Golden redfish
Sebastes norvegicus

STOCK DESCRIPTION AND MANAGEMENT UNITS

Golden redfish (*Sebastes norvegicus*) in ICES division 5.a (Iceland), 5.b (Faroe Islands) and subarea 14 (East Greenland) have been considered as one management unit. Catches in ICES Subarea 6 have traditionally been included in this report. Data from ICES Subarea 6 is, however, not used in the assessment.

SCIENTIFIC DATA

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

DIVISION 5.A

Two bottom trawl surveys are conducted in Icelandic waters, the Icelandic spring groundfish survey (spring survey) and the Icelandic autumn groundfish survey (autumn survey). The spring survey has been conducted annually in March since 1985 and the autumn survey annually in October since 1996. The autumn survey was not conducted in 2011. The calculation of the survey indices includes length dependent diel vertical migration of the species.

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

The total biomass of golden redfish as observed in the spring survey decreased from 1988 to a record low in 1995 (Figure 1 and Table 1). From 2000 to 2016 the biomass increased, with some fluctuation, to the highest value in the time-series. Since then the index has decreased and was in 2019 and 2020 similar as in 2014 and 2105. The CV of the survey indices has been considerably higher after 2002.

The total biomass index from the autumn survey shows a 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 fluctuating around the 2014 level (Figure 1 and Table 1).

Length disaggregated indices from the spring survey shows that the peaks in length 4–11 cm, which can be seen first in 1987 (the 1985 year class) and then in 1991–1992 (the 1990 year class), reached the fishable stock approximately 10 years later (Figure 2). The increase in the survey index between 1995 and 2005 reflects the recruitment of these two strong year classes. During the 1999–2008 period the abundance of small redfish was highest in 2000-2003, but lower than in 1986–1990 (Figure 1). Since 2009 very little of small redfish has been observed in the surveys. This has been confirmed by age readings (Figure 4 and Table 2). In recent years, the modes of the length distribution in both surveys has shifted to the right and is now narrower. The abundance of golden redfish smaller than 30 cm has decreased since 2006 in both surveys and is now at the lowest level in the time-series (Figures 1-3).

Age disaggregated abundance indices from the autumn survey are shown in Figure 4 and Table 2. The sharp increase in the survey indices since 2005 reflects the recruitment of the year-classes from 1996–2007. The year-classes 1996–2002 are gradually disappearing from the stock and the 2003–2008 year-classes are now the most abundant year-classes. The age disaggregated abundance indices indicate that all year-classes since 2009 are small.

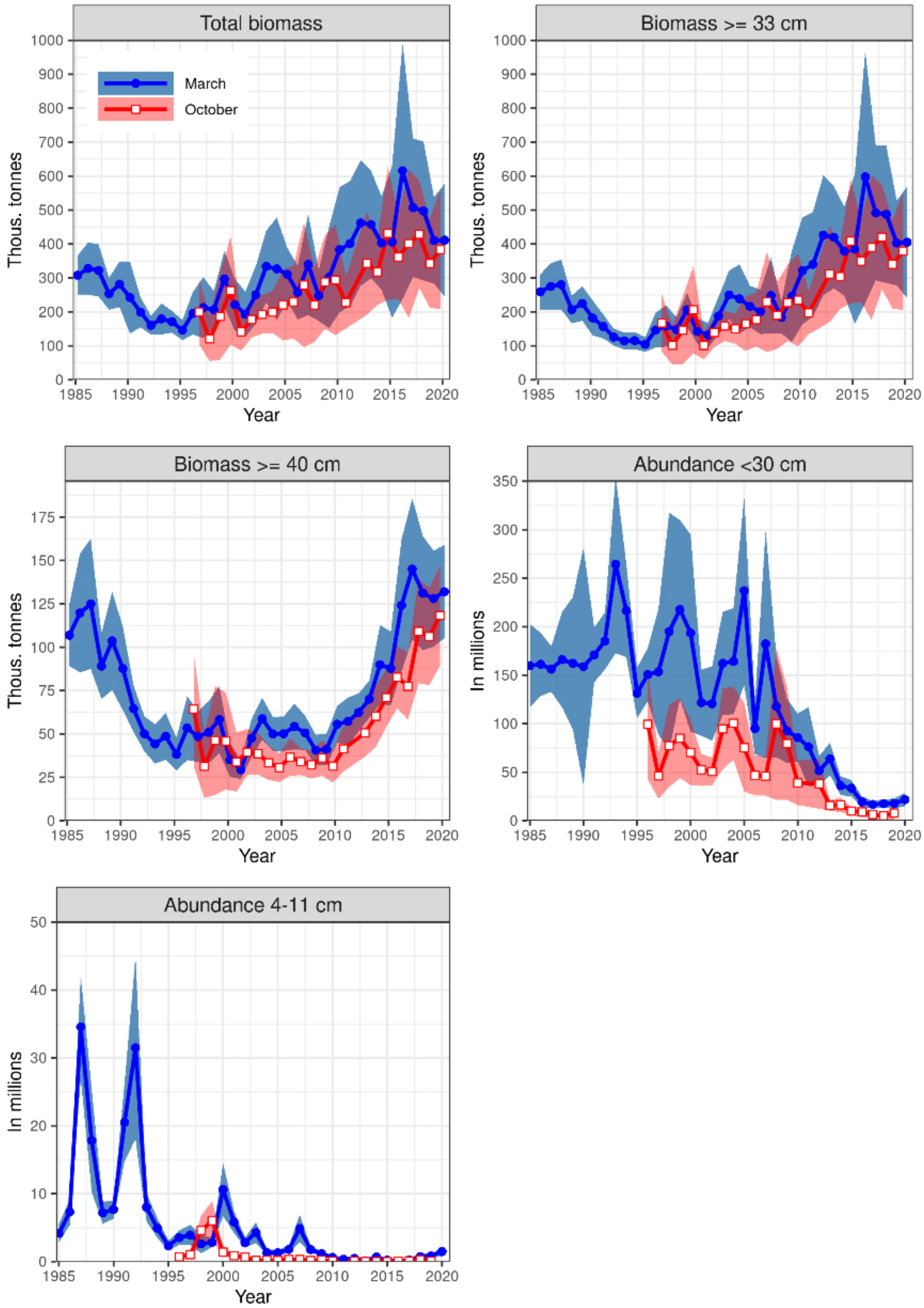

Figure 1: Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985–2020 (blue line and shaded area) and October 1996–2019 (red lines and shaded areas). The shaded areas represent 95% CI.

Mynd 1. Gullkarfi. Heildarlífmassavísitala (efst til vinstri), lífmassavísitala ≥33 cm (efst til hægri), lífmassavísitala ≥40 cm (mið til vinstri), fjöldavísitala <30 cm (mið til hægri) og nýliðunarvísitölu (4-11 cm, neðst til vinstri) úr Stofnmælingu botnfiska að vori (SMB, blá lína og skyggð svæði) 1985-2020 og Stofnmælingu botnfiska að haustlagi (SMH, rauð lína og skyggð svæði) 1996-2019, ásamt 95% öryggismörkum.

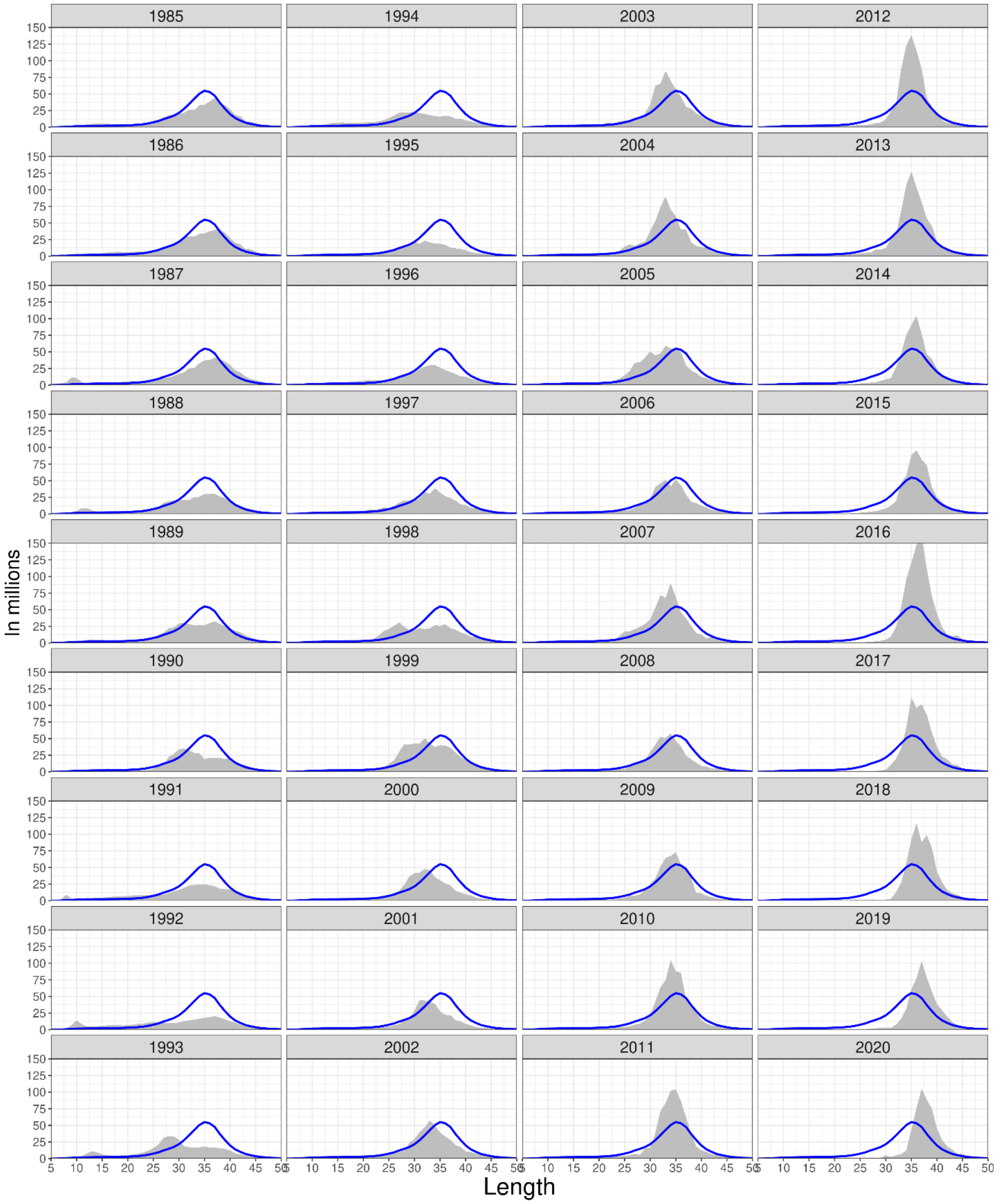

Figure 2: Length disaggregated abundance indices of golden redfish from the groundfish survey in March 1985–2020 conducted in Icelandic waters. The blue line is the mean of total indices 1985–2020.

Mynd 2. Gullkarfi. Lengdarskiptar vísitölur úr stofnmælingu botnfiska að vori (SMB) 1985-2020 ásamt meðaltali allra ára (blá lína).

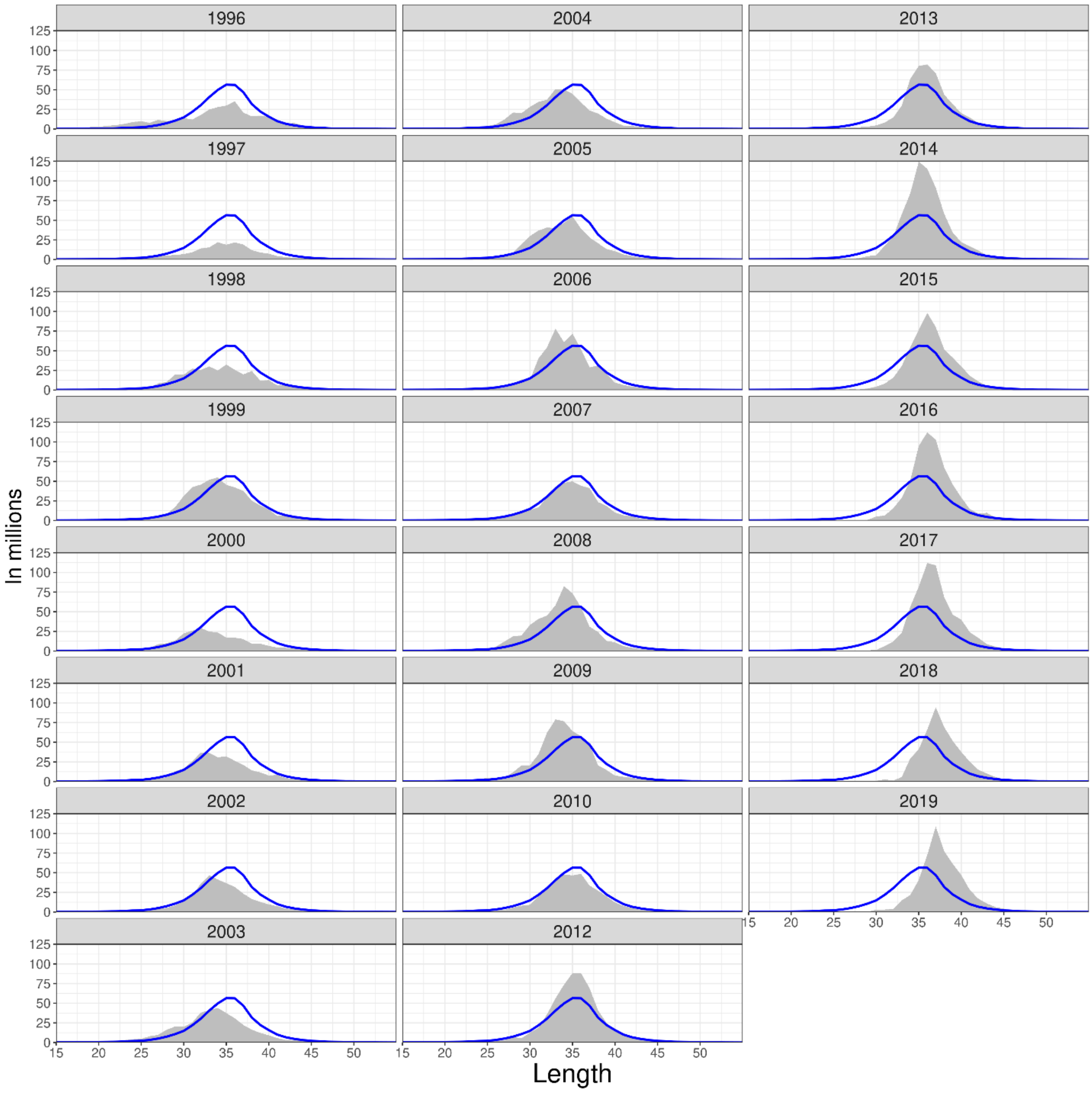

Figure 3: Length disaggregated abundance indices of golden redfish from the groundfish survey in October 1996–2019 conducted in Icelandic waters. The blue line is the mean of total indices 1996–2019. The survey was not conducted in 2011.

Mynd 3. Gullkarfi. Lengdarskiptar vísitölur úr stofnmælingu botnfiska að hausti (SMH) 2000-2019 ásamt meðaltali allra ára (blá lína). Engin stofnmæling var árið 2011.

