22 Deep Pelagic *Sebastes mentella*

22.1 Stock description and management unit

This section addresses the fishery and assessment for the biological stock deep pelagic *S. mentella* in the Irminger Sea and adjacent areas: NAFO 1-2, ICES 5, 12, and 14 at depths >500 m, including demersal habitats west of the Faeroe Islands. This stock corresponds to the management unit in the northeast Irminger Sea (ICES areas 5.a, 12 and 14).

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters in 2018. No information was available from Russia and Spain about number of factory trawlers participating in the fishery. It should be noted that some of these fleets are also fishing the Shallow Pelagic stock:

Country	Number of trawlers
Faroes	2 factory trawlers
Iceland	4 factory trawlers
Germany	1 factory trawler
Latvia	1 factory trawler
Lithuania	1 factory trawler
Norway	1 factory trawler
Russia	14 factory trawlers
Spain	1 factory trawler
Total	**25 factory trawlers**

22.2 The fishery

The historic development of the fishery can be found in the Stock Annex. Tables 22.2.1 and 22.2.2 show annual catches, as estimated by the Working Group, disaggregated by ICES and NAFO regulatory areas and by country, respectively.

The changes in the spatial pattern of the fishery for the period 1992–2018 are shown in Figure 22.2.1, and annual catches are presented in Figure 22.2.2. Catches decreased by 4988 t in 2018 to 24 903 t (Table 22.2.2).

Standardized CPUE series for Faroe Islands, Iceland, Greenland, and Norway 1994–2018 are estimated with a GLM model including the factors year, ship, month and towing time. The results from the model show that the CPUE oscillates without trend since 1995 (Figure 22.2.3).

22.3 Biological information

Age reading of deep pelagic beaked redfish in the Irminger Sea and adjacent waters has not been systematic. Age data are available from Iceland and Norway for some years during 1996–2013. Most of the age data come from the commercial catch except in 1999 where 797 age readings come from the international redfish survey (note: as the age readings from the survey correspond to a similar depth range and location as other samples, they have been included together with the commercial fishery samples). In total, 6566 otoliths have been age read. The number of age readings by year and nation is given in Table 22.3.1. Age distributions for the Icelandic data are shown in Figure 22.3.1 and for the Norwegian data in Figure 22.3.2.

Length data are available from the international redfish survey (see Section 22.6) and from the Icelandic commercial fishery. Biological information is collected from commercial catches from other nations (Russia, Norway, Spain and other EU countries). However, the data were not available to the group.

The length data from the Icelandic commercial fishery is considered to provide a reasonable representation for all nations participating in the fishery, as the fishery is conducted in a concentrated area along the Icelandic EEZ (Figure 22.2.1) in a relatively short period (mainly May and June).

The length samples from the Icelandic commercial catch are either collected by observers on board or by the fishers who send samples for further analysis to the MFRI (Marine and Freshwater Research Institute, Iceland). The number of fish measured for length and the number of hauls sampled are given in Table 22.3.2. In each sample 100–200 fish are length measured. Length distributions are shown in Figure 22.3.3 and indicate that the bulk of the catches is at around 35–45 cm of length.

22.4 Discards

Discards are not considered to be significant for the time being, according to available data from various institutes.

22.5 Illegal, Unregulated and Unreported Fishing (IUU)

The Group had again difficulties in obtaining catch estimates from several fleets. Furthermore, there are problems caused by misreported catches. The Group requests NEAFC and NAFO to provide ICES in time with all the necessary information.

22.6 Surveys

The international trawl-acoustic surveys were carried out biennially 1999–2015 and then in 2018. The survey in 2015 was carried out by Iceland and Germany (ICES, 2015). The participation of Russia was cancelled and the scope of the survey therefore had to be altered. The emphasis was on covering the deep pelagic stock found below 500 m.

In 2018, only one vessel from Russia participated in the survey as Iceland and Germany cancelled their participation (ICES, 2018). Yet again the scope of the survey had to be altered and only the northeast area (Subarea A) was surveyed (Figure 22.6.1). This is only a part of the geographical distribution of deep pelagic *S. mentella* so no total biomass was obtained.

22.6.1 Survey trawl estimates

Considering the conclusion of WKREDS (ICES, 2009a) and the recommendation of ICES on stock structure of redfish in the Irminger Sea and adjacent waters, the Group decided in the planning meeting (ICES, 2009b) to sample redfish separately above and below 500 m, i.e. to sample redfish as was done in the 1999, 2001 and 2003 surveys. The deep identification hauls covered the depth layers (headline) 550 m, 700 m, and 850 m. The description of the survey index calculation is found in the stock annex for the stock.

The most recent trawl-acoustic survey on pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters was carried out by Russia in June/July 2018. Only the northeast area (Subarea A) was surveyed or approximately 103 000 NM^2 compared to 200 000 NM^2 in 2015 and 340 000 NM^2 in 2013. A total biomass of 130 000 t was estimated in Subarea A, compared to 153 000 t observed in Subarea A in 2015 and 193 000 t in 2013 (Table 22.6.2). The results showed therefore large biomass declines in Subarea A, the main distribution area of the stock (see Figure 22.6.1 for area definition) (Table 21.6.2). Biological samples from the trawls taken at depth >500 m showed a mean length of 36.1 cm, compared to 38.6 cm mean length in 2015. Figure 22.6.2 shows the spatial distribution of samples used in the survey and Figure 22.6.3 shows the corresponding length distribution.

22.6.2 Considerations of survey indices calculations

The effect of the survey area coverage in 2015 and 2018 surveys, and the appropriateness of the biomass indices, was investigated at the 2019 meeting. The most extensive coverage was in 2001 (440 000 nmi^2) which most likely comprise most of the stock distribution. In 2003–2013 the area covered by the survey was around 350 000 nmi^2 (Table 22.6.3) and covered the main part distribution of the stock. However, in the last two surveys the area covered was reduced. In the 2015 survey, when the survey area was reduced to 201 000 nmi^2, attempts were made to ensure that the distribution of the deep pelagic stock was covered by surveying areas A and B (Figure 22.6.1 and Table 22.6.2). Relative biomass outside areas A and B has decreased from 20% in 2001 to less than 5% in the 2011 and 2013 surveys. Unfortunately, due to unforeseen circumstances in 2018 survey was unable to cover area B, reducing the survey area to area A with a coverage of 103 000 nmi^2 (Table 22.6.3). Therefore in 2018, the total area of coverage was reduced twofold in comparison with the previous survey area in 2015 (Figure 22.6.2, Figure 22.6.4 and Table 22.6.3).

There is a disagreement within the group on the appropriateness of using the 2015 and 2018 survey data for biomass estimation. The data up to 2015 was evaluated at the benchmark in 2016 (ICES, 2016). Two alternative derivations of a biomass index were presented (WD 23) and discussed at the 2019 NWWG. The aim of that work was to exclude the effect of annual changes in the size of surveyed area. Two methods of deriving indices were presented:

1. Biomass index for the deep pelagic stock was estimated in similar fashion described in the stock annex but restricted to the management unit (size 65 051 nmi^2) for the deep pelagic stock shown in Figure 18.2.1, which was covered in the survey in 1999–2015 (Table 22.2.4, Figure 22.6.5).
2. Density index (t/nmi^2) was derived from the total annual survey biomass divided by the total annual survey area covered (Table 22.6.4). Data on the stock biomass and the survey area were taken from the report of the WGIDEEPS (ICES, 20018).

The biomass index reflects the highest density area of the stock. There were concerns within the group that this approach ignores the observed reduction in density and abundance of the deep pelagic stock outside of the management area.

The density index assumes that the population densities are similar throughout the whole survey area (subareas A–E). Based on the survey results (Table 22.6.2 and Table 22.6.4) some members of the group noted that this appears to be an inappropriate assumption as the densities observed differ substantially between survey areas. As noted above the area coverage was approximately constant in 1999–2013. In relative terms this new derivation agrees with the currently used survey indices for that period, while for the 2015 and 2018 the proposed revision will result in a relative increase due to the reduction in area covered. However, as noted above, the 96% of the observed distribution in 2011 and 2013 was within the survey areas A and B which suggests that if the 2015 survey covered the same area as the 2013 survey the biomass index value would have been approximately the same with high probability.

There is no consensus within the NWWG group on how to derive survey biomass index used in the assessment (reference to stock annex). The group recommends that the compilation of the survey indices should be reviewed at WGIDEEPS.

22.7 Methods

The stock was benchmarked in August 2016 (The Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea – WKDEEPRED, ICES 2016). At the WKDEEPRED meeting a Gadget model for deep pelagic beaked redfish in the Irminger Sea was proposed as an assessment model. A description of the model setup, data, results, diagnostics and recommendations for data and model needs are found in the WKDEEPRED report (ICES, 2016). A detailed description of Gadget and references to published papers can be found in the Stock Annex for deep pelagic redfish (smn-dp_SA).

An age-length structured stock assessment model was developed with Gadget; this model also used age and length composition data. The inclusion of these data in the assessment lent stability to the assessment results and no strong retrospective pattern emerged. Fits to the data were considered overall adequate and WKDEEPRED concluded that this model provides an appropriate way of assessing the stock at this time. Although the Gadget assessment appears to capture trends on stock biomass and fishing mortality reliably, some aspects of the assessment still require further exploration, the data currently available cover only a short period relative to the lifespan of the species, and additional age data that might bring in additional insights are expected to become available over the next few years. WKDEEPRED therefore concluded that at present this assessment should be considered as a Category 2 (instead of Category 1) assessment.

