19 Golden redfish (*Sebastes norvegicus*) in subareas 5, 6 and 14

19.1 Stock description and management units

Golden redfish (*Sebastes norvegicus*) in ICES subareas 5 and 14 have been considered as one management unit. Catches in ICES Subarea 6 have traditionally been included in this report and the group continues to do so. Data from ICES Subarea 6 is, however, not used in the assessment.

19.2 Scientific data

This Section describes results from various surveys conducted annually on the continental shelves and slopes of ICES subareas 5 and 14.

19.2.1 Division 5.a

Two bottom trawl surveys are conducted in Icelandic waters, the Icelandic spring groundfish survey (spring survey) and the Icelandic autumn groundfish survey (autumn survey). The spring survey has been conducted annually in March since 1985 and the autumn survey has been conducted annually in October since 1996. The autumn survey was not conducted in 2011. Description of the Icelandic bottom trawl surveys and the calculation of the survey indices for golden redfish in ICES 5.a. are given in the Stock Annex (*reference*). The calculation of the survey indices includes length dependent diel vertical migration of the species, also described in the stock annex.

Two survey indices are calculated from these surveys but only the index from the spring survey is used in the assessment of golden redfish. Length disaggregated indices from the spring survey are used in the Gadget model. Age -length keys from the autumn survey in 2 cm length groups are used in the Gadget model.

The total biomass of golden redfish as observed in the spring survey decreased from 1988 to a record low in 1995 (Figure 19.2.1 and Table 19.2.1). From 2000 to 2016 the biomass increased, with some fluctuation, to the highest value in the time-series. Since then the index has decreased and was in 2019 similar as in 2012–2105. The CV of the measurement error has been considerably higher since 2003 than before that.

The total biomass index from the autumn survey shows similar trend as in the spring survey, that is, has gradually increased from 2000 to 2014 when it was the highest in the time-series. The total biomass index has since then been high but fluctuating (Figure 19.2.1 and Table 19.2.1).

Length disaggregated indices from the spring survey shows that the peaks in length 4–11 cm, which can be seen first in 1987 (the 1985 year class) and then in 1991–1992 (the 1990 year class), reached the fishable stock approximately 10 years later (Figure 19.2.2). The increase in the survey index between 1995 and 2005 reflects the recruitment of these two strong year classes. During the 1999–2008 period, the abundance of small redfish was lower than in 1986–1990, highest in 2000-2003 (Figure 91.2.1). Since 2009 very little of small redfish has been observed in the surveys (Figure 19.2.1). This has been confirmed by age readings (Figure 19.2.4 and Table 19.2.2). In recent years the modes of the length distribution in both surveys has shifted to the right and is narrower. The abundance of golden redfish smaller than 30 cm has decreased since 2006 in both surveys and is now at the lowest level in the time-series (figures 19.2.1, 19.2.2 and 19.2.3).

Age disaggregated abundance indices from the autumn survey are shown in Figure 19.2.4 and Table 19.2.2. The sharp increase in the survey indices since 2005 reflects the recruitment of the year-classes from 1996–2005. The year-classes 1996–1999 are gradually disappearing from the stock. The indices of the 2000–2005 year-classes are now similar to the indices of the large 1990 year-class at same age. The age disaggregated abundance indices indicate that all year-classes since 2009 are small (Table 19.2.2).

19.2.2 Division 5.b

In Division 5.b, CPUE of golden redfish were available from the Faeroes spring groundfish survey from 1994–2019 and the summer survey 1996–2018 (see stock annex for description of the survey *reference*). Both surveys show similar trends in the indices from 1998 onwards with sharp declines between 1998 and 1999 (Figure 19.2.5). CPUE in the spring survey since 2000 has been stable at low level. The CPUE index in the summer survey shows similar trend as in the spring survey and has gradually decreased and is at the lowest level recorded.

19.2.3 Subarea 14

The German groundfish survey has been conducted annually in the autumn from 1982 to 2017 covering shelf areas and the continental slopes off West and East Greenland. Description of the survey and the re-stratification in 2013 is found in the Stock Annex (*reference*). In 2017, sampling was only conducted in parts of East Greenland and one spot in NAFO 1F with a total of 46 stations. This is low compared to necessary coverage of 63–75 stations in the respective area as done in the previous years. The survey was not conducted in 2018 because of research vessel breakdown.

Relative abundance and biomass indices for *S. norvegicus* (fish >17 cm) from the German groundfish survey are illustrated in Figure 19.2.6. After a severe depletion of the *S. norvegicus* stock on the traditional fishing grounds around East Greenland in the early 1990s, the survey estimates showed a significant increase from 2003, both in biomass and abundance (Figure 19.2.6). The survey indices in 2007–2017 were high but fluctuated. The biomass survey index in 2014–2016 were at the highest level in the time-series but decreased in 2017 to similar level as in 2013 (Figure 19.2.6a). It should be noted that the CV for the indices are high and the increase is driven by few very large hauls. In 2010–2017, the biomass of pre-fishery recruits (17–30 cm) has decreased gradually compared to previous five years and in 2017 very little of 17–30 cm fish was observed (Figure 19.2.6*c*).

Abundance indices of redfish smaller than 18 cm from the German annual groundfish survey show that juveniles were abundant in 1993 and 1995–1998 (See Section 18, Figure 18.2.1). Since 2008, the survey index has been very low and in recent years at the lowest value recorded since 1982. Juvenile redfish were only classified to the genus *Sebastes* spp., as species identification of small specimens is difficult due to very similar morphological features. The 1999–2017 survey results indicate low abundance and are like those observed in the late 1980s. The Greenland shrimp and fish shallow water survey (no survey conducted in 2017 and 2018) also shows no juvenile redfish (<18 cm, not classified to species) were present (*see Figure 23.*).

19.3 Information from the fishing industry

19.3.1 Landings

Total landings gradually decreased by more than 70% from 130 429 t in 1982 to 43 515 t in 1994 (Table 19.3.1 and Figure 19.3.1). Since then, the total annual landings have varied between 33 451 and 59 698 t and have been gradually increasing since 2010. The total landings in 2018 were 53 428 t, which is 2673 t less than in 2017. Most of the golden redfish catch or 90–98% has been taken in ICES Division 5.a.

Landings of golden redfish in Division 5.a declined from 97 899 t in 1982 to 38 669 t in 1994 (Table 19.3.1). Since then, landings have varied between 31 686 t and 54 041 t, highest in 2016. The landings in 2018 were 48 014 t, about 2105 t less than in 2017. The landings were 5.6% higher than allocated quota of 45 450 t. The reasons for the implementation errors are related to the management system that allow for transfers of quota share between fishing years and conversion of TAC from one species to another. Detailed description of the Icelandic ITQ system is found in the Stock Annex for the species (smr-5614_SA).

Between 90–95% of the golden redfish catch in Division 5.a is taken by bottom trawlers targeting redfish (both fresh fish and factory trawlers; vessel length 48–65 m). The remaining catches are partly caught as bycatch in gillnet, long-line, and lobster fishery. In 2018, as in previous years, most of the catches were taken along the shelf southwest, west and northwest of Iceland (Figure 19.3.2). Higher proportion of the catches is now taken along the shelf northwest of Iceland and less south and southwest.

In Division 5.b, landings decreased from 9194 t in 1985 to 1436 t in 1999 and varied between 1139 and 2484 t from 2000–2005 (Table 19.3.1). In 2006–2016 annual landings were less than 700 t which has not been observed before in the time-series. The landings in 2017 increased substantially compared to previous 11 years and were 1397 t. That is 1232 t more landings than in 2016 and the highest landings since 2005. The landings were 1330 t in 2018. Most of the golden redfish caught in Division 5.b is taken by pair and single trawlers (vessels larger than 1000 HP).

In Subarea 14 (East Greenland waters), the landings of golden redfish reached a record high of 30 962 t in 1982, but decreased drastically within the next three years and to 2117 t in 1985 (Figure 19.3.1 and Table 19.3.1). During the period 1985–1994, the annual landings from Subarea 14 varied between 687 and 4255 t. There was little or no direct fishery for golden redfish from 1995 to 2009 and landings were 200 t or less, mainly taken as bycatch in the shrimp fishery. In 2010, landings of golden redfish increased considerable and were 1650 t. This increase is mainly due to increased *S. mentella* fishery in the area. Annual landings 2010–2015 have been between 1000 t and 2700 t but increased to 5442 t in 2016 which is the highest landings since 1983. The landings in 2018 were 4004 t, about 497 t less than in 2017.

Annual landings from Subarea 6 increased from 1978 to 1987 followed by a gradual decrease to 1992 (Table 19.3.1). From 1995 to 2004, annual landings have ranged between 400 and 800 t, but decreased to 137 t in 2005. Little or no landings of golden redfish were reported from Subarea 6 in 2006–2018 and were 80 t in 2018.

19.3.2 Discard

Comparison of sea and port samples from the Icelandic discard sampling program does not indicate significant discarding due to high grading in recent years (Pálsson *et al* 2010), possibly due to area closures of important nursery grounds west off Iceland. Substantial discard of small redfish took place in the deep-water shrimp fishery from 1986 to 1992 when sorting grids became mandatory. Since then the discard has been insignificant both due to the sorting grid and much less abundance of small redfish in the region.

Discard of redfish species in the shrimp fishery in ICES Division 14.b is currently considered insignificant (see Section 18).

19.3.3 Biological data from the commercial fishery

The table below shows the fishery related sampling by gear type and ICES divisions in 2018. No sampling of the commercial catch from Subdivision 6 was carried out.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	48,014	113	19,138	1,287
5.b	Faroe Islands	Bottom trawl	1,330		109	
14	Greenland	Bottom trawl	4,004			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976–2018 show that most of the fish caught is between 30 and 45 cm (Figure 19.3.3). The modes of the length distributions range between 35 and 38 cm. The length distributions in 2012–2018 are narrower than previously, with less than average of small fish caught.

Catch-at-age data from the Icelandic fishery in Division 5.a show that the 1985-year class dominated the catches from 1995–2002 (Figure 19.3.4 and Table 19.3.2) and in 2002 this year class still contributed to about 25% of the total catch in weight. The strong 1990-year class dominated the catch in 2003–2007 contributing between 25–30% of the total catch in weight. The share of these two year-classes has gradually been decreasing in recent years. In 2007–2010 the 1996–1999 year-classes dominated in the catches but are now gradually decreasing. The 2002–2007 year-classes (ages 11–16) were the most dominant year classes in the fishery in 2018 and contributed about 69% of the total catch in numbers. There is a substantial decrease of 7–9 year old fish in the catch, compared to recent previous years, an additional indicator of low recruitment in recent year observed in all surveys conducted in East Greenland and Icelandic waters.

The average total mortality (Z), estimated from the 24-year series of catch-at-age data (Figure 19.3.5) is about 0.22 for age 12 years and older.

Length distribution from the Faroese commercial catches 2001–2018 shows that the fish caught are on average larger than 40 cm with modes between 45 cm and 50 cm (Figure 19.3.6).

No length data from the catches have been available for several years in subareas 14 and 6.

19.3.5 CPUE

The un-standardized CPUE index from the Icelandic bottom trawl fleet was in 2018 the highest in the time-series with sharp increase in recent 12 years. Effort towards golden redfish has since 1986 gradually decreased and is at the lowest level recorded (Figure 19.3.7). CPUE derived from logbooks is not considered indicative of stock trends however the information contained in the logbooks on effort, spatial and temporal distribution the fishery is of value.

Un-standardized CPUE of the Faroese otter-board (OB) trawlers has been presented in previous reports. They are however considered unreliable and un-representative about the stock in Division 5.b. This is because no separation of S. *norvegicus*/*S. mentella* is made in the catches.

19.4 Analytical assessment

The stock was benchmarked in January 2014 and a management plan evaluated and adopted (WKREDMP, ICES 2014). The benchmark group agreed to base the advice for next five years on the Gadget model. The settings are described in the Stock Annex.

19.4.1 Gadget model

19.4.1.1 Data and model settings

Below is a brief description of the data used in the model and model settings is given. A more detailed description is given in the Stock annex.

Data used in the Gadget model are:

- Length disaggregated survey indices 19–54 cm in 2 cm length increments from the Icelandic groundfish survey in March 1985–2019 and the German survey in East Greenland 1984–2017. The German survey index in 2018 is based on the 2017 values due to lack of 2018 Greenland survey data (not conducted).
- Indices are combined (Figure 19.4.2) and the German survey gets half the weight compared to what is presented in Figure 19.2.6. This was done to avoid extrapolation to areas not surveyed, and hence reduce noise. By using the stratification used to calculate indices shown in Figure 19.2.6, each station in the German survey would get 2.5 times more weight compared to the Icelandic survey.
- Length distributions from the Icelandic, Faroe Islands and East Greenland commercial catches 1970–2018.
- Landings by 6-month period from Iceland, Faroe Islands and East Greenland.
- Age-length keys and mean length at age from the Icelandic groundfish survey in October 1996–2018.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995–2018.
- The simulation period is from 1970 to 2023 using data until the first half of 2019 for estimation. Two time-steps are used each year. The ages used were 5 to 30 years, where the oldest age is treated as a plus group (fish 30 years and older).
- Recruitment was set at age 5.

Estimated parameters are:

- Number of fishes when the simulation starts (8 parameters).
- Recruitment at age 5 each year (47 parameters).
- Length at recruitment (3 parameters).
- Parameters in the growth equation; (2 parameters).
- Parameter β of the beta-binomial distribution controlling the spread of the length distribution.
- Selection pattern of the three commercial fleets assuming logistic selection (S-shape) (3x2 parameters).
- Selection pattern of the survey fleet assuming an Andersen selection curve (bell-shape) (3 parameters).

It should be noted that the length disaggregated indices are from the spring survey, but the age data are from the autumn survey conducted six months later. The surveys could have different catchability, but the age data are used as proportions within each 2 cm length group, so it should not matter. Growth in between March and October is taken care of by the model.

The biomass from East Greenland has increased in recent decade but is only about 10% of the total biomass (Figure 19.4.2). The contribution for each length group (Figure 19.4.3) shows that large redfish is abundant in East Greenland and large part of the largest redfish (45+ cm) is found there. This affects the model results as the relatively large abundance of middle size redfish in the Icelandic spring survey (Figure 19.2.1) has not led to subsequent increase in large fish (Figure 19.2.1). Including the large fish from East Greenland does therefore affect model results and estimated SSB is 20% higher when the German survey is included, even though the German survey does only account for 10% of the total biomass as it is currently weighted. The recruitment signal from the German survey (Figure 19.4.3) is on the other hand not explaining the "missing recruitment" from Icelandic waters in recent two decades.

Assumptions done in the predictions:

- Recruitment at age 5 in 2017 and onwards was set as the average of the five smallest estimated year classes 1980–2007. The reason is indication of poor recruitment in recent years, but estimated recruitment was even lower.
- Catches in the first time-step in 2019 (first 6 months) were set at the same as in the first time-step of 2018 for all the fleets. In step 2 in 2019 and onwards the model was run at fixed effort corresponding to F_{9-19} = 0.097
- The estimated selection pattern from the Icelandic fleet was used for projections.

19.4.1.2 Results of the assessment model and predictions

Summary of the assessment is shown in Figure 19.4.4 and Table 19.4.1. The harvestable biomass and the spawning stock increased from 1995 to 2015 but has since then decreased although still high. Annual landings have increased gradually since 2003–2010 period when they were at low level. Fishing mortality has been low since 2010, but since the HCR was adopted in 2014, the fishing mortality has been above the target of 0.097, both due to TAC exceeding advice. Recruitment after 2013 is record low for the time series.

The last year class estimated is the 2013 year-class, but the following year-classes are assumed to be the average of the five smallest year classes in the 1980–2007 period. Assumptions about those year-classes will not have much effect on the advice this year because average contribution of age 10 and younger to the landings is only about 10%. Later advice will be affected as well as the development of the spawning stock in short and medium term and is expected to decrease.

Estimated selection patterns of different fleets are shown in Figure 19.4.8. The Greenlandic and Faeroese fleet catch much larger fish than the Icelandic fleet. This is in line with the results from the German survey in East Greenland that show most of the large fish in East Greenland (Figure 19.4.3).

Assessment in recent years has shown some difference between model runs (Figure 19.4.5). The results in 2018 showed some downwards revision of the assessment in recent years (Figure 19.4.5) in addition to even more pessimistic view of future recruitment. The reason for this downward revision (about 12%) were investigated and the result of the analysis was that the model had not converged to the "best solution" in recent years and analytical retros done indicated that in recent years the biomass should have been lower (Figure 19.4.6).

19.4.1.3 Mohn's roh

One of the ToR for this year (ToR b)-viii) was to evaluate the retrospective pattern of the assessment by calculating the Mohn's rho values. The default five year peels resulted in the following values:

Variable	Value
F_{bar}	-0.0186
SSB	0.0252
Rec.	-0.2194

19.4.1.4 Diagnostics

An aggregated fit to the survey index (converted to biomass) is presented in Figure 19.4.9. It shows a greater level of agreement than most runs based only on the Icelandic data but does mostly show negative residuals for the last 15 years. Residuals by length group show positive residuals in size groups 33–38 cm in recent years but negative for most other size groups, especially for fish smaller than 30 cm, indicating narrower length distributions in the survey than predicted (Figure 19.4.10).

