Stock Annex: Beaked redfish (*Sebastes mentella*) in Division 14.b, demersal (Southeast Greenland)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Beaked redfish
Working Group:	North Western Working Group (NWWG)
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A. General

A.1. Stock definition

ICES concluded in February 2009 that *S. mentella* in the northwest is to be divided into three biological stocks and that the *S. mentella* on the Icelandic continental shelf and slope should be treated as a separate biological stock and management unit. This separation of the stocks did not include the adult *S. mentella* on the Greenland continental slope. ICES therefore decided that NWWG will conduct a separate assessment of *S. mentella* in subarea 14.b until further information is available to assign stock origin.

Although not recognized as a separate stock area, WKREDS suggested that the Greenland shelf (East and West) is a common nursery ground for all the *S. mentella* stocks in the northwest Atlantic.

A.2. Fishery

The fishery for *S. mentella* on the Greenland slope is conducted almost exclusively with bottom trawl. In the 1980's and 1990's the fishery had catches as high as 19 000 tonnes (1981 and 1994) and catches ranged from 5 000 to 15 000 tonnes. The fishery declined rapidly in 1995 to 819 tonnes and remained below 1 000 tonnes/year until 2009. The fishery has been dominated by British, Faroese, Norwegian and Greenlandic vessels and in some years German vessels (ICES 2011). Since 2009 a directed fishery began for demersal *S. mentella*, with the majority being taken by Greenland and Norwegian vessels. The total catches of demersal redfish has varied between 6200 t and 7 400 tonnes but in 2014 the catch was estimated at just 4 600 tonnes partly due to smaller total catches of demersal redfish and partly due to a change in the proportion of *S. Norvegicus* in the catches. For further details on the historical development of the fishery see ICES (2011).

The directed fishery towards *S. mentella* in recent years has taken place in a limited geographical area at 64°N 36°W and just northeast from here at 64° 30′ N-65°N and 35°W on depths between 400 and 500 meters. In the years prior to this new directed fishery, *S. mentella* has been caught as by-catch in the Greenland halibut fishery, and consequently at greater depths (ICES, 2011)

The redfish fishery on the East Greenland slope is influenced by the close proximity of Greenland halibut (*Reinhardtius hippoglossoides*), Atlantic cod (*Gadus morhua*) fishing grounds.

Sorting grids are mandatory in the shrimp fishery since 2002 due to high historical by-catches of juvenile redfish. Since this implementation by-catches of redfish have decreased. With the recent lack of recruits in the area and the use of storting grids, by-catches in the shrimp fishery has been negligible.

A.3. Ecosystem aspects

S. mentella is an ovoviviparous species. The female carries sperm and eggs for months, and extrude larvae in April-May in the Irminger Sea (Cadrin et al. 2010) but the exact mating site of the different stocks is unknown. The larvae are planktonic, and drift to the nursery areas on the Greenland slope were they settle on the bottom (Magnússon and Magnússon, 1995). In this area they mix with juveniles of the very similar *Sebastes marinus*. Both species recruit to the fishery at ages 8 to 12 years.

S. mentella feeding was investigated on the West Greenland slope and it was found that planktonic crusteceans (i.e. hyperiids, copepods and euphausiids) dominated the diet in smaller fish (5-19 cm, Pedersen and Riget, 1993). In adult fish (31-33 cm.) from the Reykjanes ridge Petursdottir et al. (2008) found indications that *S. mentella* fed heavily on the euphausiid *M. norvegica*. In the Greenland slope area adult feeding on amphipods, copepods, cephalopods, shrimps and fish (including cannibalism) are probably also important (Pedersen and Riget, 1993).

Redfish spp. have been shown to comprise a significant part of the diet in both harp and hooded seals (Haug et al. 2007; Tucker et al. 2009). Greenland halibut feeding on *S. mentella* has been documented in Iceland waters (Solmundsson 2007) but data from the West Greenland shelf does not indicate that Sebastes spp. is an important prey item (Greenland Institute of Natural Resources, Unpublished data).

B. Data

B.1. Commercial catch

The information on catches in ICES 14.b are available from the Greenland Fisheries License Control (GFLK) who provide haul-by-haul information from logbooks. These log books cover three types of Redfish quota uptake that all contribute to the total catches of demersal *S. mentella*:

- Fish caught by bottom trawl and longlines on the bottom are named *S. marinus*.
- Fish caught pelagic in the Irminger Sea are named *S. mentella*
- Fish caught as by-catch in the shrimp fishery are named Sebastes sp.

