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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—2017 and the Autumn Survey in October 1996—2016. The autumn survey was not conducted in 2011. Two survey indices are calculated from these surveys and 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 disaggregated indices from the autumn survey are used as age-length keys in 2 cm length groups in the Gadget model.

The survey stratification and subsequent survey indices for golden redfish were re-calculated 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 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* shows 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 2012 the biomass increased significantly, but decreased again in 2014 and 2015 although remained high. The total biomass index in 2016 increased substantially (about 50% compared to 2015) and was the highest recorded. The total biomass index decreased in 2017 but is the second 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 gradually increased from 2000 to 2014 when it was the highest in the time series and has since then been at that level (Figure 19.2.1).

Length distribution from the spring survey shows that the peaks, which can be seen first in 1987 and then in 1991—1992, 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 a relatively strong year classes (1985-year class and then the 1990-year class). Abundance of small redfish has since then been much smaller, 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). 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 in both surveys has decreased since 2006 (Figure 19.2.1). In recent four years the abundance been at the lowest level in the time series with very few individuals less than 30 cm caught (Figures 19.2.1-19.2.3)

Age disaggregated abundance indices from the autumn survey is 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 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 *S. norvegicus* were available from the Faeroes spring groundfish survey from 1994—2017 and the summer survey 1996—2016. 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—2015 it was at the lowest level since the beginning of the series, but 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 2016 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).

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 until 2013. The survey index increased in 2014 to the highest level in the time series and was almost two times higher than in 2013 (Figure 19.2.6*a* and Figure 19.2.6*b*). The index in 2015 and 2016 were the second highest in the time series but lower than in 2014. 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, both the fishable biomass (> 30 cm) and the biomass of pre-fishery recruits (17-30 cm) have increased considerably (Figures 19.2.7*c* and 19.2.8). In 2010—2016 the biomass of 17-30 cm fish has decreased compared to previous five years whereas the fishable biomass has remained high since 2007.

Abundance indices of redfish smaller than 18 cm from the German annual groundfish urvey show that juveniles were abundant in 1993 and 1995—1998 (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—2016 survey results indicate low abundance and are similar to 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 has been gradually increasing since 2010. The total landings in 2016 were 59 698 t, which is about 8,000 t more than in 2016. The majority of the golden redfish catch has been taken in ICES Division Va that contributes to about 90—98% of the total landings.

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 2016 were about 50 041 t, about 6 800 t more than in 2015. The landings were 14.5% higher than allocated quota of 47 205 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 also 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 2016, 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 2016 were 165 t which is 105 t less than in 2015 and the lowest landings in the time series. The majority 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 1650 t, similar to 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.

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—2016 and were 50 t in 2016.

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 2016. 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	54 041	199	36 471	1 654
5.b	Faroe Islands	Bottom trawl	165	12	303	
14	Greenland	Bottom trawl	5 442			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976—2016 show that the majority 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—2016 are narrower than previously, with less than average of both small and large fish caught.

Catch-at-age data from the Icelandic fishery in Division 5.a show that the 1985-year class dominated the catches from 1995—2002 (Figure 19.3.4 and Table 19.3.2) and in 2002 this year class still contributed to about 25% of the total catch in weight. The strong 1990-year class dominated the catch in 2003-2007 contributing between 25—30% of the total catch in weight. The share of these two year classes has gradually been decreasing in recent years. In 2007—2010 the 1996—1999 year classes dominated in the catches, but are now gradually decreasing. The 2000—2005 year classes (ages 11-16) contributed in total about 65% of the total catch in 2016.

The average total mortality (Z), estimated from the 22-year series of catch-at-age data (Figure 19.3.5) is about 0.24 for age groups 15 and older.

Length distribution from the Faroese commercial catches for 2001—2016 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 was in 2016 the highest in the time series with sharp increase in recent 10 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 still only about 10% of the total biomass (Figure 19.4.2). The contribution for each length group (Figure 19.4.3) does though show 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 much of the “missing recruitment” from Icelandic waters in recent years.

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 on the basis of 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 2014-2016.

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—2017 and the German survey in East Greenland 1984-2016. Indices are added together 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—2016.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995—2016.
- The simulation period is from 1970 to 2021 using data until the first half of 2017 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 (45 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.

Projections were run using the Gadget model based fishing mortality of equal to 0.097 for ages 9 to 19 according to agreed management plan.

Assumptions done in the predictions:

- Recruitment at age 5 in 2016 and onwards was set as the average of the recruitment in 2011—2015.
- Catches in the first time step in 2017 (first 6 months) were set at the same as in the first time step of 2016 for all the fleets. In step 2 in 2017 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 and fishing mortality decreased but annual landings have increased gradually increased since 2010. The last year class estimated is the 2015 year class but the following year-classes are assumed to be the average of the 2011-2015 year classes. Compared to last year's assessment the 2007-2013 year-class is estimated larger than assumed last year (Figure 19.4.5). Later year-classes are likely to be smaller than assumed here based on information from the surveys in East Greenland and Iceland that all indicate low abundance of small redfish (Figure 19.2.1). Assumptions about those year-classes will not have much effect on the advice this year but later advice will be affected as well as the development of the spawning stock in short term.

The results of the assessment presented here are similar to what was presented at WKREDMP (ICES 2014) (Figure 19.4.5). This similarity is expected as only one year of data has been added and the model is a is a low pass filter that does usually not respond rapidly to new data except they are very far from predicted values.

Estimated selection patterns of different fleets are shown in Figure 19.4.6. 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)

19.4.2.3 Fit to data

An aggregated fit to the survey index (converted to biomass) is presented in Figure 19.4.7. 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 19.5.8).

This lack of fit between observed and predicted survey biomass was one of the main critics of WKRED 2012 (ICES 2012). As can be seen in Figure 19.4.7 the fit is still not good. That lack of fit is caused by too narrow length distribution, with both small and large fish missing but they weight much more in the tuning data than in the total biomass. When looking at the number of years with observed > predicted biomass it must be noted that the assessment converges very slowly and 10 years are comparable to less than 5 years in other species. Discussions about the problem in WKRED 2014 are still valid.

The correlation between observed and predicted survey indices is good for 33-50 cm fish (Figures 19.4.9 and 19.4.10). As the model converges slowly, predicted indices could change a number of 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 19.4.8).

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 19.4.11). One explanation could be that selection in recent years is dome shaped as the large fish is in East Greenland where the fisheries are less.

The discrepancy between predicted and observed age distributions is not as apparent as for the length distributions (Figures 19.4.12 and 19.4.13). 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 is not a problem for the catches where the otolith sampling is random, which is not the case for the survey as there is a maximum limit on the number of otoliths sampled in each tow and therefore lower proportion sampled in hauls with many fish.

19.5 Information from catch curves.

The discrepancy in different data sources can be seen by looking at catch curves from age disaggregated catch in numbers and survey indices. The 1995—1999 year-classes have disappeared more rapidly from the fisheries than predicted with average *Z* being 0.24 (*F*=0.19) for ages 12—20. Comparable number for year-classes 1985—1990 is Z=0.15.

The analyses indicate that fishing mortality was higher than predicted by the assessment models. One explanation is that we are overestimating the stock but there can be a number of alternative explanations.

1. The cohorts grow faster and mature earlier than earlier cohorts. Natural mortality, *M*, might have increased
2. The selection of the fisheries is more dome shaped than before. The fisheries concentrate on the dense schools west of Iceland where the length distribution is narrow.

3. Compared to cohorts 1985—1990 the later cohorts seem to come from other nursery areas.
4. Most of the biomass in the Icelandic surveys in the last decade comes from very dense schools west of Iceland. Catchability in those schools might be different from less dense aggregations.

19.6 Reference points

Harvest control rule (HCR) was evaluated at WKREDMP in January 2014 (ICES, 2014) based on stochastic simulations using the Gadget model. Taking into account conflicting information by different data continuing for many consequent years (sections 19.4—19.5), 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 19.6.1).

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 19.6.2 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.

19.7 State of the stock

The results from Gadget indicate that fishing mortality has reduced in recent years and is now close to F_{MSY} (Figure 19.4.4). Spawning stock and fishable stock have been increasing in recent years and are now the highest since 1986.

In Vb, survey indices are stable at low level and do not indicate an improved situation in the area although the summer survey showed large increase in 2016. In Subarea 14, the biomass of the fishable stock has been relatively high since 2007. No information is available on exploitation rates in Division 5.b and Subarea 14.

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

19.8 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 year classes 2011—2015, that is at the lowest level in the time series (Figure 19.4.4).

The results from the short term simulations based on $F_{9\text{-}19}$ is shown in Figure 19.4.4 and from short term prognosis with varying fishing mortality in 2017 and 2018 in Table 19.4.2.

19.9 Medium term forecast

No medium term forecast was carried out.

19.10 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. The main issues relate to the lack of explanation of the Gadget model (or any model for that matter) to account for the increase of abundance in intermediate length groups in the Icelandic March survey. These factors were discussed in sections 19.4—19.6 but a short list is repeated below.

- Immigration of intermediate sized redfish in to 5.a, most likely from Greenland.
- Increased aggregation of redfish in areas closed to fishing. These areas on the western part of the Icelandic shelf make up most but not all of the increase in intermediate sized golden redfish in the Icelandic surveys. However eliminating the hauls from these areas in calculation of indices does to some extend reduce this increase.
- There are indications that growth of golden redfish has changed over time. This can be seen for example in the 2001 year class which is on average larger than fish of the same age in the earlier year classes (for example, the 1985—1990 year classes). Size at maturity has also decreased that could lead to growth ceasing earlier than before explaining lack of large fish in recent years

19.11 Comparison with previous assessment and forecast

The current assessment gives similar state of the stock compared to assessments in 2015 and 2016 and the assessment presented at the benchmark 2014.

Management plans and evaluation, see chapter 19.6

19.12 Basis for advice

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

19.13 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 in 2016.

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 well in excess of 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.

19.14 Ecosystem consideration

Not evaluated for this stock.

19.15 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 at the moment 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 in order 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 in order to reduce by-catches of juvenile redfish in the shrimp fishery.

19.16 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.

19.17Changes in the environment

No information available.

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985-2017 and the autumn survey 1996-2016.

	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	461,448	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	405,696	0.281	361,380	0.175
2016	615,712	0.313	401,081	0.279
2017	504,419	0.203		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in numbers) from the autumn groundfish survey 1996-2015. 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
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
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	0.3	0.1	0.0
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
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
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
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
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
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	41.7	24.6	28.3	29.1
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	84.5	96.9	33.1	63.9
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	55.7	151.8	86.4	48.0
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	40.7	90.8	100.8	87.5
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	67.3	69.6	52.9	97.2
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	46.6	67.5	47.6	54.2
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	26.0	50.4	41.7	45.3
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	31.1	27.0	40.3	35.8
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	18.3	26.5	21.1	31.9
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	12.6	17.1	20.0	20.3
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	7.0	12.3	10.0	22.1
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	5.1	6.0	10.0	16.1
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	4.4	5.9	9.9	8.9
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	4.7	4.8	3.3	3.0
22	5.0	1.5	0.8	1.0	1.6	2.3	3.2	2.7	1.7	2.1	2.0	13.8	2.3	1.3	1.2		18.3	2.4	3.6	2.5	3.9
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	17.8	3.4	2.1	3.7
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	2.5	12.7	1.1	2.8
25	3.9	2.7	1.4	2.8	0.8	0.3	0.5	0.3	1.2	1.2	1.7	0.2	0.8	0.8	5.7		1.2	1.2	1.5	13.1	3.4
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
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
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	8.5	0.5	1.6	1.0
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	0.4	3.3	1.0	0.9
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	3.4	2.6	6.9	6.7

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	492.1	696.7	546.5	608.5

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978-2016 as officially reported to ICES. Landings statistics for 2016 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[1)]	54 041	165	50	5 442	59 698

