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 2020. No information was available from Russia 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
Germany	1 factory trawler
Lithuania	1 factory trawler
Norway	1 factory trawler
Russia	? factory trawlers
Spain	1 factory trawler
Total	**? 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 period. 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. Data was not available for 2020 as Iceland did not participate in the fishery.

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 Redfish surveys

The international trawl-acoustic redfish survey for the deep pelagic beaked redfish in the Irminger Sea and adjacent waters has been conducted since 1999. In 1999–2015 it was conducted biennially but since then triennially.

In 2021, only one vessel from Russia participated in the survey as Germany cancelled their participation (ICES, 2021). A bilateral agreement with financial compensation between Russia and Germany was reached, providing that Russia should take over the German part of the survey. Since the Russian and the German survey parts had to be carried out one after the other, the survey was extended from mid-June to mid-August 2021. The survey is usually conducted from mid-June to mid-July. Subareas A, B and E were surveyed (Figure 22.6.1) covering the geographical distribution of deep pelagic *S. mentella*.

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/August 2021. Approximately 242 000 NM^2 was surveyed (Subareas A, B, and E) compared to 103 000 NM^2 in 2018 (where only Subarea A was surveyed), 200 000 NM^2 in 2015 (Subareas A and B), and 340 000 NM^2 in 2013. A total biomass of 154 000 t was estimated in these three areas. This is the lowest biomass estimate since the survey started in 1999 and is only 15% compared to the highest value observed in 2001 (Table 22.6.2). The results also show that biomass of the redfish distributed below 500 m in Subarea A decreased by approximately 15% in 2018 compared to 2015 and is the lowest since the commence of the survey in 1999 (see Figure 22.6.1 for area definition) (Table 21.6.2). The mean length was 35.4 cm, which was 0.7 cm smaller than in 2018, and 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.

22.7 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 (reb.2127.dp).

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.

22.7.1 Diagnostics

Figure 22.7.1 shows the model fit to the biomass index. The model appears to capture sufficiently the downward trend in the survey biomass index. The fitted values fall outside the estimated range of two data points, the 2011 and 2015 survey estimates, although the model-fitted trajectory falls between these points. These discrepancies are considered to be within reasonable limits, as the model also takes into account the information provided by the length and age-length data.

The length distributions from the international redfish survey, shown in Figure 22.7.2, are well captured by the model. Similarly, the model fit to the commercial length distributions are satisfactory, although discrepancies can be seen in the early years of the fishery; this is illustrated in Figure 22.7.3, which shows that fitted mean length in the fishery is substantially higher than observed in the fishery in the first years of commercial activities. This effect is more pronounced in the first two years, and hardly present in the samples from 1998 and onwards. During those first years the commercial effort was more dispersed spatially, possibly reflecting a learning period for the fishery, before it became more concentrated.

Figure 22.7.4 compares the fitted age structure in the catch to the observed proportions at age (from the age-length composition dataset) in the commercial catches. The fit to the age data is considered acceptable, particularly in the later years of the model time. Note that the number of samples varies considerably between years and quarters, e.g., in 2003 only 74 otoliths have been analysed whereas in 2012, 1300 otoliths have been read (see Table 22.3.1). The model appears to follow the strong 1985- and 1990-year classes, present in the observed catches since the early/mid 2000s, adequately.

In this model, age composition data are important indicators of past recruitment. For ages 1 to 10 data are sparse. The youngest fish recorded in the catches (in 2004) was 5 years old; However the information on recruitment is only considered reliably available approximately 10 years after spawning.

The age–length frequencies also provide information on fish growth. Figure 22.7.5 shows a comparison between the model-fitted mean–length-at-age and the length-at-age observations from the commercial catches. The model appears to follow the general tendency of the data and to capture the spread in lengths-at-age. In most cases, however, the mean length of fish older than 30 years as well as the mean length of the youngest age classes are overestimated. This overestimation of mean length is considered to be a model artefact, as the model effectively forces all fish towards L_∞ as the fish grow older

Table 22.7.1 and Figure 22.7.6 illustrate the estimated trajectories from the Gadget model. The biomass estimates refer to biomass at the start of the year, catches are the total annual landings, recruitment is the number of 5-year-old fish that enter the model during the 1st quarter of the year, and the annual fishing mortality is the average of the quarterly apical fishing mortalities. The model estimates that the total biomass peaked in the early 1990s but has been on a steady decline since then and is now below B_{lim} of 559 kt (Figure 22.7.6). Although catches have decreased, the fishing mortality has increased substantially since the late 1990s, with the fishing mortality ranging between 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 has been relatively stable between 1985 and 2006. Estimates of recruitment after 2006 (i.e., after year class 2001) are considered unreliable as the fish do not consistently enter the fishery and the survey until they are 15 years old. Therefore, recruitment from 2009 onwards was fixed in the projections to the geometric mean recruitment (at age 5) of the years 1985–2008. 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 2019–2021 was assumed to be equal to the geometric mean of the estimated recruitment during 1985–2008, i.e., 67 million fish.

Catch in 2021 was assumed to be 17 kt, based on the catch fished by the Russin Federation in 2020, as Russia was the only nation that participated in the fishery. This assumption about catch results in F(2020) = 0.520 and SSB(2021) = 130 kt (which is below B_{lim}).

Projections at different values of F in 2022–2024 are given in Table 22.9.1.

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 for 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 lifetime 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 lifespan 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 2022–2024 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 22.7.7 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 2021 than the value that the 2019 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 5500 t TAC recommended by NEAFC for 2020 was overshot by 13 788 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 2020. It was taken from both Shallow and Deep pelagic (total catch for both stocks 23 161 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 in 2021 shows that temperature in the survey area increased compared to what was observed in recent surveys throughout studied water column (down to 1000 m) to the level of warm years.

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 Thünen 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. 31 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.

ICES. 2021. Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS). ICES Scientific Reports. 3:43. 32 pp. https://doi.org/10.17895/ices.pub.8056

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
2019	236	0	24167	0	24403
2020	0	0	19288	0	19288

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
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

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
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
2019						531		236			911		700			21964	61			24403
2020						533					908		748			17009	90			19288

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. Iceland did not participate in the fishery in 2020.

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
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

Year	Number of fish	Hauls sampled
2016	4020	20
2017	3366	
2018	612	3
2019	490	
2020	-	-

Table 22.6.1 Deep pelagic *S. mentella*. Survey estimates for depth >500 m from trawl samples taken in 2021. Areas C, D and F (Figure 22.6.1) were not surveyed.

	A	B	C	D	E	F	Total
Area (NM^2)	95 159	88 128			588622		242 148
Mean length (cm)	35.7	34.9			34.6		35.0
Mean weight (g)	584	555			538		559
Biomass (t)	**85 909**	**38 377**			**29 221**		**153 527**

Table 22.6.2. Results (biomass in ´000 t) for the international redfish surveys conducted 1999–2021 for deep pelagic *S. mentella* for each Subarea (see Figure 22.6.1), the total biomass, and the total area coverage (thousand nmi^2). Areas C–F were not surveyed in 2015 and Areas B–F were not surveyed in 2018.

Year	Subarea						Total	Area (nmi^2)
	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
2021	86	38	-	-	29	-	154	242

Table 22.6.3. Area coverage (nmi²) in the international redfish survey 1999–2021 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
2021	95,159	88,128			58,862		242,148	ICES, 2021

Table 22.7.1 Results from the Gadget model of total biomass, spawning stock biomass, recruitment at age 5 (in thousands), catch and fishing mortality. All weights are in tonnes.

