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 (smr-5614_SA). The calculation of the survey indices includes length dependent diel vertical migration of the species.

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 2019-2021 similar as in 2014 and 2015. The CV of the measurement error has been considerably higher after 2002.

The total biomass index from the autumn survey shows similar trend as in the spring survey when the index gradually increased from 2000 to the highest value in the time series in 2014. The total biomass index in 2015-2019 fluctuated around the 2014 level but decreased sharply in 2020 (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 cohort) and then in 1991–1992 (the 1990 cohort), 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). In 2009-2021, very little of small redfish has been observed in the spring survey (Figure 19.2.1). In recent years, the modes of the length distribution in both surveys have 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 in Table 19.2.2. The sharp increase in the survey indices since 2005 reflects the recruitment of the year-classes from 1996–2007. The year-classes 1996–2002 are gradually disappearing from the stock and the 2003–2008 year-classes are now the most abundant year-classes in the stock. The age disaggregated abundance indices indicate that all year-classes since 2009 are small.

19.2.2 Division 5.b

In Division 5.b, CPUE of golden redfish were available from the Faeroes spring groundfish survey from 1994–2021 and the summer survey 1996–2020 (see smr-5614 SA). 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 and in 2019-2020 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 (smr-5614 SA). 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 golden redfish (fish >17 cm) from the German groundfish survey are illustrated in Figure 19.2.6. After a severe depletion of the golden redfish 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 2017-2020 to similar level as in 2006 (Figure 19.2.6a). It should be noted that the CV for the indices is high and the increase is driven by few very large hauls. In 2010–2020, the biomass of pre-fishery recruits (17–30 cm) has decreased compared to previous five years and in 2017-2020 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 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 1999–2020 survey results indicate low abundance and are like those observed in the late 1980s. The Greenland shrimp and fish shallow water survey 2008-2020 (no survey conducted 2017–2019) also shows very little juvenile redfish (<18 cm, not classified to species) were present (see Figure 23.2.6).

19.3 Information from the fishing industry

19.3.1 Landings

Total landings of golden redfish decreased gradually by more than 70% in 1982-1994 or from 130 429 t in 1982 to 43 515 t in 1994 (Table 19.3.1 and Figure 19.3.1). Since then, the annual landings of the stock have varied between 33 451 t and 59 698 t. The total landings in 2020 were 45 893 t, which is 2 753 t less than in 2019. About 90–98% of the golden redfish catch has been taken in Icelandic Waters (ICES Division 5.a).

Landings of golden redfish in Division 5.a (Icelandic waters) 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 annual landings since 2016 have decreased and were 40 688 t in 2020, 4 058 t less than in 2019. The landings were 5% higher than allocated quota of 38 896 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. The remaining catches are caught as bycatch in the gillnet, long-line, and lobster fisheries. In 2020, 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 (Faroese waters), annual landings decreased from 9194 t in 1985 to less than 700 t in the 2006-2016 period (Table 19.3.1). In 2017 landings increased to 1397 t, the highest landings since 2005. The landings in 2020 was 1297 t. 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 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 2020 were 4105 t, 1440 t more than in 2019.

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 2006–2020 and were 100 t in 2020.

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 commercial fishery

The table below shows the fishery related sampling by gear type and ICES divisions in 2020. Sampling in 5.a was in 2020 considerably less than in previous years because of the COVID-19.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	40 688	65	9 191	834
5.b	Faroe Islands	Bottom trawl	1 297		116	
14	Greenland	Bottom trawl	4 105			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976–2020 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 40 cm and has over the past decade shifted to the right. The length distributions in 2012–2020 are narrower than previously, with less than average of small fish (<35 cm) caught, and the mean length has increased by almost 4 cm.

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). The strong 1990 cohort dominated the catch in 2003–2007 contributing between 25–30% of the total catch in weight. In 2007–2010 the 1996–1999 cohorts dominated in the catches but are now gradually decreasing. The 2003–2008 cohorts (ages 12–17) were the most dominant year classes in the fishery in 2020. There is a substantial decrease of 7–10-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 25-year series of catch-at-age data (Figure 19.3.5) is about 0.20 for age 13 years and older.

Length distribution from the Faroese commercial catches 2001–2020 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 in subareas 14 and 6 have been available for several years.

19.3.5 CPUE

The un-standardized CPUE index from the Icelandic bottom trawl fleet operating in Division 5.a has increased sharply since 2006 and is at the highest level in the time-series. Effort towards golden redfish has gradually decreased since 1986 and is now 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.

CPUE from other areas are not available. 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 1985–2021 and the German survey in East Greenland 1984–2020. The German survey index in 2018 is based on the average of the 2017 and 2019 values because the survey was not conducted in 2018.
- Survey 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 (1972-2021), Faroe Islands (1980-2020) and East Greenland (1975-2004) commercial catches.
- 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 1996–2020.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995–2020.

Model settings:

- The simulation period is from 1970 to 2025 using data until the first half of 2021 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).
- Modelled length ranged between 19-54 cm.
- Commercial catches are split by country and implemented as separate fleets. Survey catch distribution data are modelled as a separate fleet.
- Recruitment was set at age 5.

Estimated parameters are:

- Number of fishes when the simulation starts (8 parameters).
- Recruitment at age 5 each year (53 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 have an impact on the results. Growth in between March and October is included in the model.

Assumptions done in the predictions:

- Recruitment at age 5 in 2022 and onwards was set as the average of the five smallest estimated year classes 1980–2007 or 41.7 million. The reason is indication of poor recruitment in recent years, but estimated recruitment was even lower.
- Catches in 2021 were set as the sum of expected landings, accounting for interannual transfer from 2020. Previously, the catches in the first time-step in 2021 (first 6 months) were set at the same as in the first time-step of 2020 for all the fleets; in step 2 in 2021 and onwards the model was run at fixed effort corresponding to $F_{9–19}$ = 0.097. The NWWG concluded during the meeting in 2021 that the previous method of catch assumption in the intermediate year was seldom fulfilled as overshooting (catch exceeding the advice), especially in Icelandic waters, has ranged between 5-15% in recent years.
- The estimated selection pattern from the Icelandic fleet was used for projections.

19.4.1.2 Results of the assessment model

Summary of the assessment is shown in Figure 19.4.3 and Table 19.4.1. The spawning stock increased 1995-2015 but has since then decreased. 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 because the catches have exceeded the advice. Recruitment (at age 5) after 2013 is at record low levels for the time series.

Assumptions about the cohorts after the 2015 one will not have much effect on the advice this year. This is because the average proportion of fish 10 years old and younger in the landings are 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.

Although this year's assessment is consistent with previous assessments it shows a downward revision of SSB and an upward revision of fishing mortality compared to last year's assessment (Figures 19.4.4).

19.4.1.3 Mohn's rho

The retrospective pattern of the assessment (Figure 19.4.5) and the Mohn's rho values. The default five-year peels resulted in the following values:

Variable	Value
F_{bar}	-0.0533
SSB	0.0352
Rec.	0.501

The Mohn's rho values for F_{bar} and SSB are low (-5% and 3% respectively) but indicates that fishing mortality has consistently been underestimated and SSB been overestimated (Figure 19.4.5). Mohn's rho for recruitment is on the other hand high (50%) and indicates that recruitment has in previous assessments been overestimated. This value needs though to be taken with caution as recruitment estimates of the five-year peels is very low compared to previous years and any deviation from previous year may have relatively high impact. Extending the peel to, for example 10 years, may result in different value.

19.4.1.4 Diagnostics

Observed and predicted proportion by fleet: Trends in different likelihood components (Figure 19.4.6) shows how the fit to survey length distributions has become worse in recent years. This can also be seen in Figure 9.4.7 where overall fit to the predicted proportional length distributions in the survey is smaller to the observed for medium sized fish (30-40 cm fish).

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 19.4.8).

The fit between predicted and observed age distributions is better than for the length distributions (Figures 19.4.9 and 19.4.10). The model uses the data as age-length keys in 2 cm intervals for tuning.

Model fit: In Figure 19.4.11 the length disaggregated indices are plotted against the predicted numbers in the stock as a time-series. 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 number 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.

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 19.4.12). For 35–42 cm fish, the observed indices have been above predictions for 5-11 years. The indices for 41–50 cm fish do not show such temporal pattern although in recent years the observed indices have been below prediction. The correlation between observed and predicted is good for 19-34 cm fish. When looking at the temporal patterns, longevity of the fish must be considered. 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, indicates narrower length distributions in the survey than predicted (Figure 19.4.12).

19.4.2 Advice for 2021 (Last year's 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 2020 SSB was estimated at 280 100 t, and according to the management plan the TAC advice for 2021 was 38 343 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 95th quantile and the 16th and 84th 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 19.4.3). Total biomass and SSB has been decreasing since 2016 (Table 19.4.1) and 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 19.4.3).

The results from the short-term simulations based on $F_{9\text{–}19}$ is shown in Figure 19.4.3 and from short term prognosis with varying fishing mortality in 2022 and 2023 in Table 19.4.2. The results indicate that when fishing according to the management plan the SSB is expected to decrease further and to be close to MSY $B_{trigger}$ in 2023 (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 2010–2020, 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 3000–5400 t in 2016–2020.

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 was 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. The plan has not been renewed so no management plan is effective although Iceland and Greenland still follow this plan.

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

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 ICES subareas 5 and 14.

19.15 Changes in the environment

No information available.

19.16 Benchmark

Benchmark meeting for golden redfish, scheduled in 2020 was delayed because of lack of resources within the ICES system. The group recommended that the stock should be benchmarked in 2023.

Golden redfish was last benchmarked in 2014 and the group thinks that benchmarking the stock is of high importance. 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. Underutilized data sources from ICES 5.b and 14.b, mainly relevant survey and commercial samples of age and length. Biological reference points will need to be redefined depending on the assessment method, especially in relation to the Fp0.5. 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.

19.18 Tables

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985–2021 and the autumn survey 1996–2020.

Year	Spring Survey		Autumn Survey	
	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	199,793	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

Year	Spring Survey		Autumn Survey	
	Biomass	CV	Biomass	CV
2011	401,358	0.235		
2012	461,928	0.204	343,163	0.225
2013	457,448	0.177	317,125	0.156
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	428,351	0.187
2018	497,092	0.210	342,467	0.195
2019	410,550	0.158	383,532	0.233
2020	411,320	0.206	244,099	0.159
2021	441,208	0.194		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in millions) from the autumn groundfish survey 1996–2020. 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	2019	2020
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	0	0.4
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	0.1	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	0.4	1.0
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	0.8	0.7
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	1.5	1.3
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	0.9	0.8
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	15.3	0.7
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	7.8	10.9
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	7.4	3.9
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	20.3	7.4
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	46.8	18.4
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	91.5	41.0
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	58.7	39.1
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	62.7	24.3
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	45.4	39.0
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	36.1	25.7
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	18.7	10.5

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	2019	2020
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	21.7	12.1
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	22.1	12.0
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	13.7	11.1
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	14.7	6.9
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	12.3	4.6
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	7.2	4.1
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	3.7	3.3
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	1.3	2.5
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	2.0	1.8
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	1.3	1.9
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	1.7	0.8
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	10.4	1.3
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	5.3	9.6
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	531.8	297.4

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978–2020 as officially reported to ICES. Landings statistics for 2020 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	48 014	1 330	80	4 004	53 428
2019	44 746	1 053	101	2 665	48 464
20201)	40 688	1 297	100	4 105	46 190

