

Icelandic commercial catch in tonnes by month, area and gear are obtained from Statistical Iceland and Directorate of Fisheries. The geographical distribution of catches (since 1991) is obtained from log-book statistics, where location of each haul, effort, depth of trawling and total catch of Icelandic slope beaked redfish are given.

B.1.1. Splitting the redfish catch between golden redfish and Icelandic slope beaked redfish in Icelandic waters

Until the 2010/2011 fishing season, Icelandic authorities gave a joint quota for golden redfish and Icelandic slope beaked redfish in Icelandic waters. Icelandic fishermen were not required to divide the redfish catch into species. This was a problem when catch statistics of those two species were determined. Since 1993, a so-called *split-catch* method has been used to split the Icelandic redfish catches between the two species.

B.1.1.2. Data

The following data were used:

1. Data from log-books of the Icelandic fleet (information on the location of each haul, how much was caught of redfish, and if available, the species composition of the catch).
2. Information on landed products from Icelandic factory (freezer) trawlers.
3. Biological samples from the Icelandic fresh-fish trawlers sampled by MRI and Icelandic Catch Supervision (ICS) personnel.
4. Landing statistics from Germany and UK if available.
5. Landing statistics from foreign vessels fishing in Icelandic waters.
6. Official landings by gear type provided by Directorate of Fisheries in Iceland.

B.1.1.3. Splitting the redfish catch from freezer trawlers

The redfish landings statistics of the freezer fleet are divided into species in landing reports and considered reliable. However, the official landings for each fishing trip are not divided by gear type if more than one was used (in this case bottom trawl and pelagic trawl), but set on one gear type (usually bottom trawl). The freezer trawlers mainly use bottom trawl in the redfish fishery, but in some years, especially in the 1990s, they also used pelagic trawls. According to log-books, the redfish caught with pelagic trawl was Icelandic slope beaked redfish.

To get reliable species composition of the bottom trawl catch, the total catch of the freezer trawler for each species was estimated. If, for a given year, redfish was caught with pelagic trawl (total catch was based on log-books) the catch was subtracted from the total beaked redfish catch.

B.1.1.4. Splitting the redfish catch from the fresh fish trawlers

The catch is first divided into defined strata and split into species according to the ratio of golden redfish/beaked redfish observed in biological samples from each strata. Each stratum is a rectangle measuring 15 minutes Latitude by 30 minutes Longitude.

1. **For each year:** The redfish catch from each year was divided into strata and scaled to the total un-split catch of the two species for each rectangle. It is assumed that the distribution of catch not reported in logbooks was the same

as for the reported catch. Catch taken by other gears was included (usually about 2% of the total catch).

2. **For each stratum and each year:** The biological samples taken from the commercial catch were used to split the catch in each stratum into species. In this step, the average species composition in the samples in each stratum is estimated and then applied to the total catch of the fleet in that stratum (see previous step). If no information on species composition in a stratum for any given year was available, the species composition one year before was used.If it was not available either, then the species composition two years before was applied, and so forth, up to a maximum of five years before a given year. If no samples were available in this five years period, the splitting was done according to depth and the captain's experience. Only a small proportion of the catch was split into species using the last criterion.
3. The split into species of redfish landings in Germany and UK (containers or fresh landings) is based on landings reports and are considered reliable.
4. For other nations operating in Icelandic waters, the catches are split according to information given by those nations. In recent years, only Faroe Islands and Norway have operated in ICES Division Va.

B.1.1.5. Other gears

Between 92-98% of the annual redfish catch is caught with bottom trawls. The redfish caught with other gear types, i.e. long-line, gillnet, hook and line, Danish seine, and lobster trawl is assumed to be golden redfish. This is because boats using these gear types mainly operate in shallow waters were beaked redfish is not found.

B.1.2. Biological data from the commercial catch

Biological data from the commercial catch were collected from landings by scientists and technicians of the Marine Research Institute (MRI) in Iceland and directly on board on the commercial vessels (mainly length samples) by personnel of the Directorate of Fisheries in Iceland. The biological data collected are length (to the nearest cm), sex, maturity stage, weight, and otoliths for age reading. Age reading has so far been very limited.

