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DRAFT

ICES
International Council for the Exploration of the Sea
CIEM
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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.

19.2 Scientific data

This chapter describes results from various surveys conducted annually on the continental shelves and slopes of Subareas 5 and 14

19.2.1 Division 5.a

Two bottom trawl surveys are conducted in Icelandic waters: The Spring Survey in March 1985—2018 and the Autumn Survey in October 1996—2017. The autumn survey was not conducted in 2011. Two survey indices are calculated from these surveys but only the index from spring survey is used in the assessment of golden redfish in ICES 5.a. 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 survey stratification and subsequent survey indices for golden redfish were recalculated for the Autumn Survey in 2008 and for the Spring Survey in 2011. The method is described in the Stock Annex for the species. Further changes were made in the calculation of the survey indices in 2012 by taking into account length dependent diurnal vertical migration of the species. Golden redfish is known for its diurnal vertical migration showing semi-pelagic behaviour. Usually the species is in the pelagic area during the night time and close to the bottom during the day time. However, there is also a size or age difference in this pelagic behaviour where smaller fish shows opposite vertical migration pattern compared to larger fish. The method is described in more details in the Stock Annex.

This scaled diurnal variation by length was used for calculating Cochran index for golden redfish. The sum of those abundance indices multiplied by mean weight at length or age are the total indices shown in Figure 19.2.1 and Table 19.2.1.

Figure 19.2.1*a* and Table 19.2.1 show the total biomass index from the Icelandic spring and autumn groundfish surveys with ±1 standard deviation in the estimate (68% confidence interval). The total biomass of golden redfish as observed in the spring survey decreased from 1988 to a record low in 1995. Between 1996 and 2002 the stock showed signs of improvement but was low compared to the beginning of the series. From 2003 to 2018 the biomass has gradually increased, with some fluctuation, and was in 2016-2018 the highest in the time series. 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 at that level (Figure 19.2.1 and Table 19.2.1).

Length distributions from the spring survey shows that the peaks in length 4-11 cm, which can be seen first in 1987 and then in 1991—1992, reached the fishable stock approximately 10 years later (Figure 19.2.1) . The increase in the survey index between 1995 and 2005 reflects the recruitment of two strong year classes (1985-year class and then the 1990-year class). Abundance of small redfish has since then been lower, highest in 1998-2000, but since 2009 very little has been observed of small redfish (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 less than 30 cm has decreased since 2006 in both surveys and is now at the lowest level in the timeseries (Figures 19.2.1-19.2.3).

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. In 2013—2017, the abundance of fish 7 years' old and younger was at the lowest level in the time series for all age groups indicating small year classes since 2009 (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—2018 and the summer survey 1996—2017. 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 was between 2000 and 2008 stable at low level. In the period 2009—2017 it was at the lowest level since the beginning of the except in 2016 when the index increased substantially in 2016. The reason for this sharp increase in 2016 was one big haul that accounted most of the total index. The CPUE index in the summer survey has gradually decreased and is also at the lowest level recorded.

19.2.3 Subarea 14

Relative abundance and biomass indices from the German groundfish survey from 1982 to 2017 for *S. norvegicus* (fish >17 cm) are illustrated in Figure 19.2.6. In 2013, the survey was re-stratified, with 4 strata in West Greenland resembling NAFO sub-area structure, and 5 strata in East Greenland. Depth zones considered are 0—200 m and 200—400 m. The time series was recalculated accordingly. In general, the survey indices are much lower with the new stratification scheme but show similar trend (WD 30 of the 2013 NWWG report). 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.

After a severe depletion of the *S. norvegicus* stock on the traditional fishing grounds around East Greenland in the early 1990's, the survey estimates showed a significant increase in both abundance and biomass with the highest value observed in 2007 (Figure 17.2.7). The survey indices were high although fluctuating. The biomass survey index increased in 2014 to the highest level in the time series and was at that level in 2015 and 2016 but decreased again in 2017 to the similar level as in 2013 (Figure 19.2.6*a*). It should be noted that the CV for the indices are high and the increase is driven by few very large hauls. During the recent period of increase, the fishable biomass (> 30 cm) and has increased considerably (Figures 19.2.7*c* and 19.2.8). 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.

Abundance indices of redfish smaller than 18 cm from the German annual groundfish survey show that juveniles were abundant in 1993 and 1995—1998 (Figure 19.2.1). 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 also shows no juvenile redfish (<18 cm, not classified to species) were present.

19.3 Information from the fishing industry

19.3.1 Landings

Total landings gradually decreased by more than 70% from about 130 000 t in 1982 to about 43,000 t in 1994 (Table 19.3.1 and Figure 19.3.1). Since then, the total annual landings have varied between 33,500 and 60,000 t and have been gradually increasing since 2010. The total landings in 2017 were 56 101 t, which is about 3,600 t less than in 2016. Most of the golden redfish catch or 90-98% has been taken in ICES Division Va.

Landings of golden redfish in Division 5.a declined from about 98 000 t in 1982 to 39 000 t in 1994 (Table 19.3.1). Since then, landings have varied between 32 000 t and 54 000 t, highest in 2016. The landings in 2017 were 50 119 t, about 4 000 t less than in 2016. The landings were, however, 10.3% higher than allocated quota of 45 450 t. This increase is because of the Icelandic ITQ system where part of the quota of a given species can be transferred between fishing years and between species within the quota year. 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 by-catch in gillnet, long-line, and lobster fishery. In 2017, 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 dropped gradually from 1985 to 1999 from 9000 t to 1500 t and varied between 1 500 and 2 500 t from 1999—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 recent 11 year and were 1,397 t. That is 1,232 t more landings than in 2016 and the highest landings since 2005. Most of the golden redfish caught in Division Vb is taken by pair and single trawlers (vessels larger than 1000 HP).

Annual landings from Subarea 14 have been more variable than in the other areas (Table 19.3.1). After the landings reached a record high of 31 000 t in 1982, the golden redfish fishery drastically reduced within the next three years (the landings from ICES Subarea 14 were about 2 000 t in 1985). During the period 1985—1994, the annual landings from Subarea 14 varied between 600 and 4,200 t, but from 1995 to 2009 there was little or no direct fishery for golden redfish and landings were 200 t or less mainly taken as by-catch in the shrimp fishery. In 2010, landings of golden redfish increased considerable and were 1 650 t, similar as it was in early 1990s. This increase is mainly due to increased *S. mentella* fishery in the area. Annual landings 2010—2015 have been between 1 000 t and 2 700 t but increased to 5 442 t in 2016 which is the highest landings since 1983. The landings in 2017 were 4 501 t, about 950 less than in 2016.

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—2017 and were 90 t in 2017.

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 (Palsson *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 Chapter 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 2017. No sampling of the commercial catch from subdivision VI was carried out.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	50 119	161	26 817	1 732
5.b	Faroe Islands	Bottom trawl	1,397		508	
14	Greenland	Bottom trawl	4,501			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976—2017 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—2017 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 yearclasses has gradually been decreasing in recent years. In 2007—2010 the 1996—1999 yearclasses dominated in the catches but are now gradually decreasing. The 2000—2005 year lasses (ages 13-18) contributed in total about 62% of the total catch in 2017, compared to about 65% in 2016. 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 23-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 for 2001—2017 indicates 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 2017 the highest in the time series with sharp increase in recent 11 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 Methods

19.4.1 Changes to the assessment model in January 2014.

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. The following changes were done to the model compared to previous runs:

- Abundance indices from the German survey in East Greenland were included in the tuning. The indices were added to the Icelandic spring survey.
- Tuning data were limited to 19—54 cm instead of 25—54 cm as larger part of the stock area is included. 19 cm is around the length at which redfish in the German survey is classified to species. Earlier, smaller fish had gradually been removed from the tuning fleet as the nursery area for year classes 1996—2003 seemed to be outside Icelandic waters.
- Length at recruitment was estimated separately for year classes 1996—2000 and 2001 and onwards. The reason was higher mean weight at age in landings and autumn survey.

Of the changes mentioned above, the first one has the largest effect on the estimated stock size but the third one does also have considerable effect as when growth increases fishes recruit to the fisheries at younger age if selection is size dependent.

The German survey did get half weight compared to the results in Figure 19.2.6. This was done to avoid extrapolation to areas not surveyed, and hence reduce noise, but the indices are calculated as numbers per square km^2 multiplied by an area drawn around the stations (Figure 19.4.1). 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. Several things are not comparable between the two surveys, for example different gears are used and the German survey is not conducted during night while the Icelandic survey is conducted both day and night. Therefore the “correct” weight of each survey in the total is difficult to estimate and part of the benchmark work 2014 was to look at the sensitivity to the weight.

The German survey has in recent decade provided increased proportion of the total biomass 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 lead 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 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.

The weighing of individual data sets in the Gadget model is done using an iterative re-weighing algorithm. The process essentially assigns weights to each input data set based on the inverse variance of the fitted residuals. This is done to reduce the effect of low quality input data. In this year assessment the weights were the same as in the benchmark runs in January 2014 and the assessment in 2014-2017.

19.4.2 Gadget model

19.4.2.1 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—2018 and the German survey in East Greenland 1984-2017. Indices are combined and the German survey gets half the weight compared to what is presented in Figure 19.2.6.
- Length distributions from the Icelandic, Faroe Islands and East Greenland commercial catches since 1970.
- 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—2017.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995—2017.
- The simulation period is from 1970 to 2022 using data until the first half of 2018 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 (46 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 needs to be mentioned 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.

Assumptions done in the predictions:

- Recruitment at age 5 in 2015 and onwards was set as the average of the 5 smallest estimated yearclasses that are all similar in number. The reason is indication of poor recruitment in recent years, but estimated recruitment was even lower.
- Catches in the first timestep in 2018 (first 6 months) were set at the same as in the first timestep of 2017 for all the fleets. In step 2 in 2018 and onwards the model was run at fixed effort corresponding to $F_{9\text{-}19}$=0.097
- The estimated selection pattern from the Icelandic fleet was used for projections.

19.4.2.2 Results of the assessment model and predictions

Summary of the assessment is shown in Figure 19.4.4 and Table 19.4.1. The spawning stock has increased in recent years. Annual landings have increased gradually since 2003–2010 when they were at minimum. 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 and overestimation of the stock.

The last year class estimated is the 2008 year class but the following year-classes are assumed to be the average of the 5 lowest year classes in the timeseries. 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)

The results presented here show a 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 but they should not happen in this model unless considerable changes in the data were observed. The result of the analysis suggested the model had not converged to the "best solution" in the 2017 assessment and analytical retrospective analysis indicated that in recent years the biomass should have been estimated lower during last year's assessments (Figure 19.4.6).

19.4.2.3 Mohn's roh

One of the ToR for this year (ToR b)-viii) was to evaluate the retrospective pattern of the assessment (Figure 19.4.6) by calculating the Mohn's rho values. The default 5 year peels resulted in the following values:

VARIABLE	VALUE
Fbar	-0.0416
SSB	0.0543
Rec.	-0.442

19.4.2.4 Fit to data

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 14 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 considered to be 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. Even though each tow is 4 miles (1 hour), captains claim based on their acoustic devices that most of the fish enters the trawl in few minutes. The assumption of the same catchability in those dense schools compared with value that is appropriate for "normal schools" might be wrong.

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) but 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 taken into account as it lasts three times longer in the fisheries and surveys as most other stocks.

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 than ever (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 agreement between predicted and observed age distributions seems 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 $Z_{12\text{-}20}$ has been around 0.22 for the last 5-10 years or F of 0.17. Intended $F_{9\text{-}19}$ is 0.097 but $F_{12\text{-}20}$=0.17 corresponds to $F_{9\text{-}19}$=0.14-0.15 that would be the model results if all weight was put on the catch data.

19.4.2.5 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 2017 SSB was estimated at 296 000 t, and according to the management plan the TAC advice for 2019 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 auto-correlated assessment error.

The simulations done at WKREDMP 2014 (ICES, 2014) were repeated, but with deterministic recruitment and no assessment error. At WKREDMP 2014, B_{lim}=B_{loss}=160 kt was defined as the lowest SSB in the 2012 Gadget run. $B_{trigger}$=B_{pa} was defined as 220 kt by adding a precautionary buffer to the proposed B_{lim} of 160 kt: 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 19.6.1). The spawning stock decreased considerably from early 1980s to mid-1990s or from 400 kt to 200 kt. 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_{9-19} based on F_{9-19} = 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 19.4.4). Spawning stock and fishable stock have been increasing in recent years and are now the highest since 1986.

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, the question is how 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 the time series (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 2018 and 2019 in Table 19.4.2.

The stock is expected to start declining in 2019 due to expected poor recruitment.

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 Chapter 19.4.

19.10 Comparison with previous assessment and forecast

The current assessment indicates about 12% smaller stock than recent assessments. The reasons are discussed in Chapter 19.4.

For management plans and evaluation, see Chapter 19.5

19.11 Basis for advice

Harvest control rule accepted at WKREDMP 2014 (ICES 2014).

19.12 Management consideration

In 2009 a fishery targeting redfish was initiated in Subarea 14 with annual catches of between 7 300 and 8 500 t in 2010—2016. The fishery does not distinguish between species, but based on survey information, golden redfish is estimated to be between 1000 and 2 700 in 2010-2015, but 5 400 t and 4 501 t in 2016 and 2017 respectively.

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 (<30cm). While current indices of adult biomass are increasing, the absence of any indications of any incoming cohorts raises concerns about the future productivity of the stock.

19.13 Ecosystem consideration

Not evaluated for this stock.

19.14 Regulation and their effects

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

In the late 1980's, Iceland introduced a sorting grid with a bar spacing of 22 mm in the shrimp fishery to reduce the by-catch of juveniles in the shrimp fishery north of Iceland. This was partly done to avoid redfish juveniles as a by-catch 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 1990's, 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 by-catches of juvenile redfish in the shrimp fishery.

19.15 Changes in fishing technology and fishing patterns

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

19.16 Changes in the environment

No information available.