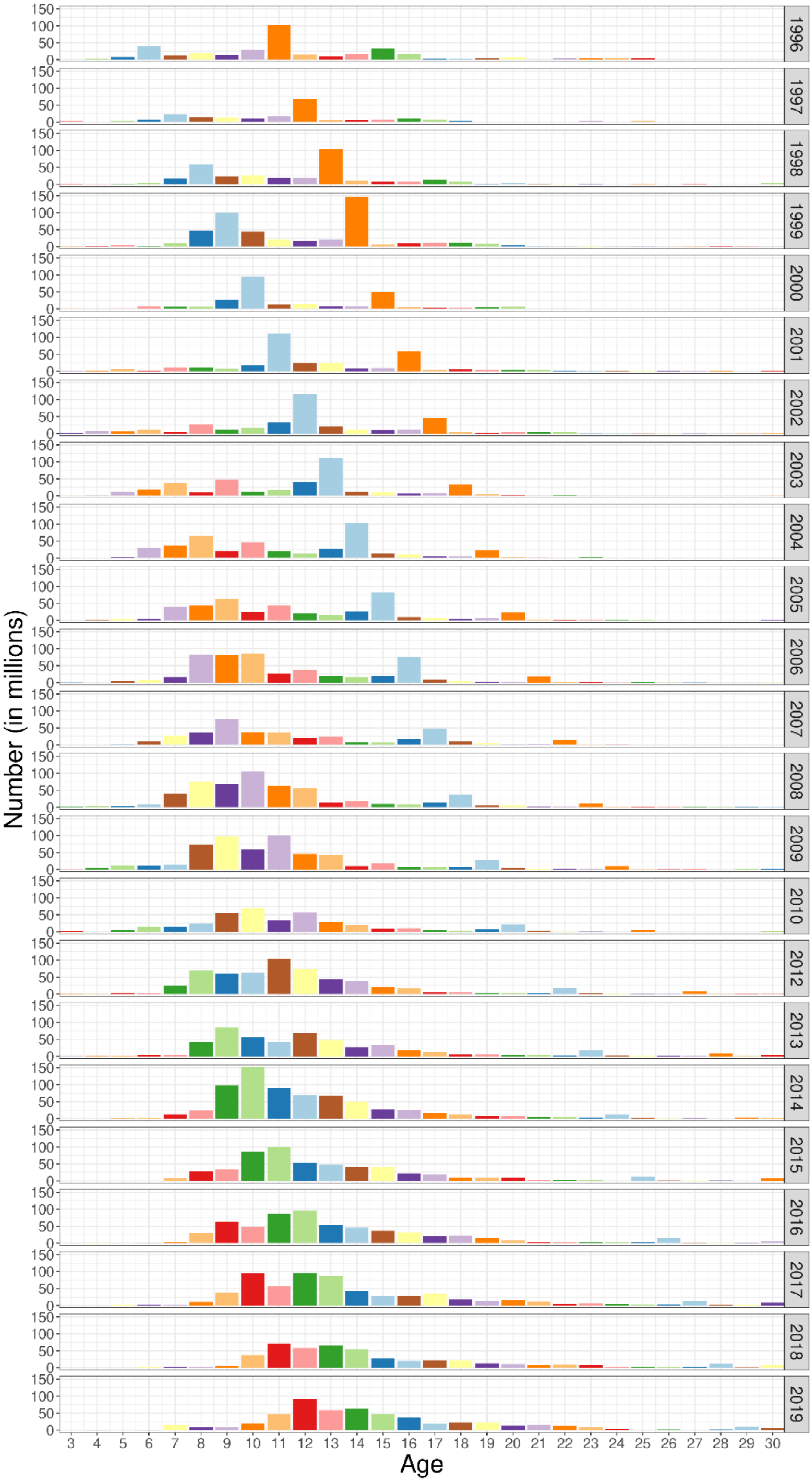

Figure 4: Age disaggregated abundance indices of golden redfish in the groundfish survey in October conducted in Icelandic waters 1996–2019. The survey was not conducted in 2011.

Mynd 4. Gullkarfi: Aldursskiptar vísitölur úr stofnmælingu botnfiska að hausti (SMH) 2000-2019. Engin stofnmæling var árið 2011.

DIVISION 5.B

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

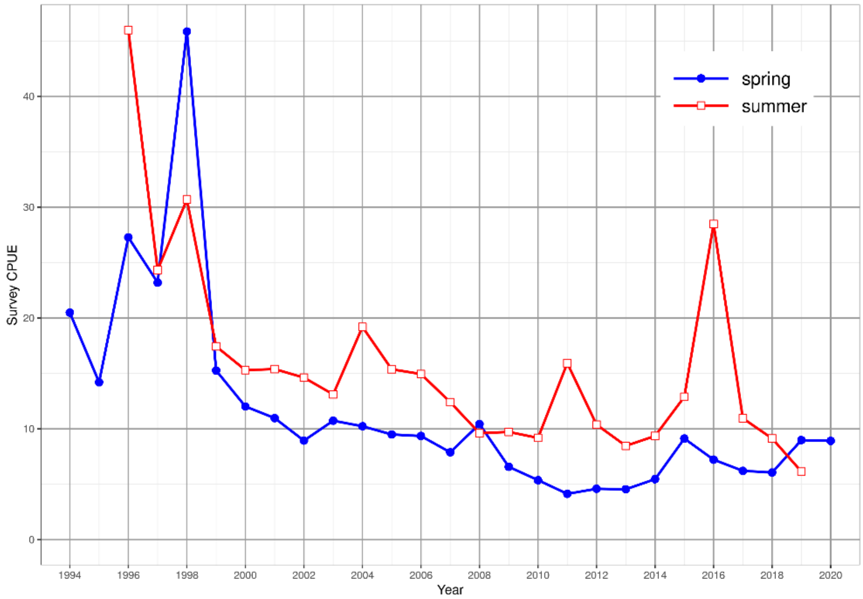

Figure 5: CPUE of golden redfish in the Faroes spring groundfish survey 1994–2020 (blue line) and the summer groundfish survey 1996–2019 (red line) in ICES Division 5.b.

Mynd 5. Gullkarfi. Afli á sóknareiningu við Færeyjar úr færeyskum stofnmælingaleiðöngrum að vori 1994-2020 (blá lína) og sumri 1996-2019 (rauð lína).

SUBAREA 14

The German groundfish survey has been conducted annually in the autumn from 1982 to 2017 and in 2019 covering shelf areas and the continental slopes off West and East Greenland. In 2017, sampling was only conducted in parts of East Greenland and one spot in NAFO 1F with a total of 46 stations. This is low compared to necessary coverage of 63–75 stations in the respective area as done in the previous years. The survey was not conducted in 2018 because of research vessel breakdown.

Relative abundance and biomass indices for golden redfish (fish >17 cm) from the German groundfish survey are illustrated in Figure 6. After a severe depletion of the golden redfish stock on the traditional fishing grounds around East Greenland in the early 1990s, the survey estimates showed a significant increase from 2003, both in biomass and abundance (Figure 6). The survey indices in 2007–2017 were high but fluctuated. The biomass survey index in 2014–2016 were at the highest level in the time-series but decreased in 2017 and 2019 to similar level as in 2010 (Figure 6a). It should be noted that the CV for the indices are high and the increase is driven by few very large hauls. In 2010–2019, the biomass of pre-fishery recruits (17–30 cm) has decreased gradually compared to previous five years and in 2017 and 2019 very little of 17–30 cm fish was observed (Figure 6c).

Abundance indices of redfish smaller than 18 cm from the German annual groundfish survey show that juveniles were abundant in 1993 and 1995–1998. 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 1999–2019 sur-vey results indicate low abundance and are like those observed in the late 1980s. The Green-land shrimp and fish shallow water survey (no survey conducted 2017-2019) also shows no juvenile redfish (<18 cm, not classified to species) were present.

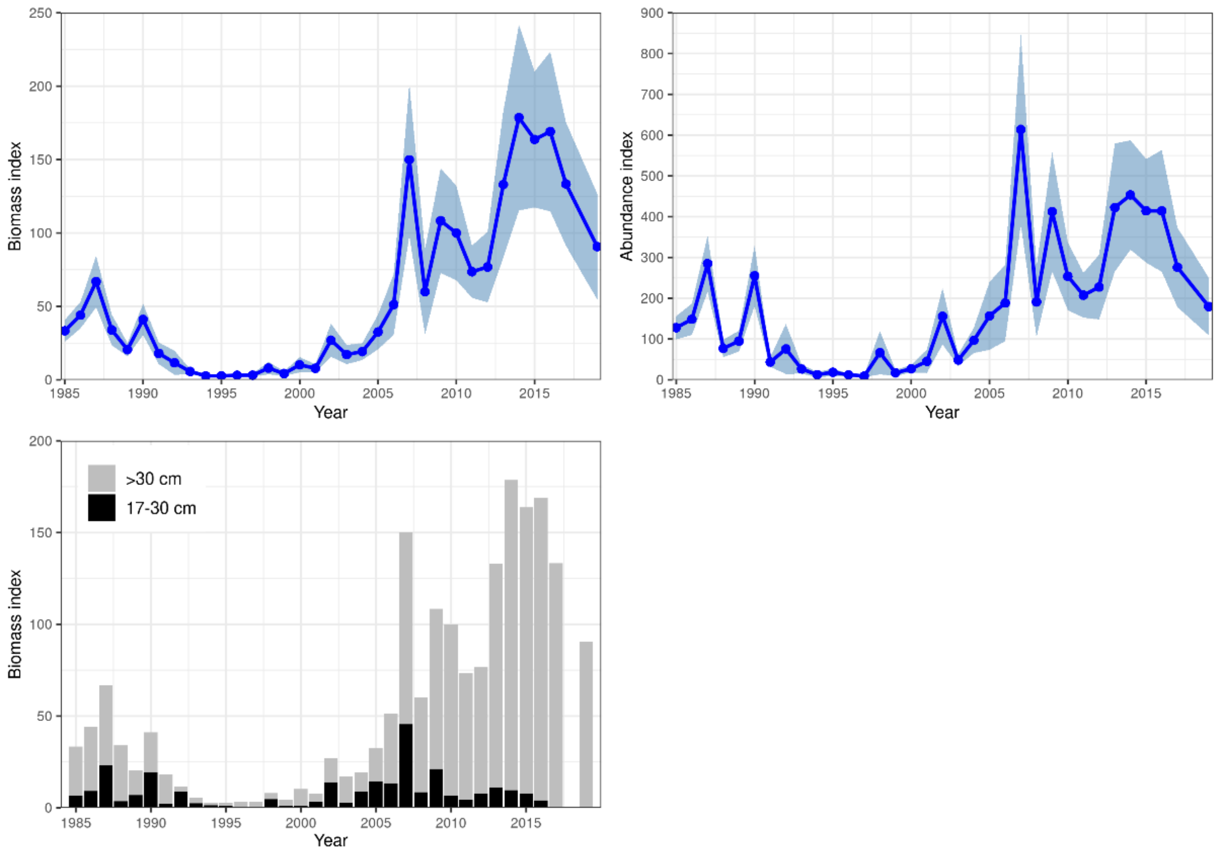

Figure 6: Golden redfish (>17 cm). Survey indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985–2019. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17–30 cm and >30 cm). The survey was not conducted in 2018.

Mynd 6. Gullkarfi. Vísitölur við Austur Grænland úr stofnmælingaleiðangri Þjóðverja 1985-2019. a) Heildarlífmassavísitala, b) heildarfjöldavísitala, c) lífmassavísitala skipt eftir stærðarflokkum (17-30 cm og >30 cm). Ekki var farið í leiðangur 2018.

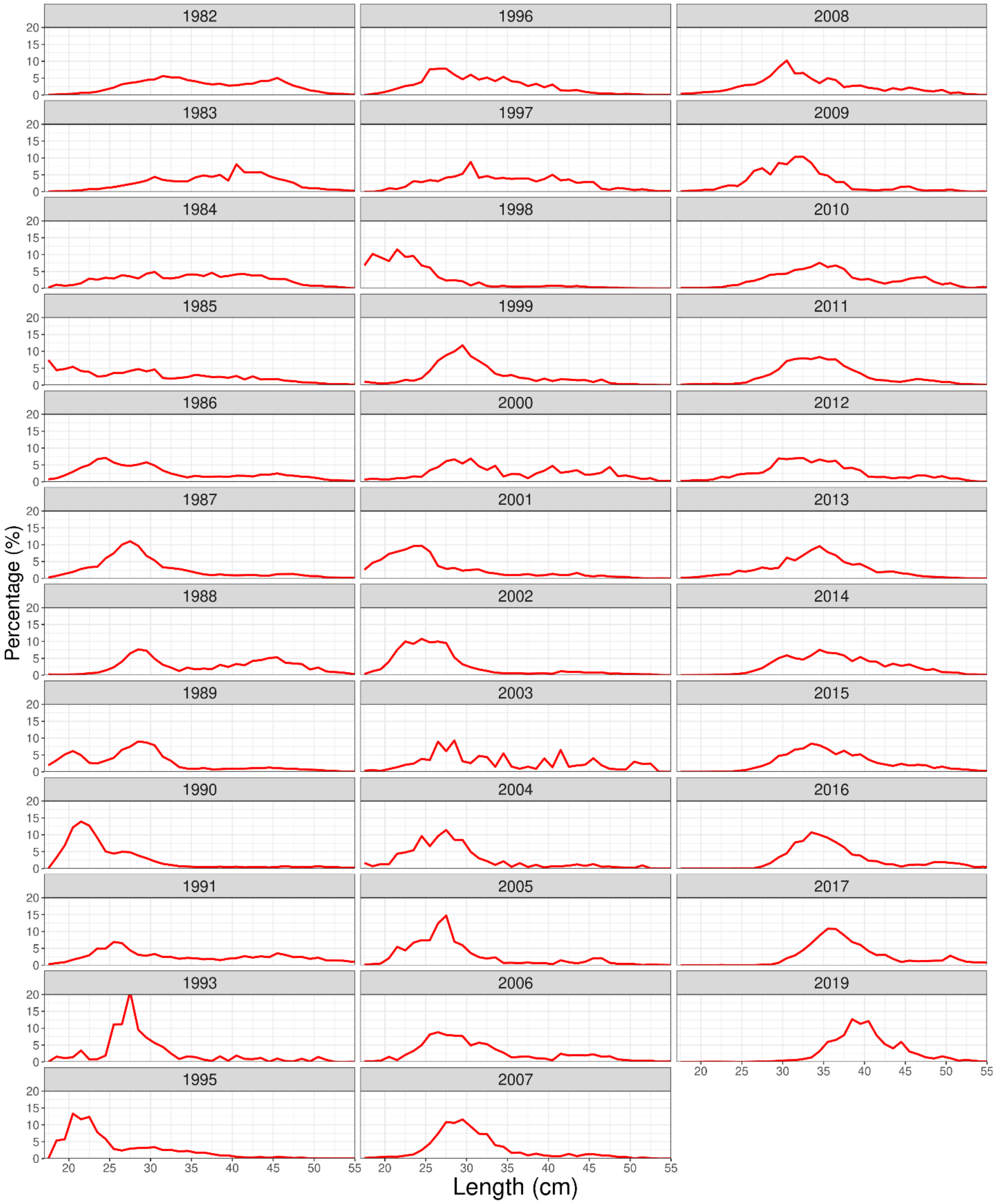

Figure 7. Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982–2019. The survey was not conducted in 2018.

Mynd 7. Gullkarfi. Lengdardreifing við Austur Grænland úr stofnmælingaleiðangri Þjóðverja 1985-2019. Ekki var farið í leiðangur 2018.

FISHERY

LANDINGS

Total landings gradually decreased by more than 70% from 130 429 t in 1982 to 43 515 t in 1994 (Table 3 and Figure 8). Since then, the total annual landings have varied between 33 451 and 59 698 t. The total landings in 2019 were 48 464 t, which is 4964 t less than in 2018. Most of the golden redfish catch or 90–98% has been taken in ICES Division 5.a.

Landings of golden redfish in Division 5.a declined from 97 899 t in 1982 to 38669 t in 1994 (Table 3). Since then, landings have varied between 31 686 t and 54 041 t, highest in 2016. The landings in 2019 were 44 746 t, or 3268 t less than in 2019. The landings were 14% higher than allocated quota of 39 240 t. The reasons for the implementation errors are related to the management system that allow for transfers of quota share between fishing years and conversion of TAC from one species to another.

Between 90–95% of the golden redfish catch in Division 5.a is taken by bottom trawlers targeting redfish (both fresh fish and factory trawlers; vessel length 48–65 m). The remaining catches are partly caught as bycatch in gillnet, long-line, and lobster fishery. In 2019, as in previous years, most of the catches were taken along the shelf southwest, west, and northwest of Iceland (Figure 9). Higher proportion of the catches is now taken along the shelf northwest of Iceland and less south and southwest.

In Division 5.b, landings decreased from 9194 t in 1985 to 1436 t in 1999 and varied between 1139 and 2484 t from 2000–2005 (Table 3). In 2006–2016 annual landings were less than 700 t which has not been observed before in the time-series. The landings in 2017 increased substantially compared to previous 11 years and were 1397 t. That is 1232 t more landings than in 2016 and the highest landings since 2005. The landings were 1330 t and 1053 t in 2018 and 2019, respectively. Most of the golden redfish caught in Division 5.b is taken by pair and single trawlers (vessels larger than 1000 HP).

In Subarea 14 (East Greenland waters), the landings of golden redfish reached a record high of 30 962 t in 1982 but decreased drastically within the next three years and to 2117 t in 1985 (Figure 8 and Table 3). During the period 1985–1994, the annual landings from Sub-area 14 varied between 687 and 4255 t. There was little or no direct fishery for golden redfish from 1995 to 2009 and landings were 200 t or less, mainly taken as bycatch in the shrimp fishery. In 2010, landings of golden redfish increased considerable and were 1650 t. This in-crease is mainly due to increased S. mentella fishery in the area. Annual landings 2010–2015 have been between 1000 t and 2700 t but increased to 5442 t in 2016 which is the highest landings since 1983. The landings in 2019 were 2665 t, about 1339 t less than in 2018.