This lack of fit between observed and predicted numbers between 33 and 40 cm is caused by data conflicts with survey indices of larger sizes and compositional data. There appears to be an internal conflict between indices of lengths of 42 cm and above and the large amount of smaller fish that was observed in the survey few years earlier. The model results are therefore a compromise between different data sets, and it is not able to follow the amount of 30–40 cm redfish in recent years. The inability of the model to fit the survey biomass in recent years has some support in the characteristics of the survey. Since 2003 most of the biomass in the Icelandic survey has been observed to be aggregated in very dense schools west of Iceland, caught on 5–10 stations every year. The size distribution in those schools is narrow and fish larger than 40 cm were rare.

The correlation between observed and predicted survey indices is good for 35–50 cm fish (figures 19.4.11 and 19.4.12). As the model converges slowly, predicted indices could change several years back when more data are added. However, it is not the magnitude of the residuals but rather the temporal pattern that is worrying (Figure 19.4.10). For 33–40 cm fish, indices have been above predictions for more than 10 years. The indices for 41–50 cm fish do not show such temporal pattern. When looking at the temporal patterns, longevity of the fish must be considered.

Trends in different likelihood components (Figure 19.4.7) shows well how the fit to survey length distributions has deteriorated in recent years.

Length distributions from the Icelandic commercial catch does usually show good fit except in the most recent period when the large fish is missing and the length distribution narrower (Figure 19.4.13). One explanation could be that selection in recent years seems to be more dome shaped as the large fish are generally found in East Greenland and North of Iceland where relatively small part of the fisheries takes place.

The fit between predicted and observed age distributions is better than for the length distributions (figures 19.4.14 and 19.4.15). The model uses the data as age-length keys in 2 cm intervals for tuning. Presenting the residuals on that scale is difficult so here the age distributions are shown as aggregates overall length groups. This presentation is appropriate for the commercial samples for the catches where the otolith sampling is random, but less so for the survey as there is a maximum limit on the number of otoliths sampled in each tow and therefore lower proportion sampled in large hauls.

The age distributions from the catches that the model seems to follow well indicate that $Z_{12–20}$ has been around 0.22 for the last 5–10 years or F of 0.17. Intended $F_{9–19}$ is 0.097 but $F_{12–20}$ = 0.17 corresponds to $F_{9–19}$ = 0.14–0.15 that would be the model results if all weight was put on the catch data.

19.4.1.5 Advice

The management plan is based on $F_{9\text{–}19} = 0.097$ reducing linearly if the spawning stock is estimated below 220 000 t ($B_{trigger}$). B_{lim} was proposed as 160 000 t, lowest SSB in the 2012 run. The 2019 SSB was estimated at 299 300 t, and according to the management plan the TAC advice for 2020 will be 43 600 t.

19.5 Reference points

Harvest control rule (HCR) was evaluated at WKREDMP in January 2014 (ICES, 2014) based on stochastic simulations using the Gadget model. Considering conflicting information by different data continuing for many consequent years (Section 19.4), the simulations were conducted using large assessment error with very high autocorrelation (CV = 0.25, rho = 0.9).

Yield-per-recruit analysis show that when average size at age 5 was allowed to change after year class 1996, $F_{9\text{–}19,MAX}$ changed from 0.097 to 0.114. The proposed fishing mortality of 0.097 is therefore around 85% of F_{MAX} with current settings. Stochastic simulations indicate that it leads to very low probability of spawning stock going below $B_{trigger}$ and B_{lim}, even with relatively large autocorrelated assessment error.

At WKREDMP 2014, B_{lim}=B_{loss}=160 000 t was defined as the lowest SSB in the 2012 Gadget run. $B_{trigger} = B_{pa}$ was defined as 220 000 t by adding a precautionary buffer to the proposed B_{lim} of 160 000 t: 160*exp(0.2*1.645). Recruitment in the stochastic simulations was the average of year-classes 1975–2003 but those year-classes were the basis for the simulations at WKREDMP 2014.

The plot of the average spawning stock against fishing mortality show that $F_{lim} = 0.226$ and F_{pa} is then 0.226/exp(1.645*0.2) = 0.163 (Figure 19.5.1). The spawning stock decreased considerably from early 1980s to mid-1990s or from 400 000 t to 200 000 t. The reduction in SSB was due to heavy fisheries but increased again gradually because of improved recruitment and lower F (Figure 19.5.1).

The probability of current SSB < $B_{trigger}$ is estimated 2.7%. For simplicity, the action of $B_{trigger}$ is not included in the simulations since Gadget is not keeping track of “perceived spawning stock”. Analysis of the stochastic prediction in R shows that if SSB is below $B_{trigger}$ it will only be noted in < 15% of the cases. The reason is that the spawning stock is only likely to go below $B_{trigger}$ in periods of severe overestimation of the stock that occur due to the assumed high autocorrelation in assessment error. This situation differs from that of the stock going below $B_{trigger}$ due to poor recruitment (worse than observed in recent decades). In this case the spawning stock should still have a resilient age structure (as discussed above) and this could reduce the need to take further action below $B_{trigger}$.

Figure 19.5.2 shows the development of $F_{9\text{–}19}$ based on $F_{9\text{–}19} = 0.097$. F is expected to be within the range of the fifth and 95^{th} quantile and the 16^{th} and 84^{th} quantile.

19.6 State of the stock

The results from Gadget indicate that fishing mortality has been low since 2009 but above F_{MSY} (Figure 19.4.4). While current indices of adult biomass are high but decreasing (Table 19.4.1), the absence of any indications of incoming cohorts raises concerns about the future productivity of the stock.

Results from surveys in Iceland and East Greenland indicate that most recent year classes are poor. The accuracy of the surveys as an indicator of recruitment is not known but recruitment is expected to be poor.

19.7 Short term forecast

The Gadget model is length based where growth is modelled based on estimated parameters. The only parameters needed for short term forecast are assumptions about size of those cohorts that have not been seen in the surveys. These year classes were assumed to be the average of five smallest year classes in 1980–2007 (Figure 19.4.4).

The results from the short-term simulations based on F_{9-19} is shown in Figure 19.4.4 and from short term prognosis with varying fishing mortality in 2019 and 2020 in Table 19.4.2.

19.8 Medium term forecast

No medium-term forecast was carried out.

19.9 Uncertainties in assessment and forecast

Various factors regarding the uncertainty and modelling challenges are listed in the WKRED-2012 (ICES, 2012) and WKREDMP-2014 (ICES, 2014) reports. In addition, this subject is discussed in Section 19.4.

19.10 Basis for advice

Harvest control rule accepted at WKREDMP 2014 (ICES, 2014) and implemented by Icelandic and Greenland authorities in 2014.

19.11 Management consideration

In 2009 a fishery targeting redfish was initiated in Subarea 14 with annual catches of between 6000 and 8500 t in 2010–2018, highest in 2015 and lowest in 2018. The fishery does not distinguish between species, but based on survey information, golden redfish is estimated to be between 1000 and 2700 in 2010–2015 but increased to 4000–5400 t in 2016–2018.

Redfish and cod in Subarea 14 are found in the same areas and depths and historically these species have been taken in the same fisheries. An increased redfish fishery may therefore affect cod. ICES presently advise that no fishery should take place on offshore cod in Greenland waters. ICES therefore recommend measures that will keep effort on cod low in the redfish fishery.

Greenland opened an offshore cod fishery in 2008. To protect spawning aggregations of cod present management measures in Greenland EEZ prohibits trawl fishery for cod north of 63°N latitude. Restrictions on cod bycatch in fisheries directed towards other demersal fish (i.e. redfish and Greenland halibut) provide some protection of cod, but additional measures such as a closure of potential redfish fisheries north of 63°N could be considered.

Subarea 14 is an important nursery area for the entire resource. Measures to protect juvenile in Subarea 14 should be continued (sorting grids in the shrimp fishery).

No formal agreement on the management of *S. norvegicus* exists among the three coastal states, Greenland, Iceland and the Faroe Islands. However, an agreement was made between Iceland and Greenland in October 2015 on the management of the golden redfish fishery based on the management plan applied in 2014. The agreement is from 2016 to the end of 2018. The agreement states that each year 90% of the TAC is allocated to Iceland and 10% is allocated to Greenland. Furthermore, 350 t are allocated each year to other areas.

In Greenland and Iceland, the fishery is regulated by a TAC and in the Faeroe Islands by effort limitation. The regulation schemes of those states have previously resulted in catches more than TACs advised by ICES.

Since 2009, surveys of redfish in the stock area have consistently shown very low abundance of young redfish (< 30 cm). Biomass (SSB and the harvestable biomass) increased from 1995 to 2015 because of recruitment of several strong year-classes to the stock. Since then the biomass has declined. The absence of any indications of any incoming cohorts raises concerns about the future productivity of the stock.

19.12 Ecosystem consideration

Not evaluated for this stock.

19.13 Regulation and their effects

The separation of golden redfish and Icelandic slope *S. mentella* quota was implemented in the 2010/2011 fishing year.

In the late 1980s, Iceland introduced a sorting grid with a bar spacing of 22 mm in the shrimp fishery to reduce the bycatch of juveniles in the shrimp fishery north of Iceland. This was partly done to avoid redfish juveniles as a bycatch in the fishery, but also juveniles of other species. Since the large year classes of golden redfish disappeared out of the shrimp fishing area, there in the early 1990s, observers report small redfish as being negligible in the Icelandic shrimp fishery. If the sorting grids work where the abundance of redfish is high is a question but not a relevant problem now in 5.b as abundance of small redfish is low and shrimp fisheries limited.

There is no minimum landing size of golden redfish in Division 5.a. However, if more than 20% of a catch observed on board is below 33 cm a small area can be closed temporarily. A large area west and southwest of Iceland is closed for fishing to protect young golden redfish.

There is no regulation of the golden redfish in Division 5.b.

Since 2002 it has been mandatory in the shrimp fishery in Subarea 14 to use sorting grids to reduce bycatches of juvenile redfish in the shrimp fishery.

19.14 Changes in fishing technology and fishing patterns

There have been no changes in the fishing technology and the fishing pattern of golden redfish in ICE subareas 5 and 14.

19.15 Changes in the environment

No information available.

19.16 Benchmark in 2020

Benchmark meeting for golden redfish will be 27–31 January 2020 and data meeting will be 25–29 November 2019.

The proposed benchmark meeting will explore several issues of current assessment model. These include poor fit to survey indices for fish between 30–40 cm; potential dome-shape in selectivity; uncertainty estimates are not available; investigate the appropriateness of the current growth and maturity model used in the assessment. In addition, the meeting will explore alternative assessment methods. Under-utilized data sources from ICES 5.b and 14.b, mainly relevant survey and commercial samples of age and length. Biological reference points will be redefined depending on the assessment method. Change in form of harvest control rule will also be explored, that is change the rule to proportion of biomass above certain size (i.e. 33 cm and bigger fish) from the F based rule that is used now.

19.17 References

ICES 2012. Report of the Benchmark Workshop on Redfish (WKRED 2012). ICES CM 2012/ACOM:48, 291 pp.

ICES 2014. Report of the Workshop on Redfish Management Plan Evaluation (WKREDMP). ICES CM 2014/ACOM:52, 269 pp.

Pálsson, Ó., Björnsson, H., Björnsson, E., Jóhannesson, G. and Ottesen Þ. 2010. Discards in demersal Icelandic fisheries 2009. Marine Research in Iceland 154.

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985–2019 and the autumn survey 1996–2018.

	Spring Survey		Autumn Survey	
Year	Biomass	CV	Biomass	CV
1985	307,926	0.095		
1986	327,765	0.120		
1987	322,081	0.122		
1988	253,763	0.094		
1989	281,117	0.122		
1990	242,450	0.223		
1991	199,128	0.114		
1992	160,545	0.088		
1993	179,275	0.130		
1994	171,080	0.097		
1995	146,100	0.102		
1996	195,630	0.164	199,786	0.248
1997	211,165	0.217	120,628	0.279
1998	206,487	0.136	186,505	0.348
1999	297,060	0.143	262,691	0.310
2000	221,279	0.176	141,335	0.200
2001	192,724	0.176	177,448	0.155
2002	250,420	0.173	192,813	0.150
2003	334,003	0.161	199,450	0.159
2004	326,868	0.236	220,308	0.241
2005	310,635	0.129	229,013	0.240
2006	257,002	0.157	279,333	0.335
2007	339,778	0.224	219,951	0.252
2008	247,887	0.154	288,149	0.244
2009	302,204	0.253	294,028	0.282
2010	383,407	0.245	227,335	0.171
2011	401,349	0.235		

	Spring Survey		Autumn Survey	
Year	Biomass	CV	Biomass	CV
2012	461,928	0.204	343,090	0.226
2013	457,448	0.177	312,063	0.158
2014	402,773	0.174	431,369	0.232
2015	406,150	0.281	361,380	0.175
2016	615,712	0.313	401,140	0.279
2017	507,058	0.205	428,409	0.187
2018	497,092	0.210	342,525	0.195
2019	410,719	0.157		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in millions) from the autumn groundfish survey 1996–2018. The survey was not conducted in 2011.

Year/Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.3	1.0	3.6	3.3	0.8	0.4	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.1
2	2.4	0.2	1.5	3.3	1.7	1.0	0.9	0.5	0.2	0.1	0.6	1.2	0.3	0.3	0.0		0.0	0.0	0.2	0.1	0.0	0.3	0.2
3	0.7	2.2	0.9	3.3	1.4	1.9	1.5	1.1	1.0	0.2	0.7	1.2	2.5	0.4	1.7		0.1	0.0	0.3	0.6	0.0	0.3	0.4
4	1.6	1.6	2.3	1.5	1.6	2.4	6.1	1.1	1.8	1.0	0.5	1.1	2.7	4.4	0.3		1.4	0.2	0.1	0.3	1.8	0.2	0.1
5	8.3	2.2	0.9	4.7	1.2	5.4	5.8	12.3	3.3	4.2	5.0	2.1	4.1	12.0	4.3		4.1	1.0	0.8	0.1	0.3	1.6	0.2
6	40.0	6.9	3.5	2.8	7.9	2.1	11.8	17.7	28.6	4.8	6.8	10.4	7.9	11.6	14.2		3.1	4.1	1.8	1.2	0.8	1.3	3.0
7	11.3	22.5	16.6	10.5	6.7	10.8	3.3	38.2	36.7	39.7	15.6	26.0	39.2	13.9	15.1		23.5	3.0	12.8	7.6	3.9	1.6	2.5
8	19.1	14.3	58.2	47.2	6.4	10.9	26.9	9.9	65.4	44.9	81.9	35.8	75.1	73.9	23.4		70.3	41.8	24.6	28.3	29.1	10.4	2.0
9	15.1	13.0	22.4	99.9	26.2	7.1	11.2	48.5	21.0	62.7	81.5	76.6	67.9	96.4	54.4		60.6	84.8	96.9	33.1	63.8	38.1	5.9
10	28.9	11.1	26.1	43.7	95.0	17.3	16.6	12.7	45.6	24.9	85.7	37.4	106.4	58.7	69.0		62.9	56.3	151.8	86.4	48.1	93.8	36.7
11	102.7	17.6	18.9	20.7	11.5	111.2	32.0	17.0	19.3	44.2	26.3	36.1	63.2	100.9	32.5		103.8	41.3	90.8	100.7	87.5	56.9	72.1
12	16.2	67.8	19.1	16.8	14.2	23.6	116.3	39.7	13.4	19.6	37.5	19.0	55.1	45.9	57.4		74.2	68.6	69.7	52.9	97.2	95.7	58.4
13	10.1	6.2	104.5	20.8	7.9	23.6	20.0	111.3	26.6	15.4	18.0	23.8	13.5	42.9	28.6		43.3	47.5	67.5	47.6	54.3	87.8	65.7
14	16.8	5.3	10.1	147.1	8.0	7.9	11.5	12.4	103.9	26.8	15.1	8.2	18.2	10.2	19.6		39.1	26.5	50.4	41.7	45.3	41.9	54.9
15	33.9	7.2	7.6	6.0	51.4	9.2	9.8	10.8	13.6	82.1	18.3	6.8	9.1	18.3	9.1		19.6	31.7	27.0	40.3	35.8	27.4	27.3
16	16.1	10.0	7.8	9.6	5.3	58.9	10.4	6.1	9.6	9.5	75.4	16.9	7.8	6.9	10.9		16.7	18.7	26.6	21.1	31.9	28.8	20.2
17	1.9	6.9	14.1	10.9	2.5	4.3	45.4	7.5	6.0	6.7	8.7	49.4	13.1	6.4	4.7		6.1	12.8	17.1	20.0	20.3	35.6	21.9

