# 20 Icelandic slope *Sebastes mentella* in 5.a and 14

## 20.1 Stock description and management units

The stock structure of *Sebastes mentella* in the Irminger Sea and adjacent water is described in Chapter 18 and Stock Annex (smn-con SA). The *S. mentella* on the continental shelf and slope of Iceland (the Iceland Sea ecoregion, which is defined to be within the Icelandic 200 NM EEZ and includes 5.a and part of Subarea 14; see figure 20.1.1) is treated as separate biological stock and management unit. Only the fishable stock (mainly fish larger than 30 cm) of Icelandic slope *S. mentella* is found in Iceland Sea ecoregion. The East Greenland shelf is most likely a common nursery area for the three biological stocks described in Chapter 18, including the Icelandic slope one.

## 20.2 Scientific data

The Icelandic autumn survey (IS-SMH) on the continental shelf and slope in Icelandic waters covers depths down to 1500 m. Data for Icelandic slope *S. mentella* is available from 2000–2020. No survey was conducted in 2011. A description of the autumn survey is given in Stock Annex (smn-con SA).

The total biomass and abundance indices were highest in 2000 and 2001, declined in 2002 and have been at that level since then (Table 20.2.1 and Figure 20.2.1). The biomass index of fish 45 cm and larger shows different trend where the index increased from the lowest value in 2007 to a high level in 2015 and has since then fluctuated without clear trend (Figure 20.2.1). The abundance index of fish 30 cm and smaller (recruits) has been at very low level since 2007 (Figure 20.2.1).

The length of the Icelandic slope *S. mentella* in the autumn survey is between 25 cm and more than 50 cm. Since 2000, the mode of the length distribution has shifted to the right or from 36-39 cm in 2000 to about 42-45 cm in 2012-2020 (Figure 20.2.2). Much less fish smaller than 35 cm was observed in the surveys after 2010 compared to previous years.

Otoliths from the autumn survey have been sampled since 2000 and otoliths from the 2000, 2006, 2009, 2010 and 2017-2019 surveys have been age read (Figure 20.2.3). The age reading shows that the stock consists of many cohorts and the age ranges from 5 to over 50 years. The 1985 and 1990 cohorts were large and were still relatively strong in the 2019 survey. In the 2017-2019 surveys the 2003-2004 cohorts (seen as 15- and 16-years old fish) were most abundant.

## 20.3 Information from the fishing industry

### 20.3.1 Landings

Total annual landings of Icelandic slope *S. mentella* from the Icelandic Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1950–2020 are presented in Table 20.3.1 and Figure 20.3.1.

During the 1950-1977 period, before the extension of the Icelandic EEZ to 200 NM, Icelandic slope *S. mentella* was mainly fished by West-Germany. The catches peaked in 1953 to about 87 000 t but gradually decreased to about 23 000 t in 1977. After the extension of the Icelandic EEZ in 1978 the fishery has almost exclusively been conducted by Icelandic vessels. Annual landings gradually decreased from 57 000 t in 1994 to 17 000 t in 2001. Landings in 2001-2010 fluctuated between 17 000 and 20 500 t except in 2003 and 2008 when annual landings were 28 500 and 24 000 t, respectively. Annual landings in 2011-2020 were between 8300 and 12 000 t. The total catch in 2020 were 11 375 t.

## 20.3.2 Fisheries and fleets

The fishery for Icelandic slope *S. mentella* in Icelandic waters is a directed bottom trawl fishery along the shelf and slope west, southwest, and southeast of Iceland at depths between 500 and 800 m (Figure 20.3.2). The proportion of Icelandic slope *S. mentella* catches taken by pelagic trawls 1991-2000 varied between 10 and 44% of the total landings (Table 20.3.2). In 2001-2020, no pelagic fishery occurred, or it was negligible except in 2003 and 2007 (see Stock Annex).

## 20.3.3 Sampling from the commercial fishery

The table below shows the 2020 biological sampling from the catch and landings of Icelandic slope *S. mentella* in Icelandic waters. Number of samples and hence, number of fish length measured, have decreased in recent years. The reason is reduced sampling effort of onboard observers from the Directorate of Fisheries, but the Covid-19 in 2020 also played part in decreased sampling effort.

Otoliths from the commercial catch have been collected, but no systematic age reading is done.

| Division/ Subarea | Nation | Gear | Landings (t) | No. samples | No. length measured |
|---|---|---|---|---|---|
| 5.a/14 | Iceland | Bottom trawl | 11 375 | 27 | 5 408 |

## 20.3.4 Length distribution from the commercial catch

Length distributions of Icelandic slope *S. mentella* from the bottom trawl fishery show an increase in the number of small fish in the catch in 1994 compared to previous years (Figure 20.3.3). The peak of about 32 cm in 1994 can be followed by approximately 1 cm annual growth in 1996—2002. The fish caught in 2004—2020 peaked around 39—42 cm. The length distribution of Icelandic slope *S. mentella* from the pelagic fishery, where available, showed that in most years the fish was on average bigger than taken in the bottom trawl fishery (Figure 20.3.3).

## 20.3.5 Catch per unit effort

Trends in non-standardized CPUE (kg/hour) and effort (thousand hours fished) are shown in Figure 20.3.4. The figure shows CPUE and effort in all bottom trawl tows where of Icelandic slope *S. mentella* was caught and were more than 50% and 80% of individual tows. CPUE of tows where more than 50% and 80% gradually decreased from 1978 to a record low in 1994. Since then, CPUE has been steadily increasing and was in 2020 highest level in the time series. From 1991 to 1994, when CPUE decreased, the fishing effort increased drastically. Since then, effort has decreased and is now at similar level as in 1980.

## 20.3.6 Discard

Although no direct measurements are available on discards, it is believed that there are no significant discards of Icelandic slope *S. mentella* in the Icelandic redfish fishery.

## 20.4 Management

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

The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including allocation of the TAC for each of the stocks subject to such limitations. Redfish (golden redfish (Chapter 19) and Icelandic slope *S. mentella*) has been within the ITQ system from the beginning. Icelandic authorities gave, however, until the 2010/2011 fishing year a joint quota for these two species, and Icelandic fishermen were not required to divide the redfish catch into species. MFRI has since 1994 provided a separate advice for the species. The separation of quotas was implemented in the fishing year that started September 1, 2010.

## 20.5 Methods

No analytical assessment was conducted on this stock.

## 20.6 Reference points

There are no reference points defined for the stock.

## 20.7 State of the stock

The Group concludes that the state of the stock is on a low level. With the information at hand, current exploitation rates cannot be evaluated for the Icelandic slope *S. mentella* in Icelandic waters.

The fishable biomass index of Icelandic slope *S. mentella* from the Icelandic autumn survey shows that the biomass index in the 2004-2020 period has been at the same level.

CPUE indices show a reduction from highs in the late 1980s, but there is an indication that the stock has started a slow recovery since the middle of 1990s, when CPUE was close to 50% of the maximum. The CPUE index gradually increased from 1995–2020 to the highest level in the time series. It is, however, not known to what extent CPUE series reflect change in stock status of Icelandic slope *S. mentella*. The nature of the redfish fishery is targeting schools of fish using advancing technology. The effect of technological advances is to increase CPUE but is unlikely to reflect biomass increase.

In 2000–2008, good recruitment was observed in the German survey on the East Greenland shelf (growth of about 2 cm/yr) which is assumed to contribute to both the Icelandic slope and pelagic stock at unknown shares. The German survey and the Greenland shrimp and fish shallow water survey both show no new recruits (>18 cm), and no juveniles are present (<18 cm). This suggests that the fishery in coming years will be based on the same cohorts.

## 20.8 Management considerations

*S. mentella* is a slow growing, late maturing deep-sea species and is therefore considered vulnerable to overexploitation and advice must be conservative.

The advice is given by calendar year, though the fishing year runs from 1 September to 31 August of the following year.

## 20.9 Basis for advice

Icelandic slope *S. mentella* is considered a data limited stock (DLS) and follows the ICES framework for such (Category 3.2; ICES 2012). Below is the description of the formulation of the advice.

Based on the North Western Working Group recommendation, the stock is treated as a stock with survey data, but no proxies for MSY $B_{trigger}$ or F values are known. The IS-SMH survey index was used as an indicator of stock development. The advice is based on a comparison of the two latest index values with the three preceding values, combined with the latest catch advice This means that the catch advice is based on the survey adjusted status quo catch equation:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

where *I* is the survey index, *x* is the number of years in the survey average, z > x, and $C_{y-1}$ is the advice last year. In this case, x = 2, which is the average of the two latest index values, and *z* = 5 the total number of survey values.

## 20.10 Regulation and their effects

There are no explicit management for Icelandic slope *S. mentella*. The species is managed under the ITQ system. A general description of management and regulation of fish populations in Icelandic waters is given in the stock annex for the stock (smn-con SA) with emphasis on Icelandic slope *S. mentella* where applicable.

Icelandic authorities gave until the 2010/2011 fishing year a joint quota for golden redfish (*S. norvegicus*) and Icelandic slope *S. mentella*. The separation of quotas was implemented in the fishing year that started September 1, 2010.