Year	Biomass	SSB	R(age5)	Catches	F_{9-19}
1985			1154		
1986			944		
1987			904		
1988			393		
1989			637		
1990			1476		
1991	1447061	1324872	838	59	0.000
1992	1439553	1340712	434	3398	0.004
1993	1424247	1344085	614	15064	0.017
1994	1370484	1335750	576	51820	0.060
1995	1343900	1288811	2249	75707	0.091
1996	1212974	1244723	773	138552	0.181
1997	1123235	1119481	648	95079	0.136
1998	1038107	1035972	686	92818	0.144
1999	965126	955767	761	84153	0.143
2000	880863	885906	636	93113	0.172
2001	808274	806193	773	86993	0.180
2002	718707	735546	685	103128	0.244
2003	631481	649096	739	104296	0.293
2004	553352	563896	575	91954	0.312
2005	523946	489685	625	45485	0.174
2006	469960	462191	506	67288	0.291
2007	417847	411984	255	58516	0.295
2008	388618	366543	70	30045	0.165

Year	Biomass	SSB	R(age5)	Catches	F_{9-19}
2009	349967	345110	559	54406	0.339
2010	307245	306961	559	59288	0.453
2011	277128	264710	559	47333	0.441
2012	261937	234687	559	32806	0.347
2013	233952	219148	559	46052	0.599
2014	228525	191355	559	23755	0.339
2015	219609	185370	559	27433	0.429
2016	209672	176171	559	28654	0.510
2017	198683	166112	559	29891	0.611
2018	193235	155190	559	24453	0.486
2019	182738	149705	559	29658	0.721
2020	165719	139512		19288	0.520
2021		130008			0.462

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

Approach	F (2022–2024)	Catch 2022	SSB 2023	Catch 2023	SSB 2024	Catch 2024	SSB 2025
Zero catch	0.000	0	127250	0	132108	0	135920
Scale * F_{MSY}	0.008	305	126963	355	131484	406	134909
F_{MSY}	0.040	1429	125907	1642	129206	2060	131253
0.1 * Status quo	0.063	2240	125145	2551	127582	2853	128679
0.2 * Status quo	0.122	4299	123210	4779	123535	5219	122386
0.3 * Status quo	0.177	6193	121431	6734	119905	7193	116884
0.4 * Status quo	0.229	7939	119793	8455	116639	8848	112052
0.5 * Status quo	0.278	9549	118283	9974	113694	10245	107787
0.6 * Status quo	0.323	11036	116889	11320	111031	11429	104006
0.7 * Status quo	0.366	12409	115602	12516	108616	12438	100641
0.8 * Status quo	0.406	13680	114412	13582	106423	13301	97636
0.9 * Status quo	0.443	14856	113311	14535	104426	14044	94942
1 * Status quo	0.478	15945	112292	15389	102605	14685	92519

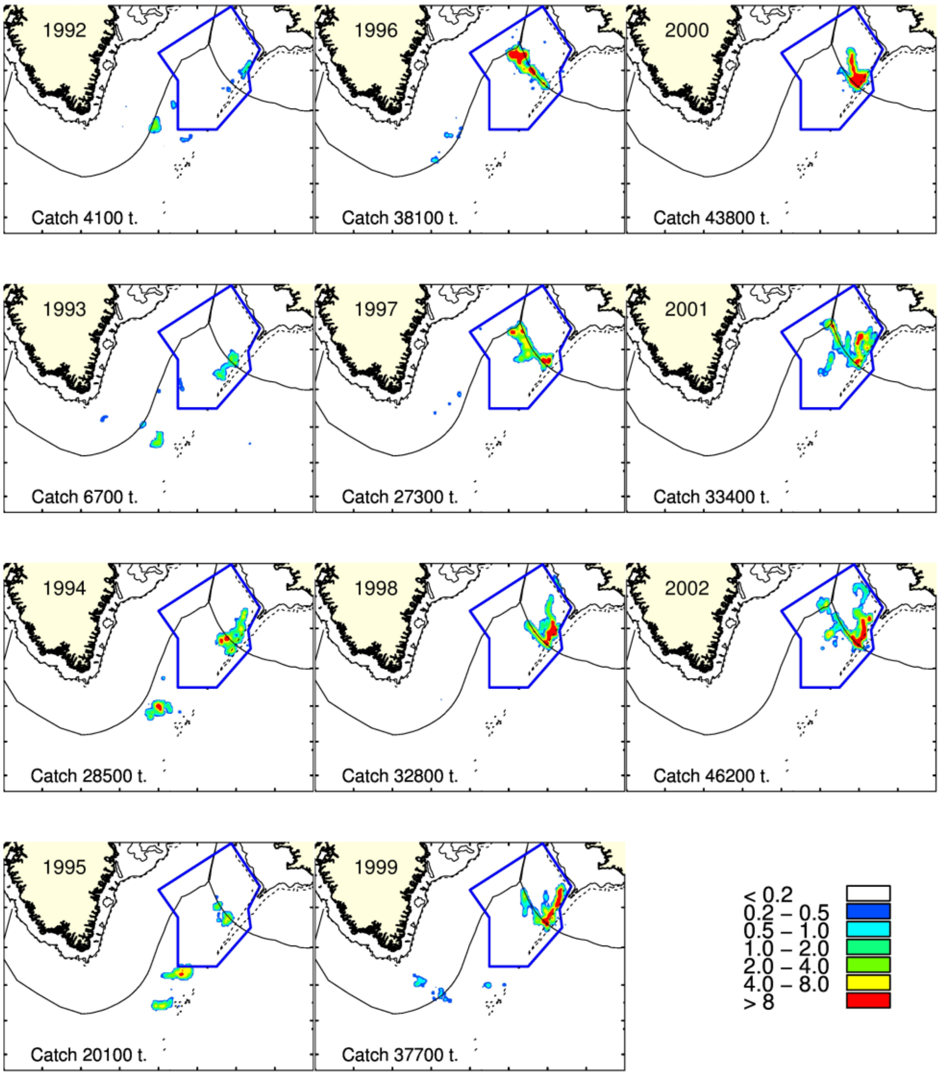

Figure 22.2.1 Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2017. Data are from the Faroe Islands (1995–2017), Germany (2011–2017) Greenland (1999–2003 and 2009–2010), Iceland (1995–2017), and Norway (1995–2003 and 2010–2017). The catches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

