GREENLAND HALIBUT

Reinhardtius hippoglossoides

GENERAL INFORMATION

Greenland halibut in ICES Subareas 5, 6 12 and 14 (East-Greenland, Iceland, Faroe-islands) are assessed as one stock. In Icelandic waters, it is found on the continental shelf around Iceland with the highest abundance west, north and east off the coast in deeper and colder waters. It is mainly found on a muddy substrate at depths ranging from 200-1500 m. The main spawning grounds are located west off the coast at around 1000 m depth and eggs and larvae drift between Iceland and the east coast of Greenland until juveniles seek bottom post metamorphosis. After spawning, Greenland halibut migrates further north and east to their main feeding grounds. No juvenile grounds are known within the assessment area, and migration is known to occur from adjacent management units.

FISHERY

Spatial distribution of the 2021 fishery and historic catch and effort in the trawl fishery in Subareas 5, 6, 12 and 14 is provided in Figures 1 and 2. Fishery in the entire area did in the past occur in a seemingly continuous belt on the continental slope from the slope of the Faroe plateau to southeast of Iceland extending north and west of Iceland and further south to southeast Greenland. Fishing depth ranges from 350-500 m southeast, east and north of Iceland to about 1500 m at East Greenland.

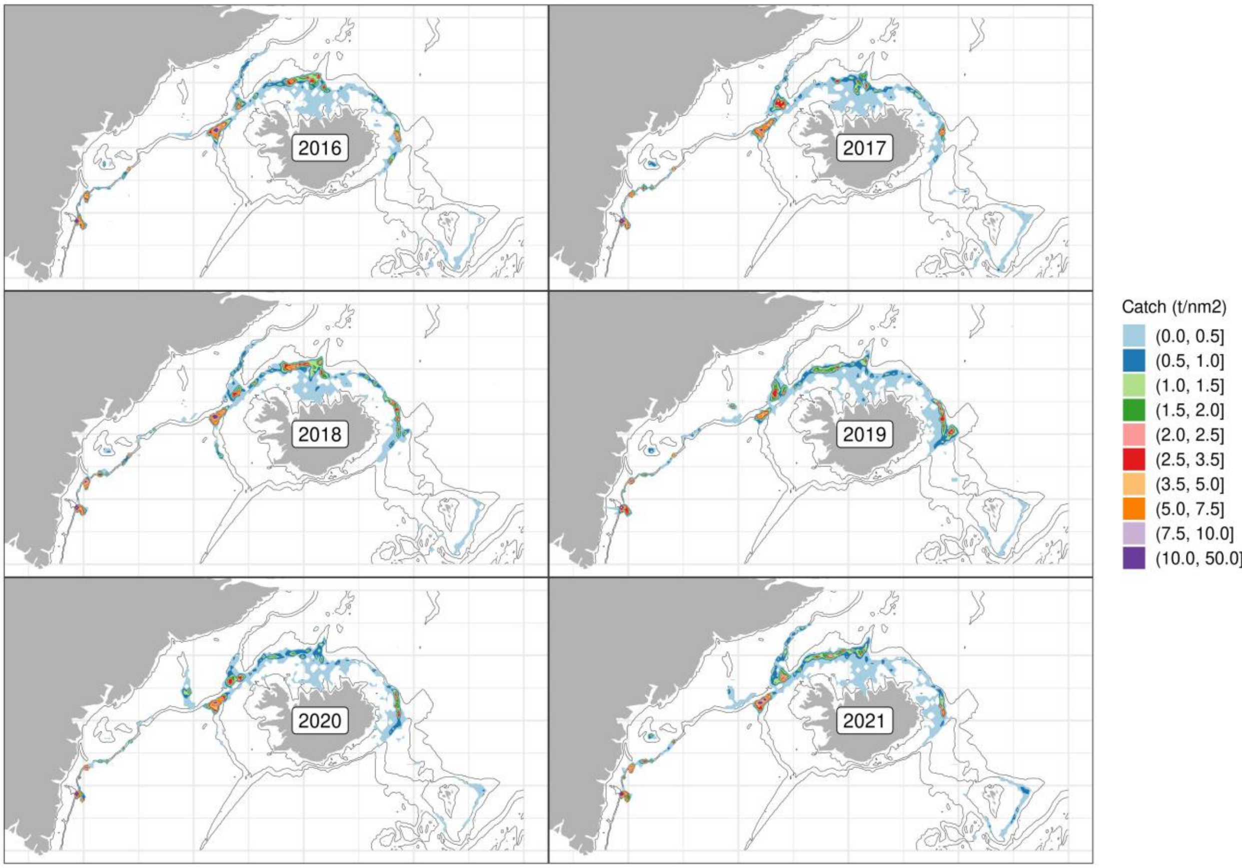

Figure 1: Greenland halibut. Geographical distribution of the fishery in division 5, 6, 12 and 14 from last six years. The 100 m, 500m and 1000 m depth contours are shown. Reported catch from logbooks, note that logbook data from the Faroe Islands is incomplete..

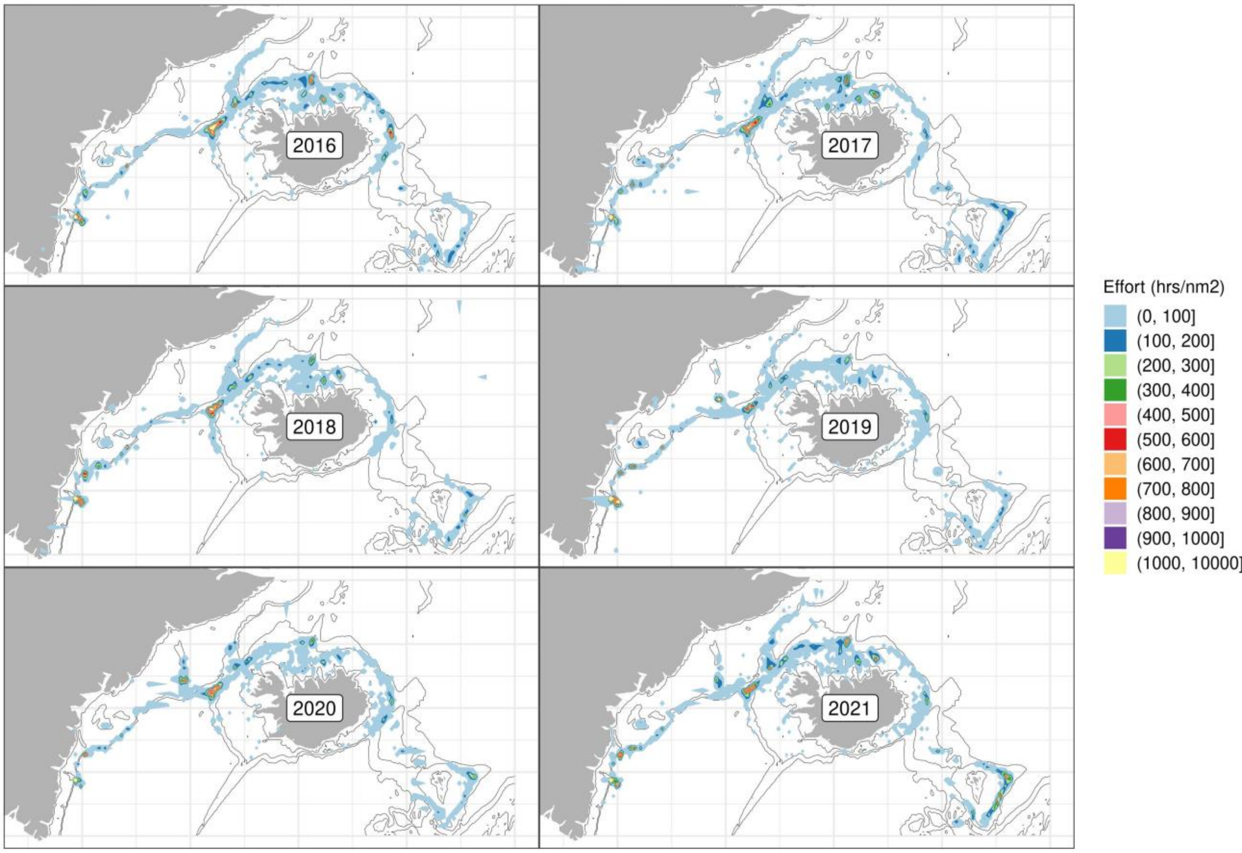

Figure 2: Greenland halibut. Geographical distribution of the fishery in division 5, 6, 12 and 14 from last six years. The 100 m, 500m and 1000 m depth contours are shown. Reported effort from logbooks, note that logbook data from the Faroe Islands is incomplete.

LANDING TRENDS

In 1980–1990, about 75–90% of catches were caught by Iceland (Figure 3). Since 1990, the Icelandic proportion has decreased, and has in recent years been 50–60%. Highest catches were recorded in 1986, about 60 thous. tonnes. Landings in Icelandic waters (usually allocated to Division 5a) have historically been predominated by the total landings in areas 5+14 (Icelandic waters), but since the mid-1990s fisheries in Subarea 14 and Division 5b have developed. Landings have since 1997 been between 20-31 thous. tonnes (Figure 4).