In the survey conducted in June/July 2018, only part of the survey area was covered, and the biomass estimate is not considered adequate. In the assessment, the 2018 estimate was scaled to the area of the 2015 survey by the proportion of biomass found outside of the 2018 survey area. In the 2015 survey, 78.1% of the total biomass observed in Subarea A and 21.9% in Subarea B. By scaling the observed biomass estimate in Subarea A in 2018, the total biomass estimate used in the current assessment was 166 kt.

The model predicts that the total biomass peaked in the early 1990s, but since it has been on a steady decline and is now below B_{lim} of 559 kt (Figure 22.7.1). Although catches have decreased the fishing mortality has increased substantially since the late 1990, with a mortality of almost five to ten times the natural mortality. Fishing mortality has exceeded F_{lim} (0.057) since 1994. Recruitment of 5 year old fish into the stock is seen to have been variable between 1990 and 2006. In the years following, recruitment to the stock is estimated to have decreased substantially after 2006. The model predicts an increase in recruitment in 2011, although data available on recruitment is currently limited. Recruitment estimates of age 5 after 2011 is similarly unreliable. The estimates of recruitment could potentially be improved with more recent data on age composition of the catches.

22.8 Reference points

WKDEEPRED (ICES, 2016) also derived precautionary and MSY reference points (B_{lim}, B_{pa}, F_{lim}, F_{pa}, F_{MSY} and MSY $B_{trigger}$) following the ICES technical guidelines for the calculation of reference points.

Below is a summary of reference points agreed by WKDEEPRED (ICES, 2016). Note: the reference point values in the ICES advice sheet will be presented as relative values with respect to the average of the F and SSB estimates over the stock assessment series, as corresponds to Category 2 assessments.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	782 kt	B_{pa}
	F_{MSY}	0.041	F that maximizes median long-term catch in stochastic simulations with recruitment drawn from 1985–2006 estimates while incorporating a factor to gradually reduce recruitment when SSB < SSB(2001) (where SSB(2001) is the B_{loss} from the converged stock–recruitment period). F_{MSY} is constrained not to exceed F_{pa}.
Precautionary approach	B_{lim}	559 kt	B_{pa} / 1.4
	B_{pa}	782 kt	SSB(2001), corresponding to B_{loss} from the years with converged SSB and recruitment estimates (year classes 1990–2001)
	F_{lim}	0.057	F corresponding to 50% long-term probability of SSB > B_{lim}.
	F_{pa}	0.041	F_{lim} / 1.4

22.9 State of the stock

22.9.1 Short term forecast

During WKDEEPRED (ICES, 2016) the workshop agreed settings to conduct short-term projection based for 2019 and 2020 as follows. The model used was the same age-length structured population dynamics model used in the stock assessment (implemented in Gadget). The results are as follows:

Assumptions needed for projections:

Recruitment (age 5) in 2019 and 2020 was assumed to be equal to the geometric mean of the estimated recruitment during 1985–2008, i.e. 67 million fish.

Catch in 2018 was assumed to be 30 kt, based on the active TAC for all nations participating in the fishery. This assumption about catch results in F(2018) = 0.712 and SSB(2019) = 170 kt (which is below B_{lim}).

Projections at different values of F in 2019–2021 are given in Table 22.7.1.

22.9.2 Uncertainties in assessment and forecast

22.9.2.1 Data considerations

Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faces problems to obtain reliable catch data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries.

As in previous years, detailed descriptions on the horizontal, vertical and seasonal distribution of the fisheries are given.

The need and importance of having catch and biological data disaggregated by depth from all nations taking part in the fishery cannot be stressed strongly enough, and the Group urges all nations involved on supplying better data. With this need in mind, ICES sent a data call to all EU countries participating in the redfish fishery, encouraging stockholders to deliver detailed catch data before the WG would meet, but the response was very limited.

Additional age composition data could be available from currently un-aged otoliths sampled from Icelandic commercial catches and should be explored for possible incorporation in future assessments.

22.9.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in Section 22.6. Given the high variability in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is very high. Furthermore, there are high uncertainties regarding the biomass estimates due to low area coverage, especially in 2018.

The reviewers of WKDEEPRED (ICES, 2016) recommend that in the future the survey procedures and gear standardization should be considered, and data should be examined to determine if the mean catch rate is better estimated across countries or by country.

An age–length-based assessment model was applied in 2016 to give relative estimates of abundance and exploitation rates for this stock. This model utilizes age and length information from the fishery in addition to the biomass index and lengths from the trawl–acoustic survey. Even though the time-series available from the fishery and the survey are short relative to the life-time of the species, the assessment captures trends in stock biomass and fishing mortality reliably and this framework is considered a major improvement to the quality of the assessment. As some aspects of the assessment and short-term forecast still require further exploration and the data presently available cover only a short period relative to the life-span of the species, ICES presently consider this assessment to be in Category 2.

Recruitment (age 5) estimates from the assessment take about 8–10 years to stabilize. For this reason, the original recruitment estimates obtained from the assessment model for the years 2009 and onwards have been replaced with the geometric mean of the estimates from 1985–2008. This has resulted in a 13% increase in the SSB and 43% increase in harvestable biomass estimates in 2018 in comparison with the estimates obtained from the assessment model without replacing recruitment. The assumed year classes, corresponding to fish at ages less than or equal to 15 in 2019, constitute approximately 67% of the SSB and 45% of the harvestable biomass in 2019. While this indicates uncertainty in the catch and SSB values presented in the catch options table (Table 22.9.1). The conclusion that the SSB will remain below B_{lim} even without any catches in 2019 and 2020 is still valid.

It is not known to what extent CPUE reflect changes in the stock status of pelagic *S. mentella*, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not

indicate or reflect actual trends in stock size, although decreasing CPUE indexes are likely to reflect a decreasing stock.

22.9.3 Comparison with previous assessment and forecast

An analytical retrospective analysis for the base model going back between 1 and 10 years was conducted. Figure 22.7.2 shows how the estimates of the spawning stock biomass, recruitment, fishing mortality and the fit to the survey biomass series changes for each year which is omitted from the model. Notably, the recruitment estimates decrease substantially as the data available is decreased in a somewhat clustered fashion. Model runs omitting the 2013 age data show substantially fewer recruits, and similarly the three runs omitting the 2009 age data have even fewer recruits.

Fishing mortality and spawning stock biomass appear to be adjusted with each new year of data as the biomass estimate needs to be adjusted with each new data point in the survey biomass series.

The results presented here show some downwards revision of the assessment in 2016 in addition to an even more pessimistic view of recent recruitment. This revision is a response to an even lower survey biomass estimate in 2018 than the value that the 2016 assessment would have predicted. There is, as noted above, uncertainty in the survey biomass estimate in 2018 due to survey coverage.

As mentioned in Section 22.7 the stock was benchmarked in 2016 (ICES, 2016) and the age-length based stock assessment model was applied for the first time to give relative estimates of abundance and exploitation rates for this stock. Previously, the assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, CPUE and biological data.

22.9.4 Management considerations

The Group needs more and better data and requests that NEAFC and NAFO provide ICES with all information leading to more reliable catch statistics.

The main feature of the fishery since 1998 is a clear distinction between two widely separated fishing grounds with pelagic redfish fished at different seasons and different depths. Since 2000, the southwestern fishing grounds extended also into the NAFO Convention Area. Biological data, however, suggest that the aggregations in the NAFO Convention Area do not constitute a separate stock. The NAFO Scientific Council agreed with this conclusion (NAFO, 2005). The Group concludes that at that time there is not enough scientific basis available to propose an appropriate split of the total TAC among the two fisheries/areas.

The 6500 t TAC set by NEAFC for 2018 was overshot by about 18 400 t. This excess is due to the unilateral decision of the Russian Federation to self-allocate an annual TAC, which was 24 900 t for 2018. It was taken from both Shallow and Deep pelagic (24 712 t) stocks, since the Russian Federation does not agree on the division of the *S. mentella* management units.

22.9.5 Ecosystem considerations

The fisheries on pelagic redfish in the Irminger Sea and adjacent waters are generally regarded as having negligible impact on the habitat and other fish or invertebrate species due to very low bycatch and discard rates, characteristic of fisheries using pelagic gear.

22.9.6 Changes in the environment

The hydrography in the survey of June/July 2013 show that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013).

The increase of water temperature in the Irminger Sea may influence spatial and vertical distribution of *S. mentella* in the feeding area (Pedchenko, 2005). The abundance and distribution of *S. mentella* in relation to oceanographic conditions were analysed in a special multistage workshop (WKREDOCE1-3, see ICES, 2012b). Based on 20 years of survey data, the results reveal the average relation of redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58°N, 40°W, 300 m, 34.89 and 4.4°C, respectively. The spatial distribution of *S. mentella* in the Irminger Sea mainly in waters <500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (> 4.5°C and salinity > 34.94) in the north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES, 2012b).

Results based on international redfish survey data suggest that the inter-annual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES, 2012b). Whether the results of the study mentioned are applicable to the conditions for the deep pelagic stock needs further investigation.