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995–2020. 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
7	46	0	33	24	6	38	125	127	191	226	227	176	135	215	103	60	138	68	30	235
8	321	389	226	280	342	62	143	884	201	855	755	987	446	1,057	936	359	558	612	555	475
9	1,432	867	481	586	1,592	825	402	736	1,312	501	1,877	2,134	1,727	2,164	1,689	2,218	1,626	1,603	2,197	1,752
10	8,598	3,887	1,039	1,193	1,252	4,180	1,653	808	1,080	2,107	1,496	3,605	2,442	5,006	3,059	2,725	4,772	3,444	3,886	6,176
11	2,570	9,575	2,708	1,118	1,843	1,843	7,768	3,192	1,160	828	3,093	2,017	3,319	3,997	4,964	2,786	5,699	6,725	5,952	6,751
12	1,286	2,170	11,609	3,221	2,521	2,224	1,810	10,955	3,863	989	1,899	2,789	1,911	4,682	4,457	4,921	4,899	7,345	9,488	5,807
13	3,616	1,354	2,828	12,425	2,447	1,665	1,930	3,012	9,576	2,017	1,366	1,624	3,068	2,297	3,430	3,895	6,235	4,021	6,896	5,809
14	5,787	1,523	1,366	2,068	15,536	2,329	1,243	2,548	2,304	8,612	3,021	1,275	1,050	2,819	1,848	2,740	3,772	4,721	4,032	4,776
15	6,229	4,293	3,106	2,020	1,242	14,598	826	1,805	1,932	2,148	11,840	2,818	955	1,546	2,008	1,378	2,501	2,668	4,466	3,061
16	1,833	5,033	3,579	2,394	1,250	1,752	11,487	2,998	1,202	1,656	2,073	10,318	2,168	1,067	1,247	1,201	1,309	1,525	3,043	2,538
17	912	954	2,968	3,404	1,795	1,170	515	11,726	2,231	870	1,447	2,074	9,337	1,804	681	820	981	820	1,720	1,921
18	395	372	869	2,029	2,619	1,602	769	2,054	6,494	1,381	1,243	1,191	1,329	8,188	1,502	648	602	813	1,205	1,245
19	1,244	252	616	1,013	2,194	2,400	1,025	1,150	784	5,065	1,241	722	741	1,503	6,158	1,086	691	492	764	464
20	1,232	343	919	723	1,237	2,141	1,684	622	390	1,093	6,387	956	717	966	970	4,980	987	808	488	1,202
21	549	1,059	440	528	452	538	916	1,360	585	342	387	5,524	876	567	654	901	5,052	627	510	438
22	674	698	534	397	211	438	386	982	840	464	456	552	4,765	831	576	762	1,056	3,512	772	425
23	1,521	790	641	426	326	283	399	697	788	599	758	226	732	4,231	342	519	753	477	3,298	486

Year/Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
24	695	0	567	660	215	63	155	352	426	528	591	396	113	382	2,561	665	204	324	183	2,929
25	777	0	703	536	810	408	119	270	307	239	417	457	599	254	98	2,151	134	225	199	183
26	396	0	263	382	264	361	109	176	71	94	94	97	329	433	97	199	1,336	237	171	195
27	372	0	135	432	592	220	265	80	74	187	253	254	345	337	199	348	77	1,326	108	142
28	799	0	186	358	227	520	182	287	26	123	161	200	199	169	94	131	201	198	918	57
29	0	0	137	54	105	379	142	469	95	127	28	168	36	171	359	155	44	72	37	674
30+	230	0	388	501	745	1,152	1,015	1,280	643	636	1,484	962	1,024	851	411	507	145	426	414	33
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

Year/Age	2015	2016	2017	2018	2019	2020
7	14	49	0	0	214	0
8	563	751	104	51	144	507
9	902	2,717	949	212	64	288
10	3,154	3,713	4,503	2,279	1,227	575
11	7,118	8,111	3,523	4,890	4,678	2,185
12	7,104	9,393	7,077	4,812	6,176	4,928
13	5,553	6,688	8,748	6,507	4,028	4,154
14	5,673	4,705	5,370	7,779	5,710	3,148
15	4,774	4,024	3,790	4,278	5,127	8,115
16	3,015	2,629	3,576	3,243	4,006	5,032
17	2,651	2,729	3,012	2,748	2,607	2,253
18	1,861	2,013	1,866	2,614	2,301	1,545
19	780	1,724	1,412	1,282	1,376	1,329
20	1,192	663	1,187	1,347	1,512	1,564
21	288	536	990	1,211	1,147	788
22	275	350	438	629	508	970
23	196	223	489	496	518	522
24	424	241	313	277	161	600
25	1,816	304	324	336	56	82
26	243	1,335	148	167	184	45
27	214	176	1,265	35	350	62
28	189	29	87	1,663	103	122
29	87	25	192	26	1,161	162
30+	682	907	756	1,133	1,387	1,713
Total	48,770	54,043	50,117	48,015	44,745	40,689

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

Year	Biomass	SSB	$R_{(age5)}$	Catches	F_{9-19}
1971	592,688	385,364	224.6	67,880	0.097
1972	585,040	366,016	194.6	50,890	0.076
1973	596,246	363,465	449.8	43,719	0.067
1974	647,827	371,946	210.0	50,598	0.075
1975	678,100	380,040	126.0	61,920	0.089
1976	691,360	384,693	208.0	94,420	0.136
1977	681,081	368,349	194.7	53,753	0.081
1978	712,262	391,917	124.3	48,736	0.067
1979	741,928	424,207	159.3	77,212	0.101
1980	744,944	435,865	105.5	89,143	0.115
1981	728,026	437,113	75.1	101,966	0.136
1982	690,292	425,061	63.5	130,322	0.185
1983	616,389	383,937	67.6	106,050	0.163
1984	561,081	355,600	73.6	95,288	0.155
1985	512,208	329,523	131.3	78,531	0.132
1986	483,029	311,358	121.2	76,908	0.140
1987	453,283	290,108	64.5	76,559	0.152
1988	416,486	264,653	41.0	89,804	0.205
1989	360,837	224,158	44.7	56,645	0.145
1990	335,904	208,638	351.9	66,314	0.192
1991	333,916	184,710	58.6	56,015	0.180
1992	317,701	168,464	39.8	55,826	0.198
1993	298,393	152,681	53.3	50,179	0.196
1994	284,236	142,758	63.1	42,520	0.174
1995	277,249	140,425	332.4	44,263	0.184
1996	297,955	138,562	85.7	35,595	0.146
1997	307,793	144,271	39.9	38,996	0.155
1998	308,836	148,107	40.6	39,694	0.155

Year	Biomass	SSB	$R_{(age5)}$	Catches	F_{9-19}
1999	307,147	152,416	79.6	42,463	0.165
2000	304,501	155,307	50.1	42,607	0.161
2001	297,015	157,792	106.8	36,744	0.133
2002	305,139	164,665	116.6	50,730	0.183
2003	300,878	159,968	170.5	38,219	0.138
2004	318,857	165,141	105.5	32,766	0.115
2005	334,915	175,637	161.7	46,619	0.161
2006	346,600	177,029	160.3	42,108	0.149
2007	370,004	185,676	104.2	39,154	0.134
2008	387,798	199,490	127.4	46,195	0.151
2009	402,766	211,267	198.1	39,301	0.121
2010	438,971	232,027	163.9	38,504	0.109
2011	472,705	256,507	90.3	45,146	0.118
2012	486,828	277,152	127.3	45,423	0.112
2013	505,856	298,153	75.8	53,223	0.125
2014	506,254	311,737	29.8	50,697	0.114
2015	497,121	323,870	9.6	51,621	0.113
2016	478,180	330,363	12.2	59,697	0.129
2017	446,064	323,901	35.2	56,334	0.123
2018	417,018	313,496	4.4	53,368	0.121
2019	381,530	298,408	10.0	48,484	0.116
2020	348,080	281,111	20.4	46,110	0.118
2021	315,798	260,093	33.2		

Table 19.4.2 Assumption and output from short term prognosis. All weights are in tonnes.

Biomass (2021)	SSB (2021)	F_{9-19} (2021)	Landings (2021)	Biomass (2022)	SSB (2022)
315 798	260 093	0.121	43 222	286 276	237 099

Basis	Total catch (2022)	F_{9-19} (2022)	Biomass 5+ (2023)	SSB (2023)
Management plan	31 855	0.1	269 968	221 719
Other catch options				
F_{MSY}	30 833	0.097	270 949	222 608
F_0	0	0	302 091	250 829
$F_{sq} = F_{2020}$	37 170	0.118	264 609	216 864

19.19 Figures

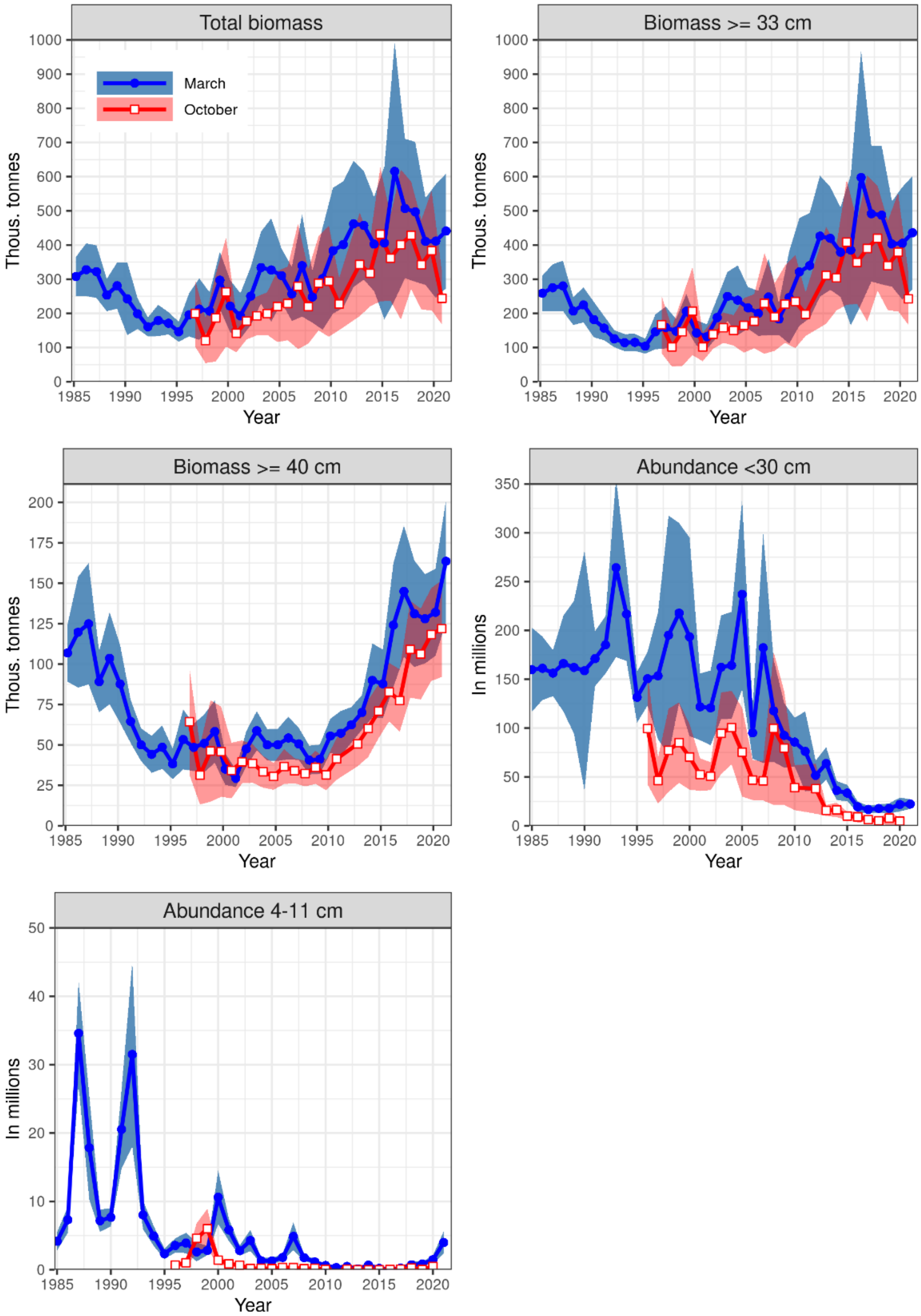

Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985–2021 (blue line and shaded area) and October 1996–2020 (red lines and shaded areas). The shaded areas represent 95% CI.