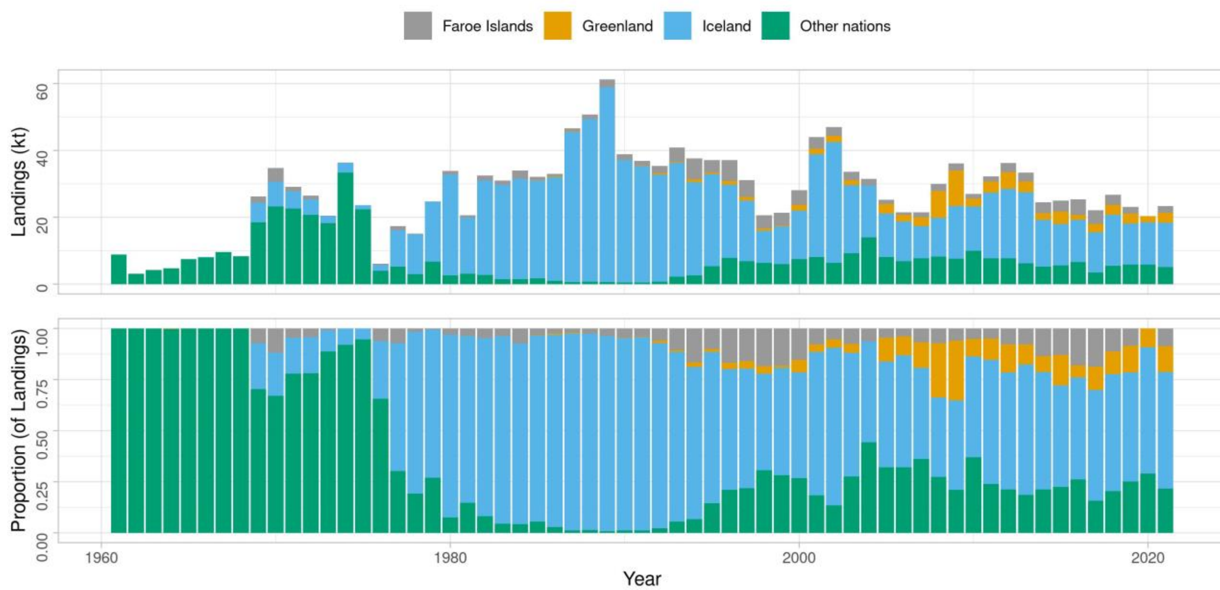

Figure 3: Greenland halibut. Landings from ICES Subareas 5,6,12 and 14 by nations (Greenland, Iceland, and Faroe Islands) in 1961-2020. All gears combined.

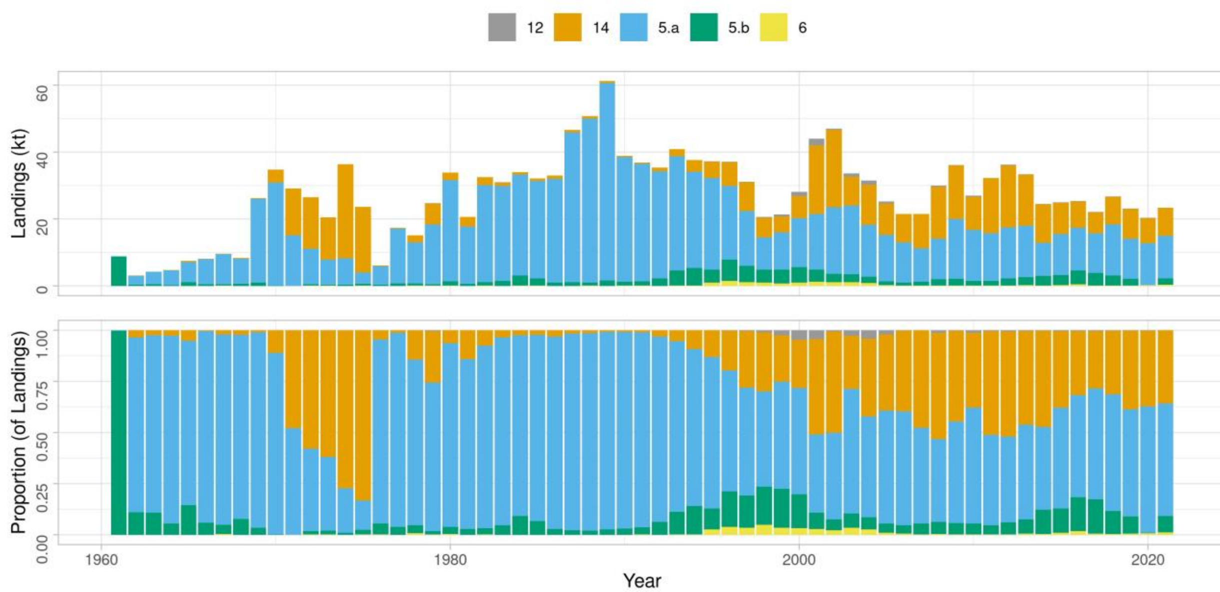

Figure 4: Greenland halibut. Spatial distribution of catch between ICES subareas 5.a, 5.b, 6, 12 and 14 in 1961-2020. All gears combined

Demersal trawl has been the main fishing gear for Greenland halibut in Icelandic waters, followed by gillnets, while a small proportion of the catch is taken on longlines and in shrimp trawls. Since 2015, landings by gillnets have, however, increased, reaching 62% of total catch in 2019 (Figure 5). The Greenland halibut trawl fishery is considered clean with respect to by-catches. The mandatory use of sorting grids in the shrimp fishery in Icelandic and Greenland waters since 2002 is observed to have reduced by-catches of Greenland halibut considerably. Greenland halibut is caught in relatively deep waters, with most of the catch (70%) taken between 400-800 meters depth. In 2003, most of Greenland halibut was caught at 800 meters or deeper (73%), but since then, catch has increased steadily in more shallow waters (Figure 6). Changes in depth range where Greenland halibut was caught seem to be reasonably synchronized with changes in fleet and therefore gear structure that target Greenland halibut in most recent years (Figures 5 and 6).

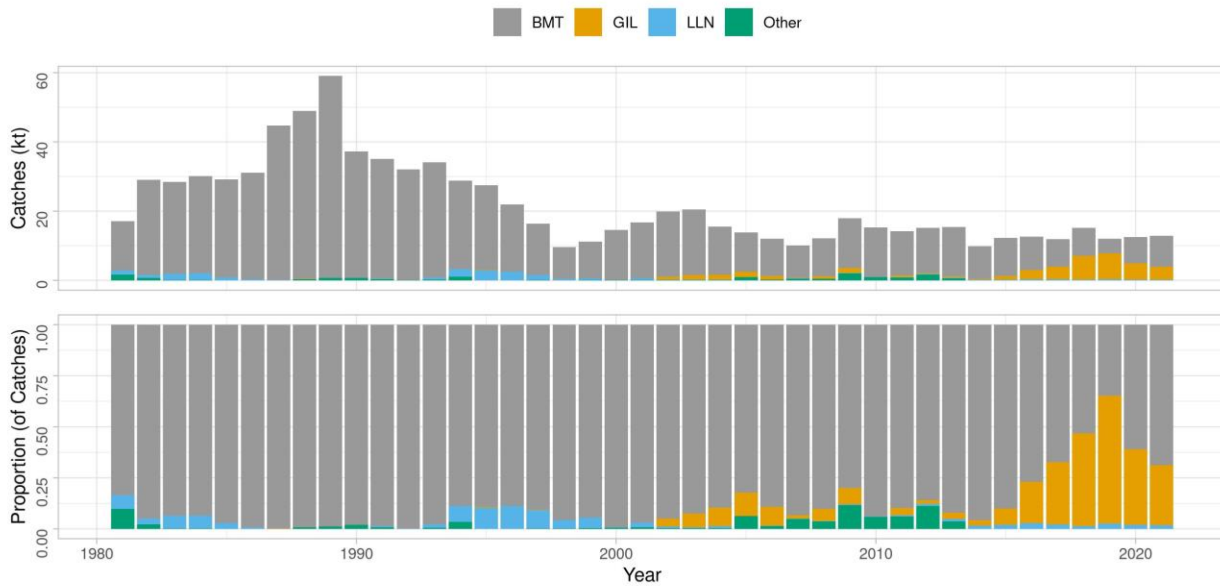

Figure 5: Greenland halibut. Total catch (landings) by fishing gear since 1994 in Icelandic waters, according to statistics from the Directorate of Fisheries.

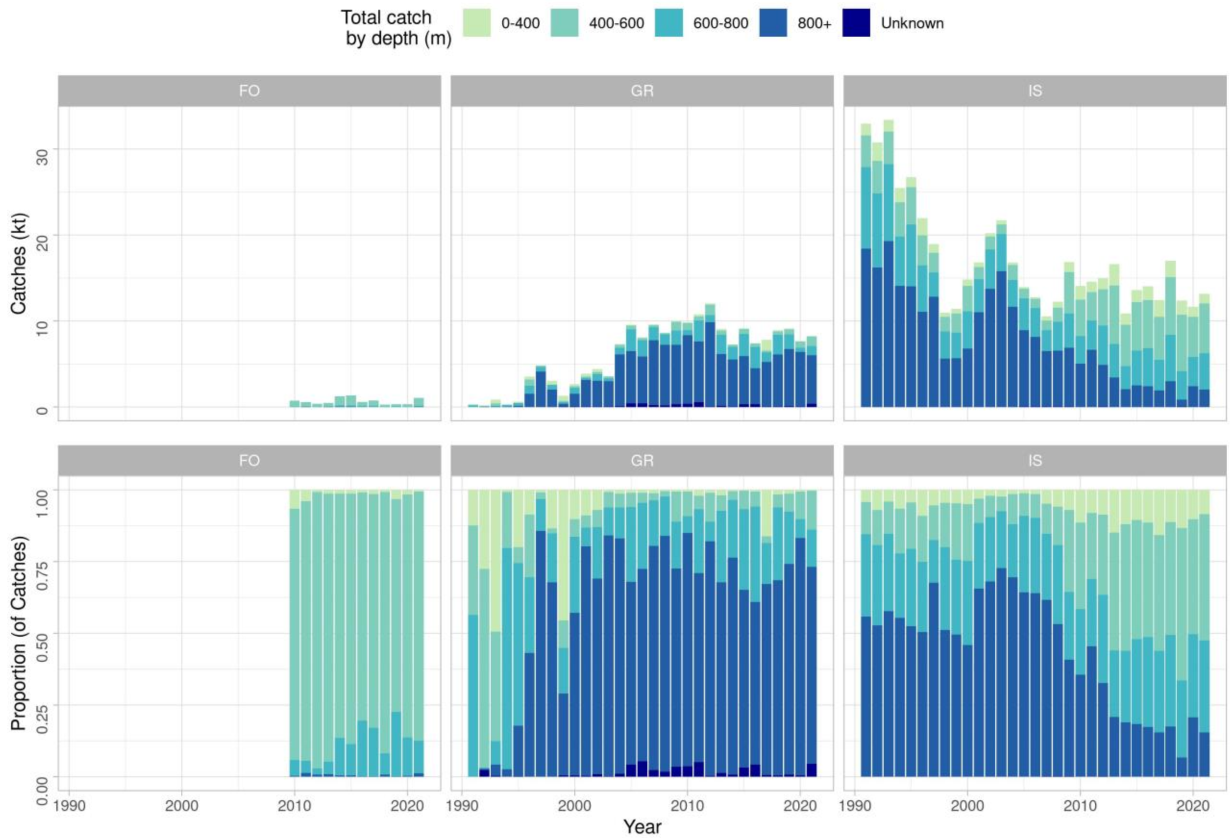

Figure 6: Greenland halibut. Depth distribution of catches in Faroese (FO), Greenlandic (GR) and Icelandic (IS) waters according to combined logbooks, note that logbook data from the Faroe Islands is incomplete.