Year/Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
18	1.7	3.9	7.6	11.1	2.5	5.0	4.6	32.7	6.1	3.7	4.3	10.4	36.6	7.4	3.1		5.9	7.2	12.3	10.0	22.1	17.8	21.1
19	4.3	2.0	0.5	8.4	4.6	3.6	3.0	4.5	21.6	5.0	2.8	4.5	6.2	28.4	6.6		3.9	5.2	6.0	10.0	16.1	14.7	12.9
20	6.6	1.4	3.2	3.9	6.5	4.1	3.2	1.6	3.1	22.0	3.1	1.5	5.7	4.7	22.2		3.9	4.5	5.9	9.9	8.9	16.8	11.3
21	1.1	0.8	2.3	2.8	1.0	3.7	3.9	1.1	1.8	2.5	17.8	4.0	2.1	2.1	3.1		3.5	4.8	4.8	3.3	3.0	11.5	6.0
22	5.0	1.5	0.8	1.0	1.6	2.3	3.2	2.7	1.7	2.1	2.0	13.8	2.3	1.3	1.2		18.3	2.4	3.6	2.5	3.9	4.8	10.3
23	3.9	2.4	2.2	2.1	0.4	0.3	0.8	1.1	2.5	2.4	1.7	1.3	11.0	2.0	1.6		2.9	18.2	3.4	2.1	3.7	6.1	6.9
24	4.6	0.8	0.4	0.6	1.0	0.5	0.4	0.3	0.0	0.9	1.0	1.3	1.4	10.2	0.7		2.0	2.6	12.7	1.1	2.8	4.8	2.8
25	3.9	2.7	1.4	2.8	0.8	0.3	0.5	0.3	1.2	1.2	1.7	0.2	0.8	0.8	5.7		1.2	1.2	1.5	13.1	3.4	2.9	2.6
26	0.9	1.1	0.2	1.2	0.7	0.5	0.6	0.2	0.4	0.3	0.9	0.6	0.9	1.0	0.6		1.7	1.1	0.9	1.5	15.0	2.6	2.9
27	0.9	0.2	0.9	2.9	0.5	0.8	0.3	0.3	0.0	0.1	0.9	0.3	1.2	1.3	0.4		7.5	0.8	0.9	1.4	1.0	13.9	2.6
28	0.8	0.4	0.5	1.5	0.7	0.5	0.2	0.0	0.2	0.2	0.2	0.0	0.6	0.2	0.7		0.4	8.7	0.5	1.6	1.0	1.7	11.5
29	0.1	0.0	0.5	1.2	0.5	0.2	0.7	0.1	0.2	0.0	0.4	0.4	0.8	1.6	0.4		0.4	0.5	3.3	1.0	0.9	1.8	1.5
30+	0.8	1.4	3.0	1.1	1.3	2.3	1.7	1.5	1.6	2.1	1.0	0.9	1.5	1.7	2.0		2.1	3.5	2.6	6.9	6.7	7.9	7.5
Total	360.0	214.6	341.6	492.7	271.8	322.1	352.7	393.2	436.4	429.4	515.6	391.3	557.2	565.9	393.5		582.5	499.2	696.9	546.3	608.9	629.0	472.0

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978–2017 as officially reported to ICES. Landings statistics for 2017 are provisional.

Year	Area				Total
	5.a	5.b	6	14	
1978	31 300	2 039	313	15 477	49 129
1979	56 616	4 805	6	15 787	77 214
1980	62 052	4 920	2	22 203	89 177
1981	75 828	2 538	3	23 608	101 977
1982	97 899	1 810	28	30 692	130 429
1983	87 412	3 394	60	15 636	106 502
1984	84 766	6 228	86	5 040	96 120
1985	67 312	9 194	245	2 117	78 868
1986	67 772	6 300	288	2 988	77 348
1987	69 212	6 143	576	1 196	77 127
1988	80 472	5 020	533	3 964	89 989
1989	51 852	4 140	373	685	57 050
1990	63 156	2 407	382	687	66 632
1991	49 677	2 140	292	4 255	56 364
1992	51 464	3 460	40	746	55 710
1993	45 890	2 621	101	1 738	50 350
1994	38 669	2 274	129	1 443	42 515
1995	41 516	2 581	606	62	44 765
1996	33 558	2 316	664	59	36 597
1997	36 342	2 839	542	37	39 761
1998	36 771	2 565	379	109	39 825
1999	39 824	1 436	773	7	42 040
2000	41 187	1 498	776	89	43 550
2001	35 067	1 631	535	93	37 326
2002	48 570	1 941	392	189	51 092
2003	36 577	1 459	968	215	39 220
2004	31 686	1 139	519	107	33 451

Year	Area				Total
	5.a	5.b	6	14	
2005	42 593	2 484	137	115	45 329
2006	41 521	656	0	34	42 211
2007	38 364	689	0	83	39 134
2008	45 538	569	64	80	46 251
2009	38 442	462	50	224	39 177
2010	36 155	620	220	1 653	38 648
2011	43 773	493	83	1 005	45 354
2012	43 089	491	41	2 017	45 635
2013	51 330	372	92	1 499	53 263
2014	47 769	201	60	2 706	50 736
2015	48 769	270	44	2 562	51 645
2016	54 041	165	50	5 442	59 698
2017	50 119	1 397	93	4 501	56 101
2018[1)]	48 014	1 330	80	4 004	53 428

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995–2018. It should be noted that the catch-at-age results for 1996 are only based on three samples, which explains that there are no specimens older than 23 years.

Year/Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
7	47	0	32	23	6	38	117	125	189	216	219	175	126	205	101	58	136	69	30	221	14	47	0	0
8	327	354	219	277	339	62	134	871	199	822	737	995	418	1,019	912	348	546	609	549	448	575	723	103	48
9	1,452	803	470	584	1,576	830	389	737	1,330	485	1,840	2,113	1,643	2,100	1,649	2,161	1,581	1,598	2,171	1,678	914	2,661	946	210
10	8,698	3,654	1,014	1,189	1,237	4,216	1,608	815	1,095	2,059	1,470	3,573	2,345	4,896	3,003	2,663	4,670	3,431	3,846	5,974	3,169	3,668	4,490	2,269
11	2,583	9,026	2,641	1,115	1,823	1,861	7,611	3,097	1,178	777	3,052	2,077	3,210	3,923	4,900	2,733	5,604	6,702	5,900	6,574	7,128	7,854	3,514	4
12	1,284	2,078	11,406	3,215	2,498	2,245	1,786	10,777	3,899	965	1,873	2,774	1,858	4,622	4,423	4,855	4,848	7,316	9,427	5,691	7,077	9,353	7,063	688
13	3,574	1,313	2,796	12,421	2,428	1,678	1,912	3,021	9,675	2,001	1,349	1,622	3,017	2,283	3,421	3,857	6,209	4,003	6,866	5,732	5,517	6,657	8,743	4,847
14	5,718	1,468	1,363	2,073	15,444	2,344	1,235	2,571	2,342	8,548	2,984	1,287	1,039	2,831	1,851	2,720	3,785	4,700	4,027	4,739	5,628	4,672	5,363	6,449
15	6,124	4,376	3,125	2,031	1,236	14,675	826	1,823	1,960	2,127	11,727	2,813	946	1,545	2,16	1,372	2,515	2,658	4,478	3,049	4,735	4,080	3,785	7,620
16	1,801	5,533	3,648	2,408	1,254	1,753	11,529	2,956	1,212	1,677	2,067	10,126	2,163	1,071	1,252	1,195	1,317	1,518	3,052	2,544	2,986	2,663	3,573	4,277
17	889	927	3,016	3,407	1,812	1,172	518	11,787	2,249	809	1,445	2,091	9,370	1,813	686	814	991	814	1,733	1,939	2,685	2,787	3,010	3,306
18	384	385	893	2,043	2,641	1,592	780	2,055	6,402	1,380	1,249	1,182	1,340	8,264	1,510	646	607	813	1,222	1,269	1,848	2,075	1,865	2,738
19	1,218	266	637	1,015	2,212	2,383	1,043	1,133	756	5,194	1,246	688	748	1,526	6,211	1,082	700	494	766	473	775	1,792	1,411	2,583
20	1,216	339	943	723	1,259	2,124	1,730	636	411	1,115	6,463	970	732	999	981	5,054	1,004	805	492	1,255	1,267	668	1,186	1,310
21	559	1,188	453	520	461	535	935	1,392	607	336	391	5,641	893	572	661	910	5,167	626	519	535	284	560	1,060	1,300
22	684	1,034	525	394	214	438	411	1,003	798	489	469	631	4,876	850	584	765	1,085	3,522	789	516	274	365	438	718
23	1,574	814	673	424	331	270	411	723	754	618	795	229	753	4,217	348	572	773	474	3,346	504	211	230	489	599

Year/Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
24	709	0	584	660	216	63	164	372	392	567	619	377	113	392	2,601	670	208	340	234	3,310	424	251	313	283
25	824	0	734	520	848	392	123	288	300	258	420	472	627	260	100	2,168	143	224	20,	188	1,829	315	325	343
26	407	0	275	399	270	337	114	180	74	105	100	73	341	443	97	284	1,406	236	173	203	243	1,433	148	207
27	384	0	139	427	615	198	275	80	83	183	279	263	353	343	201	398	79	1,443	110	143	213	182	1,266	36
28	808	0	202	357	229	516	189	296	27	141	169	204	205	172	96	132	205	198	937	58	187	30	87	1,730
29	0	0	143	53	106	364	146	498	105	138	29	168	37	178	390	187	45	71	38	692	87	26	192	26
30+	251	0	408	493	768	1,102	1,080	1,333	539	678	1,599	976	1,211	913	449	512	149	424	423	33	700	941	756	1,189
Total	41,515	33,558	36,339	36,771	39,823	41,188	35,066	48,569	36,576	31,688	42,591	41,520	38,364	45,537	38,443	36,156	43,773	43,088	51,328	47,768	48,770	54,043	50,117	48,014

Table 19.4.1 Results from the Gadget model of total biomass, spawning stock biomass, recruitment at age 5, catch and fishing mortality, projections are in italic. All weights are in thousand tonnes.

Year	Biomass	SSB	$R_{(age5)}$	Catches	F_{9-19}
1971	616035	391613	218.3	67880	0.092
1972	614855	380946	189.3	50890	0.073
1973	653534	384985	444	43719	0.064
1974	684074	395085	208.9	50598	0.072
1975	701055	401476	129.2	61920	0.086
1976	704695	395918	211.7	94420	0.133
1977	713547	397844	198.3	53753	0.079
1978	740176	420352	126.2	48736	0.066
1979	757096	436570	159.5	77212	0.100
1980	747206	437729	105.6	89143	0.114
1981	717974	427858	75.1	101966	0.136
1982	661095	398935	63.3	130322	0.185
1983	595897	362748	67.4	106050	0.163
1984	543435	334028	73.7	95288	0.155
1985	506208	311013	131.8	78531	0.132
1986	475989	291454	121.7	76908	0.140
1987	440131	269224	65.1	76559	0.152
1988	392737	238752	41.3	89804	0.205
1989	352231	212571	44.9	56645	0.145
1990	351135	196612	353.0	66314	0.192
1991	330175	179652	59.0	56015	0.180
1992	311654	166132	40.0	55826	0.198
1993	295451	155027	53.6	50179	0.196
1994	285229	149252	63.3	42520	0.174
1995	303237	148736	335.4	44263	0.184
1996	308831	151132	87.5	35595	0.145
1997	308716	153024	41.0	38996	0.155
1998	310648	157912	41.6	39694	0.155

Year	Biomass	SSB	$R_{(age5)}$	Catches	F_{9-19}
1999	308034	158914	83.2	42463	0.165
2000	303203	160684	52.0	42607	0.161
2001	309078	164556	111.0	36744	0.133
2002	311525	165076	121.6	50730	0.181
2003	324866	168167	179.3	38219	0.137
2004	341408	178515	110.4	32766	0.113
2005	360083	186135	170.8	46619	0.159
2006	383158	195346	173.4	42108	0.145
2007	398937	206210	111.4	39154	0.130
2008	424105	222962	138.5	46195	0.145
2009	458130	239893	222.7	39301	0.116
2010	497663	265753	174.3	38504	0.103
2011	522494	289874	91.4	45146	0.112
2012	540454	307070	130.1	45423	0.105
2013	549306	324289	64.3	53223	0.116
2014	538736	331802	21.9	50697	0.105
2015	524645	338145	4.9	51621	0.103
2016	498429	334077	12.3	59697	0.117
2017	472748	327515	23.3	56334	0.111
2018	441018	312332	41.7	52824	0.107
2019	*415073*	*299040*	*41.7*	*45882*	*0.098*
2020	*391292*	*285401*	*41.7*	*43568*	*0.097*
2021	*368396*	*270513*	*41.7*	*40839*	*0.097*
2022	*347209*	*255469*	*41.7*	*38063*	*0.097*
2023	*328067*	*240956*	*41.7*	*35437*	*0.097*

Table 19.4.2 Output from short term prognosis. Multiplier is based on reference to the adopted HCR F_{9-19} = 0.097. Biomasses are in the beginning of the year to apply to ICES standard in short term prognosis in other places in the report they are in the middle of the year. All weights are in thousand tonnes.

F(2018) = **0.107** C(2018) = **53 348 t**

2019				
Bio 5+	SSB	F_{mult}	F_{9-19}	Landings
424192	339997	1.00	0.106	52824

			2020		2021	
F_{mult}	F_{9-19}	Bio 5+	SSB	Landings	Bio 5+	SSB
0.0	0	424191	346011	20	445987	369498
0.1	0.01	421898	343978	4751	438876	363064
0.2	0.019	419605	341945	9397	431850	356709
0.3	0.029	417312	339912	13959	424908	350431
0.4	0.039	415019	337879	18438	418051	344230
0.5	0.049	412726	335846	22834	411277	338107
0.6	0.059	410433	333813	27147	404587	332059
0.7	0.069	408139	331780	31378	397979	326087
0.8	0.079	405846	329748	35528	391453	320190
0.9	0.089	403553	327715	39597	385009	314368
1.0	0.099	401260	325682	43585	378645	308621
1.1	0.109	398967	323649	47494	372362	302947
1.2	0.119	396674	321616	51323	366159	297346
1.3	0.129	394381	319583	55073	360036	291818
1.4	0.139	392088	317550	58746	353991	286363
1.5	0.149	389794	315517	62340	348025	280980
1.6	0.160	387501	313484	65857	342137	275667
1.7	0.170	385208	311452	69297	336326	270426
1.8	0.180	382915	309419	72661	330592	265255
1.9	0.191	380622	307386	75949	324934	260154
2.0	0.201	378329	305353	79162	319352	255123

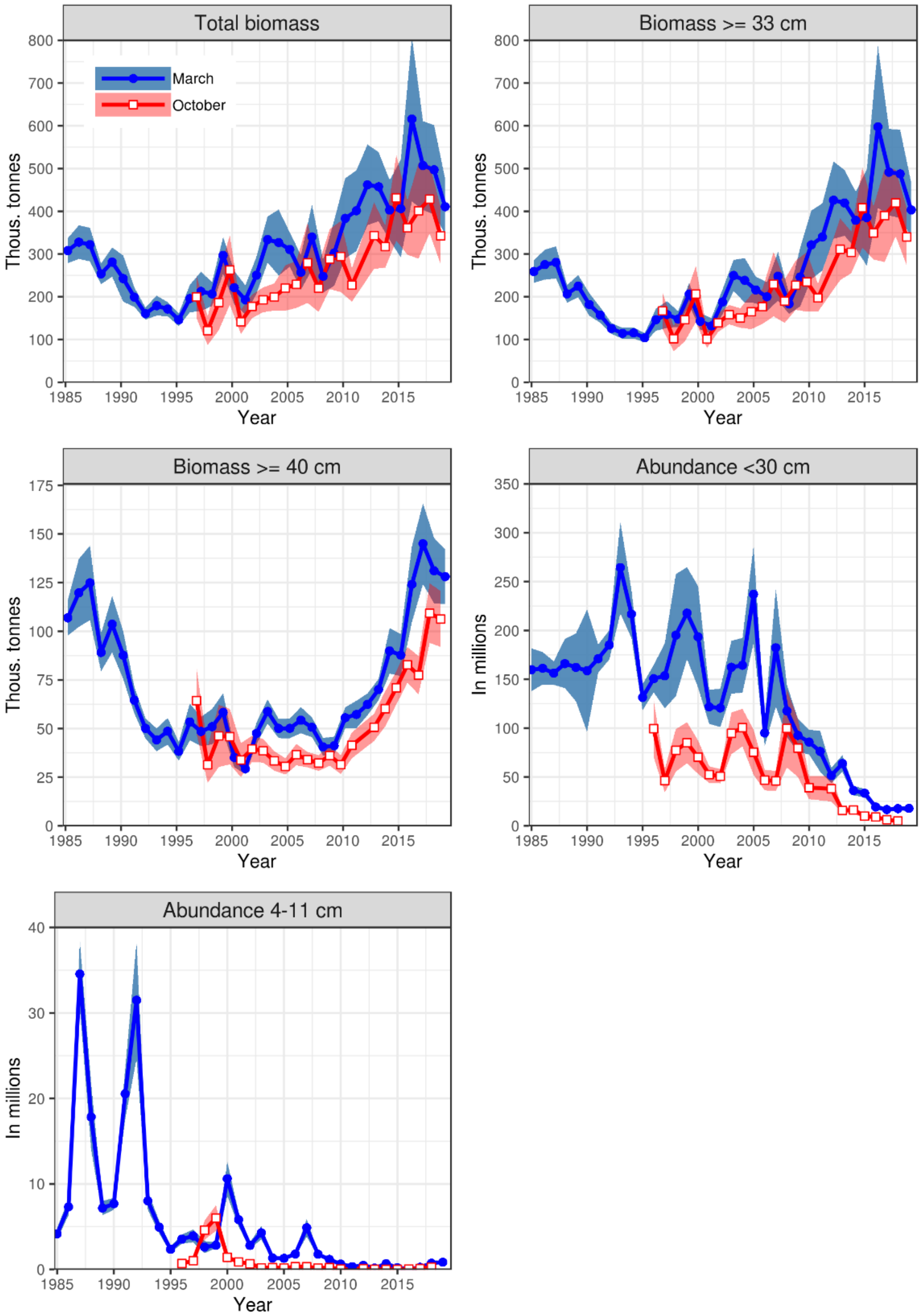


Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985–2019 (blue line and shaded area) and October 1996–2018 (red lines and shaded areas). The shaded areas show ±1 standard error of the estimate.