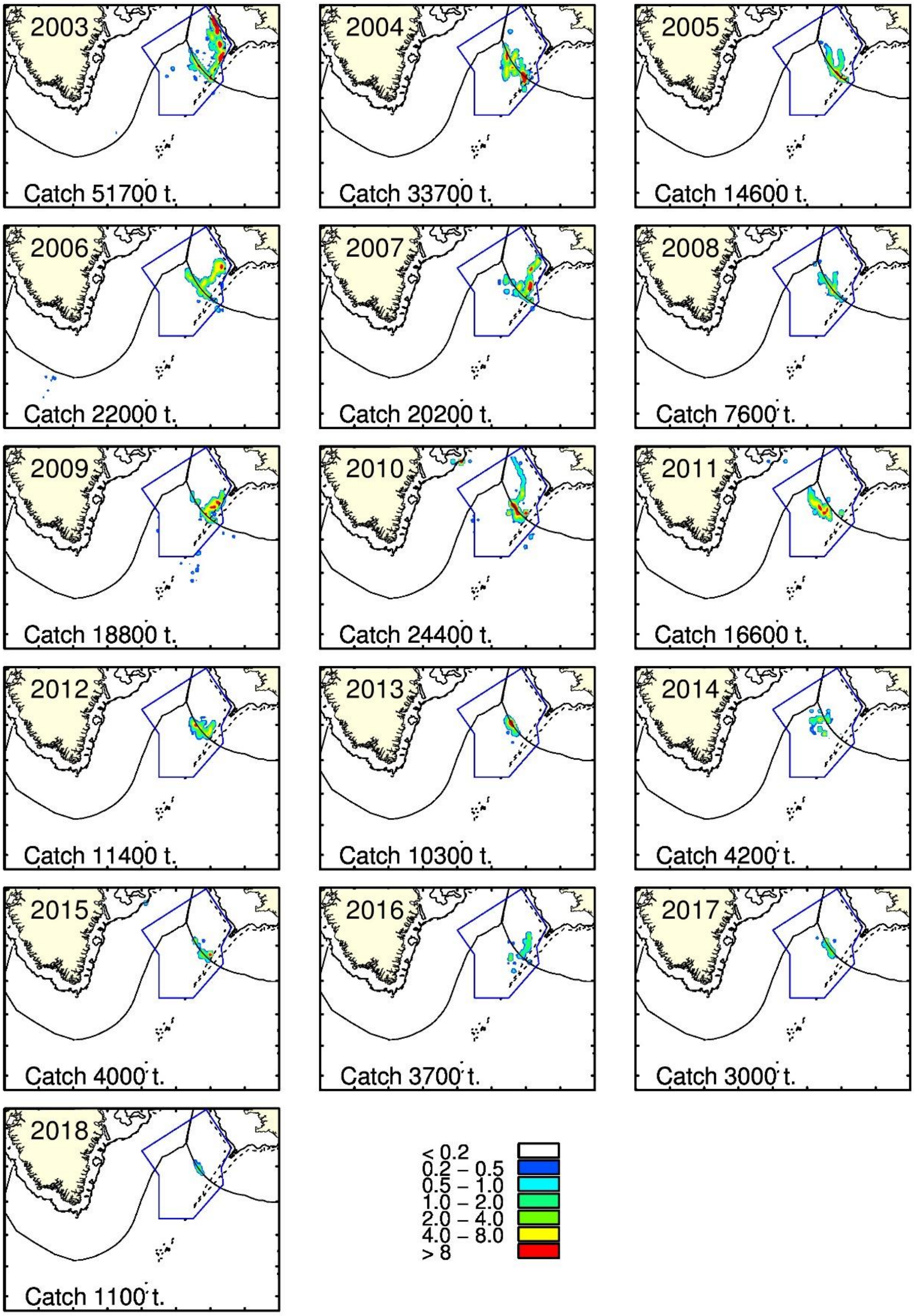

Figure 22.2.1 (Cont.) Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2017. Data are from the Faroe Islands (1995–2017), Germany (2011–2017) Greenland (1999–2003 and 2009–2010), Iceland (1995–2017), and Norway (1995–2003 and 2010–2017).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

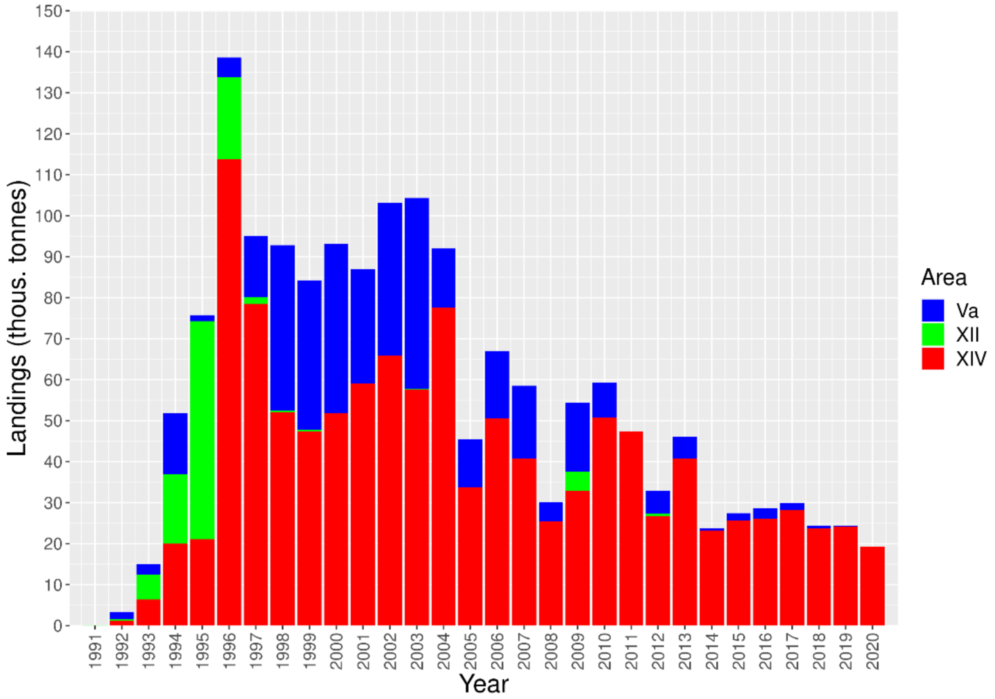

Figure 22.2.2 Landings of deep pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

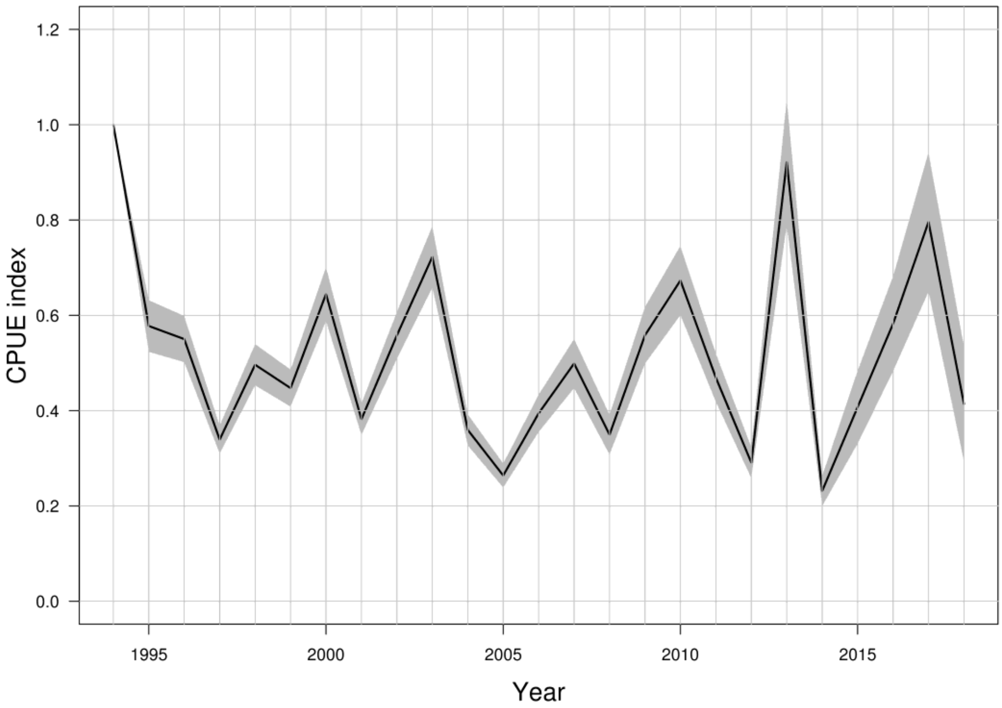

Figure 22.2.3 Trends in standardized CPUE of the deep pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroe Islands, Iceland, Germany, Greenland and Norway. Only data from Iceland were available in 2018.