The number of vessels accounting for 95% of the catch of Greenland halibut in Icelandic waters changed from about 75 vessels in 1994-1998 to little less than 20 (Figure 7). This change coincided with reduced catches. Since 1998, the number of vessels accounting for 95% of the catch has been relatively constant despite variable annual catches, with the lowest number of vessels observed in 2018

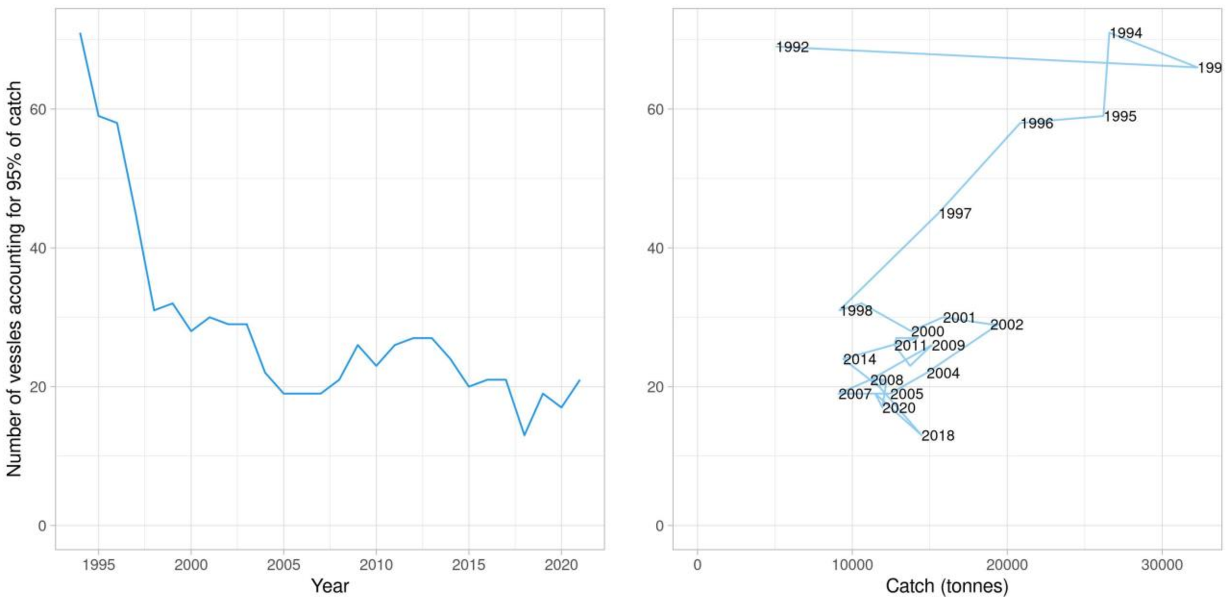

Figure 7: Greenland halibut. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

CATCH PER UNIT EFFORT

Estimates of catch per unit effort (CPUE) for the Icelandic trawl fleet directed at Greenland halibut for the period 1985–onwards is provided in Figure 8. The overall CPUE index for the Icelandic fishery is compiled as the average of the standardized indices from the whole area. Catch rates of Icelandic bottom trawlers decreased for all fishing grounds during 1990–1996 but peaked again in 2001. Since 2003, CPUE has been relatively stable. The Icelandic CPUE series has for many years been used as one of the biomass indicators in the assessment of the stock. The CPUE from trawlers in subareas 12, 14 (Greenland), shown in Figure 10, and 5b (Faroese waters) have not been used in the assessment, as the stock production model is not able to accommodate the contrasting indices (Icelandic CPUE and Greenlandic/Icelandic autumn surveys) and these CPUE series are therefore not used.

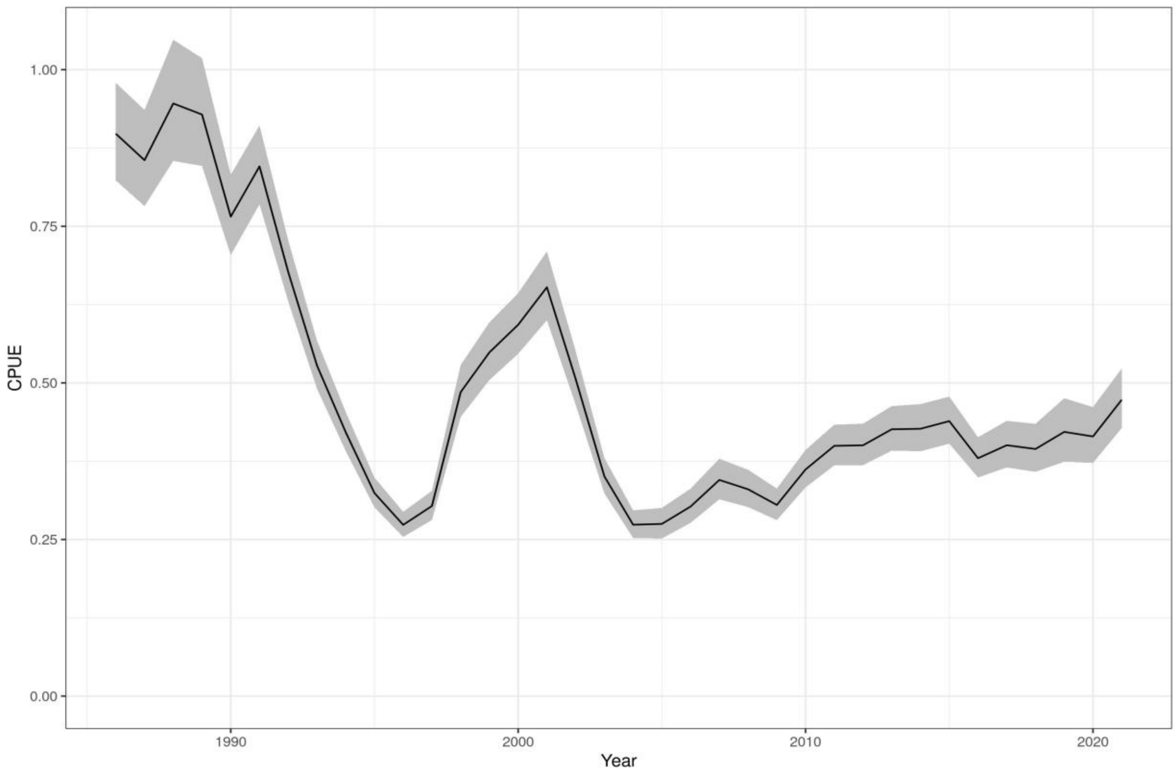

Figure 8: Greenland halibut. Catch per unit effort (CPUE, log-transformed) from the Icelandic trawler fleet in 5a. 95% CI indicated.

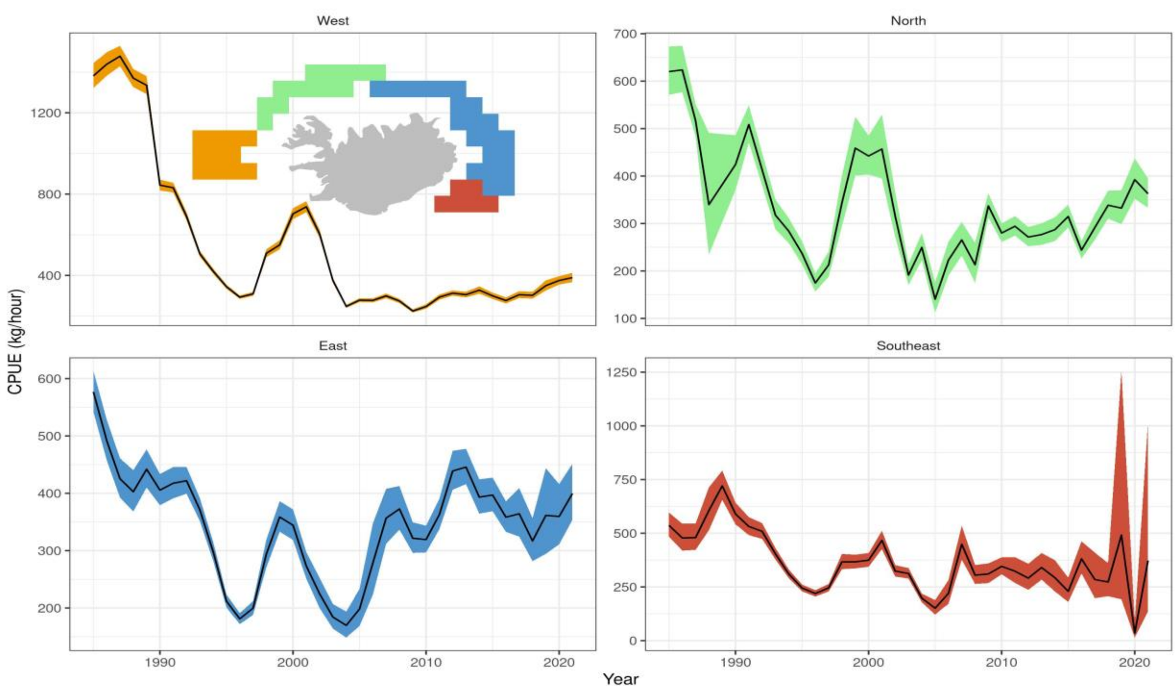

Figure 9: Greenland halibut. Catch per unit effort (CPUE) from the Icelandic trawler fleet in 5a, split by area indicated by the overlayed figure of Iceland. 95% CI indicated.