19.17 Proposal for benchmark in 2020

During the meeting, it was proposed by the group that golden redfish in ICES Subareas 5, 6 and 14 should be benchmarked in 2020, prior to the NWWG meeting. The stock was benchmarked in January 2014 (WKREDMP, ICES 2014) where it was agreed to base the advice for the next five years on the Gadget model. At the WKREDMP a management plan was also evaluated and adopted.

The proposed benchmark meeting should 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 should explore alternative assessment methods. Underutilized data sources from ICES 5b and 14b, 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.

Below is a table indicating issues that will be discussed during the proposed benchmark meeting.

Stock	**Golden redfish in SA 5, 6,12 and 14**	
Stock coordinator	Name: Kristjan Kristinsson	Email: kristjan.kristinsson@hafogvatn.is
Stock assessor	Name: Kristjan Kristinsson	Email: kristjan.kristinsson@hafogvatn.is
Data contact	Name: Kristjan Kristinsson	Email: kristjan.kristinsson@hafogvatn.is

19.18

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**Responsible expert from WG**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified	Underutilised data from 5b and 14b	Collection of relevant survey data and commercial samples	These data are available, and can be obtained from the relevant institutes	Helle Torp Christensen (GR) Luis Ridao Cruz (FO)	
	Possibly compare age distributions between areas	Age – read available otolith samples in 5b and 14b.	Resources will be needed to complete this task	Helle Torp Christensen (GR) Luis Ridao Cruz (FO)	
Tuning series	Combine survey estimates 5b and 14b with existing tuning series	Combine the indices	Data are available	Helle Torp Christensen (GR) Luis Ridao Cruz (FO) Kristjan Kristinsson (ICE)	
Bycatch/misreporting	Investigate the extent of misreporting the redfish fishery	Investigation of the spatial structure of catches of the different redfish species to confirm the reported landings	Logbooks and survey data are available from all areas	Helle Torp Christensen (GR) Luis Ridao Cruz (FO) Kristjan Kristinsson (ICE)	
Biological Parameters	Time varying growth and maturity	Investigate the appropriateness of the current growth and maturity model used in the assessment	Biological information are available in 5a		

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
Fisheries & ecosystem issues and data	Low recruitment in recent years				
Assessment method	Exploration of assessment methods	Currently an age-length based model (Gadget) is used to assess the stock. Issues with the current assessment include: • Poor fit to survey indices for fish between 30 and 40 cm • Potential dome-shape in selectivity • Uncertainty estimates are not available Alternative assessment methods should also be explored	All data which are available	Bjarki Elvarsson Hoskuldur Bjornsson Kristinn Kristinsson Rasmus Hedeholm Helle Torp Christensen Luis Ridao Cruz	

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**Responsible expert from WG**	**External expertise needed at benchmark type of expertise / proposed names**
Biological Reference Points	Revisit definition of reference points	Redefine if needed		Bjarki Elvarsson Hoskuldur Bjornsson Kristinn Kristinsson Rasmus Hedeholm Helle Torp Christensen Luis Ridao Cruz	
Other	None				

19.19 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.

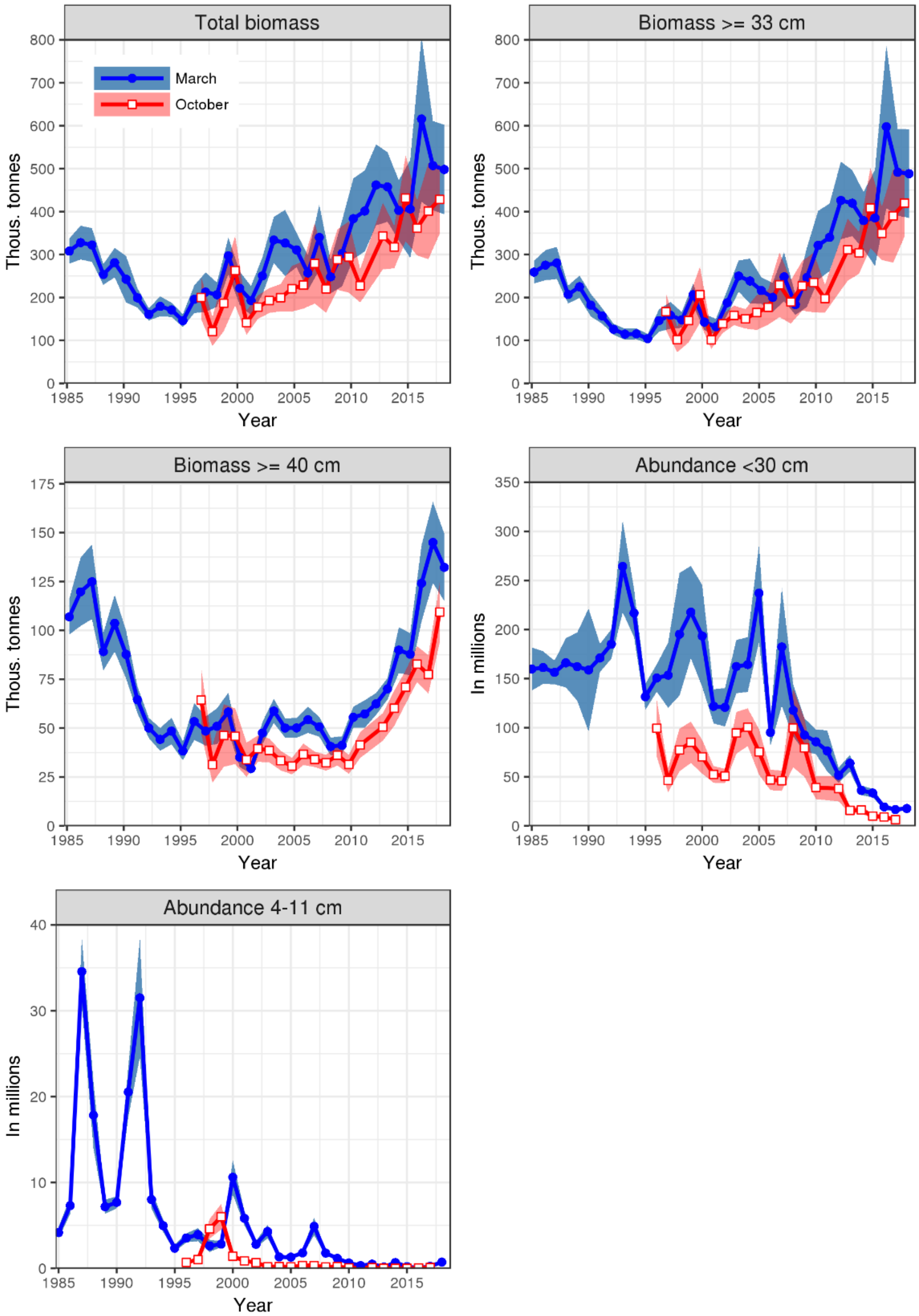

Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985-2018 (blue line and shaded area) and October 1996-2017 (red lines and shaded areas). The shaded areas show ±1 standard error of the estimate.

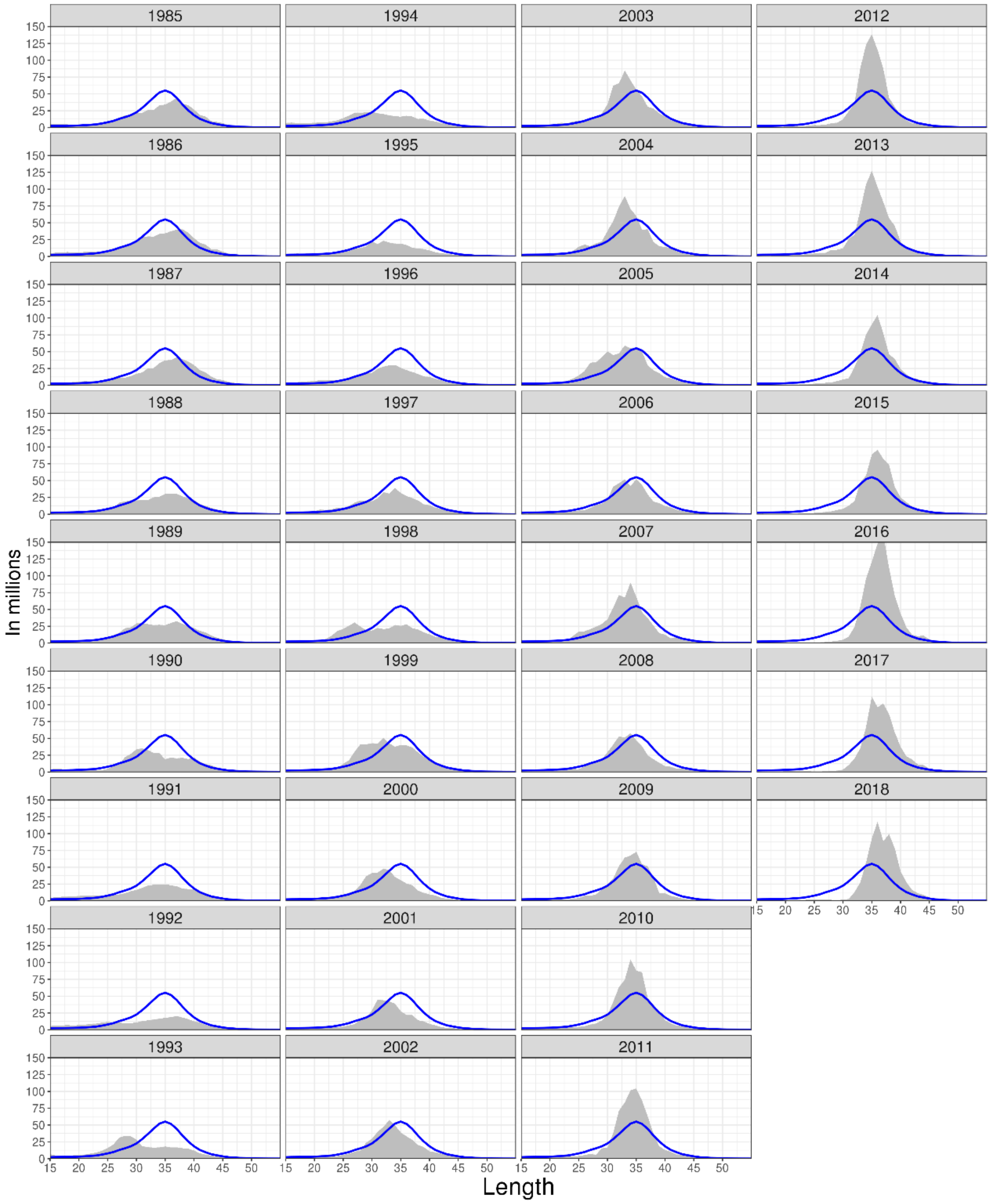

Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985-2018 conducted in Icelandic waters. The blue line is the mean of total indices 1985-2018.

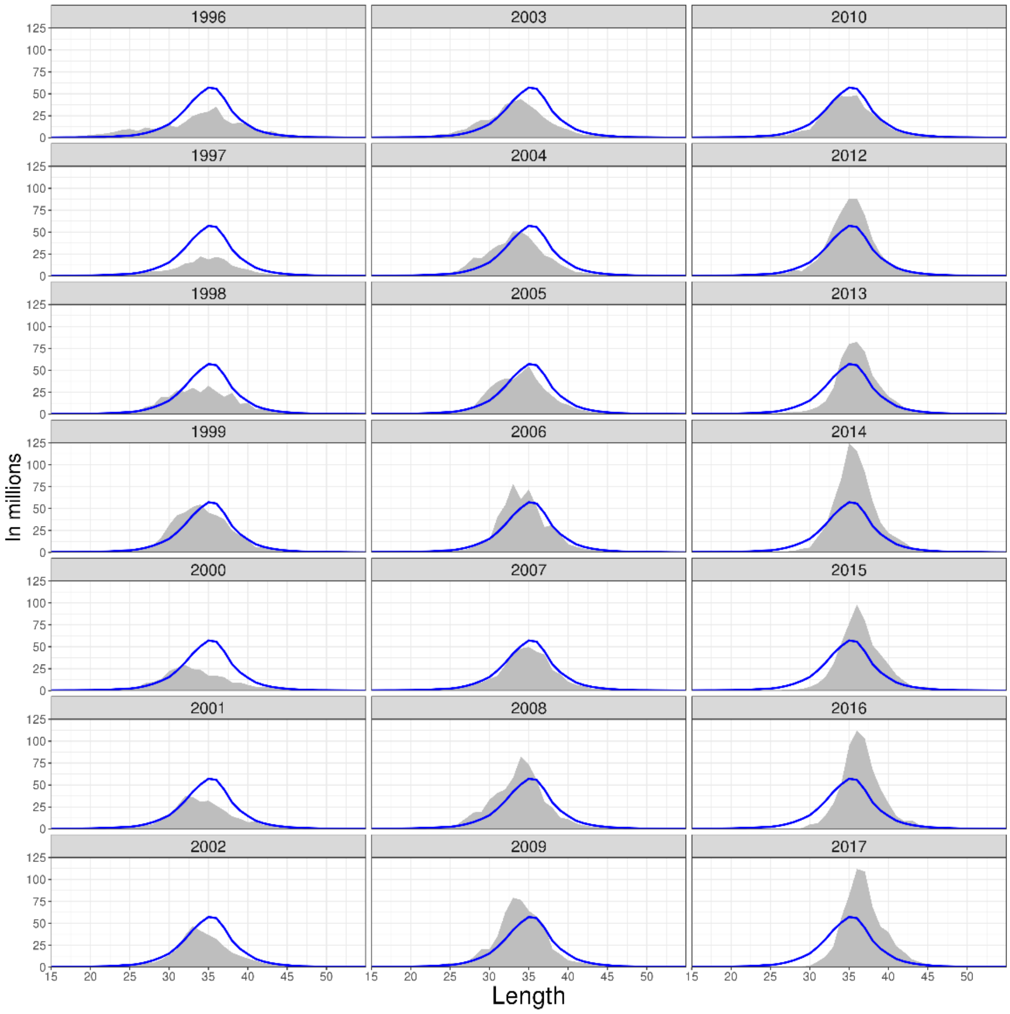

Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996-2017 conducted in Icelandic waters. The blue line is the mean of total indices 1996-2017. The survey was not conducted in 2011.