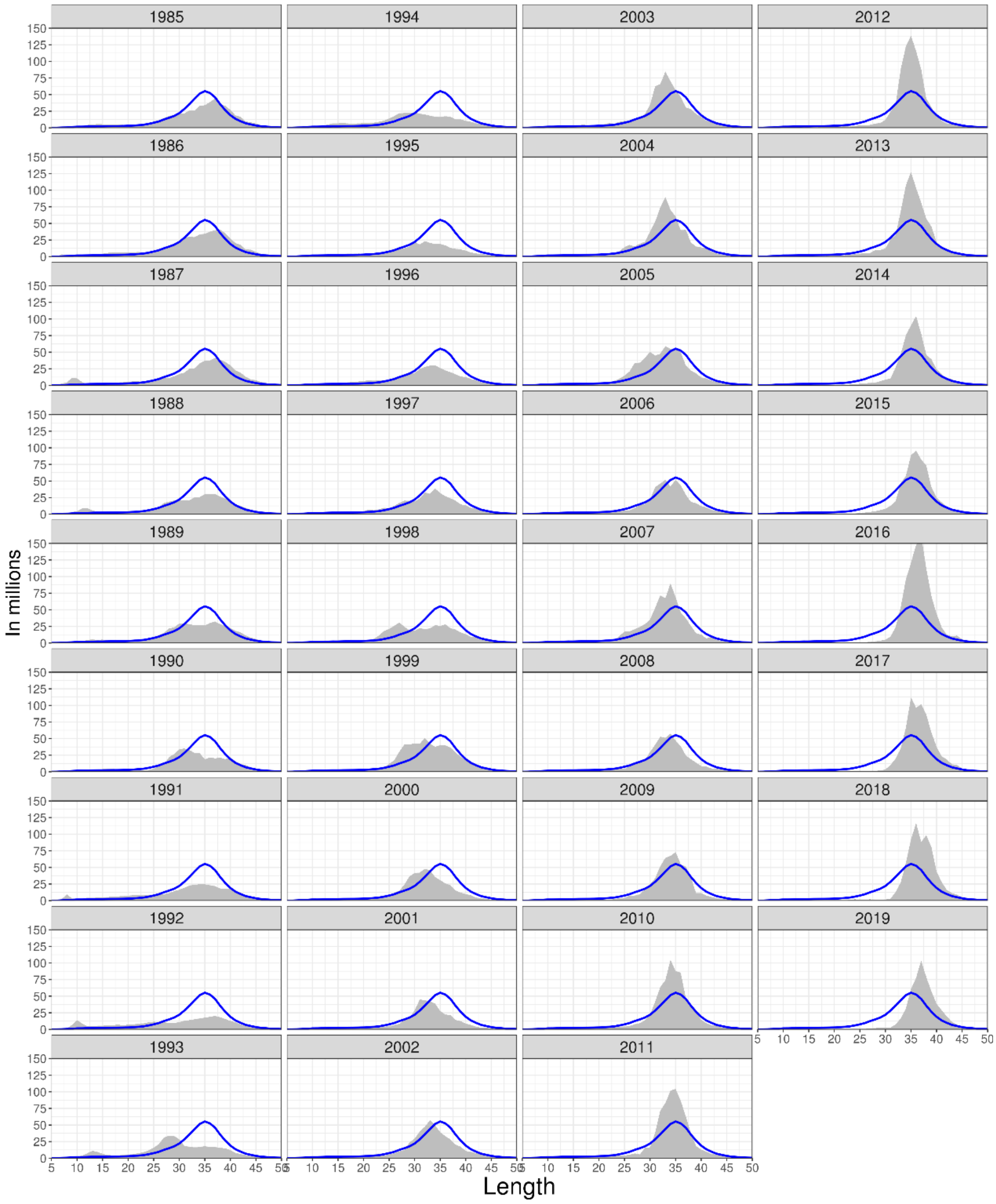


Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985–2019 conducted in Icelandic waters. The blue line is the mean of total indices 1985–2019.

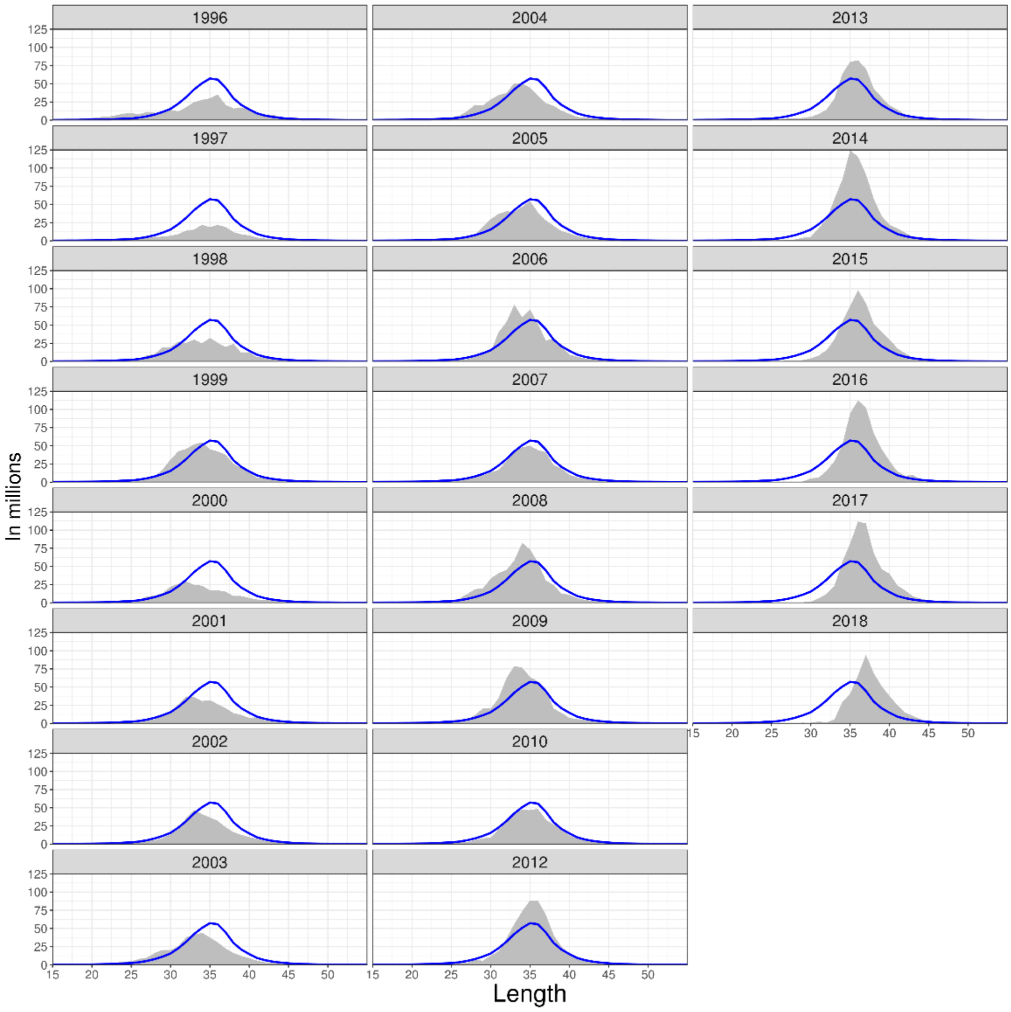


Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996–2018 conducted in Icelandic waters. The blue line is the mean of total indices 1996–2018. The survey was not conducted in 2011.

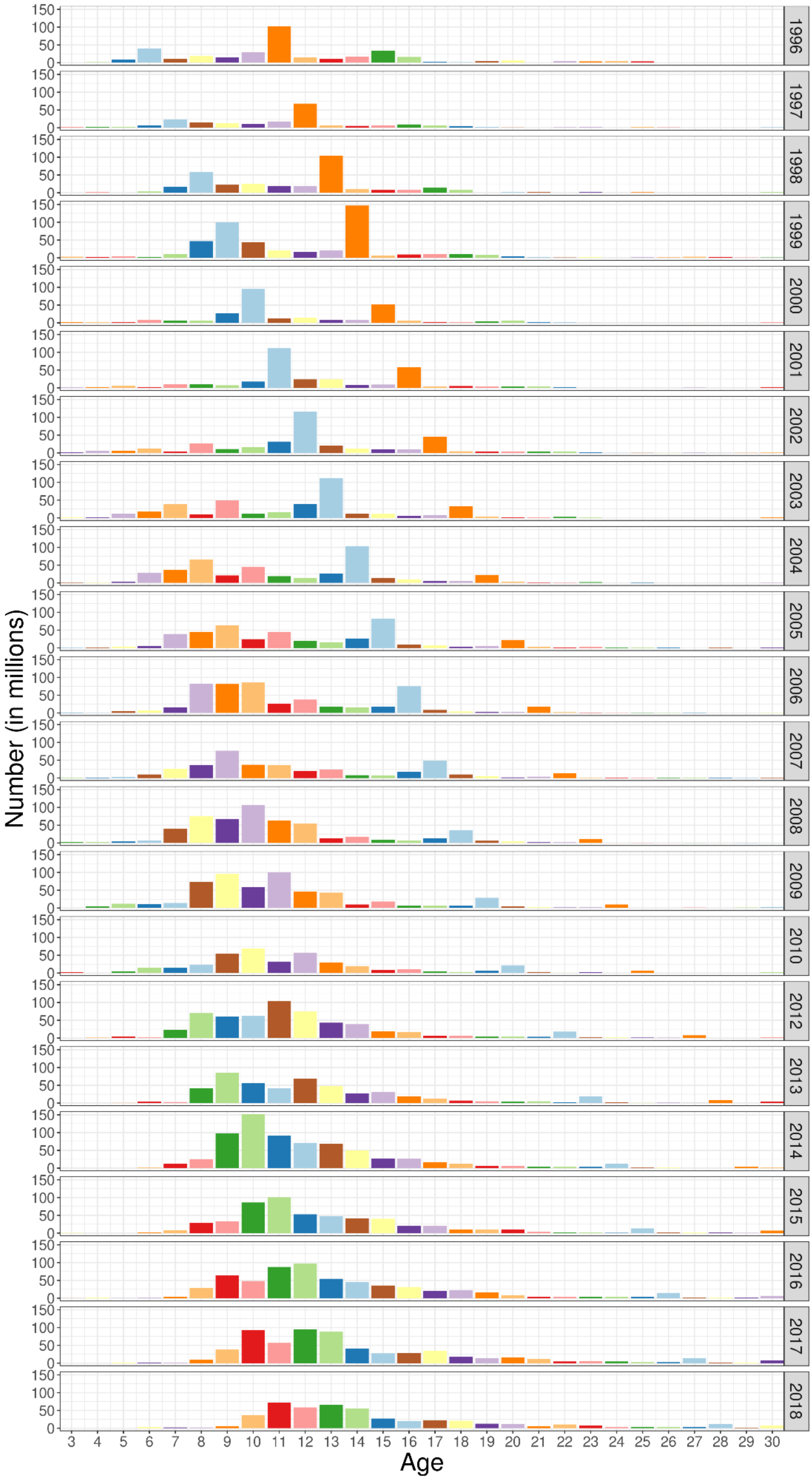


Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996–2018. The survey was not conducted in 2011.

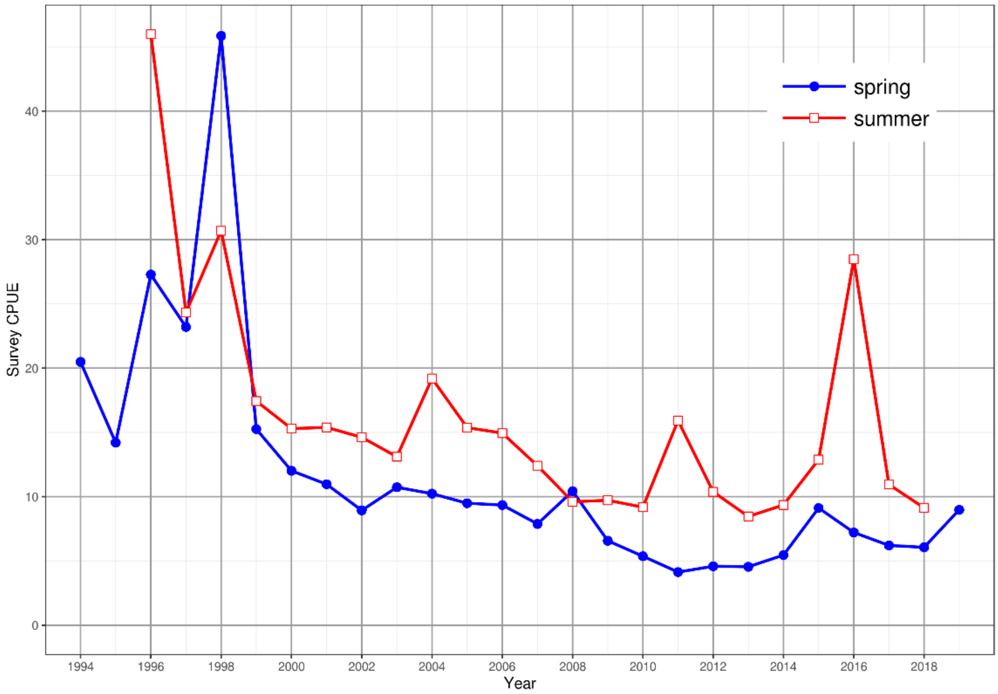


Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994–2019 (blue line) and the summer groundfish survey 1996–2018 (red line) in ICES Division 5.b.

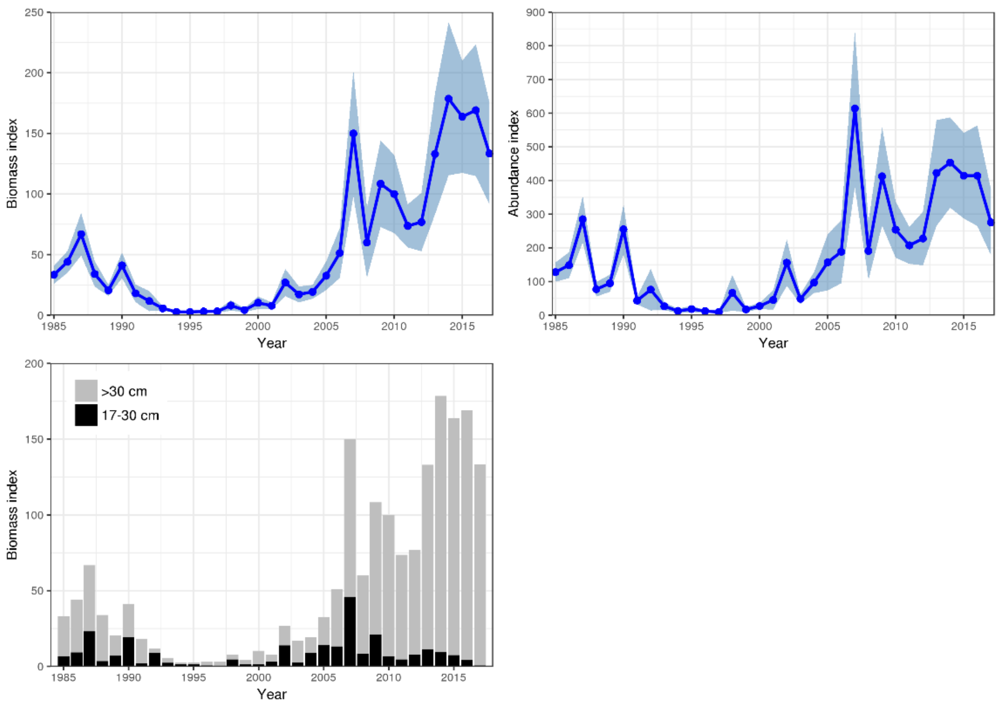


Figure 19.2.6 Golden redfish (> 17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985–2017. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17–30 cm and > 30 cm). No survey was conducted in 2018.