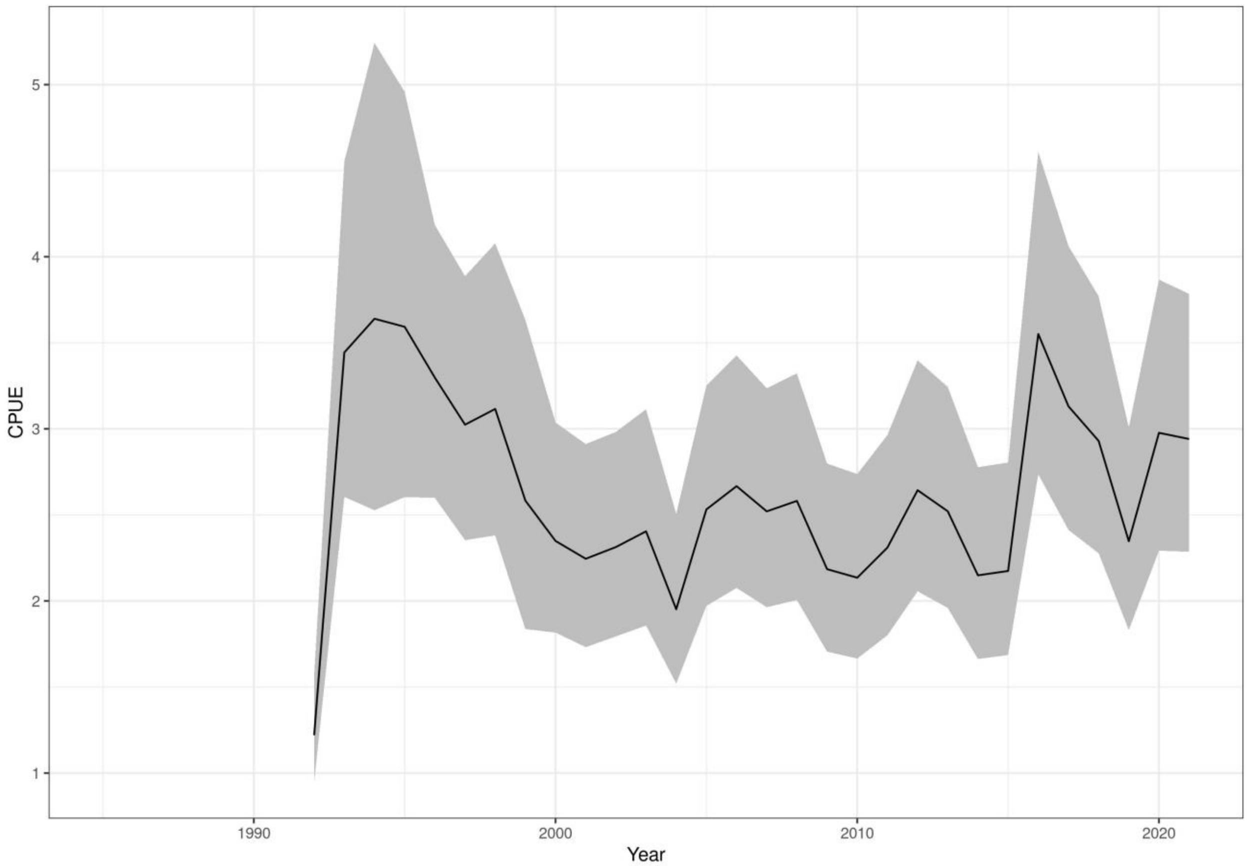

Figure 10: Greenland halibut. Standardised estimates of CPUE from trawl catches east of Greenaland (area 12 and 14). 95% confidence interval is indicated with gray shading.

SAMPLING OF LANDED GREENLAND HALIBUT

In general sampling is considered good from commercial catches in Icelandic waters from the main gears (gillnets, longlines and trawls). The sampling does seem to cover the spatial and seasonal distribution of catches (see Figures 12 and 11). In 2020 sampling effort was reduced substantially, on-board sampling in particular, due to the COVID-19 pandemic. This reduction in sampling is, however, considered to be sufficiently representative of the fishing operations and thus not considered to substantially affect the assessment of the stock.

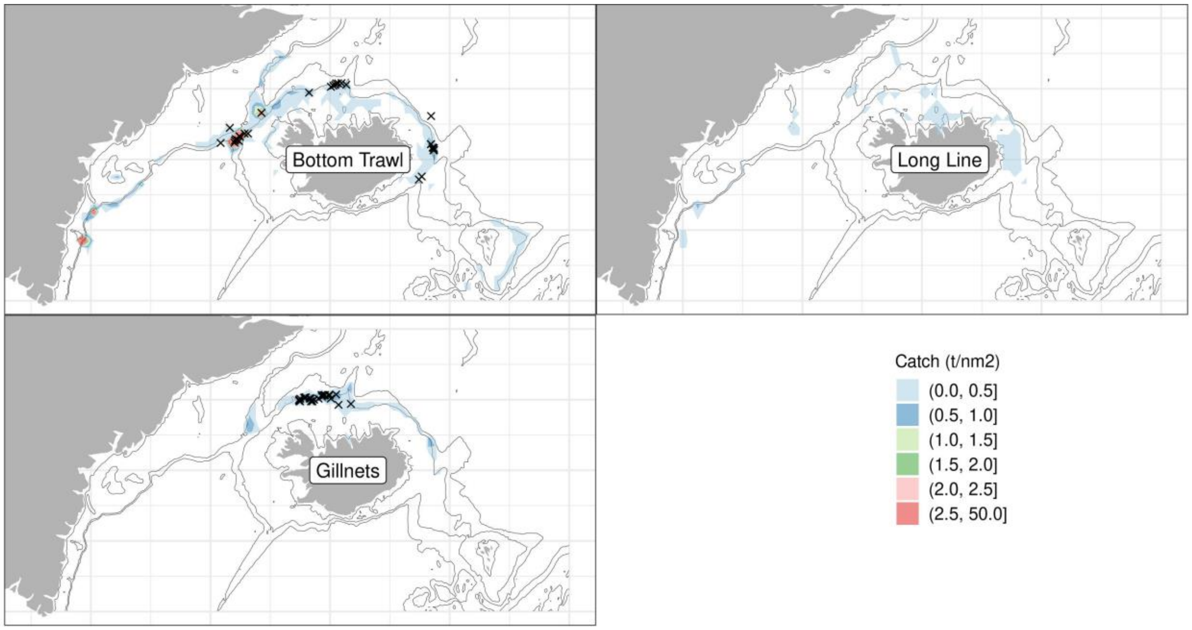

Figure 11: Greenland halibut. Fishing grounds in 2020 as reported in logbooks and positions of samples taken from landings (asterisks). Note that sampling locations are only available from Icelandic sources

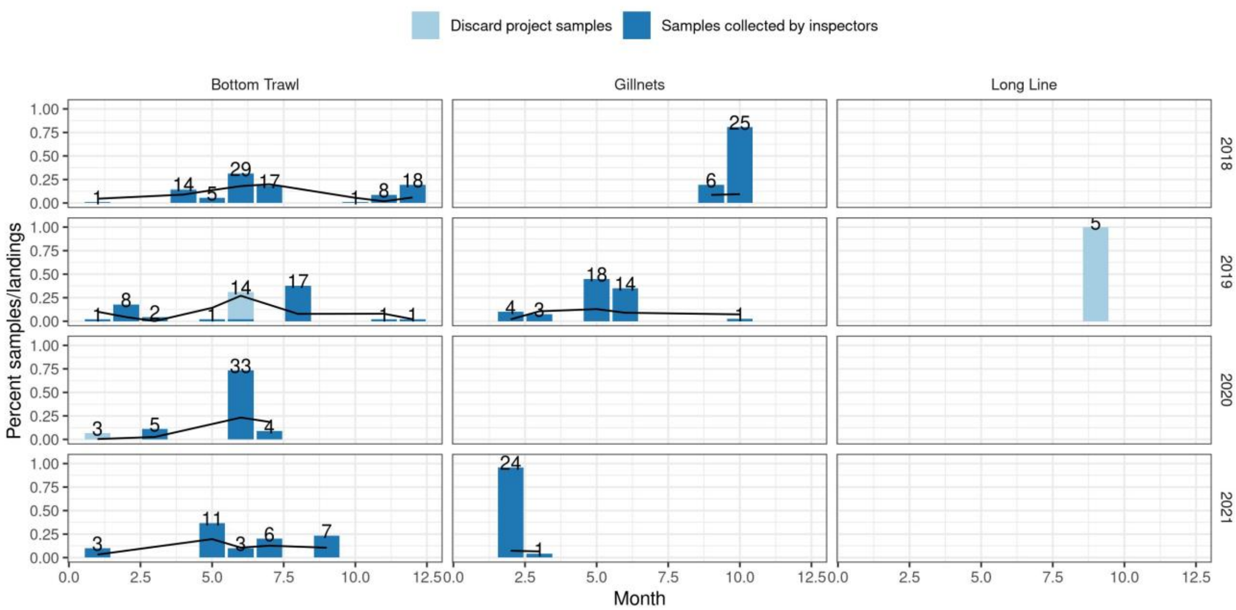

Figure 12: Greenland halibut. Ratio of samples by month (blue bars) compared with landings by month (solid black line) split by year and main gear types. Numbers of above the bars indicate number of samples by year, month and gear. Each sample typically consists of 50 fish.

LENGTH DISTRIBUTION OF LANDED GREENLAND HALIBUT

The bulk of the length measurements are from the three main fleet segments, i.e. trawls, longlines and gillnets. The number of available length measurements by gear has fluctuated in recent years in relation to the changes in the fleet composition.

Length distributions from the main fleet segments are shown in 13. The sizes caught by the main gear types (bottom trawl and gillnets) appear to be fairly stable, primarily catching halibut in the size range between 40 and 80 cm. Gillnets tend to catch slightly larger fish, while shrimp trawl appears to catch juvenile halibut when present in Icelandic waters.