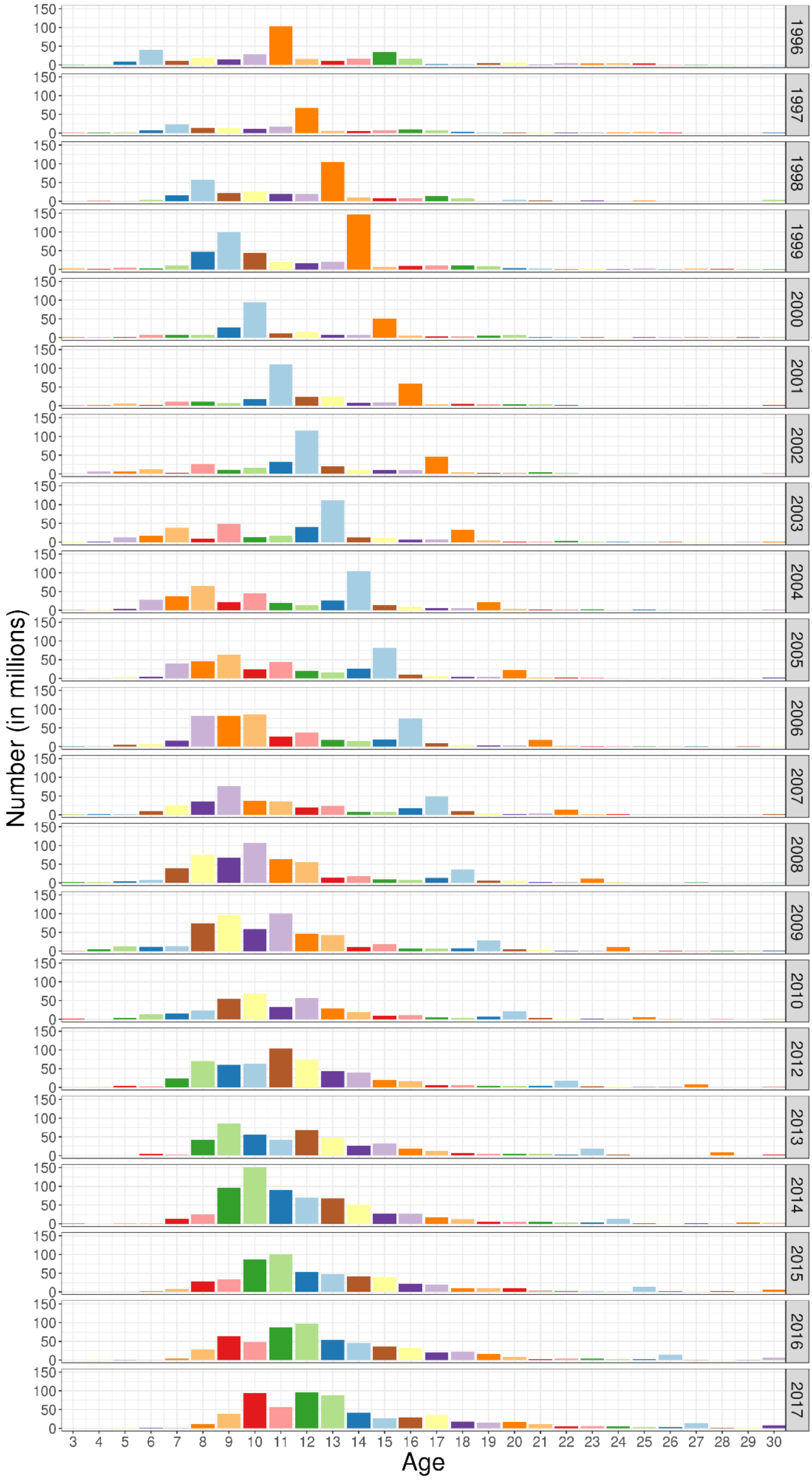

Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996-2017. The survey was not conducted in 2011.

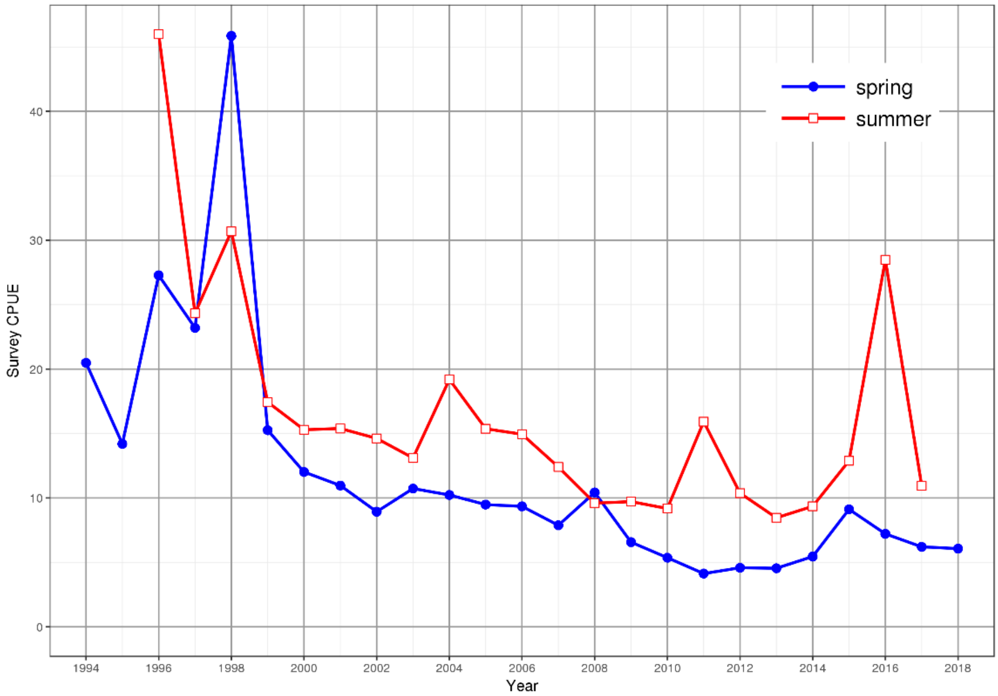

Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994-2018 (blue line) and the summer groundfish survey 1996-2017 (red line) in ICES Division 5.b.

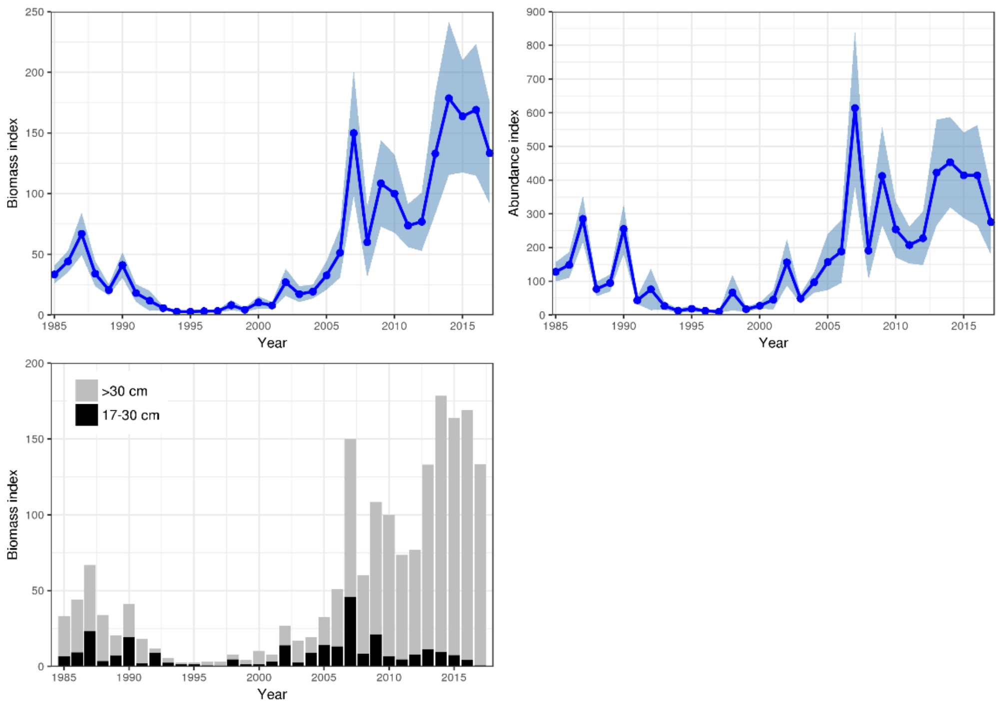

Figure 19.2.6 Golden redfish (>17 cm). Survey abundance indices for East Greenland (ICES Sub-area 14) from the German groundfish survey 1985-2017. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17-30 cm and > 30 cm).

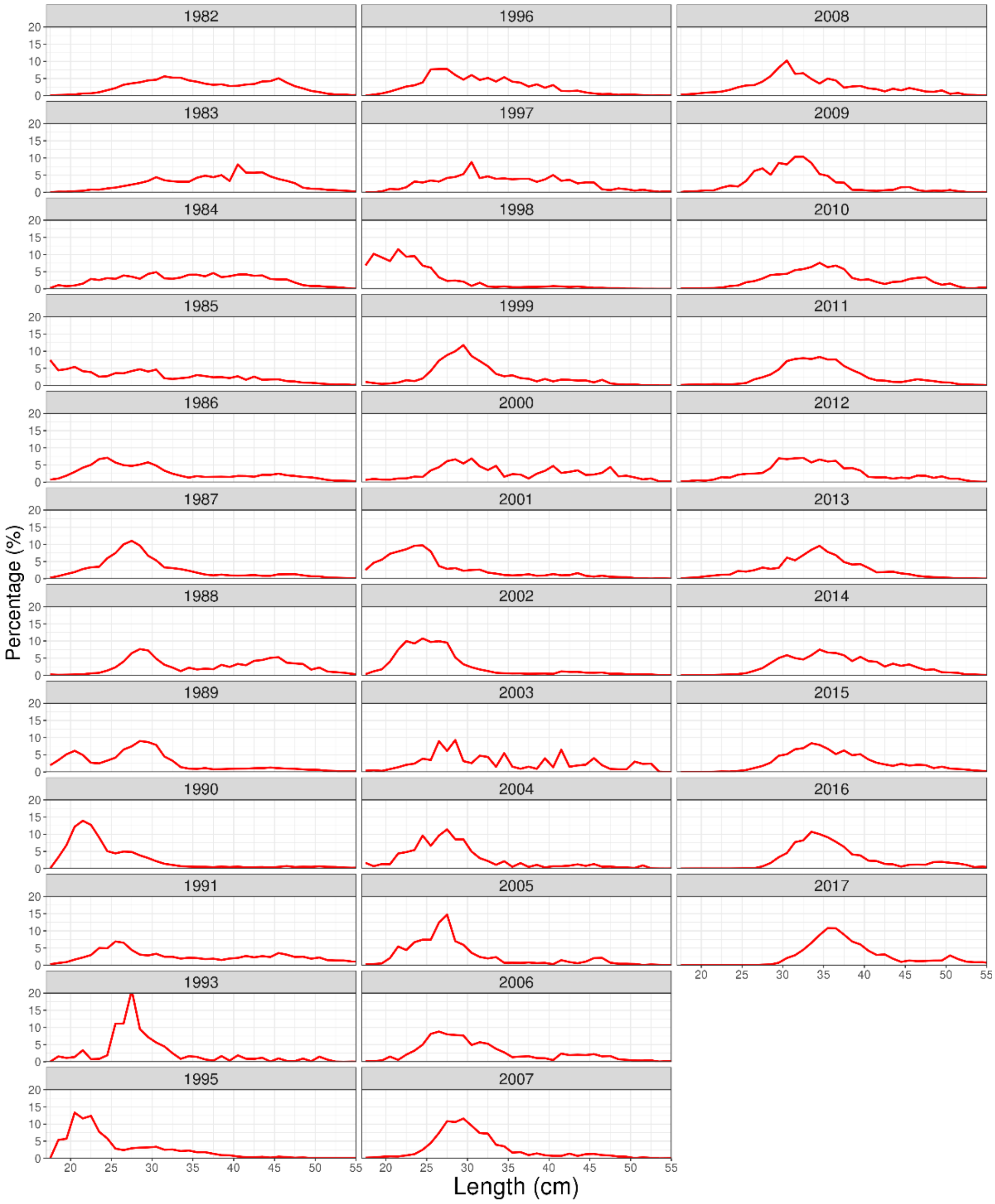

Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982-2017.