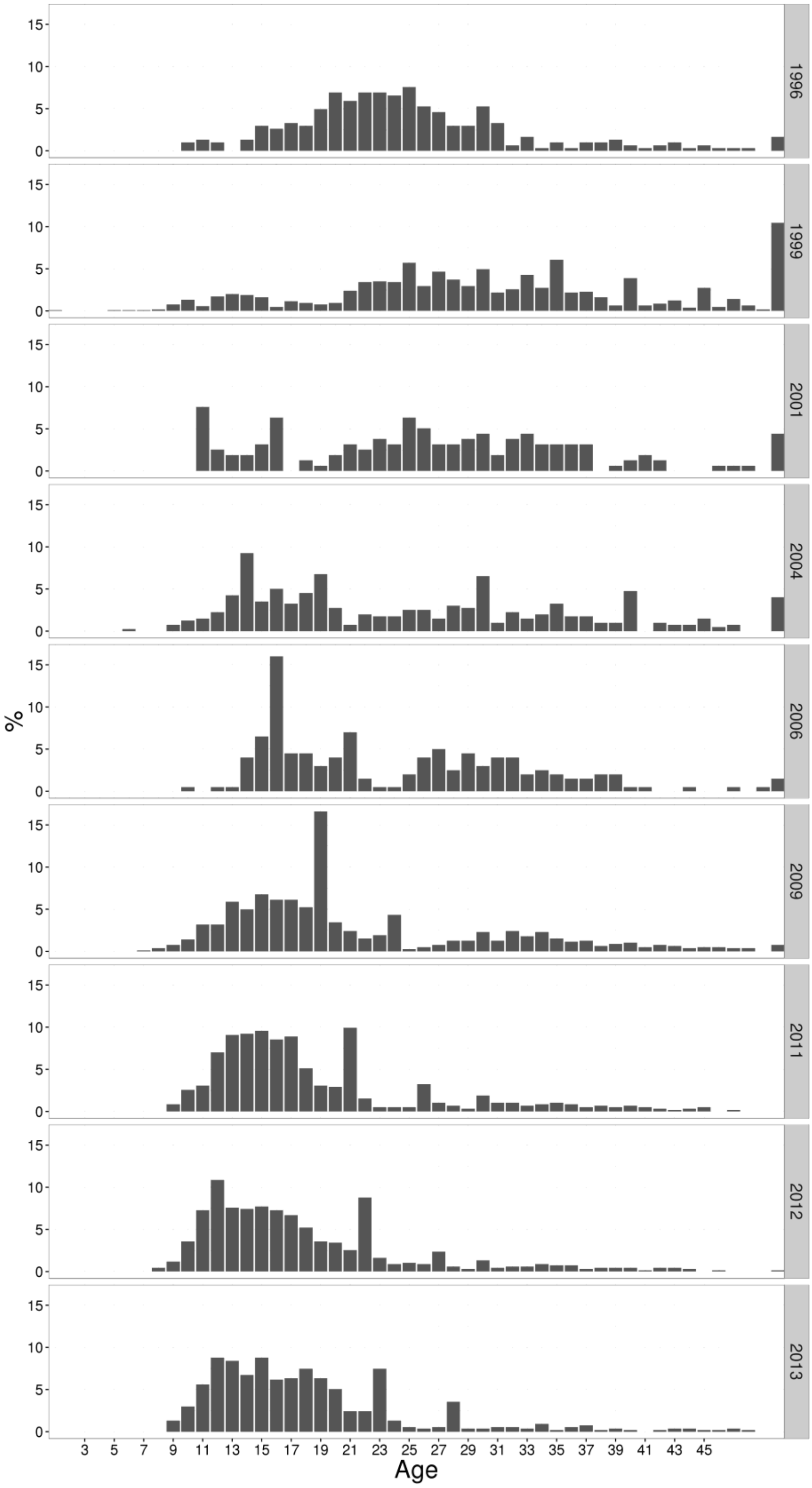

Figure 22.3.1 Age distribution of deep pelagic beaked redfish based on age reading from the Icelandic commercial catch.