## 20.11 Benchmark in 2022

The stock will be benchmarked in early 2022. The aim of the benchmark is to apply an analytical assessment model (Gadget) and move the stock from category 3 to category 1. Furthermore, the aim is to define reference points for the stock. In Chapter 20.12, an exploratory analytical assessment model (Gadget) is presented. Below is a table indicating issues that will be discussed during the benchmark meeting.

| Issue | Problem/Aim | Work needed / possible direction of solution | Data needed to be able to do this: are these available / where should these come from? | Responsible expert from WG | External expertise needed at benchmark type of expertise / proposed names |
|---|---|---|---|---|---|
| (New) data to be Considered and/or quantified | Underutilised data from the area. | Collection of relevant survey data and commercial samples | These data sets are available | Kristján Kristinsson | |
| | | | | | |
| Tuning series | One survey, the Icelandic autumn survey. | | Survey data 2000-2020 is available. | Kristján Kristinsson | |
| Bycatch/misreporting | | | | | |
| Biological Parameters | Ageing/growth: Ageing from the autumn survey is done systematically. Age disaggregated data is now available for 7 years. This will allow use of length/agebased assessment model (Gadget). | Continuation of ageing. | Otoliths are available from the autumn survey 2000-2020. | Kristján Kristinsson | |
| | Stock ID; The stock structure of beaked redfish is complicated. The stock/fishery of this stock is covering the Icelandic Waters Ecoregion where only adult population is found. Information suggest that recruitment comes coming from East Greenland. Furthermore, there is indication of two different ecotypes of beaked redfish co-occurring in the area (slope and deep pelagic). | Continue genetic studies. | Initiatives are being taken by several institutes and collaboration is ongoing. Expected results in 2021. | Kristján Kristinsson | |
| Fisheries & ecosystem issues and data | Low recruitment in recent years | | | | |
| Assessment method | No analytical assessment model. Currently, the stock is a category 3 stock, where assessment is based on survey trends. A length/age based model (Gadget) has been under development in order to utilize more biological information. | 1) Continuation of the ageing programme. 2) Analysis of growth from age data. 3) Explore assessment models which includes data of different ecotypes and from different areas (inclusion of data | All data which are available. Age data for some years from the Icelandic autumn survey is now available. | Kristján Kristinsson Bjarki Elvarsson | |

| Issue | Problem/Aim | Work needed / possible direction of solution | Data needed to be able to do this: are these available / where should these come from? | Responsible expert from WG | External expertise needed at benchmark type of expertise / proposed names |
|---|---|---|---|---|---|
| | | from East Greenland and the deep pelagic beaked redfish stock in the Irminger Sea). | | | |
| Biological Reference Points | No biological reference points defined | Should be defined in accordance with a new model approach | | Kristján Kristinsson<br>Bjarki Elvarsson | |
| Other | | | | | |

## 20.12 Exploratory analytical assessment with Gadget

No analytical assessment is conducted on this stock. In this chapter, preliminary run and analysis of a Gadget model is presented. The purpose is to explore assessment methods as a potential category 1 assessment. Current assessment (based on survey trends) is not considered to capture true state of the stock.

Model settings and results from a run that was done in 2020 are presented.

### 20.12.1 Data used and model settings

Beaked redfish is a long-lived species, and the maximum age is set at 50 years as a plus group. Simulation begins in 1970, but the fishery started in 1950. No biological data are available prior to 1970. The immature stock matures at age 20 at the latest. Recruitment to the immature stock component occurs at age 3. The length range in the model ranged between 10 and 55 cm (with no mature individual <18 cm). An overview of the data sets and model parameters used in the model study is shown in Table 20.12.1.

Below is a brief description of the data used in the model and model settings is given.

**Model settings:**

- The simulation period is from 1970 to 2024 using data until the end of 2019 for estimation.
- Four time-steps (3-month period) are used each year.
- The ages used were 3 to 50 years, where the oldest age is treated as a plus group (fish 50 years and older).
- Modelled length ranged between 10-60 cm.
- The length increments in the survey were 10-20 cm, 21-25 cm, 26-30 cm … 41-45 cm and 46-55 cm. The survey vas not conducted in 2011.
- One commercial fleet (bottom trawl). Survey catch distribution data are modelled as a separate fleet.
- Recruitment was set at age 3.

**List of parameters in the Gadget model:**

- Natural mortality, $M_a$, fixed at 0.05 for all ages. The value chosen was based on settings in other redfish stocks.
- Length-based Von Bertalanffy growth function, $k$, $L_\infty$, informed by age–length frequencies.
- Parameter $\beta$ of the beta-binomial distribution controlling the spread of the length distribution.
- Logistic fleet selection, $b_f$, $l_{50,f}$ ; one set for each of the fleets (Autumn survey or Commercial).
- Initial abundance at ages 3-50 in 1970 by $\eta_{sa}$ and $a \in (3, 50^+)$. $\sigma_a^2$, i.e. variance in initial length at age $a$ was fixed and based on length distributions obtained in the autumn survey. Initial lengths at age were defined based on the growth function.
- Initial guess of the logistic maturity ogive, $\lambda$, $l_{50}$, was estimated from survey data.
- Length at recruitment, $l_0$, $\sigma_0$: mean length (at age 3) and std. deviation in length at recruitment.
- Number of recruits by year, $R_y$, and y $\in$ (1970, 2019).
- Length-weight relationship $\mu_s$, $\omega_s$, were fixed based on the means of log-linear regression of survey data.
- Scalars, $R_c$, $I_{c,s}$, $F_0$ : recruitment scalar (multiplied against all $R_y$ to help optimization), initial numbers at age scalars (by stock $s$, multiplied against all $\eta_{sa}$ to help optimization) and

initial fishing mortality (applied to all age groups and all years, steepens initial numbers at age distribution to reflect previous effects of fishing).

## 20.12.2 Diagnostics

Survey indices can be variable for Icelandic slope beaked redfish due to its tendency to be influenced by a few very large hauls. The index data used as input here are the total raw numbers of fish caught (within length slices) in the entire autumn survey. Although they are expected to represent the entire stock, they are also expected to be highly variable because no treatment or data pre-processing has been performed to reduce this variability. This variability is reflected in the model's fit to the survey index data (Figure 20.12.1). In general, the model appears to follow the stock trends historically except for the 25-30 cm and 30-35 cm length groups. In these length groups model underestimates the first three years. Furthermore, the terminal estimate is not seen to deviate substantially from the observed value for most length groups, except for the largest one, 45-55 cm, with model overestimating the abundance.

Model fits to the age-length distribution data from the autumn survey show that the fit is not particularly good for the oldest ages (30+) where the model underestimates these ages (Figure 20.12.2). Furthermore, the model overestimates certain age classes which can be followed through years, first in 2009 as 12-19 years old fish and then again in 2017 and 2018 as 20–28 year old fish.

The main portions of the length distributions appear to have a reasonable fit (Figure 20.12.3). In some years, the overall fit to the predicted proportional length distributions in the survey is smaller to the observed for fish with the greatest density within the fished population (ca. 40-45 cm fish).

Length distributions from the commercial catch does usually show good fit (Figure 20.12.5) the fit between predicted and observed age distributions is much worse and could be related to few age readings in each time step (Figures 20.12.4).

Residual plots generally show the same trends in fits to the length data of the commercial and survey data with an underestimation of the smallest fish (roughly < 20 cm), good estimation of the sizes contributing most to the exploitable fishery (roughly 30-50 cm), and an underestimation of the largest fish (roughly >50 cm (Figures 20.12.6 and 20.12.7). Because inter-age and inter-length correlations are not included in Gadget, some blocks of similar residuals can be seen, and are more pronounced in the length bubble plot because of its finer resolution.

## 20.12.3 Retrospective plots

In Figure 20.12.8, the results of an analytical retrospective analysis are presented. The analysis indicates that there was an upward revision of biomass over the first 4 years of the 5-year peel followed by a downward revision of biomass (SSB) over the last year, and subsequently a downward then upward revision of F. Estimates of recruitment are all over the place in the beginning but are since 2000 decently stable for the first 4 years of the 5-year peel. The last year is though strange.

Growth patterns predicted by the model does not follow closely to the data of fish 10 years old and younger (Figure 20.12.9).

## 20.12.4 Model results

Summary of the assessment is shown in Figure 20.12.10. The spawning stock has since 1990 decreased and has since 2010 been below $B_{lim}$ (defined as the median SSB for 2000-2005). The total biomass has also decreased and is now at similar level as the SSB indicating very few immature fish in the stock. Fishing mortality has decreased substantially from highest level in the late 1990s. Fishing mortality were relatively stable around $F_{lim}$ in 2013-2019, but above $F_{MSY}$. Recruitment after 2010 is record low for the time series.

The relationship between spawning stock and recruitment at age 3 is shown, with a minimum spawning stock biomass in 2019 (Figure 20.12.11). Spawning stock biomass has decreased since the 1990 with correspondent decrease in recruitment.

## 20.12.5 Reference points

From the Gadget model it is possible to define reference points for this stock (Table 20.12.2 and Figure 20.12.13).

Stochastic simulations show that the $F_{MSY}$ = 0.06. $B_{lim}$ = 169 200 t is defined as the median of SSB in 2000-2005 when the stock was stable at low levels. $B_{pa}$ was defined as 236 880 t by adding precautionary buffer to the proposed $B_{lim}$ * 1.4 (approximation of 169000*exp(0.2*1.645). The plot of the average spawning stock against fishing mortality show that $F_{lim}$ = 0.08 and $F_{pa}$ is then 0.08/exp(1.645*0.2) = 0.058 (Figure 20.12.13)

# 20.13 References

ICES. 2012. Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68.

**Table 20.2.1 Total biomass index of Icelandic slope *S. mentella* in the Icelandic Autumn Groundfish survey 2000–2020. No survey was conducted in 2011.**

| Year | Biomass | lower 5th percentile | upper 95th percentile |
|---|---|---|---|
| 2000 | 135,994 | 96,811 | 175,176 |
| 2001 | 161,733 | 104,040 | 219,427 |
| 2002 | 95,059 | 68,975 | 121,143 |
| 2003 | 63,188 | 47,459 | 78,916 |
| 2004 | 96,465 | 64,134 | 128,797 |
| 2005 | 109,196 | 55,690 | 162,702 |
| 2006 | 123,018 | 82,993 | 163,043 |
| 2007 | 82,035 | 52,610 | 111,459 |
| 2008 | 80,011 | 57,899 | 102,123 |
| 2009 | 93,653 | 61,714 | 125,592 |
| 2010 | 77,800 | 54,317 | 101,283 |
| 2011 | 0 | 0 | 0 |
| 2012 | 74,604 | 53,402 | 95,806 |
| 2013 | 69,935 | 48,552 | 91,319 |
| 2014 | 103,051 | 64,473 | 141,629 |
| 2015 | 107,423 | 70,788 | 144,059 |
| 2016 | 80,855 | 61,363 | 100,348 |
| 2017 | 125,611 | 83,265 | 167,957 |
| 2018 | 122,292 | 72,196 | 172,387 |
| 2019 | 85,157 | 61,456 | 108,858 |
| 2020 | 90,371 | 64,687 | 116,054 |