The general process of the sampling strategy is to take one sample of Icelandic slope beaked redfish for every 500 tonnes landed. Each sample consists of 200 fishes: otoliths are extracted from 30 fishes which are also length measured, weighed, and sex and maturity determined; 70 fishes are length measured, weighted, sex and maturity determined; the remaining 100 are length measured and sex and maturity determined.

The data are stored in a data base at the Marine Research Institute.

B.2. Biological

B.3. Surveys – The Icelandic Autumn Groundfish Survey

The Icelandic Autumn Groundfish Survey has been conducted annually in October 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 and Icelandic slope beaked redfish. This is because the Spring Survey conducted annually in March since 1985 does not cover the distribution of these deep-water species. The 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, in order to improve the precision of stock assessment.

The text in the following description of the surveys is mostly a translation from Björnsson et al. (2007). The emphasis has been put on golden redfish where applicable. The report, written in Icelandic with English abstract and English text under each table and figure, can be found at the MRI website under the following link: http://www.hafro.is/Bokasafn/Timarit/rall_2007.pdf. An English version of the survey manual can be found at http://www.hafro.is/Bokasafn/Timarit/fjolrit-156.pdf.

B.3.1. Timing, area covered and tow location

The Autumn Survey is conducted in October as it is considered the most suitable month in relation to diurnal vertical migration, distribution and availability of Greenland halibut and Icelandic slope beaked redfish. The research area is the Icelandic continental shelf and slopes within the Icelandic Exclusive Economic Zone (EEZ) 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. Preparation and later alterations to the survey

Initially, a total of 430 stations were divided between the shallow and deep-water 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 log-books of the commercial bottom-trawl fleet fishing for Greenland halibut and Icelandic slope beaked 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 of this magnitude, it was decided to focus the deep water part of the survey on the Greenland halibut main distributional area. Important Icelandic slope beaked redfish areas south and west of Iceland were omitted. The number and location of stations in the shallow-water area were unchanged. For this reason, only the years from 2000 can be compared for Icelandic slope beaked redfish.

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 log-book 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 Icelandic slope beaked redfish and the location of the stations selected in a similar manner as for Greenland halibut. A total of 30 stations was 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 log-books of the bottom trawl fleet 1996-1999 (Figure B.3.1).

In addition, 14 stations were randomly added in the deep-water area in areas where great variation had been observed in 1996-1999. 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, increasing the total number of stations in the shallow-water area to 162. The total number of stations taken in 2000-2009 has been around 381 (Table B.3.1).

In 2010, 16 stations were omitted in the deep water area and the total number of stations in the area was reduced from 219 to 203. All these stations have in common that they are in areas where stations are many and dense (close to each other), and with little variation. Four stations, aimed at Icelandic slope beaked redfish, were omitted south-east of Iceland. The rest or 12 stations were omitted west and north-west of Iceland, these were stations originally aimed at Greenland halibut.

B3.3. Vessels

The r/v "Bjarni Sæmundsson" has been used in the shallow-water area from the beginning of the survey. For the deep-water area, the MRI rented one commercial trawler 1996-1999, which was replaced in 2000 by the r/v "Árni Friðriksson" (Table B.3.1).

B3.4. 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 shape of the trawls is the same but the trawl used in deep waters is larger. The trawls were common among the Icelandic bottom trawl fleet in the mid 1990's and are well suited for fisheries on cod, Greenland halibut, and redfish.

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

B.3.5. Data sampling

B.3.5.1. Length measurements and counting

All fish species are length measured, the majority of them, including Icelandic slope beaked redfish, 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 is to measure at least 5 times the length interval of deep-water redfish. Example: If the continuous length distribution of beaked redfish 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 beaked redfish 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.

Each beaked redfish that is length measured is both sex and maturity determined.

B.3.5.2. Otolith sampling

For beaked redfish, a minimum of one and a maximum of 25 otoliths are collected in the Autumn Survey. Otoliths are sampled at a 10 fish interval, so that if in total 200 deep-water redfish are caught in a single haul, 20 otoliths are sampled.

Each beaked redfish taken in the otolith sampling is sex and maturity determined, weighed ungutted, and the stomach content is analysed onboard.