22.10 References

ICES. 1999. Report of the Workshop on Redfish Stock Structure (WKREDS). ICES CM 2009/ACOM:37.

ICES. 2002. Report of the Planning Group on Redfish Stocks (PGRS). ICES CM 2002/D:08. 46 pp.

ICES. 2003. Report of the Planning Group on Redfish Stocks (PGRS). ICES CM 2003/D:08. 43 pp.

ICES. 2005. Report of the Study Group on Redfish Surveys (SGRS). ICES CM 2005/D:03. 49 pp.

ICES. 2007. Report of the Study Group on Redfish Surveys (SGRS). ICES CM 2007/RMC:12. 54 pp.

ICES. 2009a. Report of the Workshop on Redfish Stock Structure (WKREDS). ICES CM 2009/ACOM:37.

ICES. 2009b. Report of the Planning Group on Redfish Surveys (PGRS). ICES CM 2009/RMC:01.

ICES. 2009c. Report of the Planning Group on Redfish Surveys (PGRS). ICES CM 2009/RMC:05. 56 pp.

ICES. 2011. Report of the Working Group on Redfish Surveys (WGRS). ICES CM 2011/SSGESST:21. 62 pp.

ICES. 2012a. Report of the Benchmark Workshop on Redfish (WKRED 2012), 1–8 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:48. 291 pp.

ICES. 2012b. Report of the Third Workshop on Redfish and Oceanographic Conditions (WKREDOCE3), 16-17 August 2012, Johann Heinrich von Thunen Institute, Hamburg, Germany. ICES CM 2012/ACOM:25. 70 pp.

ICES. 2013. Report of the Working Group on Redfish Surveys (WGRS), 6-8 August 2013, Hamburg, Germany. ICES CM 2013/SSGESST:14. 56 pp.

ICES. 2014. Report of the Workshop on Redfish Management Plan Evaluation (WKREDMP) ICES CM 2014/ACOM: 52.

ICES. 2015. Third Interim Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS), 4-6 August 2015, Marine Research Institute, Reykjavík (Iceland). ICES CM 2015/SSGIEOM:03. 49 pp.

ICES. 2016. Report of the Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea (WKDEEPRED), 23-25 August 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:52. 29 pp.

ICES. 2018. Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS). 6-8 August 2018. Bremerhaven, Germany. ICES CM 2018/EOSG:40. 50 pp.

NAFO 2005. Scientific Council Reports 2004, 306 pp

Pedchenko, A. P. 2000. Specification of oceanographic conditions of the Irminger Sea and their influence on the distribution of feeding redfish in 1999. ICES North-Western Working Group 2000, Working Document 22, 13 pp.

Pedchenko, A. P. 2005. The role of interannual environmental variations in the geographic range of spawning and feeding concentrations of redfish *Sebastes mentella* in the Irminger Sea. ICES Journal of Marine Science 62: 1501-1510.

Table 22.2.1 Deep Pelagic *S. mentella* (stock unit >500 m). Catches (in tonnes) by area as used by the Working Group.

Year	5.a	12	14	NAFO 1F	Total
1991	0	7	52	0	59
1992	1862	280	1257	0	3398
1993	2603	6068	6393	0	15064
1994	14807	16977	20036	0	51820
1995	1466	53141	21100	0	75707
1996	4728	20060	113765	0	138552
1997	14980	1615	78485	0	95079
1998	40328	444	52046	0	92818
1999	36359	373	47421	0	84153
2000	41302	0	51811	0	93113
2001	27920	0	59073	0	86993
2002	37269	2	65858	0	103128
2003	46627	21	57648	0	104296
2004	14446	0	77508	0	91954
2005	11726	0	33759	0	45485
2006	16452	51	50531	254	67 288
2007	17769	0	40748	0	58516
2008	4602	0	25443	0	30045
2009	16828	4658	32920	0	54406
2010	8552	0	50736	0	59288
2011	0	7	47326	0	47333
2012	5530	608	26668	0	32806
2013	5274	0	40778	0	46052
2014	603	0	23152	0	23755
2015	1821	0	25612	0	27433
2016	2601	0	26053	0	28654
2017	1639	0	28252	0	29891
2018	711	0	23742	0	24453

Table 22.2.2. Deep pelagic *S. mentella* catches (in tonnes) in ICES Div.5.a, subareas 12, 14 and NAFO Div. 1F, 2H and 2J by countries used by the Working Group.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
1991								59												59
1992								3398												3398
1993				310		1135		12741					878							15064
1994						2019		47435					523		377	1465				51820
1995	1140	181	5056	1572	68	8271	1579	25898	396	1501	6868	4	3169		2955	15868	227		956	75707
1996	1654	307	3351	3748		15549	1671	57143	196	512	5031		5161		1903	36400	5558	123	245	138552
1997		9	315	435		11200		36830	3				2849		3307	33237	6895			95079
1998			76	4484		8368	302	46537	1		34		438		4073	25748	2758			92818
1999			53	3466		8218	3271	40261					3337		4240	11419	9885	5		84153
2000			7733	2367		6827	3327	41466			0		3108		3694	14851	9740			93113
2001			878	3377		5914	2360	27727			7515		4275		2488	23810	8649			86993
2002			15	3664		7858	3442	39263			9771		4197		2208	25309	7402			103128
2003				3938		7028	3403	44620			0		5185		2109	28638	9374			104296
2004				4670		2251	2419	31098			0		6277	1889	2286	31067	9996			91954
2005				1800		1836	1431	12919			1027		3950	1240	1088	16323	3871			45485
2006				3498		1830	744	20942			1294		5968	1356	1313	23670	6673			67288

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
2007				2902		1110	1961	18097		575	1394		4628	636	2067	21337	3810			58516
2008				2632			1170	6723			749		571	219	1733	15106	1142			30045
2009				3206			1519	15125		1355	2613			178	1596	25309	2907			54006
2010				3195			1932	14772		1963	2228		2388	3	2203	22803	7801			59288
2011				2028		1787		11994		845	1348		1066		1540	22364	4361			47333
2012				1438		1523		5912		724	558		3362		250	18377	632			32806
2013				1882		1176		8545		1200	1163		2979			26463	2644			46052
2014				721		890		2081		867	1024		1965			15475	732			23755
2015				779		918		1968			330		1547		202	20214	1475			27433
2016				567		715		2601		549	803		1396			21619	404			28654
2017				559		772		1929			911		970			24355	395			29891
2018				438		357		1138		441	900		868			20113	198			24453

Table 22.3.1 Available age data (number of otoliths read) of deep pelagic beaked redfish in the Irminger Sea and adjacent waters.

Year	Iceland	Norway	Total
1996	304		304
1999	1052	258	1310
2001	158	758	916
2003		75	75
2004	399		399
2006	200		200
2009	783		783
2011	585		585
2012	672	628	1300
2013	535	159	694
Total	**4688**	**1878**	**6566**

Table 22.3.2 Number of length measurements of deep pelagic beaked redfish and number of hauls sampled from the Icelandic commercial fishery.

Year	Number of fish	Hauls sampled
1992	447	5
1994	6915	41
1995	8128	49
1996	12185	141
1997	19258	200
1998	10104	94
1999	16264	115
2000	11079	97
2001	10589	83
2002	3840	48
2003	6705	63
2004	14774	87
2005	5693	34

Year	Number of fish	Hauls sampled
2006	15296	78
2007	14449	79
2008	4993	40
2009	9231	73
2010	4113	34
2011	7339	52
2012	9458	70
2013	4093	35
2014	2927	19
2015	998	6
2016	4020	20
2017	3366	
2018	612	3

Table 22.6.1 Deep pelagic *S. mentella*. Survey estimates for depth >500 m from trawl samples taken in 2018. Areas B–F (Figure 22.6.1) were not surveyed.

	A	B	C	D	E	F	Total
Area (NM^2)	103 075						
Mean length (cm)	36.1						
Mean weight (g)	613						
Biomass (t)	130 221						

Table 22.6.2. Results (biomass in ´000 t) for the international redfish surveys conducted 1999–2018 for deep pelagic *S. mentella* for each Subarea (see Figure 22.6.1), the total biomass, and the total area coverage (thousand nmi²). Areas C–F were not surveyed in 2015 and Areas B–F were not surveyed in 2018.

Year	Subarea						Total	Area (nmi²)
	A	B	C	D	E	F		
1999	277	568	12	27	52	0	935	296
2001	497	316	28	79	64	18	1001	420
2003	476	142	20	13	27	0	678	405
2005	221	95	0	8	65	3	392	386
2007	276	166	1	5	62	11	522	349
2009	291	121	0	8	37	1	458	360
2011	342	112	0	1	18	0	474	343
2013	193	75	0	2	10	0	280	340
2015	153	43	-	-	-	-	196	201
2018	130	-	-	-	-	-	-	103

Table 22.6.3. Area coverage (nmi²) in the international redfish survey 1999–2018 by subarea (see Figure 22.6.1). Blank cells mean that the area was not surveyed.