**Table 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* 1950–2020 from the Iceland Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ).**

| Year | Iceland | Others | Total |
|---|---|---|---|
| 1950 | 1 458 | 36 269 | 37 727 |
| 1951 | 1 944 | 45 825 | 47 769 |
| 1952 | 885 | 55 554 | 56 439 |
| 1953 | 658 | 86 011 | 86 669 |
| 1954 | 577 | 75 972 | 76 459 |
| 1955 | 654 | 52 784 | 53 438 |
| 1956 | 674 | 40 047 | 40 721 |
| 1957 | 558 | 35 993 | 36 551 |
| 1958 | 409 | 43 820 | 44 229 |
| 1959 | 398 | 40 175 | 40 573 |
| 1960 | 407 | 38 428 | 38 836 |
| 1961 | 307 | 31 534 | 31 841 |
| 1962 | 264 | 35 122 | 35 386 |
| 1963 | 456 | 38 338 | 38 794 |
| 1964 | 362 | 45 414 | 45 776 |
| 1965 | 473 | 55 930 | 56 403 |
| 1966 | 332 | 47 491 | 47 823 |
| 1967 | 357 | 47 313 | 47 670 |
| 1968 | 494 | 50 892 | 51 386 |
| 1969 | 486 | 38 358 | 39 345 |
| 1970 | 500 | 35 800 | 36 300 |
| 1971 | 495 | 34 376 | 34 871 |
| 1972 | 593 | 39 874 | 40 468 |
| 1973 | 794 | 35 251 | 36 045 |
| 1974 | 806 | 32 103 | 32 909 |
| 1975 | 1 404 | 29 301 | 30 705 |
| 1976 | 715 | 28 632 | 29 346 |
| 1977 | 590 | 22 427 | 23 018 |
| 1978 | 3 693 | 209 | 3 902 |
| 1979 | 7 448 | 246 | 7 694 |
| 1980 | 9 849 | 348 | 10 197 |
| 1981 | 19 242 | 447 | 19 689 |
| 1982 | 18 279 | 213 | 18 492 |
| 1983 | 36 585 | 530 | 37 115 |
| 1984 | 24 271 | 222 | 24 493 |
| 1985 | 24 580 | 188 | 24 768 |
| 1986 | 18 750 | 148 | 18 898 |
| 1987 | 19 132 | 161 | 19 293 |
| 1988 | 14 177 | 113 | 14 290 |

| Year | Iceland | Others | Total |
|---|---|---|---|
| 1989 | 40 013 | 256 | 40 269 |
| 1990 | 28 214 | 215 | 28 429 |
| 1991 | 47 378 | 273 | 47 651 |
| 1992 | 43 414 | 0 | 43 414 |
| 1993 | 51 221 | 0 | 51 221 |
| 1994 | 56 674 | 46 | 56 720 |
| 1995 | 48 479 | 229 | 48 708 |
| 1996 | 34 508 | 233 | 34 741 |
| 1997 | 37 876 | 0 | 37 876 |
| 1998 | 32 841 | 284 | 33 125 |
| 1999 | 27 475 | 1 115 | 28 590 |
| 2000 | 30 185 | 1 208 | 31 393 |
| 2001 | 15 415 | 1 815 | 17 230 |
| 2002 | 17 870 | 1 175 | 19 045 |
| 2003 | 26 295 | 2 183 | 28 478 |
| 2004 | 16 226 | 1 338 | 17 564 |
| 2005 | 19 109 | 1 454 | 20 563 |
| 2006 | 16 339 | 869 | 17 208 |
| 2007 | 17 091 | 282 | 17 373 |
| 2008 | 24 123 | 0 | 24 123 |
| 2009 | 19 430 | 0 | 19 430 |
| 2010 | 17 642 | 0 | 17 642 |
| 2011 | 11 738 | 0 | 11 738 |
| 2012 | 11 965 | 0 | 11 965 |
| 2013 | 8 761 | 0 | 8 761 |
| 2014 | 9 500 | 0 | 9 500 |
| 2015 | 9 311 | 0 | 9 311 |
| 2016 | 9 536 | 0 | 9 536 |
| 2017 | 8 371 | 0 | 8 371 |
| 2018 | 9 995 | 0 | 9 995 |
| 2019 | 8 716 | 0 | 8 716 |
| 2020[1)] | 11 375 | 0 | 11 375 |

**1) Provisional**

**Table 20.3.2 Proportion of the landings of Icelandic slope *S. mentella* taken in the Iceland Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) by pelagic and bottom trawls 1991–2020.**

| Year | Pelagic trawl | Bottom trawl |
|---|---|---|
| 1991 | 22% | 78% |
| 1992 | 27% | 73% |
| 1993 | 32% | 68% |
| 1994 | 44% | 56% |
| 1995 | 36% | 64% |
| 1996 | 31% | 69% |
| 1997 | 11% | 89% |
| 1998 | 37% | 63% |
| 1999 | 10% | 90% |
| 2000 | 24% | 76% |
| 2001 | 3% | 97% |
| 2002 | 3% | 97% |
| 2003 | 28% | 72% |
| 2004 | 0% | 100% |
| 2005 | 0% | 100% |
| 2006 | 0% | 100% |
| 2007 | 17% | 83% |
| 2008-2020 | 0% | 100% |

**Table 20.12.1: Overview of the likelihood data used in the model. Survey indices are calculated from the length distributions and are disaggregated (sliced) into seven groups. Number of data-points refer to aggregated data used as inputs in the Gadget model and represent the original dataset. All data obtained from the Marine and Freshwater Research Institute, Iceland.**

| Component name | Qarters | Year range | N | Delta 1 | Type |
|---|---|---|---|---|---|
| aldist.aut | 4 | 2000-2019 | | 1 cm | Age- length distribution |
| aldist.comm | All quarters | 1998-2018 | | 1 cm | Age- length distribution |
| ldist.aut | 4 | 2000-2019 | | 1 cm | Length distribution |
| ldist.comm | All quarters | 1976-2019 | | 1 cm | Length-distribution |
| matp.aut | 4 | 2000-2019 | | | Ratio of immature:mature by length group |
| si.10-20.aut | 4 | 2000-2019 | | 10-20 cm | Survey indices |
| si.20-25.aut | 4 | 2000-2019 | | 20-25 cm | Survey indices |
| si.25-30.aut | 4 | 2000-2019 | | 25-30 cm | Survey indices |
| si.30-35.aut | 4 | 2000-2019 | | 30-35 cm | Survey indices |
| si.35-40.aut | 4 | 2000-2019 | | 35-40 cm | Survey indices |
| si.40-45.aut | 4 | 2000-2019 | | 40-45 cm | Survey indices |
| si.45-55.aut | 4 | 2000-2019 | | 45-55 cm | Survey indices |

**Table 20.12.1: Reference points from stochastic simulations.**

| Framework | Reference points | Value | Technical basis |
|---|---|---|---|
| MSY approach | MSY $B_{trigger}$ | 236 880 t | $B_{pa}$ |
| | $HR_{MSY}$ | 0.06 | $F_{MSY}$ |
| | $F_{MSY}$ | 0.06 | Stochastic simulations. |
| Precautionary approach | $B_{lim}$ | 169 200 t | Median SSB for 2000-2005 |
| | $B_{pa}$ | 236 880 t | $B_{lim} * 1.4$ |
| | $HR_{lim}$ | 0.08 | $F_{lim}$ |
| | $F_{lim}$ | 0.08 | Equilibrium F that will maintain the stock above $B_{lim}$ with a 50% probability |
| | $F_{pa}$ | 0.058 | $F_{lim}$/exp(0.2*1.645) |
| | $HR_{pa}$ | 0.055 | $F_{pa}$ |

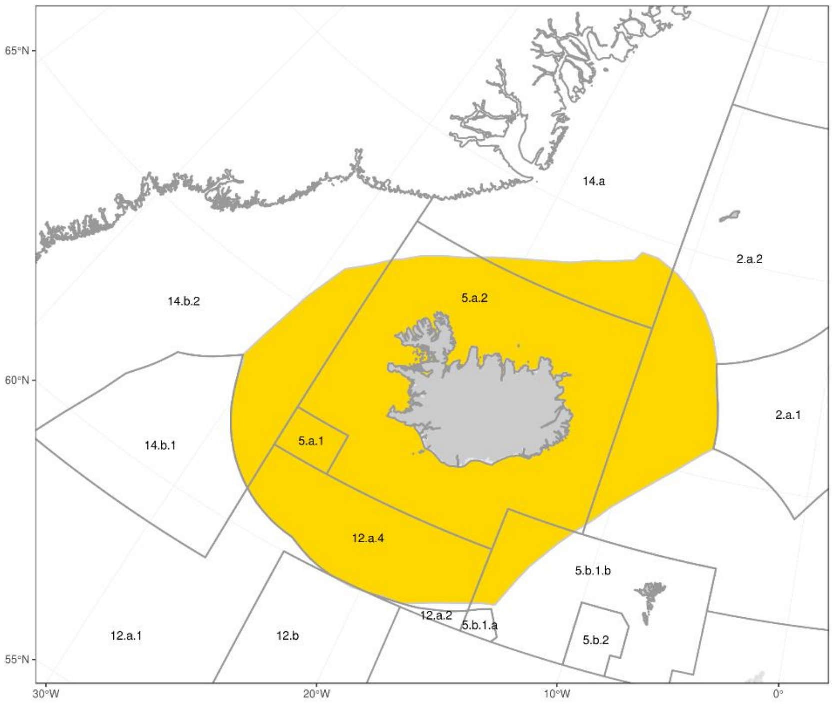


**Figure 20.1.1 The Iceland Sea ecoregion (in yellow) as defined by ICES. The relevant ICES statistical areas are shown.**

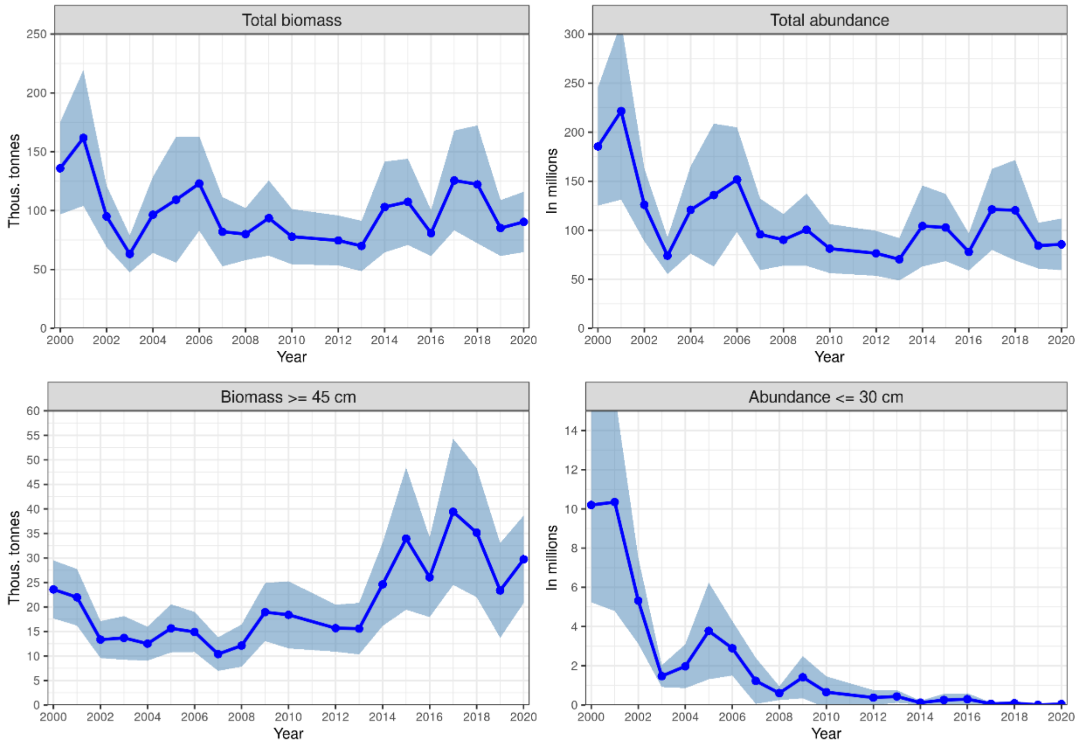


**Figure 20.2.1 Survey indices of the Icelandic slope *S. mentella* in the autumn survey in Icelandic waters (ICES Division 5.a and part of Subarea 14) 2000–2020. No survey was conducted in 2011. The figure shows the total biomass index, total abundance index in millions of fish, biomass index of fish 45 cm and larger and abundance index of fish 30 cm and smaller.**