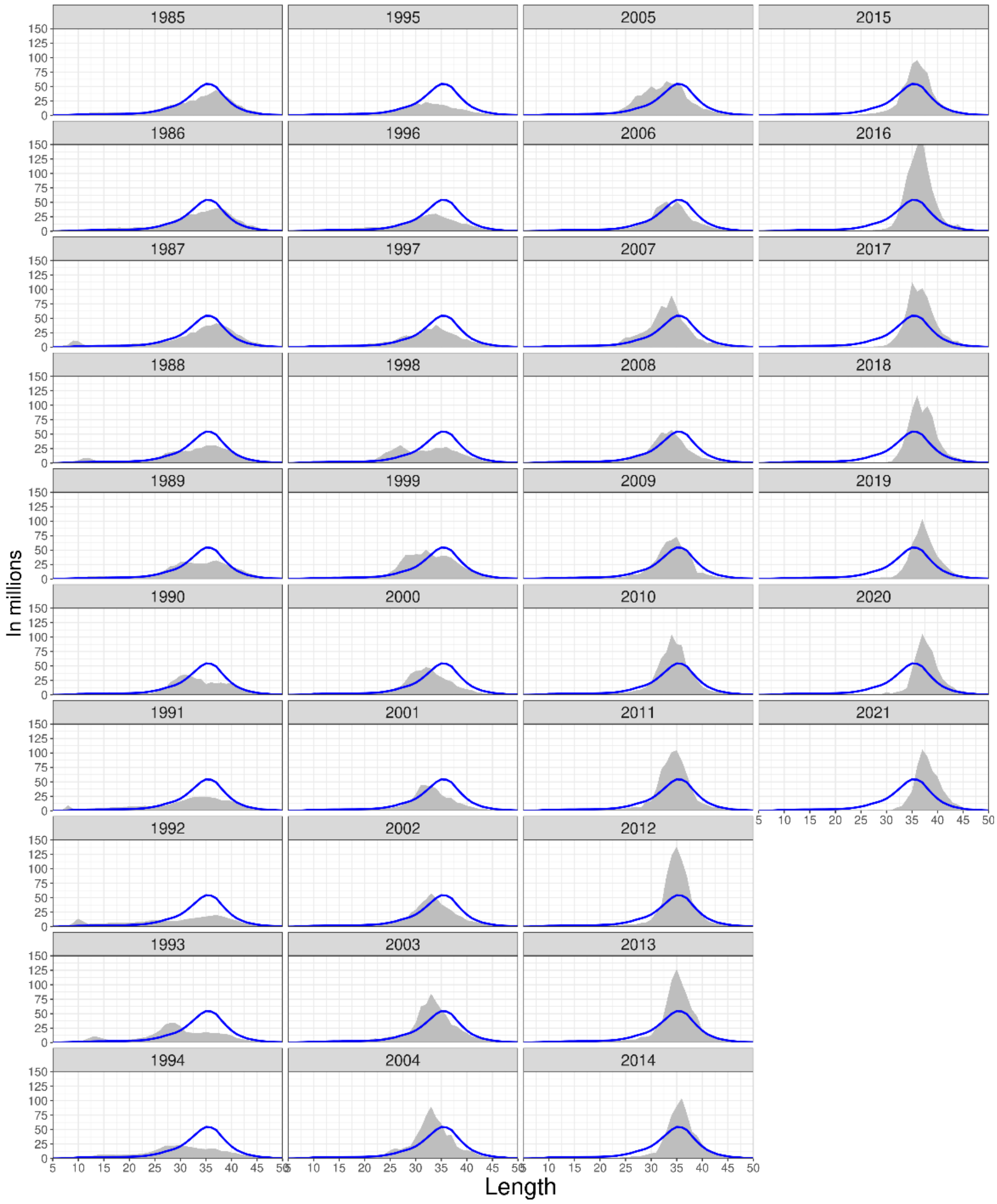

Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985–2021 conducted in Icelandic waters. The blue line is the mean of total indices 1985–2021.

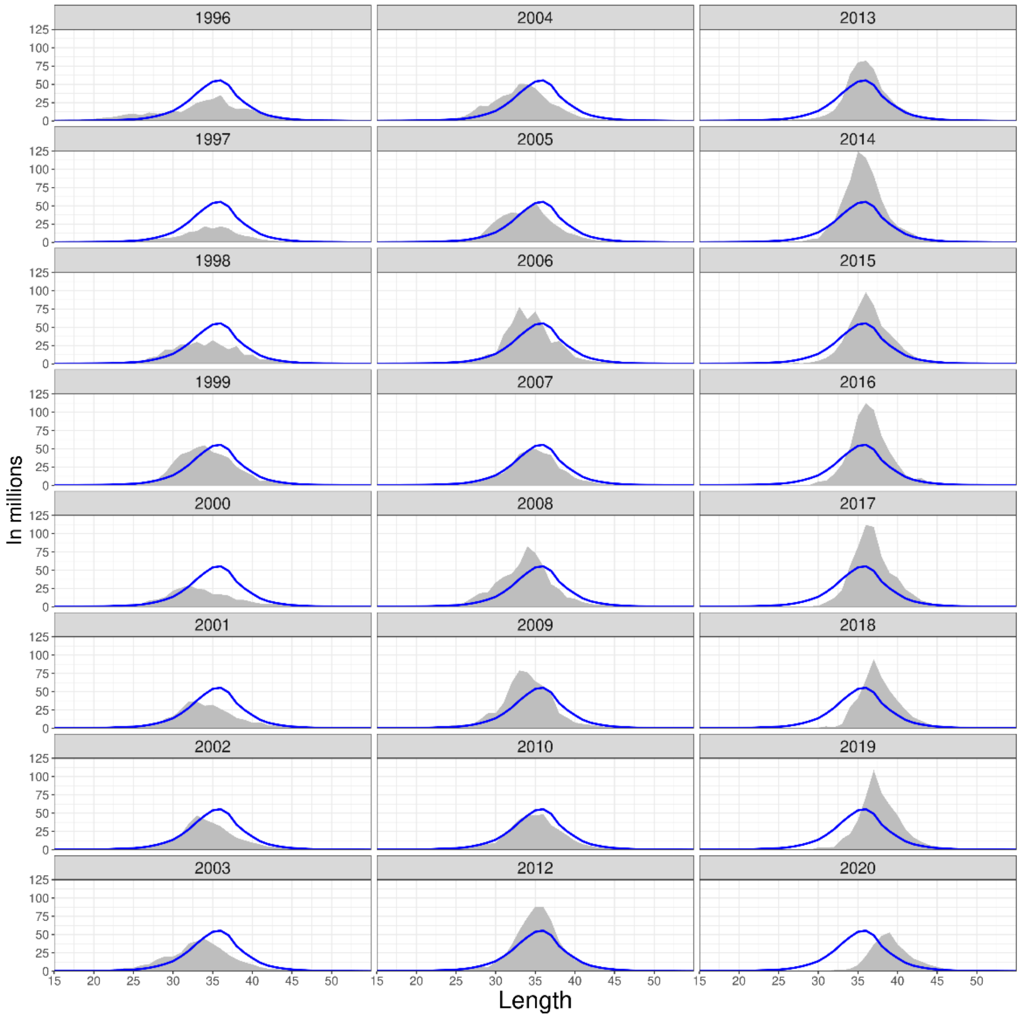

Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996–2020 conducted in Icelandic waters. The blue line is the mean of total indices 1996–2020. The survey was not conducted in 2011.

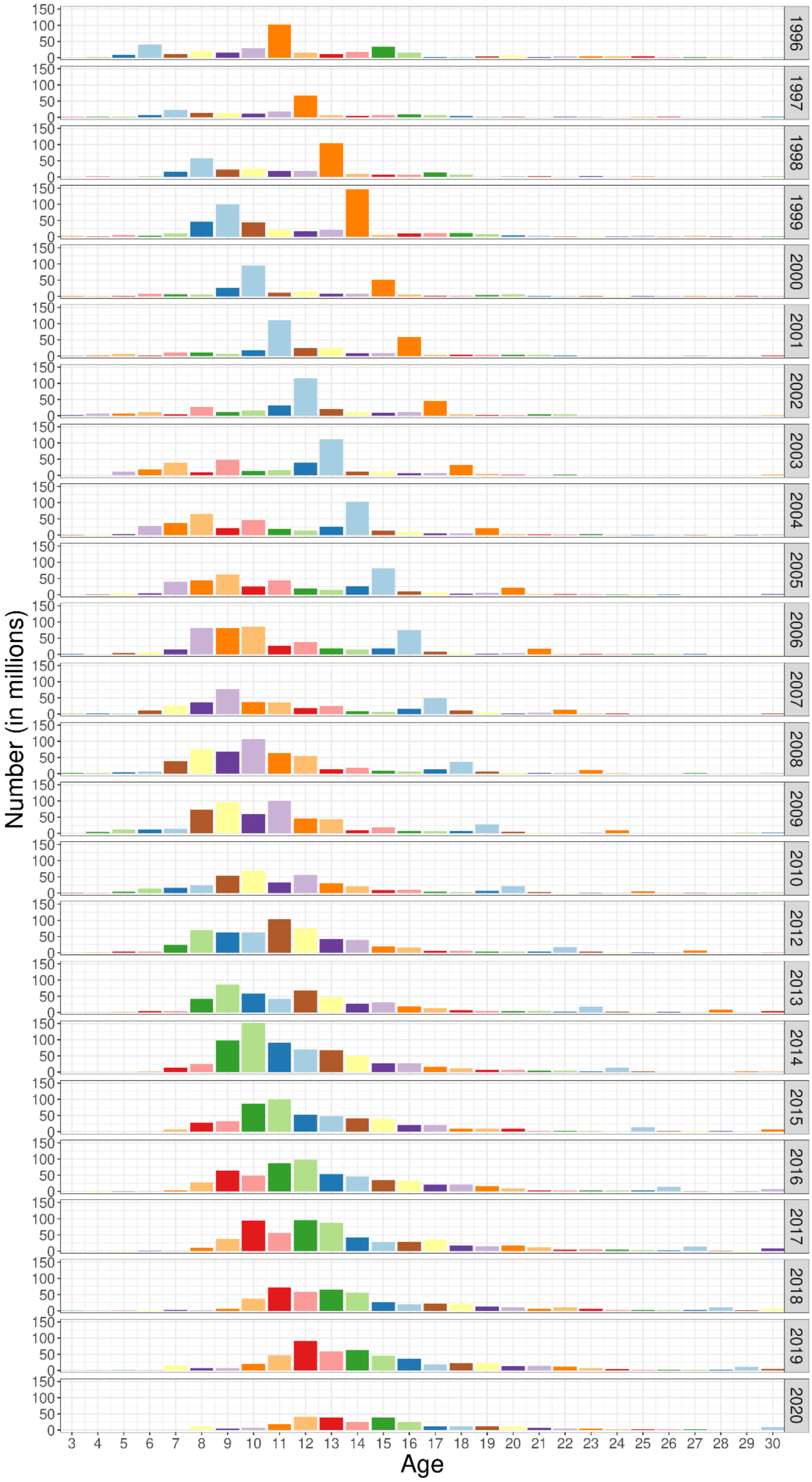

Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996–2020. The survey was not conducted in 2011.

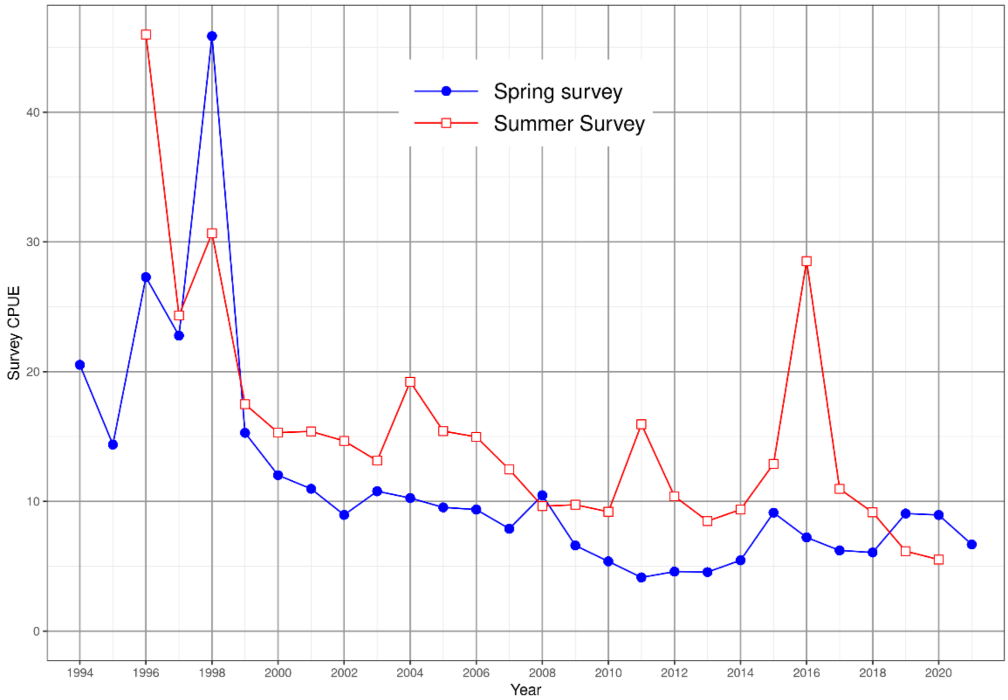

Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994–2021 (blue line) and the summer groundfish survey 1996–2020 (red line) in ICES Division 5.b.