Until 2011, catches reported as *S. marinus* were used to distinguish between Greenland slope demersal *S. mentella* catches and pelagic *S. mentella* catches in the Irminger Sea. Since 2011, the catches have been devided in pelagic and demersal based on a line following the outside of the 1000 meter depth curve (Table I, Figure 1). This is done to avoid the situation seen in 2010, were some vessels fished on their pelagic quota on the shelf (2 179 tons, ICES, 2011). Both survey results and analyses of commercial catches shows that *S. mentella* dominates the catch on the slope, and the catches have historically been split into species based a best estimate of species proportions. Hence, in 2010 these were set at 80/20, but it is uncertain how the catches were separated in earlier

years. In 2014 the proportion of *S. mentella* in the total catches of 7 314 tonnes was estimated at just 63 % *S.mentella* and 37 % *S. norvegicus*.

Table I: Positions (decimal degrees and degrees) used to separate the fish found demersal on the slope at East Greenland and the pelagic stocks in the Irminger area. See figure 1.

Point	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)
1	59.25	-54.43	59°15'	54°26'
2	59.25	-44.00	59°15'	44°00'
3	59.50	-42.75	59°30'	42°45'
4	60.00	-42.00	60°00'	42°00'
5	62.00	-40.50	62°00'	40°30'
6	62.00	-40.00	62°00'	40°00'
7	62.67	-40.25	62°40'	40°15'
8	63.15	-39.67	63°09'	39°40'
9	63.50	-37.25	63°30'	37°15'
10	64.33	-35.00	64°20'	35°00'
11	65.25	-32.50	65°15'	32°30'
12	65.25	-29.84	65°15'	29°50'

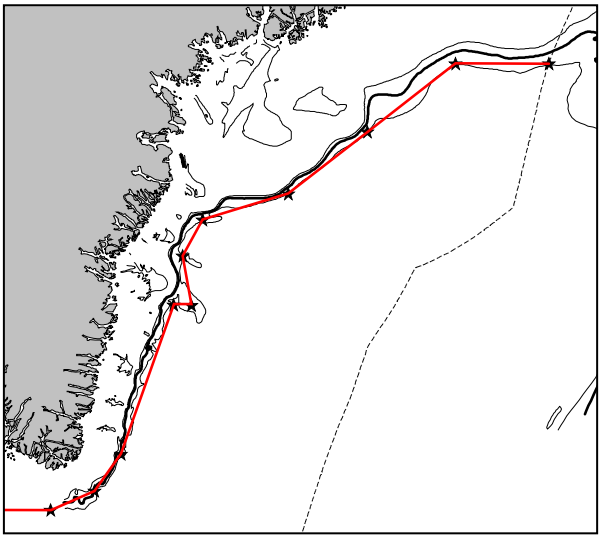


Figure 1: The red line following the outside of the 1000 meter depth curve delimits the shelf area where ICES gives separate advice from the pelagic stocks. 500, 1000 and 1500 m depth curves are on the map with the 1000 meter depth curve being bold. The dashed line is the 200 nm fishery zone line.

B.2. Biological

Sampling for further information on stock structure based on DNA is taking place under the European Commission's Fifth Framework Programme (1998-2002). This includes samples from surveys and commercial catches in ICES areas 5, 12 and 14 as well as NAFO 1.

B.3. Surveys

There are currently three surveys in 14.b. A German survey directed towards cod in Greenland waters (0-400m.), the Greenland deep water survey (400-1500m.) targeting

Greenland halibut and the Greenland shallow water survey (0-600 meters) targeting mainly cod. All surveys are reported as Working Documents prior to the yearly North Western Working Group.

The German survey

The survey commenced in 1982 and was designed for the assessment of cod. The surveyed area is the 0-400 m depth zone that is divided into 7 geographical strata and two depth zones (1-200m; 201-400m, Table II, Figure 2). The numbers of hauls were initially ca. 200 per year but were reduced from the early 1990s to 80-100 per year.

The surveys were carried out by the research vessel (R/V) WALTHER HERWIG (II) in 1982-1993 (except 1984 when R/V ANTON DOHRN was used) and since 1994 by R/V WALTHER HERWIG III. The fishing gear used was a standardized 140-feet bottom trawl, its net frame rigged with heavy ground gear because of the rough nature of the fishing grounds. A small mesh liner (10mm) was used inside the cod end. The horizontal distance between wingends is 25 m at 300 m depth, the vertical net opening being 4 m. In 1994, smaller Polyvalent doors (4.5 m2, 1,500 kg) were used for the first time to reduce net damages due to overspread caused by bigger doors (6 m2, 1,700 kg), which have been used earlier.