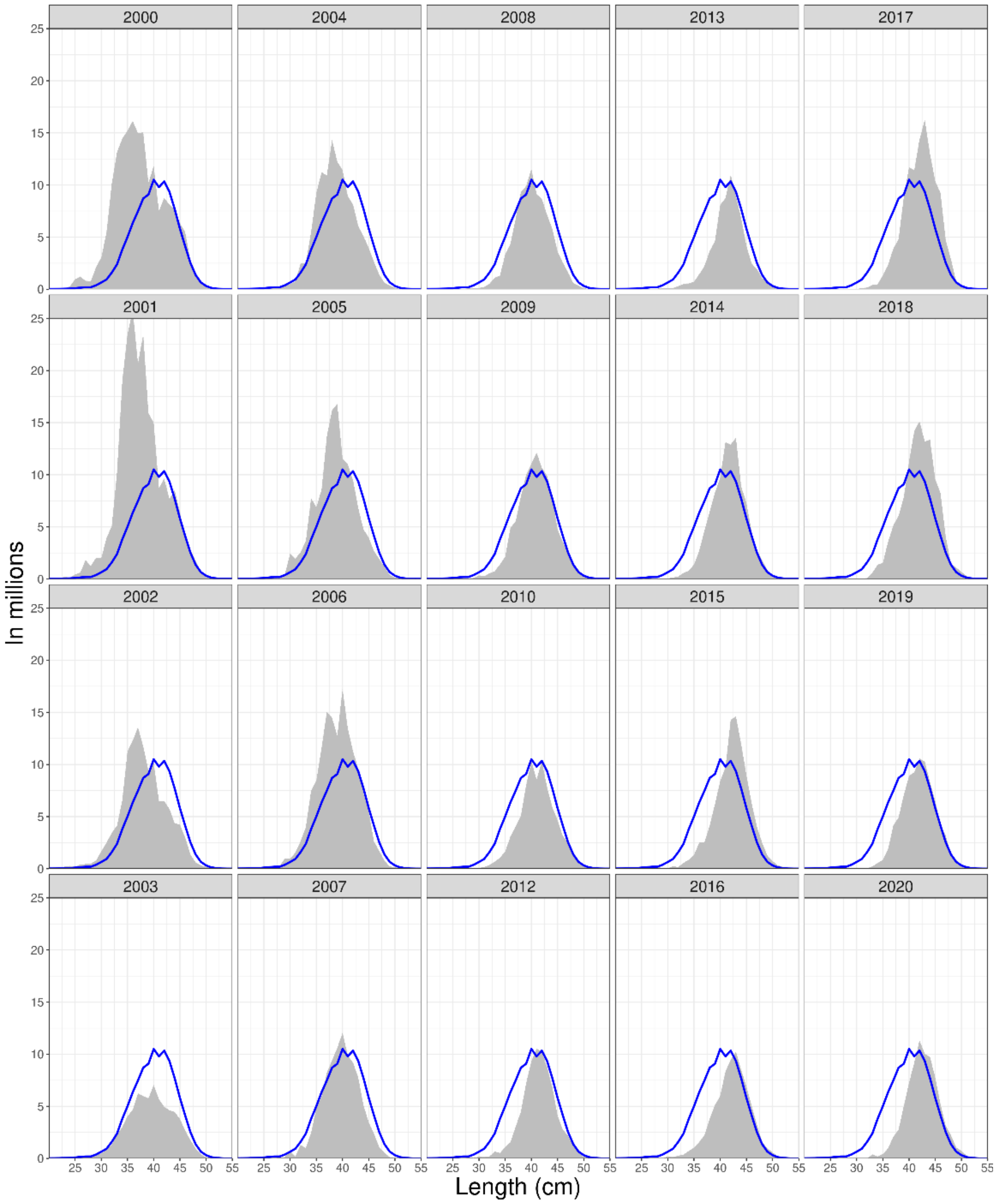


**Figure 20.2.2 Length distribution of Icelandic slope *S. mentella* in the Autumn Groundfish Survey in October 2001–2020 in Icelandic waters (ICES Division 5.a and part of Subarea 14). No survey was conducted in 2011. The blue line is the mean of 2000–2020.**

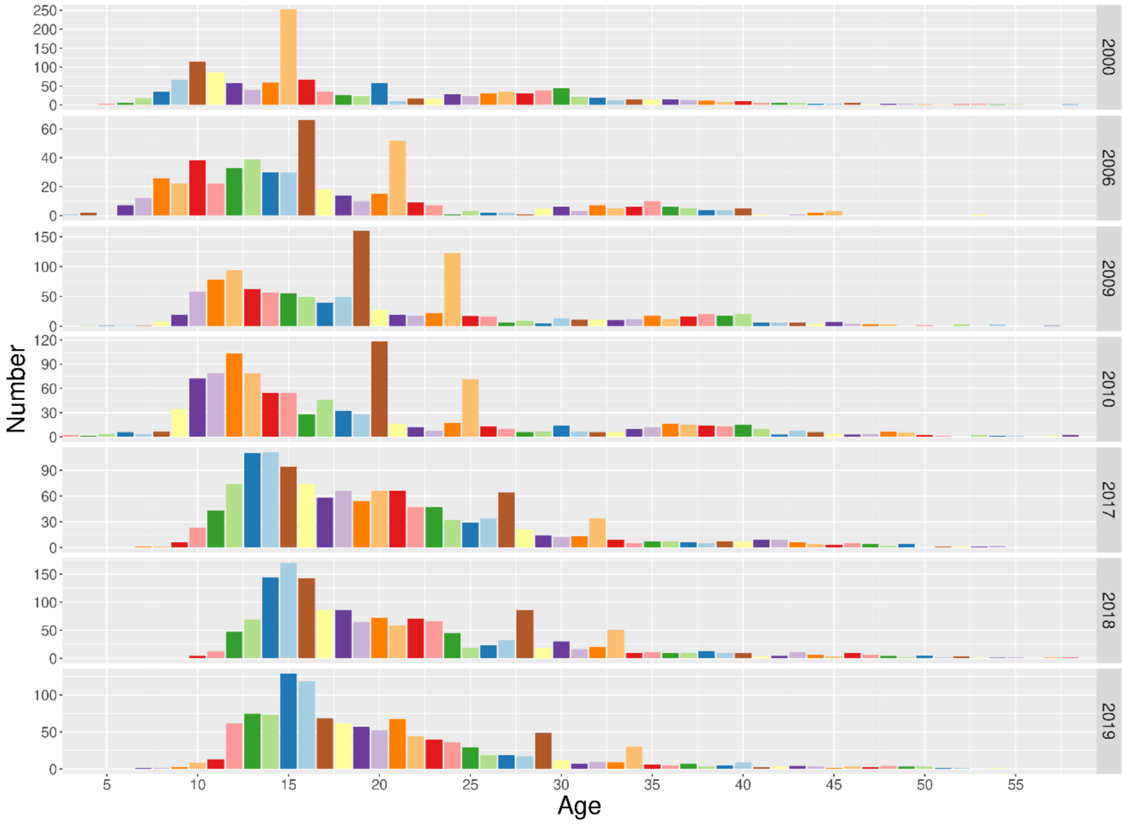


**Figure 20.2.3 Age distribution of Icelandic slope *S. mentella* from the Autumn Survey in 2000 (n = 1 405), 2006 (n = 536), 2009 (n = 1 205), 2010 (n = 1 099), 2017 (n = 1 298), 2018 (n = 1 568), and 2019 (n = 1 176). The age class 60 are the combined age-classes of 60 years and older.**

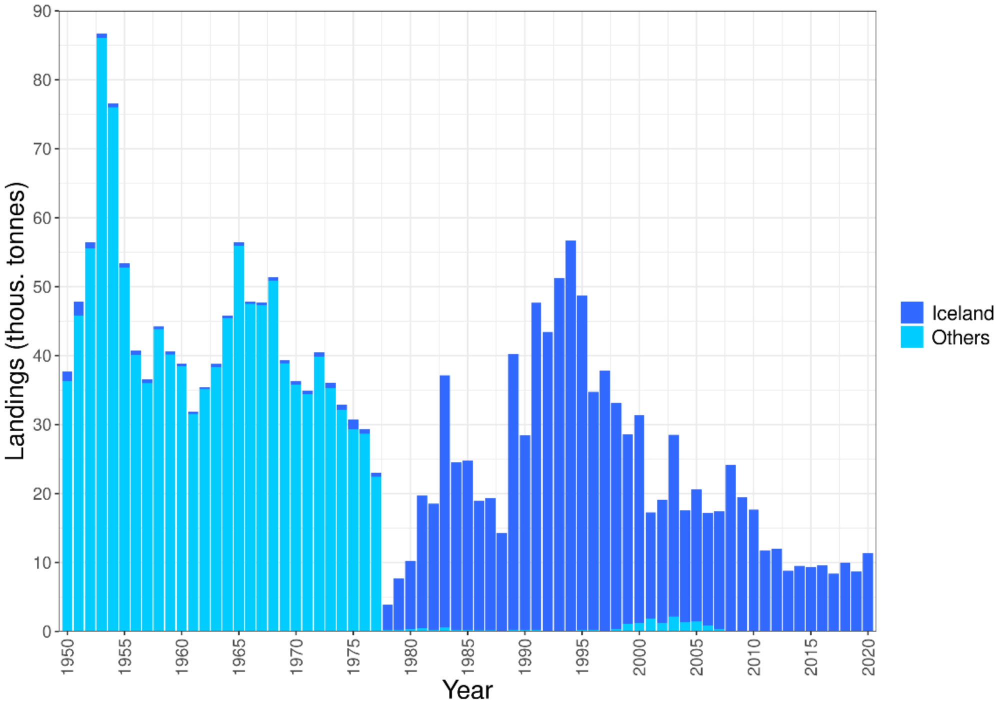


**Figure 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* from Icelandic waters (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1950–2020.**