Only otoliths from the Autumn Survey in 2000 have been age-read.

B.3.5.3. Information on tow, gear and environmental factors

At each station/haul, relevant information on the haul and environmental factors is recorded by the captain and the first officer in co-operation with the cruise leader.

- Tow information:

  General: Station, Vessel registry no., Cruise ID, Day/Month/Year, Statistical Square, Sub-square, Tow number, Gear type no., Mesh size, Briddles length (m).

  Start of haul: Position North, Position West, Time (hour:min), Tow direction in degrees, Bottom depth (m), Towing depth (m), Vertical opening (m), Horizontal opening (m).

  End of haul: Position North, Position West, Time (hour:min), Warp length (fm), Bottom depth (m), Tow length (nautical miles), Tow time (min), Tow speed (knots).

- Environmental factors:

  Wind direction, Air temperature (°C), Wind speed, Bottom temperature (°C), Sea surface, Surface temperatrue (°C), Cloud cover, Air pressure, Drift ice.

B.3.6. Data processing

Abundance and biomass estimates at a given station

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

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

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

where $n_{measured}$ is the number of fished measured and $n_{counted}$ is the number of fish counted. Biomass of a given species at a given station is calculated as:

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

where L_i is length and α and β are coefficients of the length-weight relationship.

B.3.6.1. Index calculation

For calculation of indices the Cochran method is used (Cochran 1977). The survey area is split into strata (see Section B.3.6.2). Index for each stratum is calculated as the mean number in a standardized tow, divided by the area covered multiplied with the size of the stratum. The total index is then a summed up estimates from the strata.

A "tow-mile" is assumed to be 0.00918 NM^2. 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:

$$\overline{Z}_i = \frac{\sum_i Z_i}{N_i}$$

where $\overline{Z}_i$ is the mean catch (number or biomass) in the *i*-th stratum, Z_i is the total quantity of the index (abundance or biomass) in the *i*-th stratum and N_i the total number of tows in the *i*-th stratum. The index (abundance or biomass) of a stratum (I_i) is:

$$I_i = \overline{Z}_i \left(\frac{A_i}{A_{tow}} \right)$$

And the sample variance in the *i*-th stratum:

$$\sigma_i^2 = \left(\frac{\sum_i (Z_i - \overline{Z}_i)^2}{N_i - 1} \right) \left(\frac{A_i}{A_{tow}} \right)^2$$

where A_i is the size of the *i*-th stratum in NM^2 and A_{tow} is the size of the area surveyed in a single tow in NM^2.

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

and the variance is

$$\sigma_{strata}^2 = \sum_{region} \sigma_i^2$$

and the coefficient of variation is

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

B.3.6.2. Stratification

The strata used for survey index calculation for Icelandic slope beaked redfish in the Autumn Survey are shown in Figure B.3.2. The stratification is in general based on depth stratification and similar oceanographic conditions within each stratum.

The stratification for the Autumn Survey was revised in 2008. This was because the majority of the total catch of species, such as golden redfish, comes in a few but large tows, leading to high uncertainties in the estimates of the biomass/abundance indices (high CV). The aim of this revision was, therefore, to reduce the weight of certain tows (the few but large tows that account for the bulk of the total catch) and to reduce the area weight. The number of strata was reduced from 74 to 33. Figure B.3.3 shows the stratification of the survey area that was used before 2008. The average size of stratum subsequently increased and number of tows within stratum increased. It should also be noted that some strata at the edge of the survey area were reduced.

Comparison of total biomass index for Icelandic slope beaked redfish based on the old and new stratification is shown in Figure B.3.4. In general, the measurement errors of the indices based on the new stratification are lower than the ones based on the old one. The indices are similar and show the same trend (except for 2010).

B.4. Commercial CPUE

Catch per unit of effort are routinely calculated during the annual assessment process. Data used to estimate CPUE for Icelandic slope *S. mentella* in Division Va since 1978 were obtained from log-books of the Icelandic bottom trawl fleet. Only those hauls taken below 450 m depth (combined golden redfish and Icelandic slope *S. mentella*) and that were comprised of at least 50% Icelandic slope *S. mentella* (assumed to be the directed fishery towards the species – between 70-90% of the total annual catch were from those hauls) were used. Non-standardized CPUE and effort are calculated for each year:

$$E_y = \frac{Y_y}{CPUE_y},$$

where E is the total fishing effort and Y is the total reported landings.