Annual landings from Subarea 6 increased from 1978 to 1987 followed by a gradual decrease to 1992 (Table 3). 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 2006–2019 and were 101 t in 2019.

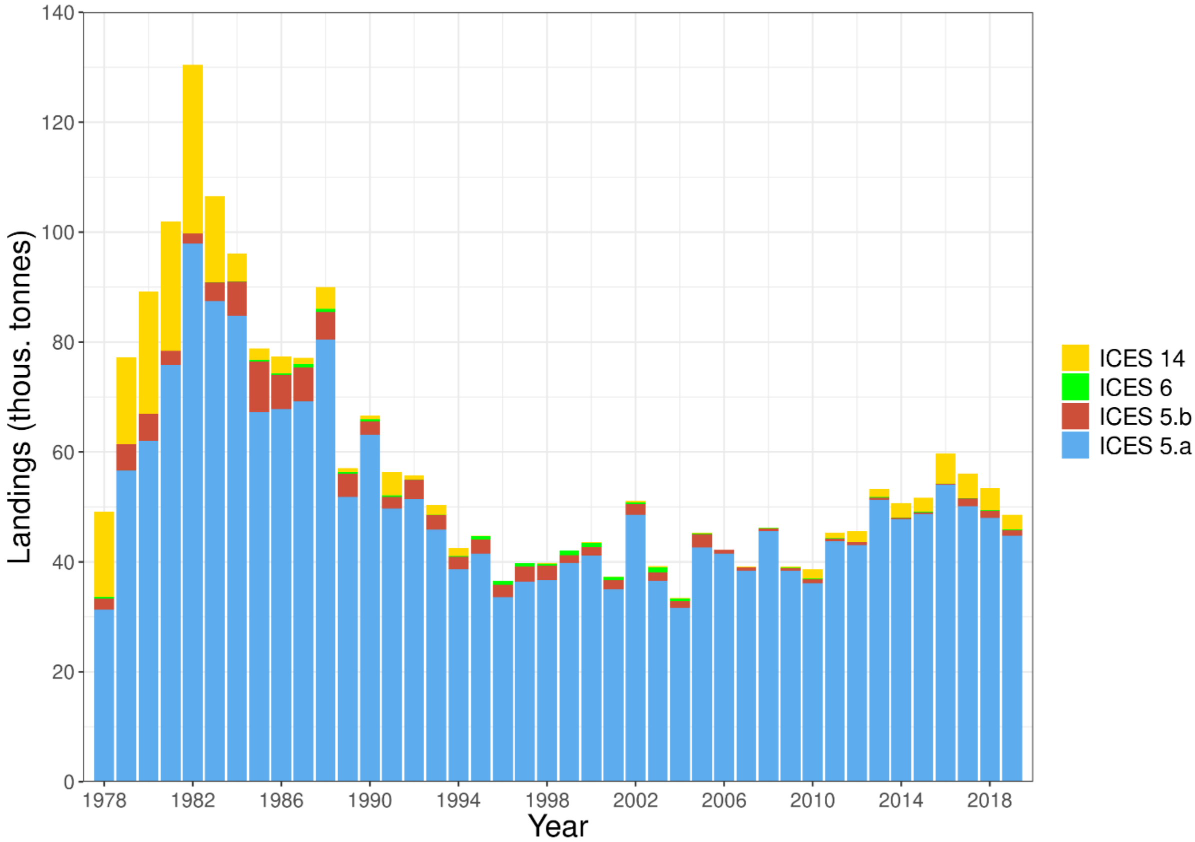

Figure 8. Nominal landings of golden redfish in tonnes by ICES Divisions 1978–2019.

Mynd 8. Gullkarfi. Landaður afli (í þús. tonnum) við Austur Grænland (ICES 14), Ísland (ICES 5.a), Færeyjar (ICES 5.b) og ICES svæði 6.

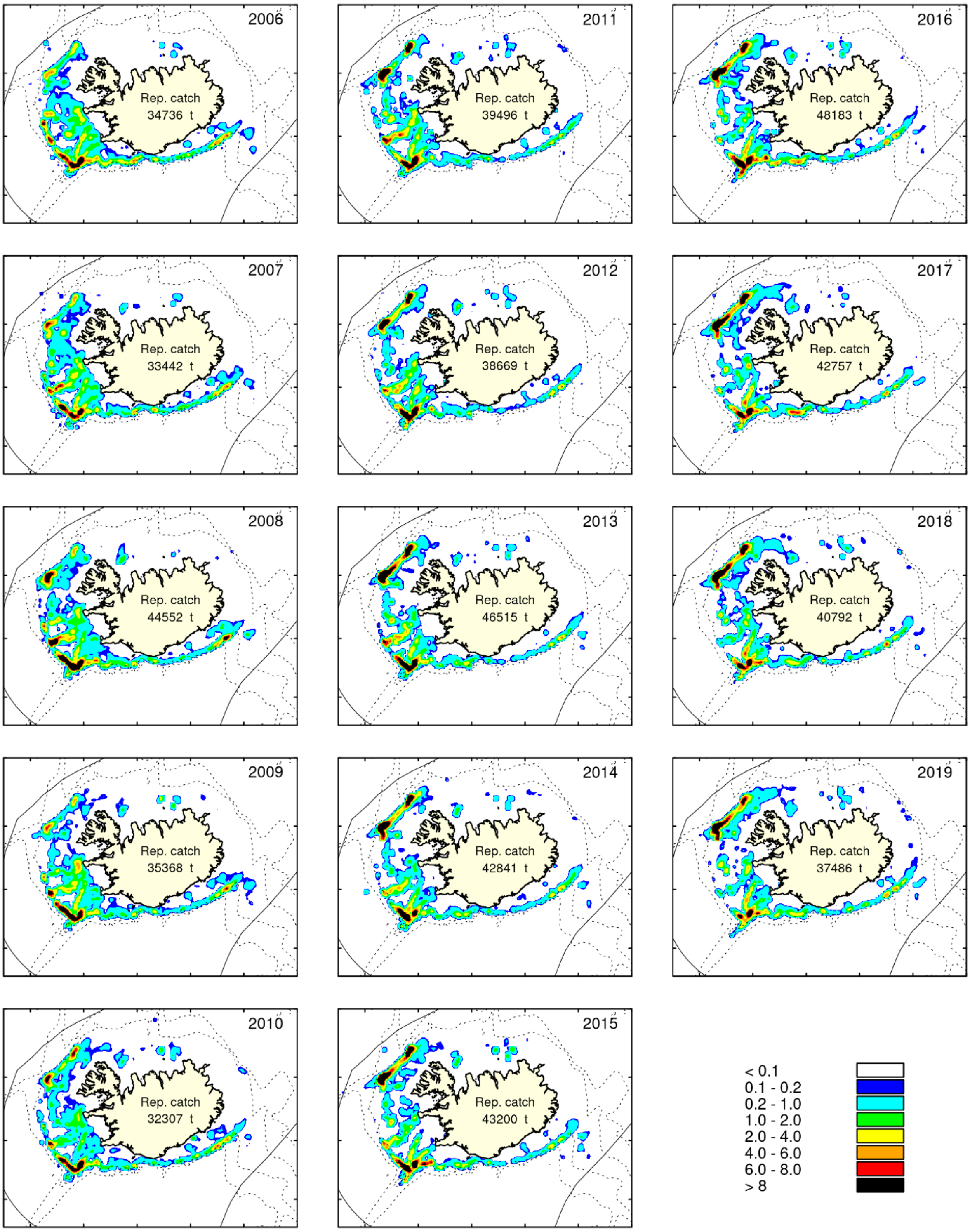

Figure 9. Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2006–2019.

Mynd 9. Gullkarfi. Útbreiðsla botnvörpuveiða á Íslandsmiðum 2006-2019 samkvæmt afladagbókum.

DISCARD

Comparison of sea and port samples from the Icelandic discard sampling program does not indicate significant discarding due to high grading in recent years (Pálsson et al 2010), possibly due to area closures of important nursery grounds west off Iceland. Substantial discard of small redfish took place in the deep-water shrimp fishery from 1986 to 1992, before 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.

BIOLOGICAL DATA FROM THE COMMERCIAL FISHERY

The table below shows the fishery related sampling by gear type and ICES divisions in 2019. No sampling of the commercial catch from Subarea 6 was carried out.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	44 746	161	28 233	1239
5.b	Faroe Islands	Bottom trawl	1053		116	
14	Greenland	Bottom trawl	2665			

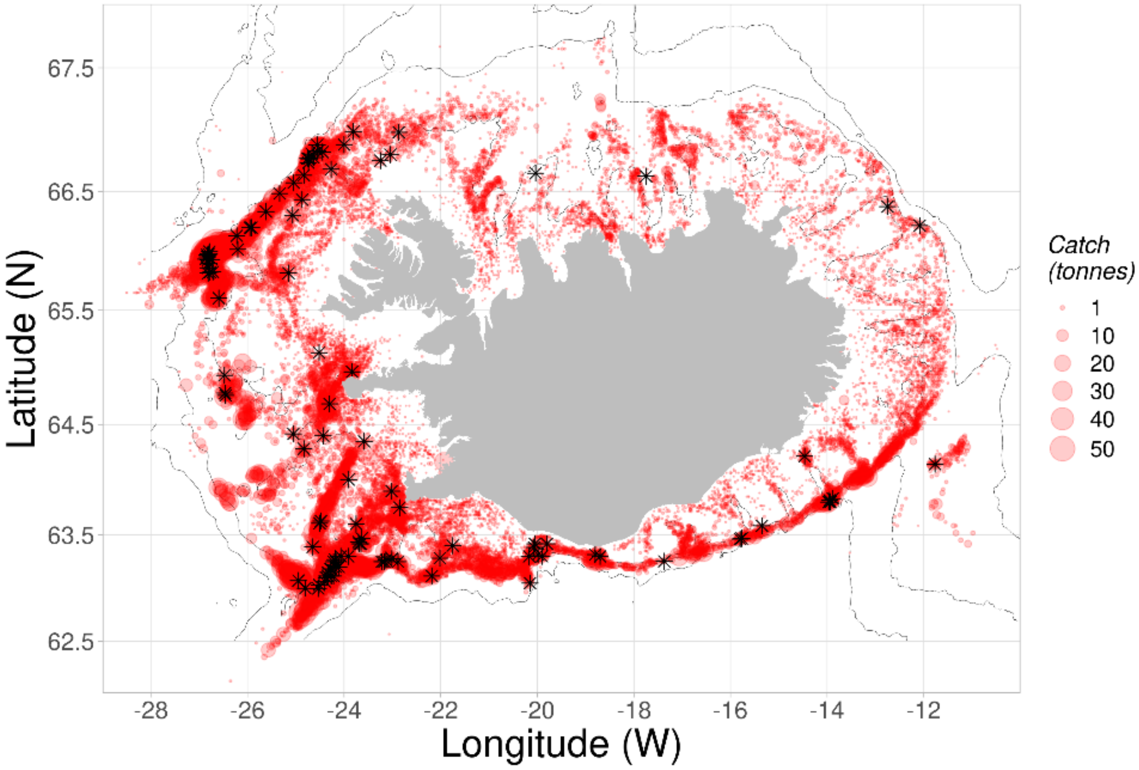

Figure 10. Fishing grounds of golden redfish by commercial trawlers in 2019 as reported in logbooks (red) and positions of length samples taken from landings (black dots).

Mynd 10. Gullkarfi. Veiðisvæði við Ísland árið 2019 samkvæmt afladagbókum (rautt) og staðsetningar sýna úr lönduðum afla (stjörnur).

LANDINGS BY LENGTH AND AGE

The length distributions from the Icelandic commercial trawler fleet in 1976–2019 show that most of the fish caught is between 30 and 45 cm (Figure 11). The modes of the length distributions range between 35 and 40 cm and has over the past decade shifted to the right. The length distributions in 2012–2019 are narrower than previously, with less than average of small fish (<35 cm), and the mean length has increased by almost 3 cm.

Catch-at-age data from the Icelandic fishery in Division 5.a show that the 1985-year class dominated the catches from 1995–2002 (Figure 12 and Table 4) 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. In 2007–2010 the 1996–1999 year-classes dominated in the catches but are now gradually decreasing. The 2003–2008 year-classes (ages 11–16) were the most dominant year classes in the fishery in 2019. There is a substantial decrease of 7–10-year-old fish in the catch, compared to recent previous years, an additional indicator of low recruitment in recent year observed in all surveys conducted in East Greenland and Icelandic waters.

The average total mortality (Z), estimated from the 25-year series of catch-at-age data (Figure 13) is about 0.20 for age 13 years and older.

Length distribution from the Faroese commercial catches 2001–2019 shows that the fish caught are on average larger than 40 cm with modes between 45 cm and 50 cm (Figure 14).

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

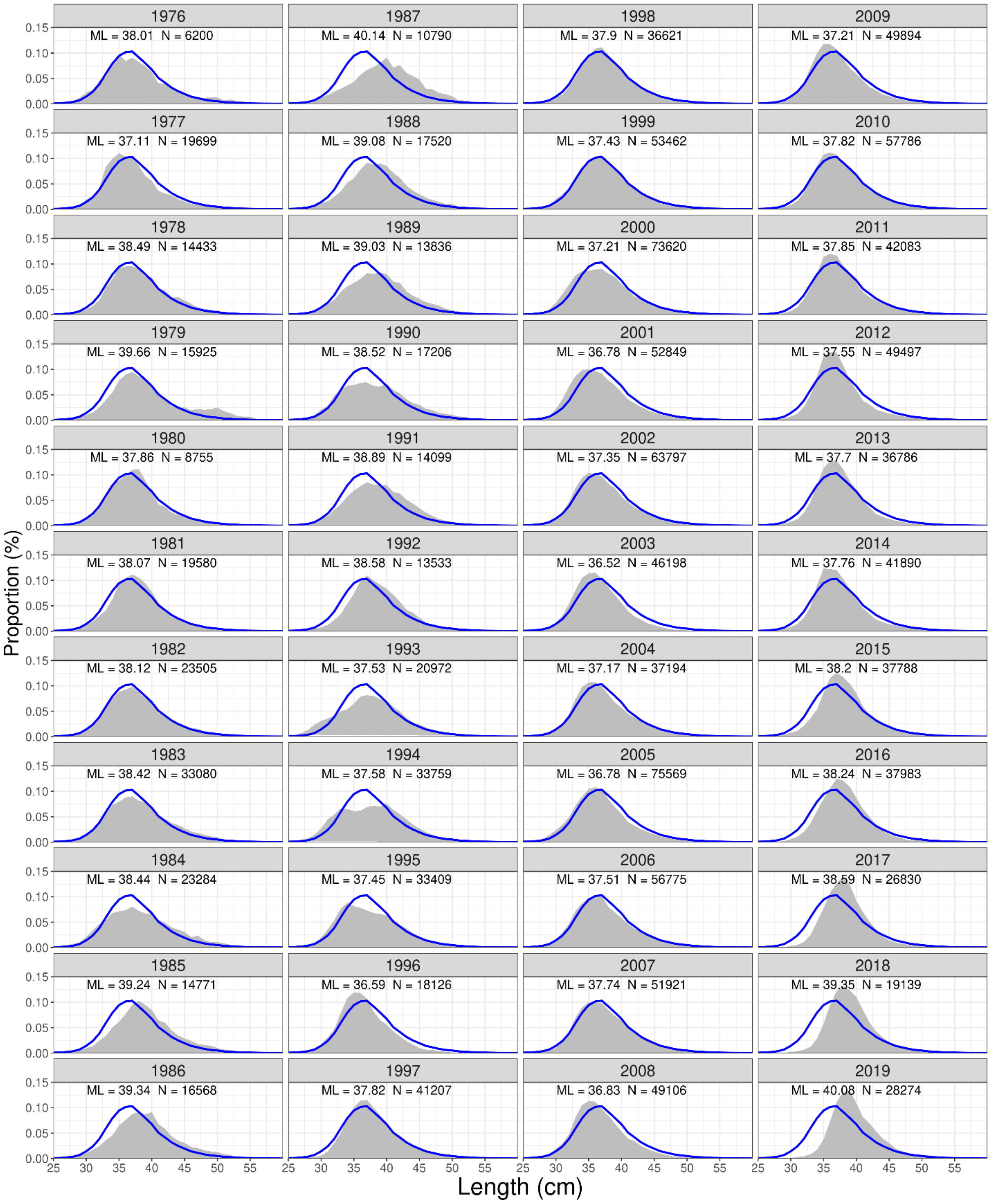

Figure 11. Length distribution (grey shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976–2019. The blue line is the mean of the years 1976–2019.