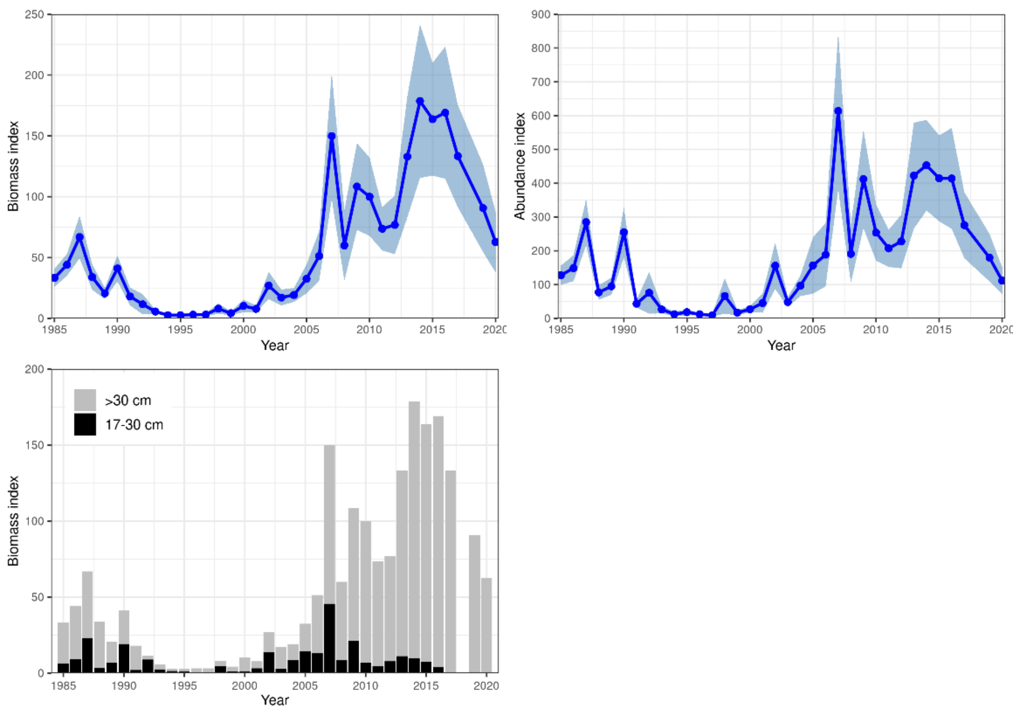

Figure 19.2.6 Golden redfish (> 17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985–2020. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17–30 cm and > 30 cm). The survey was not conducted in 2018.

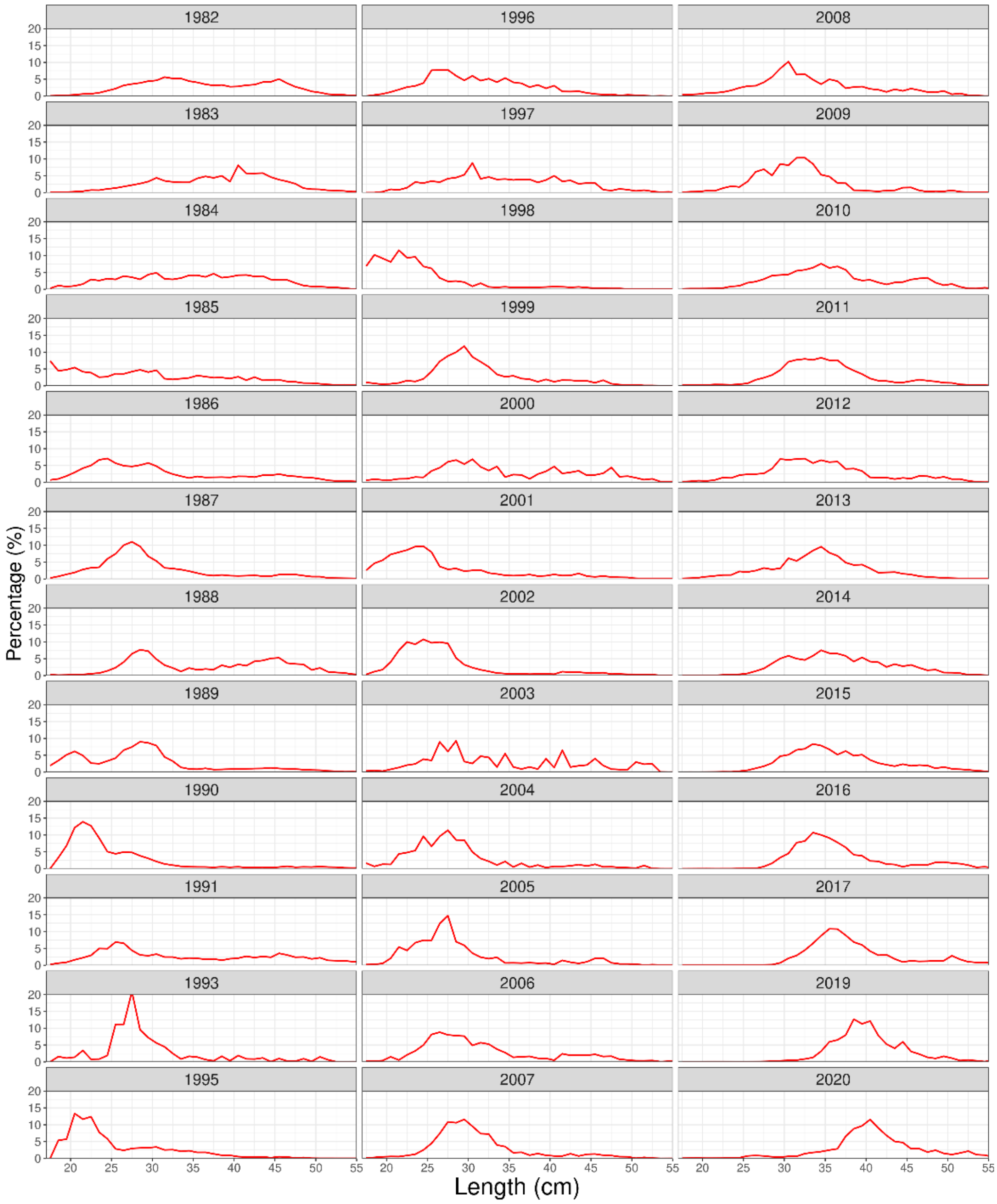

Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982–2020. The survey was not conducted in 2018.

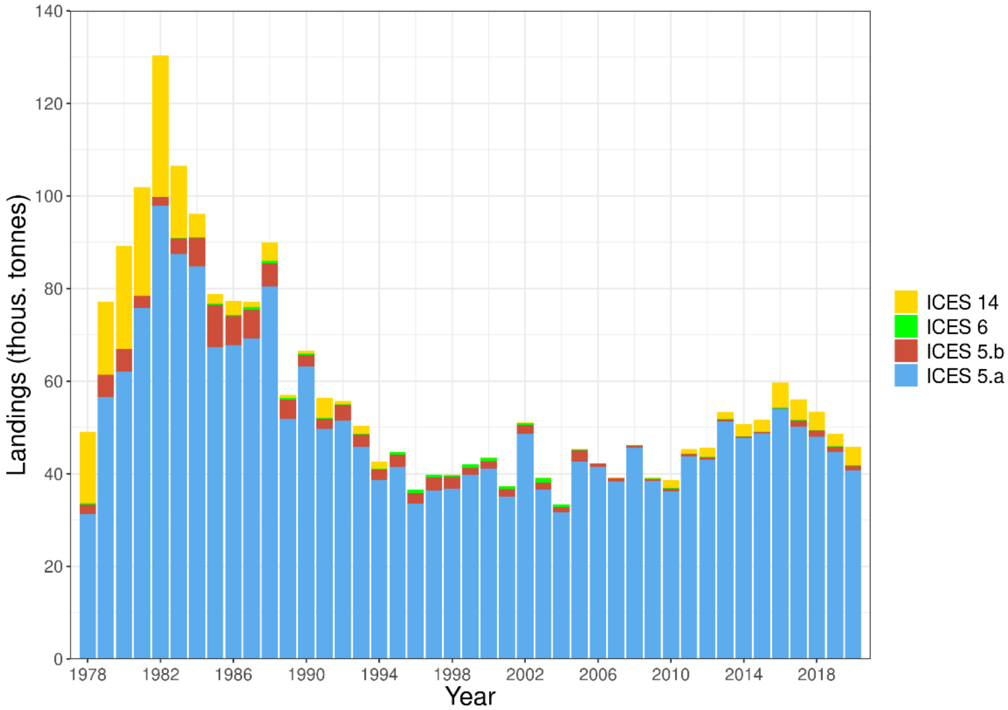

Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978–2020. Landings statistics for 2020 are provisional.

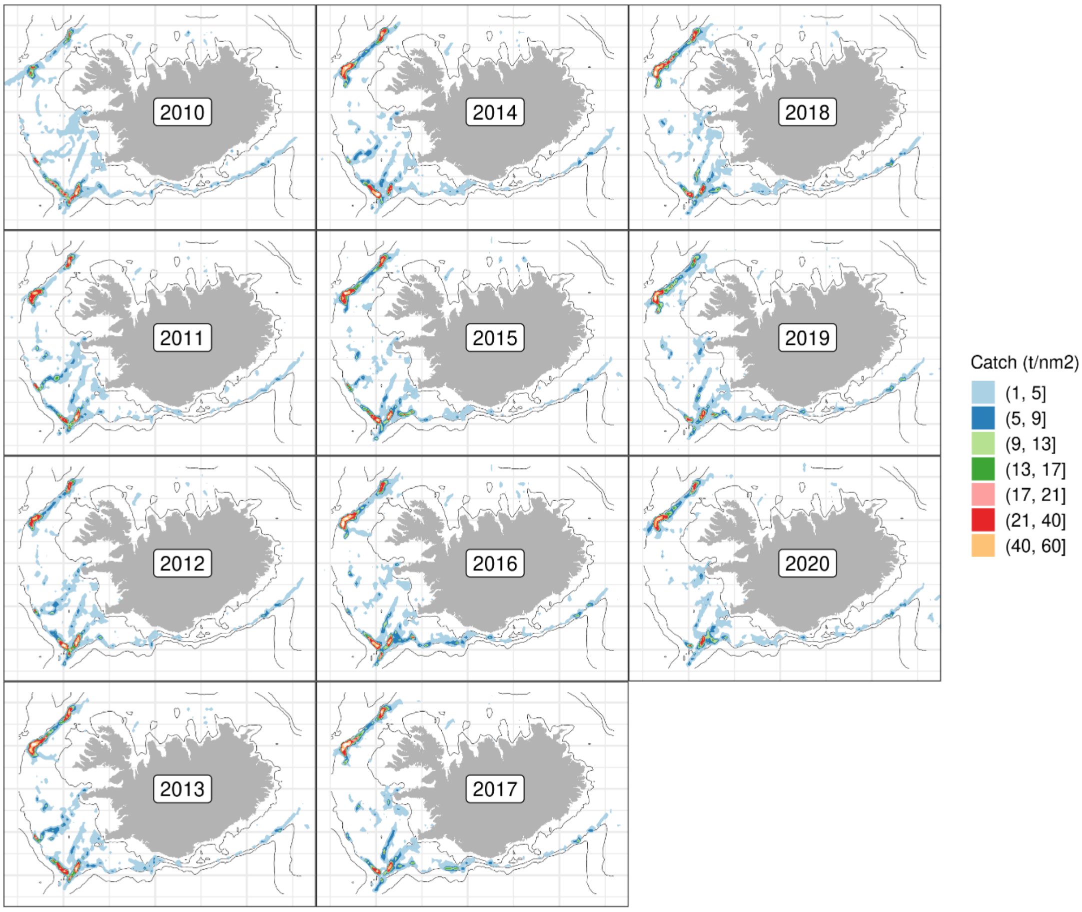

Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2010–2020.