For historical reasons strata with less than 5 hauls were not included in the annual stock calculations op to 2008. From 2009 all valid hauls have been included and the entire time series have been corrected. In some years (notable 1992 and 1994) several strata were not covered due to weather conditions/vessel problems, implying that the survey estimate implicitly refers to varying geographical areas.

Table 2: The survey area (nm_2) in the German groundfish Survey in Greenland.

Strata	Depth (m)	Area (nm2)
1.1	1-200	6805
1.2	201-400	1881
2.1	1-200	2350
2.2	201-400	1018
3.1	1-200	1938
3.2	201-400	742
4.1	1-200	2568
4.2	201-400	971
5.1	1-200	2468
5.2	201-400	3126
6.1	1-200	1120
6.2	201-400	7795
7.1	1-200	92
7.2	201-400	4589
Total		37463

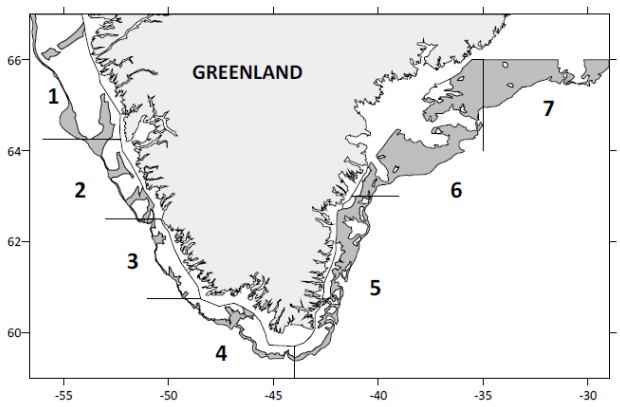


Figure 2: The stratification areas used in the German groundfish survey. Each stratum is divided into two depth zones (1-200m and 201-400m)

The East Greenland deep water survey

The East Greenland deep water survey is a stratified random survey. From 1989-1996 the Greenland Institute of Natural Resources conducted annual shrimp trawl surveys with R/V PAAMIUT (722 GRT)at East Greenland (Anon. 1997), but the surveys only covered depths down to 600 m with a poor coverage of depths > 400 m. In 1998 a bottom trawl surveys series with R/V PAAMIUT, which has been rigged for deep sea trawling, was initiated. The survey was not conducted at East Greenland in 2001. Until 2008 the survey was conducted in June, but suffered in most years under the ice coverage found at the east coast of Greenland during early summer. Therefore the surveys from 2008 and onwards, have taken place in August/September where the ice induced problems have mostly vanished.

The stratification was changed in 2004 in order to reduce the variance on the biomass estimate of Greenland halibut and to get larger strata. The purpose of larger strata was to reduce the number of strata and thereby avoid strata without observations caused by bad weather or ice etc. The "old" stratum Q1 was divided into two strata. The northern, shallow part of the stratum has been separated from the rest of the stratum primarily because the fish fauna here is different and because Greenland halibut is generally smaller in this area than on the shelf. This northern shallow area is now stratum Q1. The remaining part of the old Q1 has been combined with Q2 as there was no difference in the catches of Greenland halibut in the two areas. The depth strata 1001-1200m 1201-1400m and 1401-1500m have been combined to one stratum as Greenland halibut catches generally have been small in these strata. In Q5, the two small depth strata 801-1000 and 1001-1200 were combined as catches of Greenland halibut have been at the same level in the two strata throughout the years.

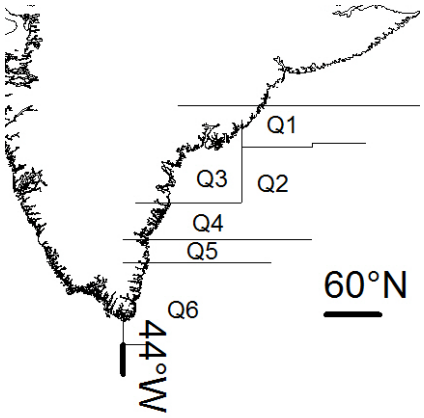
The Greenland shallow water survey

The Greenland shallow water survey has been conducted since 2007 in combination with the Greenland deep water survey. However, logistical problems entailed that few valid hauls were conducted in 2007, and furthermore no species distinction was made with regard to redfish. Hence, species specific results are only available from 2008. The survey covers the Greenlandic coast east of 44˚00W and north to 67˚00N and is delimited by the 3 mile limit and the 600 m depth contour. The region is stratified into six areas (Q1-Q6) which are further stratified into three depth strata: 0-200m, 201-400m and 401-600m (Table III, Figure 3). Within each area strata, stations are allocated randomly from known trawlable sites, as Greenland East Coast bottom topography severely limits the number of trawlable areas.