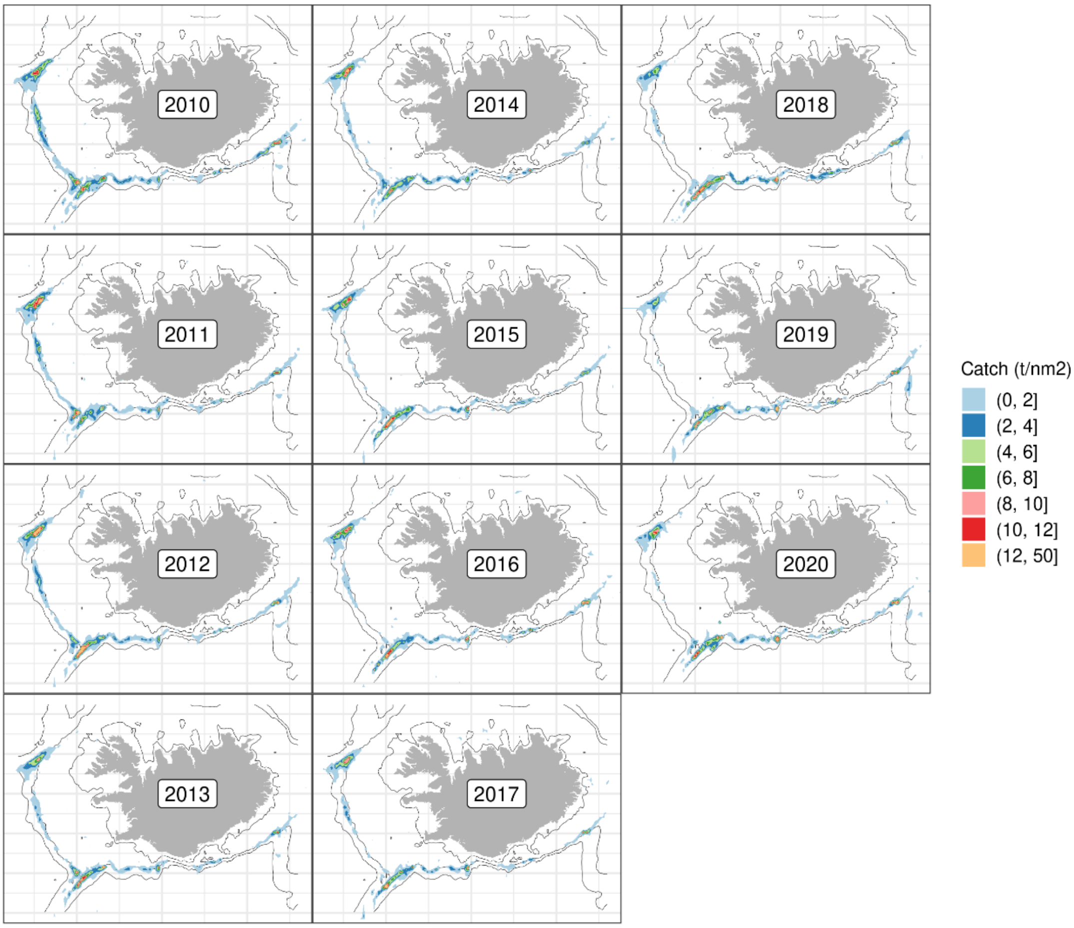


**Figure 20.3.2 Geographical location of the Icelandic slope *S. mentella* catches (t/nmi², coloured area) in Icelandic waters (ICES Division 5.a and Subarea 14 and within the Icelandic EEZ) 2010–2020 as reported in logbooks (rep. catch) of the Icelandic fleet using bottom trawl. The black solid line indicates the boundaries of the Icelandic EEZ.**

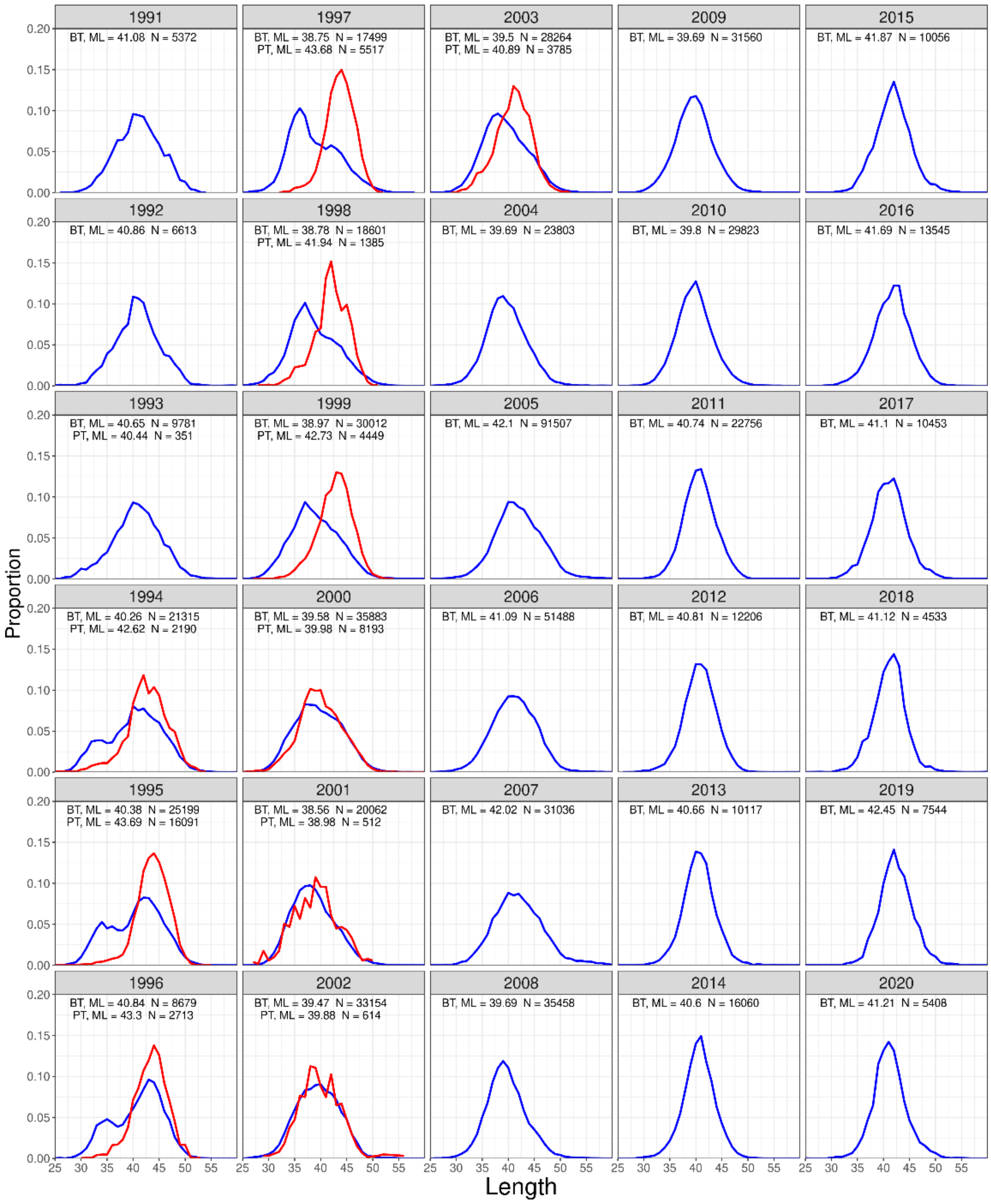

**Figure 20.3.3Length distributions of Icelandic slope *S. mentella* from the Icelandic landings taken with bottom trawl (blue line) and pelagic trawl (red line) in Icelandic waters (ICES Division 5.a and Subarea 14) 1991–2020.**

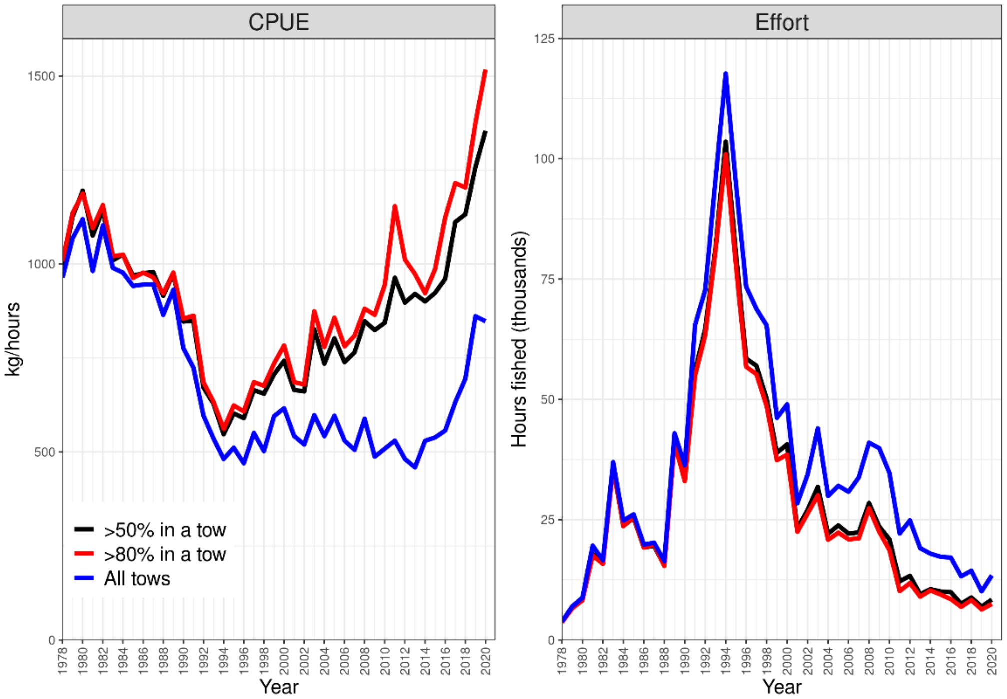


**Figure 20.3.4 Non-standardized CPUE (kg/hour) and effort (thousand hours fished) of Icelandic slope *S. mentella* from the Icelandic bottom trawl fishery in Icelandic waters (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1978–2020. The black lines show CPUE/effort where more than the 50% of the catch in individual tows were Icelandic slope *S. mentella*, the red lines where more than 80% of the catch in individual tows were Icelandic slope *S. mentella*, and the blue lines all tows were Icelandic slope *S. mentella* was caught.**