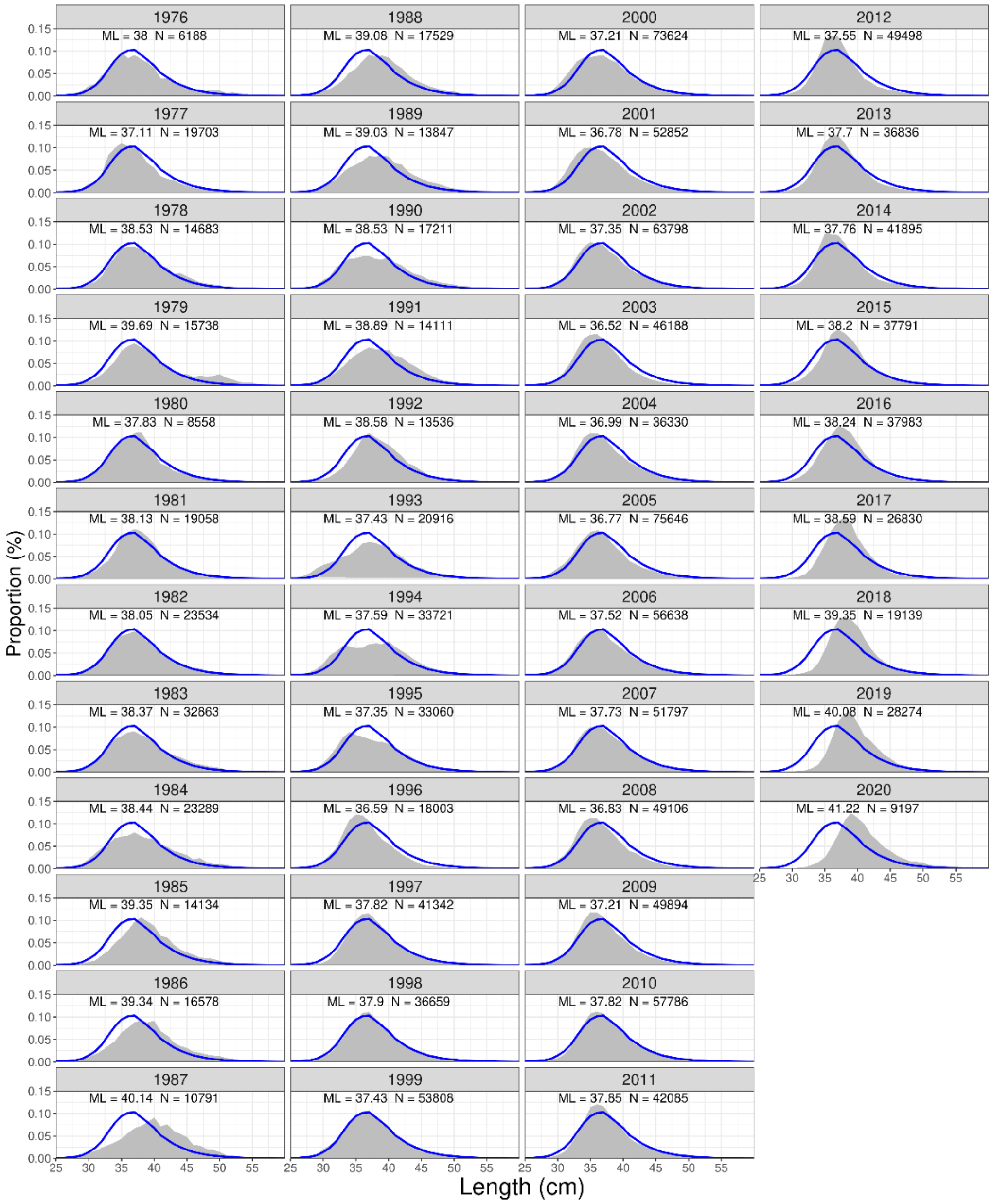

Figure 19.3.3 Length distribution (grey shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976–2020. The blue line is the mean of the years 1976–2019.

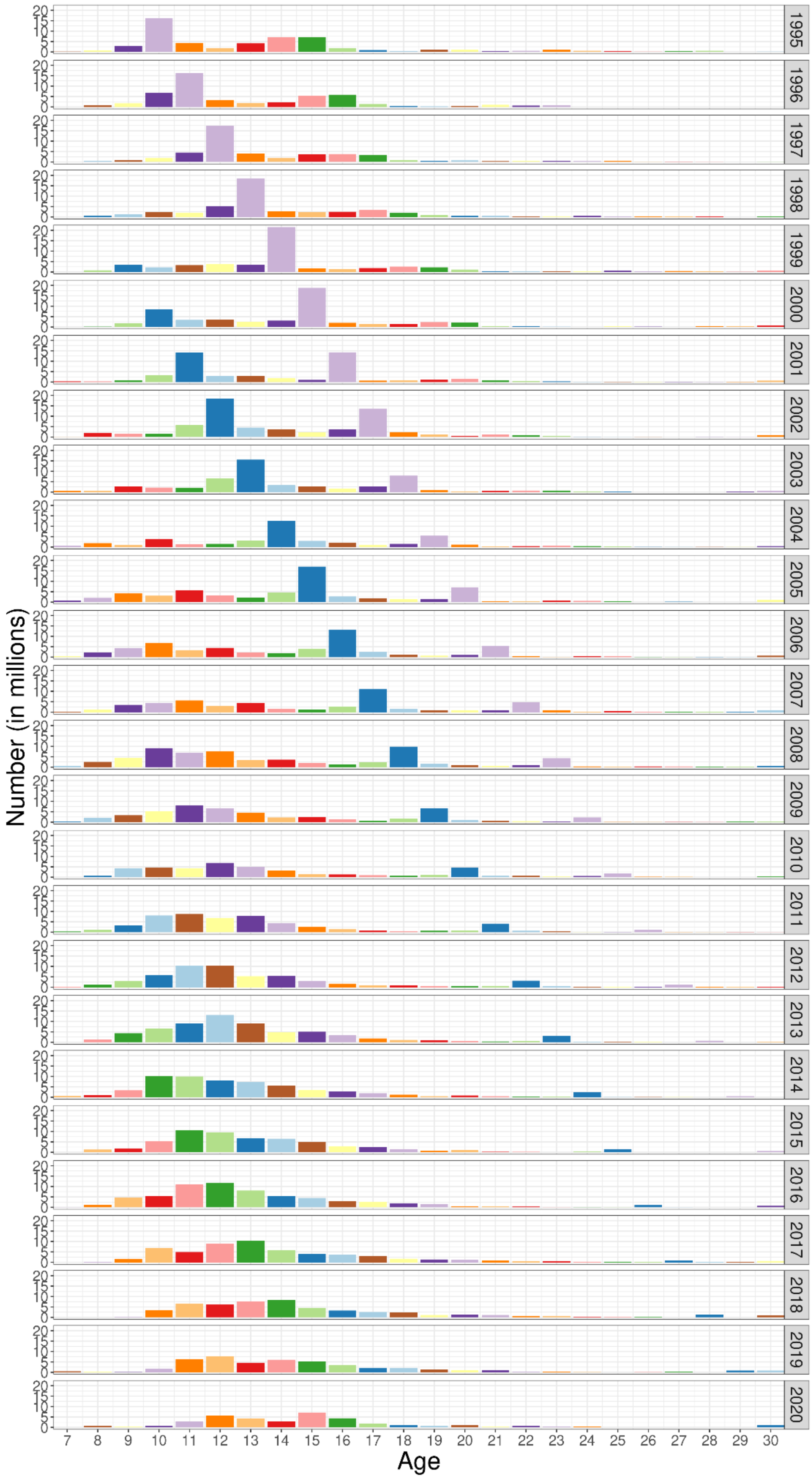

Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Division 5.a 1995–2020.

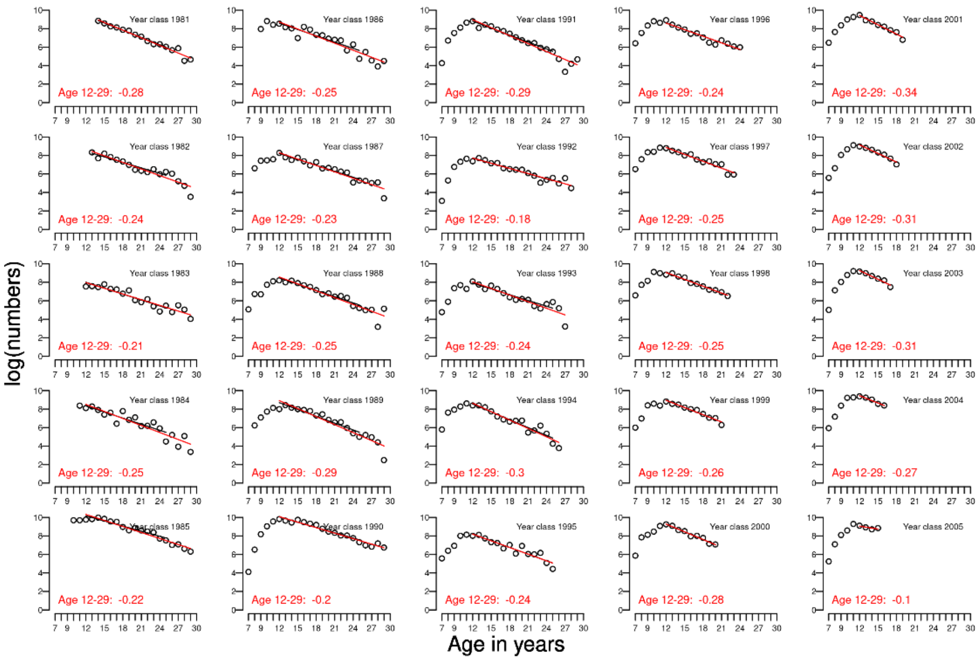

Figure 19.3.5 Catch curve of the 1981–2005 year-classes of golden redfish based on the catch-at-age data in ICES Division 5.a 1995–2020.

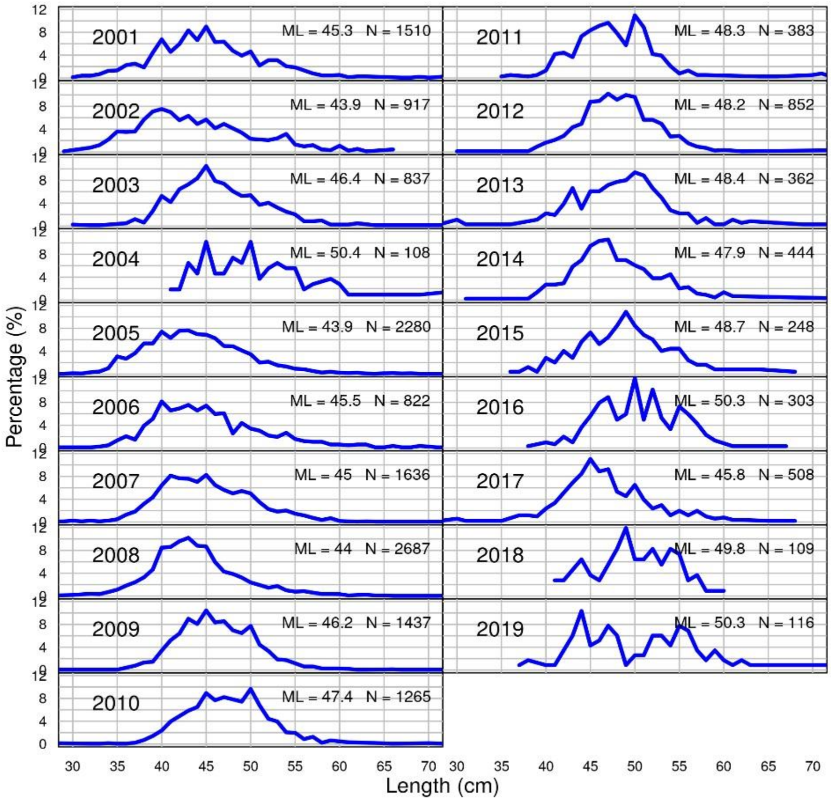

Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001–2019.