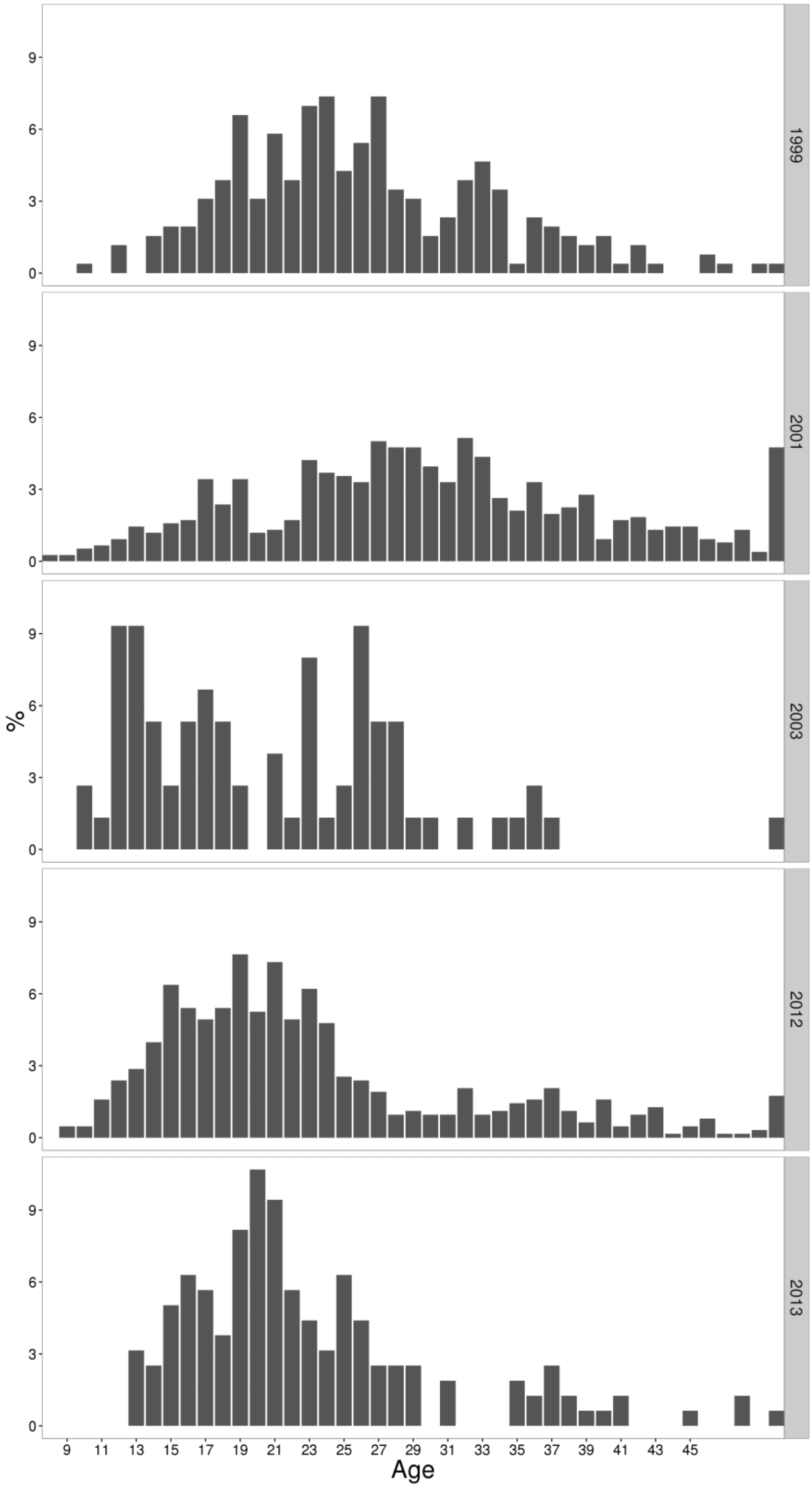

Figure 22.3.2 Age distribution of deep pelagic beaked redfish based on age reading from the Norwegian commercial catch.

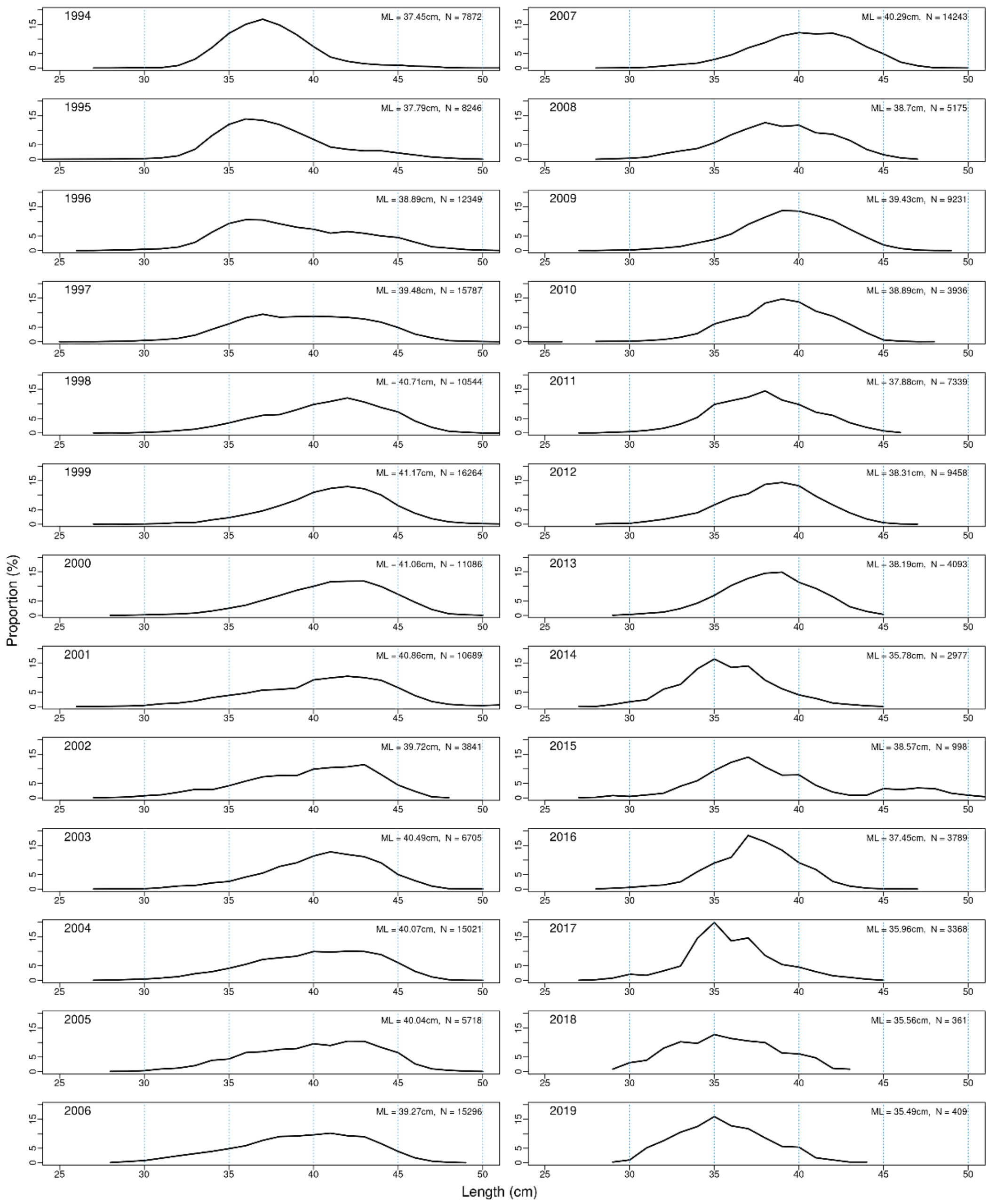

Figure 22.3.3 Length distribution from Icelandic landings of deep pelagic *S. mentella* 1994–2019. No data was available in 2020 as Iceland did not participate in the survey.