Year	A	B	C	D	E	F	Total	Reference
1999	110,524	124,014	8,403	4,201	27,435		274,577	ICES 1999
2001	125,975	127,125	28,934	62,897	69,000	32,470	446,401	ICES 2002
2003	114,289	120,561	31,931	41,128	62,742	8,217	378,868	ICES 2003
2005	126,403	84,020	25,694	64,533	73,693	11,920	386,263	ICES 2005
2007	129,614	106,594	8,464	33,855	62,623	8,052	349,202	ICES 2007
2009	122,519	91,863	8,362	55,468	69,931	11,921	360,064	ICES 2009c
2011	133,281	90,801	4,181	55,468	55,206	1,078	340,015	ICES 2011
2013	125,531	83,385	4,181	51,185	67,730	15,683	347,695	ICES 2013
2015	113,450	87,994					201,444	ICES 2015
2018	103,075						103,075	ICES 2018

Table 22.6.4. Biomass index (1000 tonnes) for the deep pelagic stock was estimated in similar fashion described in the stock annex but restricted to the management unit (65 051 nmi^2) for the deep pelagic stock (see Figure 18.1.1).

Year	Biomass (thous. tonnes)
1999	148
2001	391
2003	267
2005	126
2007	169
2009	147
2011	248
2013	135
2015	95

Table 22.6.5. Total biomass (1000 tonnes), total area surveyed (1000 nmi^2) and standardized index (t/NM^2) is calculated by dividing the total biomass (see Table 22.6.2) with the total area surveyed in NM^2.

Year	Total biomass	Area (nmi^2)	Standarized index
1999	935	296	3.16
2001	1001	420	2.38
2003	678	405	1.67
2005	392	386	1.02
2007	522	349	1.50
2009	458	360	1.27
2011	474	343	1.38
2013	280	340	0.82
2015	196	201	0.98
2018	130	103	1.26

Table 22.6.6. Standardized index (t/nmi^2) by subarea (see Figure 22.6.1) in the international redfish survey 1999–2018. Blank cells mean that the area was not surveyed.

Year	A	B	C	D	E	F
1999	2.51	4.58	1.43	6.43	1.90	
2001	4.27	2.56	0.96	1.30	0.93	0.59
2003	4.16	1.17	0.62	0.32	0.44	0.00
2005	1.75	1.13	0.00	0.12	0.88	0.25
2007	2.13	1.56	0.12	0.15	0.99	1.37
2009	2.38	1.31	0.00	0.15	0.53	0.07
2011	2.57	1.24	0.00	0.02	0.34	0.00
2013	1.54	0.90	0.00	0.04	0.15	0.00
2015	1.35	0.49				
2018	1.26					

Table 22.9.1: Short-term forecast. Values of catch and SSB are in kt.

man.type	F 2019	SSB 2019	Catch 2019	F 2020	SSB 2020	Catch 2020	F 2021	SSB 2021	Catch 2021
0.1 * Status quo	0.115	170.31	4.521	0.115	187.89	5.287	0.115	204.95	6.090
0.2 * Status quo	0.230	170.31	8.432	0.230	184.15	9.519	0.230	197.14	10.611
0.3 * Status quo	0.345	170.31	11.825	0.345	180.91	12.944	0.345	190.60	14.031
0.4 * Status quo	0.460	170.31	14.778	0.460	178.09	15.743	0.460	185.10	16.661
0.5 * Status quo	0.574	170.31	17.354	0.574	175.63	18.049	0.574	180.43	18.715
0.6 * Status quo	0.689	170.31	19.607	0.689	173.48	19.966	0.689	176.44	20.342
0.7 * Status quo	0.804	170.31	21.581	0.804	171.60	21.570	0.804	173.03	21.646
0.8 * Status quo	0.919	170.31	23.314	0.919	169.95	22.922	0.919	170.08	22.703
0.9 * Status quo	1.034	170.31	24.838	1.034	168.50	24.067	1.034	167.54	23.568
1 * Status quo	1.149	170.31	26.180	1.149	167.22	25.042	1.149	165.33	24.283
F_{MSY}	0.041	170.31	1.683	0.041	190.60	2.018	0.041	210.82	2.382
Scale * F_{MSY}	0.010	170.31	408	0.010	191.82	495	0.010	213.51	590
Zero catch	0.0	170.31	0	0.0	192.21	0	0.0	214.38	0

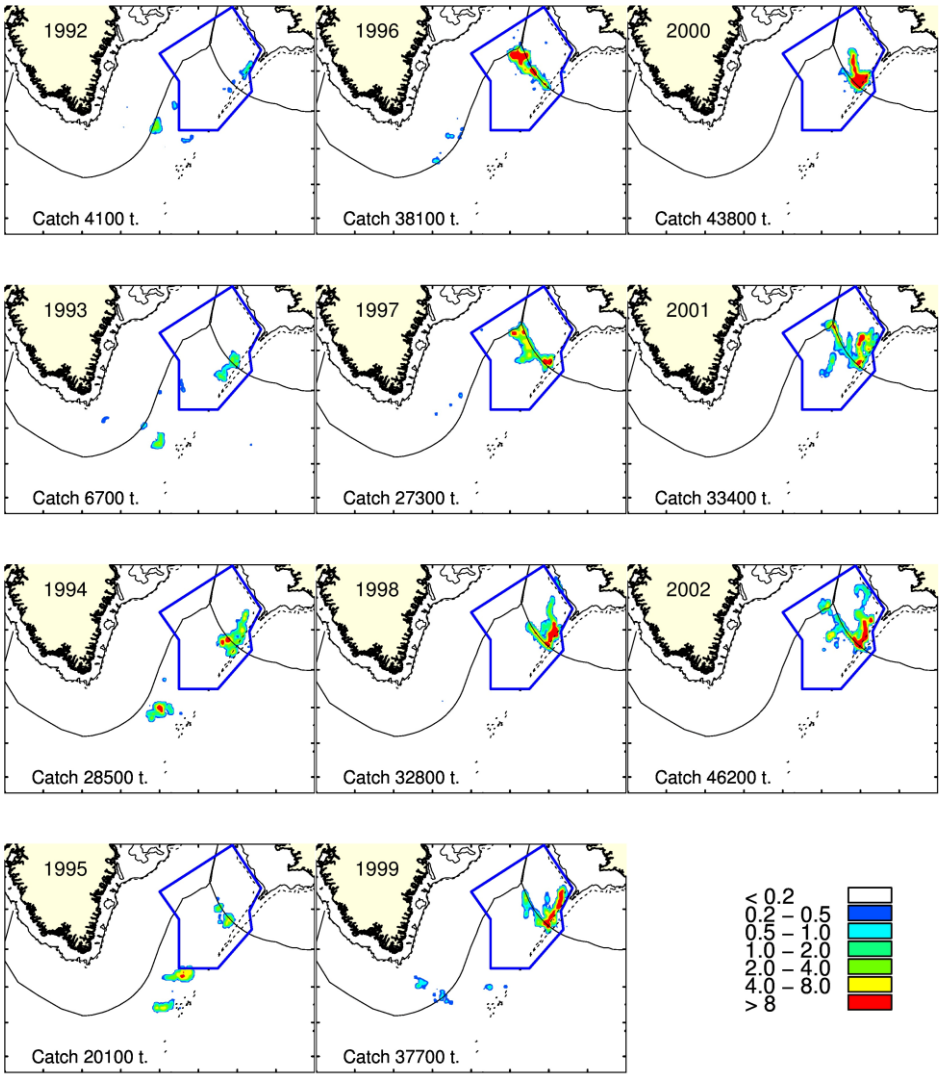

Figure 22.2.1 Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2017. Data are from the Faroe Islands (1995–2017), Germany (2011–2017) Greenland (1999–2003 and 2009–2010), Iceland (1995–2017), and Norway (1995–2003 and 2010–2017). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