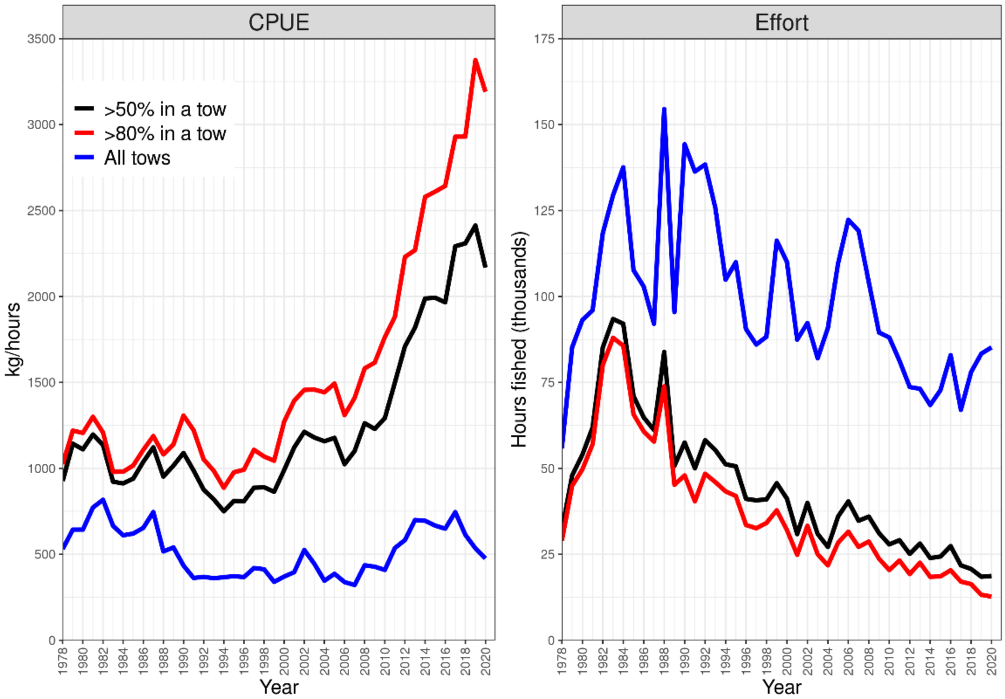

Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978–2020 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

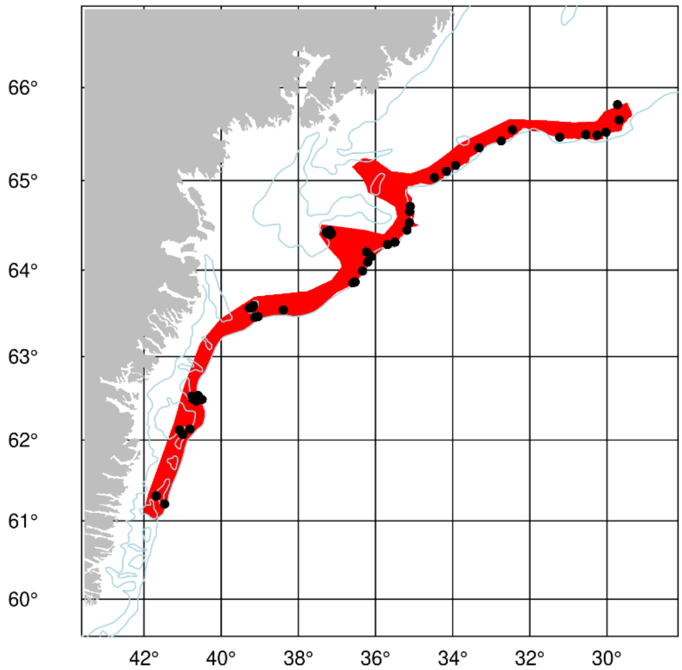

Figure 19.4.1 Stations in the German survey in East Greenland in 2020 with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

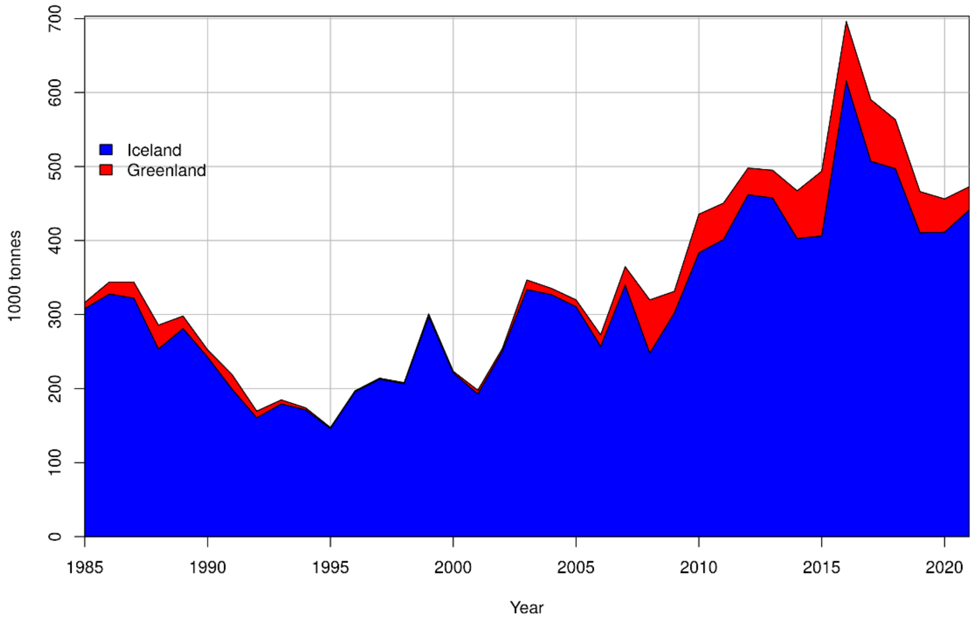

Figure 19.4.2 Biomass index from Iceland (blue) and Greenland (red), based on weighting the German survey data in Figure 19.2.7 by 0.5. In 2019, the survey index is based on the Icelandic survey and the average of the 2017 and 2019 values from the German survey in Greenland because it was not conducted in 2018.

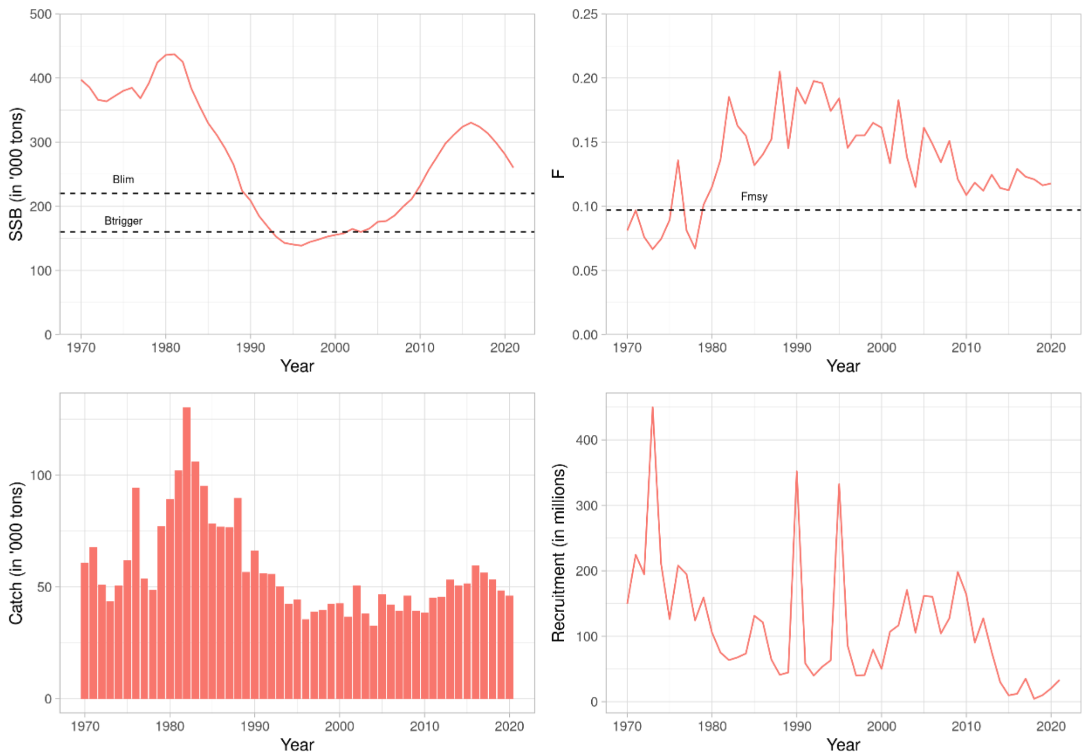

Figure 19.4.3. Summary from the assessment in 2021.

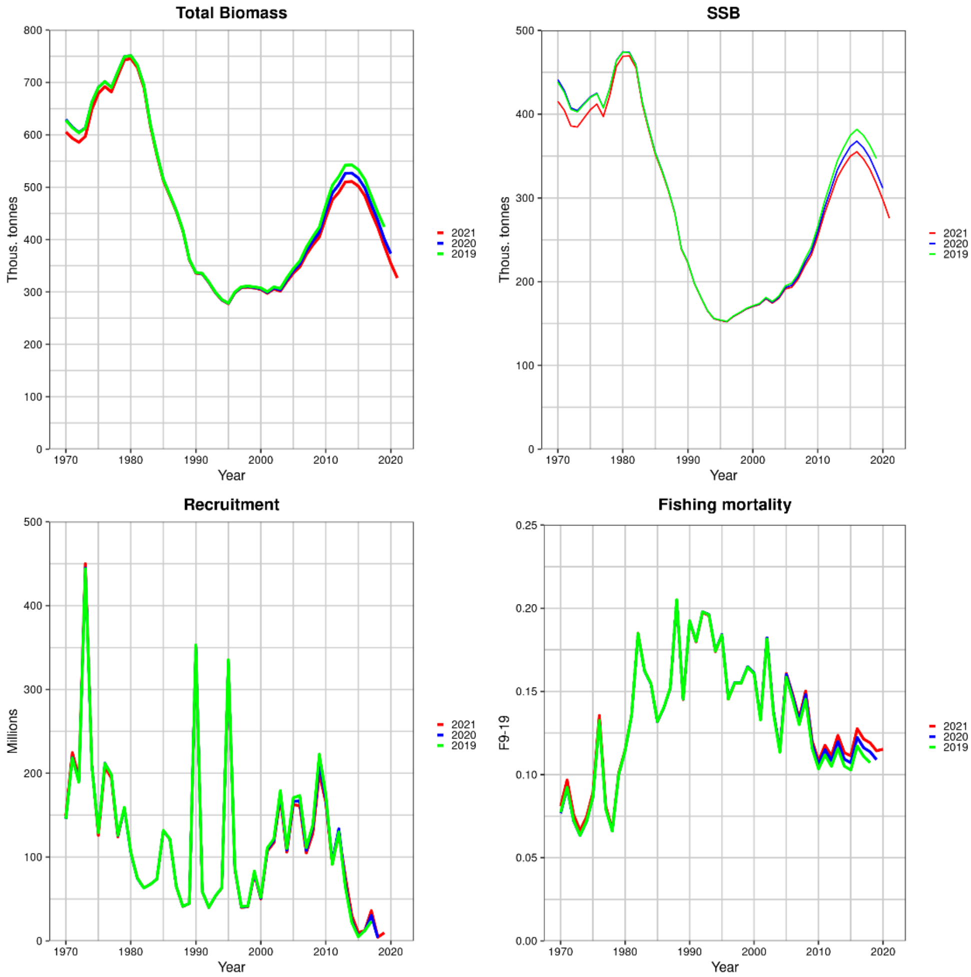

Figure 19.4.4. Comparison of the current assessment (red line) and the same assessment done in 2019 (green line) and 2020 (blue line) for the total biomass, spawning stock biomass, fishing mortality and recruitment.

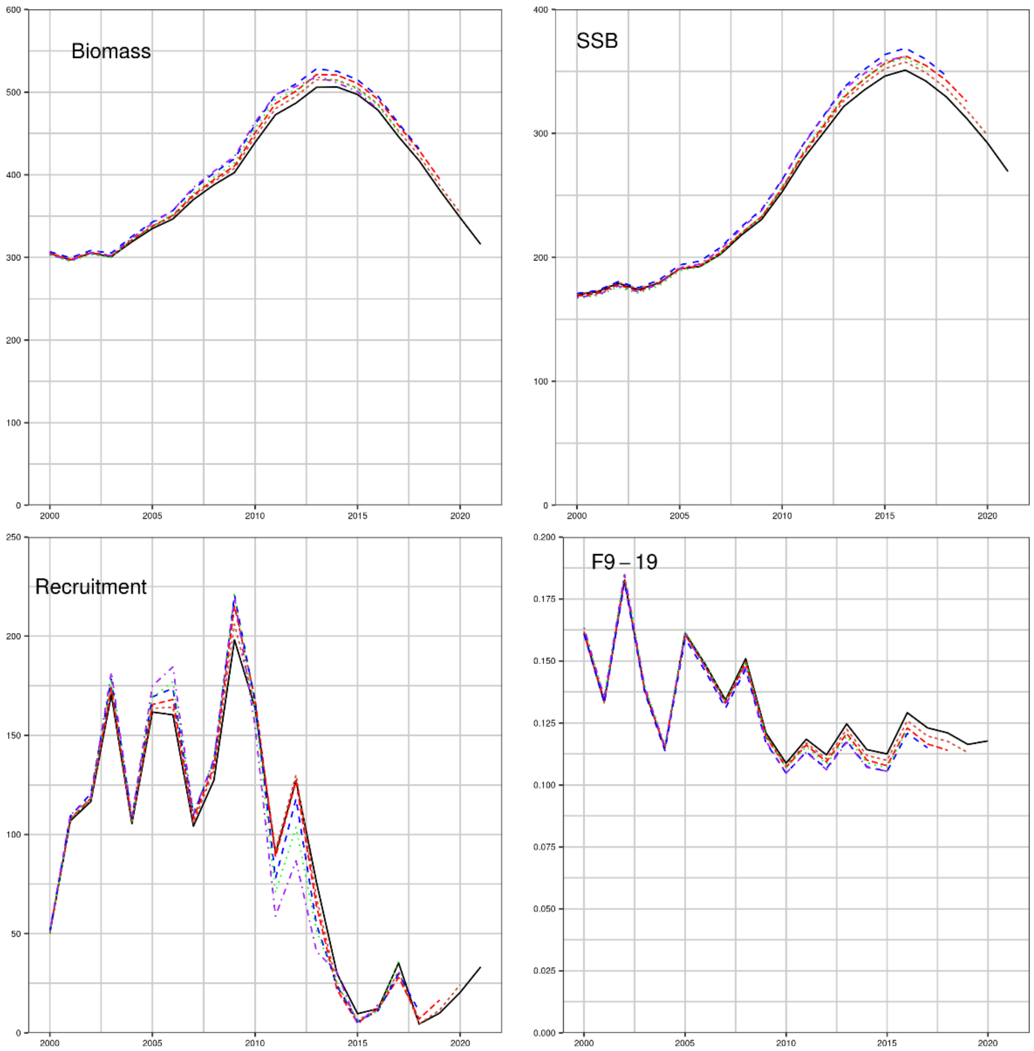

Figure 19.4.5. Analytical retrospective pattern of the base run. Recruitment is at age 5 and F shows the development of ages 9–19.