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995-2016. 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
7	47	0	32	23	6	38	117	125	189	216	219	175	128	211	106	59	140	71	31	229	16	20
8	327	354	219	277	339	62	134	871	199	822	737	995	428	1,051	961	351	550	627	572	465	486	889
9	1,452	803	470	584	1,576	830	389	737	1,330	485	1,840	2,113	1,689	2,101	1,730	2,179	1,545	1,642	2,256	1,715	834	2,586
10	8,698	3,654	1,014	1,189	1,237	4,216	1,608	815	1,095	2,059	1,470	3,573	2,403	5,012	3,119	2,685	4,492	3,504	3,954	5,931	3,304	3,198
11	2,583	9,026	2,641	1,115	1,823	1,861	7,611	3,097	1,178	777	3,052	2,077	3,273	3,990	5,030	2,751	5,435	6,808	6,008	6,543	6,876	7,660
12	1,284	2,078	11,406	3,215	2,498	2,245	1,786	10,777	3,899	965	1,873	2,774	1,886	4,710	4,482	4,875	4,866	7,324	9,423	5,748	7,218	9,135
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	3,039	2,309	3,421	3,865	6,248	4,014	6,897	5,806	5,675	6,712
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	1,042	2,820	1,829	2,724	3,815	4,582	4,087	4,725	5,660	4,372
15	6,124	4,376	3,125	2,031	1,236	14,675	826	1,823	1,960	2,127	11,727	2,813	949	1,519	1,981	1,373	2,464	2,606	4,494	2,990	4,788	4,160
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	2,155	1,082	1,233	1,194	1,383	1,527	3,080	2,608	2,973	2,916
17	889	927	3,016	3,407	1,812	1,172	518	11,787	2,249	809	1,445	2,091	9,323	1,843	667	814	916	830	1,747	1,946	2,598	2,969
18	384	385	893	2,043	2,641	1,592	780	2,055	6,402	1,380	1,249	1,182	1,323	8,265	1,488	645	640	797	1,218	1,282	1,857	2,267
19	1,218	266	637	1,015	2,212	2,383	1,043	1,133	756	5,194	1,246	688	741	1,515	6,064	1,084	808	494	776	410	736	1,895
20	1,216	339	943	723	1,259	2,124	1,730	636	411	1,115	6,463	970	726	925	947	5,002	846	789	459	1,214	1,243	737
21	559	1,188	453	520	461	535	935	1,392	607	336	391	5,641	878	531	641	906	5,174	612	523	525	273	528
22	684	1,034	525	394	214	438	411	1,003	798	489	469	631	4,809	837	568	762	1,173	3,460	714	531	278	461
23	1,574	814	673	424	331	270	411	723	754	618	795	229	736	4,235	335	574	761	456	3,176	538	214	256
24	709	0	584	660	216	63	164	372	392	567	619	377	112	380	2,529	667	221	340	190	3,204	438	265
25	824	0	734	520	848	392	123	288	300	258	420	472	618	253	97	2,165	67	226	201	201	1,848	371
26	407	0	275	399	270	337	114	180	74	105	100	73	333	427	96	267	1,602	238	173	209	250	1,321
27	384	0	139	427	615	198	275	80	83	183	279	263	349	340	191	389	86	1,441	74	116	218	216
28	808	0	202	357	229	516	189	296	27	141	169	204	200	170	92	132	178	200	822	64	190	37
29	0	0	143	53	106	364	146	498	105	138	29	168	36	172	386	179	47	73	38	733	89	39
30+	251	0	408	493	768	1,102	1,080	1,333	539	678	1,599	976	1,187	841	448	511	317	427	417	35	708	1,031

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	38,363	45,539	38,441	36,153	43,774	43,088	51,330	47,768	48,770	54,041

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.

Year	Biomass	SSB	R(age5)	Catches	F9-19
1971	607.5	375.4	206.5	67.9	0.097
1972	609.0	369.2	191.5	50.9	0.075
1973	651.5	376.8	457.9	43.7	0.065
1974	683.4	389.9	200.4	50.6	0.073
1975	701.4	399.0	122.1	61.9	0.087
1976	706.1	395.8	207.5	94.4	0.133
1977	715.7	399.4	196.3	53.8	0.079
1978	743.4	422.9	133.9	48.7	0.065
1979	760.5	439.7	157.7	77.2	0.099
1980	750.5	441.1	103.7	89.1	0.113
1981	721.1	431.2	74.8	102.0	0.135
1982	664.1	402.1	63.5	130.3	0.184
1983	598.7	365.7	67.9	106.0	0.162
1984	546.2	336.8	74.0	95.3	0.154
1985	509.0	313.6	131.8	78.5	0.131
1986	478.7	293.9	121.4	76.9	0.140
1987	442.7	271.6	64.2	76.6	0.152
1988	395.2	241.0	41.2	89.8	0.204
1989	354.6	214.7	44.9	56.6	0.145
1990	353.8	198.8	352.0	66.3	0.191
1991	332.7	181.7	58.7	56.0	0.179
1992	313.9	168.1	39.8	55.8	0.196
1993	297.6	156.9	54.1	50.2	0.194
1994	287.4	151.0	64.2	42.5	0.173
1995	305.9	150.5	336.3	44.3	0.182
1996	311.6	152.9	89.1	35.6	0.144
1997	311.5	154.8	41.3	39.0	0.154
1998	313.5	159.7	42.0	39.7	0.154
1999	311.2	160.8	85.2	42.5	0.163
2000	306.6	162.7	52.9	42.6	0.159
2001	313.1	166.8	113.3	36.7	0.132
2002	316.5	167.7	125.0	50.7	0.180
2003	332.0	171.5	189.3	38.2	0.135
2004	349.9	182.6	113.7	32.8	0.112
2005	371.1	191.3	180.3	46.6	0.156
2006	397.1	201.8	189.0	42.1	0.142
2007	414.9	214.0	117.2	39.2	0.126
2008	442.4	232.2	145.5	46.2	0.140
2009	479.2	250.7	234.0	39.3	0.111
2010	519.6	278.0	171.0	38.5	0.099
2011	542.4	303.0	70.5	45.1	0.106
2012	556.8	320.6	106.4	45.2	0.099
2013	563.8	338.0	56.2	53.1	0.109
2014	553.6	345.6	28.8	50.8	0.099

YEAR	BIOMASS	SSB	R(AGE5)	CATCHES	F9-19
2015	539.2	351.8	6.4	51.8	0.098
2016	519.0	348.5	51.0	59.7	0.111
2017	497.4	342.1	51.0	52.7	0.100
2018	*476.0*	*333.8*	*51.0*	*50.8*	*0.099*
2019	*453.6*	*322.5*	*51.0*	*48.9*	*0.099*
2020	*431.3*	*309.3*	*51.0*	*46.5*	*0.099*
2021	*409.9*	*295.2*	*51.0*	*43.9*	*0.099*

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

F(2016)=0.111 C(2016)=**59 700** tons.

2017				
Bio 5+	SSB	Fmult	F9-19	Landings
504	381	1.017	0.1	53

			2017		2018	
Fmult	F9-19	Bio 5+	SSB	Landings	Bio 5+	SSB
0.0	0.049	509	397	0	539	433
0.1	0.054	507	395	6	531	425
0.2	0.058	504	392	11	523	418
0.3	0.063	501	390	16	515	411
0.4	0.068	499	388	21	507	404
0.5	0.073	496	386	27	499	397
0.6	0.078	493	383	32	491	390
0.7	0.083	491	381	37	483	383
0.8	0.088	488	379	41	476	377
0.9	0.094	486	377	46	468	370
1.0	0.099	483	374	51	461	363
1.1	0.104	480	372	55	454	357
1.2	0.109	478	370	60	446	350
1.3	0.114	475	368	64	439	344
1.4	0.119	472	365	69	432	338
1.5	0.125	470	363	73	425	332
1.6	0.130	467	361	77	418	326
1.7	0.135	465	359	81	411	320
1.8	0.141	462	356	85	405	314
1.9	0.146	459	354	89	398	308
2.0	0.151	457	352	93	392	302

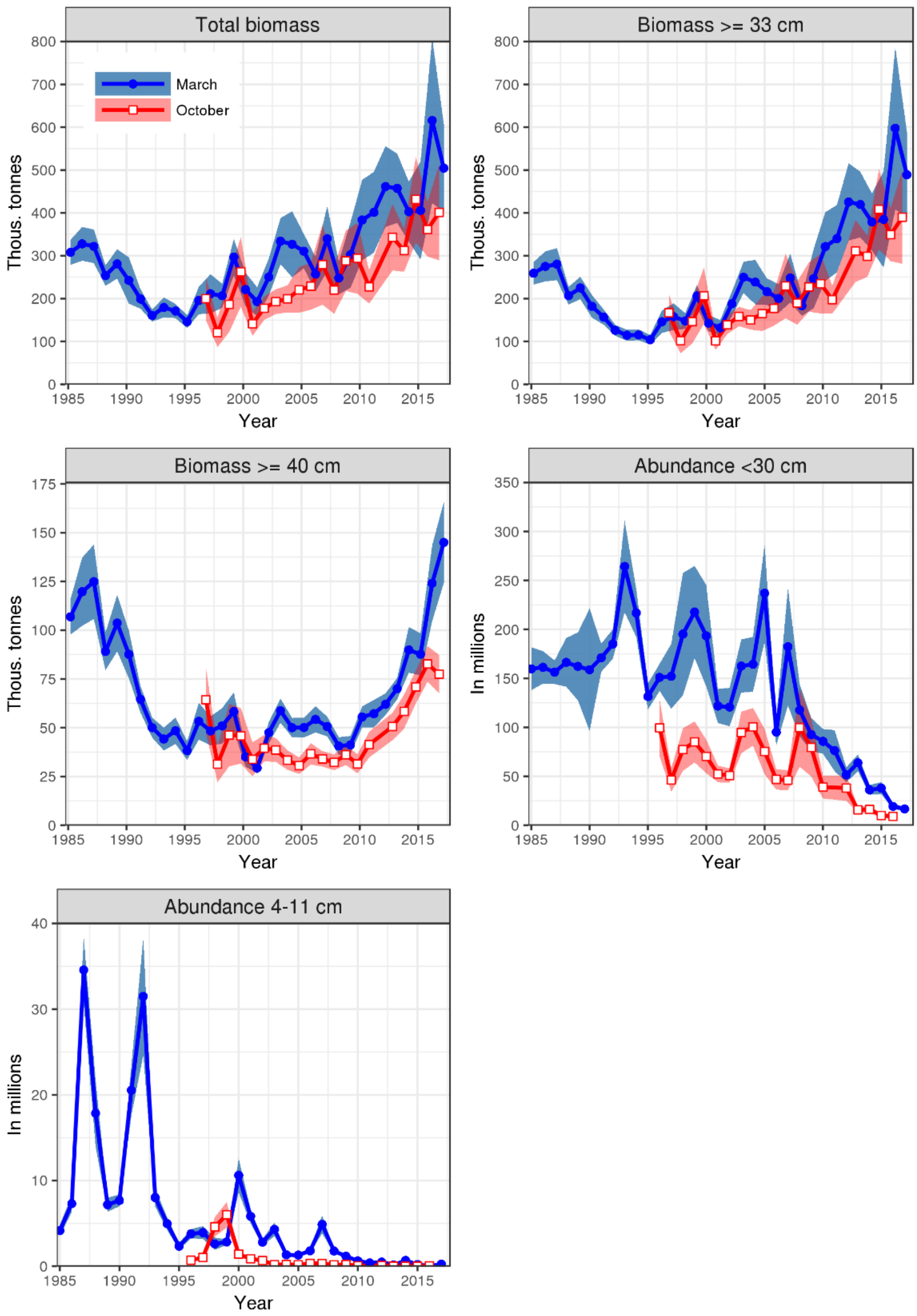

Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985-2017 (blue line and shaded area) and October 1996-2016 (red lines and shaded areas). The shaded areas show ±1 standard error of the estimate.

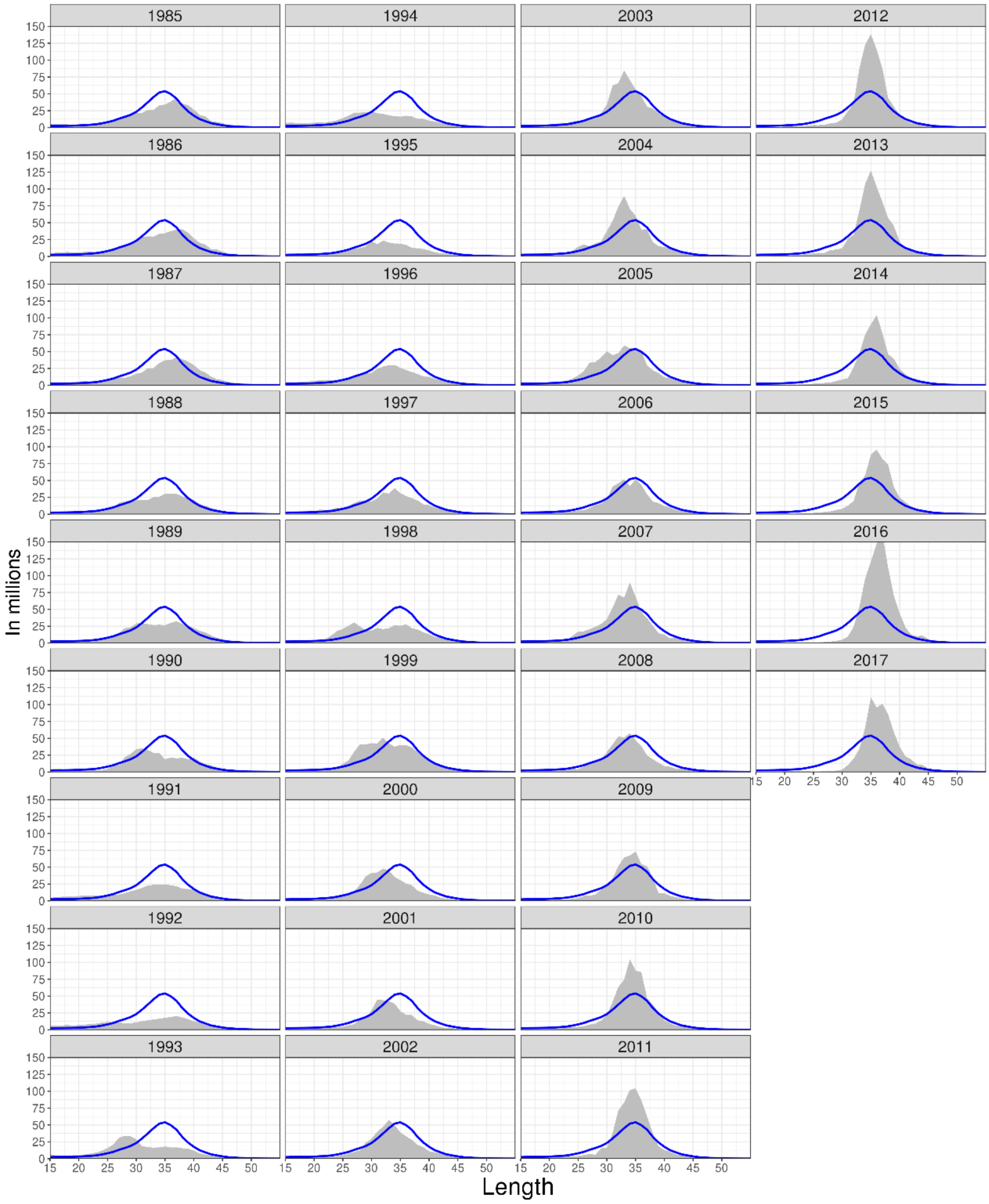

Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985-2017 conducted in Icelandic waters. The blue line is the mean of total indices 1985-2017.