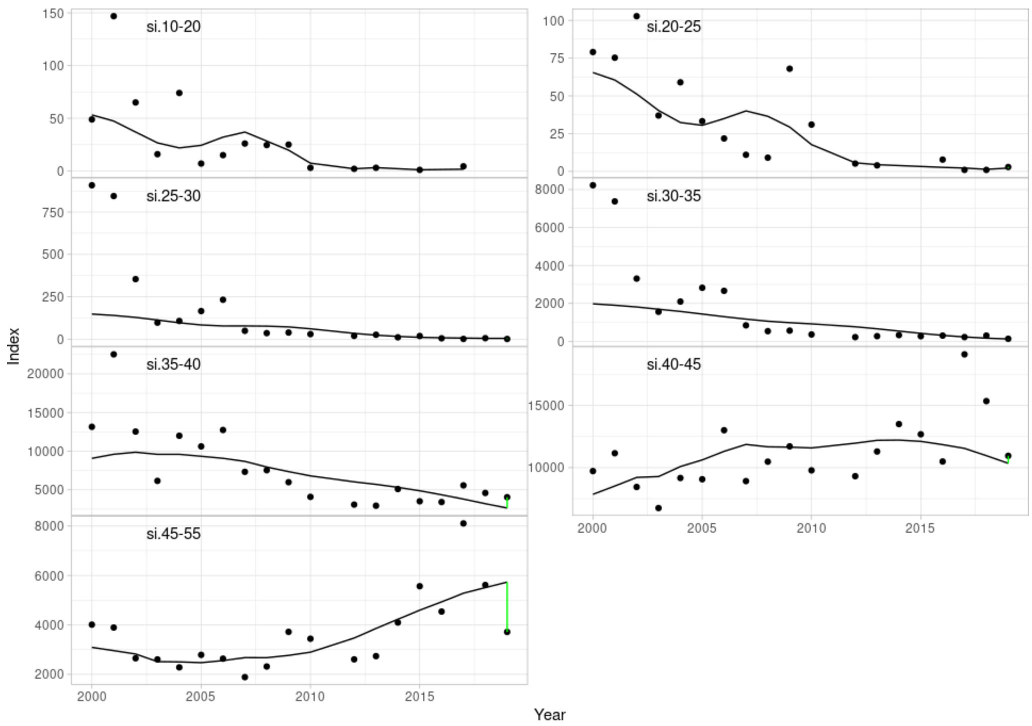


**Figure 20.12.1. Icelandic slope beaked redfish. Autumn survey index number fits (lines) to data (points). The green line indicates the difference between model and data values in the last year.**

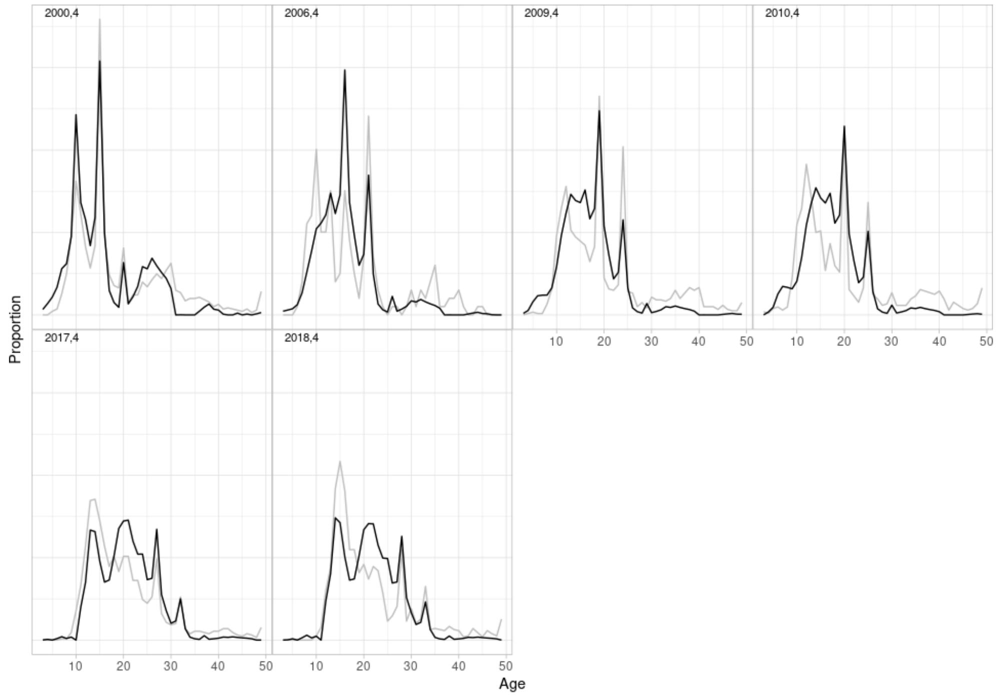


**Figure 20.12.2. Icelandic slope beaked redfish. Comparison of autumn survey age distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.**

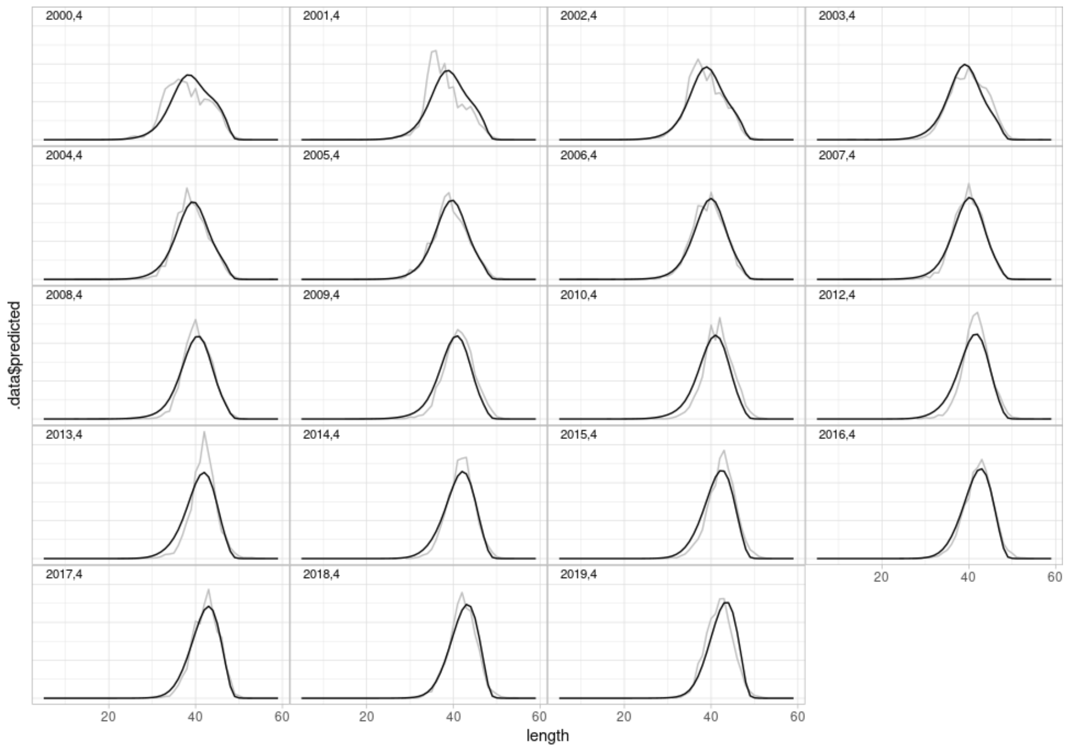


**Figure 20.12.3. Icelandic slope beaked redfish. Comparison of autumn survey length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.**

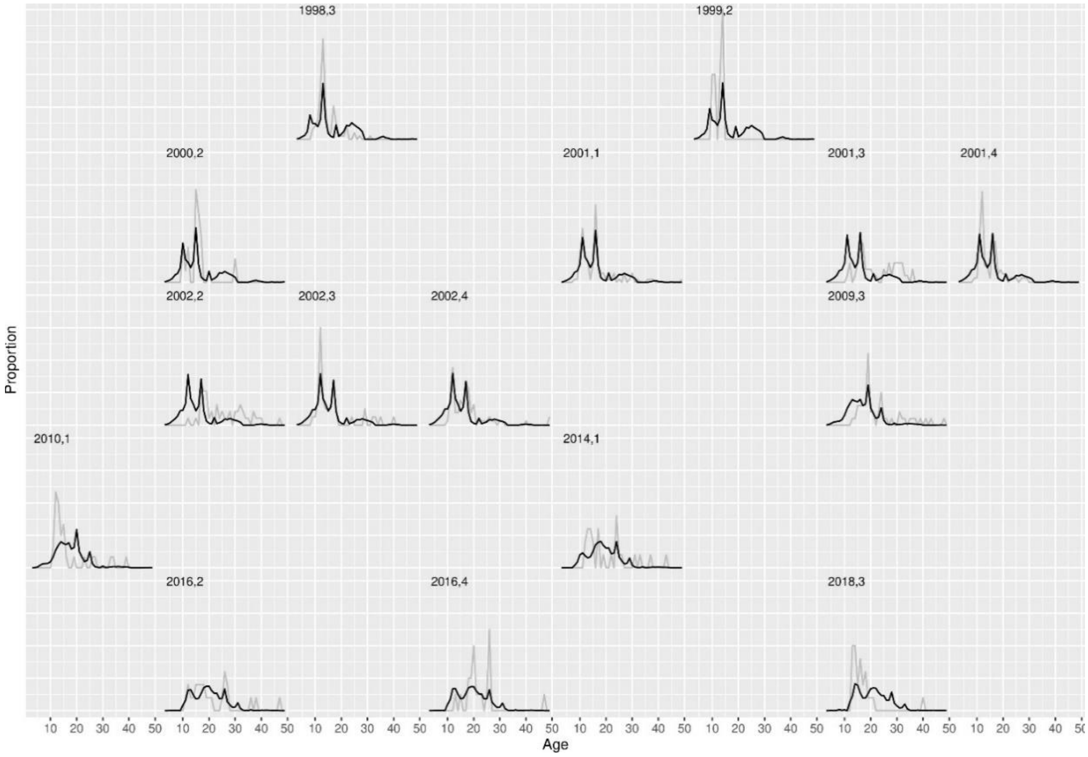

**Figure 20.12.4. Icelandic slope beaked redfish. Comparison of commercial sample age-length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.**