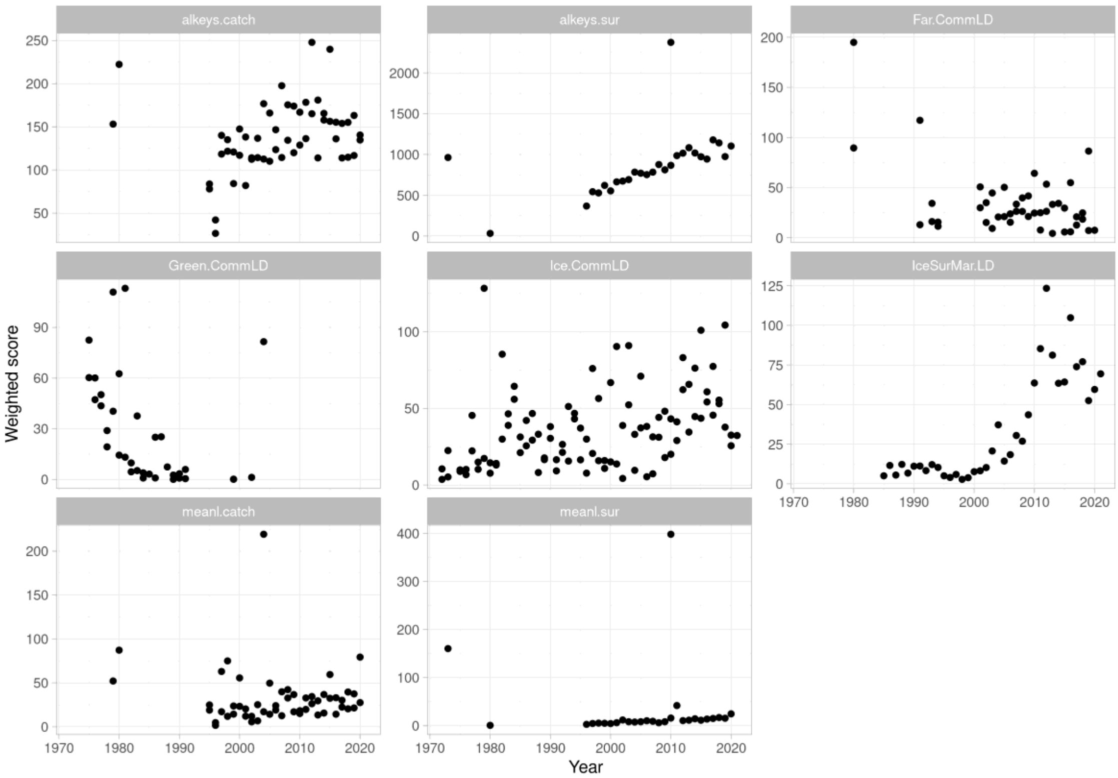

Figure 19.4.6. Development of component of the objective function with time.

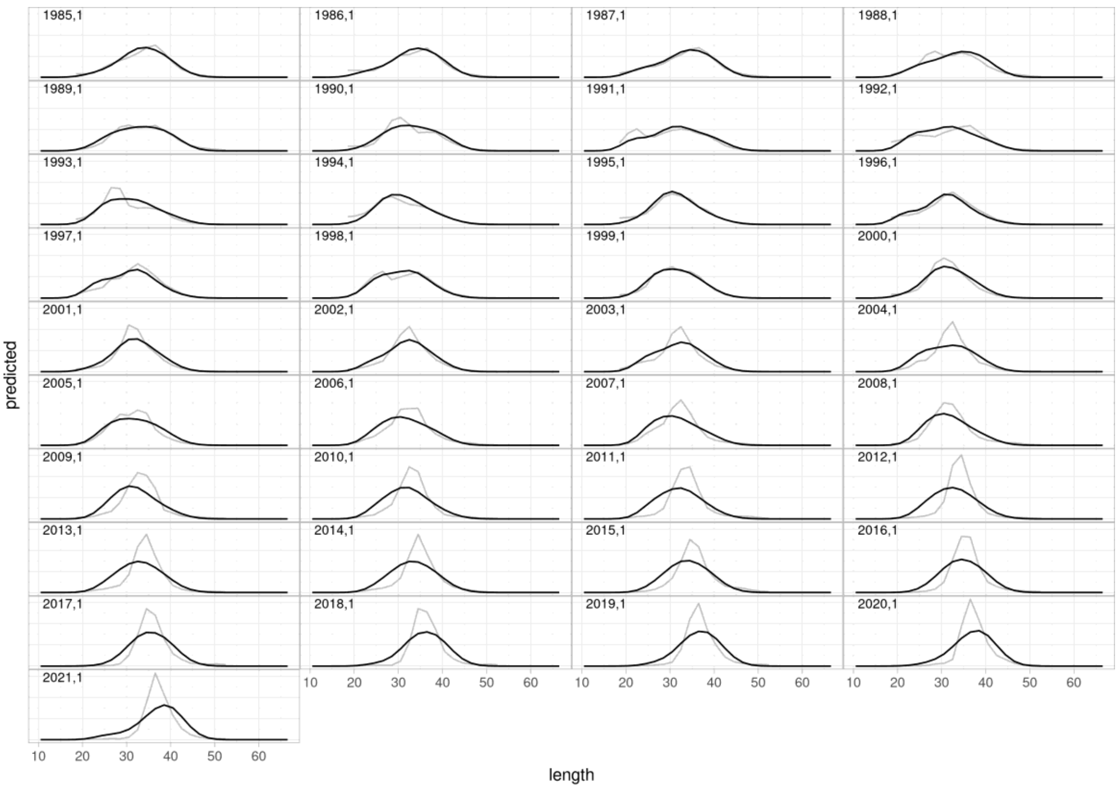

Figure 19.4.7. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines).

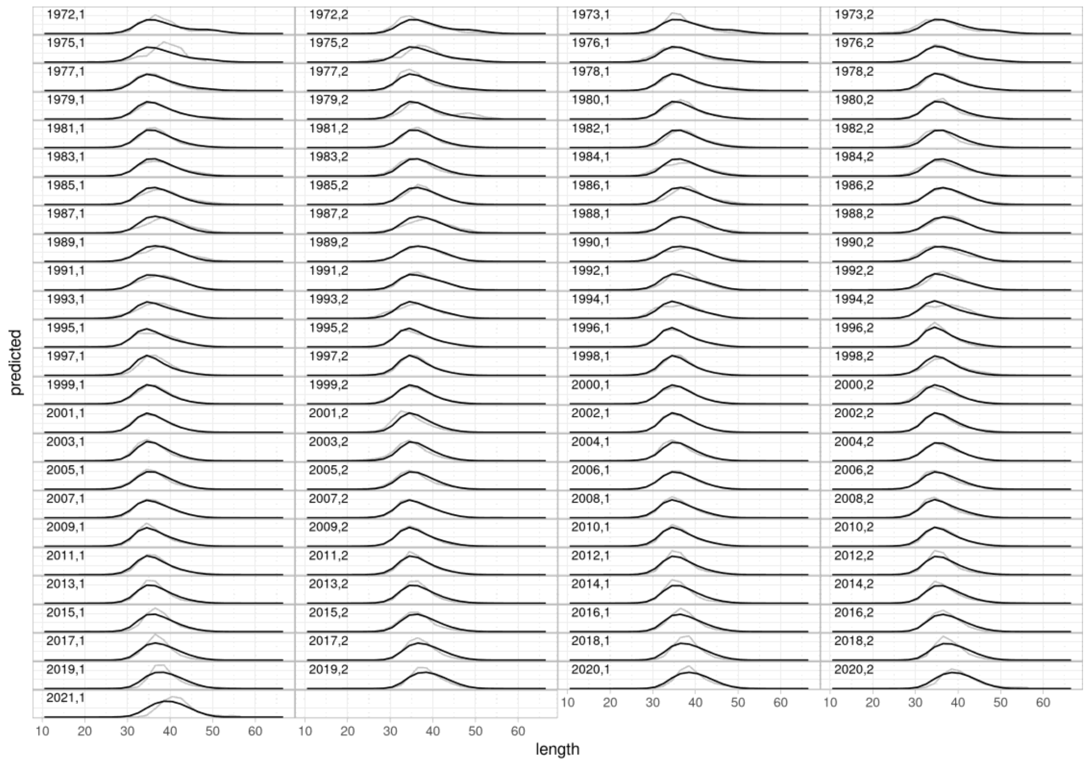

Figure 19.4.8. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

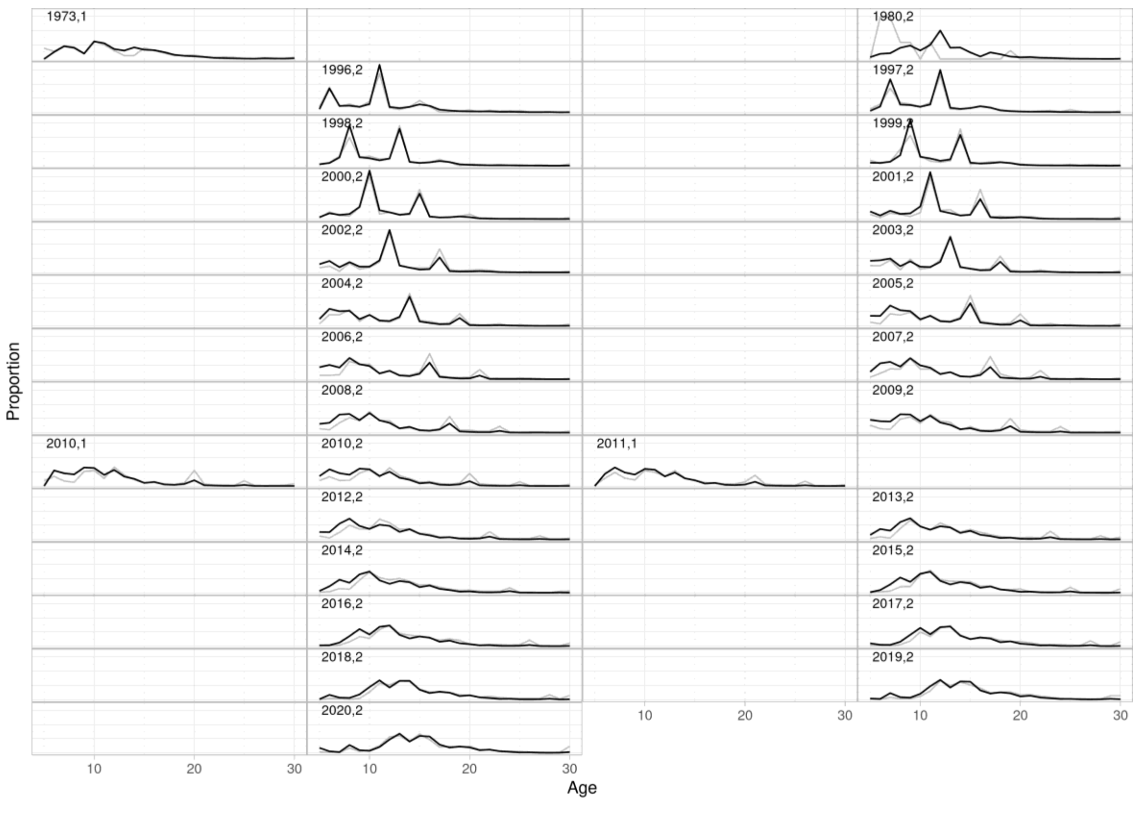

Figure 19.4.9. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey (grey lines).