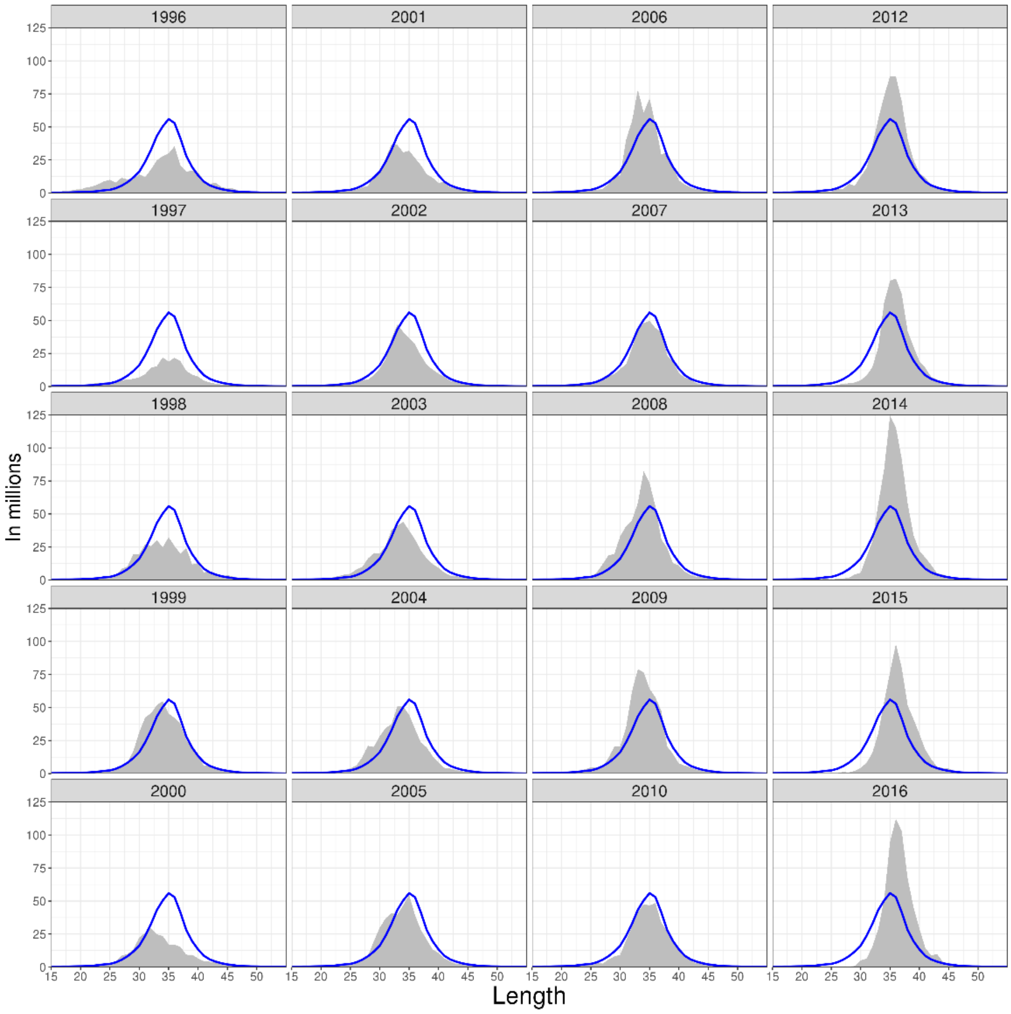

Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996-2016 conducted in Icelandic waters. The blue line is the mean of total indices 1996-2016. The survey was not conducted in 2011.

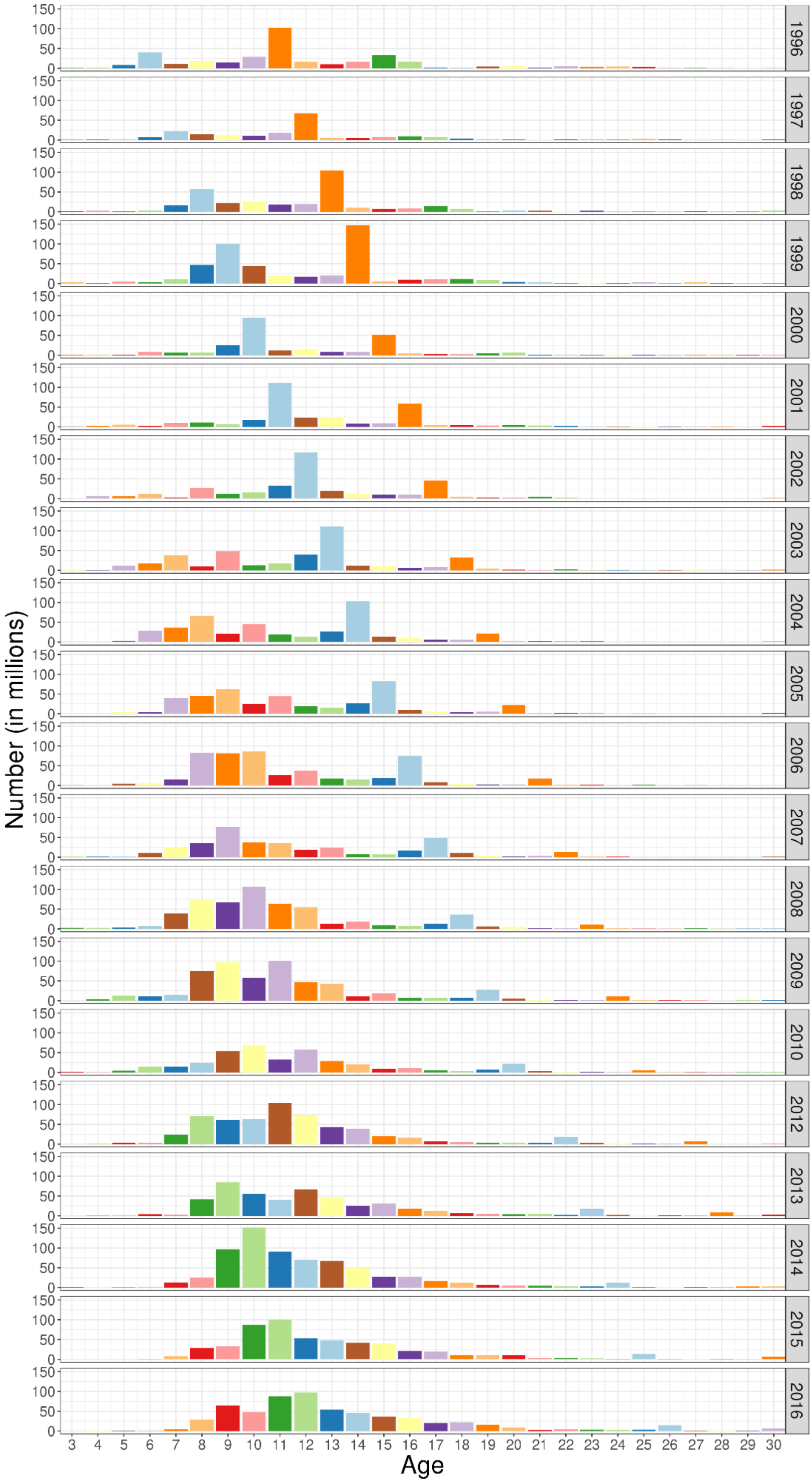

Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996-2016. The survey was not conducted in 2011.

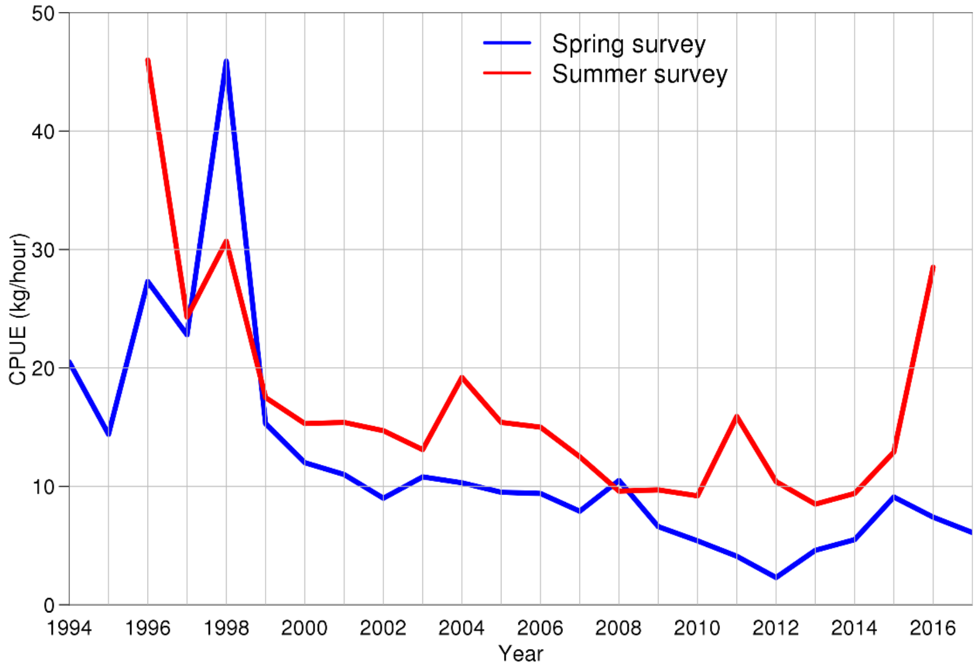

Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994-2017 and the summer groundfish survey 1996-2016 in ICES Division 5.b.

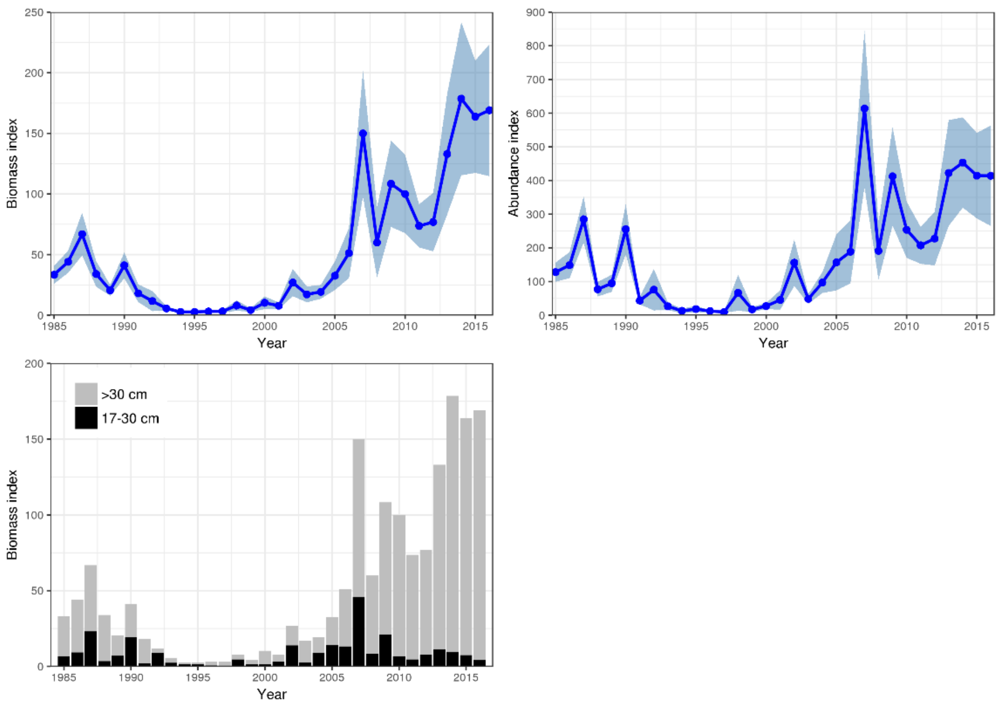

Figure 19.2.6 Golden redfish (>17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985-2016. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17-30 cm and > 30 cm).