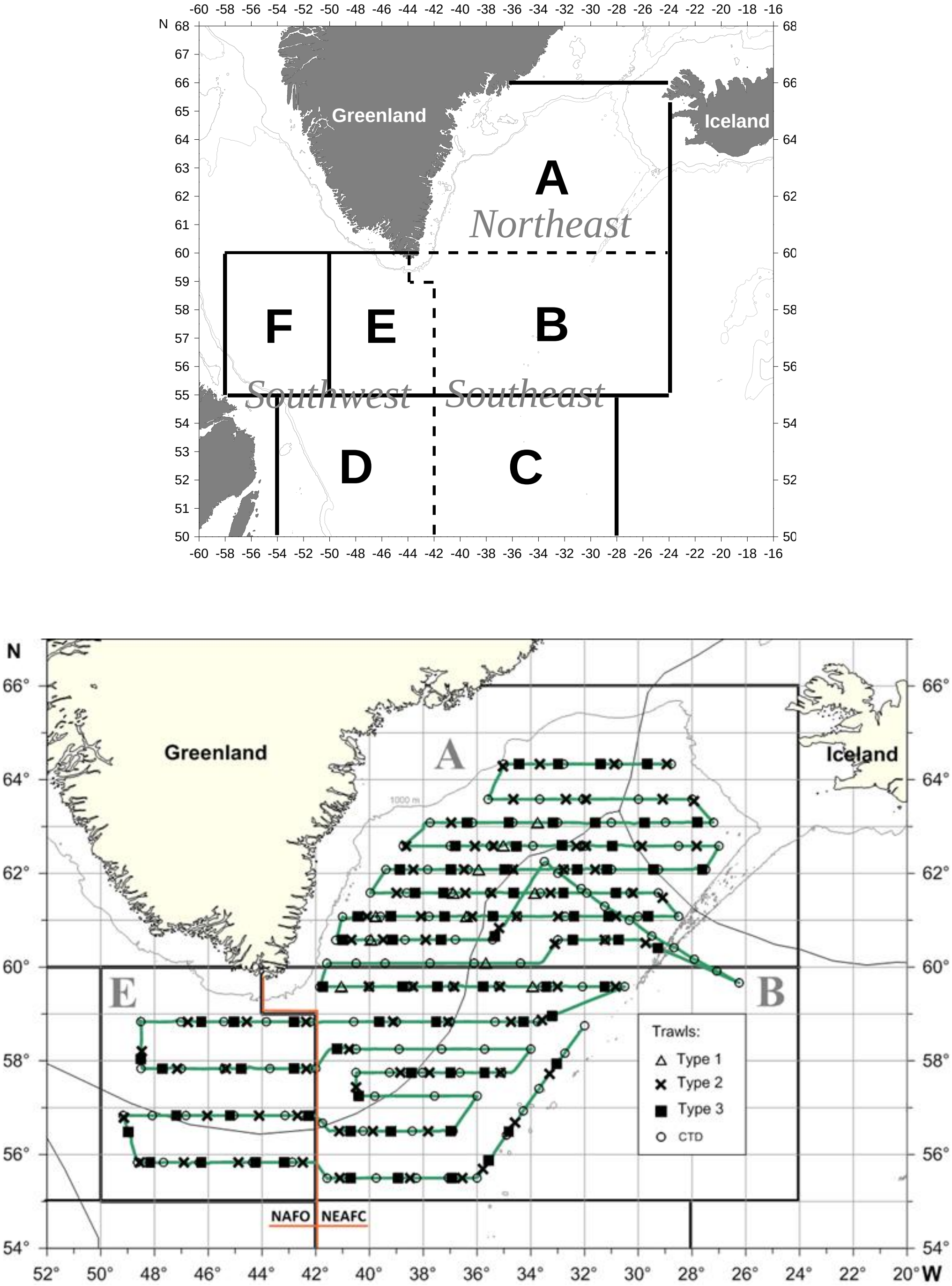

Figure 22.6.1 Upper: Subareas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines). Lower: Cruise tracks and stations taken in the joint international redfish survey in June–August 2021. The areas A, B and E were surveyed.

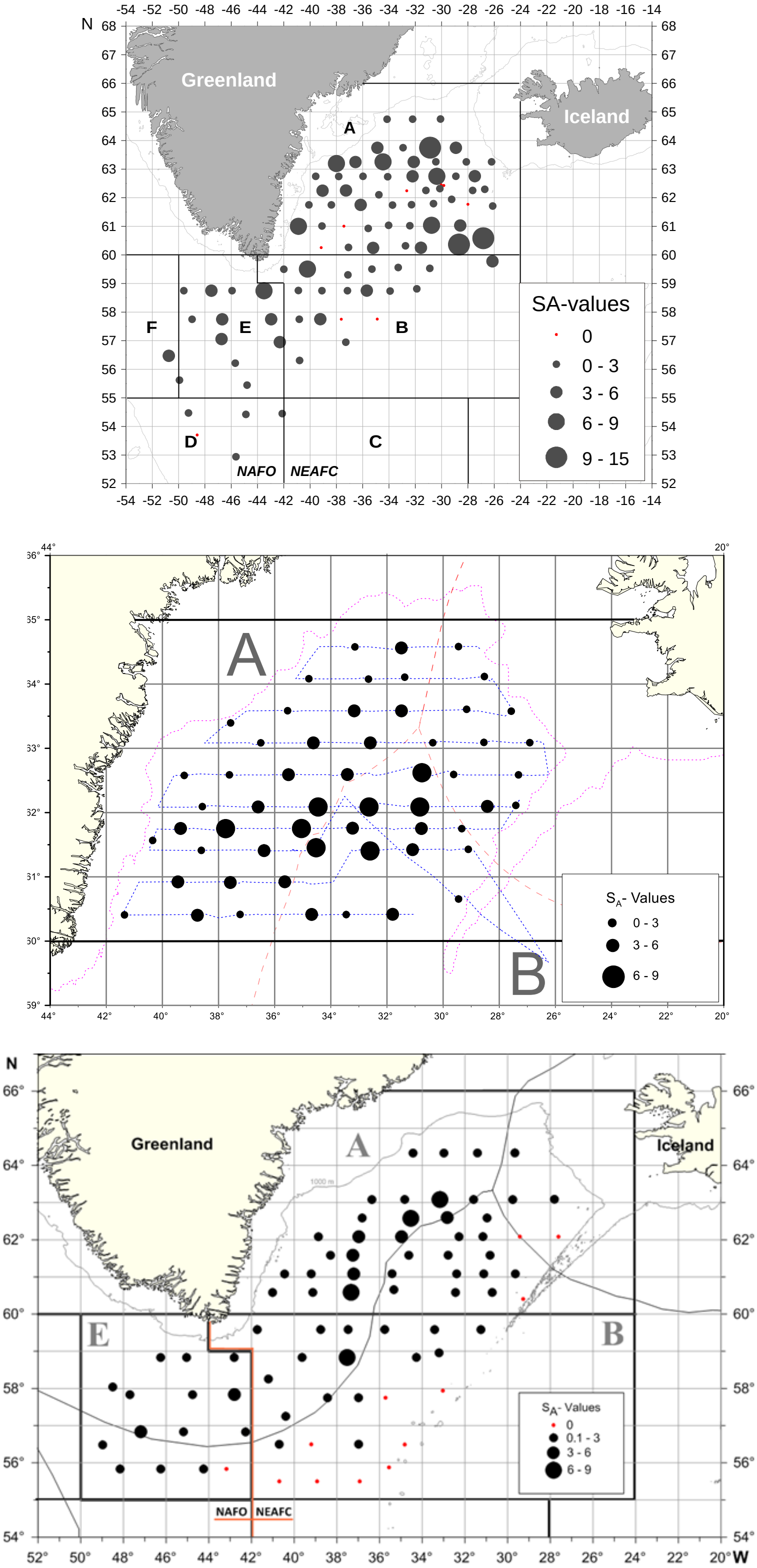

Figure 22.6.2. Redfish trawl estimates deeper than 500 m (type 3 trawls). sA values calculated by the trawl method (see WGRS Report, 2013) during the joint international redfish survey in June/July 2013 (top), June/July 2018 (middle) and June–August 2021 (bottom).