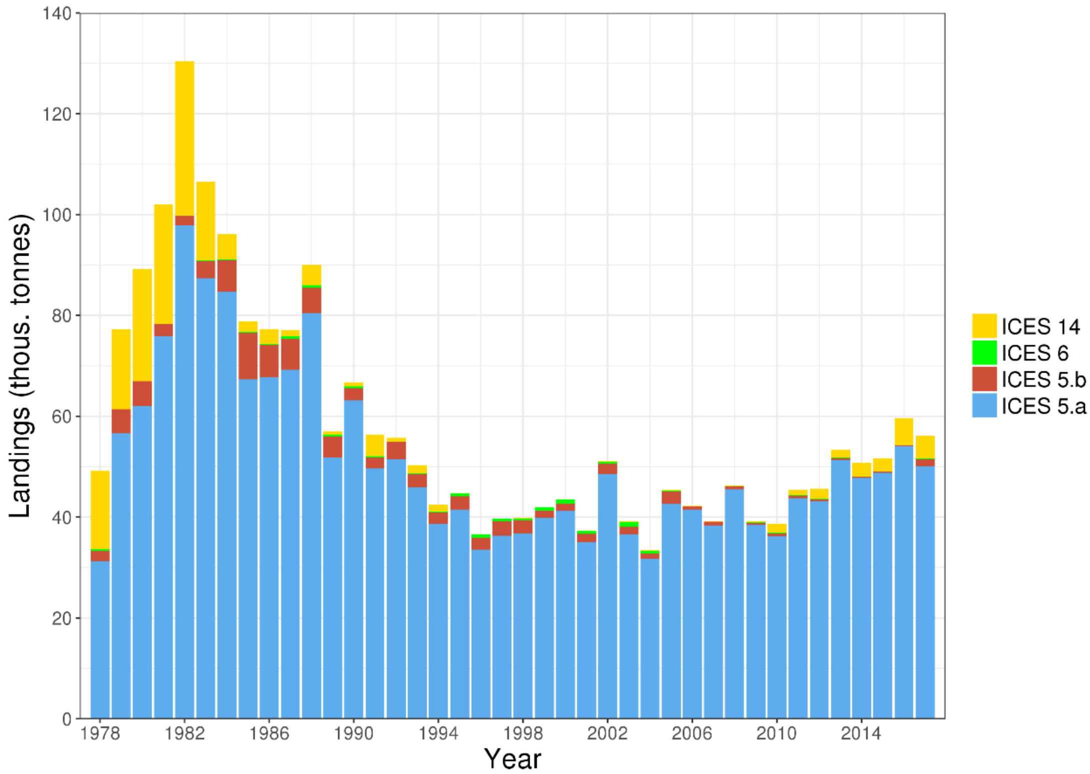

Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978-2017. Landings statistics for 2017 are provisional.

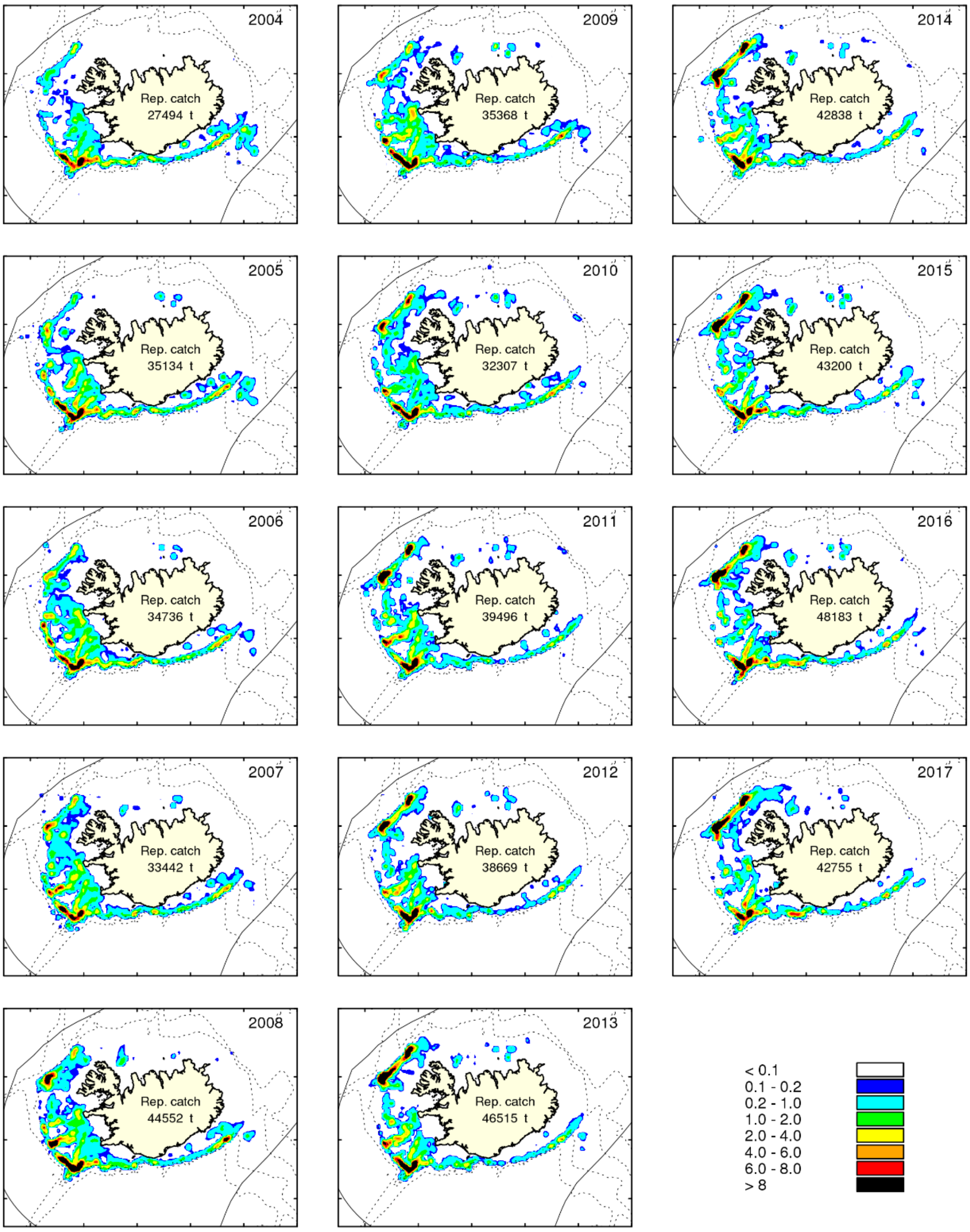

Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2004-2017.

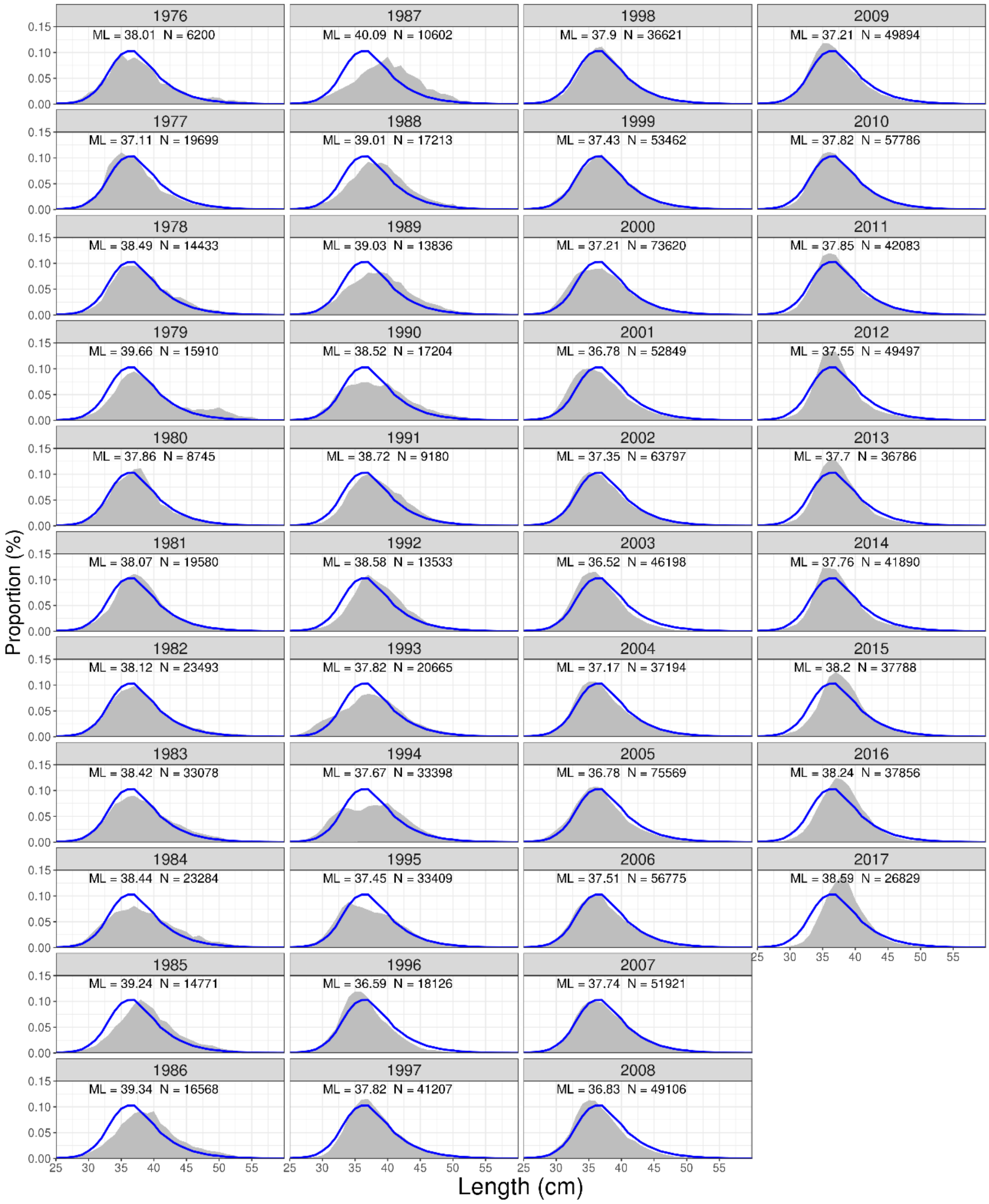

Figure 19.3.3 Length distribution (gray shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976-2016. The blue line is the mean of the years 1976-2017.

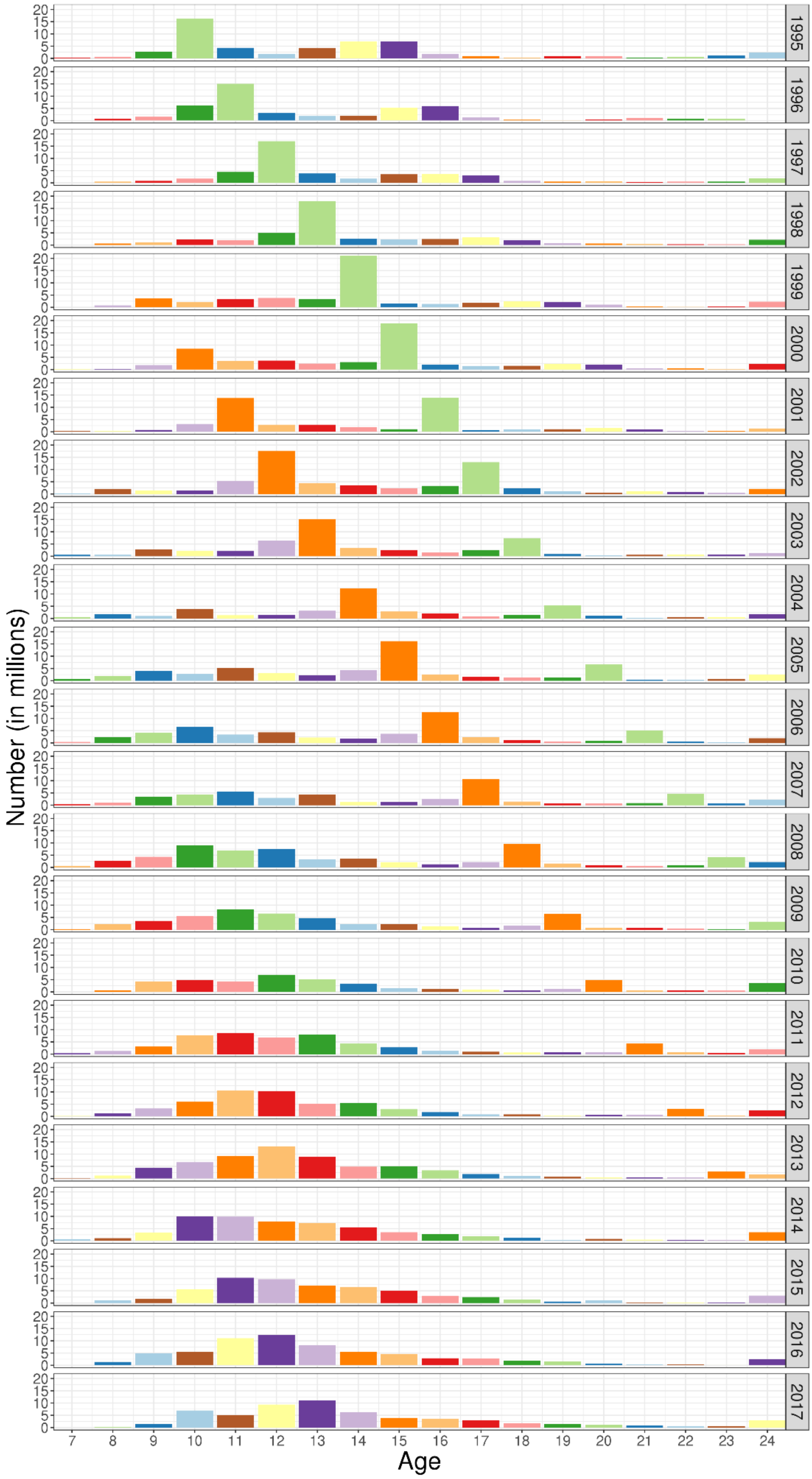

Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Subdivision 5.a 1995-2017.