Table III: Areas (km²) of the different area and depth strata surveyed in the East Greenland shallow water survey

		Depth strata (m)		
Area strata	Area (km2)	0-200	201-400	401-600
Q1	42 637	217	35 445	6 975
Q2	8 996	93	7 657	1 246
Q3	35 740	3 363	22 547	9 830
Q4	11 161	1 337	7 770	2 054
Q5	5 073	469	2 785	1 819
Q6	14 500	6 307	6 130	2 063
Total	118 107	11 786	82 334	23 987

Figure 3: The East Greenland shallow water survey area strata



The survey is conducted using a "Cosmos" trouser trawl with 20 mm cod end. The standard towing time at 2.5 knots has in all years been 15 minutes, but shorter tows are included in the calculations if they are deemed valid. All hauls were performed at daytime. A temperature sensor (Seamon, 0.1˚C) is mounted on a trawl door and a bottom temperature is noted for each haul. If a depth stratum in a given year was not successfully trawled, the area was joined with the neighboring depth stratum to allow for abundance and biomass estimation.

B.4. Commercial CPUE

Log books on a haul-by-haul basis are available from 1992-present. However, from 1992-98 the data quality is poor due to incorrect species reporting and further does not cover all catches. Consequently this time period is omitted from the data. From 1999 and onwards the data are of a sufficient quality. The standardised CPUE calculated from the redfish directed fishery has been evaluated, and is not proposed to be used in the assessment for several reasons. The fishery targets an aggregating species and further the fishery is presently in a very restricted area. This means large catches in short hauls and eventual searching time is unknown, implying little correlation between recorded effort and landings.

A redfish by-catch CPUE calculated based on the Greenland halibut directed fishery is available. The rationale for using by-catch CPUE is that a longer time series is available and the fishery more dispersed thereby covering the stock distribution more appropriate. The index is based on hauls were Greenland halibut make up >50% of the catch by

weight. This cut-off was based on the distribution of redfish catches in all hauls, which typically made up either 0-20% (i.e. by-catch) or 90-100% (i.e. redfish directed fishery). Furthermore, all hauls at depths >1000m were discarded as this is outside the depth range of *S. mentella*. This by-catch CPUE covers a wider area on the Greenland slope than the redfish directed fishery, and since the Greenland halibut fishery has been fairly stable in the past decade, the by-catch CPUE could possibly considered in future assessments. Regarding the by-catch CPUE it should however be noted that by-catches are reported as "redfish" thus including both *S. mentella* and *S.marinus*, but the Greenland halibut fishery takes place at depths of 400m and deeper, and from the Greenland survey it is observed that at these depths *S. mentella* constitutes at least 90%, and the confounding effect of the *S. marinus* contribution is probably negligible.

C. Assessment: data and method

Otoliths are not sampled and no age-based assessment is therefore possible. The qualitative assessment is based on survey indices and catch information. In 2014, the advice is based on the Data Limited Stock approach (DLS) including biomass indices from the Greenland shallow water survey in the most recent 5 years combined with the recent advice, applying a cap and a precautionary buffer. The ratio is applied to the 2014 advice as catches are well above current advice. The advice for 2016 is 2 240 t.

During the 2012 benchmark (WKRED) the external panel evaluated the possible use of a stock production model to produce quantitative advice for this stock (ICES 2012). The external panel considered that although the biomass dynamic model (specifically the Schaefer model – see ICES 2012) 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 German shallow water trawl survey, and external information used to inform on the likely range of the value for the stock productivity parameter *r*. 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 81-86% with CVs ranging from 31 to 19% correspondingly. Estimates of RY range from about 3.4 (SE 0.1) to 3.8 (SE 0.5) thousand tons, by comparison with an average annual catch over the 2000 to 2010 period of about 1.2 thousand tons. As status is estimated relatively close to pristine, catch advice might be better based on the Schaefer maximum sustainable yield estimates. These are 7 and 6 thousand tons for $r = 0.05$ and 0.10, respectively, but with high CVs of about 160% and 50%, respectively. Until further data allow improved precision, an RY basis for management might still therefore be best at the present time. Although the precision of these RY estimates is reasonably good, the panel still draws attention to the approach suggested in the general recommendations section of the WKRED report 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 should these become 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 appropri-

ate 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.

Some members of the workshop thought that the stock production model approach has a questionable use for advice purposes in terms of absolute numbers, even though the estimates seem robust. Sustainable current yields of approximately 3500 t from the model versus an arbitrary number of 1000 t (present advice) derived from 2009 catches (when fishery started again) are not from comparable approaches and both numbers are therefore candidates for advice.

I. References

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