Mynd 11. Gullkarfi. Lengdardreifing úr afla botnvörpu við Ísland (grátt svæði) 1976-2019 ásamt meðaltali allra ára (blá lína).

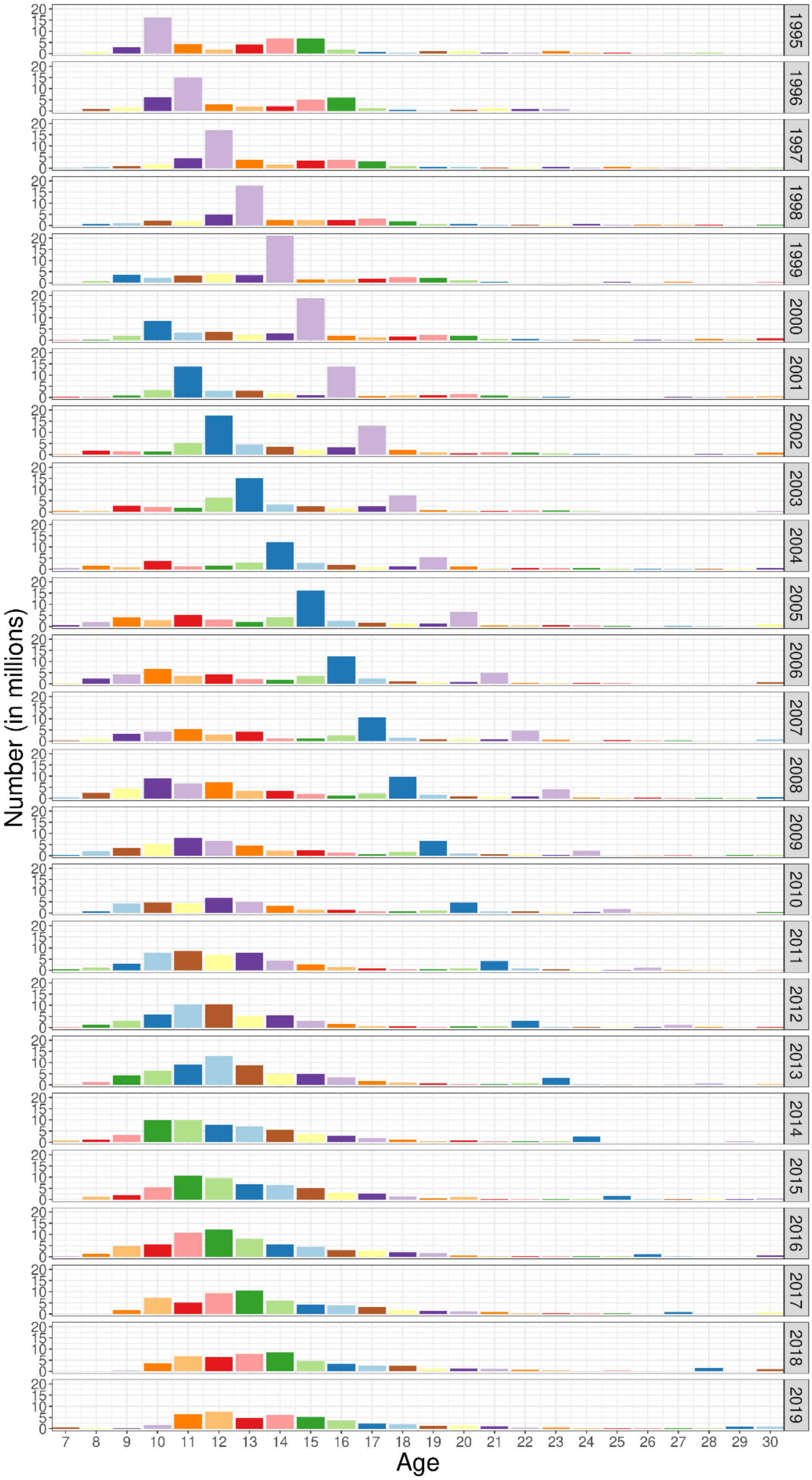

Figure 12. Catch-at-age of golden redfish in numbers in ICES Division 5.a 1995–2019. Bar size is indicative of the catch in numbers and bars are colored by cohort.

Mynd 12. Gullkarfi. Aldurskitpur afli á Íslandsmiðum 1995-2019. Súlur gefa til kynna afla í fjölda eftir aldri og eru litaðar eftir árgangi.

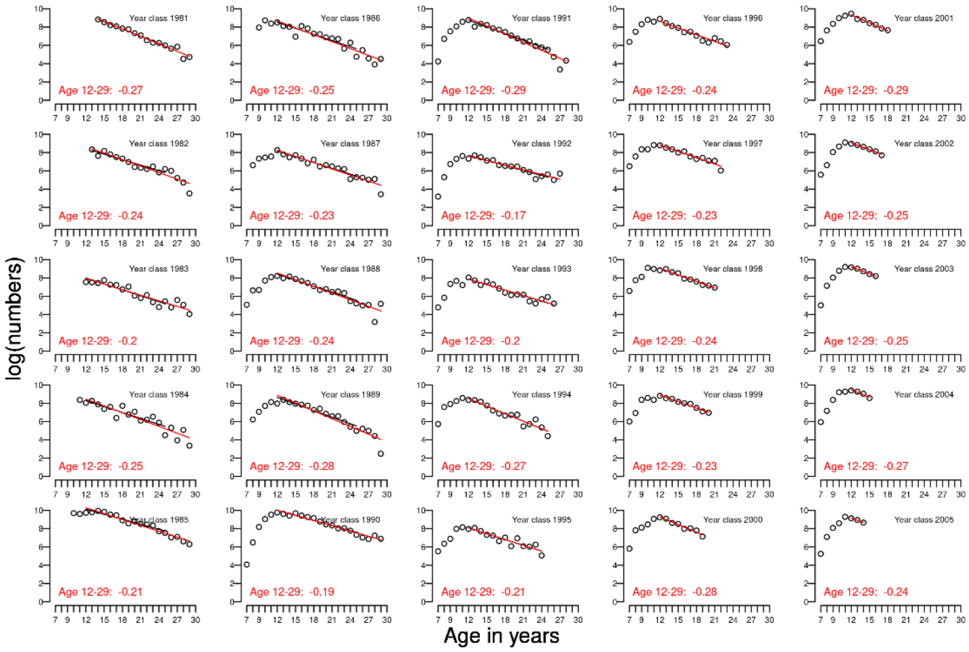

Figure 13. Catch curve of the 1981–2005 year-classes of golden redfish based on the catch-at-age data in ICES Division 5.a 1995–2019.

Mynd 14. Gullkarfi. Aflakúrfa árganga 1981-2005 byggt á aldurskiptum afla við Ísland 1995-2019.

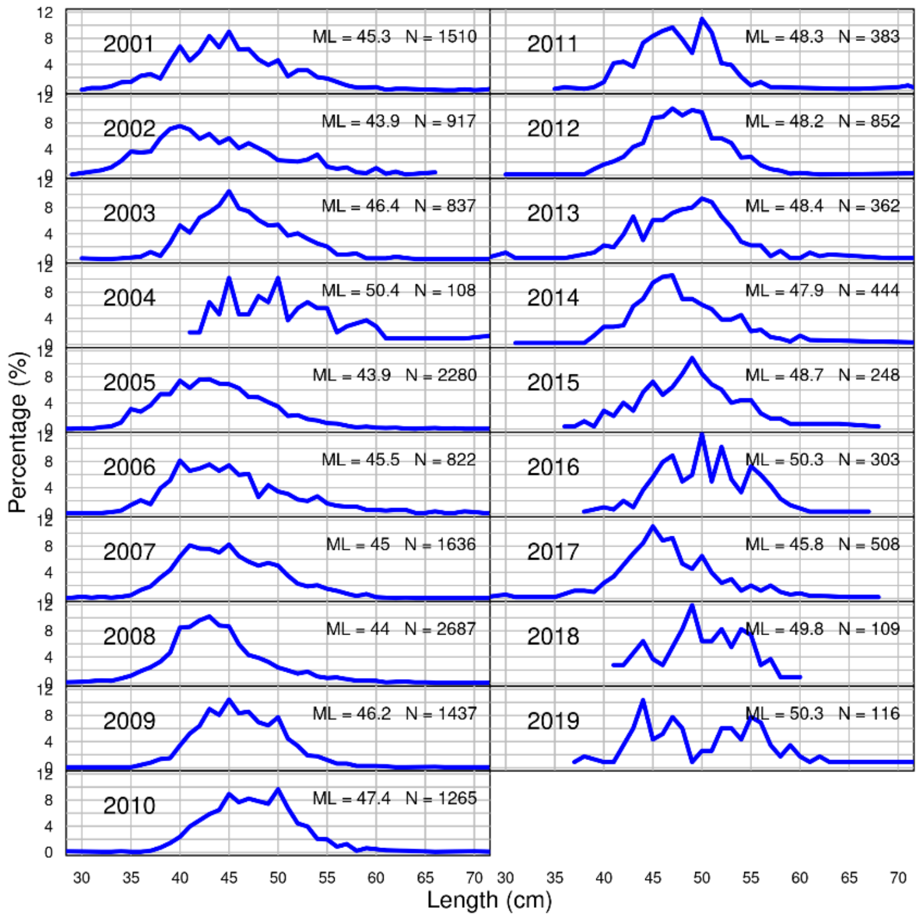

Figure 14. Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001-2019.
Mynd 14. Gullkarfi. Lengdardreifing úr afla við Færeyjar 2001-2019.

CATCH PER UNIT EFFORT

The un-standardized CPUE index from the Icelandic bottom trawl fleet was in 2019 the highest in the time-series with sharp increase in the past two decades. Effort towards golden redfish has since 1986 gradually decreased and is at the lowest level recorded (Figure 15). CPUE derived from logbooks is not considered indicative of stock trends, however the information contained in the logbooks on effort, spatial and temporal distribution of the fishery is of value.

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

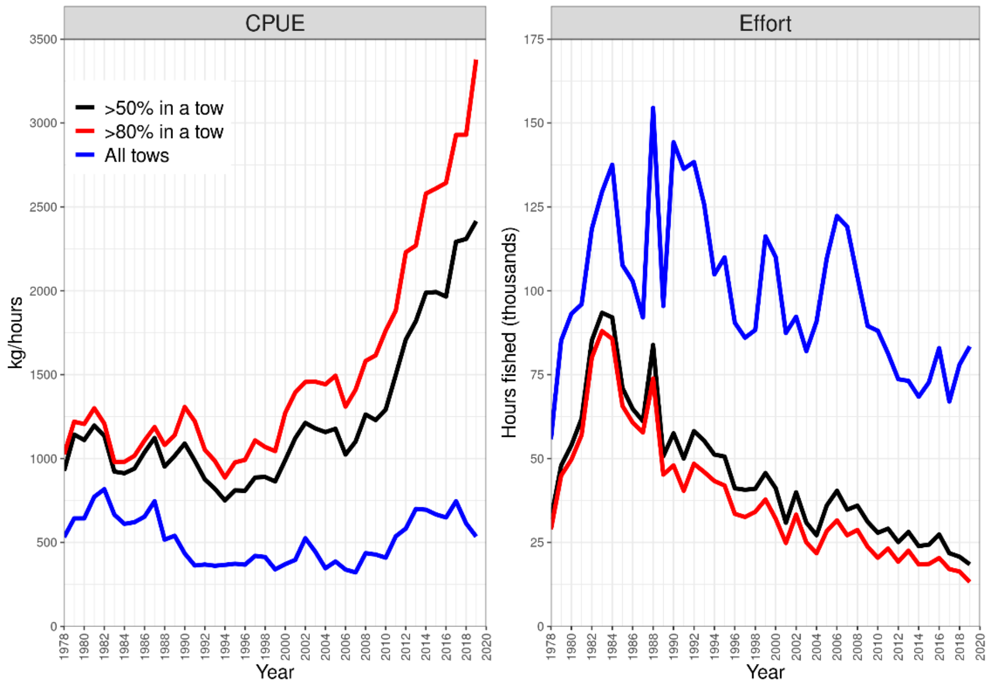

Figure 15. CPUE of golden redfish from Icelandic trawlers 1978–2019 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line).

Mynd 15. Gullkarfi. Afli á sóknareiningu (vinstri) og sókn (hægri) í botnvörpu frá íslenskum skipum 1978-2019 þar sem gullkarfi var að minsta kosti 50% af heildarafla í hverju togi (svört lína, 80% af heildarafla í hverju togi (rauð lína) og þar sem gullkarfi kom fyrir í hverju togi (blá lína).

ANALYTICAL ASSESSMENT

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

GADGET MODEL

DATA AND MODEL SETTINGS

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

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 1985–2020 and the German survey in East Greenland 1984–2019. The German survey index in 2018 is based on the average of the 2017 and 2019 values because the survey was not conducted in 2018.
- Survey indices are combined (Figure 16) and the German survey gets half the weight compared to what is presented in Figure 6. This was done to avoid extrapolation to areas not surveyed, and hence reduce noise. By using the stratification used to calculate indices shown in Figure 16, each station in the German survey would get 2.5 times more weight compared to the Icelandic survey.
- Length distributions from the Icelandic (1972-2020), Faroe Islands (1980-2012) and East Greenland (1975-2004) commercial catches.
- Landings by 6-month period from Iceland, Faroe Islands and East Greenland.
- Age-length keys and mean length at age from the Icelandic groundfish survey in October 1996–2019.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995–2019.

Model settings:

- The simulation period is from 1970 to 2024 using data until the first half of 2020 for estimation. Two time-steps are used each year. The ages used were 5 to 30 years, where the oldest age is treated as a plus group (fish 30 years and older).
- Modelled length ranged between 19-54 cm.
- Commercial catches are split by country and implemented as separate fleets. Survey catch distribution data are modelled as a separate fleet.
- Recruitment was set at age 5.

Estimated parameters are:

- Number of fishes when the simulation starts (8 parameters).
- Recruitment at age 5 each year (48 parameters).
- Length at recruitment (3 parameters).
- Parameters in the growth equation; (2 parameters).
- Parameter β of the beta-binomial distribution controlling the spread of the length distribution.
- Selection pattern of the three commercial fleets assuming logistic selection (S-shape) (3x2 parameters).
- Selection pattern of the survey fleet assuming an Andersen selection curve (bell-shape) (3 parameters).

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

Assumptions done in the predictions:

- Recruitment at age 5 in 2019 and onwards was set as the average of the five smallest estimated year classes 1980–2007 or 41.7 million. The reason is indication of poor recruitment in recent years, but estimated recruitment was even lower.
- Catches in the first time-step in 2020 (first 6 months) were set at the same as in the first time-step of 2019 for all the fleets. In step 2 in 2020 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.

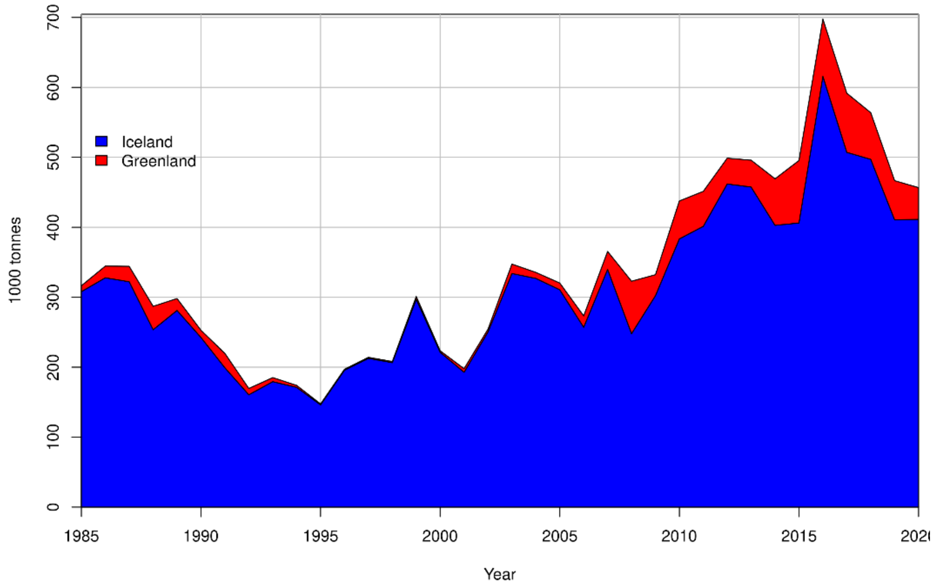

Figure 16. Biomass index from Iceland (blue) and Greenland (red), based on weighting the German survey data in Figure 6 by 0.5. The survey index in East Greenland for 2018 is the average of the 2017 and 2019 values because it was not conducted in 2018.