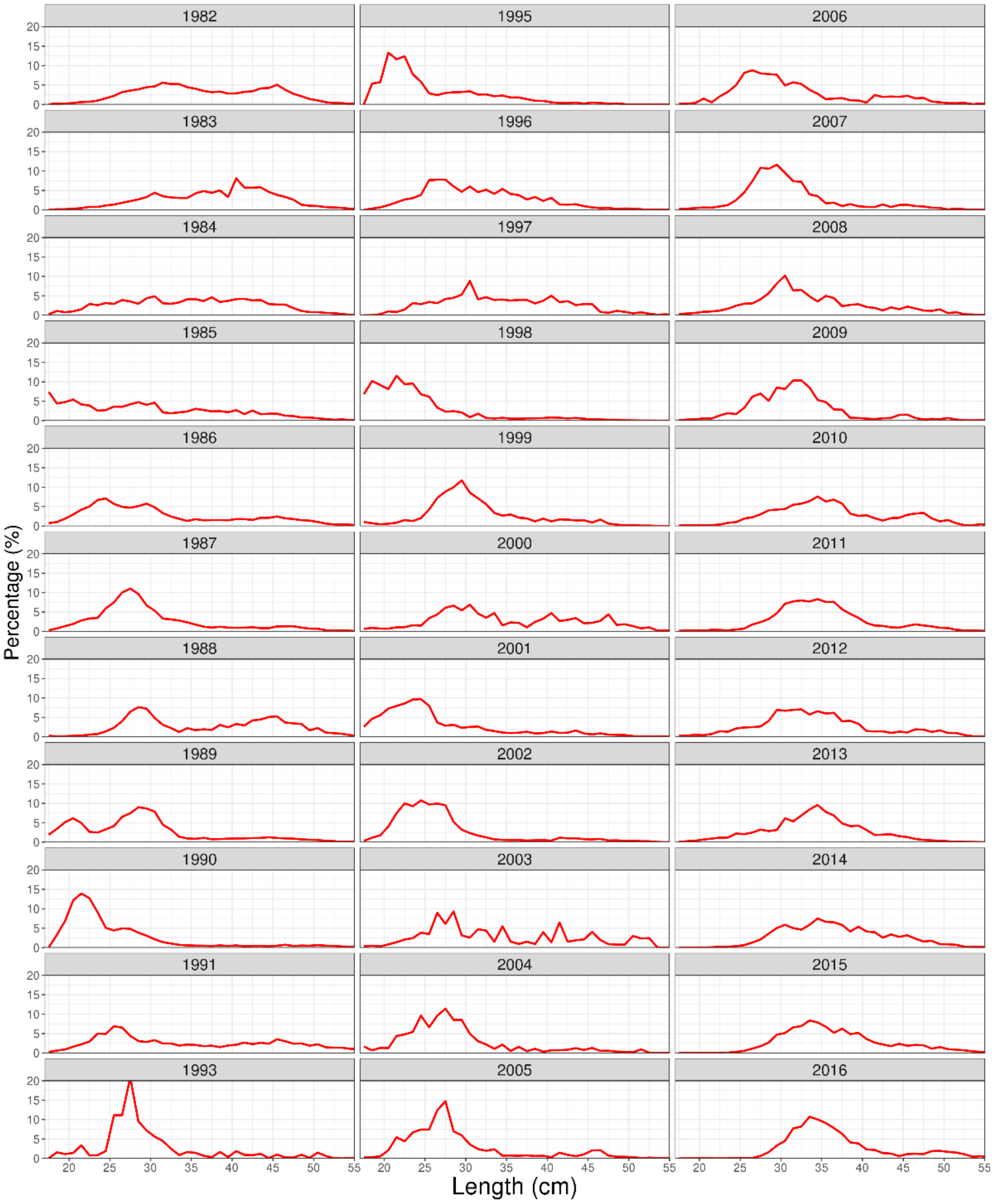

Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982-2016.

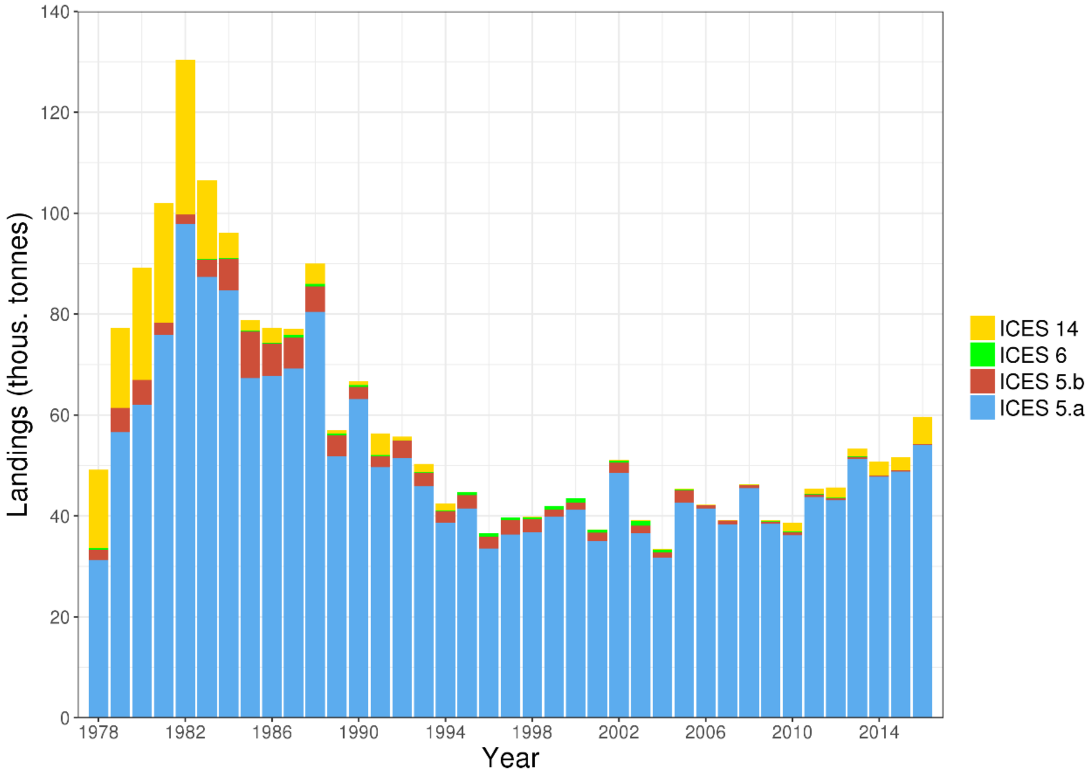

Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978-2016. Landings statistics for 2016 are provisional.

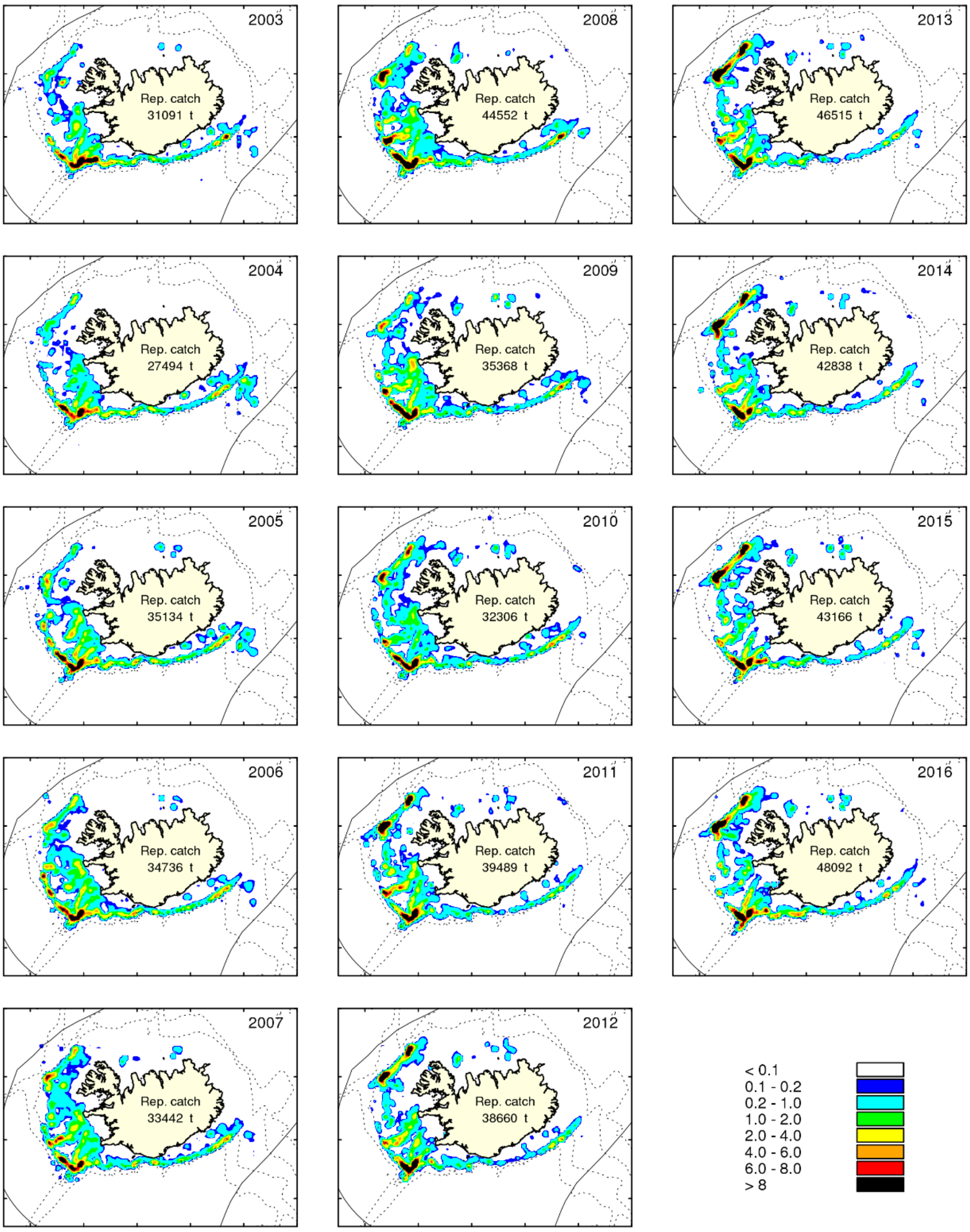

Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2003-2016.

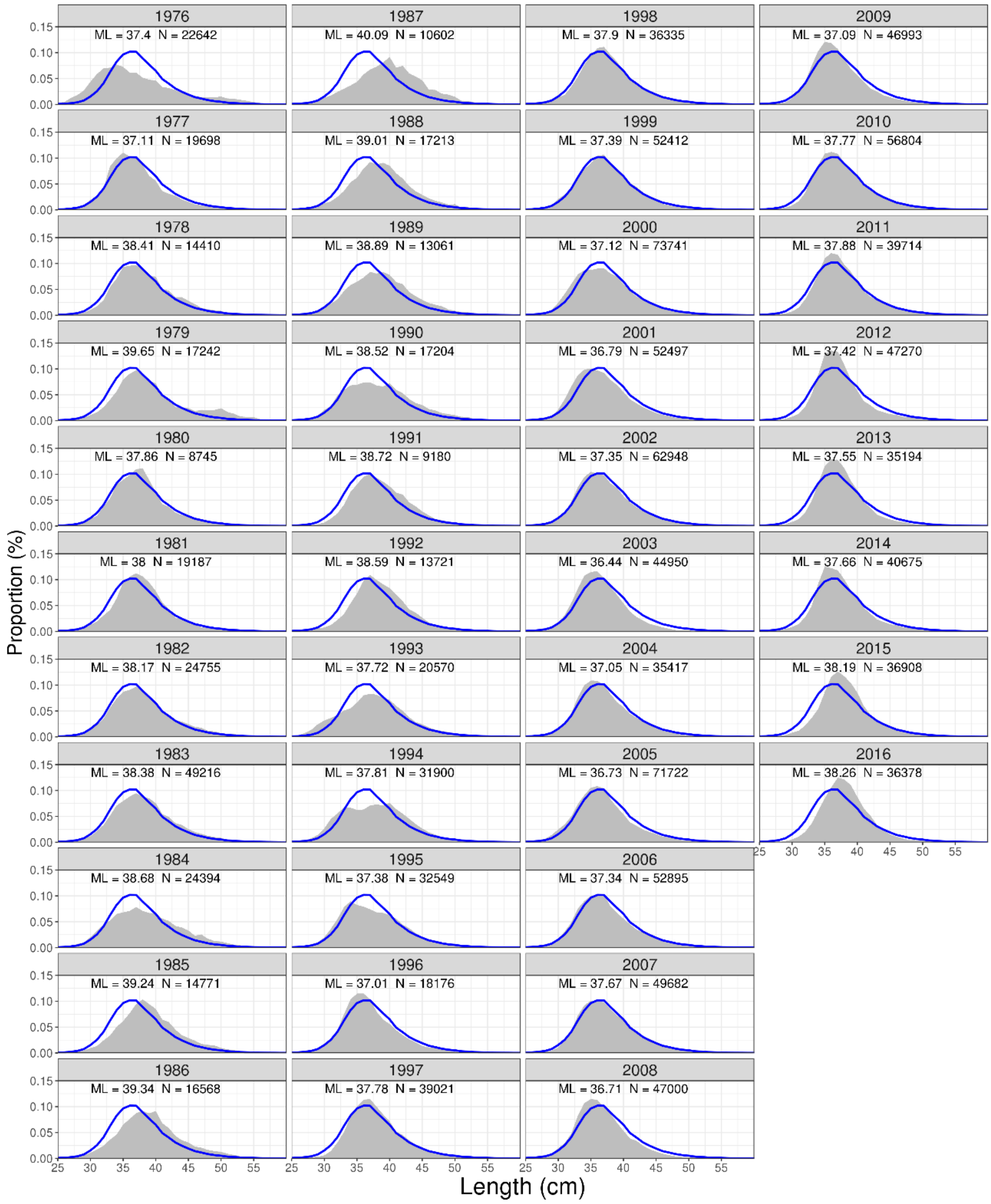

Figure 19.3.3 Length distribution (gray shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976-2016. The blue line is the mean of the years 1976-2016.