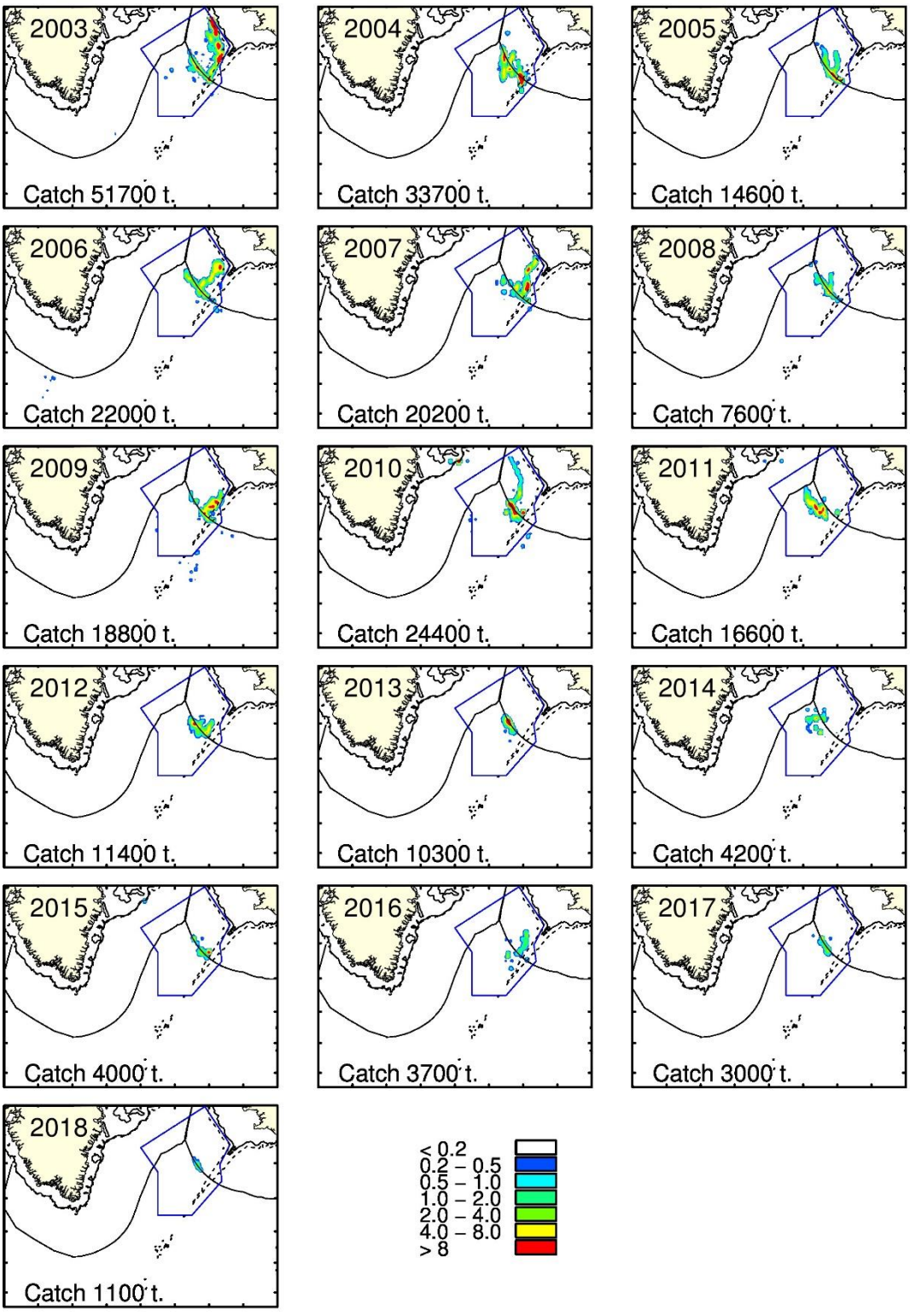

Figure 22.2.1 (Cont.) Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2017. Data are from the Faroe Islands (1995–2017), Germany (2011–2017) Greenland (1999–2003 and 2009–2010), Iceland (1995–2017), and Norway (1995–2003 and 2010–2017). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

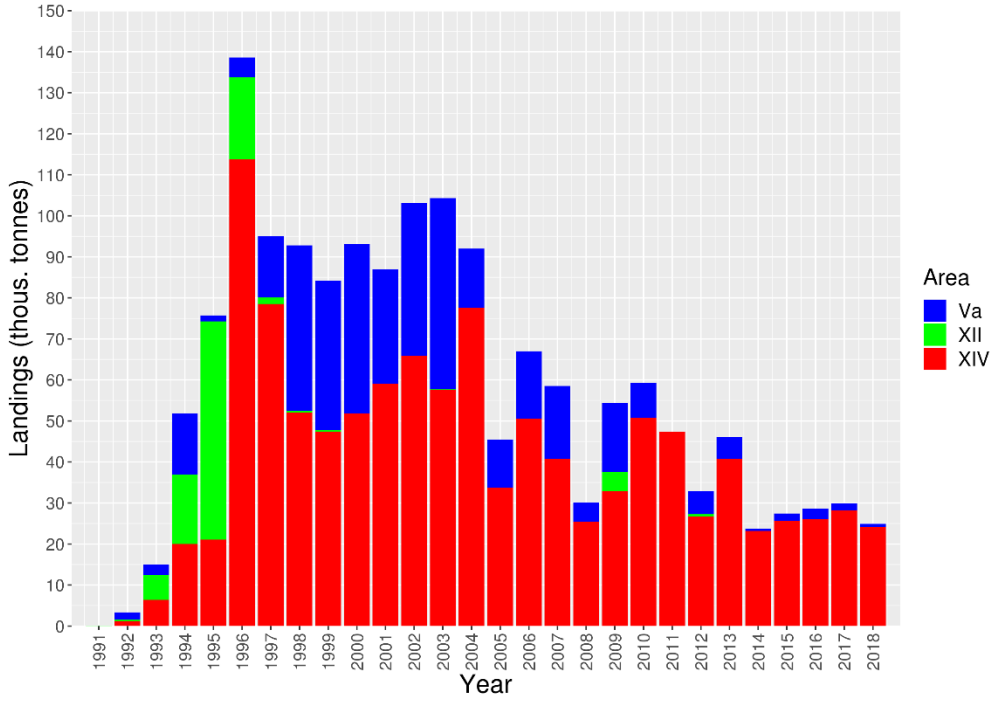

Figure 22.2.2 Landings of deep pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

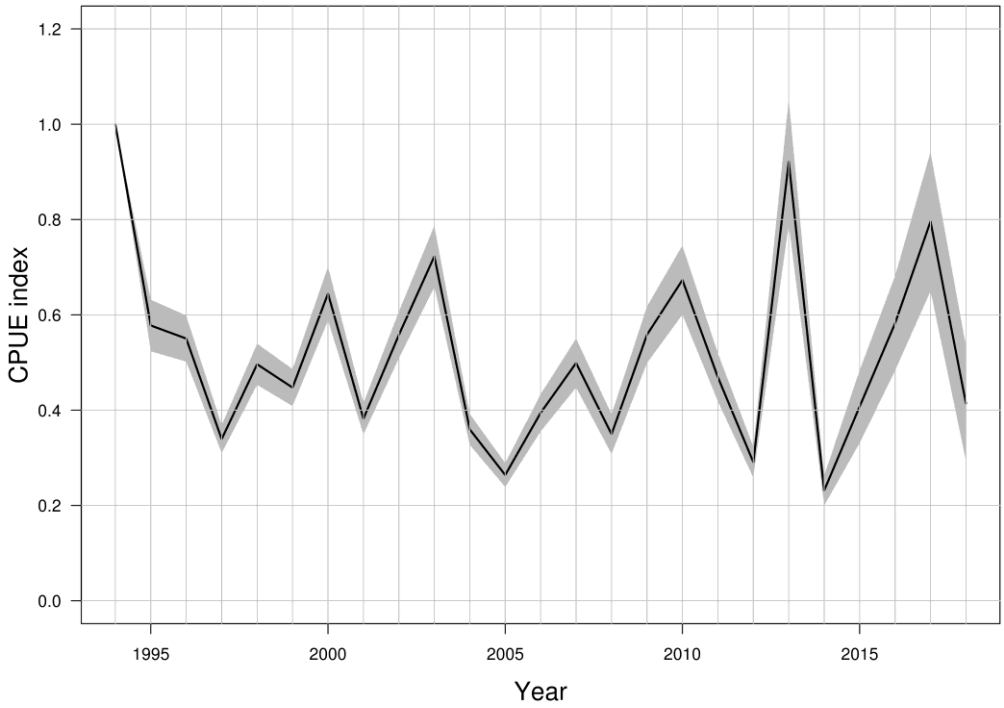

Figure 22.2.3 Trends in standardized CPUE of the deep pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroe Islands, Iceland, Germany, Greenland and Norway. Only data from Iceland were available in 2018.