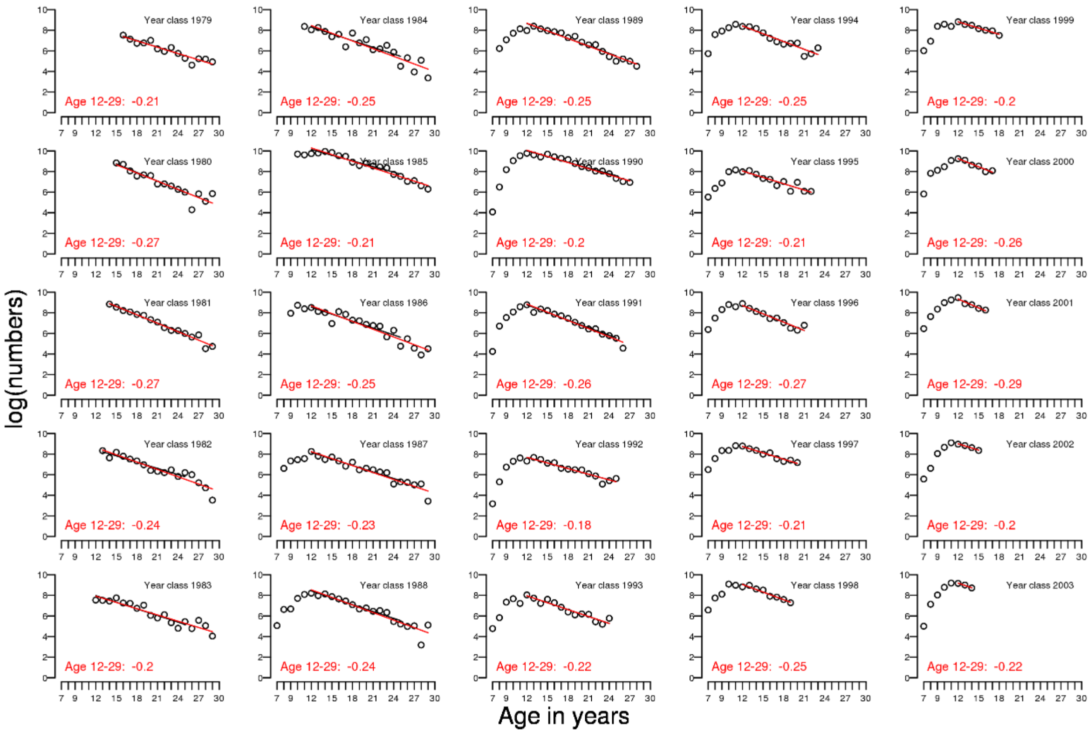

Figure 19.3.5 Catch curve of the 1979-2003 year classes of golden redfish based on the catch-at-age data in ICES Division 5.a 1995-2017.

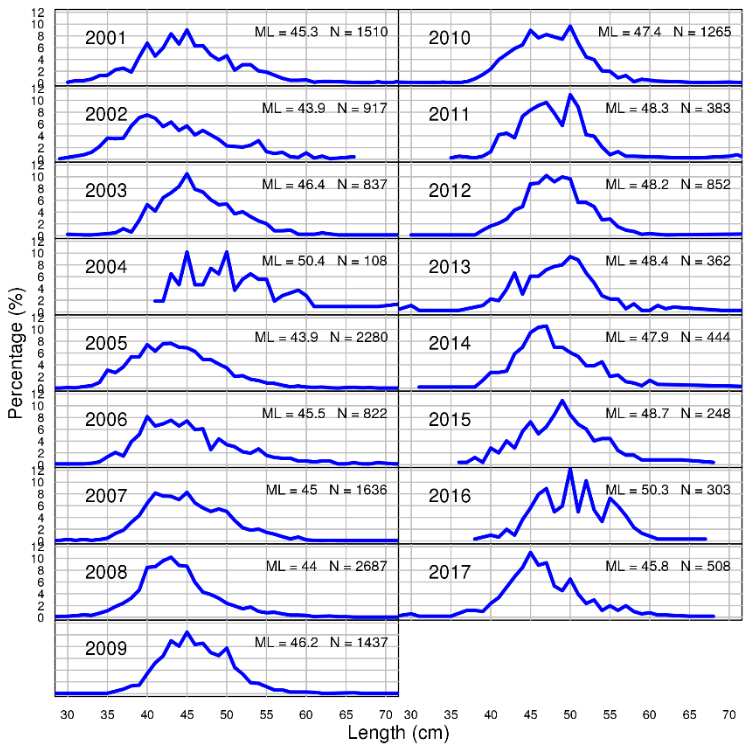

Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001-2017.

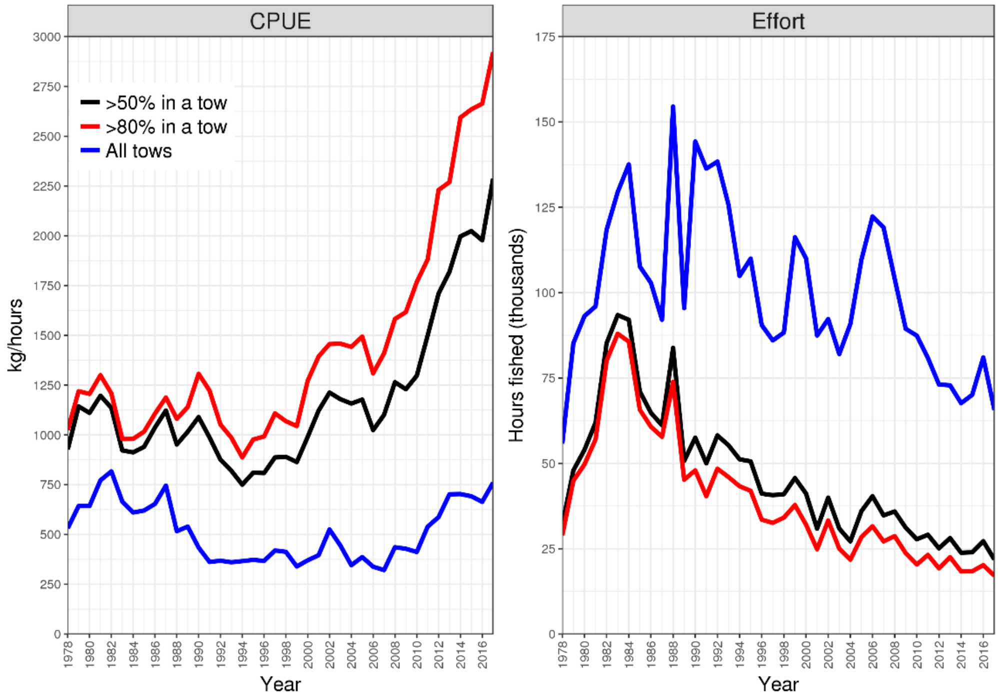

Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978-2017 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

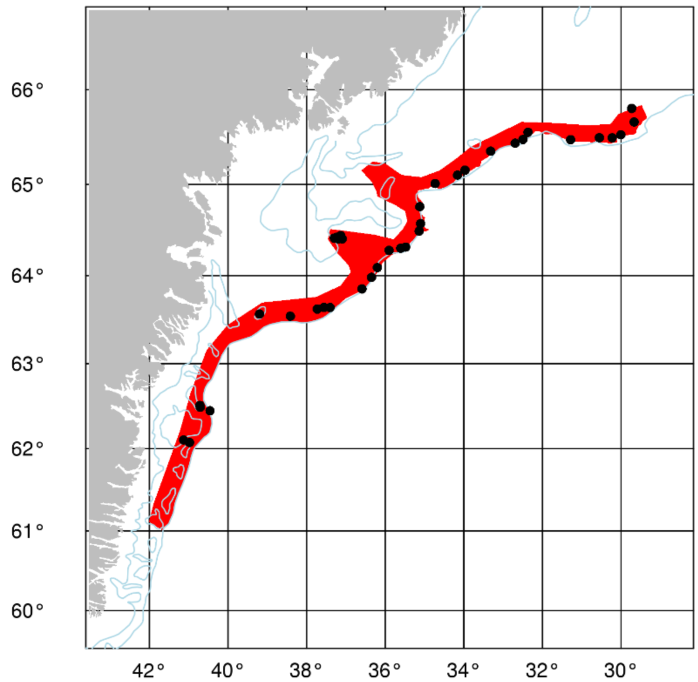

Figure 19.4.1 Stations in the German survey in East Greenland with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

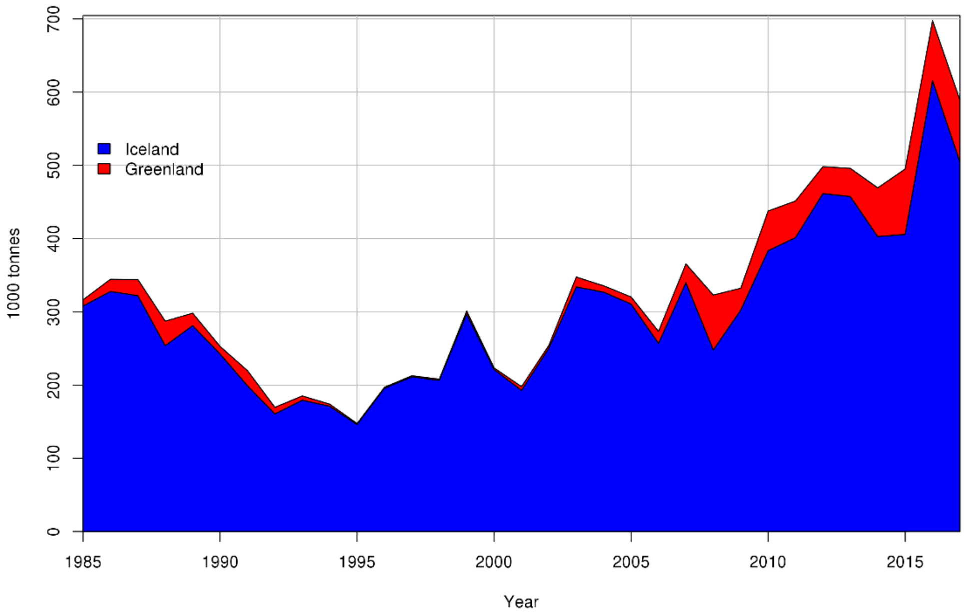

Figure 19.4.2 Biomass index from Iceland (blue) and Greenland black, based on weighting the German survey data in Figure 19.2.7 by 0.5.

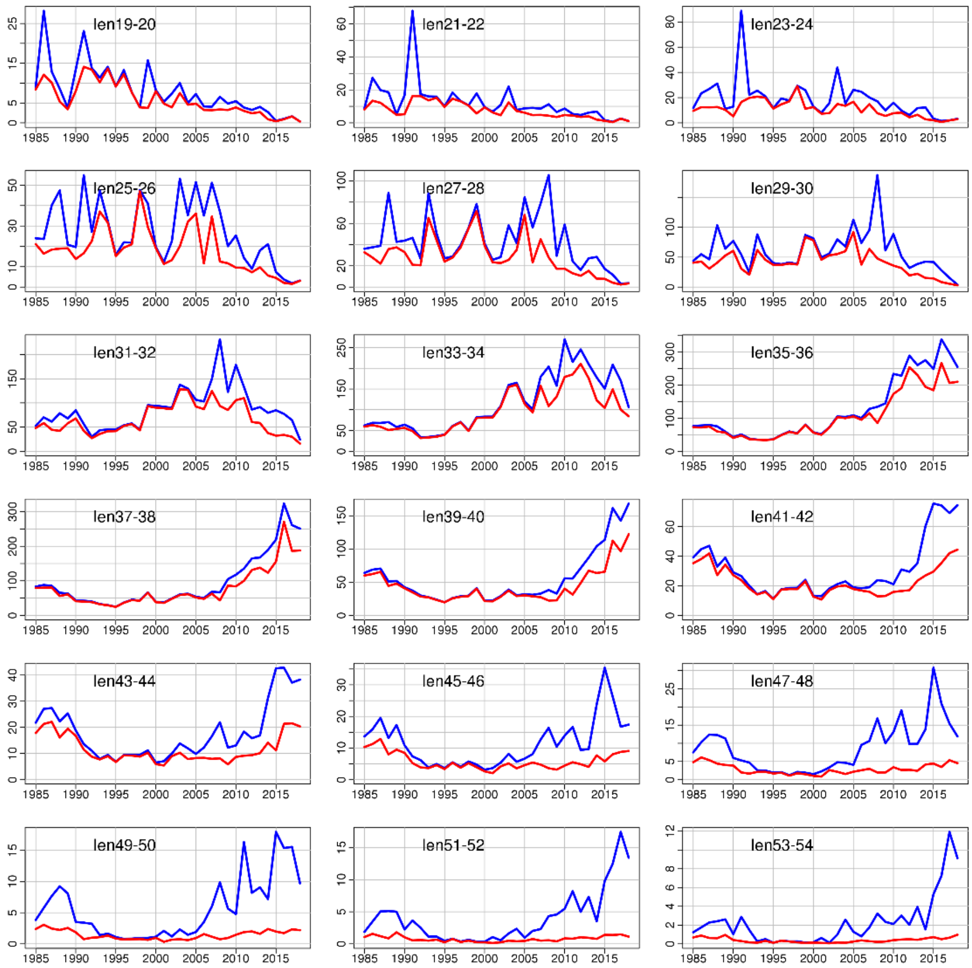

Figure 19.4.3. Indices from the Icelandic March survey (red) and the Icelandic March survey +German survey in East Greenland (blue) by length group.