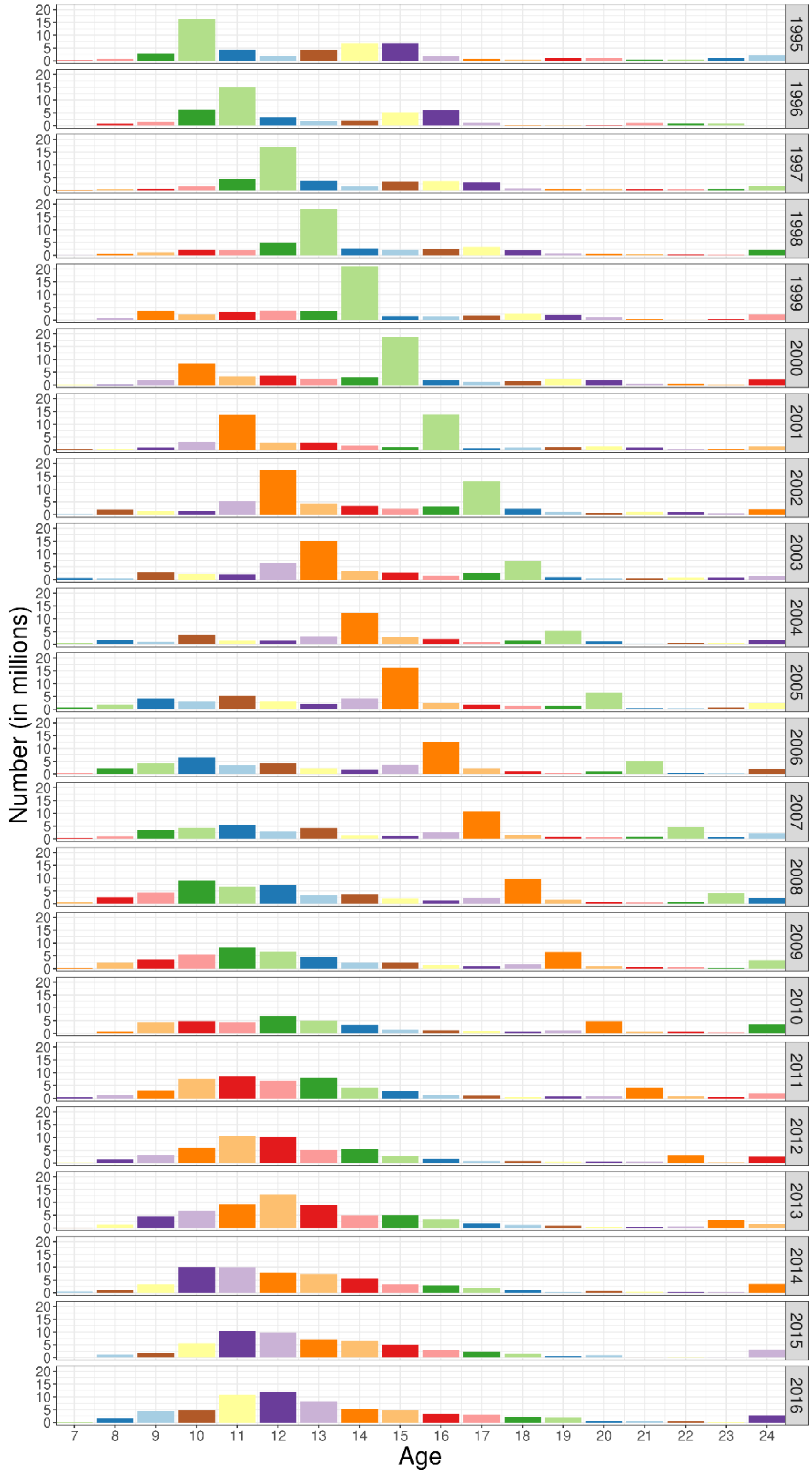

Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Subdivision 5.a 1995-2016.

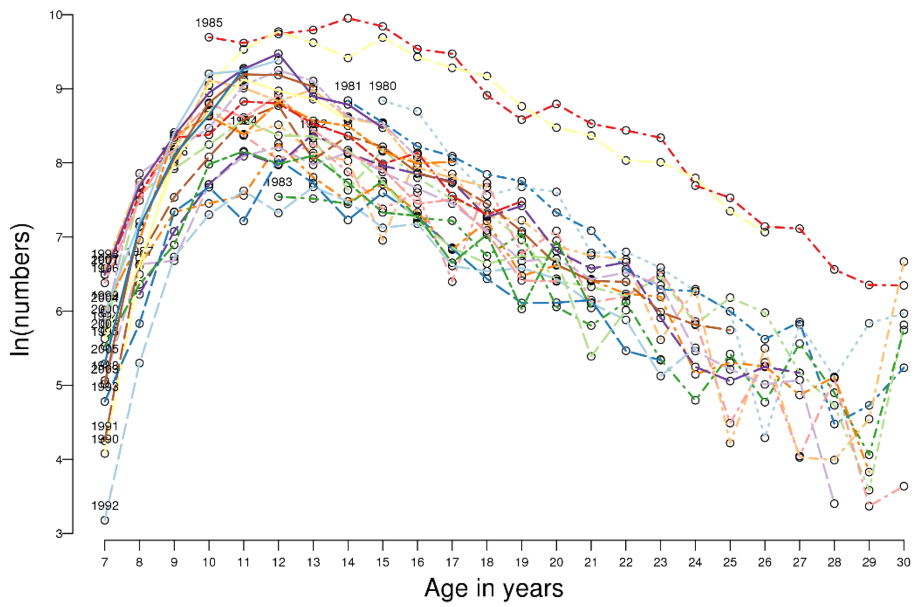

Figure 19.3.5 Catch curve of golden redfish based on the catch-at-age data in ICES Division 5.a 1995-2016.

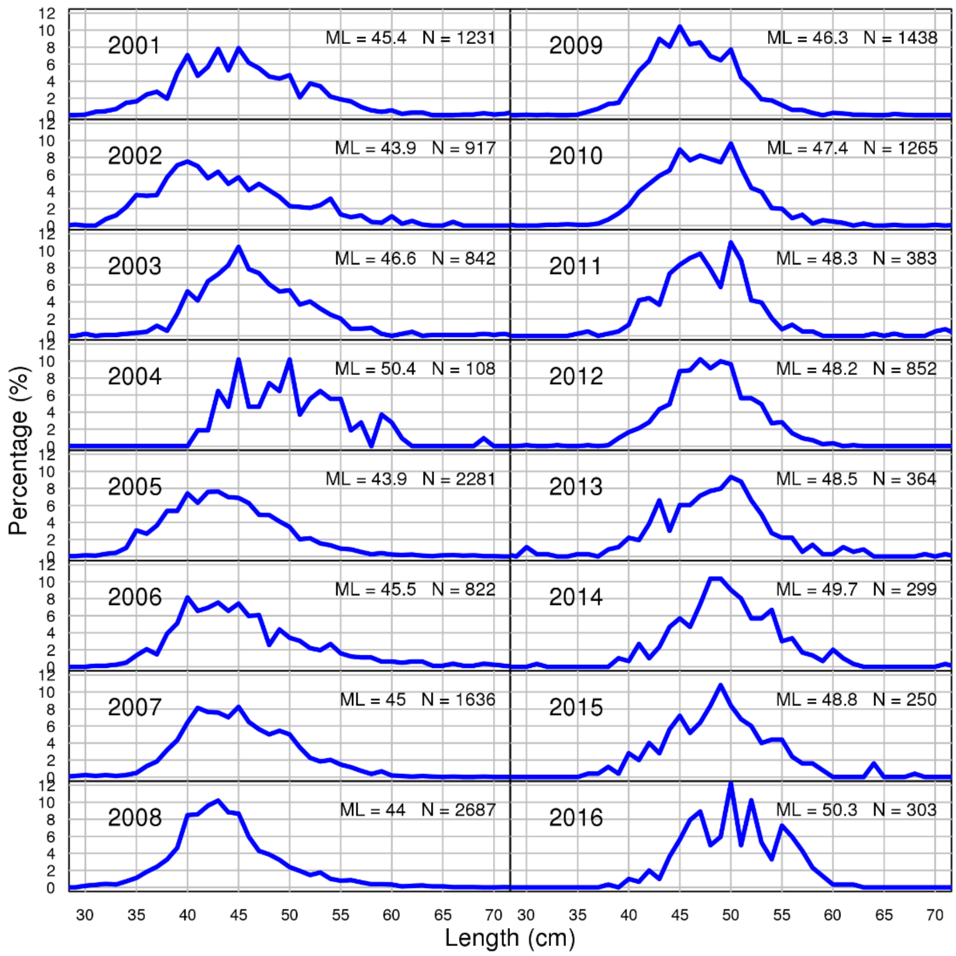

Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001-2016.

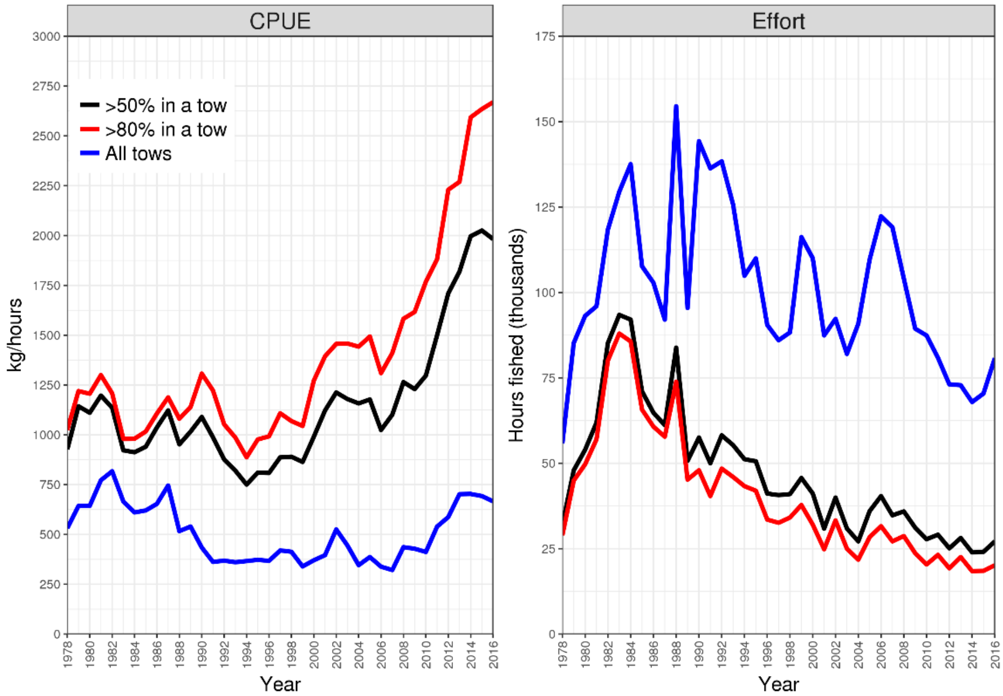

Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978-2016 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

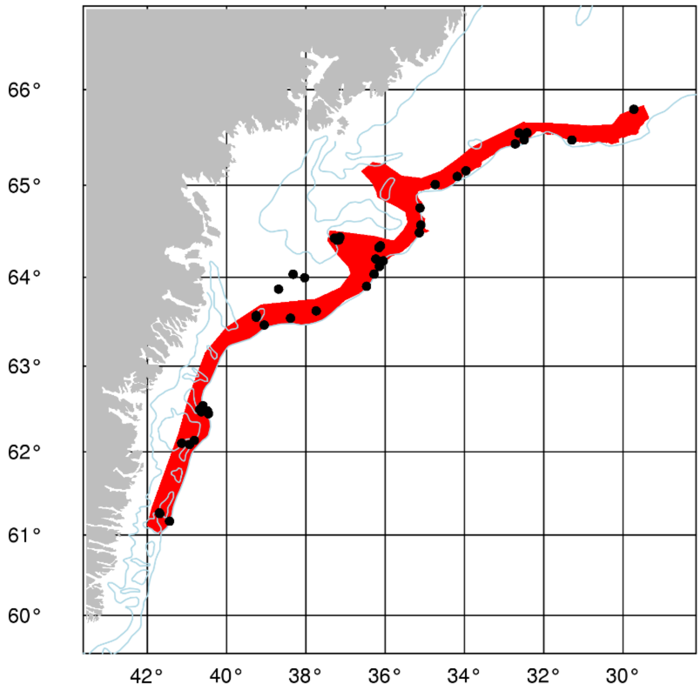

Figure 19.4.1 Stations in the German survey in East Greenland with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

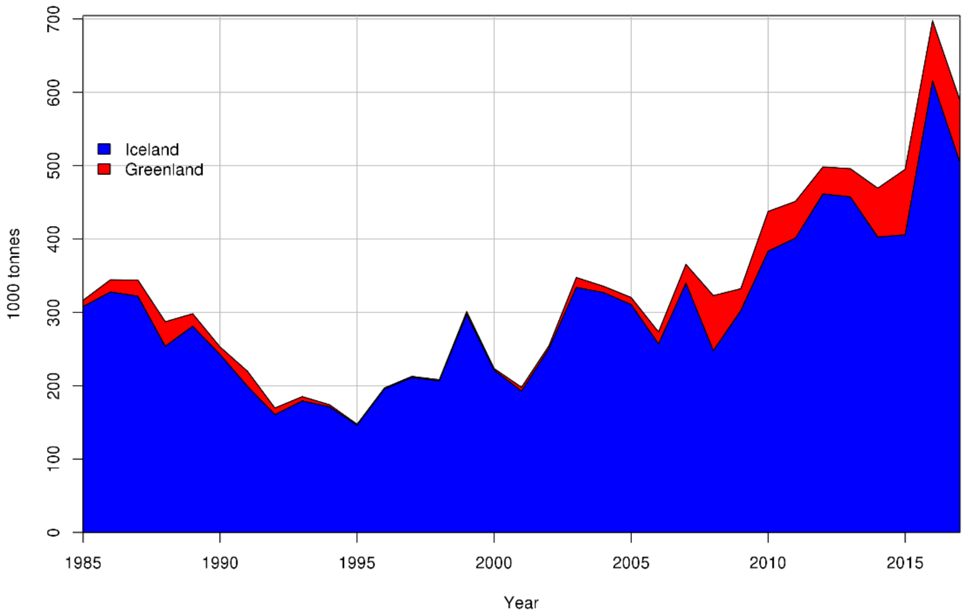

Figure 19.4.2 Biomass index from Iceland (blue) and Greenland black, based on weighting the German survey data in Figure 19.2.7 by 0.5.