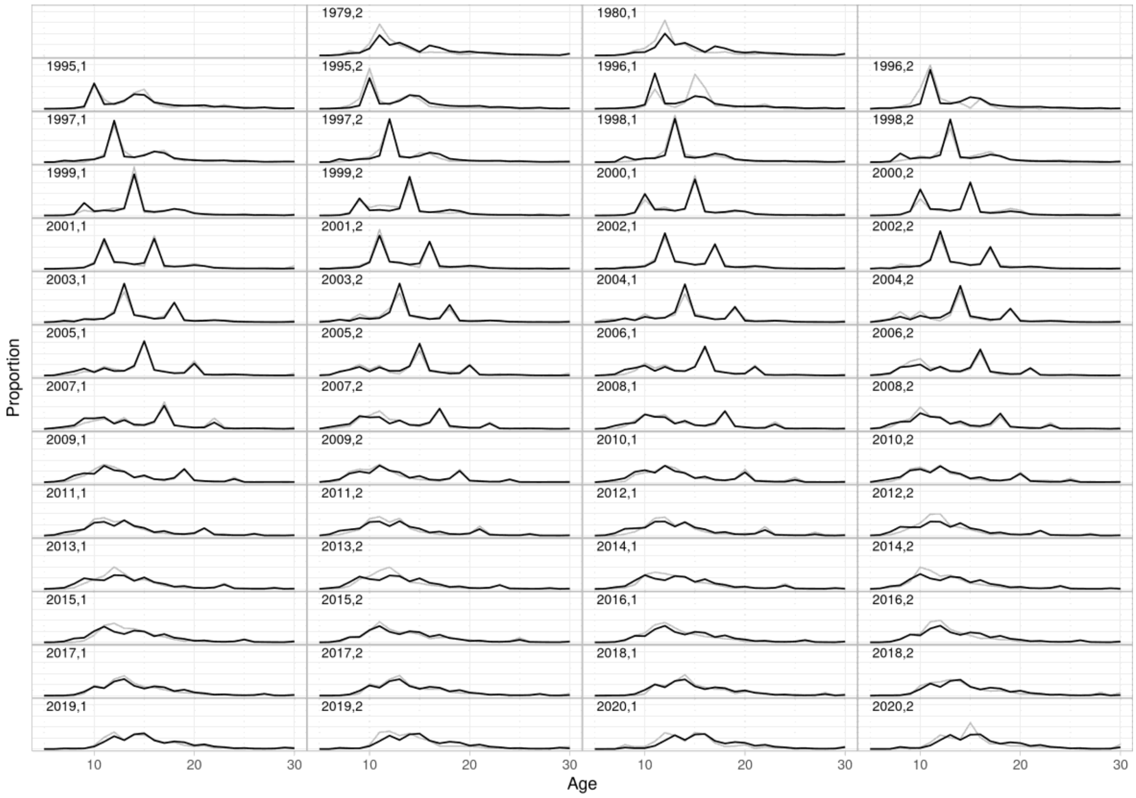

Figure 19.4.10. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

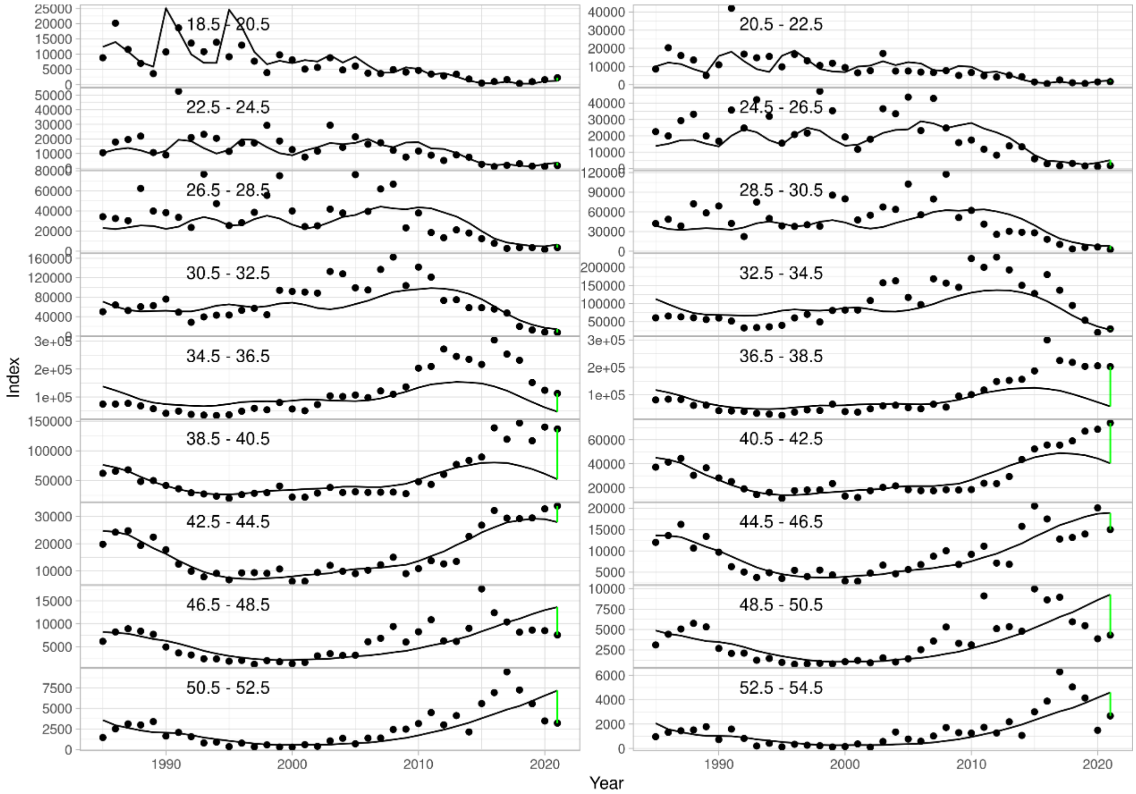

Figure 19.4.11 Gadget fit to indices from disaggregated abundance by length indices from the spring survey.

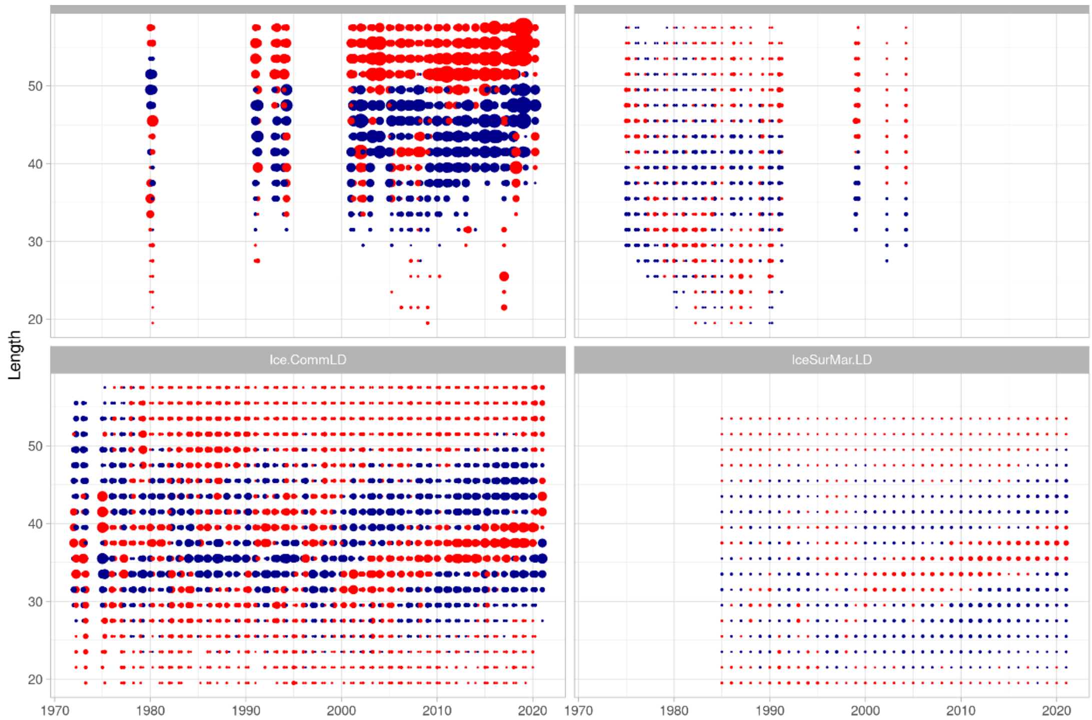

Figure 19.4.12. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

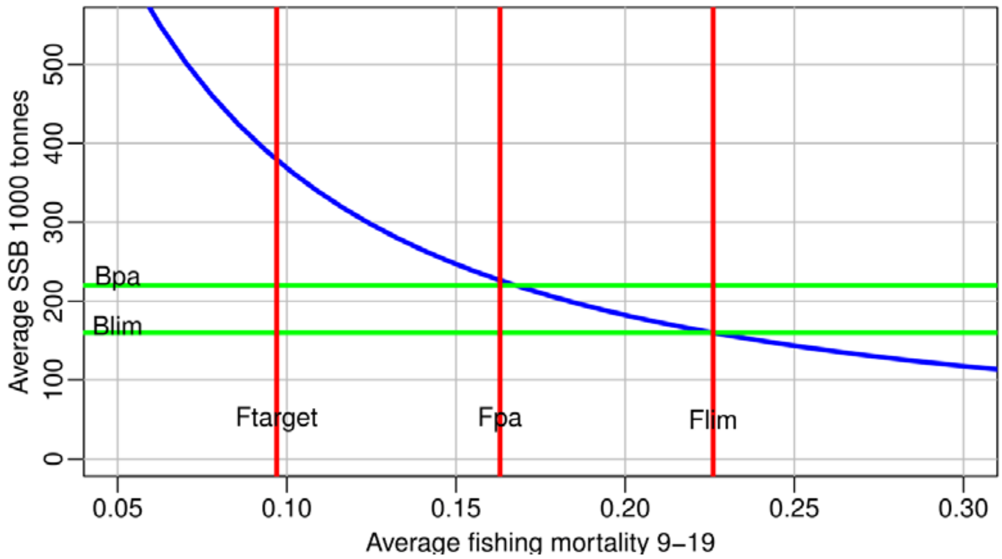

Figure 19.5.1. Average SSB against average fishing mortality and defined reference points.

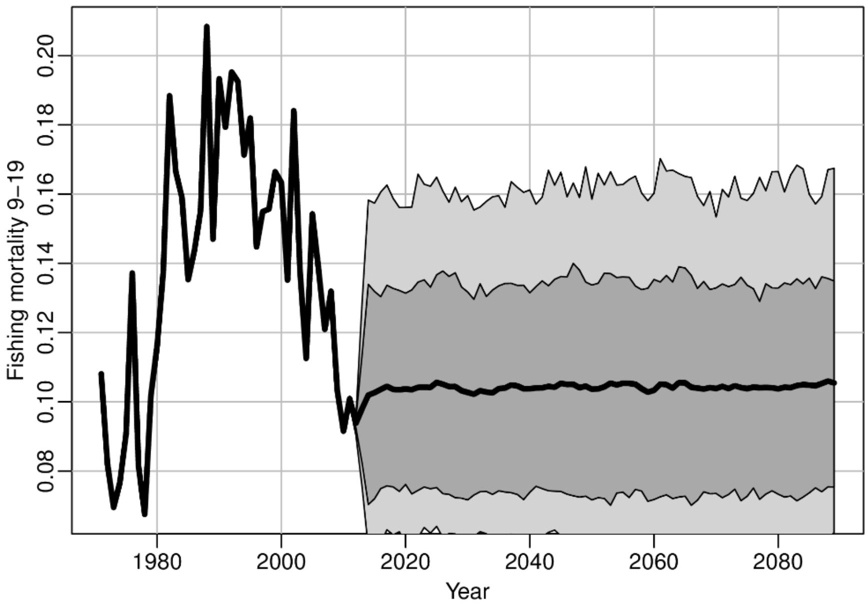

Figure 19.5.2. Development of $F_{9\text{–}19}$ based on $F_{9\text{-}19}$ = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.