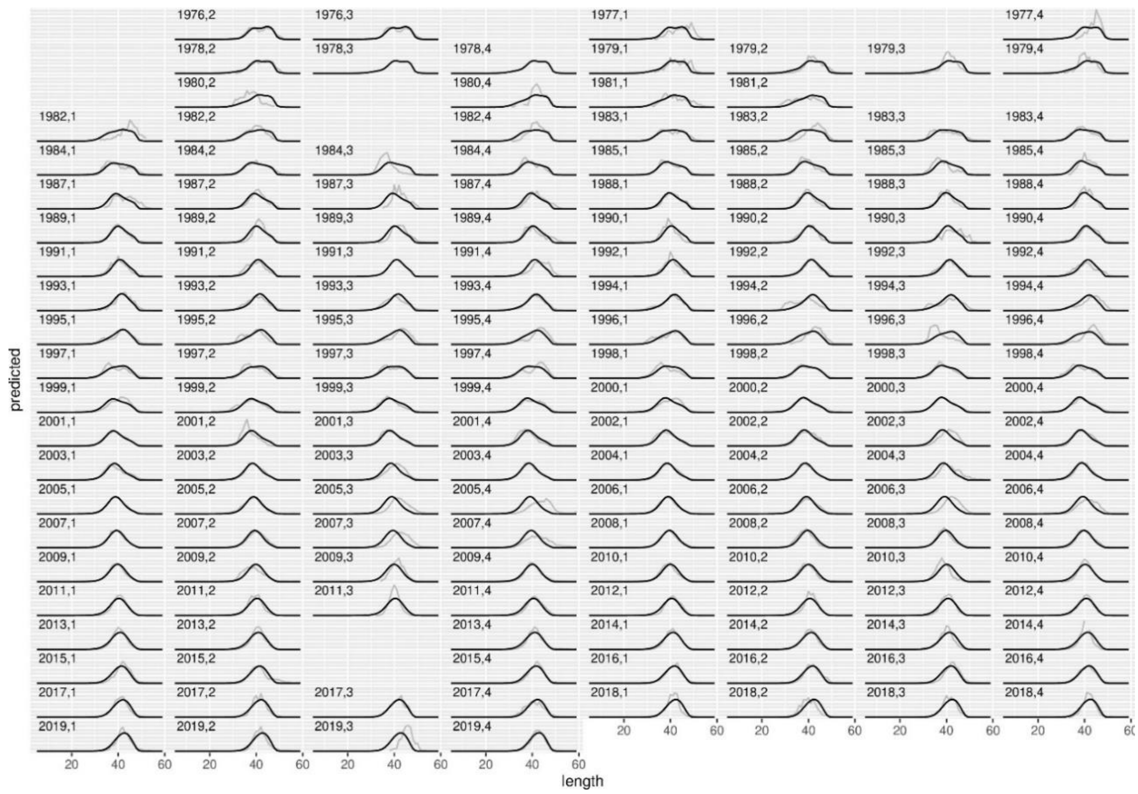

**Figure 20.12.5. Icelandic slope beaked redfish. Comparison of commercial sample length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.**

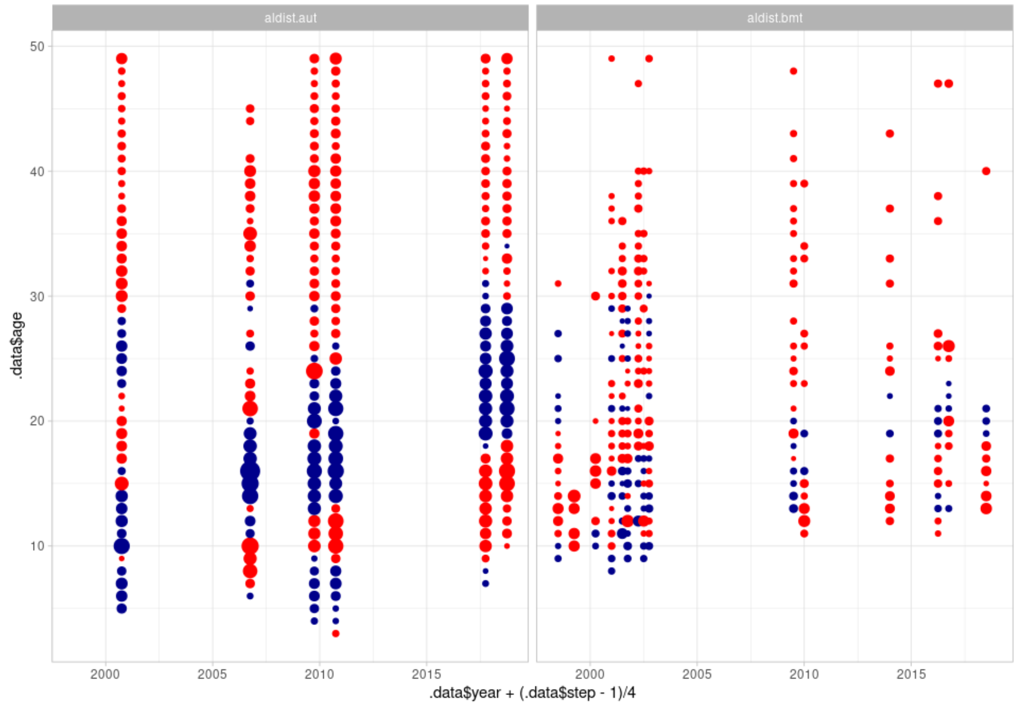


**Figure 20.12.6. Icelandic slope beaked redfish. Bubble plots illustrating age-length distribution residuals between model predictions and data. Red bubbles indicate positive residuals (underestimation); blue bubbles indicate negative residuals (overestimation).**

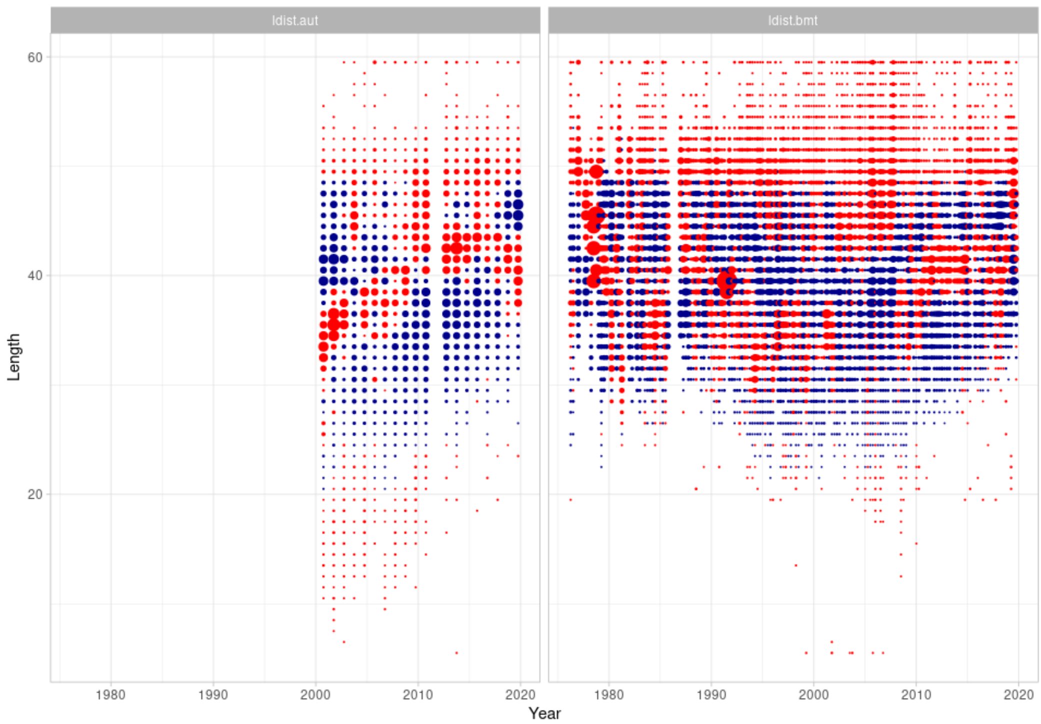


**Figure 20.12.7. Icelandic slope beaked redfish. Bubble plots illustrating length distribution residuals between model predictions and data. Red bubbles indicate positive residuals (underestimation); blue bubbles indicate negative residuals (overestimation).**