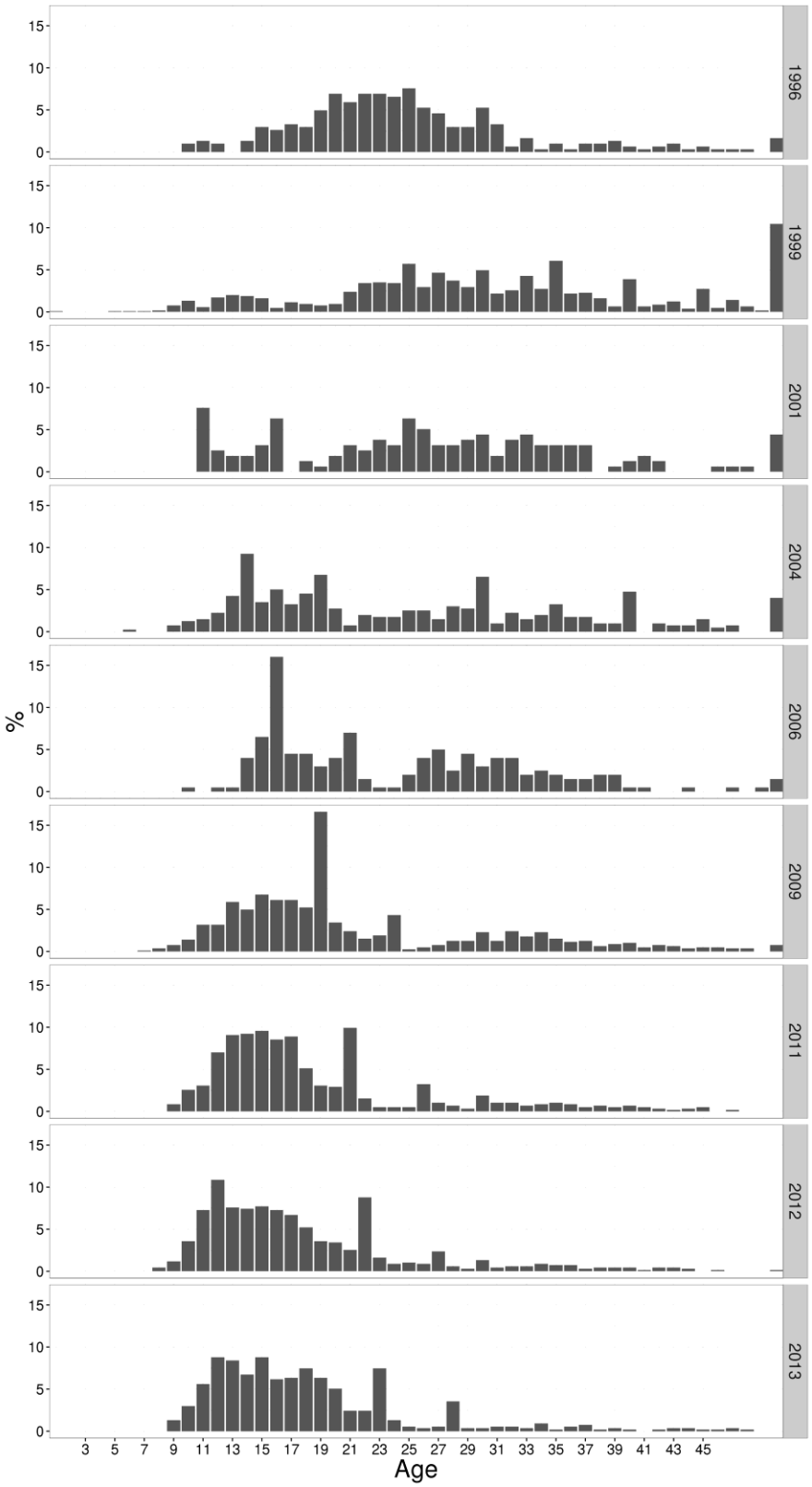

Figure 22.3.1 Age distribution of deep pelagic beaked redfish based on age reading from the Icelandic commercial catch.

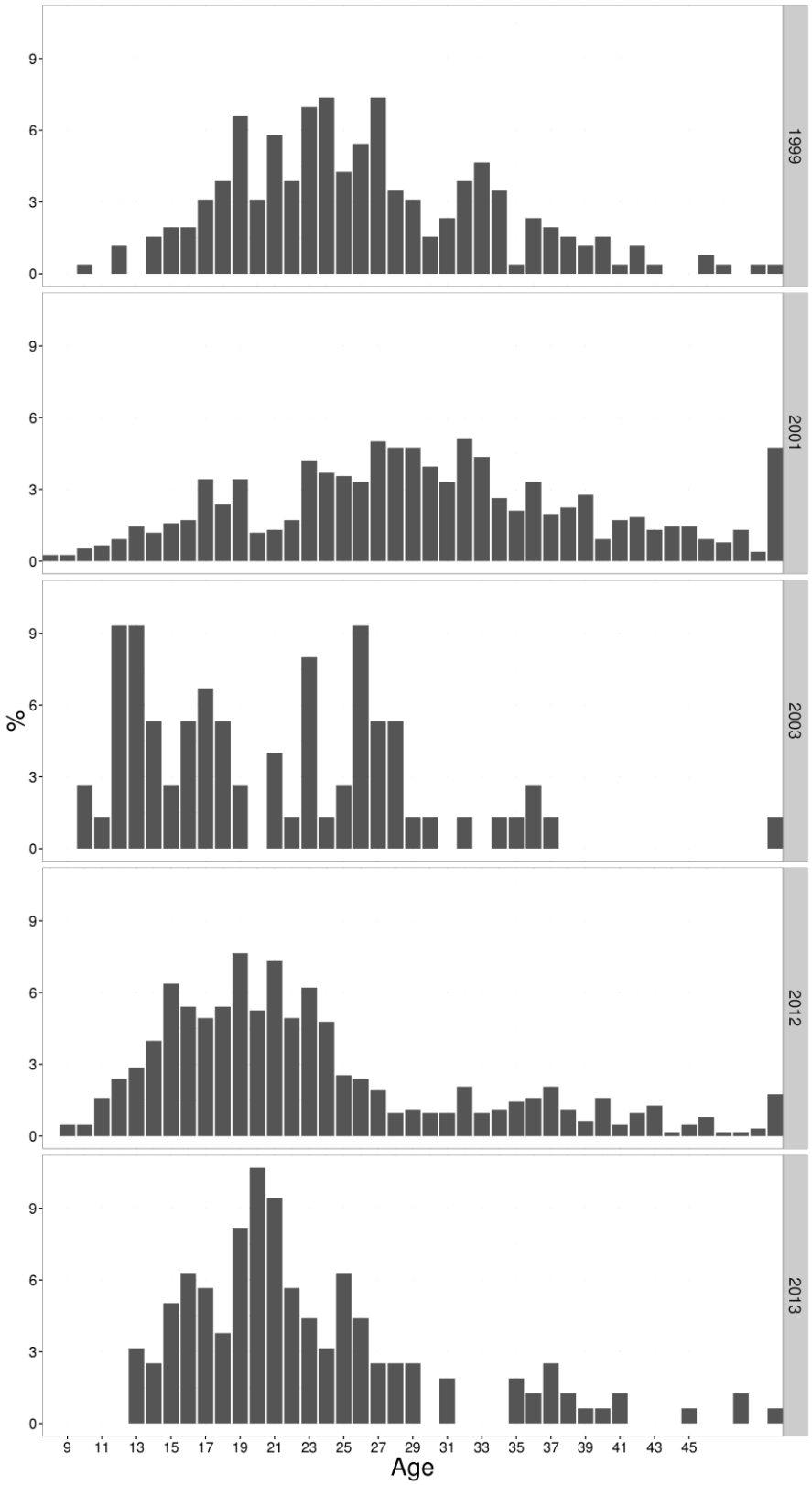

Figure 22.3.2 Age distribution of deep pelagic beaked redfish based on age reading from the Norwegian commercial catch.

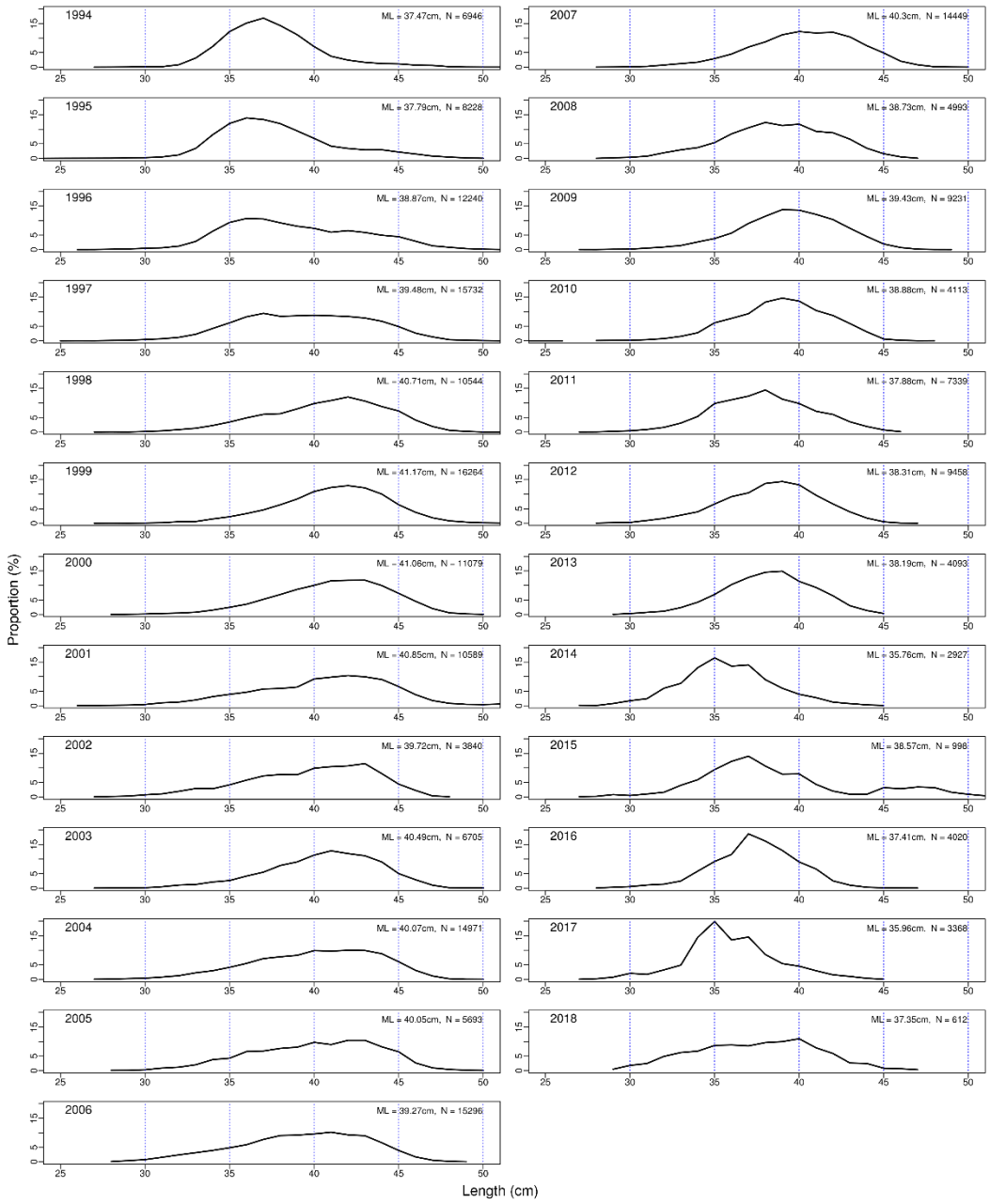

Figure 22.3.3 Length distribution from Icelandic landings of deep pelagic *S. mentella* 1994–2018.