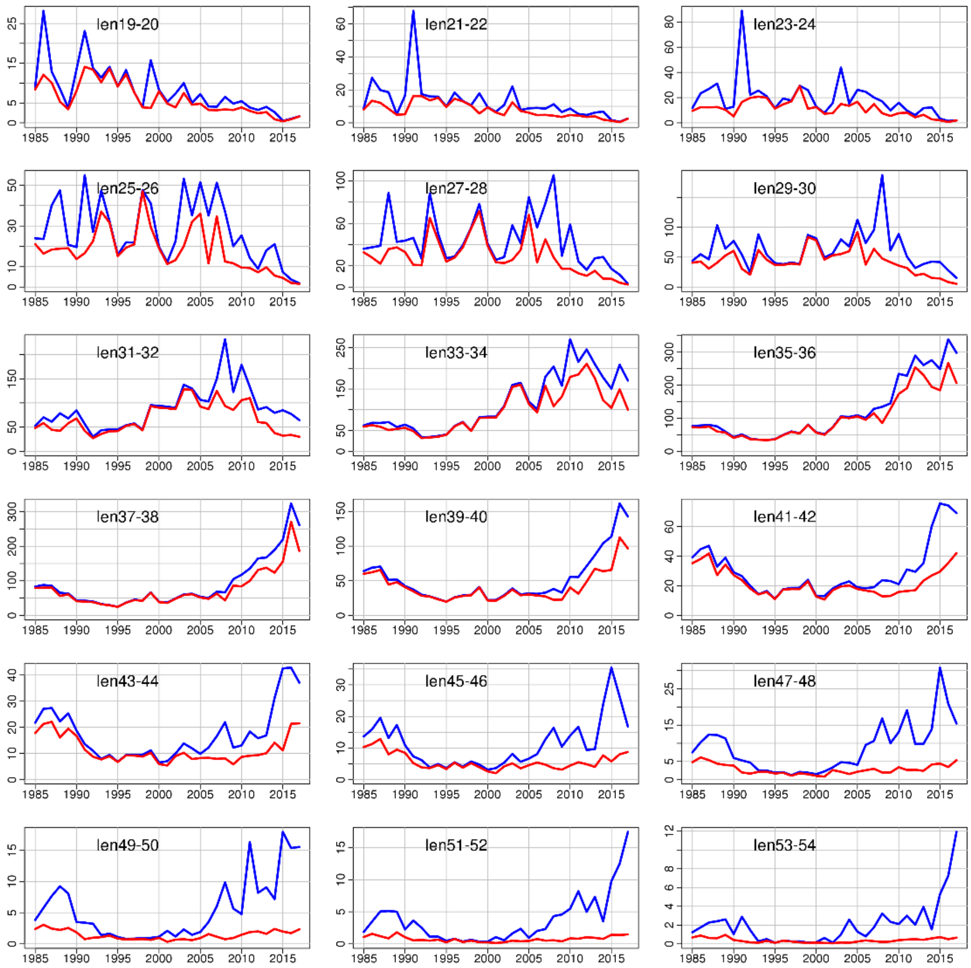

Figure 19.4.3. Indices from the Icelandic March survey (red) and the German survey in East Greenland (blue) by length group.

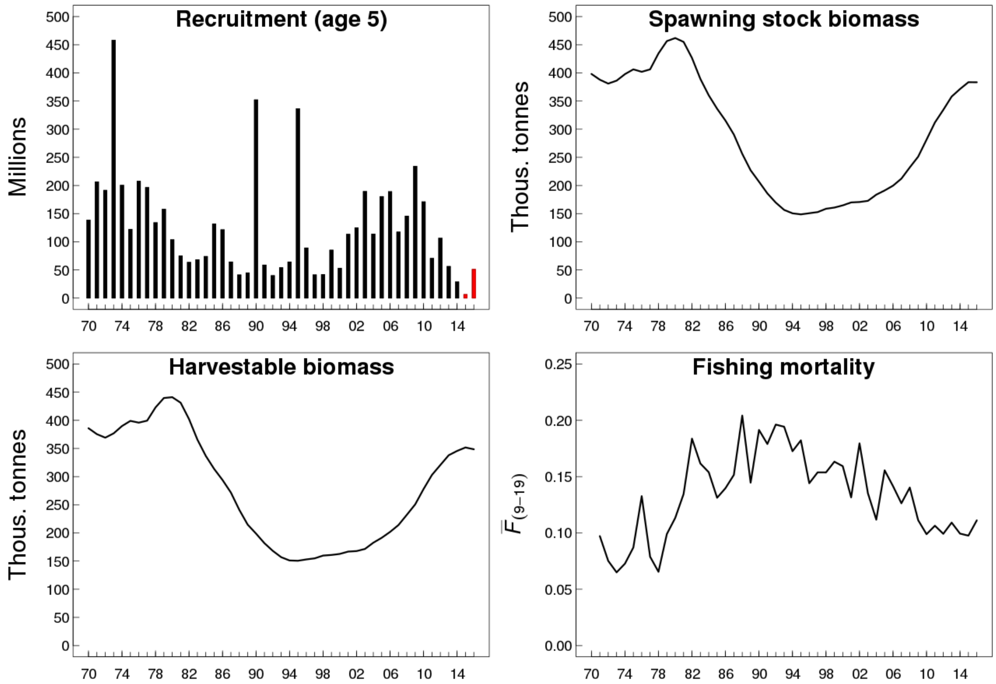

Figure 19.4.4. Summary from the assessment. Red values are predictions. Spawning stock is compiled using a fixed maturity ogive with L50=33cm.

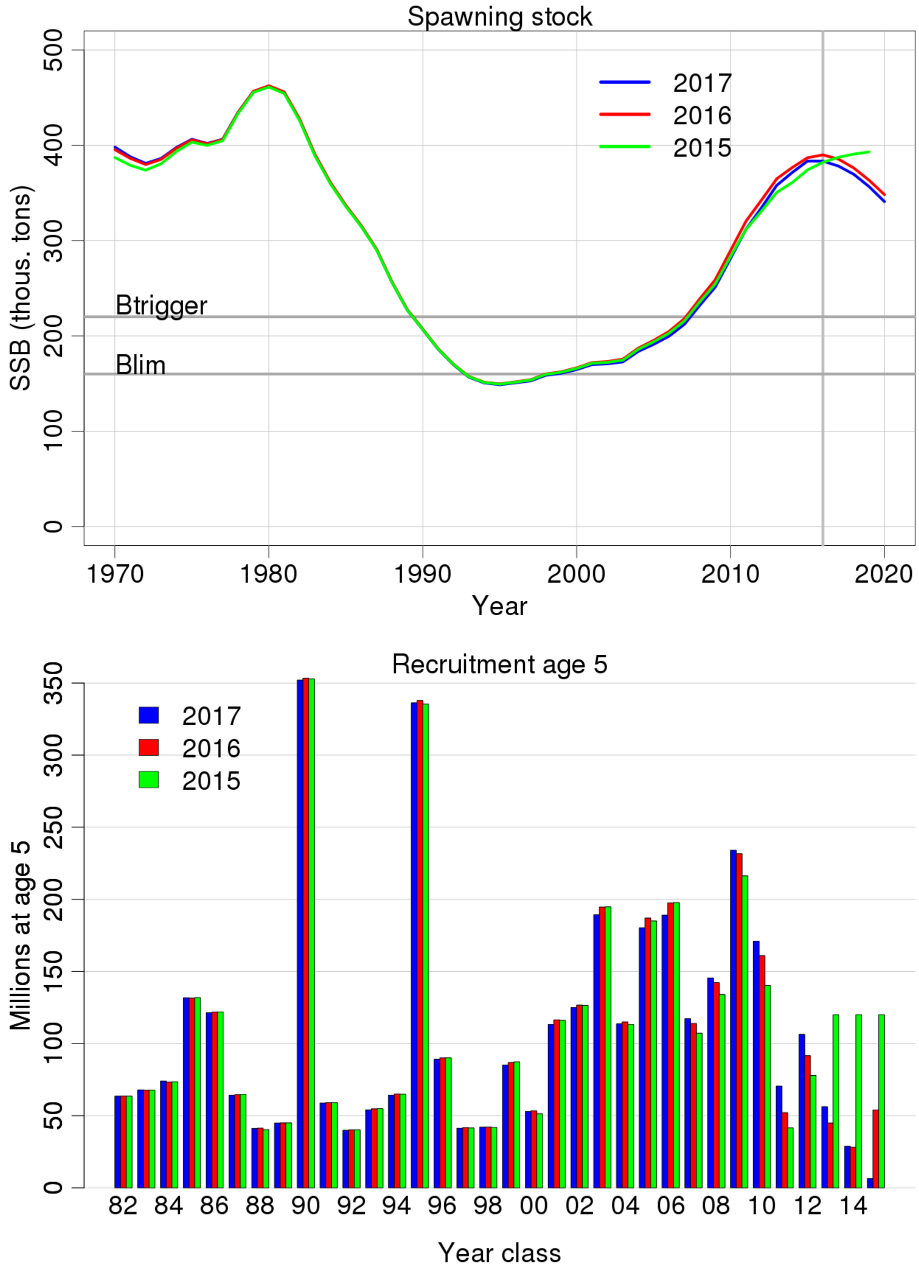

Figure 19.4.5. Comparison of the current assessment and the same assessment done in 2015 and 2016.

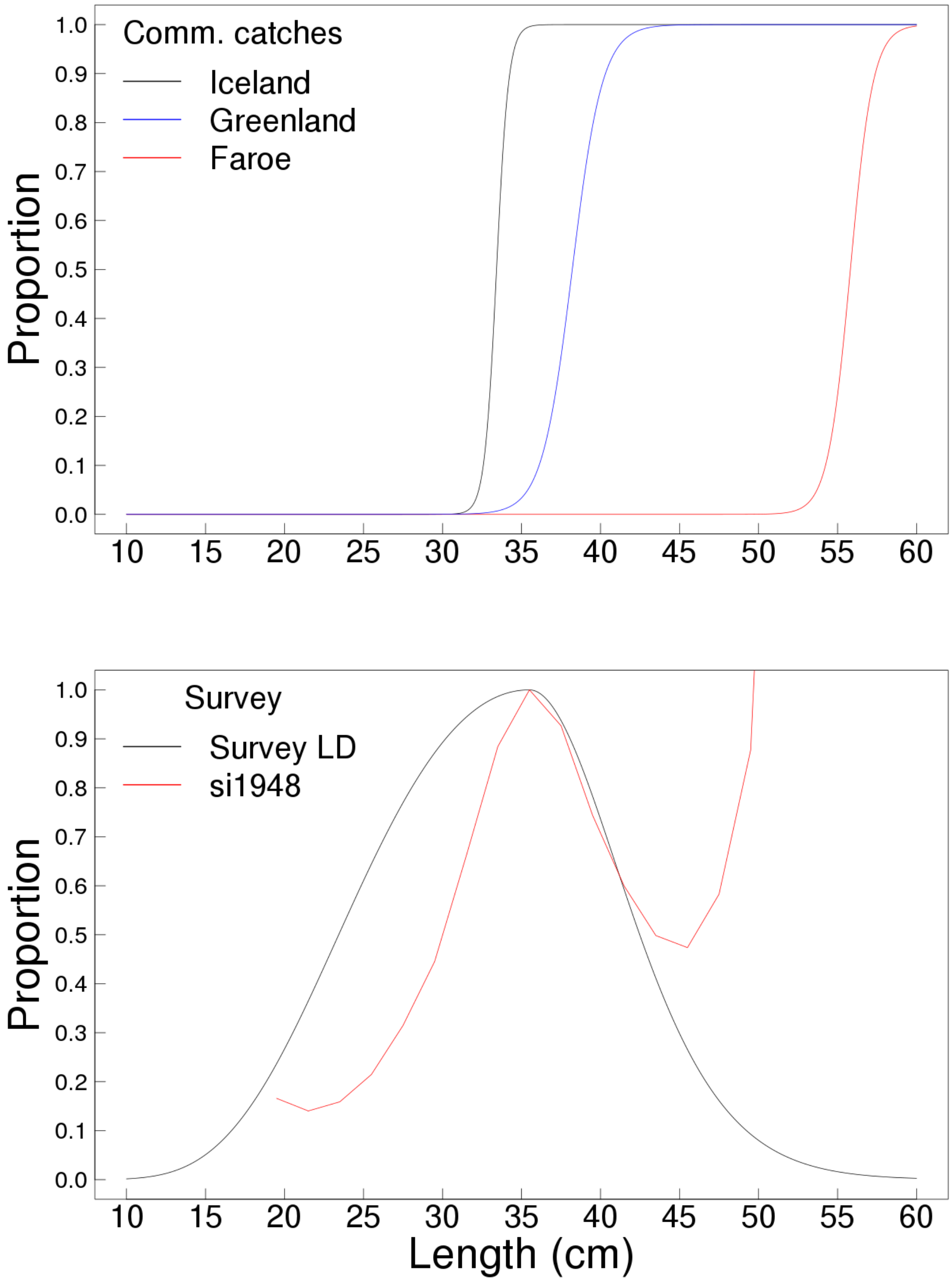

Figure 19.4.6. Estimates of selection curves from commercial catches (upper panel) and from the Icelandic March survey. The black line is the estimated selection curve fitted to the length distributional data and the red line is the estimated q from the disaggregated tuning indices, scaled to one.