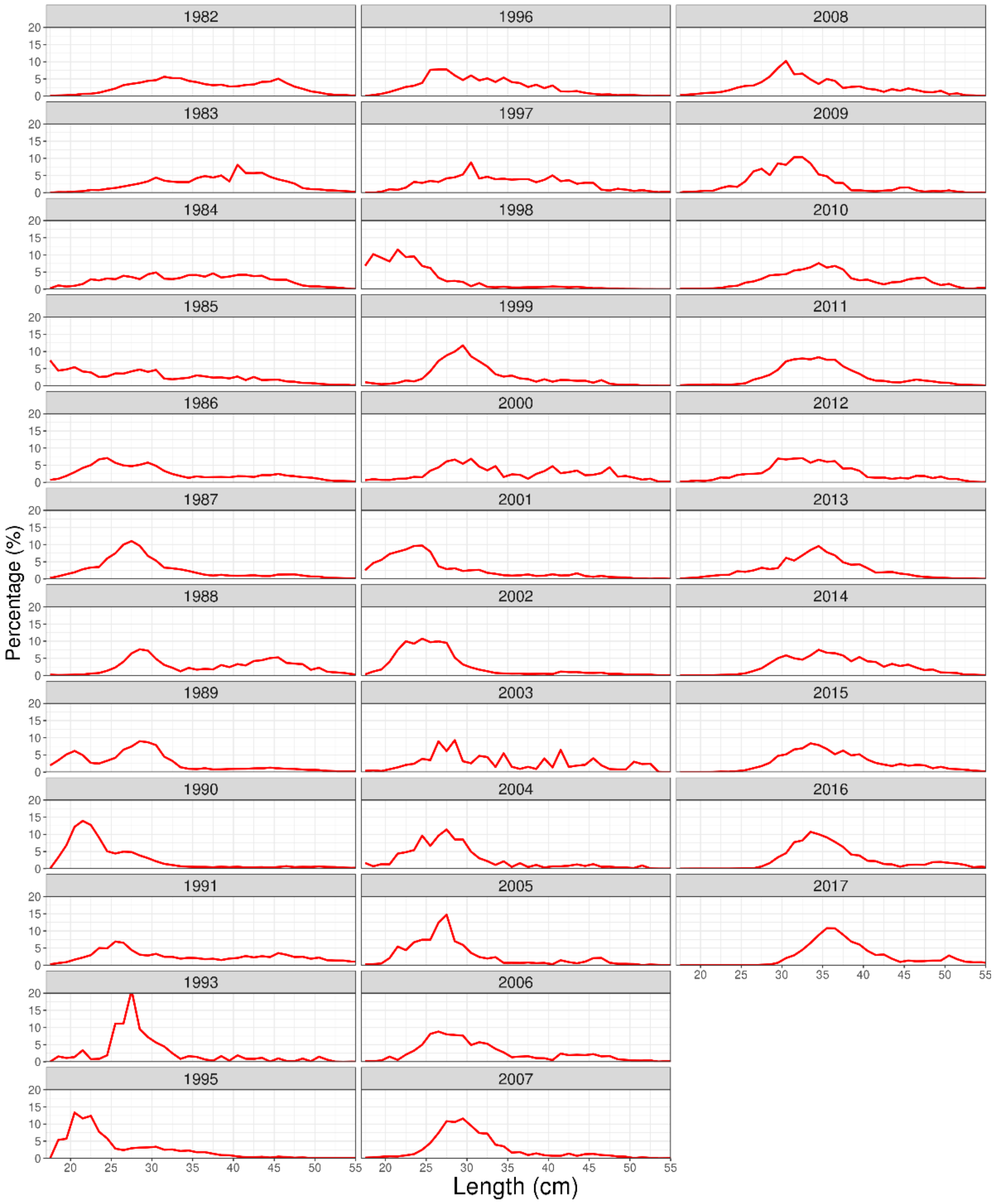


Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982–2017. No survey was conducted in 2018.

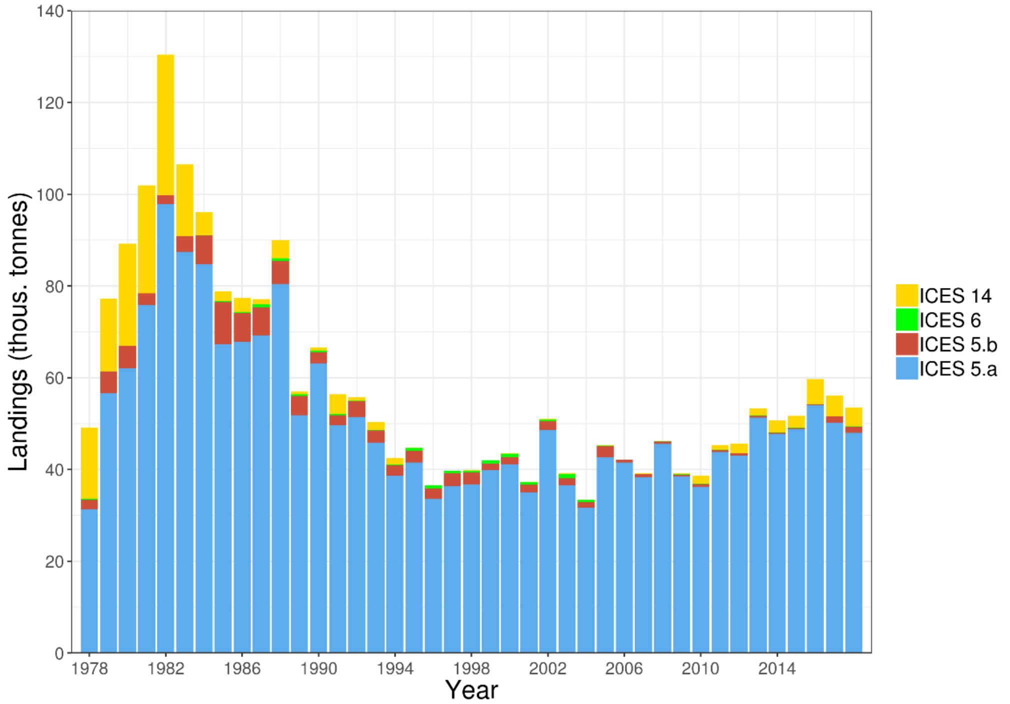


Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978–2018. Landings statistics for 2018 are provisional.

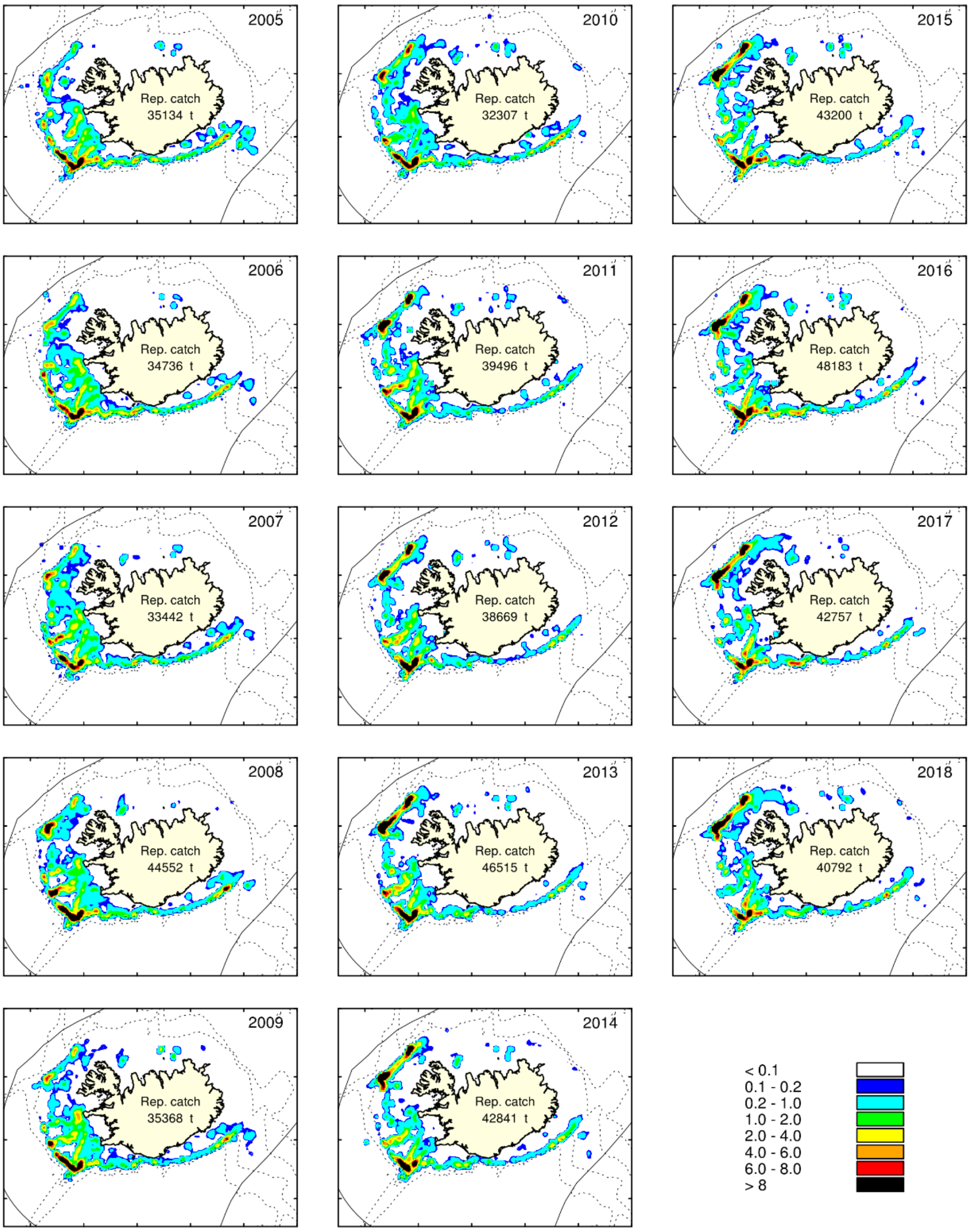


Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2005–2018.

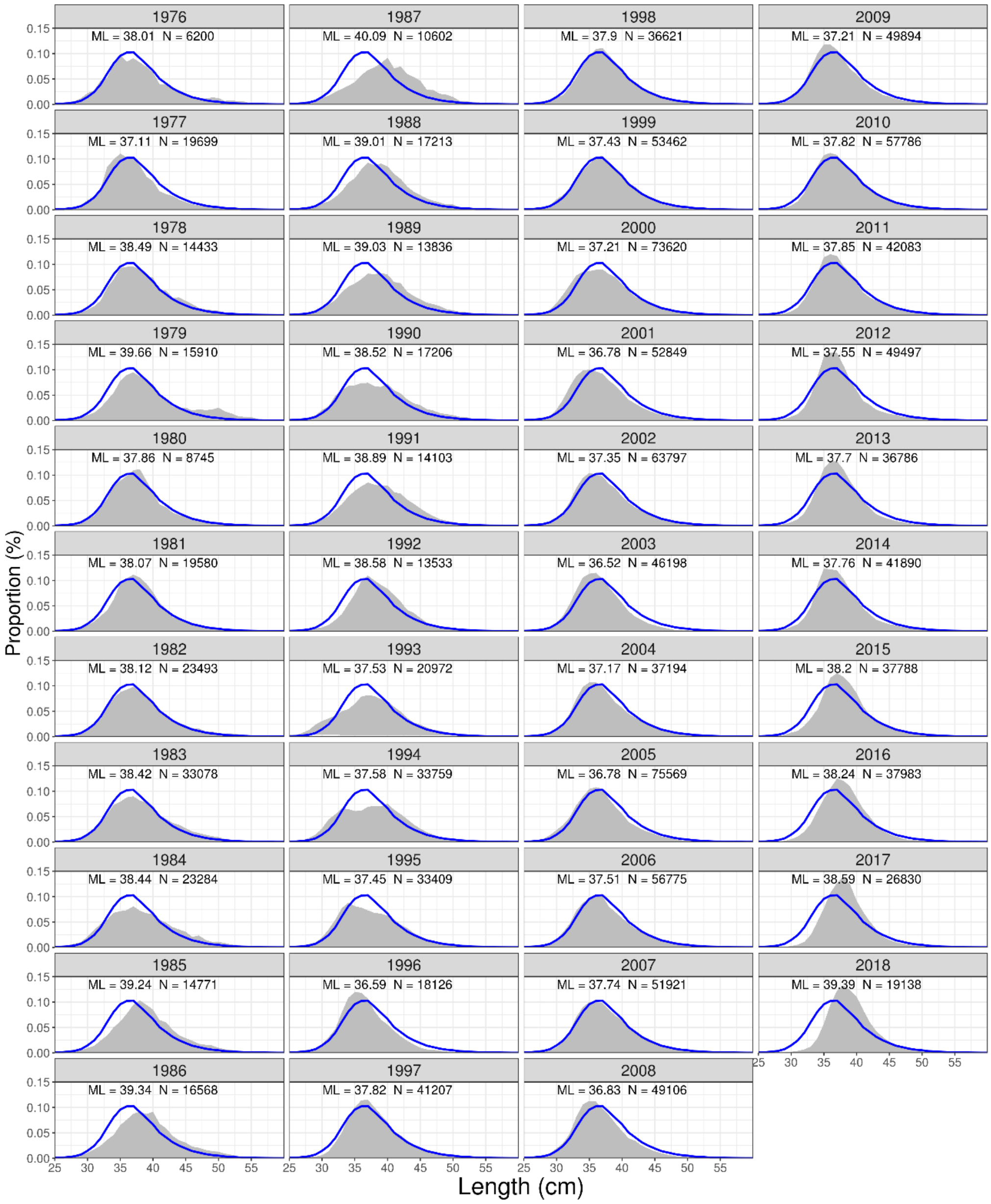


Figure 19.3.3 Length distribution (grey shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976–2018. The blue line is the mean of the years 1976–2018.

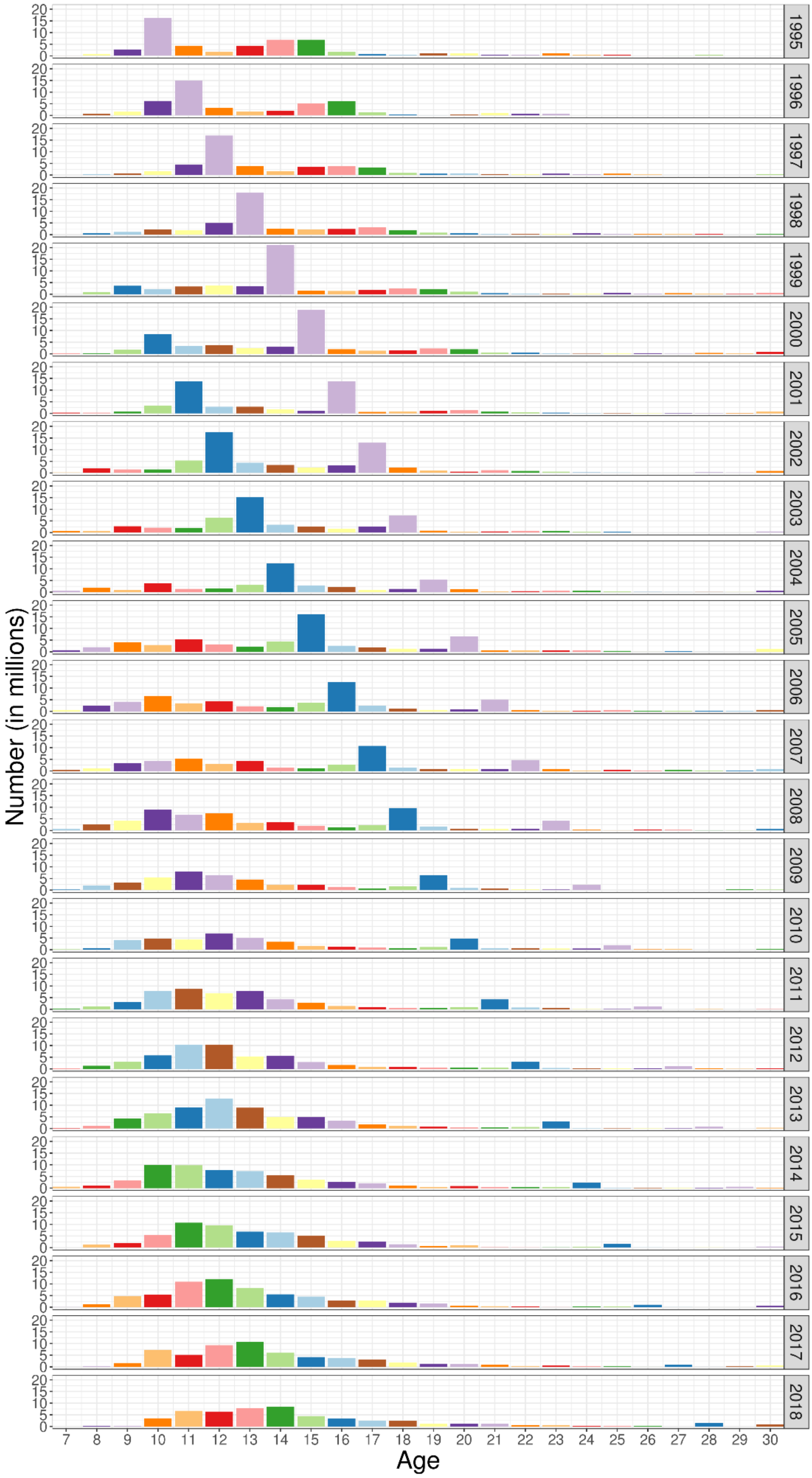


Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Division 5.a 1995–2018.