Mynd 16. Gullkarfi. Lífmassavísitölur frá Íslandi (blátt svæði) og Grænlandi (rautt svæði) byggt á endurvigtun á vísitalna við Grænland á mynd 6 með því að margfalda vísitölur með 0.5. Vísitala við Austur Grænland fyrir árið 2018 er meðaltal gilda 2017 og 2019 þar sem ekki varð farið í leiðangur á svæðinu árið 2018.

RESULTS OF THE ASSESSMENT MODEL

It should be noted that the SSB estimates, shown in Table 5, were not calculated correctly in 2015-2019. This error was noted in April 2020 and SSB values were corrected in the 2019 assessment and the NWWG 2019 report corrected accordingly.

The SSB is compiled from the total biomass by length and is based on fixed sized-based maturity ogive:

$$P_L = \frac{1}{1 + e^{-0.3122(L-33.54)}}$$

The error arose because wrong values were used in the function, i.e. 0.1645 instead of 0.3122 and 33.40 instead of 33.54, making the SSB approximately 10% smaller than it is when using the correct values in the logistic function. As the calculation of SSB is done after model run based on total biomass as estimated by the model, this error does not have any effect on advised catch, estimates of fishing mortality and recruitment, nor the perception of SSB being above biomass reference points. Corrected SSB values in the 2019 assessment have been incorporated into the 2019 ICES advice for this stock.

Summary of the assessment is shown in Figure 17 and Table 5. The spawning stock increased 1995-2015 but has since then decreased. Fishing mortality has been low since 2010, but since the HCR was adopted in 2014, the fishing mortality has been above the target of 0.097 because the catches have exceeded the advice. Recruitment after 2013 is record low for the time series.

Assumptions about the year classes after the 2014 one will not have much effect on the advice this year. This is because the average proportion of fish 10-years old and younger in the landings are only about 10%. Later advice will be affected as well as the development of the spawning stock in short and medium term and is expected to decrease.

Although this year's assessment is consistent with previous assessments it shows a downward revision of SSB and an upward revision of fishing mortality compared to last year's assessment (Figures 18).

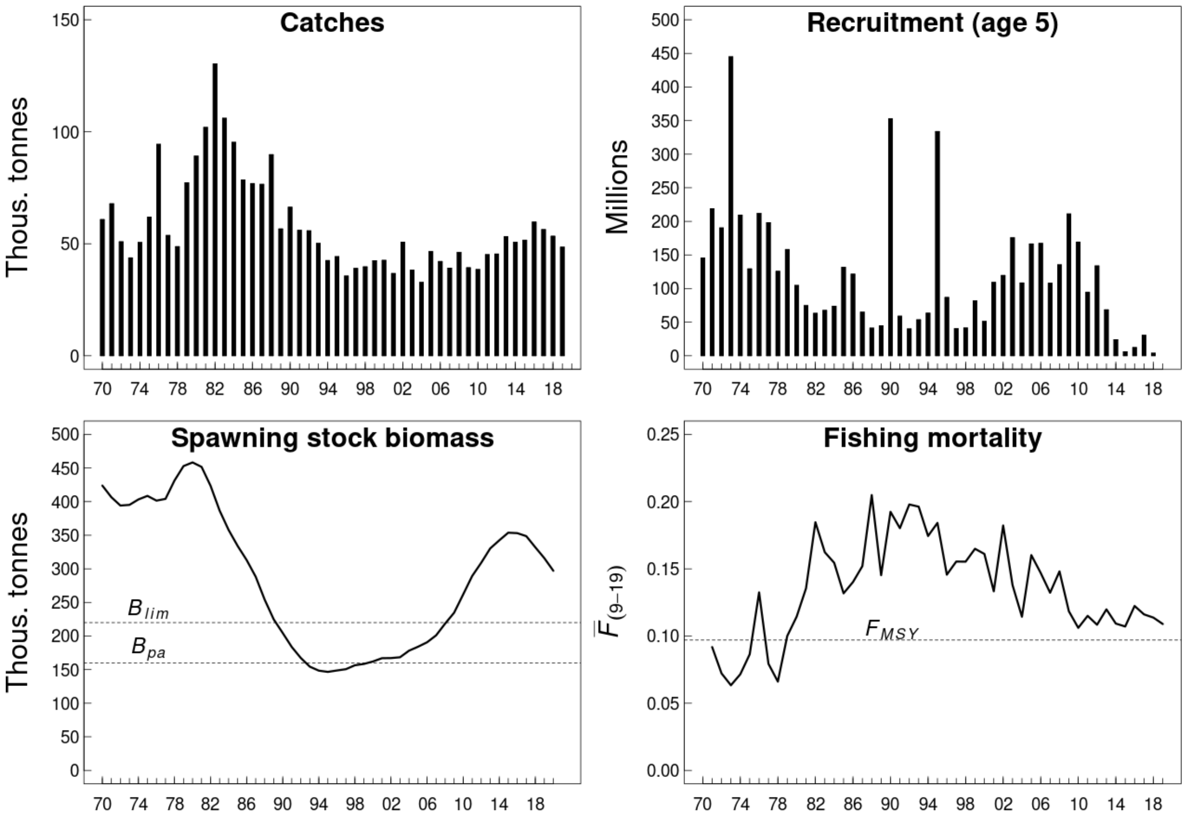

Figure 17. Golden redfish. Summary from the assessment 2020. The figure shows total catches, recruitment (age 5) spawning stock biomass (SSB) and fishing mortality for ages 9-19. The dashed line in the SSB plot represents B_{pa} and B_{lim}. The dashed line in the fishing mortality plot indicates the target fishing mortality.

Mynd 17. Gullkarfi. Niðurstöður stofnmats 2020. Myndin sýnir heildarafla, nýliðun (5 ára), lífmassa hrygningarstofns og veiðidánartölu. Brotnar línur við lífmassa hrygningarstofns sýnir gátmörk (B_{pa} og B_{lim}). Brotna línan við veiðidauða sýnir það gildi sem stefnt er að með aflareglu.

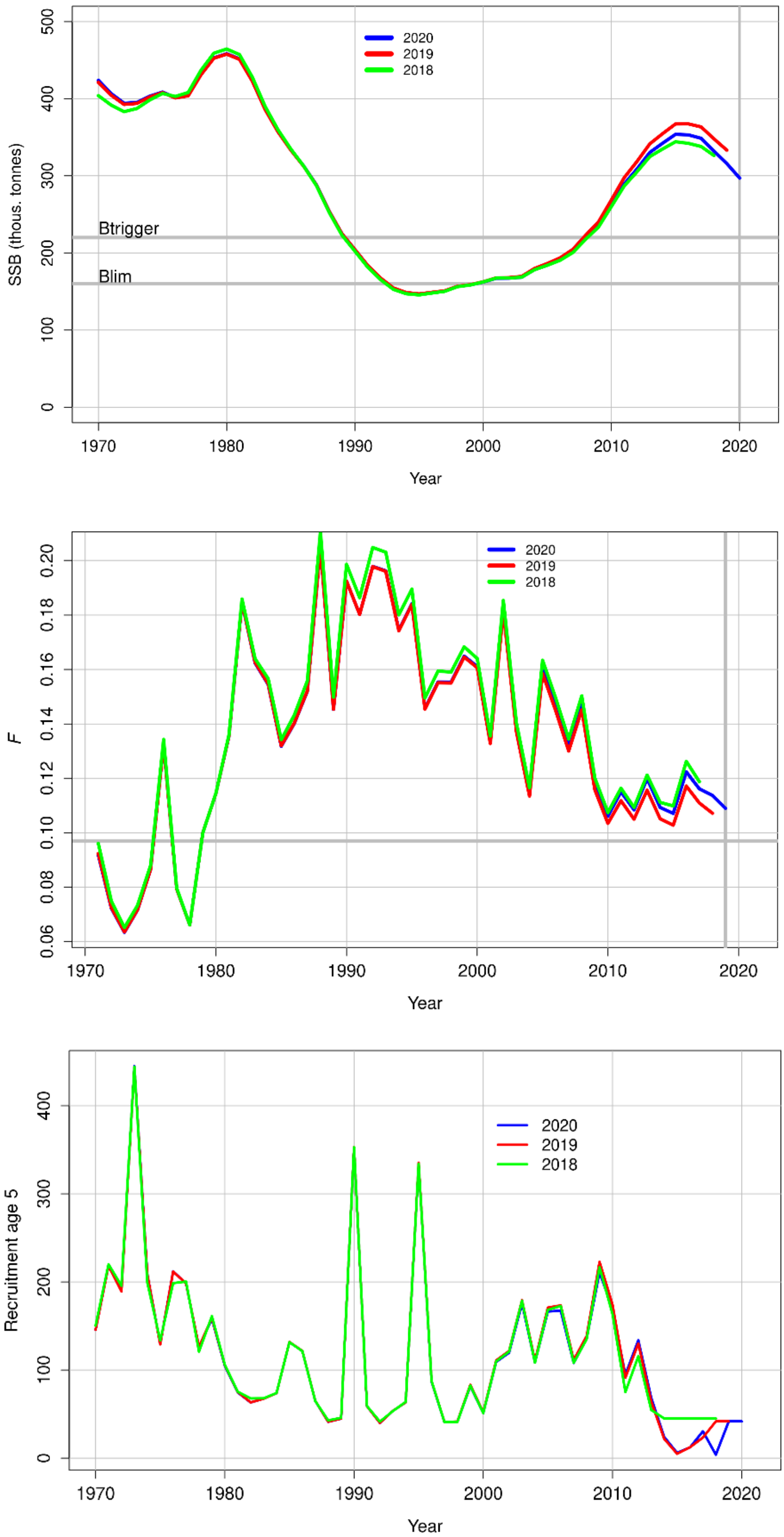

Figure 18. Golden redfish. Comparison of the current assessment (blue line) and the same assessment done in 2018 (red line) and 2019 (green line) for the spawning stock biomass (top), fishing mortality (middle) and recruitment (bottom).

Mynd 18. Gullkarfi. Stofnmat ársins í ár (blá lína) borið saman við stofnmatið fyrir árið 2019 (rauð lína) og árið 2018 (græn lína. Áætlaður lífmassi hrygningarstofns (efst), veiðidánartala (miðja) og nýliðun (neðst).

MOHN'S RHO

The evaluation retrospective pattern of the assessment (Figure 19) is done by calculating the Mohn's rho values. The default five-year peels resulted in the following values:

Variable	Value
F_{bar}	-0.0585
SSB	0.0568
Rec.	-0.0588

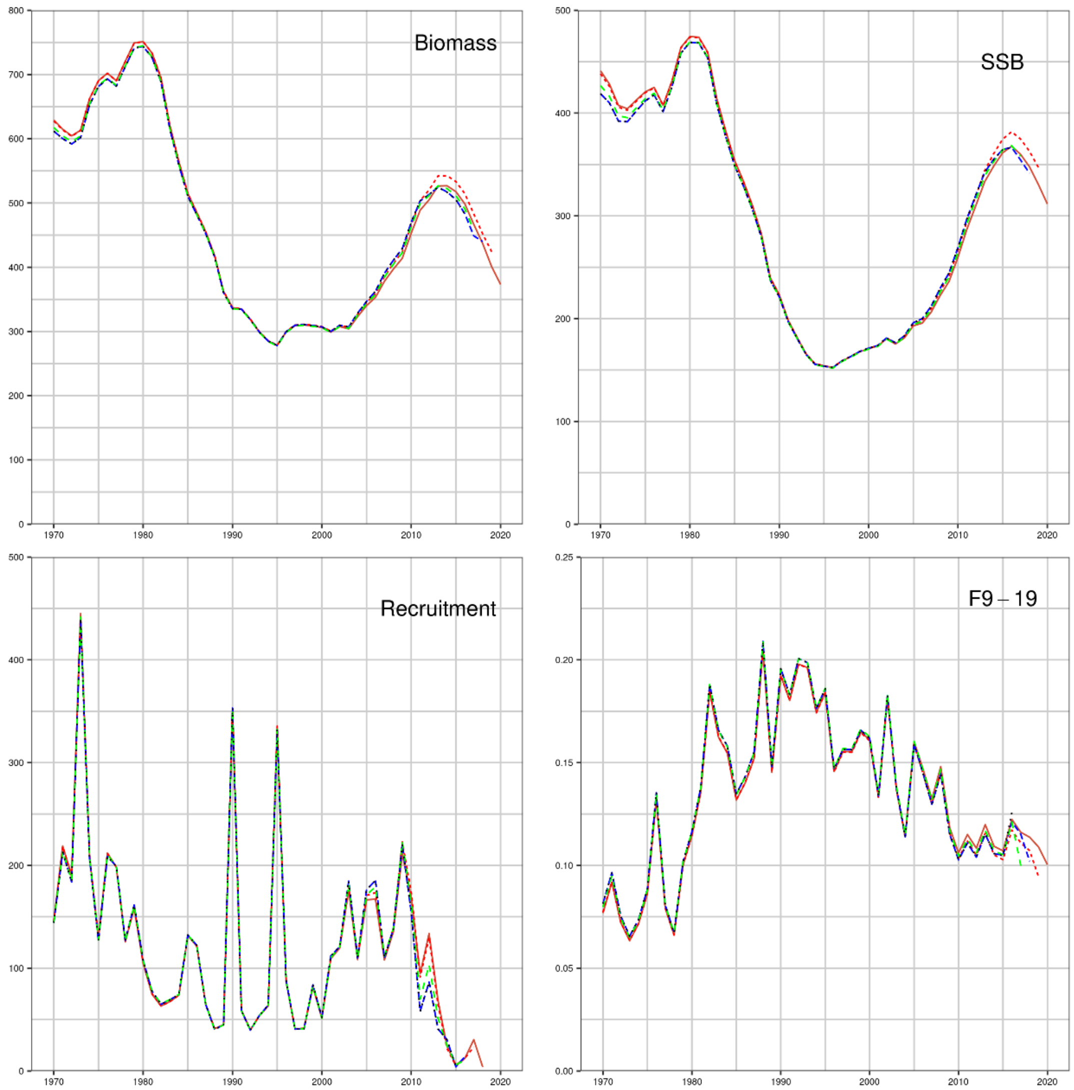

Figure 19. Golden redfish. Analytical retrospective pattern of the base run. Recruitment is at age 5 and F shows the development of ages 9–19.

Mynd 19. Gullkarfi. Endurlitsgreining sem sýnir stöðuleika í mati líkansins fimm ár aftur í tímann. Niðurstöður eru sýndar fyrir heildarlífmassa, hrygningarstofn, nýliðun (5 ára) og fiskveiðidánartölu, F, 9-19 ára.

DIAGNOSTICS

Observed and predicted proportion by fleet: Trends in different likelihood components (Figure 20) shows well how the fit to survey length distributions has deteriorated in recent years. This can also be seen in Figure 21 where overall fit to the predicted proportional length distributions in the survey is smaller to the observed for medium sized fish (30-40 cm fish).

Length distributions from the Icelandic commercial catch does usually show good fit except in the most recent period when the large fish is missing and the length distribution narrower (Figure 22).

The fit between predicted and observed age distributions is better than for the length distributions (Figures 23 and 24). The model uses the data as age-length keys in 2 cm intervals for tuning.

Model fit: An aggregated fit to the survey index (converted to biomass) is presented in Figure 25. It shows a greater level of agreement than most runs based only on the Icelandic data but does mostly show negative residuals for the last 15 years. Residuals by length group show positive residuals in size groups 33–38 cm in recent years but negative for most other size groups, especially for fish smaller than 30 cm, indicating narrower length distributions in the survey than predicted (Figure 26).

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

In Figure 27 the length disaggregated indices are plotted against the predicted numbers in the stock as a time-series. 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 26). For 35–42 cm fish, the observed indices have been above predictions for 5-11 years. The indices for 41–50 cm fish do not show such temporal pattern although in recent three years the observed indices have been below prediction. The correlation between observed and predicted is good for 19-34 cm fish. When looking at the temporal patterns, longevity of the fish must be considered.