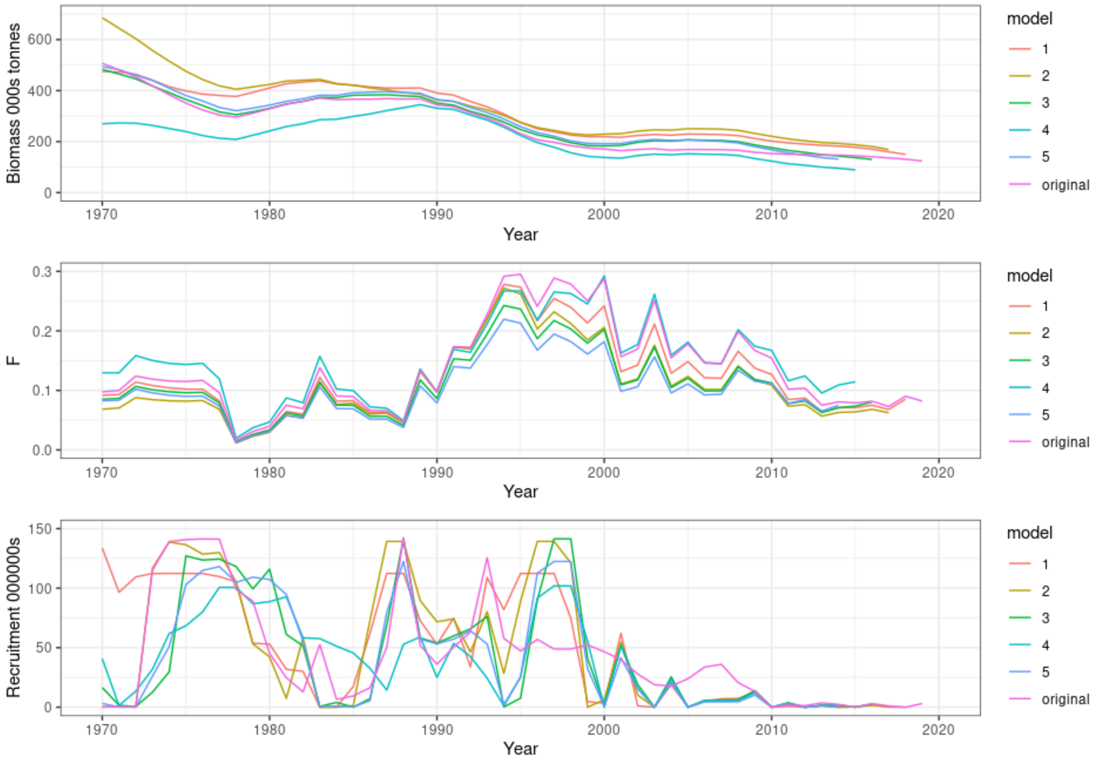


**Figure 20.12.8. Icelandic slope beaked redfish. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.**

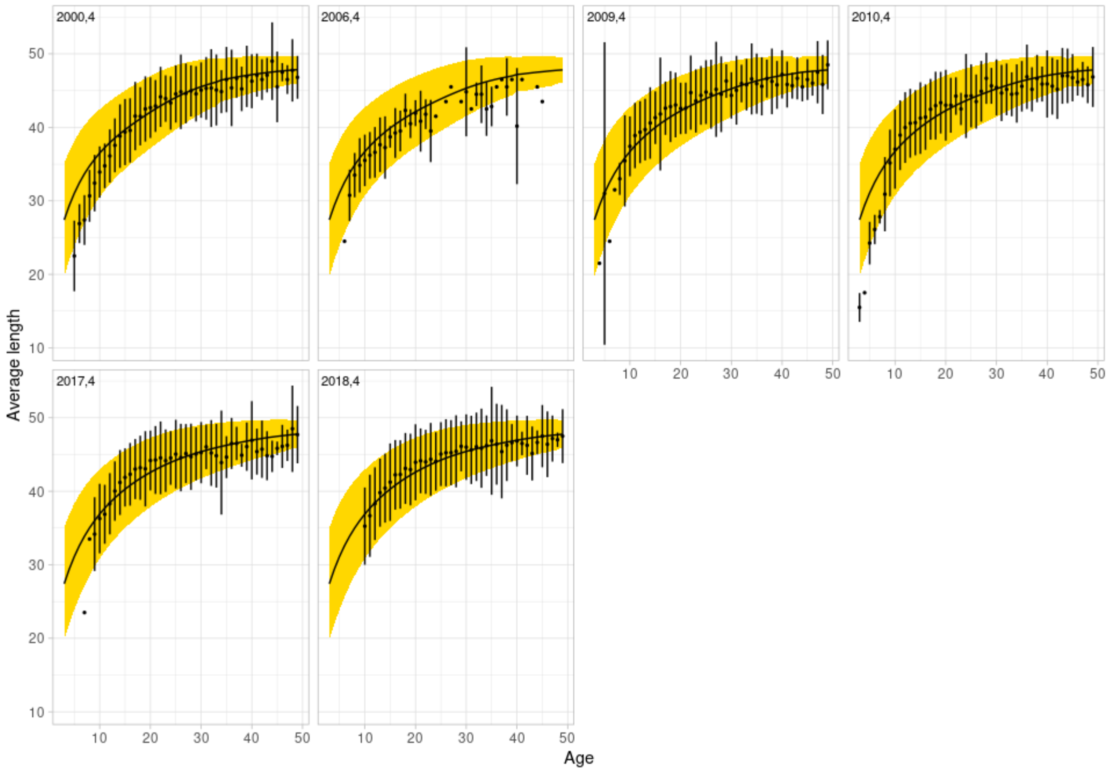


**Figure 20.12.9. Icelandic slope beaked redfish. Growth estimations by fleet from the Gadget model. Yellow bands and the black line show where the mean and 95% confidence intervals of the of model predictions, whereas the points and error bars show the mean and 95% confidence intervals of the data.**

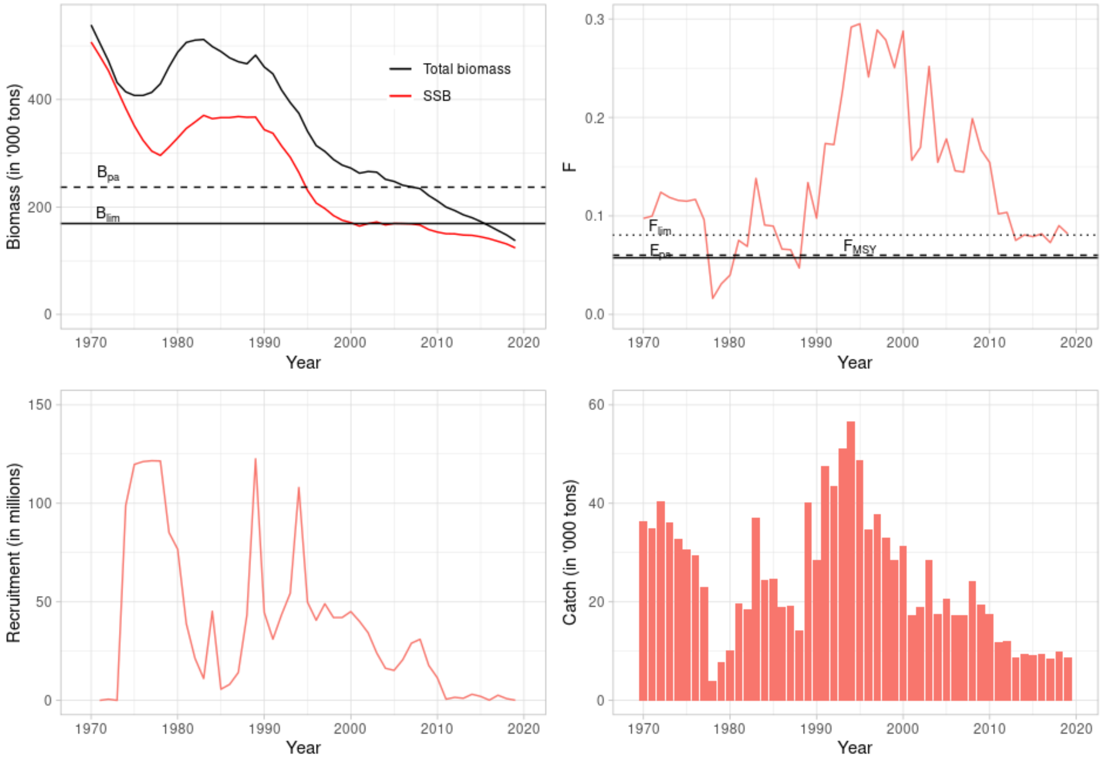


**Figure 20.12.10. Icelandic slope beaked redfish. Summary from the assessment 2020.**


**Figure 20.12.11. Icelandic slope beaked redfish. Plots of the estimated recruitment age 3 versus spawning stock biomass (lagged by 1 year).**

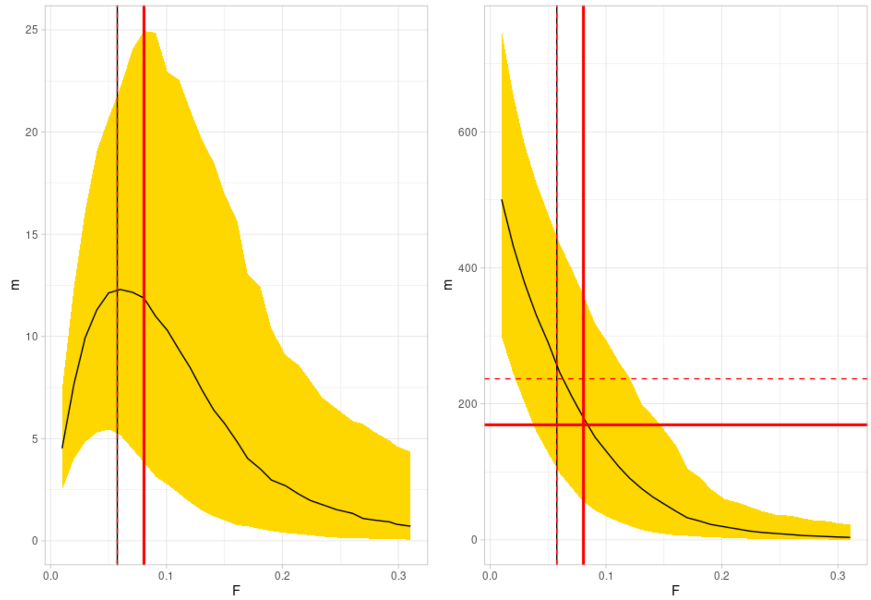


**Figure 20.12.12. Icelandic slope beaked redfish. Yield-per-recruit (left) and average SSB against average fishing mortality (right). Also shown are the defined reference points.**

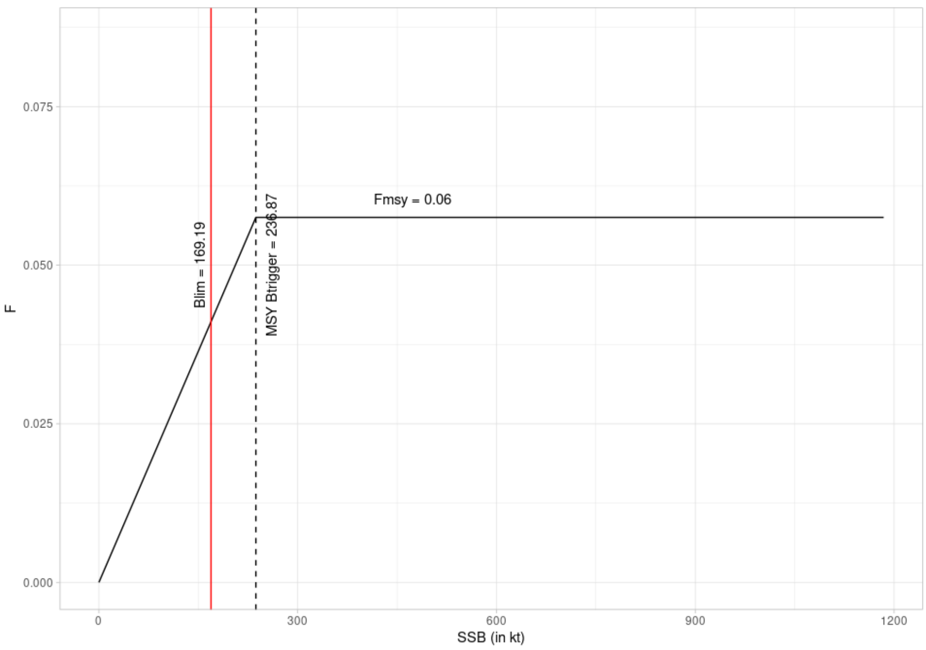


**Figure 20.12.13. Icelandic slope beaked redfish. Proposed management plan.**