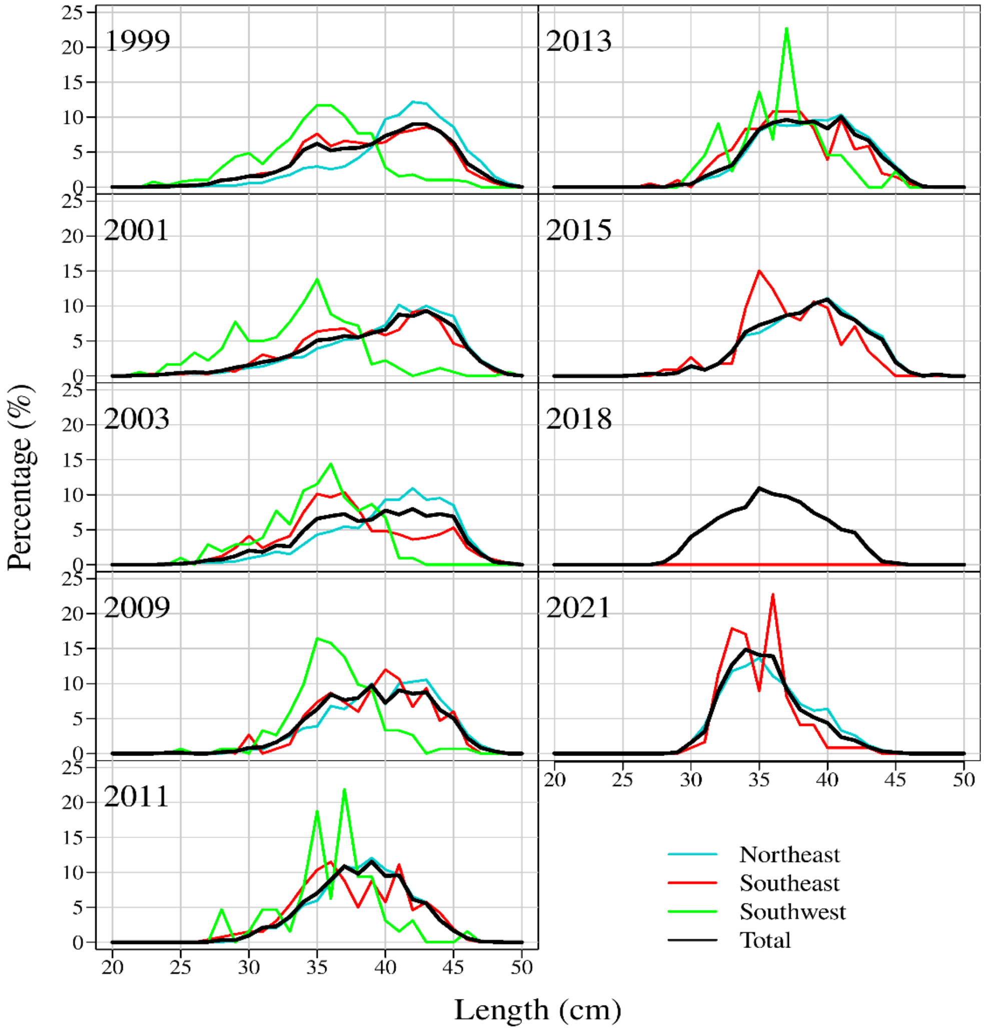

Figure 22.6.3 Length distribution of redfish by geographical areas (see Figure 22.6.1) and total, from fish caught deeper than 500 m 1999–2003 and 2009–2021 (in 2018, the survey only covered the northeast area).

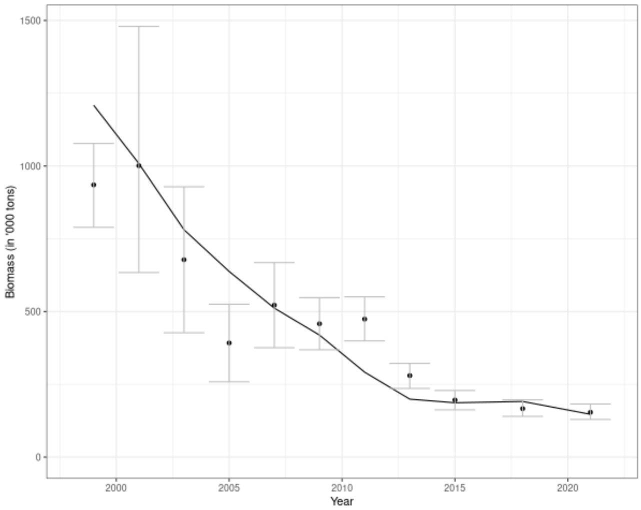

Figure 22.7.1. Deep-pelagic redfish in the Irminger Sea. Biomass index from the international redfish survey in the Irminger sea. Black line is the estimated trajectory from the stock assessment model, dots the observed values and error bars the 95% confidence interval for the observed values.

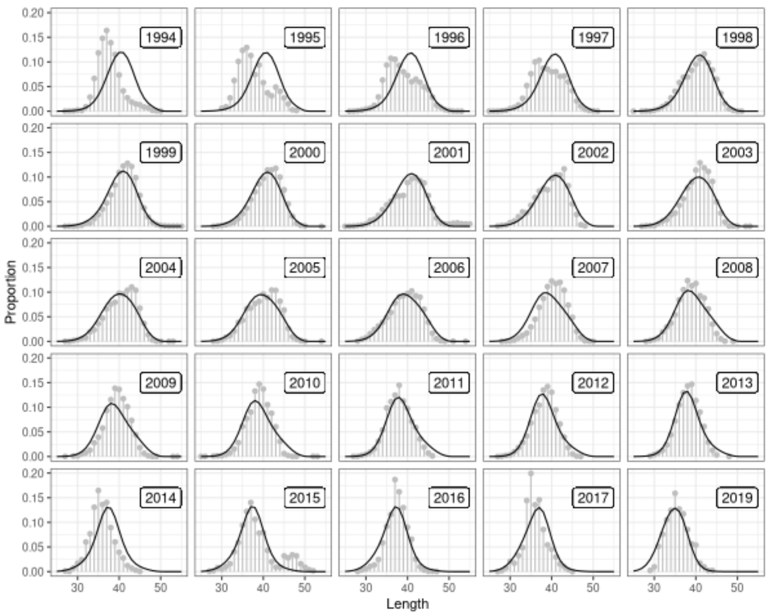

Figure 22.7.2. Deep-pelagic redfish in the Irminger Sea. Length distribution (proportions at length) from commercial redfish samples in the 2nd quarter, the fit to other quarters is omitted for brevity. Grey bars denote the observed values and solid black lines the predictions by the base model.

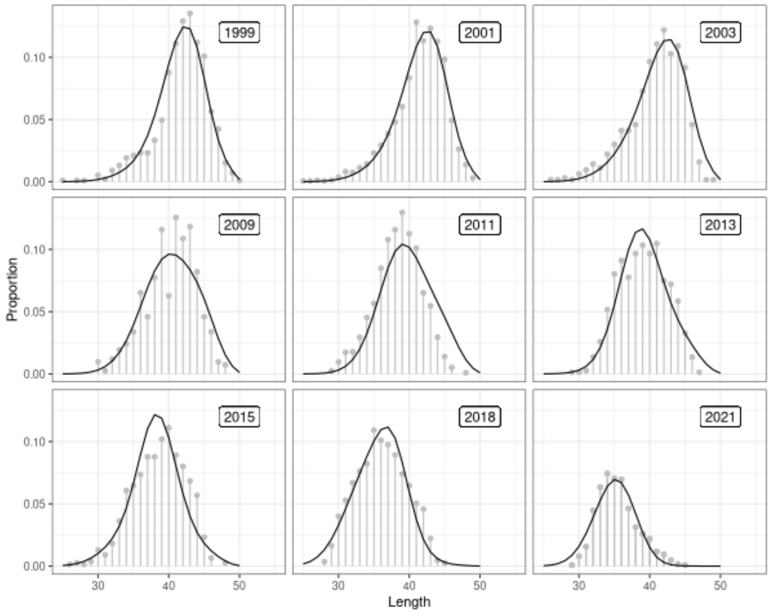

Figure 22.7.3. Deep-pelagic redfish in the Irminger sea. Length distributions (proportions at length) from the international redfish survey (ITAS). Grey bars denote the observed values and solid black lines the predictions by the base model.