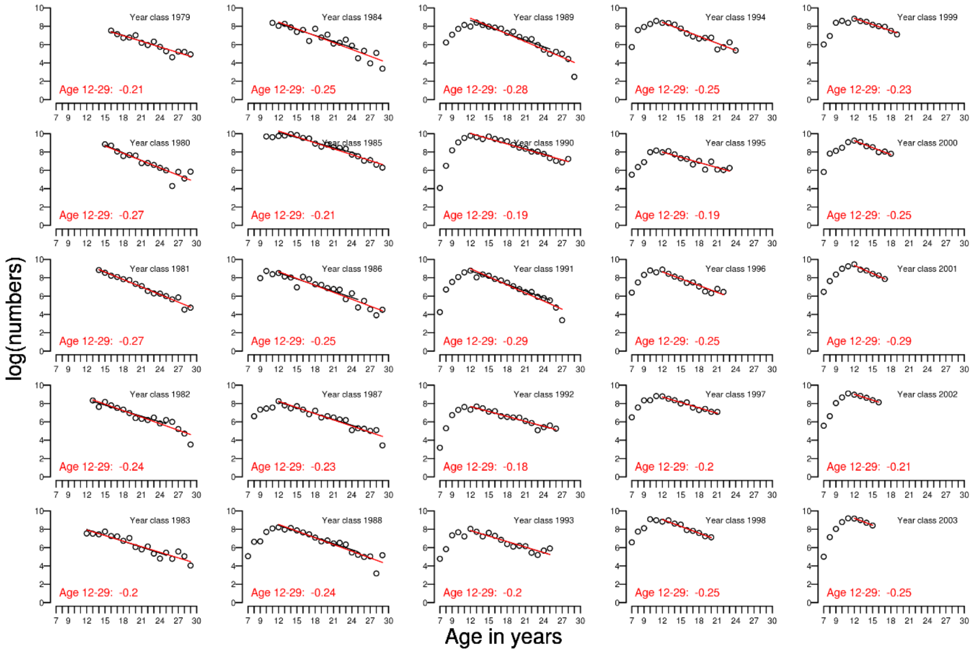


Figure 19.3.5 Catch curve of the 1979–2003 year-classes of golden redfish based on the catch-at-age data in ICES Division 5.a 1995–2018.

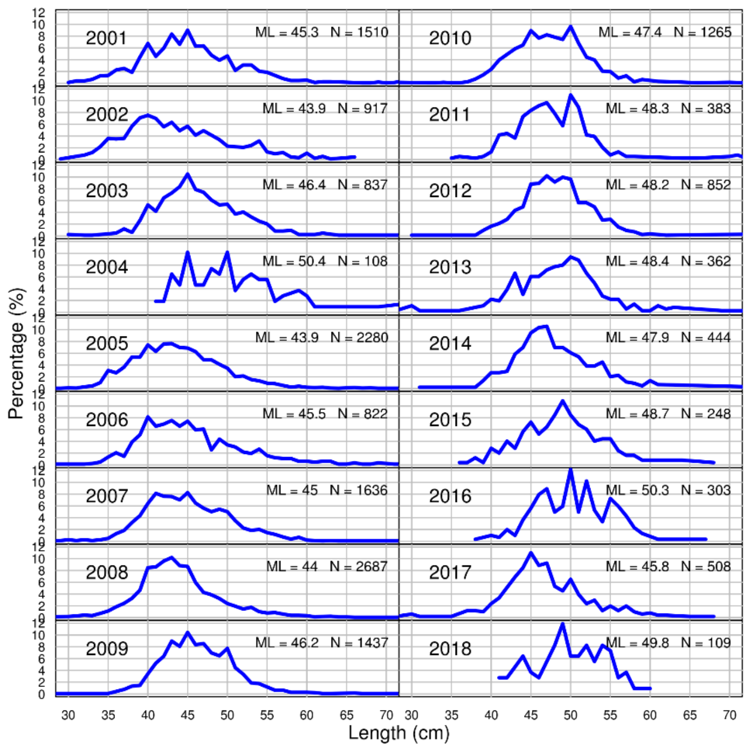


Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001–2018.

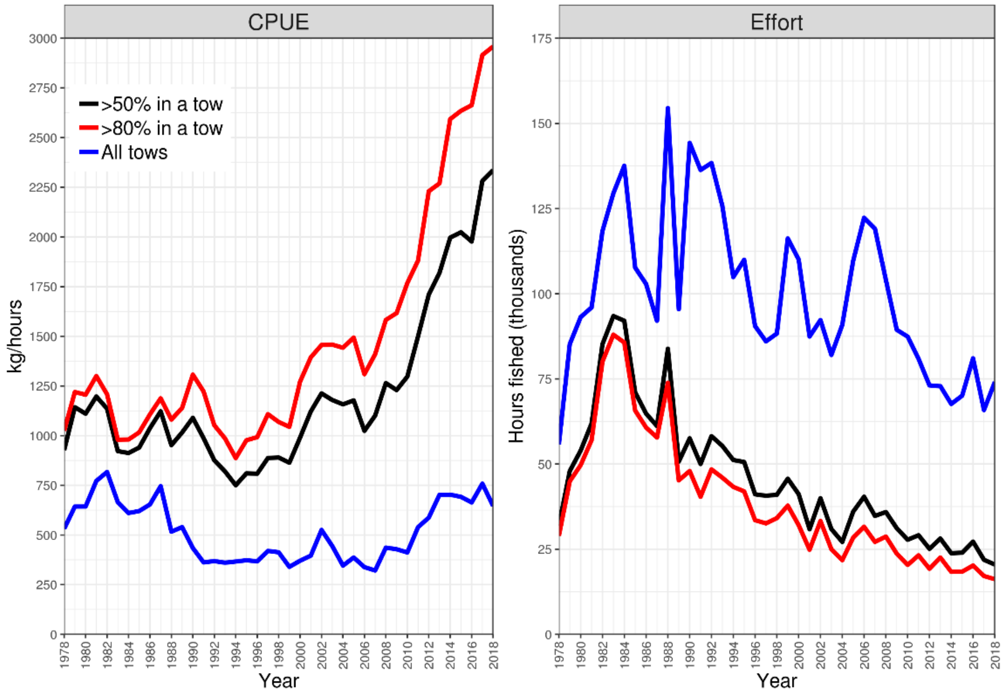


Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978–2018 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

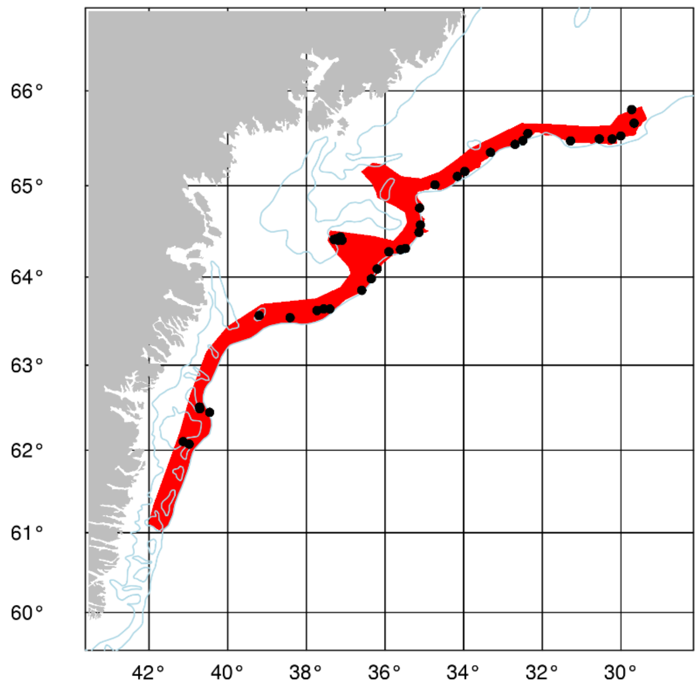


Figure 19.4.1 Stations in the German survey in East Greenland with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

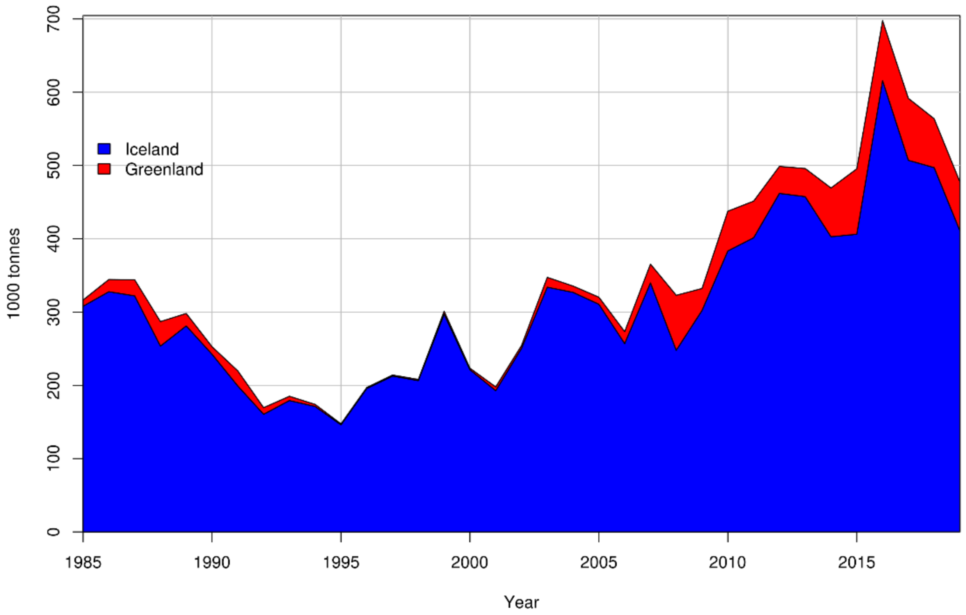


Figure 19.4.2 Biomass index from Iceland (blue) and Greenland black, based on weighting the German survey data in Figure 19.2.7 by 0.5. In 2019, the survey index is based on the Icelandic survey and 2017 values from the Greenland survey due to lack of 2018 Greenland survey data (not conducted).

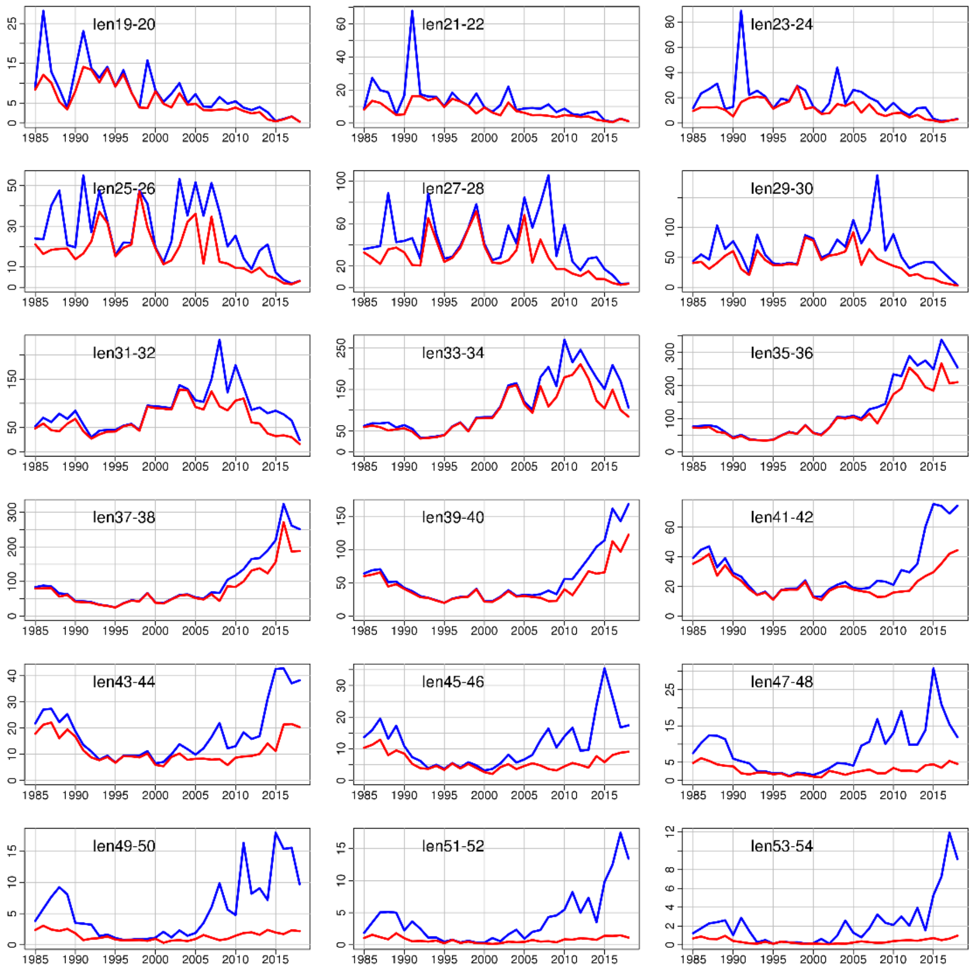


Figure 19.4.3. Indices from the Icelandic March survey (red) and the Icelandic March survey +German survey in East Greenland (blue) by length group.

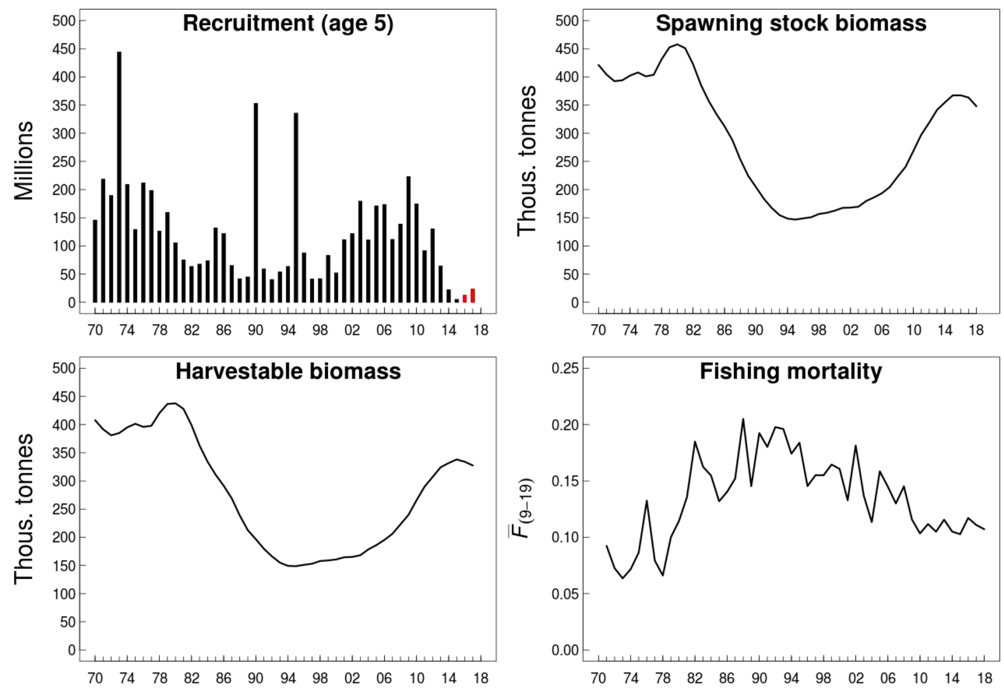
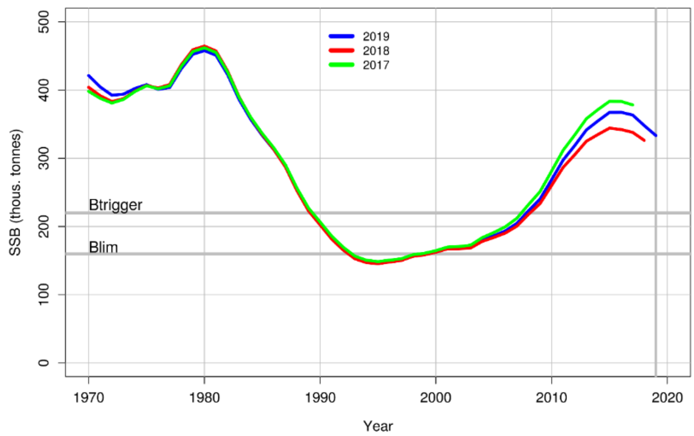
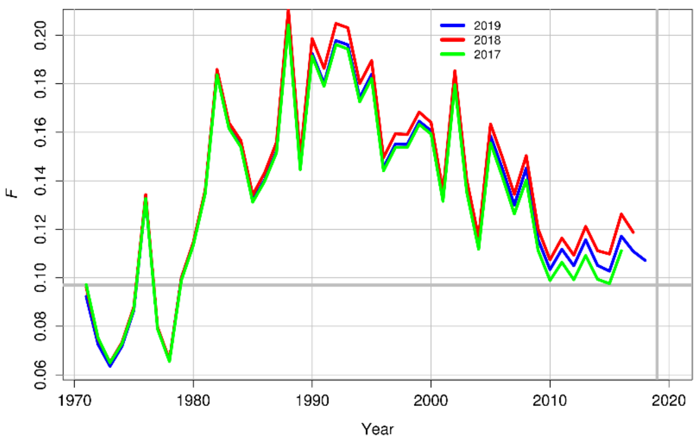