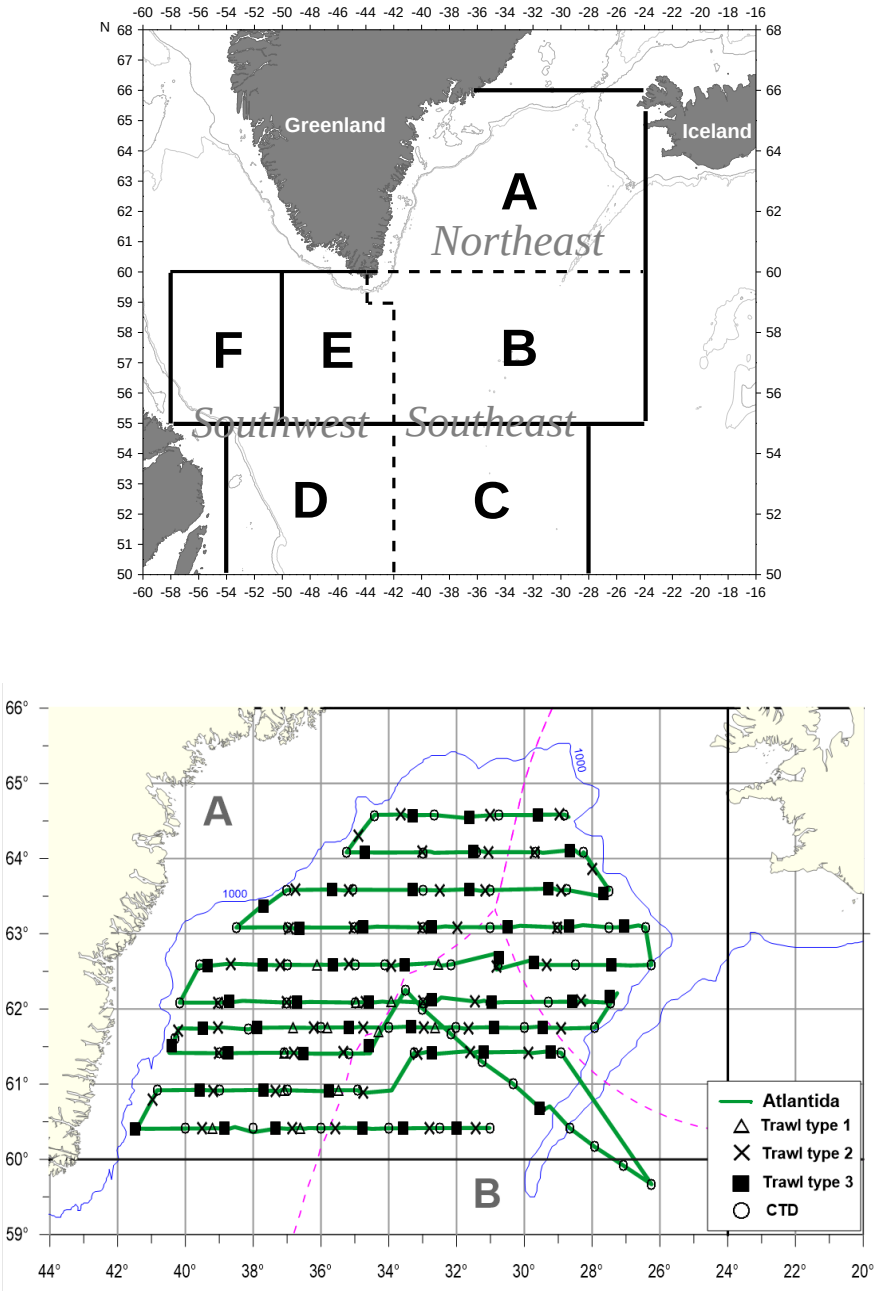

Figure 22.6.1 Upper: Subareas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines). Lower: Cruise tracks and stations taken in the joint international redfish survey in June/July 2018. Only the northeast area (subarea A) was surveyed.

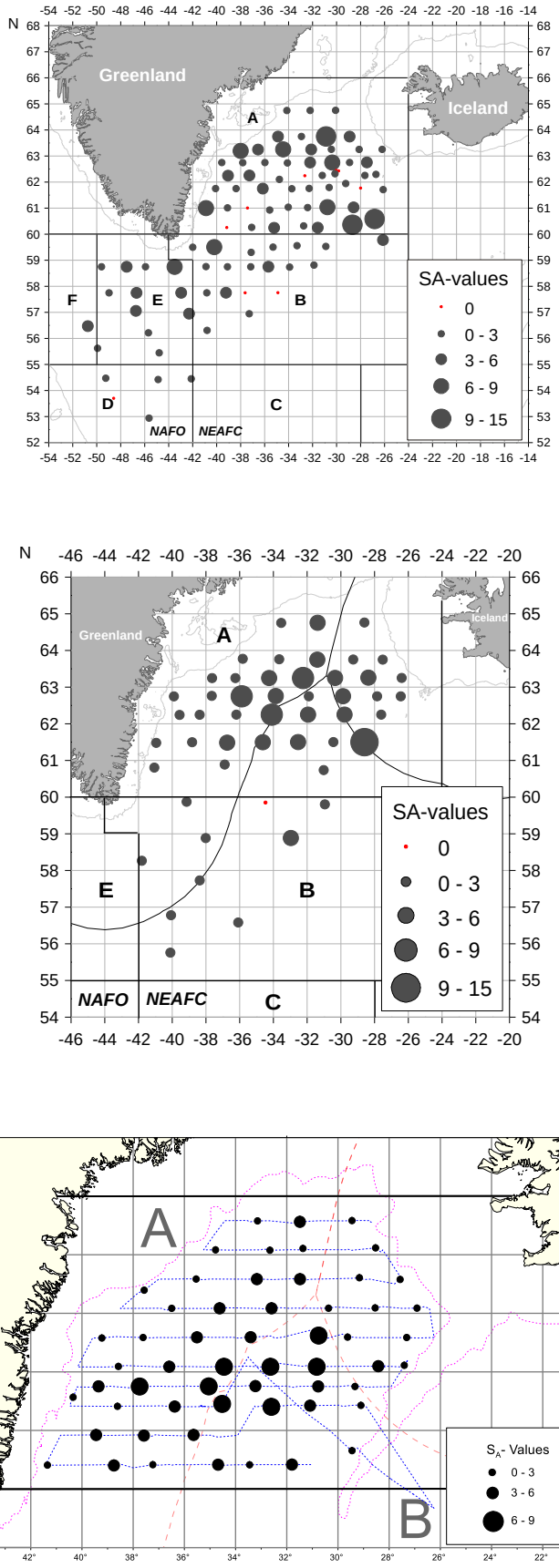

Figure 22.6.2. Redfish trawl estimates deeper than 500 m (type 3 trawls). s_A values calculated by the trawl method (see WGRS Report, 2013) during the joint international redfish survey in June/July 2013 (top), June/July 2015 (middle) and June/July 2018 (bottom).

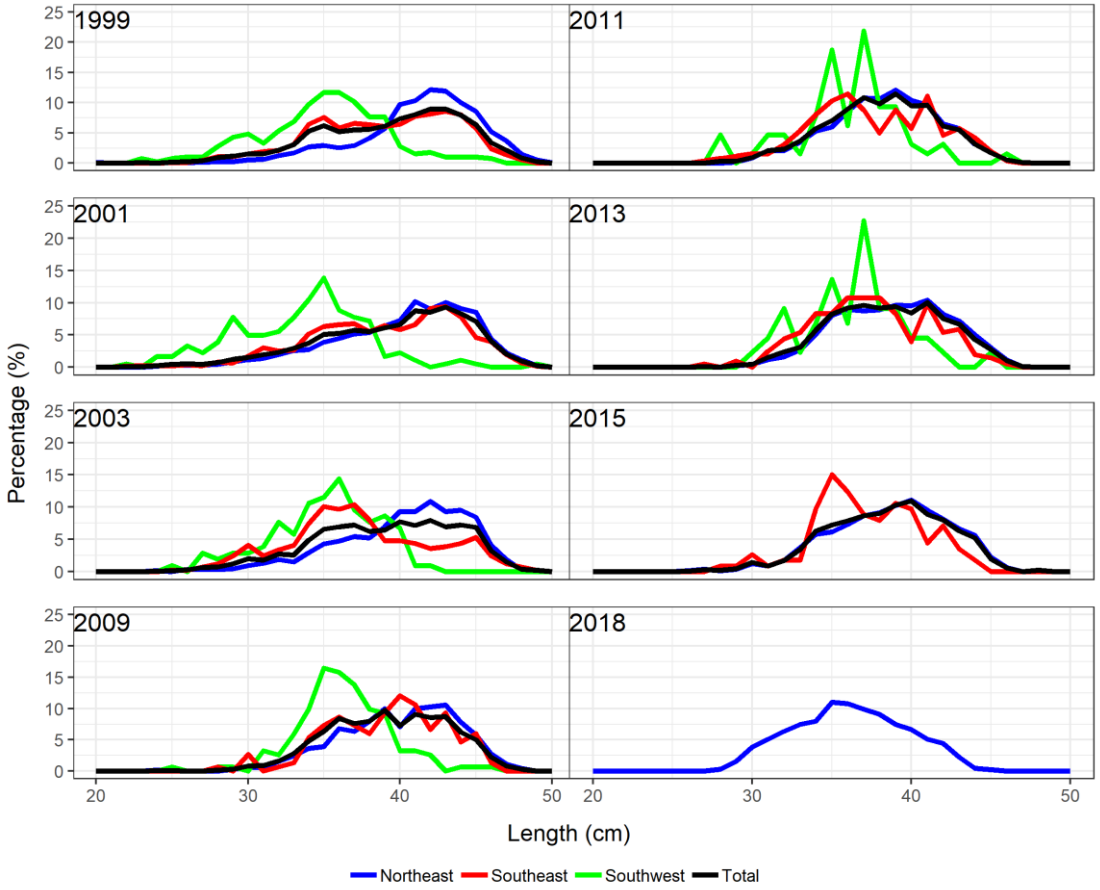

Figure 22.6.3 Length distribution of redfish by geographical areas (see Figure 22.6.1) and total, from fish caught deeper than 500 m 1999–2003 and 2009–2018 (in 2018, the survey only covered the northeast area).