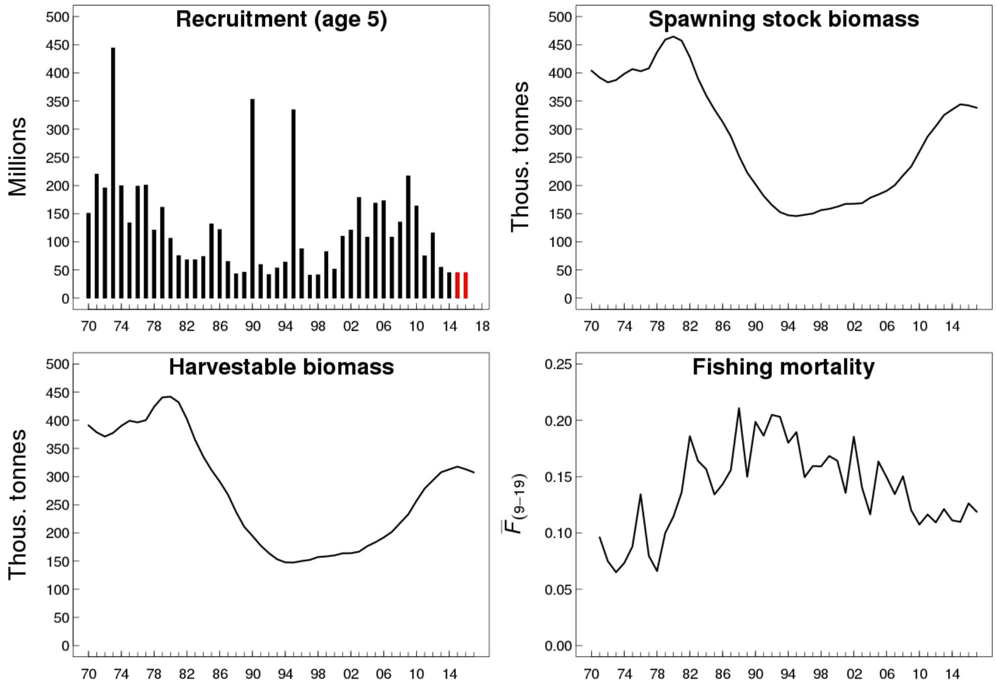

Figure 19.4.4. Summary from the assessment. Red values are predictions. Spawning stock is compiled using a fixed maturity ogive with L50=33cm. PUT reference points to the plot!

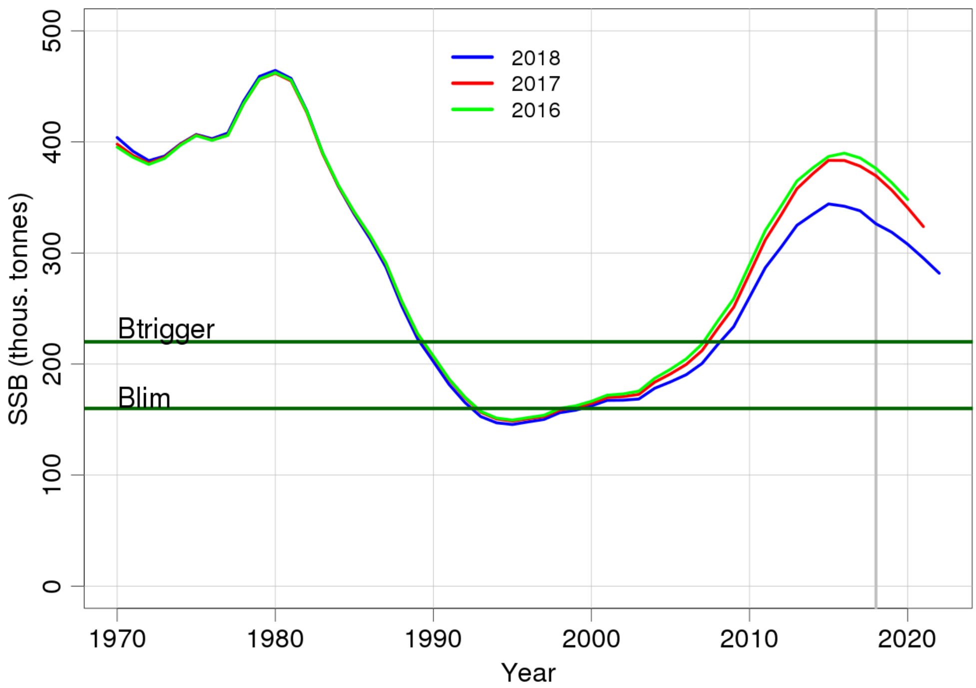

Figure 19.4.5. Comparison of the current assessment and the same assessment done in 2016 and 2017.

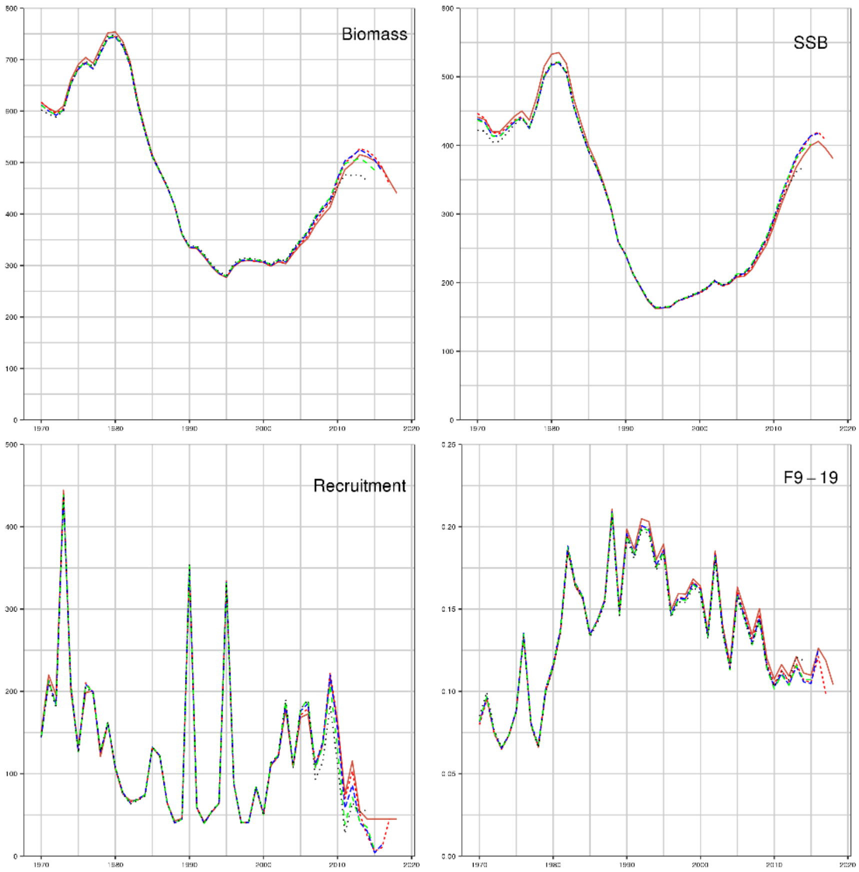

Figure 19.4.6. Analytical retrospective pattern of the base run. Recruitment is at age 5 and F shows the development of ages 9-19.

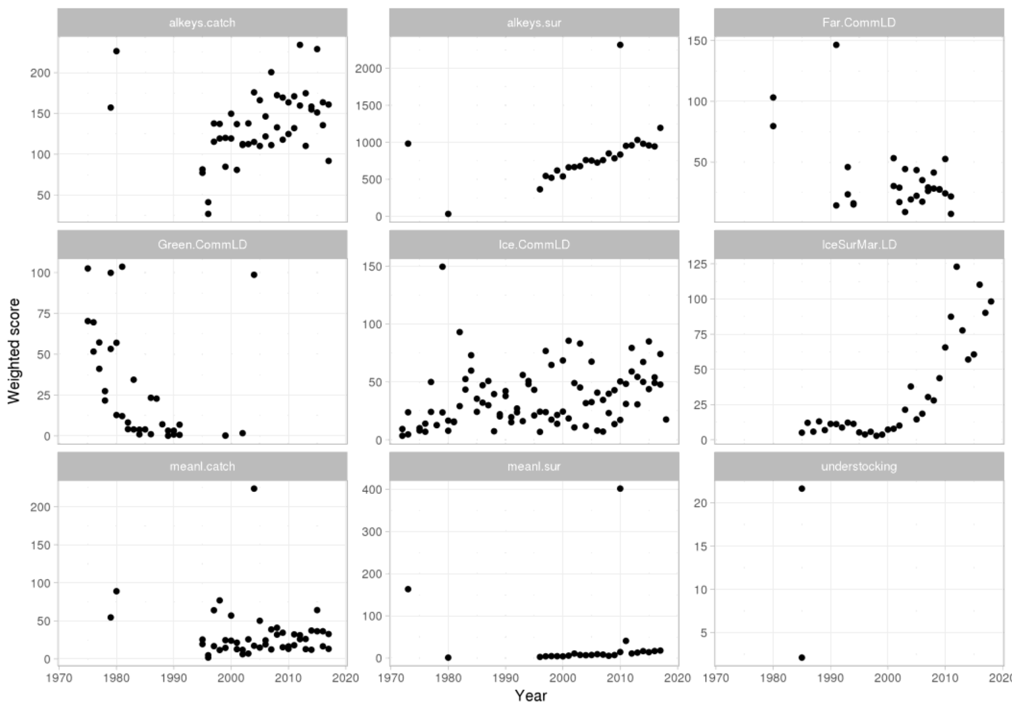

Figure 19.4.7. Development of component of the objective function with time.

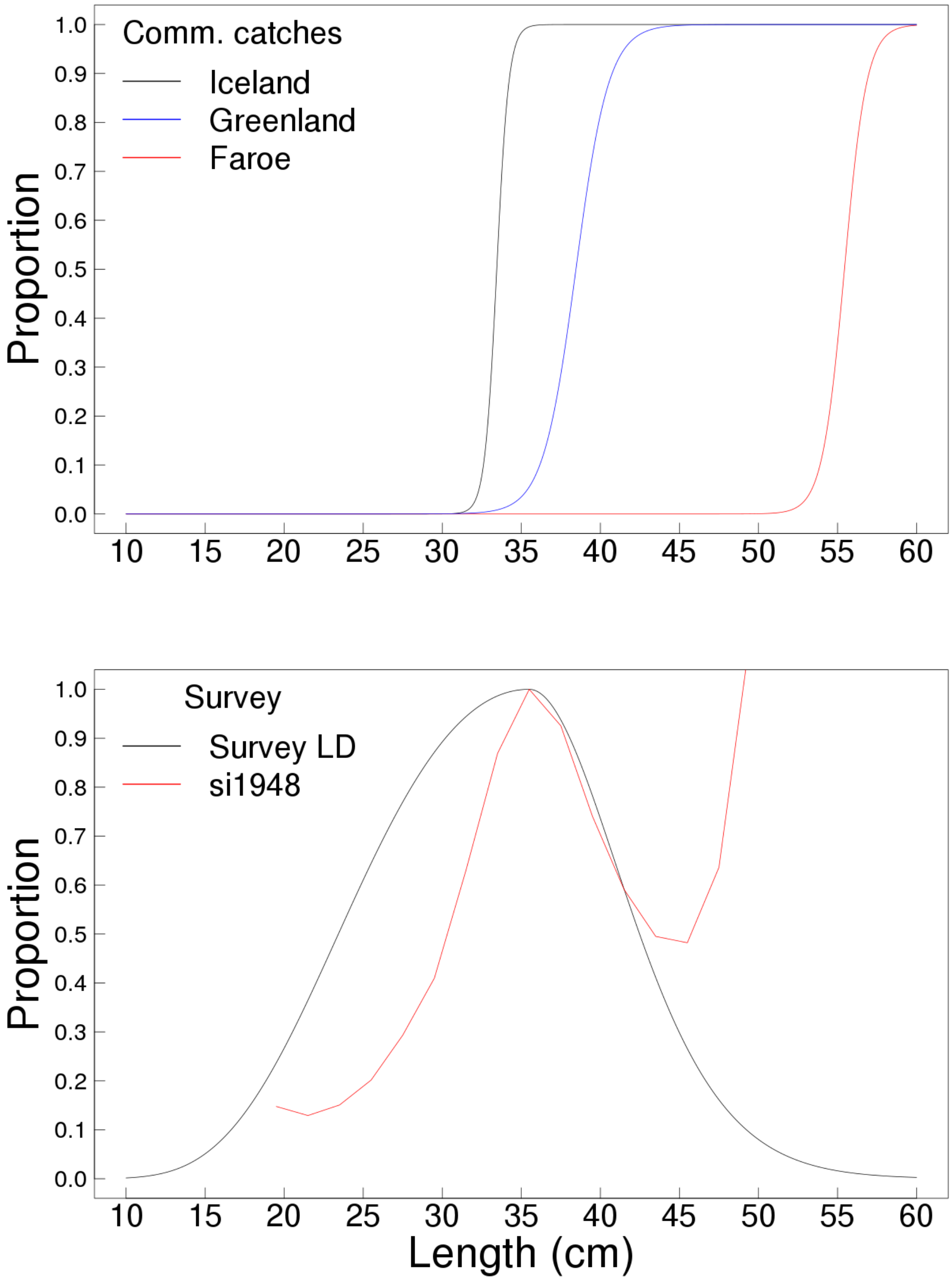

Figure 19.4.8. Estimates of selection curves from commercial catches (upper panel) and from the Icelandic March survey. The black line is the estimated selection curve fitted to the length distributional data based on 3 parameter domeshaped curve and the red line is the estimated q from the disaggregated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

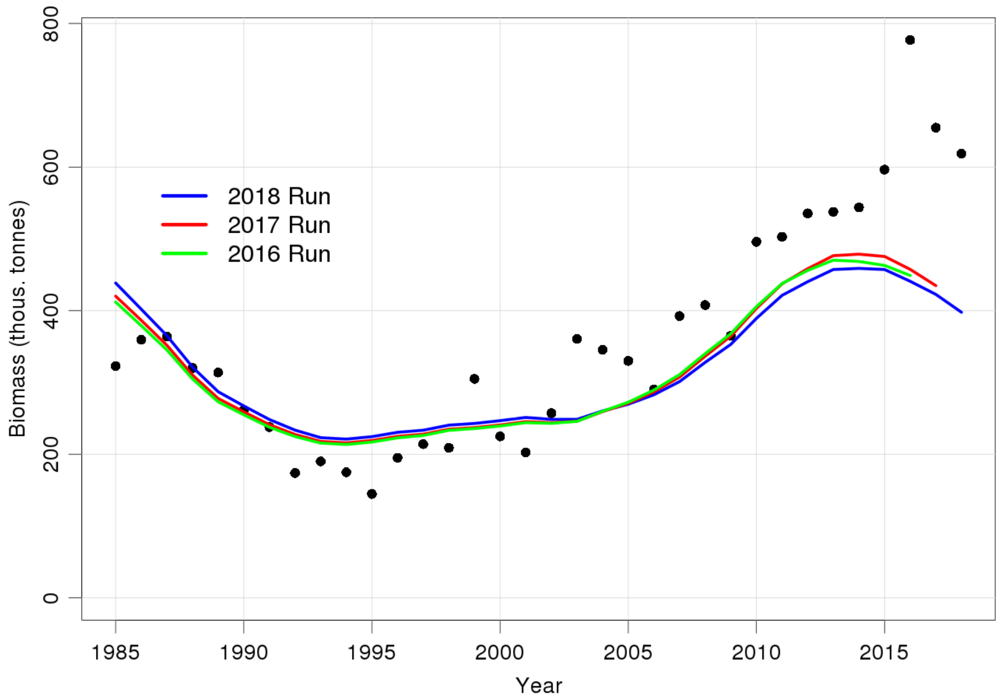

Figure 19.4.9. Comparison of observed and predicted survey biomass from the 2017 (blue line), 206 (red line) and 2015 (green line) runs.