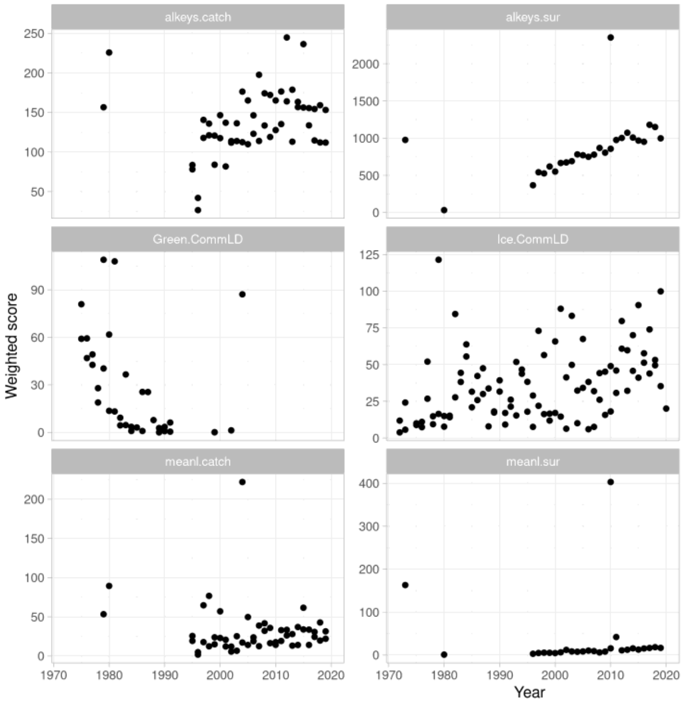

Figure 20. Golden redfish. Development of components of the objective function with time.

Mynd 20. Gullkarfi. Þróun nokkurra hluta viðfangsfalls eftir tíma.

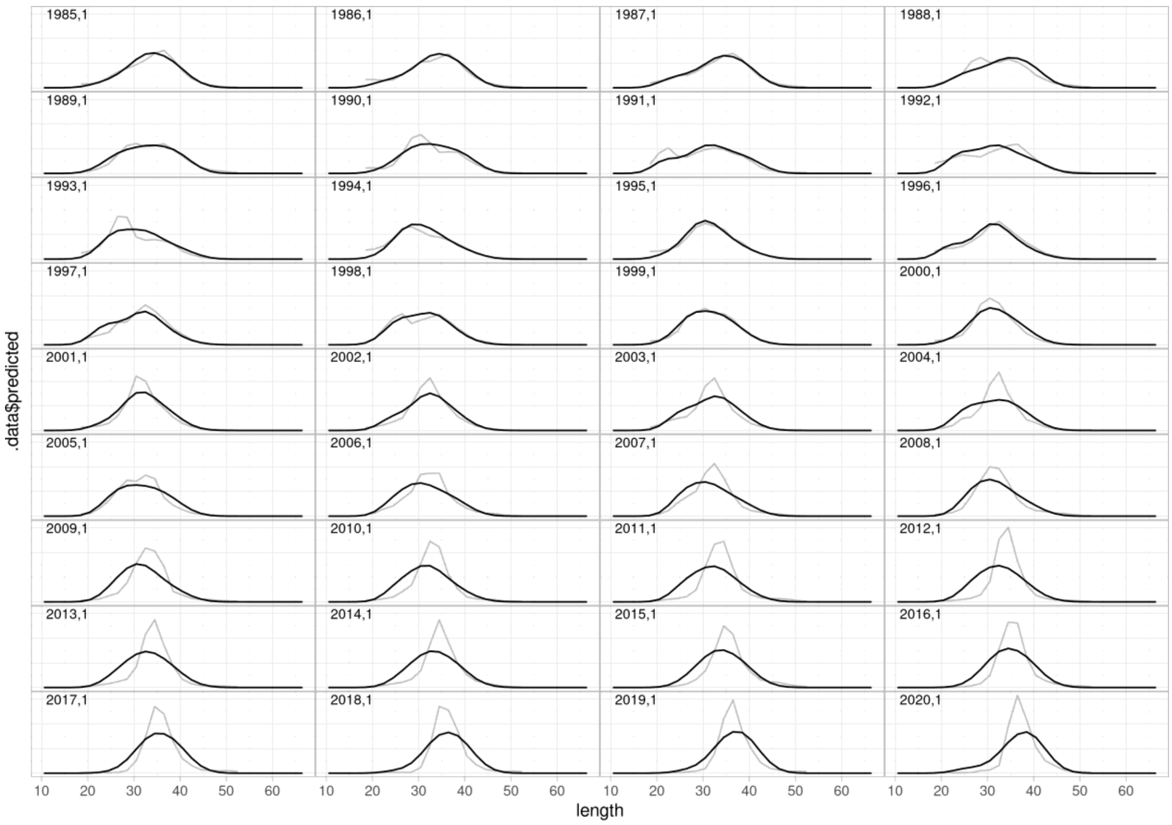

Figure 21. Golden redfish. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines).

Mynd 21. Gullkarfi. Hlutfall eftir lengd úr Gadget líkani (svartar línur) samanborið við hlutföll í vorralli (gráar línur).

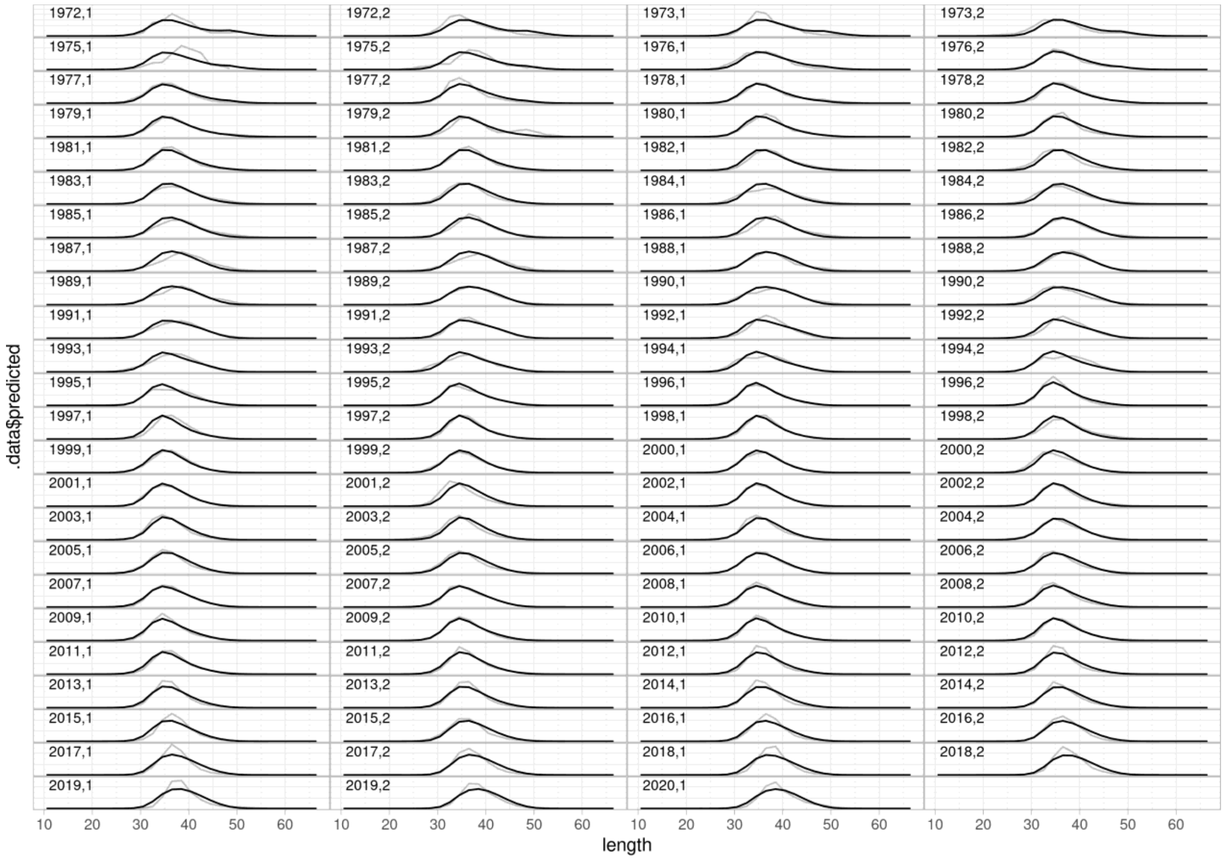

Figure 22. Golden redfish. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

Mynd 22. Gullkarfi. Hlutfall eftir lengd úr Gadget líkani (svartar línur) samanborið við hlutföll úr afla við Ísland (gráar línur).

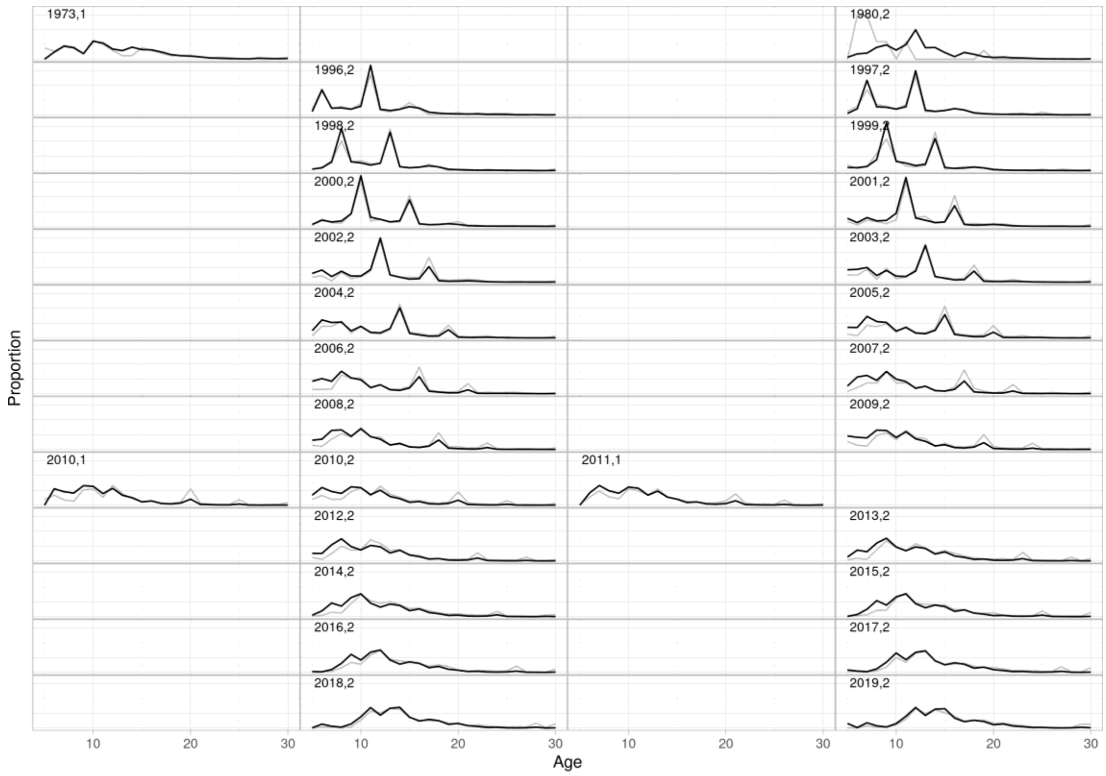

Figure 23. Golden redfish. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in bottom trawl surveys survey (grey lines).

Mynd 23. Gullkarfi. Hlutfall eftir aldri úr Gadget líkani (svartar línur) samanborið við hlutföll úr stofnmælingaleiðögrum (gráar línur).

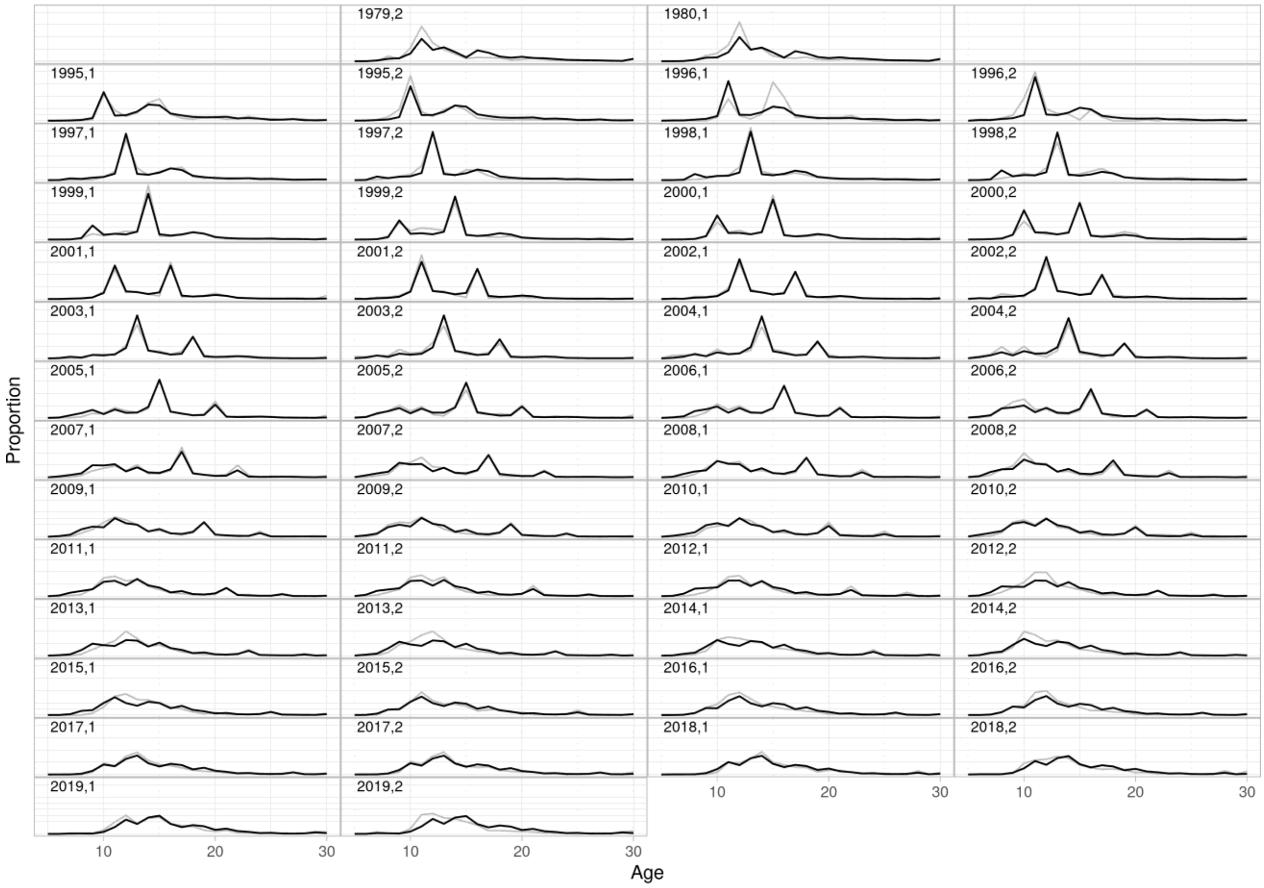

Figure 24. Golden redfish. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

Mynd 24. Gullkarfi. Hlutfall eftir aldri úr Gadget líkani (svartar línur) samanborið við hlutföll úr afli við Ísland (gráar línur).

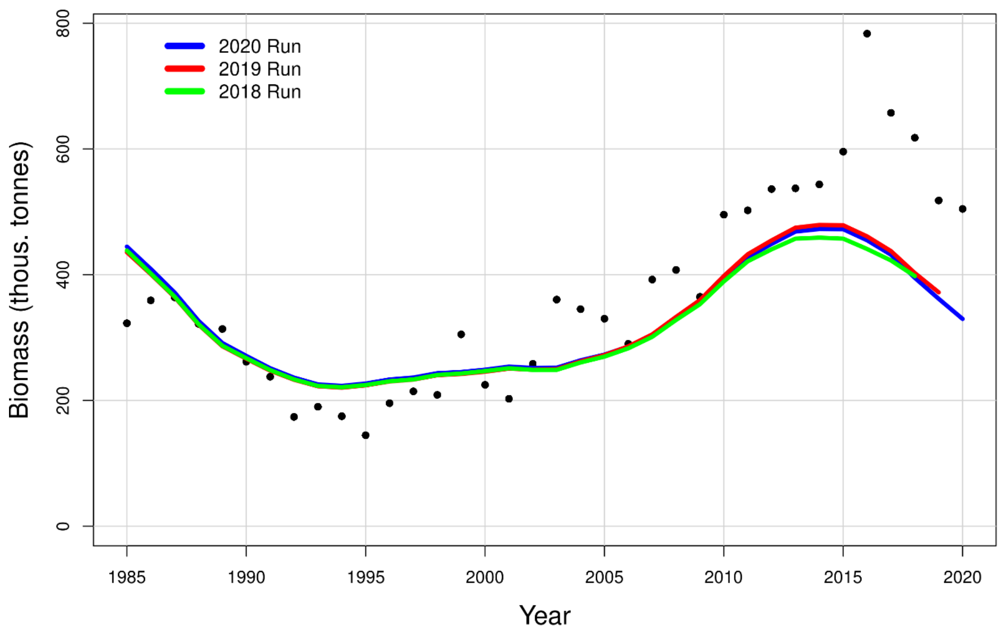

Figure 25. Golden redfish. Comparison of observed and predicted spring survey biomass from the 2020 (blue line), 2019 (red line) and 2018 (green line) assessment runs.