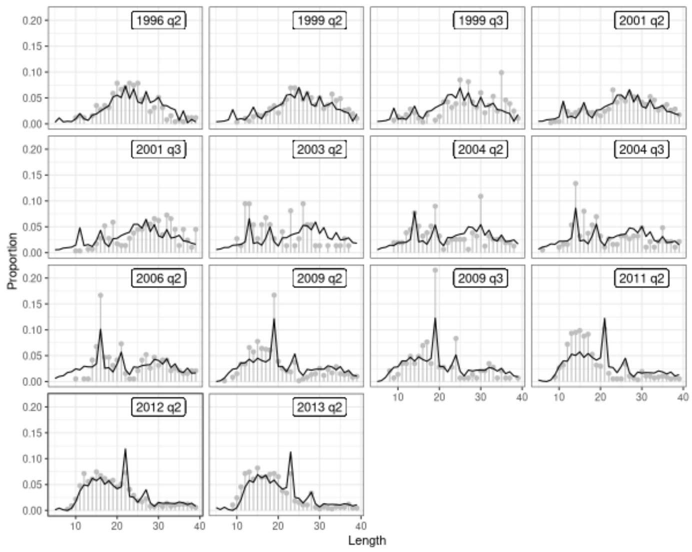

Figure 22.7.4. Deep-pelagic redfish in Irminger sea. Age distribution (proportions at age) from commercial redfish samples split by year and quarter. Grey bars denote the observed values and solid black lines the predictions by the base model.

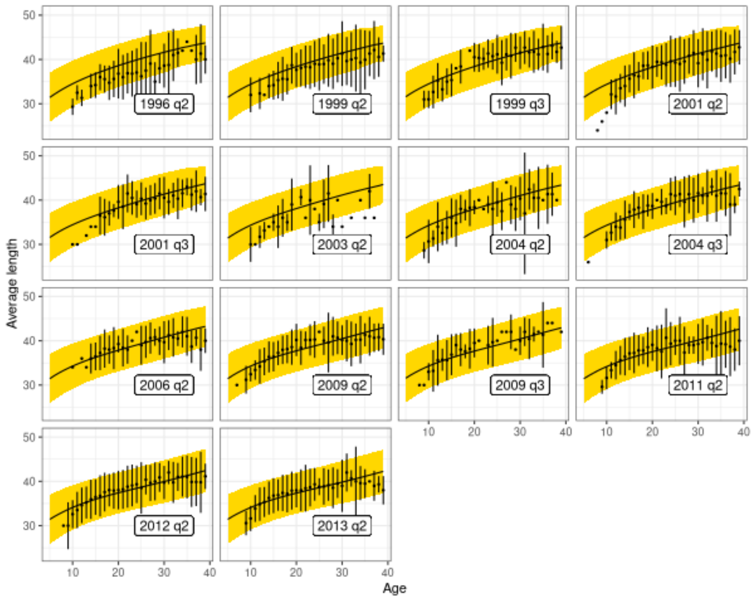

Figure 22.7.5. Deep-pelagic redfish in the Irminger Sea. Mean length-at-age by year and quarter from commercial catches. Black dots represent observed mean values, vertical bars 95% confidence range for the observations (where possible), solid line fitted mean and yellow ribbon the predicted 95% confidence limit.

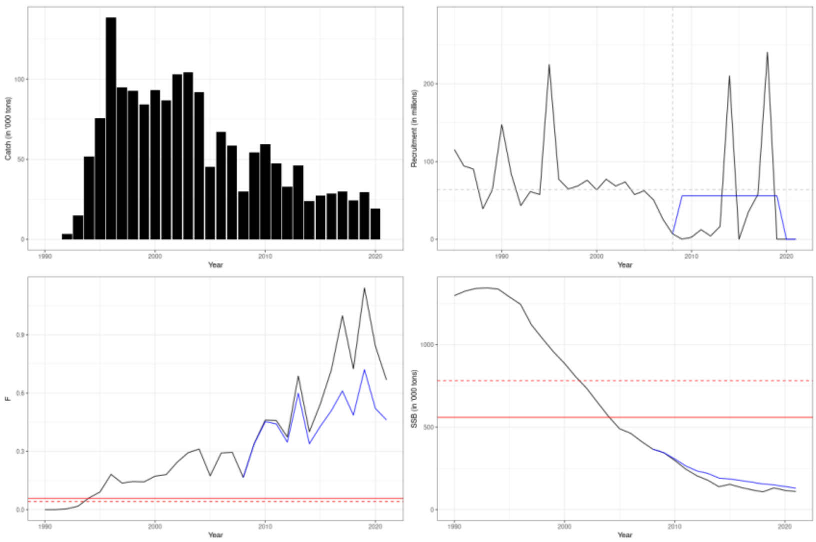

Figure 22.7.6: Summary of stock assessment agreed by WKDEEPRED, see Table 5.2.2 for a tabulation of results (to be presented as a Category 2 assessment, i.e., with Recruitment, F and SSB on relative, rather than absolute, scale). Recruitment after 2008 is not considered to be reliably estimated and has been replaced by the geometric mean of the estimated recruitment during 1985–2008 (blue line). SSB and F values after 2006 were recalculated accordingly, to match the observed catches in those years.

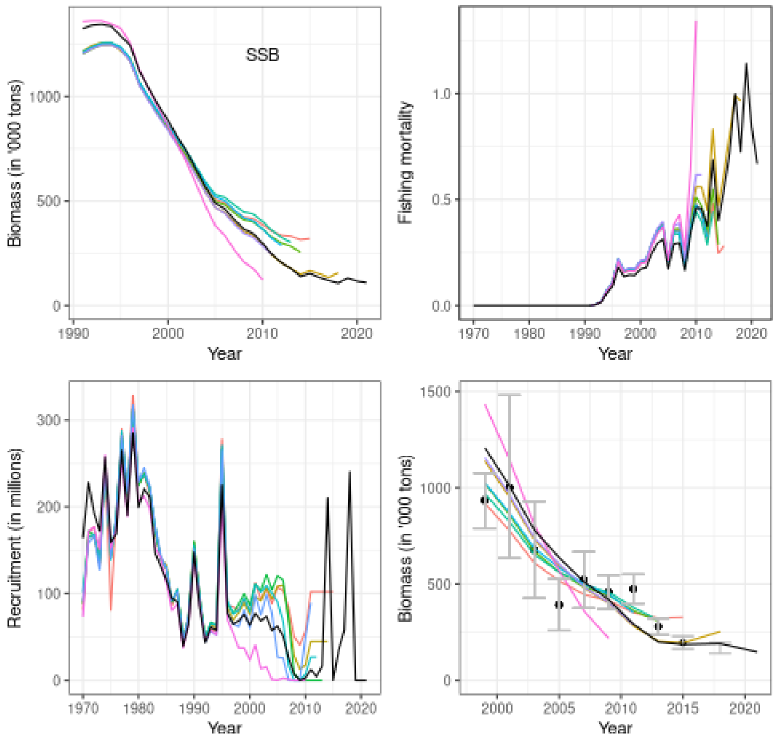

Figure 22.7.7: Deep-pelagic redfish in the Irminger Sea. Analytical retrospective estimates, for the last 10 years, of spawning-stock biomass, recruitment (age 5), fishing mortality (apical), and the fit the biomass index.