Figure 19.4.4. Summary from the assessment. Red values are predictions. Spawning stock is compiled using a fixed maturity ogive with L_{50} = 33 cm. PUT reference points to the plot!

a)



b)



c)

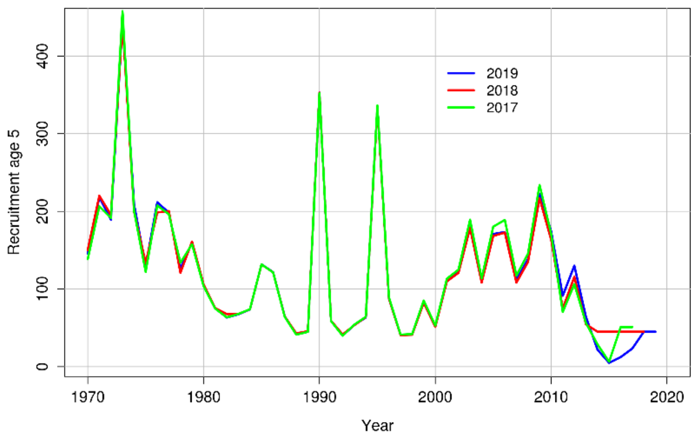


Figure 19.4.5. Comparison of the current assessment and the same assessment done in 2016 and 2017 for the spawning stock biomass (a), fishing mortality (b) and recruitment (c).

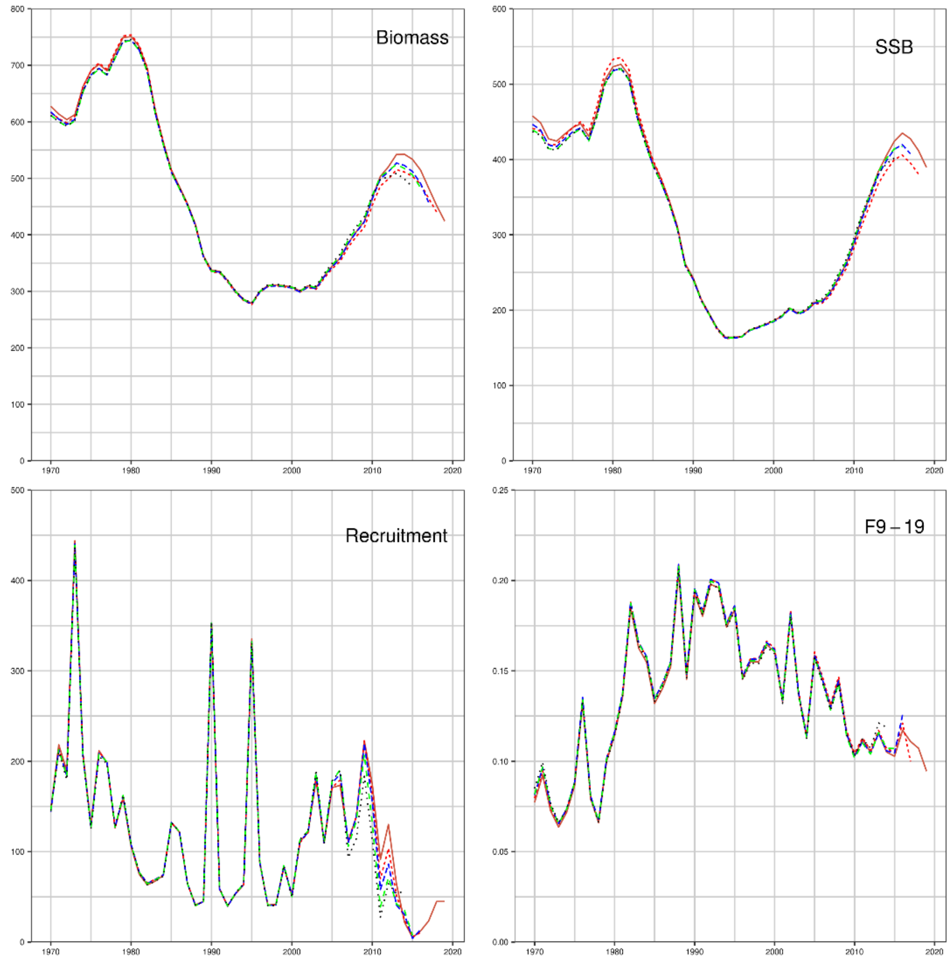


Figure 19.4.6. Analytical retrospective pattern of the base run. Recruitment is at age 5 and F shows the development of ages 9–19.

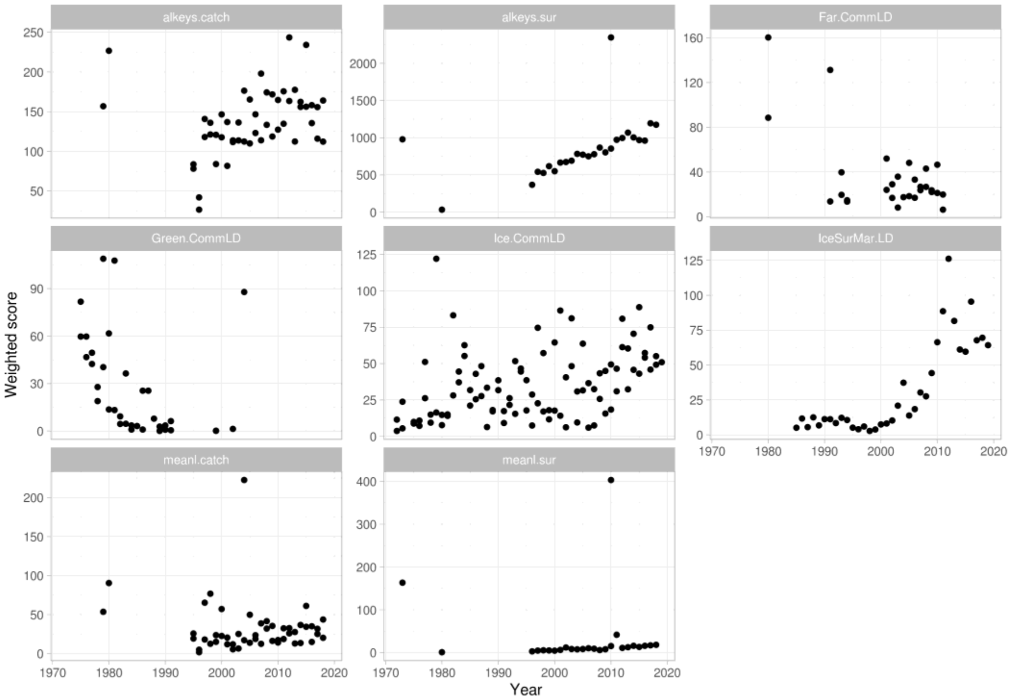


Figure 19.4.7. Development of component of the objective function with time.

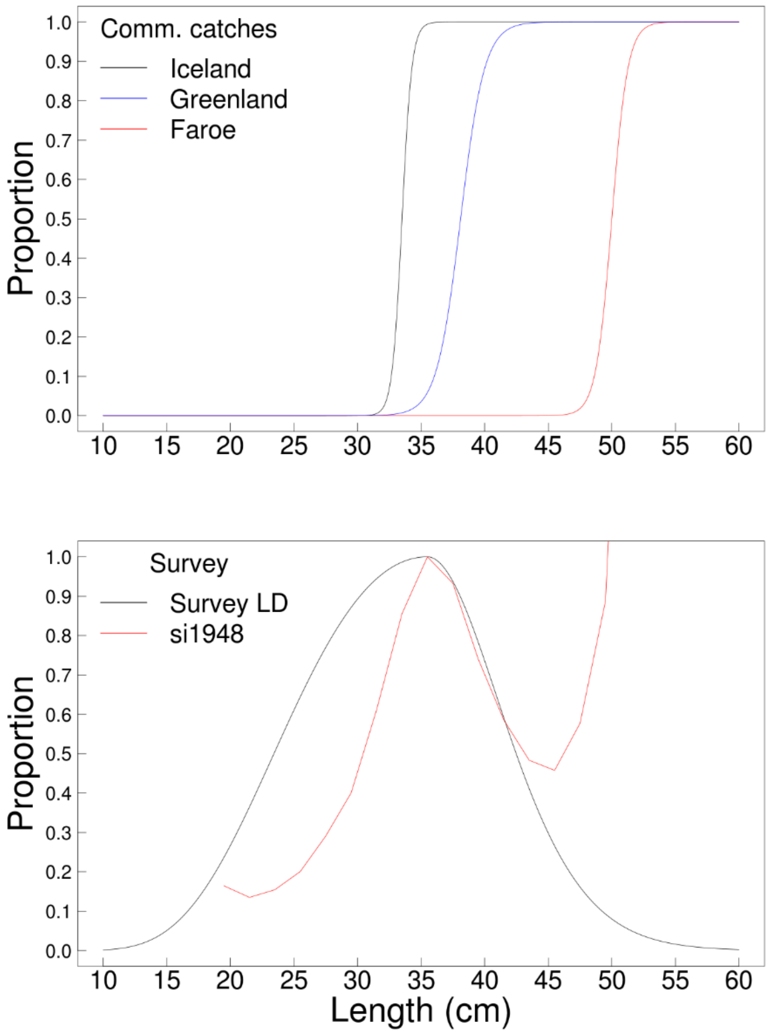


Figure 19.4.8. Estimates of selection curves from commercial catches (upper panel) and from the Icelandic March survey. The black line is the estimated selection curve fitted to the length distributional data based on 3 parameter dome-shaped curve and the red line is the estimated q from the disaggregated tuning indices in 2 cm length groups, scaled to one.

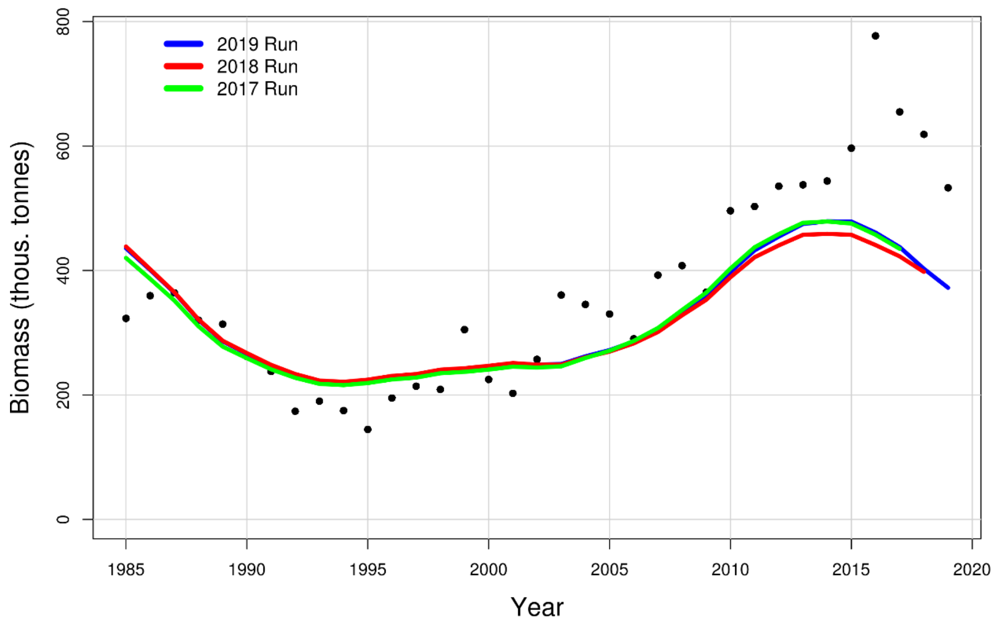


Figure 19.4.9. Comparison of observed and predicted survey biomass from the 2019 (blue line), 2018 (red line) and 2017 (green line) assessment runs.

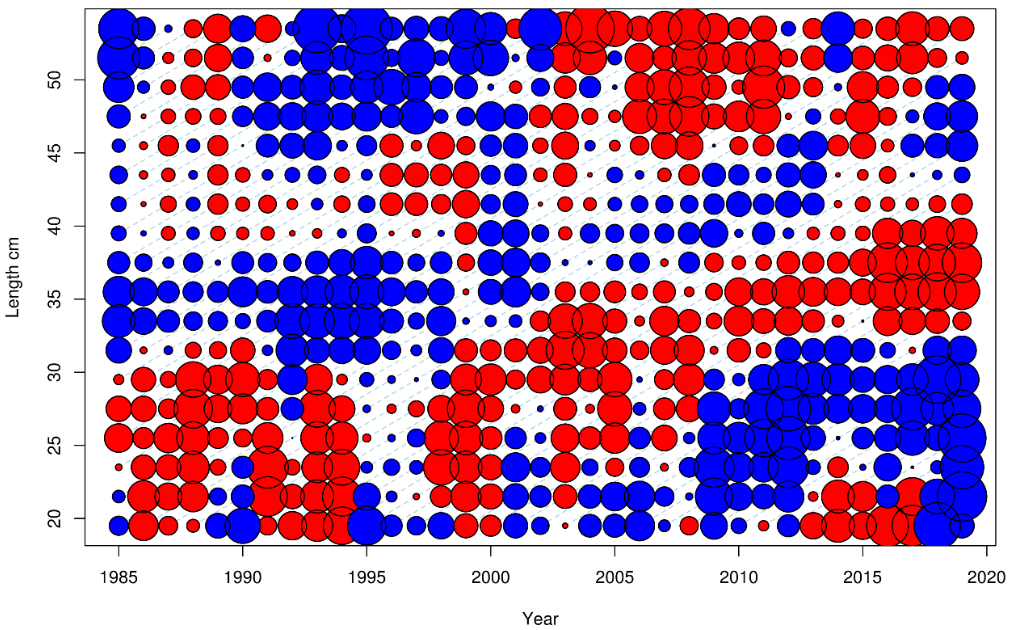


Figure 19.4.10. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

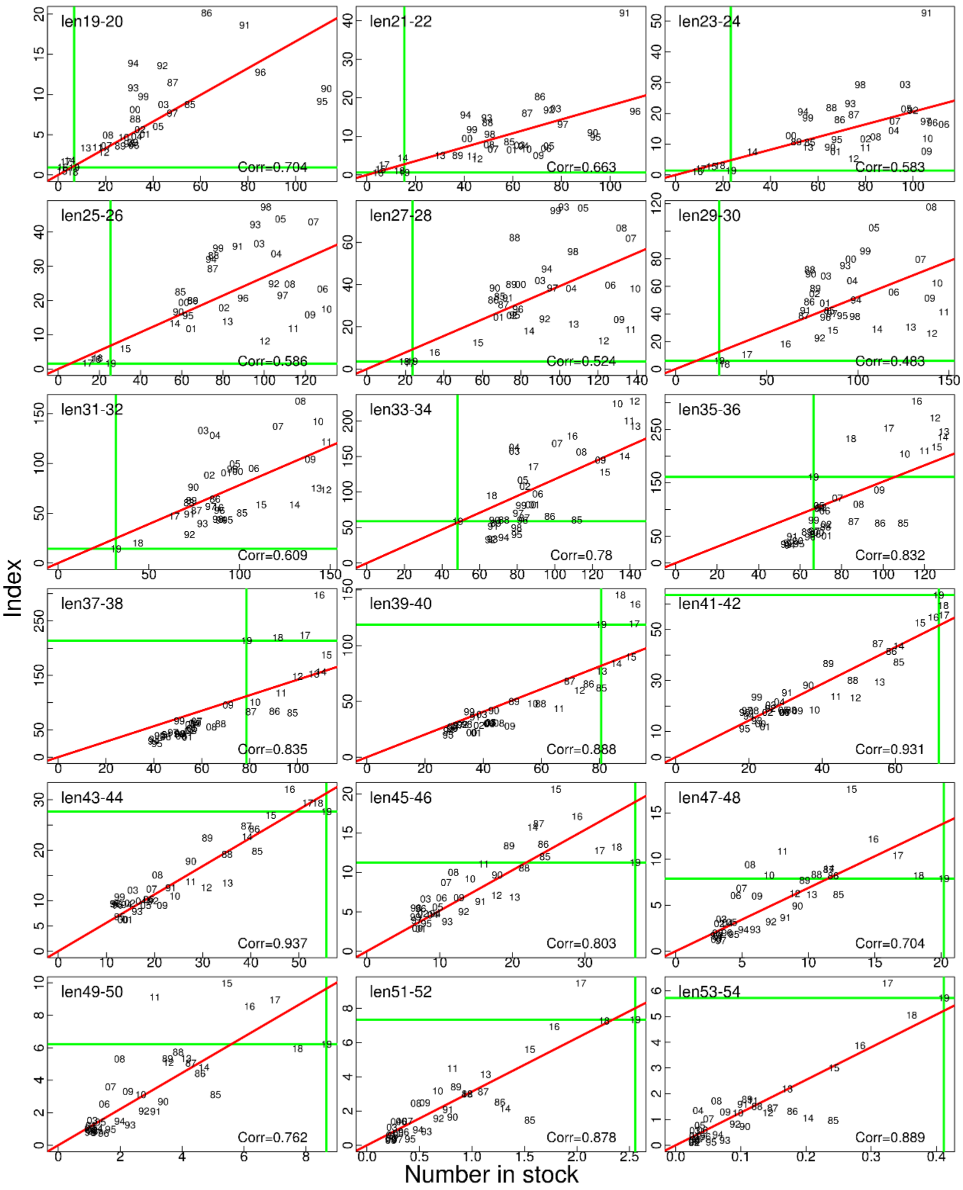


Figure 19.4.11. Fit to length disaggregated survey indices from Gadget run as XY-scatter. The red line is fitted going through the 0-point, the green cross goes over the terminal year.