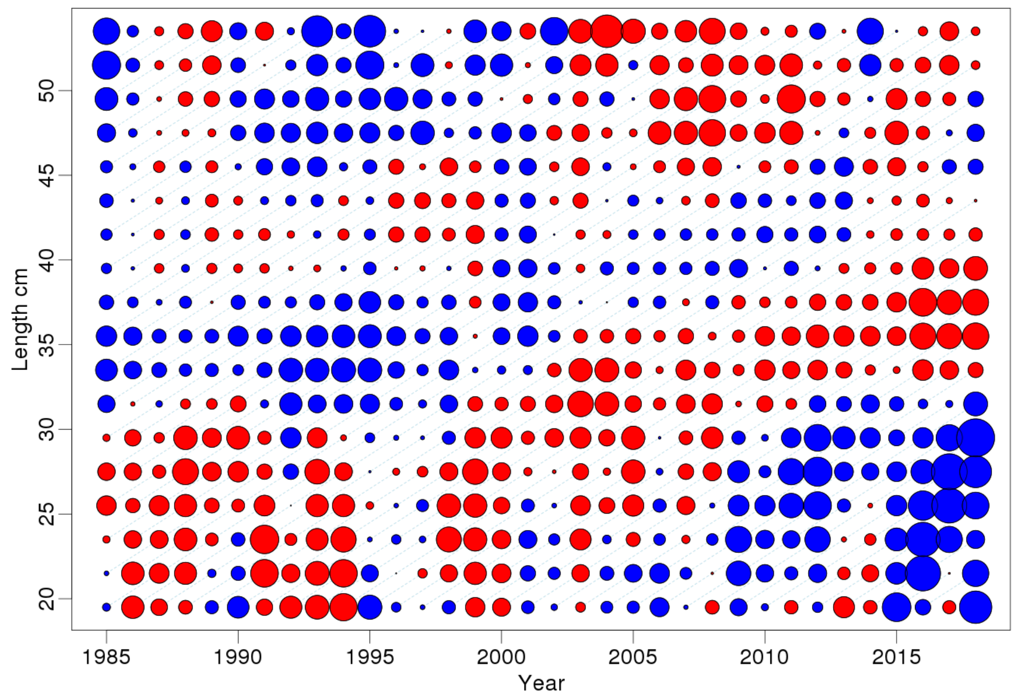

Figure 19.4.10. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

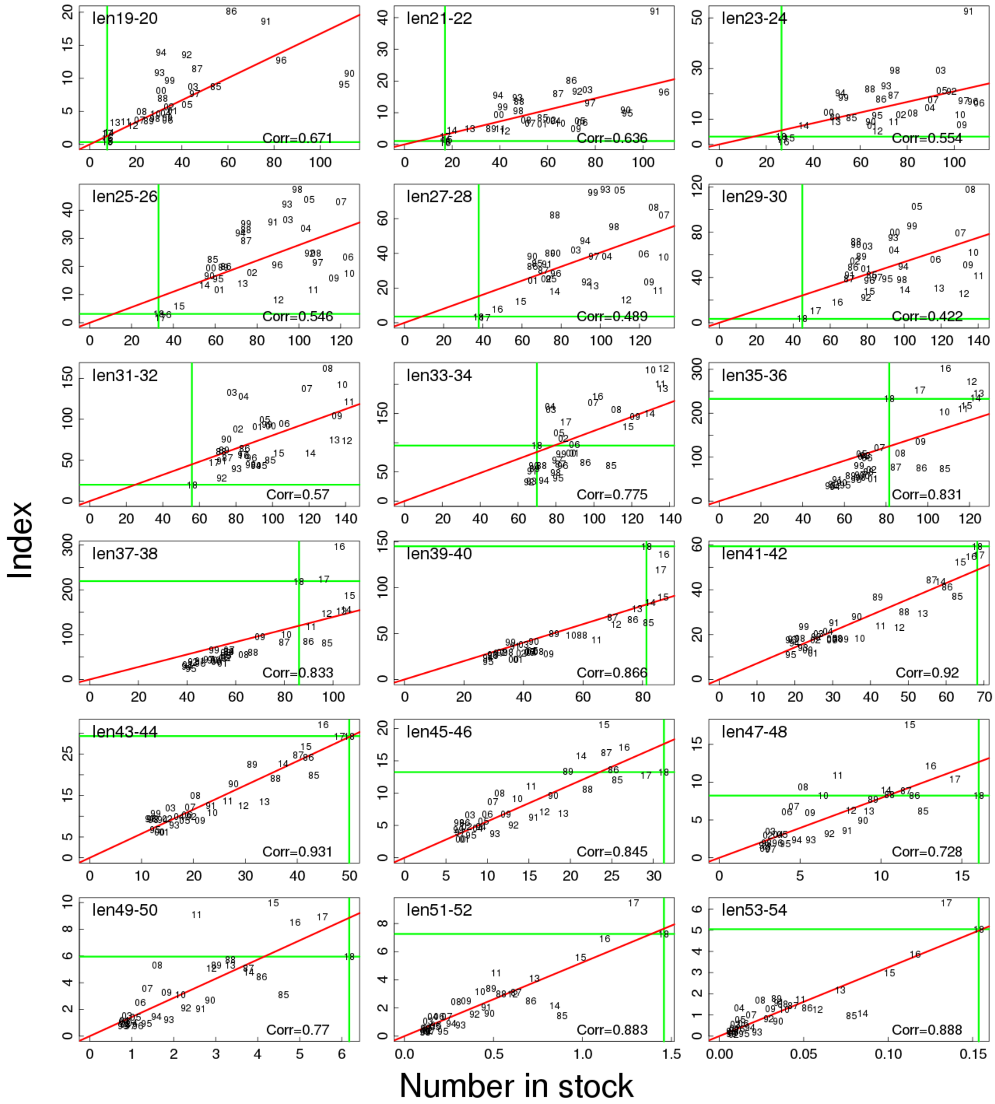

Figure 19.4.11. Fit to length disaggregated survey indices from Gadget run as XY-scatter. The red line is fitted going through the 0-point, the green cross goes over the terminal year.

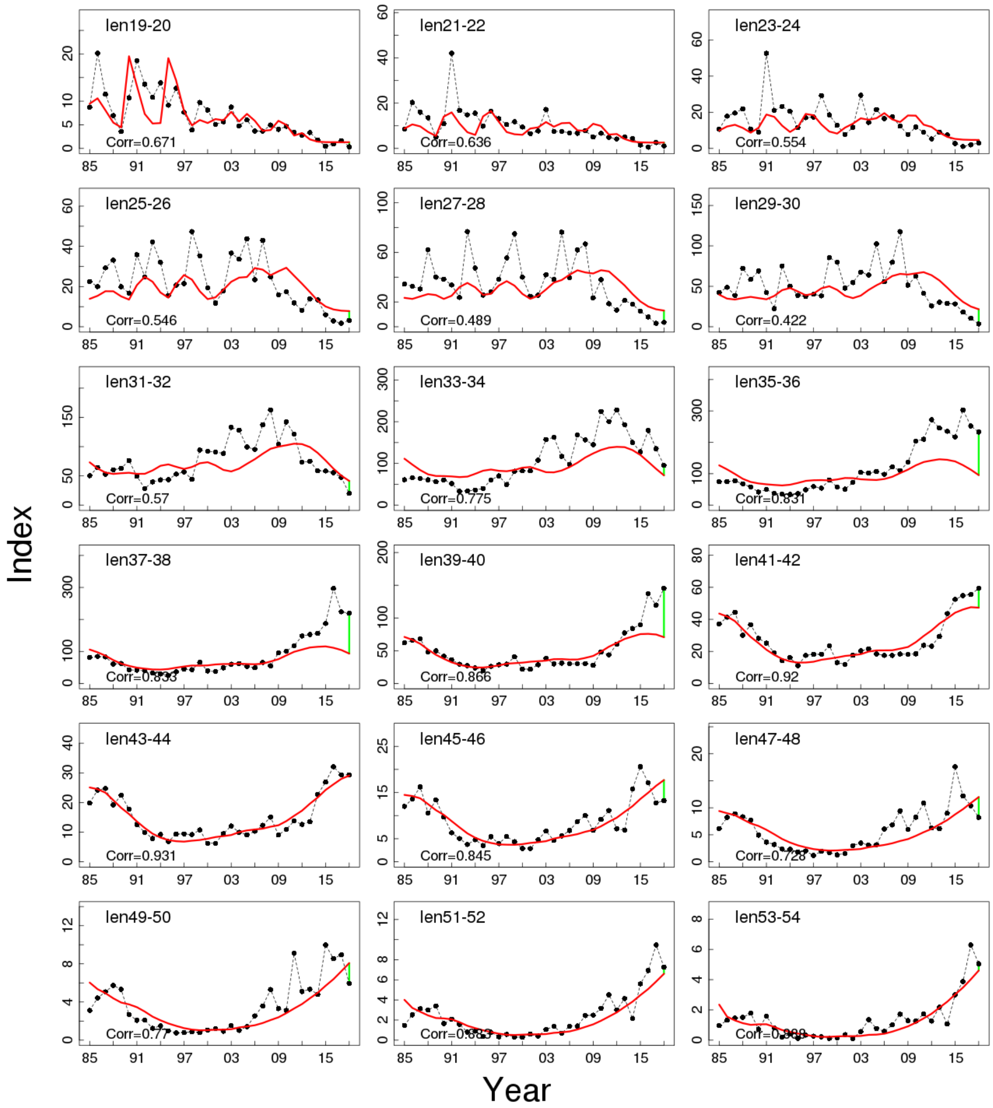

Figure 19.4.12. Fit (red lines) to length disaggregated survey indices (broken lines and points) from Gadget run as time series.

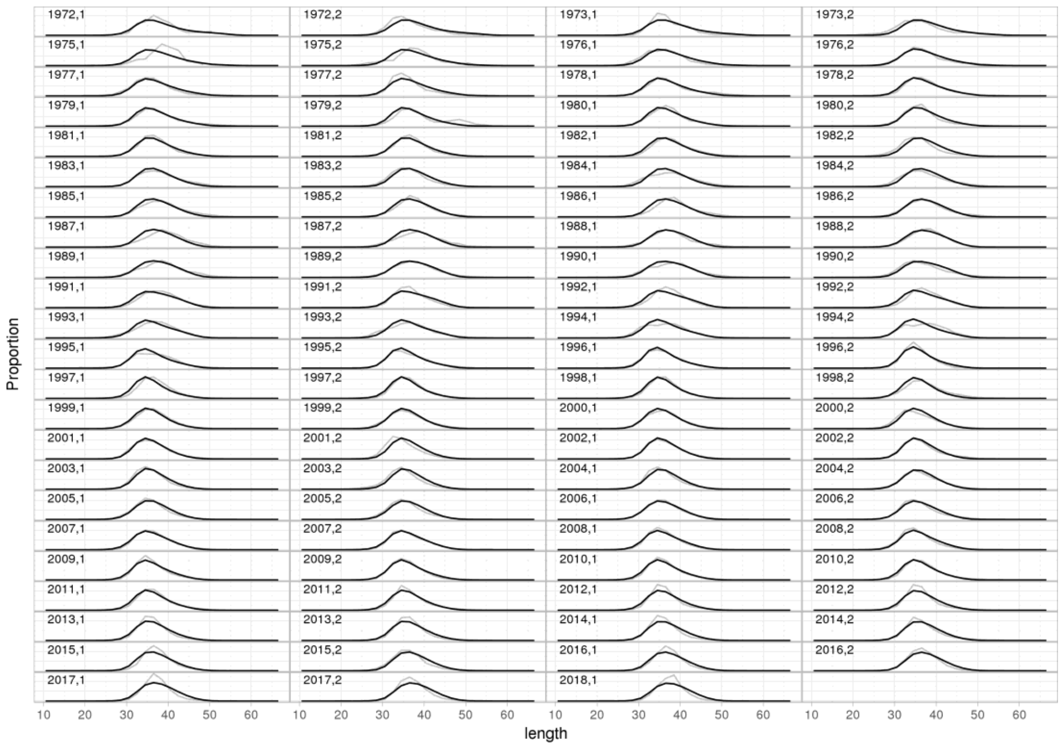

Figure 19.4.13. Fit (red line) to Icelandic commercial length distributions aggregated by 3 years.