There has been a gradual shift towards larger fish in the length distribution of landed catch (Figure 14). Males measured from landed catch have the tendency to be smaller than females, as observed from the proportion of catches by sex (Figure 14).

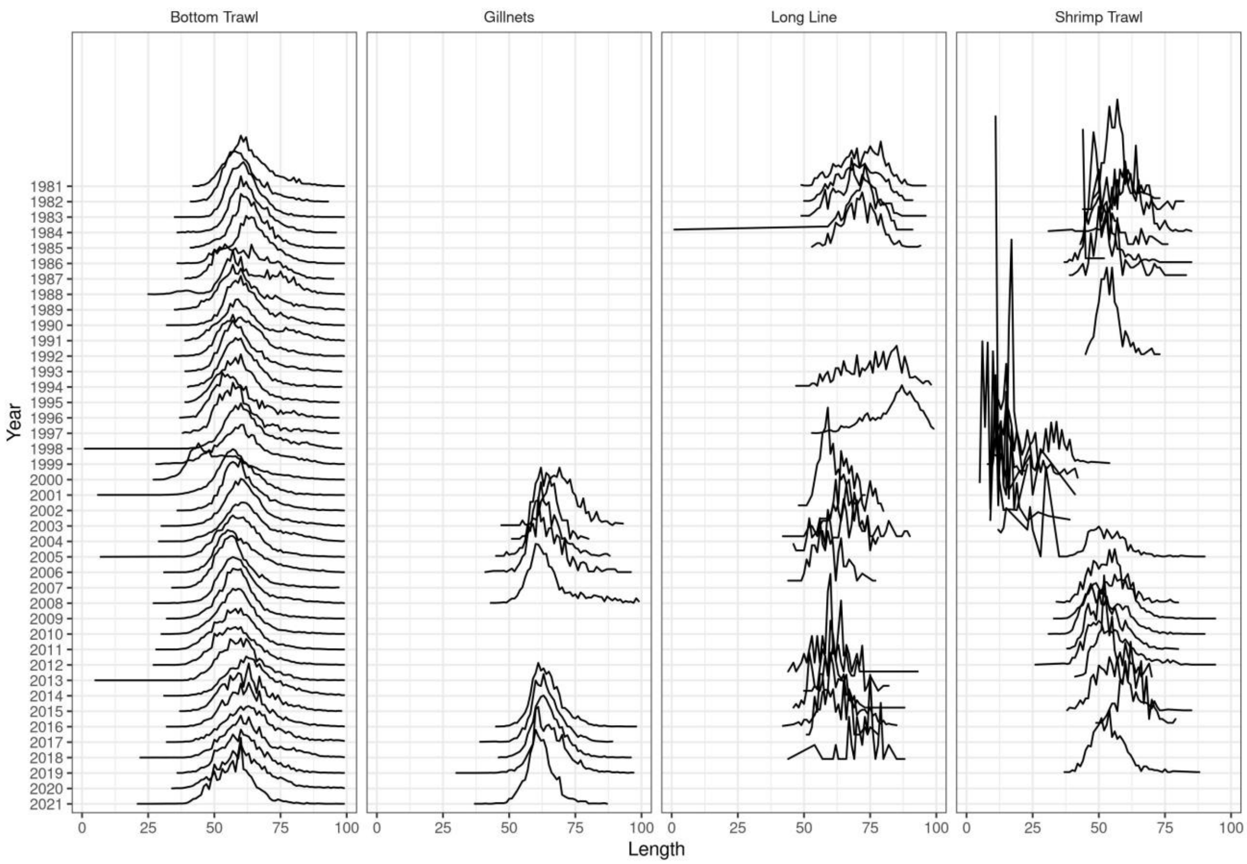

Figure 13: Greenland halibut. Commercial length distributions by gear and year

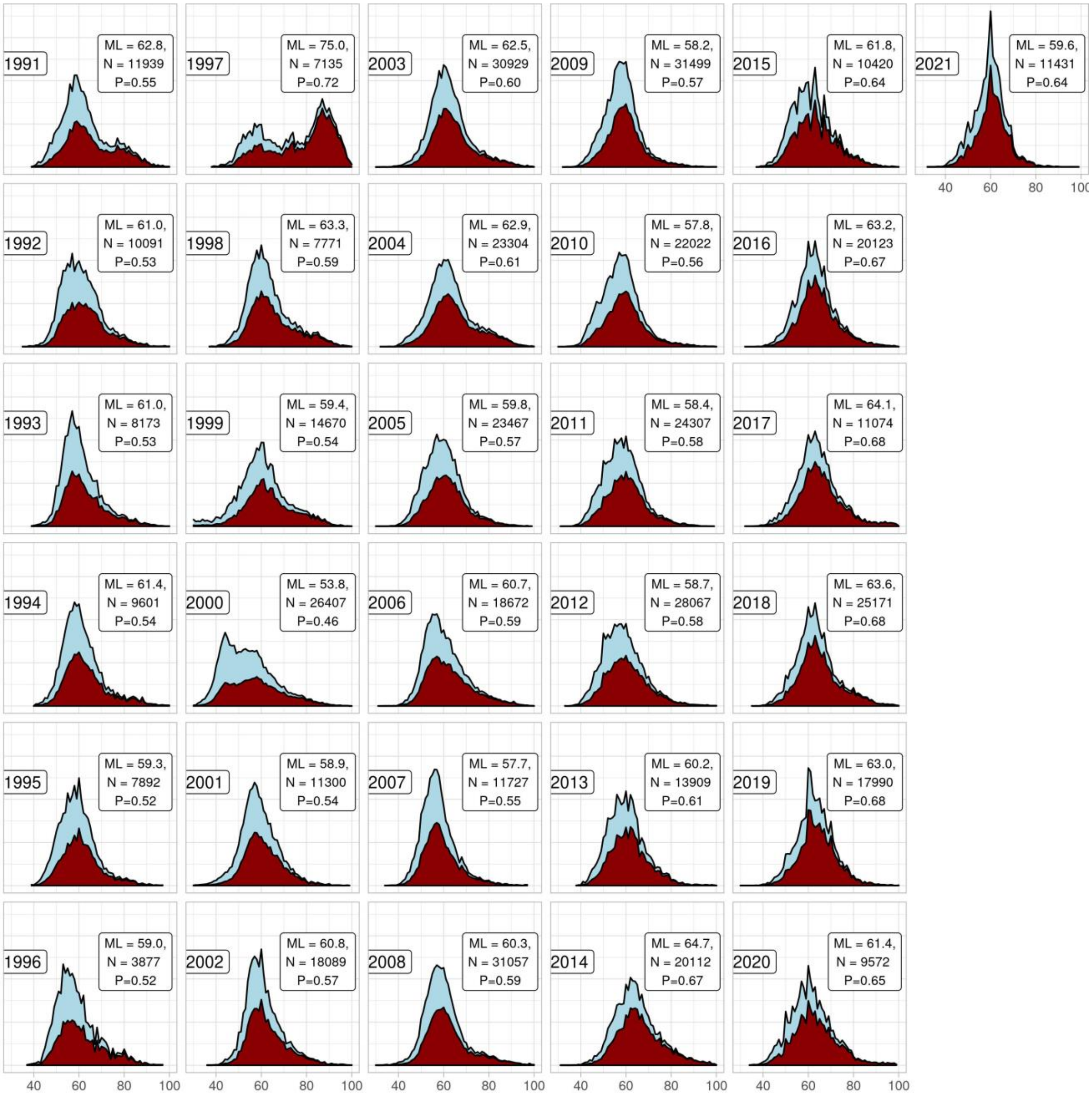

Figure 14: Greenland halibut. Aggregated commercial length distributions by sex and year.

SURVEY DATA

The Icelandic autumn groundfish survey (hereafter autumn survey) was commenced in 1996. The autumn survey was not conducted in 2011. Spatial distribution and abundance in recent years are shown in Figures 15 and 16 while Figure 17 shows trends in various biomass indices, and a recruitment index based on abundance of Greenland halibut ≤ 40 cm. Survey length distributions are shown in Figure 18. In the recent years, Greenland halibut were mainly caught on the continental slope south east, north, and north-west of the country (Figure 16).

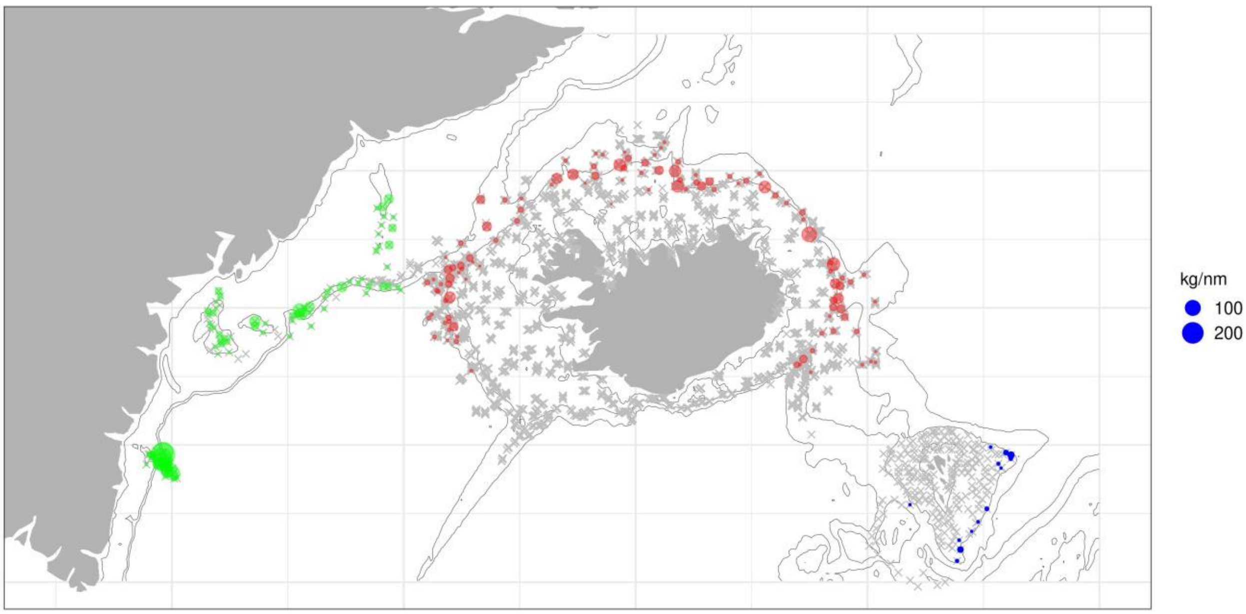

Figure 15: Greenland halibut. Spatial distribution of Greenland halibut in the Icelandic autumn survey (red), Greenlandic Greenland halibut survey (green) and Faroese surveys (blue). Size of the points indicates catch at the location, grey crosses the stations were no halibut were observed.