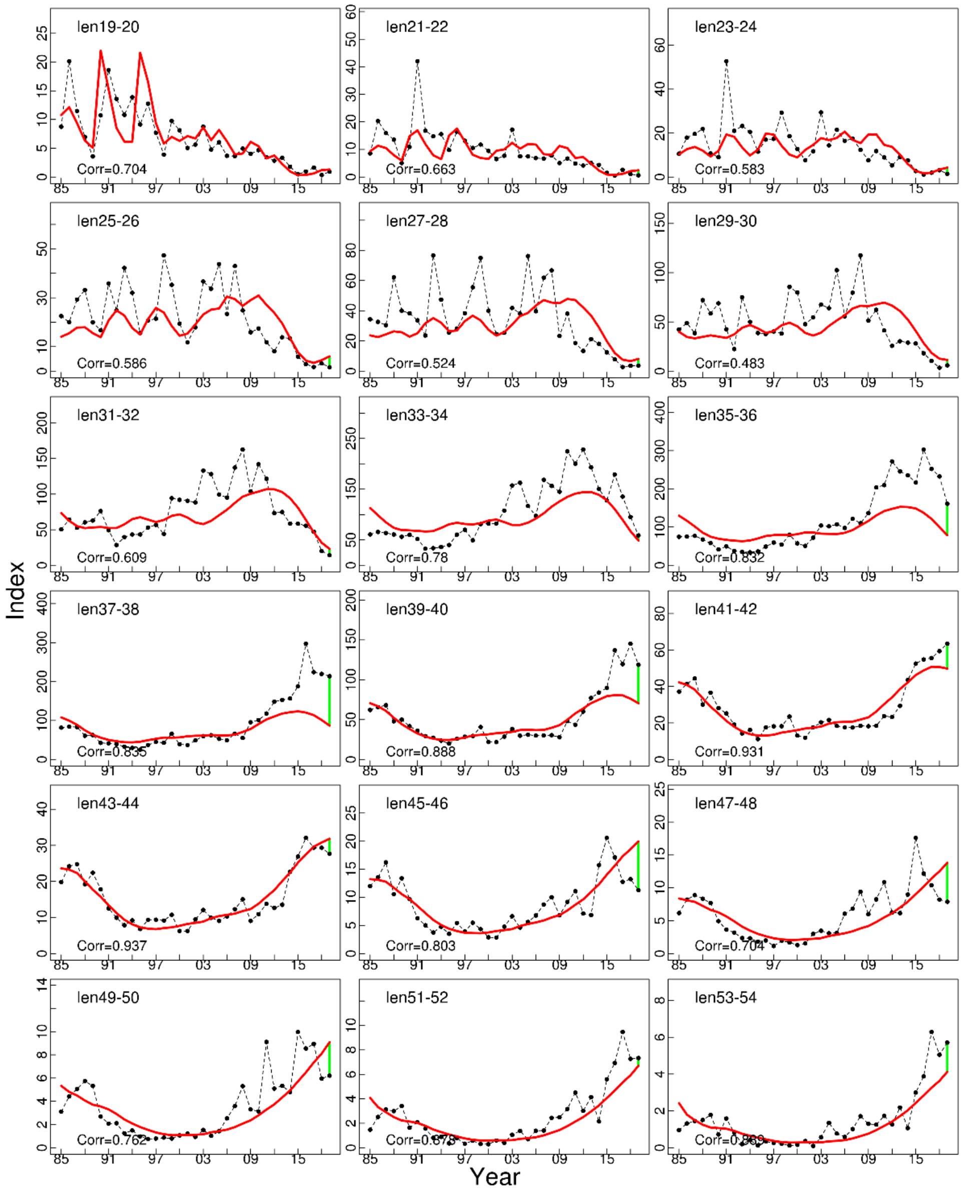


Figure 19.4.12. Fit (red lines) to length disaggregated survey indices (broken lines and points) from Gadget run as time series.

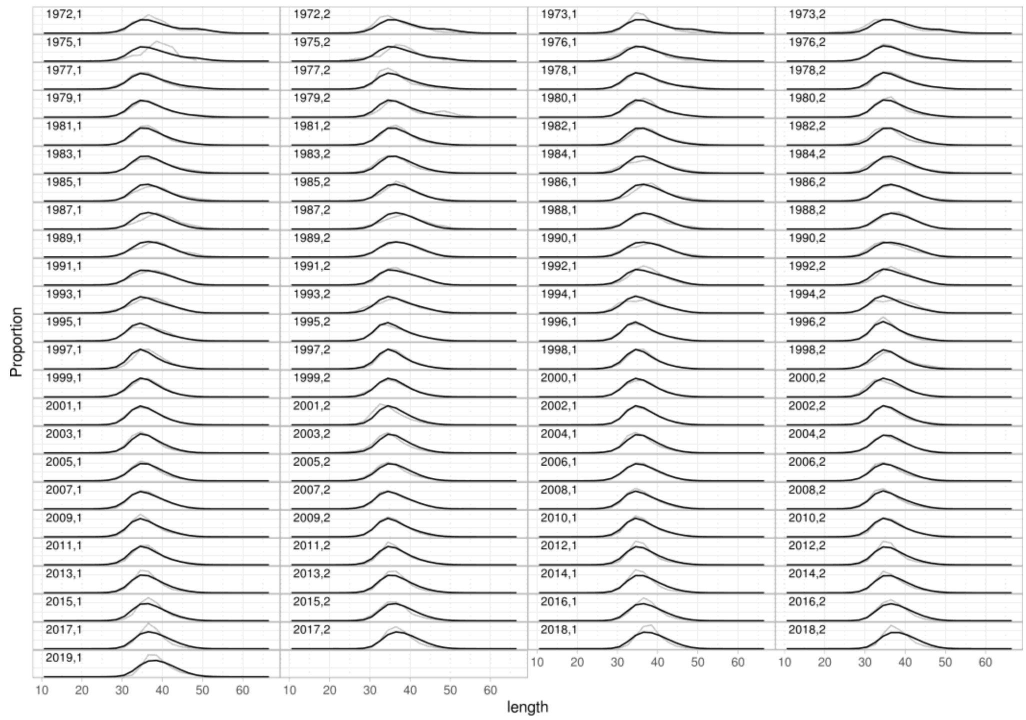


Figure 19.4.13. Fit (red line) to Icelandic commercial length distributions aggregated by 3 years.

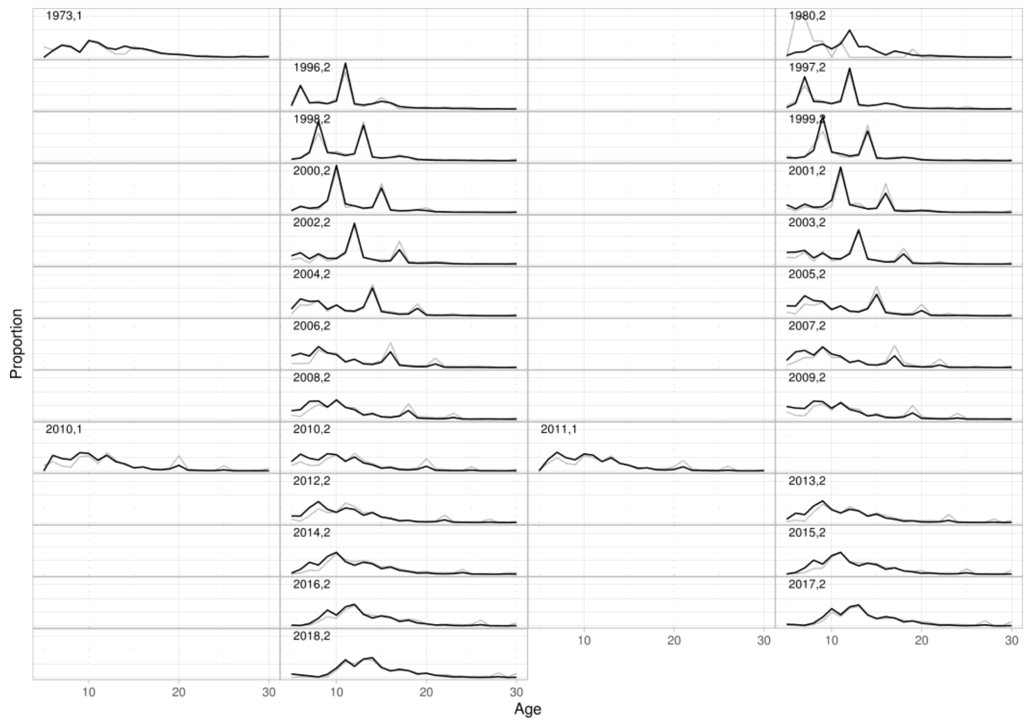


Figure 19.4.14. Fit to survey age data (run 1). Bars represent the data and red lines the fit. The likelihood data are used in the model as proportions in each 2 cm length group but presented here as total for each age group something that should only be comparable if catchability was independent of size (age).

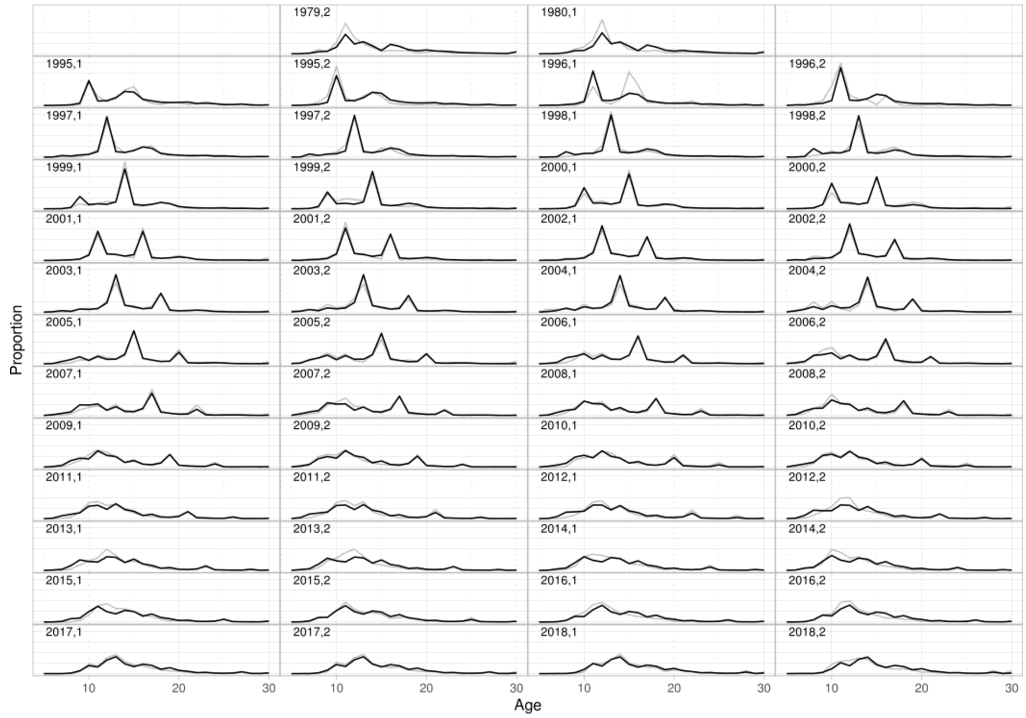


Figure 19.4.15. Predicted (red) and observed (blue) age distributions from Icelandic commercial fishery.

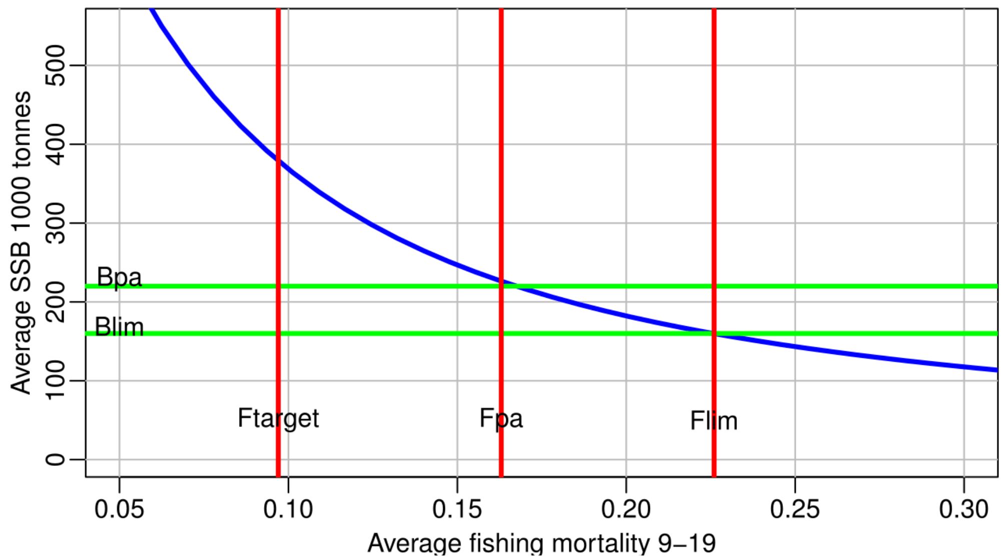


Figure 19.5.1. Average SSB against average fishing mortality and defined reference points.

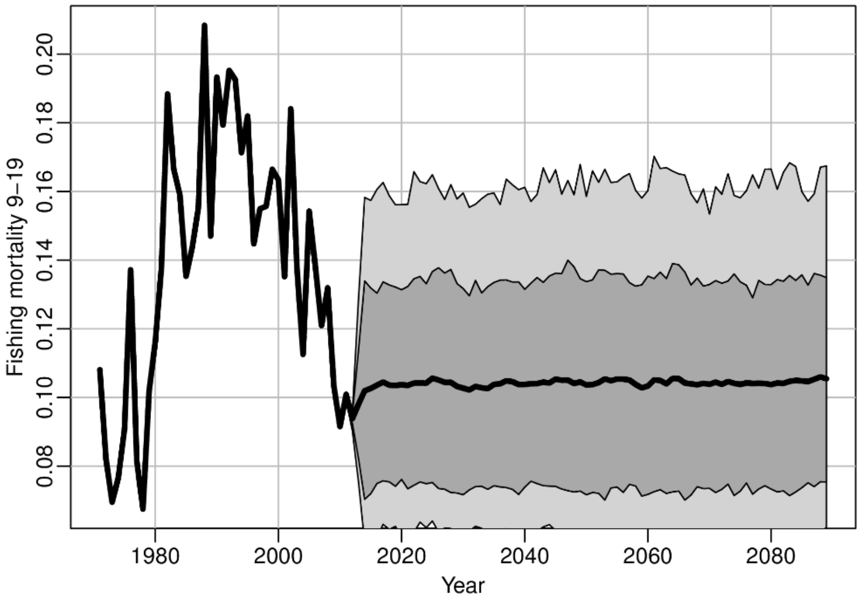


Figure 19.5.2. Development of F_{9-19} based on $F_{9\text{-}19}$ = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.