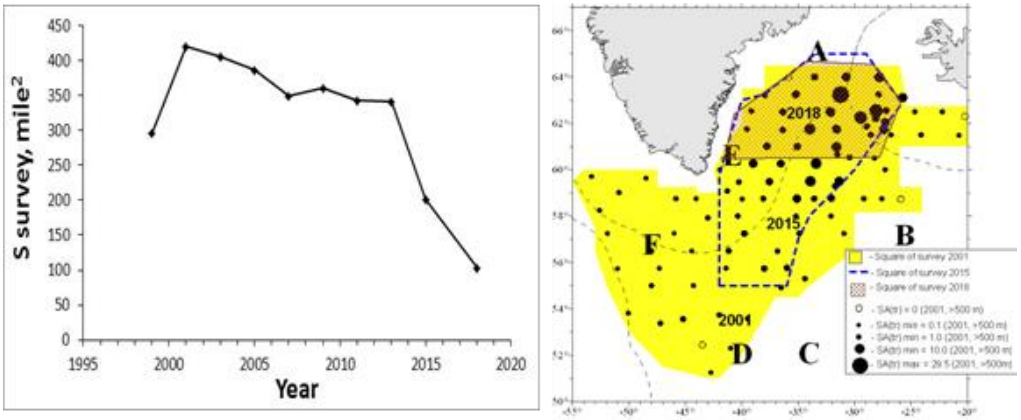

Figure 22.6.4 Left: Total area coverage (thousand nmi²) by survey 1999-2018. Right: Area coverage of the survey in 2001 (yellow), 2015 (blue dotted line) and 2018 (orange) and trawl estimate of deep pelagic redfish (deeper than 500 m) in the 2001 survey.

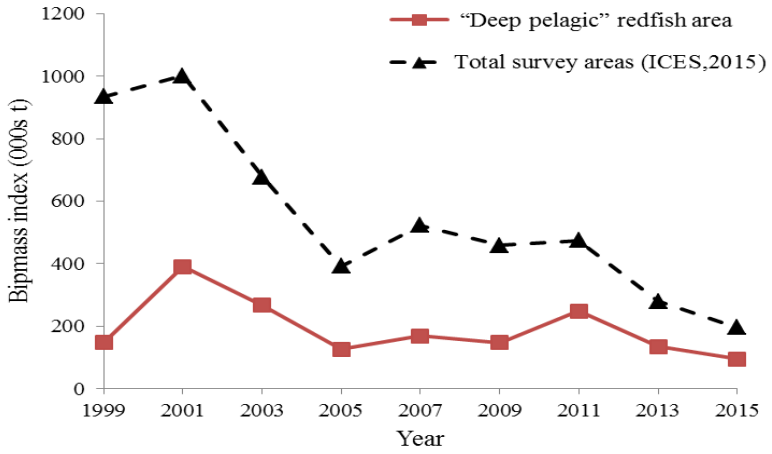

Figure 22.6.5. Total biomass index (dotted black line) of deep pelagic redfish stock 1999-2015 (see Table 22.6.2) and biomass index (red line, see Table 22.6.4) estimated in similar fashion as the total biomass index but restricted to the management unit (65 051 nmi²) for the deep pelagic stock (see Figure 18.1.1).

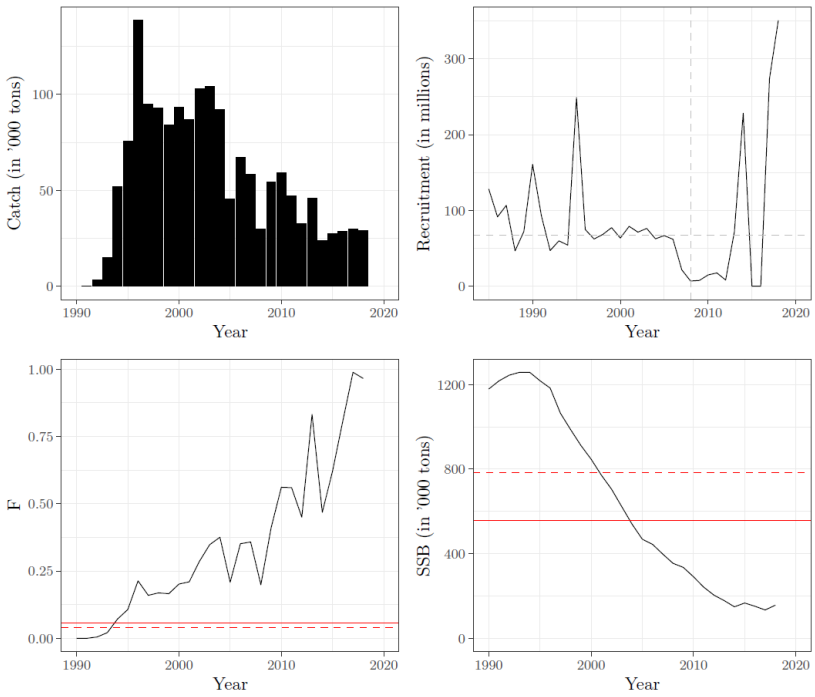

Figure 22.7.1: Summary of stock assessment agreed by WKDEEPRED, see Table 5.2.2 for a tabulation of results (to be presented as a Category 2 assessment, i.e. with Recruitment, F and SSB on relative, rather than absolute, scale). Recruitment after 2008 is not considered to be reliably estimated and has been replaced by the geometric mean of the estimated recruitment during 1985–2006. SSB and F values after 2006 were recalculated accordingly, so as to match the observed catches in those years.

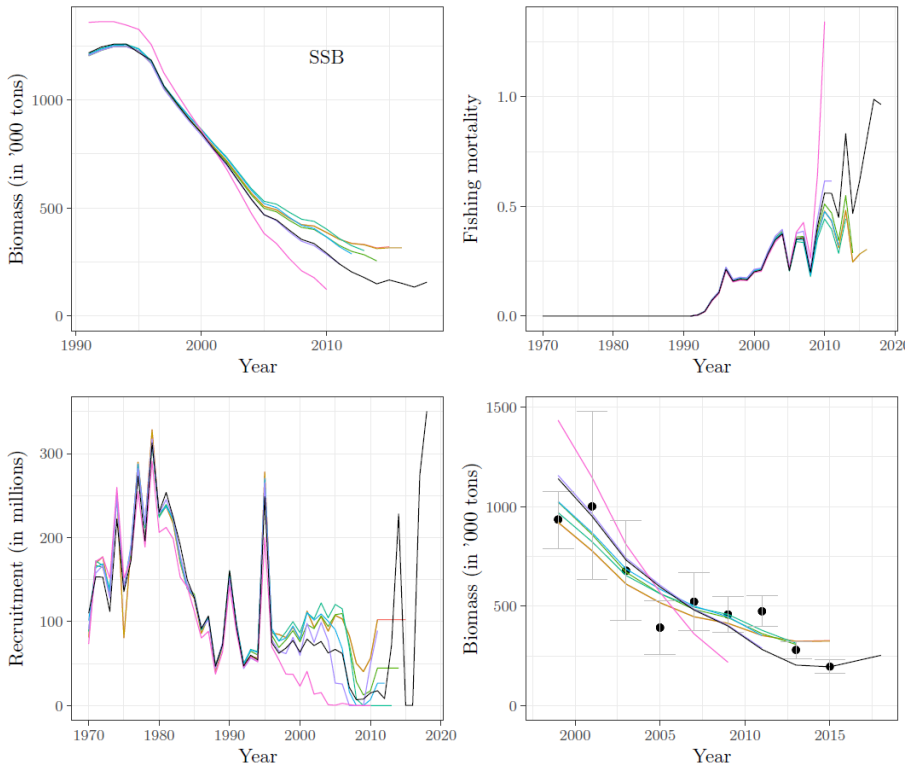

Figure 22.7.2: Analytical retrospective estimates of spawning stock biomass, recruitment in millions, fishing mortality and the fit the abundance index.