Since the survey was commenced in 1996, the distributional pattern has remained quite stable, with the greatest biomass index in the northeast and northwest. Since 1996, biomass index in the west has been steadily decreasing, while increasing in the southeast (Figure 16).

Biomass indices for the total stock of Greenland halibut and Greenland halibut larger than 40 cm (harvestable part of the stock), that are based on the combined Icelandic and Greenlandic autumn surveys, showed an increase from 1996-2001. After peaking in 2001, indices dropped but increased steadily from 2004 till 2017 when the stock started to decrease (Figure 17). The same holds for the index of Greenland halibut larger than 60 cm. The index of juvenile abundance (<40 cm) has fluctuated between years, peaking in 2002 but remained low in the past six years (Figure 17). Since 2016 the East Greenland area has not been surveyed, and for the indices the values from 2016 are used for the years after that.

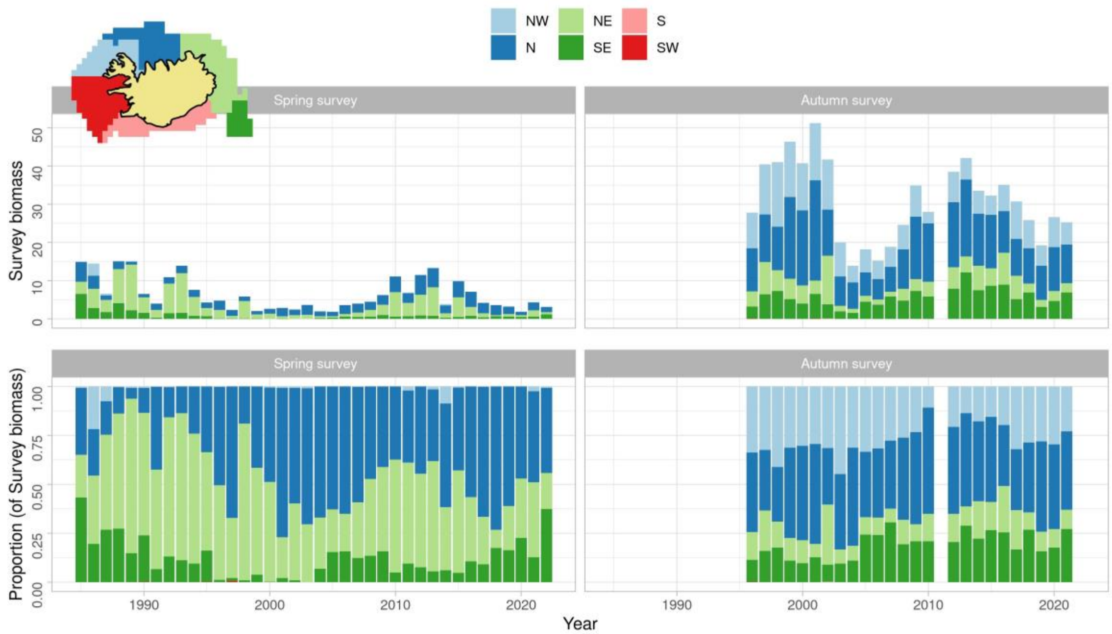

Figure 16: Greenland halibut. Spatial distribution of the biomass index from the spring and autumn surveys. Note that the autumn survey extends into deeper waters.

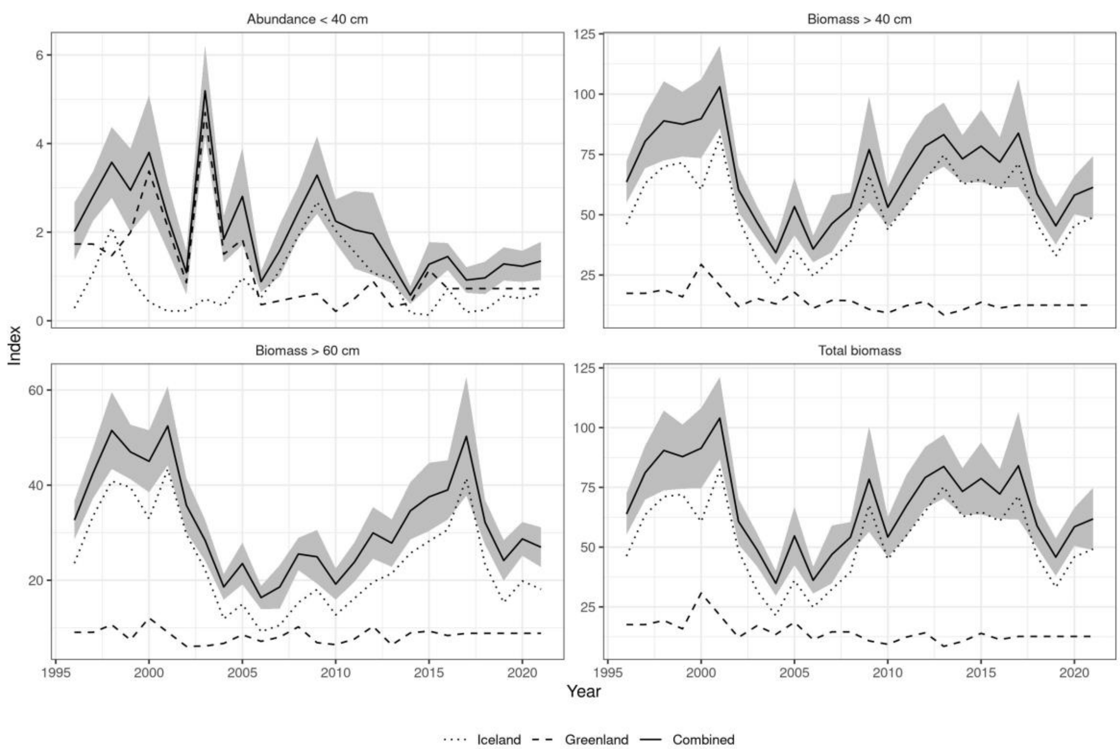

Figure 17: Greenland halibut. Indices from Iceland (smaller dots) Greenland (larger dots) and combined (straight line) with 95% CI indicated. Harvestable biomass indices (>40 cm) (upper right), juvenile abundance indices (<40 cm) (upper left), biomass indices of larger ind. (>60cm) (lower left) and total biomass indices (lover right)

Length distributions from the survey show a similar trend as in landed catch. Females tend to be larger than males and in greater abundance. The average length for females fluctuates from 51-61 cm throughout the years when males fluctuate from 50-59 cm. The length distribution has been gradually increasing since 2010, and in 2019, the mean length of males and females was 54.3 and 59.0 cm, respectively.

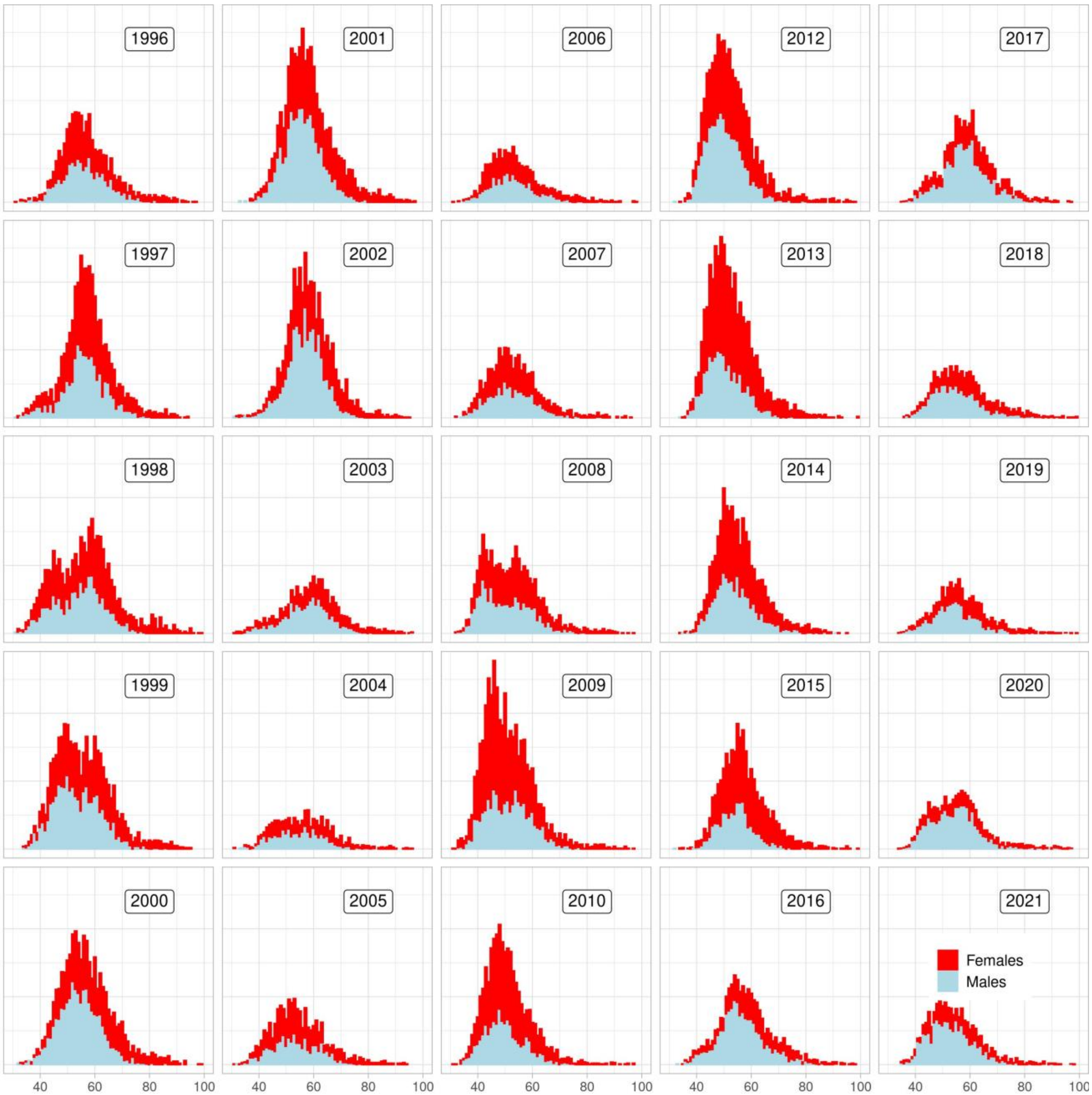

Figure 18: Greenland halibut. Length distribution of females and males from the autumn survey since 1996

Age distribution of the sexes of Greenland halibut from the autumn survey 2015-onwards show that the greatest proportion males are between 9 and 10 years old and range between 4-16 years. The greatest proportion of females are 11-13 years old and range from 3 to 22 years (Figure 19).