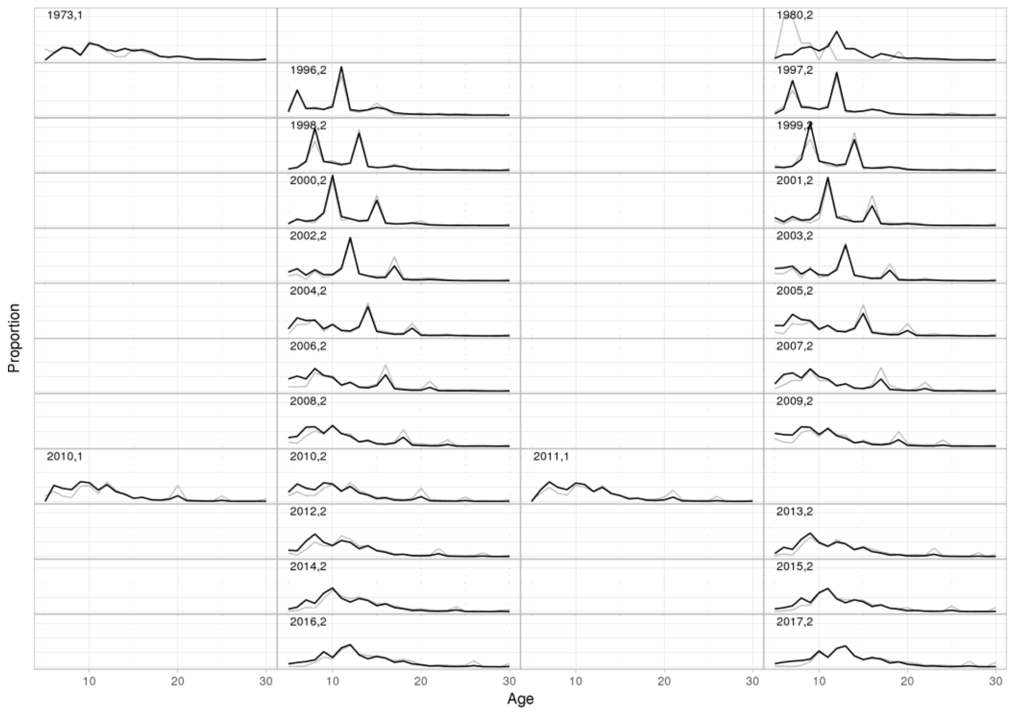

Figure 19.4.14. Fit to survey age data (run 1). Bars represent the data and red lines the fit. The likelihood data are used in the model as proportions in each 2 cm length group but presented here as total for each age group something that should only be comparable if catchability was independent of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

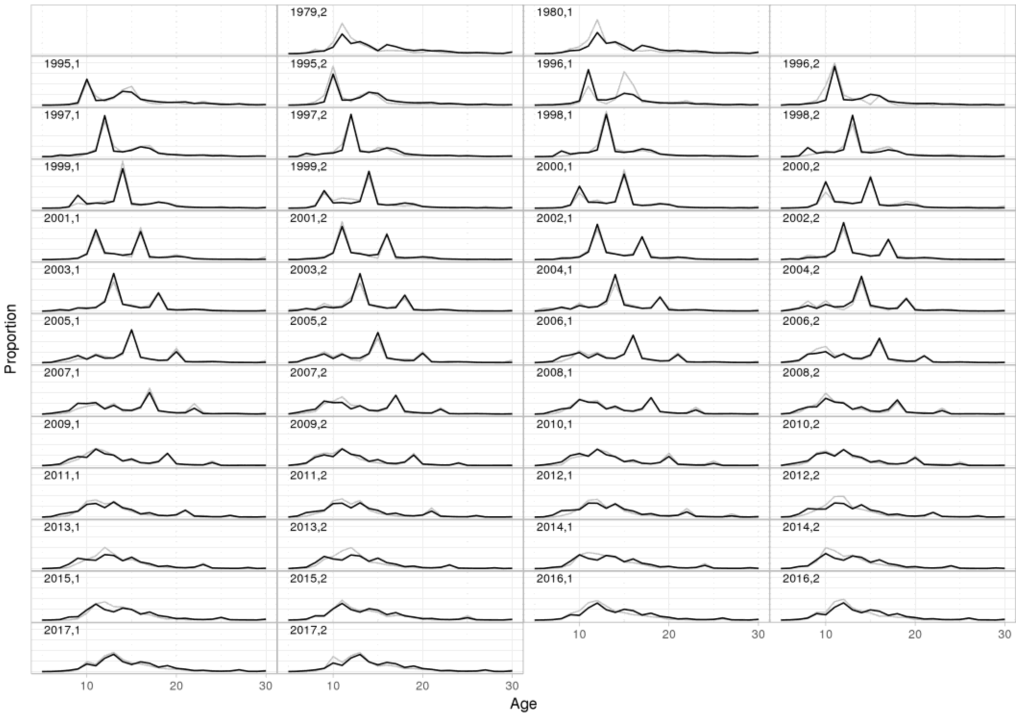

Figure 19.4.15. Predicted (red) and observed (blue) age distributions from Icelandic commercial fishery.

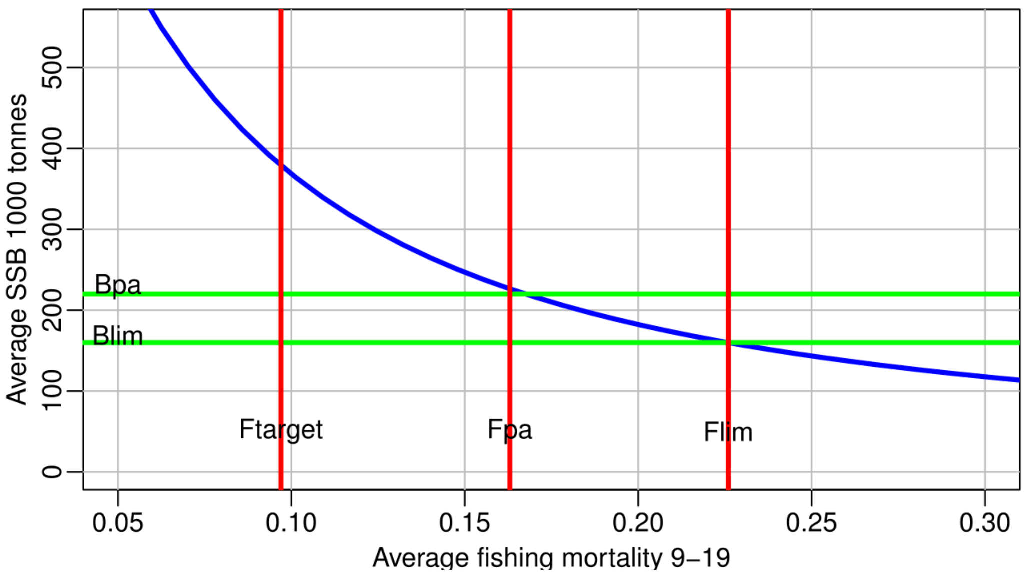

Figure 19.6.1. Average SSB against average fishing mortality and defined reference points.

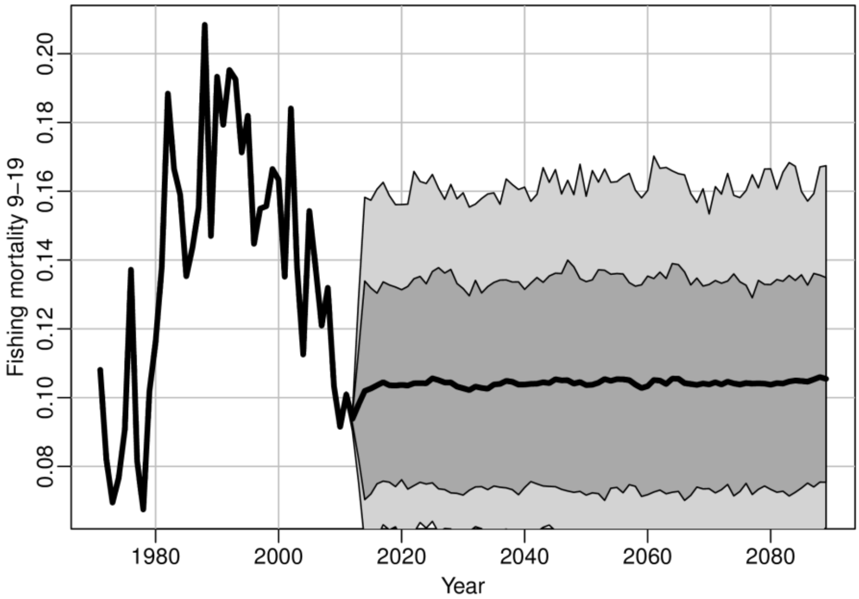

Figure 19.6.2. Development of F_{9-19} based on F_{9-19} = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985-2018 and the autumn survey 1996-2017.

	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		
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	401,139	0.279
2017	507,058	0.205	428,453	0.187
2018	498,043	0,209		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in numbers) from the autumn groundfish survey 1996-2017. 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
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
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
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
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
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
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
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
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
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
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
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
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
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
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	41.8
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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	628.8

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.

		Area			
Year	5.a	5.b	6	14	Total
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
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[1)]	50 119	1 397	93	4 501	56 101

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995-2017. 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
7	47	0	32	23	6	38	117	125	189	216	219	175	126	205	101	58	136	69	30	221	14	47	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
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	949
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	4,476
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	3,408
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	6,775
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	8,571
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	5,380
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	3,734
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	3,640
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	3,141
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	1,851
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	1,490
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	1,318
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	1,053
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	450
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	517
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	350
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	332
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	112
27	384	0	139	427	615	198	275	80	83	183	279	263	353	343	201	398	79	1,443	110	143	213	182	1,377
28	808	0	202	357	229	516	189	296	27	141	169	204	205	172	96	132	205	198	937	58	187	30	95
29	0	0	143	53	106	364	146	498	105	138	29	168	37	178	390	187	45	71	38	692	87	26	175
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	822
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	50,119

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 weight are in thousand tons.

Year	Biomass	SSB	R(age5)	Catches	F9-19
1971	609.0	378.7	220.1	67.9	0.096
1972	610.6	371.1	195.6	50.9	0.075
1973	651.4	377.7	444.3	43.7	0.065
1974	683.2	390.2	199.4	50.6	0.073
1975	702.5	399.2	133.5	61.9	0.088
1976	706.7	396.4	198.6	94.4	0.134
1977	716.7	400.3	200.4	53.8	0.080
1978	743.2	423.9	120.9	48.7	0.066
1979	760.1	440.7	161.2	77.2	0.100
1980	749.8	442.0	106.0	89.1	0.115
1981	719.9	431.9	75.4	102.0	0.136
1982	662.5	402.3	67.8	130.3	0.186
1983	596.5	365.3	67.9	106.1	0.164
1984	543.2	335.7	73.9	95.3	0.157
1985	505.2	311.7	131.6	78.5	0.134
1986	474.4	291.3	121.4	76.9	0.143
1987	438.0	268.4	64.8	76.6	0.156
1988	390.3	237.3	42.9	89.8	0.211
1989	349.5	210.8	45.8	56.6	0.150
1990	348.3	194.6	352.8	66.3	0.199
1991	327.5	177.6	59.2	56.0	0.186
1992	309.2	164.2	41.5	55.8	0.205
1993	293.2	153.3	53.3	50.2	0.203
1994	283.1	147.7	63.9	42.5	0.180
1995	301.2	147.4	334.1	44.3	0.190
1996	307.0	150.1	87.6	35.6	0.150
1997	307.1	152.1	40.7	39.0	0.159
1998	309.1	157.2	41.1	39.7	0.159
1999	306.3	158.3	82.3	42.5	0.168
2000	301.3	160.1	51.1	42.6	0.164
2001	306.6	163.8	109.9	36.7	0.136
2002	308.4	164.0	120.9	50.7	0.185
2003	321.0	166.7	178.6	38.2	0.140
2004	336.7	176.5	108.3	32.8	0.117
2005	354.4	183.5	168.3	46.6	0.163
2006	376.2	191.9	172.7	42.1	0.150
2007	390.5	201.8	108.3	39.2	0.134
2008	413.9	217.5	134.9	46.2	0.150
2009	445.2	232.9	216.7	39.3	0.120
2010	481.3	256.9	163.4	38.5	0.107
2011	501.7	278.8	75.0	45.1	0.116
2012	514.7	293.4	115.6	45.2	0.109
2013	519.3	307.7	54.6	53.1	0.121
2014	509.5	312.8	45.0	50.8	0.111
2015	500.2	317.7	45.0	51.8	0.110
2016	479.3	313.1	45.0	59.8	0.126
2017	459.3	307.5	45.0	55.2	0.119
2018	433.9	296.0	45.0	46.4	0.103
2019	*416.3*	*288.9*	*45.0*	*43.6*	*0.100*
2020	*397.8*	*279.4*	*45.0*	*42.1*	*0.100*
2021	*379.2*	*268.6*	*45.0*	*40.2*	*0.100*
2022	*361.4*	*257.1*	*45.0*	*38.2*	*0.100*

Table 19.4.2 Output from short term prognosis. Multiplier is based on reference to the adopted HCR $F_{9\text{-}19}$=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 tons.

F(2017) = 0.119 C(2017) = **56 101**.

2018				
Bio 5+	SSB	Fmult	F9-19	Landings
440	330	1.05	0.117	55 207 t

		2018			2019	
Fmult	F9-19	Bio 5+	SSB	Landings	Bio 5+	SSB
0.0	0.052	444	342	24	471	373
0.1	0.056	442	340	26	464	367
0.2	0.061	440	338	29	457	360
0.3	0.066	437	336	31	450	354
0.4	0.071	435	334	33	443	348
0.5	0.076	433	333	35	436	342
0.6	0.081	431	331	37	430	336
0.7	0.086	428	329	40	423	331
0.8	0.092	426	327	42	416	325
0.9	0.097	424	325	44	410	319
1.0	0.102	422	323	46	404	314
1.1	0.107	419	321	49	397	308
1.2	0.112	417	319	51	391	303
1.3	0.117	415	317	53	385	297
1.4	0.123	413	315	55	379	292
1.5	0.128	410	313	57	373	287
1.6	0.133	408	311	60	367	281
1.7	0.139	406	309	62	361	276
1.8	0.144	404	307	64	356	271
1.9	0.150	401	305	66	350	266
2.0	0.155	399	303	69	344	261