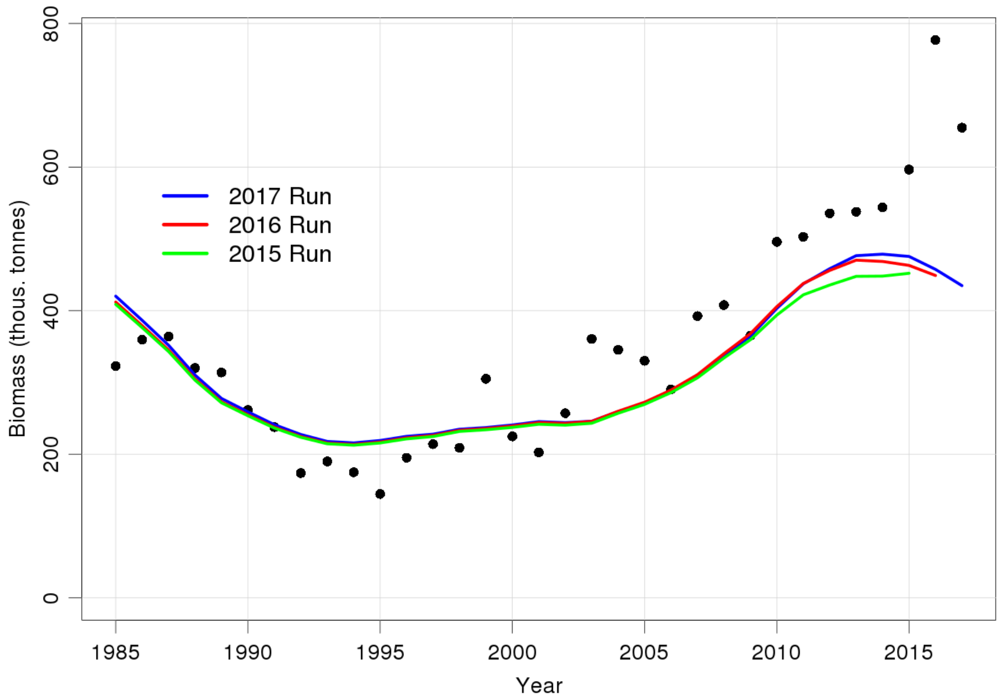

Figure 19.4.7. Comparison of observed and predicted survey biomass from the 2017 (blue line), 206 (red line) and 2015 (green line) runs.

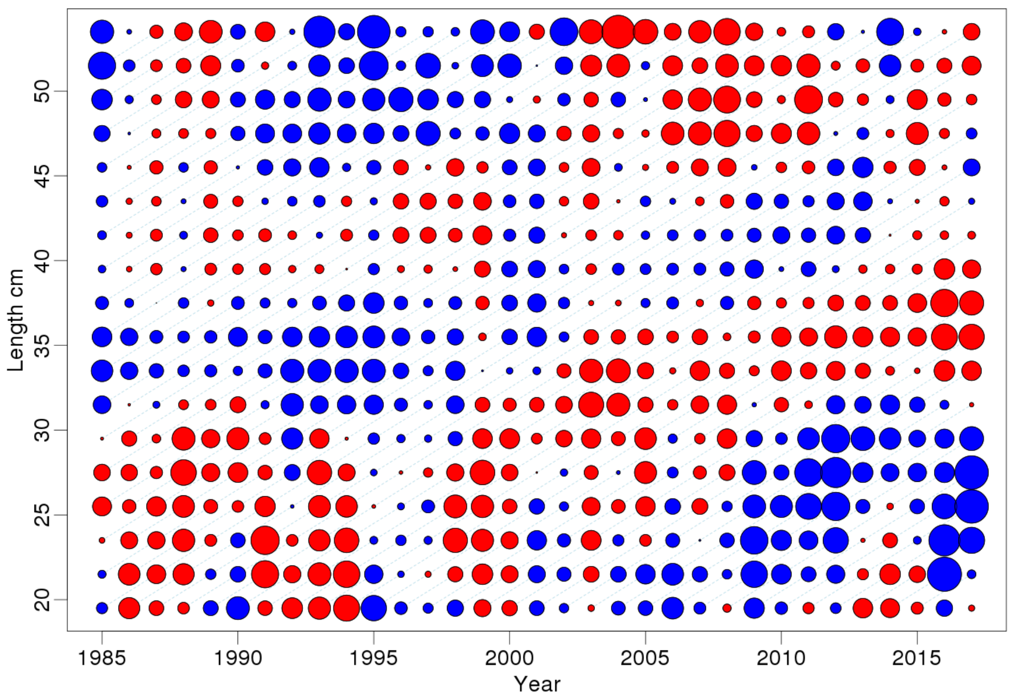

Figure 19.4.8. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

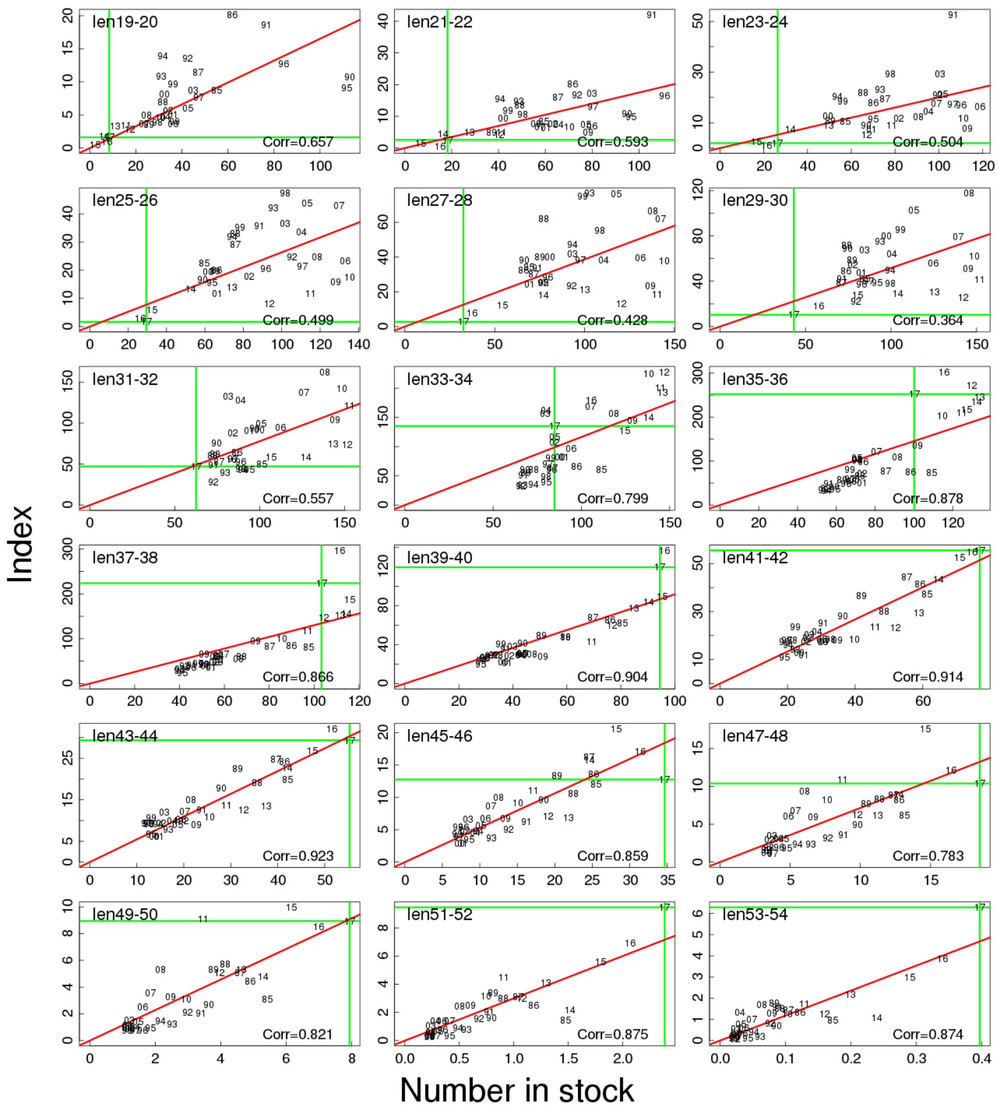

Figure 19.4.9. Fit to length disaggregated survey indices from Gadget run as XY-scatter. The red line is fitted going through the 0-point, the green cross goes over the terminal year.

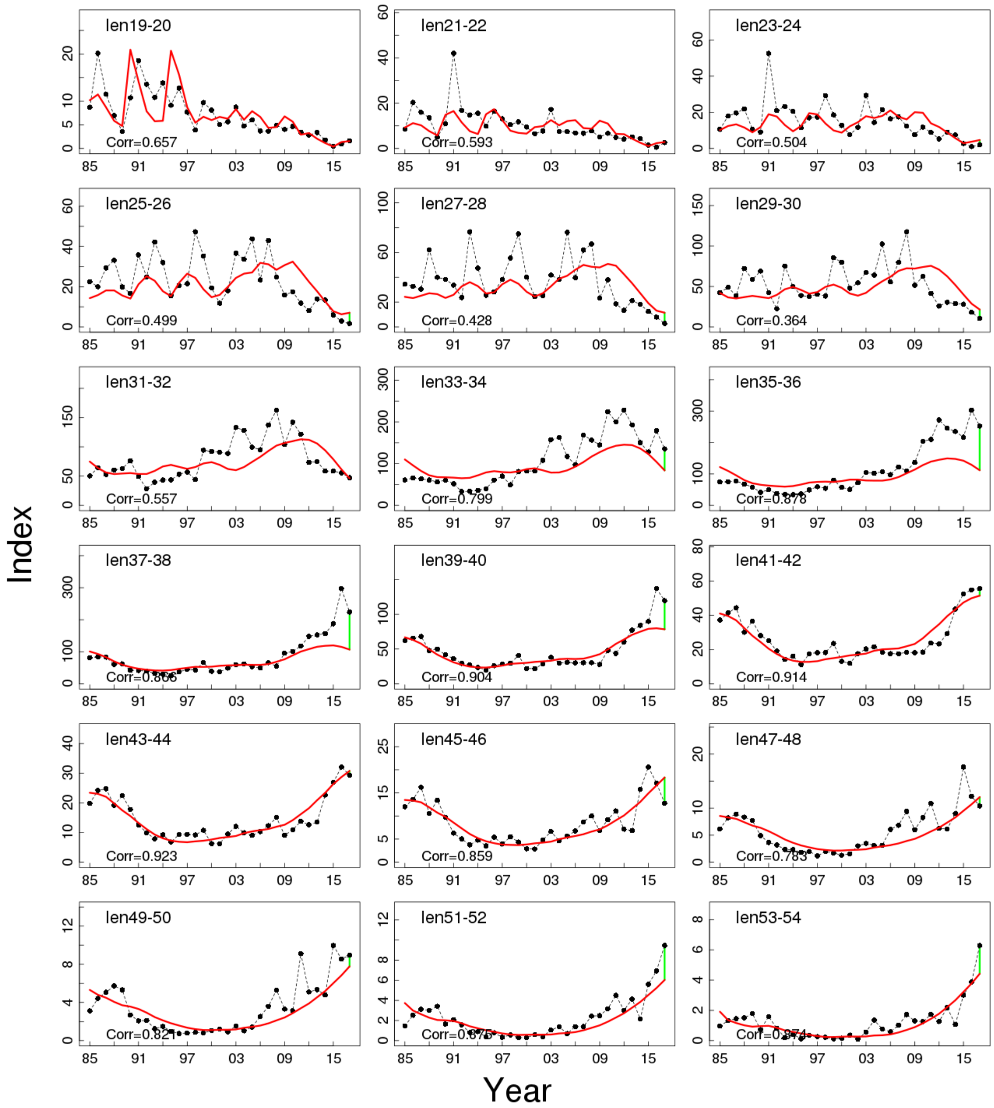

Figure 19.4.10. Fit (red lines) to length disaggregated survey indices (broken lines and points) from Gadget run as time series.