It is worth noting that aging recently resumed after a long period where otoliths were sampled but not age read. Recent advances in age reading techniques suggested that older age reading methods used previously were biased and thus older age-readings are not considered representative of the age structure in the population. Further, otoliths sampled prior to 2015 were not stored in a manner compatible with the newer age-reading method. It is therefore uncertain whether data on the historic age structure will ever be available.

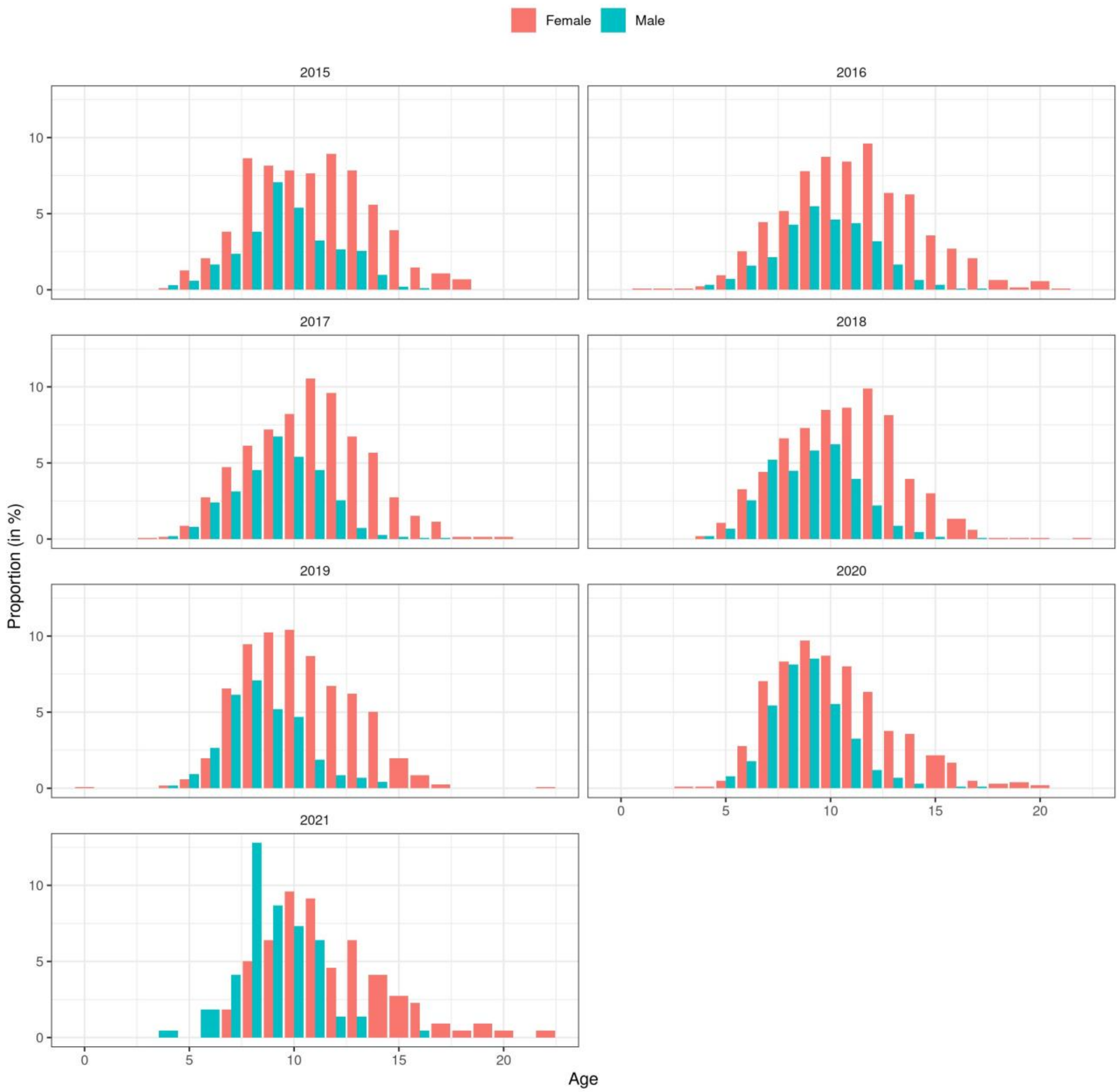

Figure 19: Greenland halibut. Proportion by age from the autumn survey from 2015

According to the length distribution by age of Greenland halibut, it reaches 60 cm at the roughly the age of 12 on the average (Figure 20). The growth of Greenland halibut appears to be similar between the sexes, while female exhibit larger variability in size. It is noteworthy that males tend to be on average smaller in the catches than females, even though both sexes seem to have similar mean length at age. This may suggest differences in behavior of the sexes, such as catchability with respect to gear and/or natural mortality.

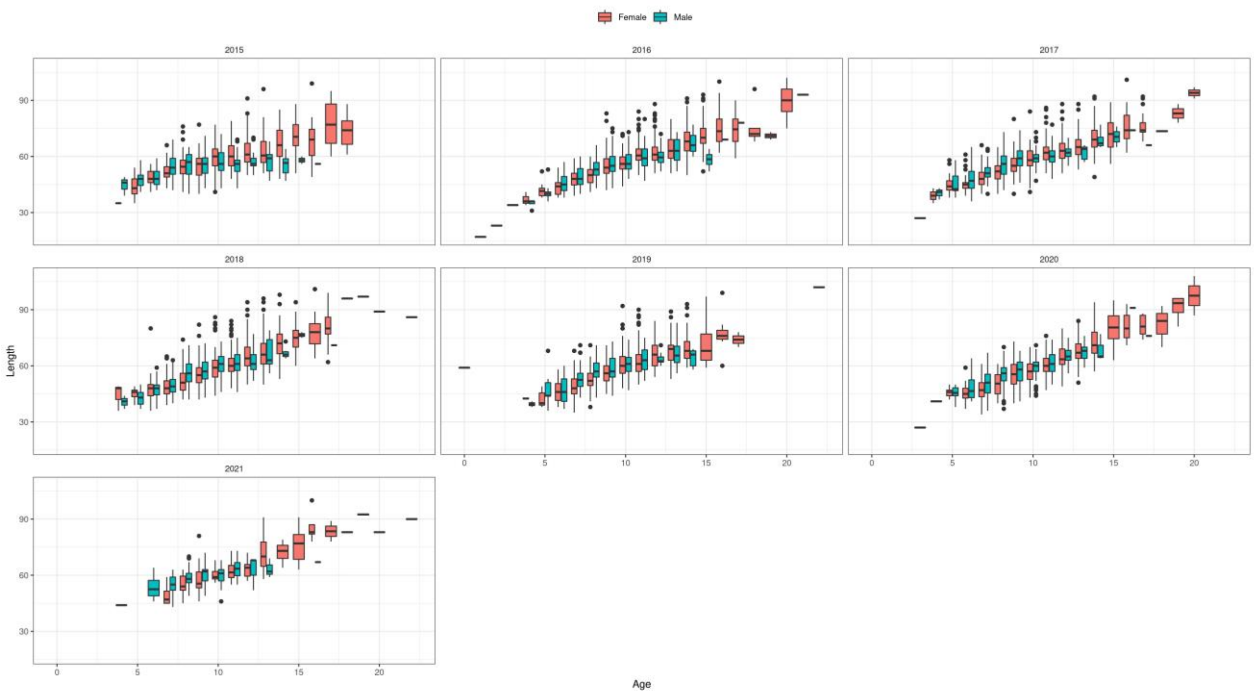

Figure 20: Greenland halibut. Distribution of length at age by sex from the autumn survey

STOCK ASSESSMENT

The assessment uses a stochastic version of the logistic production model and Bayesian inference according to the Stock Annex in which a more detailed formulation of the model and its performance is found.

INPUT DATA

The model synthesizes information from input priors and two independent series of Greenland halibut biomass indices and one series of catches by the fishery (see the Stock Annex). The two series of biomass indices are a revised annually for use in assessment: a standardised series of annual commercial-vessel catch rates in 5a in 1985–2019, $CPUE_t$, and a combined trawl-survey biomass index (5a and 14b) for 1996–2019, Isurt,. From 2017 to 2022 the survey index is based on the Icelandic survey and the 2016 values from the Greenland survey due to lack Greenland survey data (see Figure 17). Total reported catch in ICES Subareas 5, 6, 12 and 14 1961–2022 was used as yield data (Figure 3). Since the fishery has no major discarding problems or misreporting, the reported catches were entered into the model as error-free. The assumed catches for 2022 was 25 000 t based on agreed TACs for 5a and 14b and a continued catch level for 5b.

MODEL PERFORMANCE

The model parameters were estimated (posterior) based on the prior assumptions (Figure 21). The data could not be expected to carry much information on the parameter P_{1960} – the initial stock size 25 years prior to when the series of stock biomass series start – and the posterior resembled the prior. The prior for K was updated but similar to previous estimates. However, the posterior still had a wide distribution with an inter-quartile range of 713–1069 kt.