Mynd 25. Gullkarfi. Lífmassavísitala úr Gadget líkani fyrir árið 2020 (blá lína), 2019 (rauð lína) og 2018 (græn lína) borin saman við heildarlífmassa gullkarfa í vorralli (punktar).

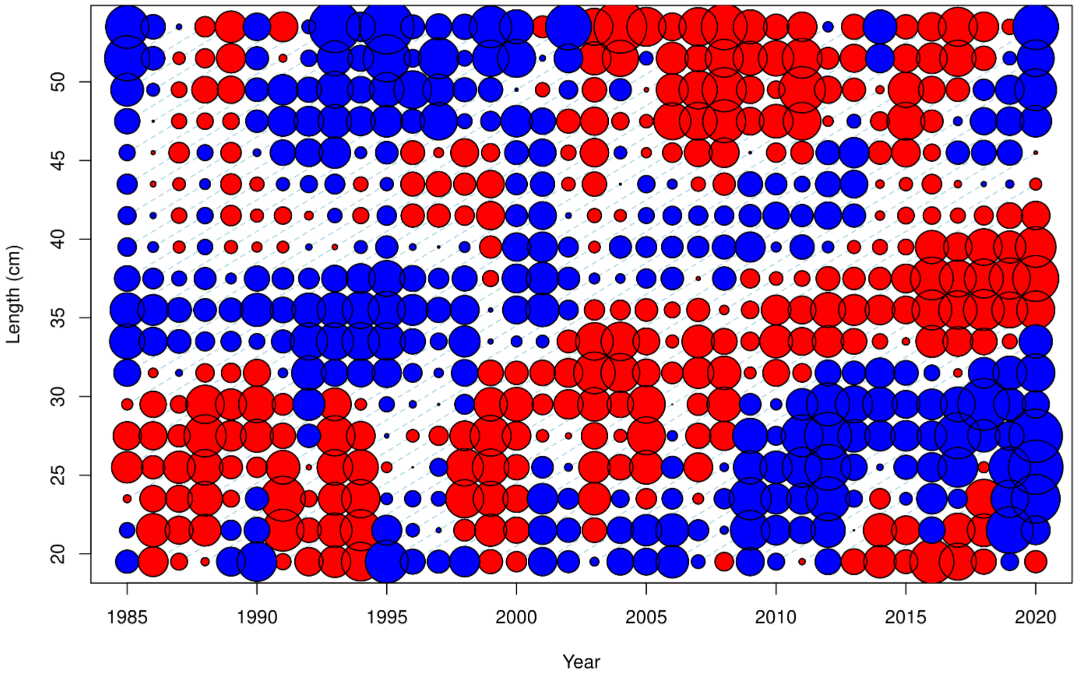

Figure 26. Golden redfish. Residuals from the fit between model and spring survey indices. The red circles indicate positive residuals (survey results exceed model prediction).

Mynd 28. Gullkarfi. Leifar líkans og vísitölum úr SMB eftir lengdarflokkum. Rauðir hringir tákna jákvæð aðhvarfsfrávik (niðurstöður stofnmælingar eru stærri en spágildi).

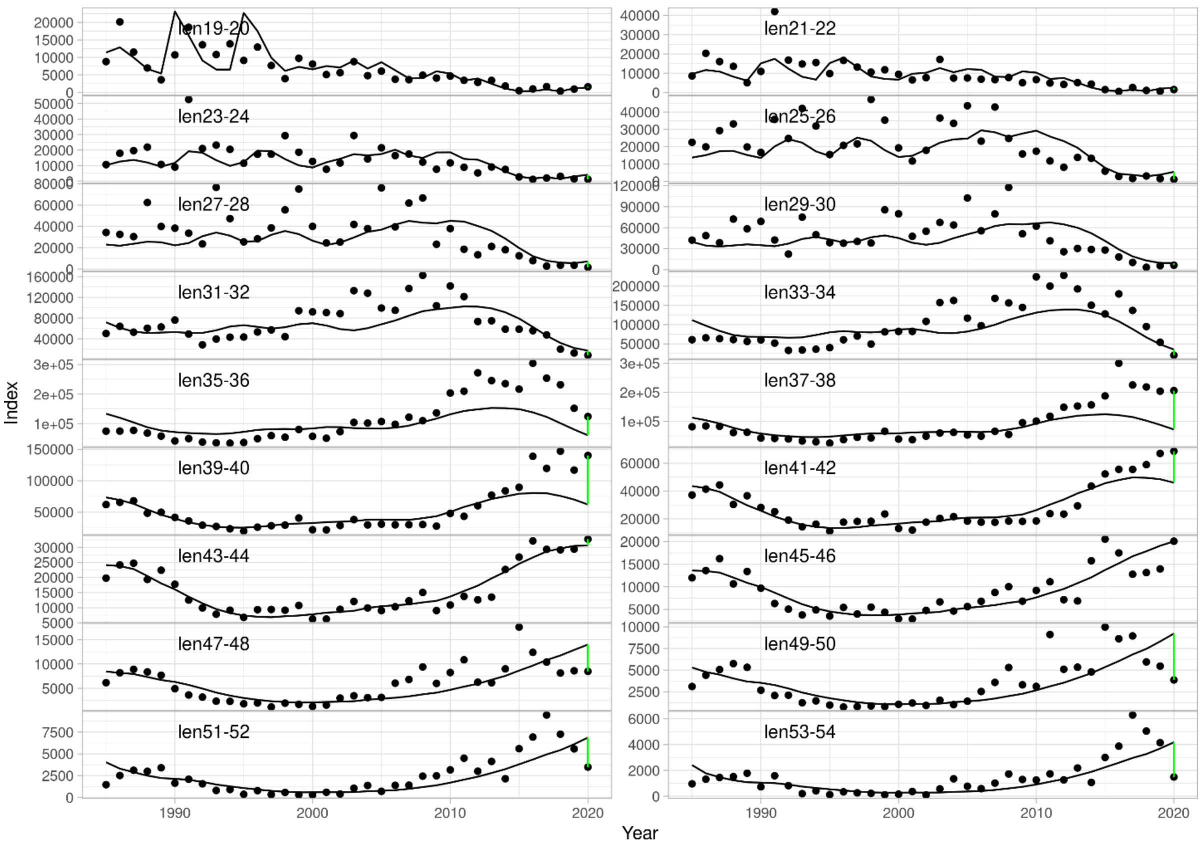

Figure 27. Golden redfish. Gadget fit to disaggregated abundance indices by length from the spring survey.

Mynd 27. Gullkarfi. Lífmassavísitala úr Gadget líkani (svartar línur) eftir stærðarflokkum borin saman við fjölda gullkarfa í vorralli (punktar). Grænar línur sýna muninn á samsvörun gagna og líkans við lok tímabilsins.

ADVICE

The management plan is based on F_{9-19} = 0.097 reducing linearly if the spawning stock is estimated below 220 000 t ($B_{trigger}$). B_{lim} was proposed as 160 000 t, lowest SSB in the 2012 run. The 2019 SSB was estimated at 299 300 t.

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, 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, $F_{9-19,MAX}$ changed from 0.097 to 0.114. The proposed fishing mortality of 0.097 is therefore around 85% of FMAX 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.

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

The plot of the average spawning stock against fishing mortality shows that F_{lim} = 0.226 and F_{pa} is then 0.226/exp(1.645*0.2) = 0.163 (Figure 28). The spawning stock decreased considerably from early 1980s to mid-1990s or from 400 000 t to 200 000 t. The reduction in SSB was due to heavy fisheries but SSB increased again gradually because of improved recruitment and lower F.

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 29 shows the development of F_{9-19} based on F_{9-19} = 0.097. F is expected to be within the range of the 5^{th} and 95^{th} quantile and the 16^{th} and 84^{th} quantile.

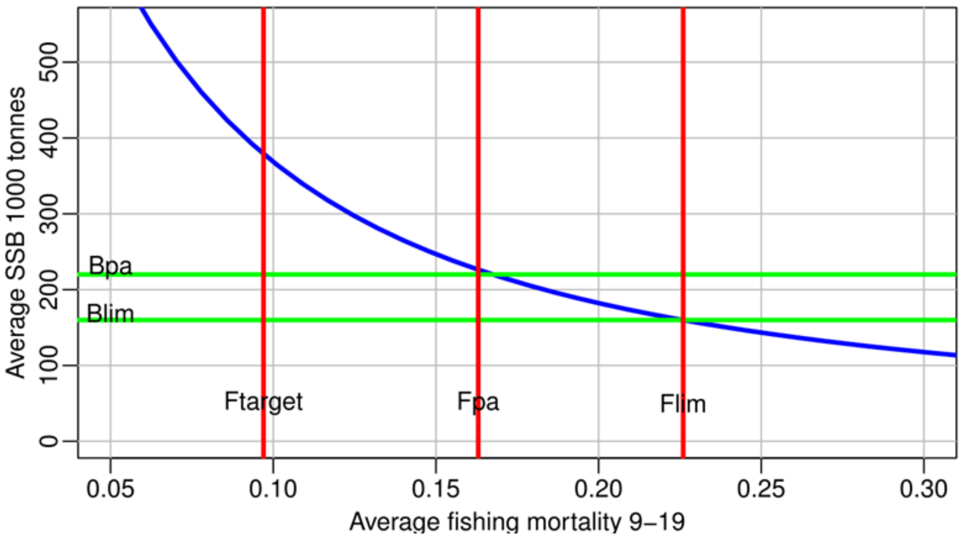

Figure 28. Golden redfish. Average SSB against average fishing mortality and defined reference points.

Mynd 28. Gullkarfi. Meðalstærð hrygningarstofns og skilgreind gátmörk.

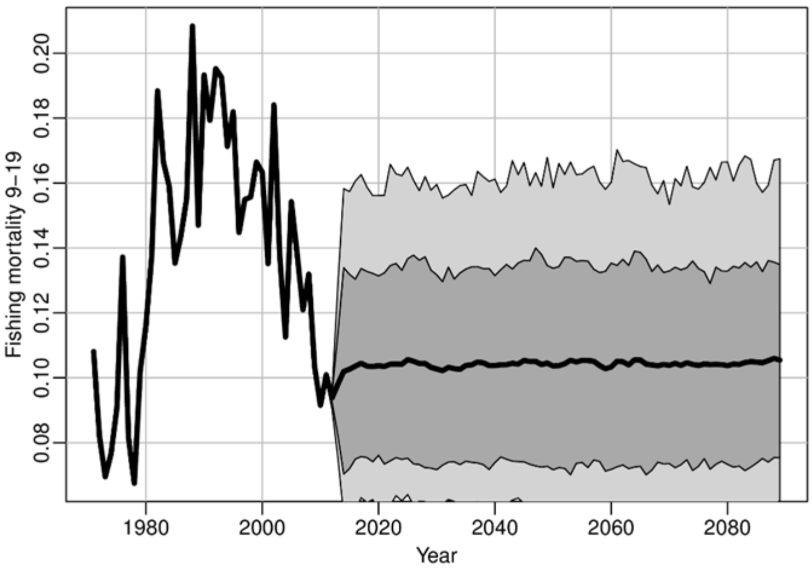

Figure 29. Golden redfish. Development of F_{9-19} based on $F_{9\text{-}19}$ = 0.097. The light grey area shows 5th and 95th quantiles and the dark areas 16th and 84th quantiles.

Mynd 29. Gullkarfi. Þróun F_{9-19} byggt á $F_{9\text{-}19}$ = 0.097. Ljósgráa svæðið sýnir 5tu og 95tu brotmörk og dökkráu svæðið sýnir 16u og 84u brotmörk.

STATUS OF THE STOCK

The results from Gadget indicate that fishing mortality has been low since 2009 but above F_{MSY} (Figure 16). Total biomass and SSB have been decreasing since 2016 (Table 5) and the absence of any indications of incoming cohorts raises concerns about the future productivity of the stock.

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

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 the five smallest year classes in 1980–2007.

The results from the short-term simulations based on $_{F9–19}$ is shown in and from short term prognosis with varying fishing mortality in 2021 and 2022 in Table 6.

MEDIUM TERM FORECAST

No medium-term forecast was carried out.

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.

BASIS FOR ADVICE

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

MANAGEMENT CONSIDERATION

In 2009 a fishery targeting redfish was initiated in Subarea 14 with annual catches of between 6000 and 8500 t in 2010–2019, highest in 2015 and lowest in 2018. The fishery does not distinguish between species, but based on survey information, golden redfish is estimated to be between 1000 and 2700 in 2010–2015 but increased to 3000–5400 t in 2016–2019, lowest in 2019.

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

No formal agreement on the management of *S. norvegicus* exists among the three coastal states, Greenland, Iceland, and the Faroe Islands. However, an agreement was made between Iceland and Greenland in October 2015 on the management of the golden redfish fishery based on the management plan applied in 2014. The agreement was from 2016 to the end of 2018. The agreement states that each year 90% of the TAC is allocated to Iceland and 10% is allocated to Greenland. Furthermore, 350 t are allocated each year to other areas. The plan has not been renewed so no management plan is effective although Iceland and Greenland still follow this plan.

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

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

ECOSYSTEM CONSIDERATION

Not evaluated for this stock.

REGULATIONS AND THEIR EFFECTS

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

In the late 1980s, Iceland introduced a sorting grid with a bar spacing of 22 mm in the shrimp fishery to reduce the bycatch of fish juveniles in the shrimp fishery north of Iceland. This was partly done to avoid redfish juveniles as a bycatch in the fishery, but also juveniles of other species. Since the large year classes of golden redfish disappeared out of the shrimp fishing area in the early 1990s, observers report small redfish as being negligible in the Icelandic shrimp fishery. Whether the sorting grids work where the abundance of redfish is high is not known, 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 permanently 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 re-duce bycatches of juvenile redfish in the shrimp fishery.

CHANGES IN FISHING TECHNOLOGY AND FISHING PATTERNS

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

BENCHMARK IN 2022

Benchmark meeting for golden redfish, scheduled in 2020 was delayed because of lack of resources within the ICES system in 2020. The group proposes that the stock should be benchmarked in 2022.

The proposed benchmark meeting will explore several issues of current assessment model. These include poor fit to survey indices for fish between 30–40 cm; potential dome-shape in selectivity; uncertainty estimates are not available; investigate the appropriateness of the current growth and maturity model used in the assessment. In addition, the meeting will explore alternative assessment methods. Under-utilized data sources from ICES 5.b and 14.b, mainly to include more 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.

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.

TABLES

Table 1. Survey indices and CV of golden redfish from the spring survey 1985–2020 and the autumn survey 1996–2019.

Tafla 1. Gullkarfi. Stofnvísitölur og CV úr SMB 1985-2020 og SMH 1996-2019.

	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	401,140	0.279
2017	507,058	0.205	428,351	0.187
2018	497,092	0.210	342,467	0.195
2019	410,550	0.158	383,532	0.233
2020	411,320	0.206		

Table 2. Golden redfish in 5.a. Age disaggregated indices (in millions) from the autumn groundfish survey 1996–2019. The survey was not conducted in 2011.

Tafla 2. Gullkarfi. Aldursskiptar vísitölur úr SMH 1996-2019.