CPUE indices were also estimated from this data set using a GLM multiplicative model (generalized linear models). This model takes into account changes in vessels over time, area (ICES statistical square), month and year effects:

glm(log(catch) ~ log(effort) + factor(year) + factor(month) + factor(area) + factor(vessel), family=gaussian())

C. Historical Stock Development

Icelandic slope beaked redfish in ICES Division Va has previously been assessed based on trends in survey biomass indices from the Icelandic Autumn survey in terms of the ICES "trends based assessment" approach. Supplementary data used includes relevant information from the fishery and length distributions from the commercial catch and the Autumn Survey.

At the WKRED-2012 meeting working document (# 12) was presented where the trend in survey indices for the Icelandic slope beaked redfish was estimated as well as F_{proxy} (catch divided by index for the same stock). The trend in the survey indices was estimated to be around 5% per year (uncertain estimate) so assuming F=M 10% reduction in total mortality was required to stop the trend and 20% to reverse it. If F > M, which is considered a likely hypotheses considering the state of the stock, less than 20% reduction in F is needed to get the intended 10% reduction in Z. The only data available to support that F and M are similar are results from limited age-readings that indicate Z to be around 0.1 and M "is known" to be 0.05. The approach in the working document #12 makes no special reference to the status of the stock which is considered difficult to assess. Similar ideas are put forward in working document #16 for the deep pelagic beaked redfish in the Irminger Sea.

The method proposed in working document #12 has three major shortcomings.

- The survey data are noisy and the trend is not clear
- The survey series are short (11 years) compared to the lifespan of the species. One year class can take more than five years to recruit to the stock so the survey period might be characterized by abnormally high or low

recruitment leading to trend in indices reflecting recruitment anomaly rather than deviations from sustainable fishing effort.

- Catches may not be correctly allocated to stocks. Spatial distribution of the catches west of Iceland in some years indicate that part of the catch for deep sea pelagic beaked redfish could be Icelandic slope beaked redfish and vice versa.

The external panel rejected the approaches of working documents #12 and #16 as they did not make any reference to the state of the stock and depended on the assumption F=M. In response it was stated that most likely F > M and therefore the method is if anything conservative.

Some participants in the Working Group considered that at present analytical assessments cannot be conducted because, for example, of little age data and the relative shortness of the time-series available.

The external panel considered that although the biomass dynamic model (specifically the Schaefer form off this approach) is preliminary and should be improved, it is possible to use this approach to initially assess stock status and current replacement yield (RY, being the annual catch estimated to maintain abundance at its present level) based on information on past catches, the autumn survey, and external information used to inform on the likely range of the value for stock productivity parameter. For the values of stock productivity parameter considered the most realistic ($r = 0.05$ to $r = 0.10$), this approach provides estimates of the current depletion (the present to pre-exploitation abundance ratio) of this resource to be from 18-19% with CVs between 40% and 50%. Estimates of RY range from about 10 (SE 4) to 13 (SE 4) thousand tons, by comparison with an average annual catch over the 2000 to 2010 period of about 21 thousand tons. Although the precision of these RY estimates is poor, the panel draws attention to the approach suggested in the general recommendations section whereby the requirements of the precautionary approach can be addressed by decreasing catch limit estimates by some multiple of the associated SE estimate. The panel does not suggest that the Schaefer model approach used here is to be final; to the contrary it is offered as a first step (from which interim management advice might be formulated) while the assessment is extended to an Age Structured Production Model framework which could, for example, also take account of the commercial catch-at-length and limited ageing data available for this resource. While the projection and reference point computations referenced below are possible within this Schaefer model framework, the panel did not consider it appropriate to report them at this stage, given the interim and intermediate nature of this approach. The difficulties found by the panel with the “trends based assessment” approach are set out in the general recommendations section.

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978-2010		
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			

West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Autumn Survey	2000-2010	Not available
Tuning fleet 2			
Tuning fleet 3			

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 Icelandic slope beaked redfish in Division Va.

I References

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