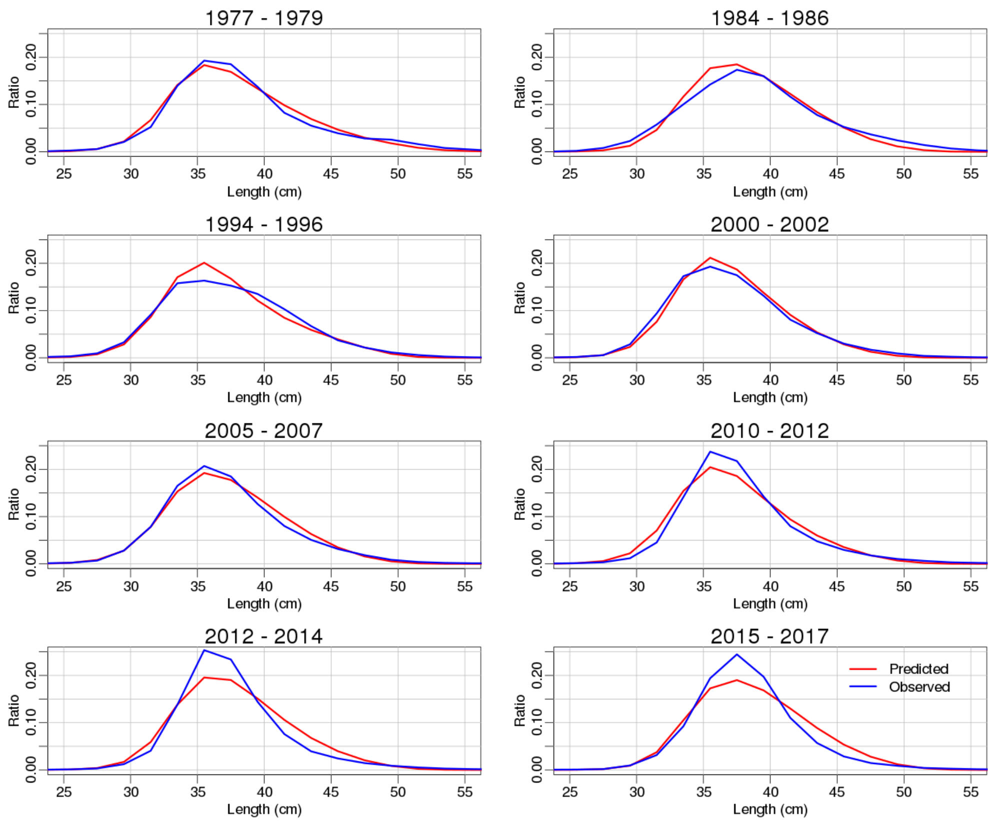

Figure 19.4.11. Fit (red line) to Icelandic commercial length distributions aggregated by 3 years.

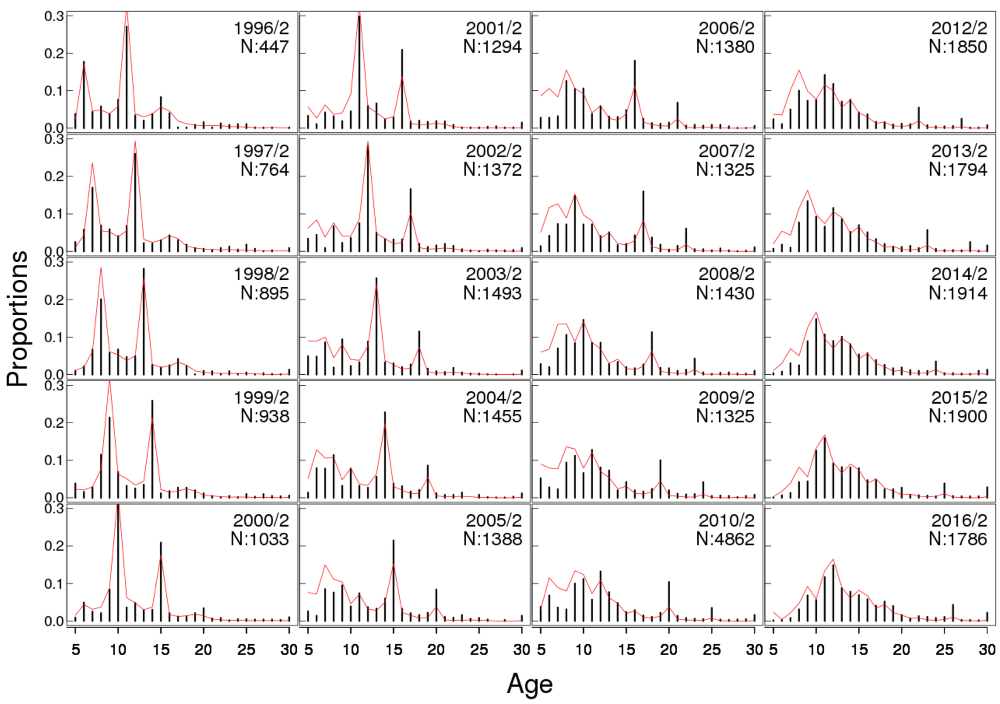

Figure 19.4.12. Fit to survey age data (run 1). Bars represent the data and red lines the fit. The likelihood data are used in the model as proportions in each 2 cm length group but presented here as total for each age group something that should only be comparable if catchability was independent of size (age).

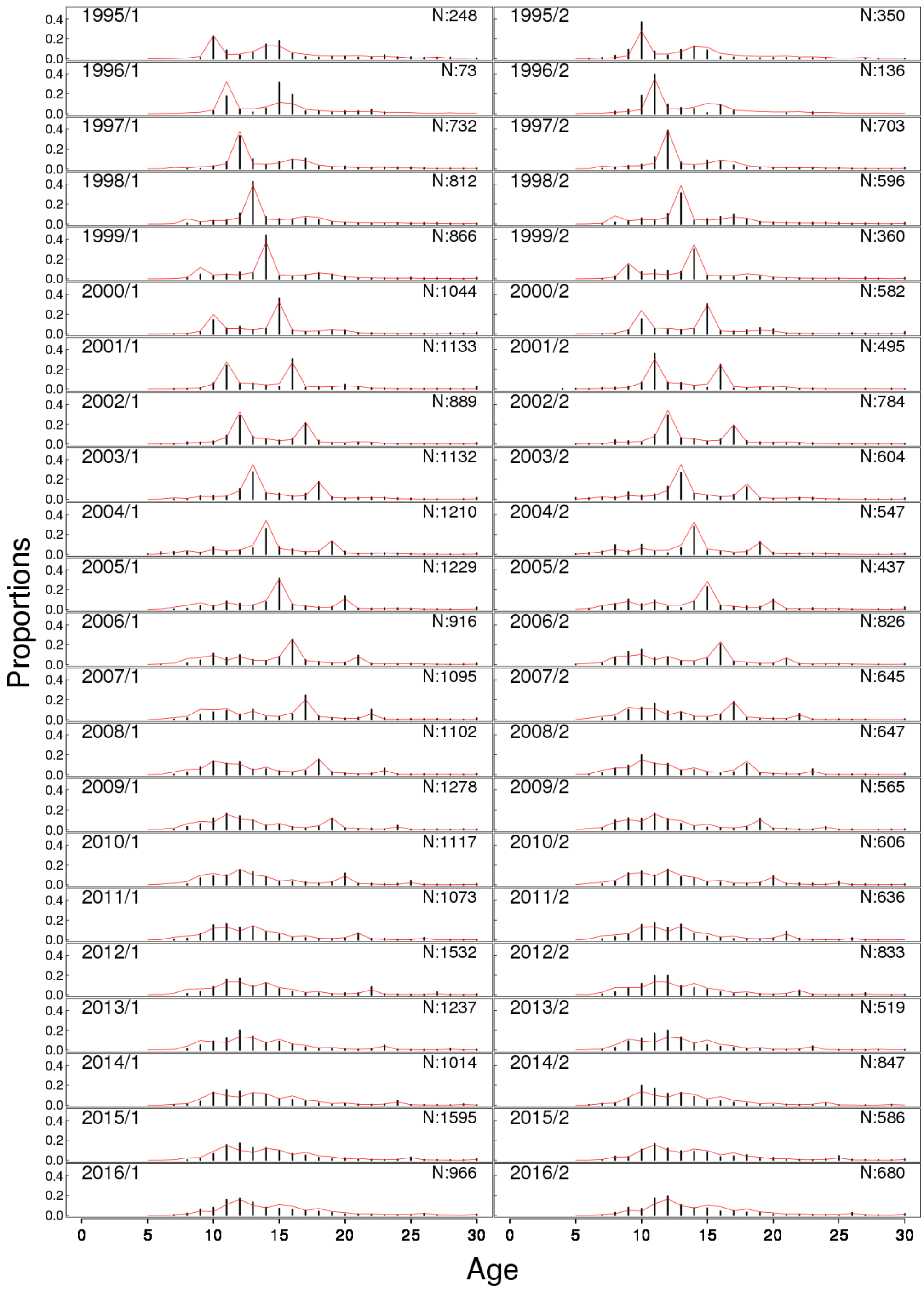

Figure 19.4.13. Predicted (red) and observed (blue) age distributions from Icelandic commercial fishery.

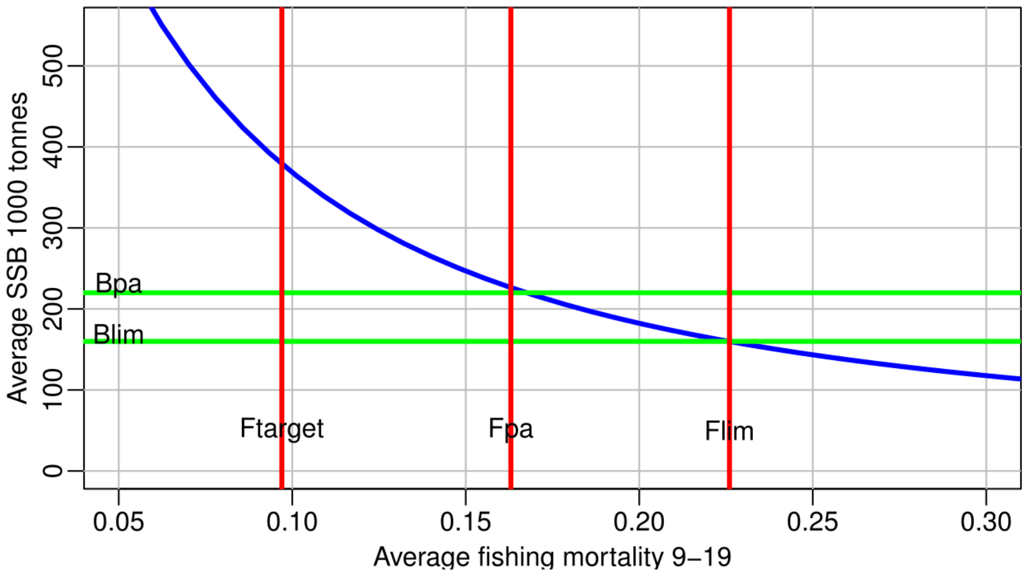

Figure 19.6.1. Average SSB against average fishing mortality and defined reference points.

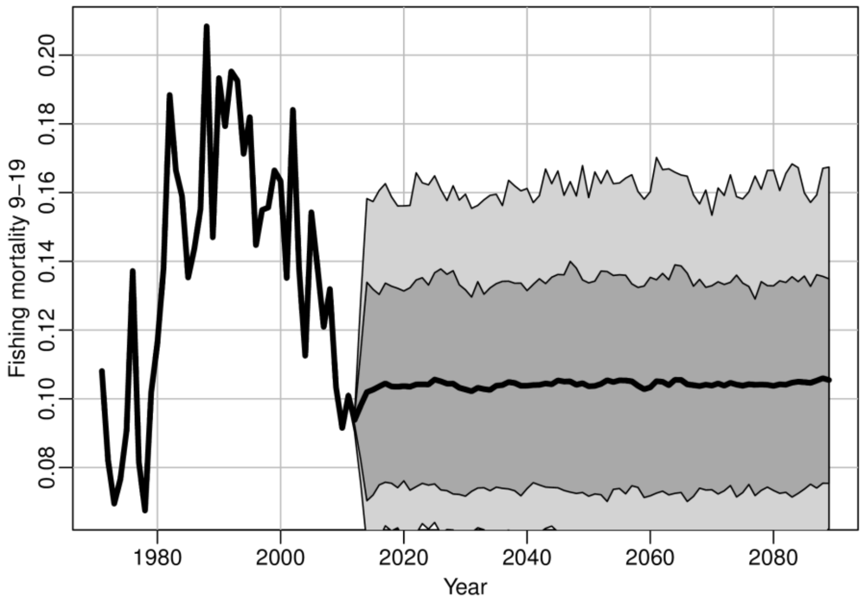

Figure 19.6.2. Development of $F_{9\text{–}19}$ based on $F_{9\text{-}19} = 0.097$. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.