YEAR/AGE	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.3	1.0	3.6	3.3	0.8	0.4	0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.1	0
2	2.4	0.2	1.5	3.3	1.7	1.0	0.9	0.5	0.2	0.1	0.6	1.2	0.3	0.3	0.0		0.0	0.0	0.2	0.1	0.0	0.3	0.2	0.1
3	0.7	2.2	0.9	3.3	1.4	1.9	1.5	1.1	1.0	0.2	0.7	1.2	2.5	0.4	1.7		0.1	0.0	0.3	0.6	0.0	0.3	0.4	0.4
4	1.6	1.6	2.3	1.5	1.6	2.4	6.1	1.1	1.8	1.0	0.5	1.1	2.7	4.4	0.3		1.4	0.2	0.1	0.3	1.8	0.2	0.1	0.8
5	8.3	2.2	0.9	4.7	1.2	5.4	5.8	12.3	3.3	4.2	5.0	2.1	4.1	12.0	4.3		4.1	1.0	0.8	0.1	0.3	1.6	0.2	1.5
6	40.0	6.9	3.5	2.8	7.9	2.1	11.8	17.7	28.6	4.8	6.8	10.4	7.9	11.6	14.2		3.1	4.1	1.8	1.2	0.8	1.3	3.0	0.9
7	11.3	22.5	16.6	10.5	6.7	10.8	3.3	38.2	36.7	39.7	15.6	26.0	39.2	13.9	15.1		23.5	3.0	12.8	7.6	3.9	1.6	2.5	15.3
8	19.1	14.3	58.2	47.2	6.4	10.9	26.9	9.9	65.4	44.9	81.9	35.8	75.1	73.9	23.4		70.3	41.8	24.6	28.3	29.1	10.4	2.0	7.8
9	15.1	13.0	22.4	99.9	26.2	7.1	11.2	48.5	21.0	62.7	81.5	76.6	67.9	96.4	54.4		60.6	84.8	96.9	33.1	63.8	38.1	5.9	7.4
10	28.9	11.1	26.1	43.7	95.0	17.3	16.6	12.7	45.6	24.9	85.7	37.4	106.4	58.7	69.0		62.9	56.3	151.8	86.4	48.1	93.8	36.7	20.3
11	102.7	17.6	18.9	20.7	11.5	111.2	32.0	17.0	19.3	44.2	26.3	36.1	63.2	100.9	32.5		103.8	41.3	90.8	100.7	87.5	56.9	72.1	46.8
12	16.2	67.8	19.1	16.8	14.2	23.6	116.3	39.7	13.4	19.6	37.5	19.0	55.1	45.9	57.4		74.2	68.6	69.7	52.9	97.2	95.7	58.4	91.5
13	10.1	6.2	104.5	20.8	7.9	23.6	20.0	111.3	26.6	15.4	18.0	23.8	13.5	42.9	28.6		43.3	47.5	67.5	47.6	54.3	87.8	65.7	58.7
14	16.8	5.3	10.1	147.1	8.0	7.9	11.5	12.4	103.9	26.8	15.1	8.2	18.2	10.2	19.6		39.1	26.5	50.4	41.7	45.3	41.9	54.9	62.7
15	33.9	7.2	7.6	6.0	51.4	9.2	9.8	10.8	13.6	82.1	18.3	6.8	9.1	18.3	9.1		19.6	31.7	27.0	40.3	35.8	27.4	27.3	45.4
16	16.1	10.0	7.8	9.6	5.3	58.9	10.4	6.1	9.6	9.5	75.4	16.9	7.8	6.9	10.9		16.7	18.7	26.6	21.1	31.9	28.8	20.2	36.1
17	1.9	6.9	14.1	10.9	2.5	4.3	45.4	7.5	6.0	6.7	8.7	49.4	13.1	6.4	4.7		6.1	12.8	17.1	20.0	20.3	35.6	21.9	18.7
18	1.7	3.9	7.6	11.1	2.5	5.0	4.6	32.7	6.1	3.7	4.3	10.4	36.6	7.4	3.1		5.9	7.2	12.3	10.0	22.1	17.8	21.1	21.7
19	4.3	2.0	0.5	8.4	4.6	3.6	3.0	4.5	21.6	5.0	2.8	4.5	6.2	28.4	6.6		3.9	5.2	6.0	10.0	16.1	14.7	12.9	22.1
20	6.6	1.4	3.2	3.9	6.5	4.1	3.2	1.6	3.1	22.0	3.1	1.5	5.7	4.7	22.2		3.9	4.5	5.9	9.9	8.9	16.8	11.3	13.7
21	1.1	0.8	2.3	2.8	1.0	3.7	3.9	1.1	1.8	2.5	17.8	4.0	2.1	2.1	3.1		3.5	4.8	4.8	3.3	3.0	11.5	6.0	14.7
22	5.0	1.5	0.8	1.0	1.6	2.3	3.2	2.7	1.7	2.1	2.0	13.8	2.3	1.3	1.2		18.3	2.4	3.6	2.5	3.9	4.8	10.3	12.3
23	3.9	2.4	2.2	2.1	0.4	0.3	0.8	1.1	2.5	2.4	1.7	1.3	11.0	2.0	1.6		2.9	18.2	3.4	2.1	3.7	6.1	6.9	7.2
24	4.6	0.8	0.4	0.6	1.0	0.5	0.4	0.3	0.0	0.9	1.0	1.3	1.4	10.2	0.7		2.0	2.6	12.7	1.1	2.8	4.8	2.8	3.7
25	3.9	2.7	1.4	2.8	0.8	0.3	0.5	0.3	1.2	1.2	1.7	0.2	0.8	0.8	5.7		1.2	1.2	1.5	13.1	3.4	2.9	2.6	1.3
26	0.9	1.1	0.2	1.2	0.7	0.5	0.6	0.2	0.4	0.3	0.9	0.6	0.9	1.0	0.6		1.7	1.1	0.9	1.5	15.0	2.6	2.9	2.0
27	0.9	0.2	0.9	2.9	0.5	0.8	0.3	0.3	0.0	0.1	0.9	0.3	1.2	1.3	0.4		7.5	0.8	0.9	1.4	1.0	13.9	2.6	1.3
28	0.8	0.4	0.5	1.5	0.7	0.5	0.2	0.0	0.2	0.2	0.2	0.0	0.6	0.2	0.7		0.4	8.7	0.5	1.6	1.0	1.7	11.5	1.7
29	0.1	0.0	0.5	1.2	0.5	0.2	0.7	0.1	0.2	0.0	0.4	0.4	0.8	1.6	0.4		0.4	0.5	3.3	1.0	0.9	1.8	1.5	10.4
30+	0.8	1.4	3.0	1.1	1.3	2.3	1.7	1.5	1.6	2.1	1.0	0.9	1.5	1.7	2.0		2.1	3.5	2.6	6.9	6.7	7.9	7.5	5.3
TOTAL	360.0	214.6	341.6	492.7	271.8	322.1	352.7	393.2	436.4	429.4	515.6	391.3	557.2	565.9	393.5		582.5	499.2	696.9	546.3	608.9	629.0	472.0	531.8

Table 3. Official landings (in tonnes) of golden redfish, by area, 1978–2019 as officially reported to ICES.

Tafla 3. Gullkarfi. Landaður afli (í tonnum) við Ísland (ICES 5.A), Færeyjar (ICES 5.B) og Austur Grænland (ICES 14) ásamt afla á ICES svæði 6..

YEAR	AREA				TOTAL
	ICES 5.A	ICES 5.B	ICES 6	ICES 14	
1978	31 300	2 039	313	15 477	49 129
1979	56 616	4 805	6	15 787	77 214
1980	62 052	4 920	2	22 203	89 177
1981	75 828	2 538	3	23 608	101 977
1982	97 899	1 810	28	30 692	130 429
1983	87 412	3 394	60	15 636	106 502
1984	84 766	6 228	86	5 040	96 120
1985	67 312	9 194	245	2 117	78 868
1986	67 772	6 300	288	2 988	77 348
1987	69 212	6 143	576	1 196	77 127
1988	80 472	5 020	533	3 964	89 989
1989	51 852	4 140	373	685	57 050
1990	63 156	2 407	382	687	66 632
1991	49 677	2 140	292	4 255	56 364
1992	51 464	3 460	40	746	55 710
1993	45 890	2 621	101	1 738	50 350
1994	38 669	2 274	129	1 443	42 515
1995	41 516	2 581	606	62	44 765
1996	33 558	2 316	664	59	36 597
1997	36 342	2 839	542	37	39 761
1998	36 771	2 565	379	109	39 825
1999	39 824	1 436	773	7	42 040
2000	41 187	1 498	776	89	43 550
2001	35 067	1 631	535	93	37 326
2002	48 570	1 941	392	189	51 092
2003	36 577	1 459	968	215	39 220
2004	31 686	1 139	519	107	33 451
2005	42 593	2 484	137	115	45 329
2006	41 521	656	0	34	42 211
2007	38 364	689	0	83	39 134
2008	45 538	569	64	80	46 251
2009	38 442	462	50	224	39 177
2010	36 155	620	220	1 653	38 648
2011	43 773	493	83	1 005	45 354
2012	43 089	491	41	2 017	45 635
2013	51 330	372	92	1 499	53 263
2014	47 769	201	60	2 706	50 736
2015	48 769	270	44	2 562	51 645
2016	54 041	165	50	5 442	59 698
2017	50 119	1 397	93	4 501	56 101
2018	48 014	1 330	80	4 004	53 428
2019[1)]	44 746	1 053	101	2 665	48 464

1) Provisional

Table 4. Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995–2019.

Tafla 4. Gullkarfi. Aldurskitpur afli (tonn) á Íslandsmiðum 1995-2019.

YEAR/AGE	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
7	47	0	32	23	6	38	117	125	189	216	219	175	126	205	101	58	136	69	30	221
8	327	354	219	277	339	62	134	871	199	822	737	995	418	1,019	912	348	546	609	549	448
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
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
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
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
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
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
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
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
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
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
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
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
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
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
23	1,574	814	673	424	331	270	411	723	754	618	795	229	753	4,217	348	572	773	474	3,346	504
24	709	0	584	660	216	63	164	372	392	567	619	377	113	392	2,601	670	208	340	234	3,310
25	824	0	734	520	848	392	123	288	300	258	420	472	627	260	100	2,168	143	224	20,	188
26	407	0	275	399	270	337	114	180	74	105	100	73	341	443	97	284	1,406	236	173	203
27	384	0	139	427	615	198	275	80	83	183	279	263	353	343	201	398	79	1,443	110	143
28	808	0	202	357	229	516	189	296	27	141	169	204	205	172	96	132	205	198	937	58
29	0	0	143	53	106	364	146	498	105	138	29	168	37	178	390	187	45	71	38	692
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
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

Table 4. Golden redfish in 5.a. Continued.

Tafla 4. Gullkarfi. Frh.

YEAR/AGE	2015	2016	2017	2018	2019
7	14	47	0	0	210
8	575	723	103	49	142
9	914	2,661	946	210	63
10	3,169	3,668	4,490	2,270	1,215
11	7,128	7,854	3,514	4,689	4,633
12	7,077	9,353	7,063	4,847	6,128
13	5,517	6,657	8,743	6,449	4,003
14	5,628	4,672	5,363	7,620	5,687
15	4,735	4,080	3,785	4,277	5,112
16	2,986	2,663	3,573	3,305	3,992
17	2,685	2,787	3,010	2,737	2,630
18	1,848	2,075	1,865	2,583	2,303
19	775	1,792	1,411	1,310	1,375
20	1,267	668	1,186	1,337	1,520
21	284	560	1,060	1,238	1,148
22	274	365	438	718	511
23	211	230	489	599	584
24	424	251	313	283	161
25	1,829	315	325	343	56
26	243	1,433	148	170	184
27	213	182	1,266	36	352
28	187	30	87	1,730	104
29	87	26	192	26	1,238
30+	700	941	756	1,189	1,398
TOTAL	48,770	54,043	50,117	48,015	44,749

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

Tafla 5. Gullkarfi. Niðurstöður stofnmats 2020. Taflan sýnir heildarlífmassa, lífmassa hrygningarstofns, nýliðun (5 ára), heildarafla og veiðidánartölu. Framreikningar eru skáletraðar. Allar þyngdartölur eru í tonnum.

YEAR	BIOMASS	SSB	R(AGE5)	CATCHES	F9-19
1971	616 898	406 553	218.9	67 880	0.092
1972	615 462	394 172	190.3	50 890	0.073
1973	653 758	395 169	445	43 719	0.064
1974	684 178	403 262	209.4	50 598	0.072
1975	701 150	408 546	129.4	61 920	0.086
1976	704 766	401 493	212	94 420	0.133
1977	713 626	404 083	198.2	53 753	0.079
1978	740 311	431468	125.7	48 736	0.066
1979	757 188	452 919	158.2	77 212	0.100
1980	747 291	458 335	104.7	89 143	0.114
1981	718 069	451 678	74.6	101 966	0.136
1982	661 202	423 483	63.2	130 322	0.185
1983	596 006	386 697	67.5	106 050	0.163
1984	543 517	357 778	73.7	95 288	0.155
1985	506 176	334052	131.6	78 531	0.132
1986	475 838	313 003	121.5	76 908	0.140
1987	439 922	288 257	64.9	76 559	0.152
1988	392 501	253 986	41.2	89 804	0.205
1989	351 972	224 740	44.8	56 645	0.145
1990	350 557	204 411	352.7	66 314	0.192
1991	329 588	183 673	58.9	56 015	0.180
1992	311 096	167 354	39.9	55 826	0.198
1993	294 921	154 416	53.5	50 179	0.196
1994	284 727	148 451	63.4	42 520	0.174
1995	302 360	146 627	333.8	44 263	0.184
1996	307 851	148 694	86.8	35 595	0.145
1997	307 687	150 645	40.6	38 996	0.155
1998	309 570	156 488	41.3	39 694	0.155
1999	306 724	158 441	81.6	42 463	0.165
2000	301 702	162 123	51.1	42 607	0.161
2001	307 095	166 980	109.2	36 744	0.133
2002	308 950	167 168	119.6	50 730	0.182
2003	321 335	168 373	175.6	38 219	0.138
2004	337 112	178 183	108.4	32 766	0.114
2005	354 561	184 074	166.5	46 619	0.160
2006	376 199	190 673	167.2	42 108	0.147
2007	390 773	200 949	108	39 154	0.132
2008	414 707	218 427	135.3	46 195	0.148
2009	446 058	234 681	211	39 301	0.118
2010	483 606	261 787	169.2	38 504	0.106
2011	507 679	289 267	94.6	45 146	0.115
2012	525 228	308 918	133.7	45 423	0.108
2013	533 968	330 333	68.5	53 223	0.120
2014	523 196	342 322	24.1	50 697	0.109
2015	508 885	353 757	6	51 621	0.107
2016	482 382	353 091	12.2	59 697	0.122
2017	457 732	348 639	30.5	56 334	0.116
2018	419 145	332 059	3.9	53 368	0.114
2019	391 085	315 915	41.7	48 484	0.109
2020	364 314	297 105	*41.7*	*42 026*	*0.101*
2021	*342 818*	*280 100*	*41.7*	*38 343*	*0.097*
2022	*323 071*	*262 557*	*41.7*	*35 667*	*0.097*
2023	*305 468*	*245 670*	*41.7*	*33 100*	*0.097*
2024	*290 075*	*230 158*	*41.7*	*30 785*	*0.097*

Table 6. Golden redfish. Output from short term prognosis. Multiplier is based on reference to the adopted HCR F_{9-19} = 0.097. All weights are in tonnes.

Tafla 6. Gullkarfi. Niðurstöður skammtíma horfum þróun heildarlífmassa, lífmassa hrygningarstofns og afla miðað við mismunandi veiðidánartölu. Allar þyngdir eru í tonnum.

F(2019) = **0.109** C(2019) = **48 484 t**

2020				
BIO 5+	SSB	F_{MULT}	F9-19	LANDINGS
364 314	297 105	1.032	0.1	42 026

		2021			2022	
F_{MULT}	**F_{9-19}**	**BIO 5+**	**SSB**	**LANDINGS**	**BIO 5+**	**SSB**
0.0	0	382 900	316 366	0	400 794	333 959
0.1	0.01	378 779	312 636	4 167	392 359	326 202
0.2	0.019	374 684	308 930	8 259	384 076	318 587
0.3	0.029	370 613	305 246	12 276	375 944	311 112
0.4	0.039	366 568	301 585	16 218	367 960	303 775
0.5	0.049	362 547	297 947	20 088	360 122	296 574
0.6	0.059	358 552	294 332	23 883	352 430	289 508
0.7	0.069	354 581	290 739	27 606	344 880	282 575
0.8	0.079	350 635	287 170	31 257	337 472	275 773
0.9	0.089	346 714	283 623	34 836	330 203	269 101
1.0	0.099	342 818	280 100	38 343	323 071	262 557
1.1	0.109	338 947	276 599	41 779	316 076	256 139
1.2	0.119	335 101	273 121	45 145	309 214	249 846
1.3	0.129	331 280	269 666	48 441	302 485	243 675
1.4	0.140	327 484	266 234	51 667	295 886	237 626
1.5	0.150	323 713	262 824	54 824	289 416	231 696
1.6	0.160	319 967	259 438	57 913	283 073	225 885
1.7	0.171	316 245	256 074	60 933	276 856	220 190
1.8	0.181	312 549	252 734	63 886	270 762	214 610
1.9	0.191	308 878	249 416	66 771	264 790	209 144
2.0	0.202	305 231	246 121	69 590	258 938	203 789