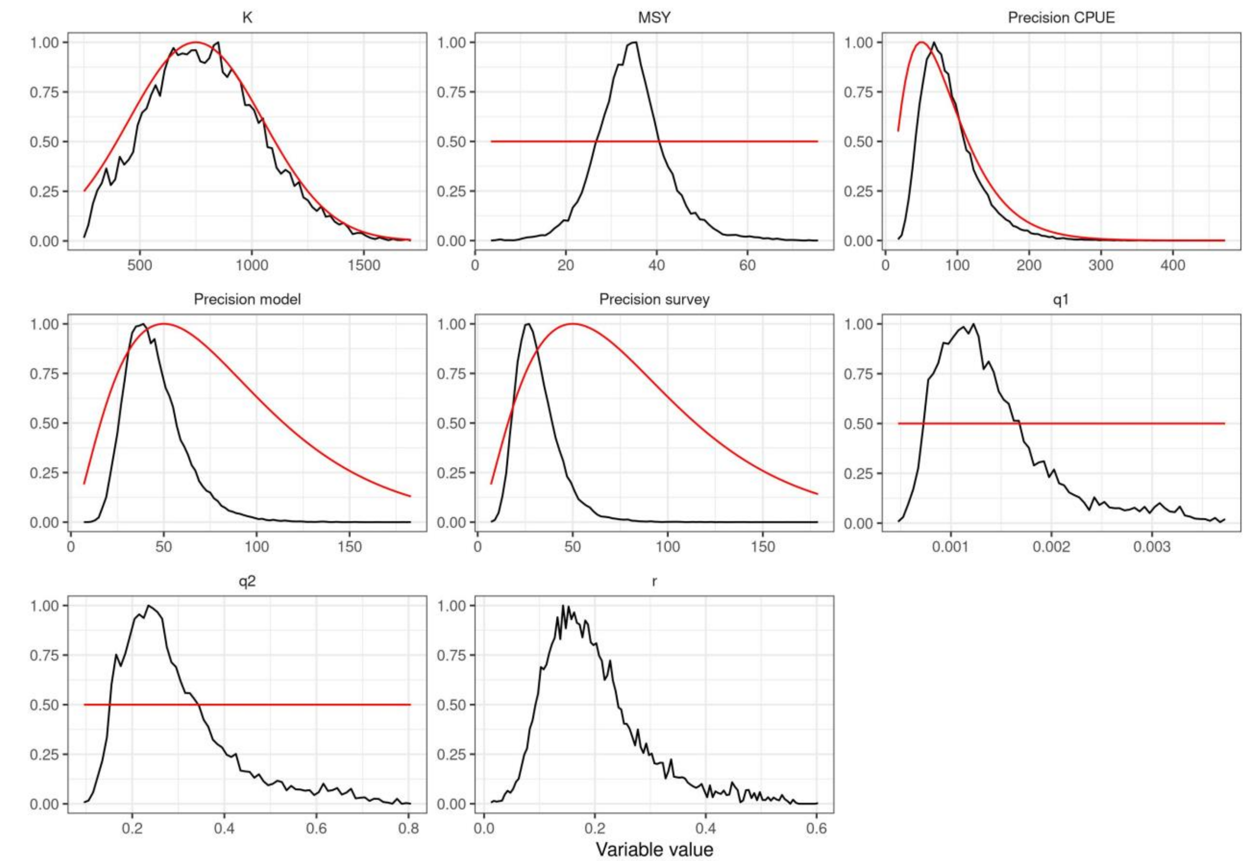

Figure 21: Greenland halibut. Probability density distributions of model parameters: estimated posterior (black line) and prior (red line) distributions.

The posterior for MSY was positively skewed with upper and lower quartiles at 26 kt and 40 kt. MSY appears to be informed by the data and is relatively insensitive to changes in prior distributions. The model was able to produce a reasonable simulation of the observed data (Figure 22). The 2022 observations have, however, high residuals for both indices (-12% and 9%) both outside the quantiles of the model estimate. The retrospective runs suggest high consistency for both biomass and fishing mortality within +- 20% (range -0.02 to 0.06, Figure 23).

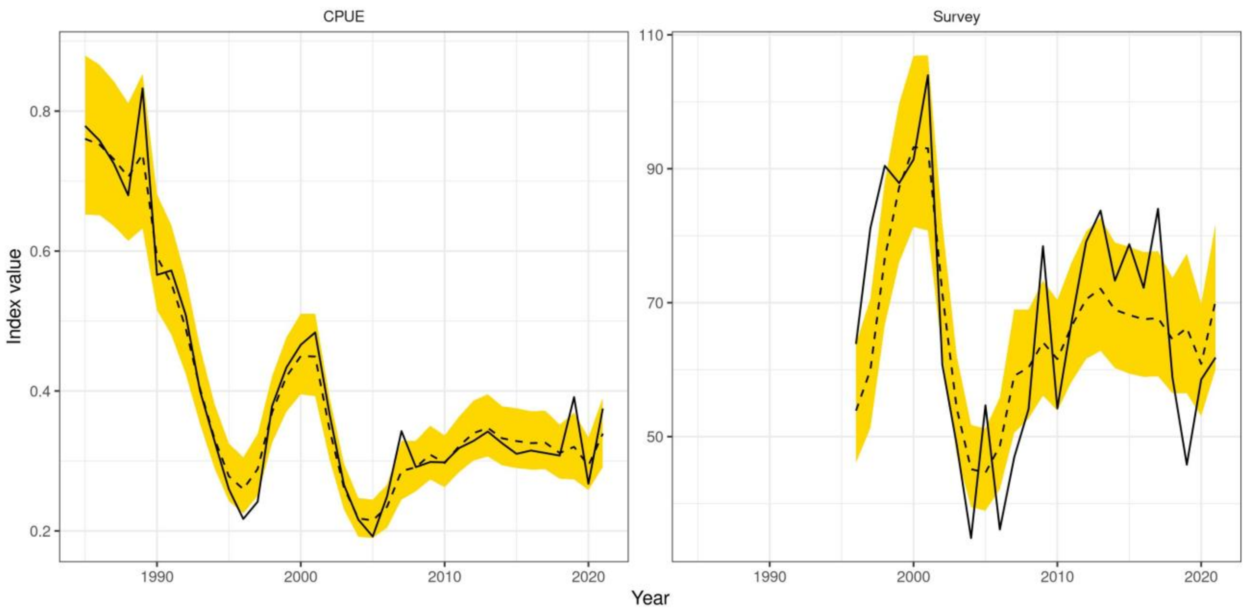

Figure 22: Greenland halibut. Observed (black solid lines) and predicted (dashed lines) series of the two biomass indices input to the model. Shaded regions are the 95%-tile range of the model estimates.

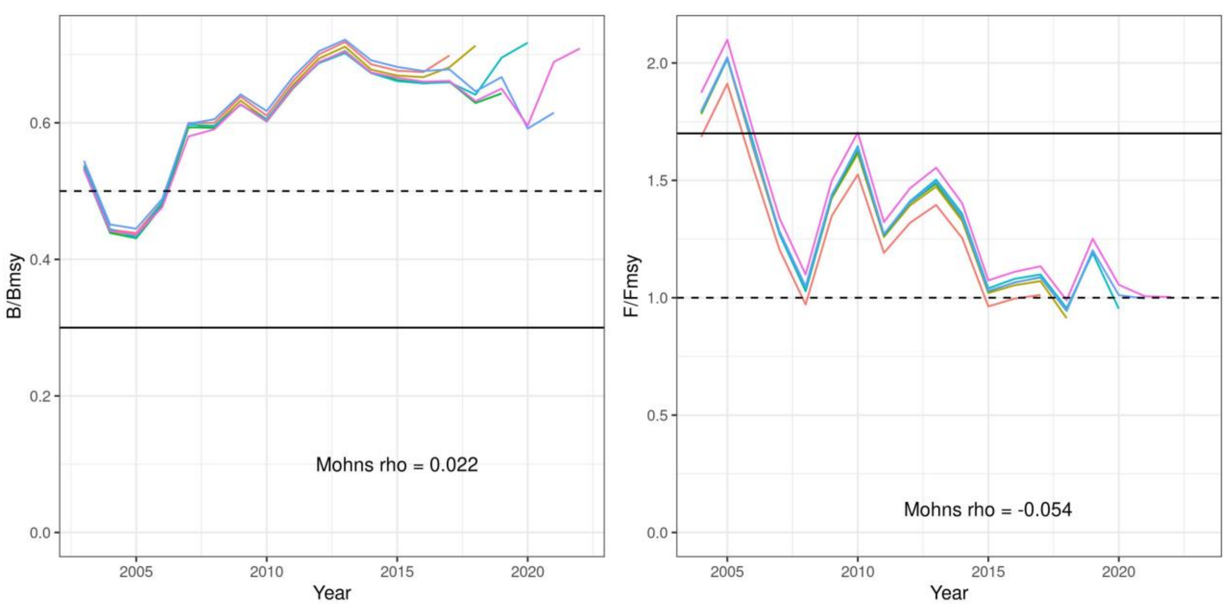

Figure 23: Greenland halibut. Analytical retrospective analyses of medians of relative biomass (B/Bmsy) and fishing mortality (F/Fmsy).

ASSESSMENT RESULTS

The time series of estimated median biomass-ratios starts in 1960 as a virgin stock at K (2 x B_{msy}, Figure 24). The fishery on the stock starts in 1961. Under continuously increasing fishing mortality the stock declined sharply in the mid–1990s to levels below the optimum, BMSY. Some rebuilding towards B_{MSY} was then seen in the late 1990s. Since then the stock started to increase from its lowest level in 2004–5 of approx. 48% of B_{MSY} and has in recent years been around 70% of B_{MSY} with a slight increase in 2020. The median fishing mortality ratio (F/F_{MSY}) has exceeded F_{MSY} since the 1990s but has in recent years decreased and are now close to F_{MSY} (Figures 24 and 25). Relative fishing mortality can only be estimated with large uncertainty and the posteriors therefore also include values below F_{MSY}. However, the probability that F exceed F_{MSY} is high for most of the years.

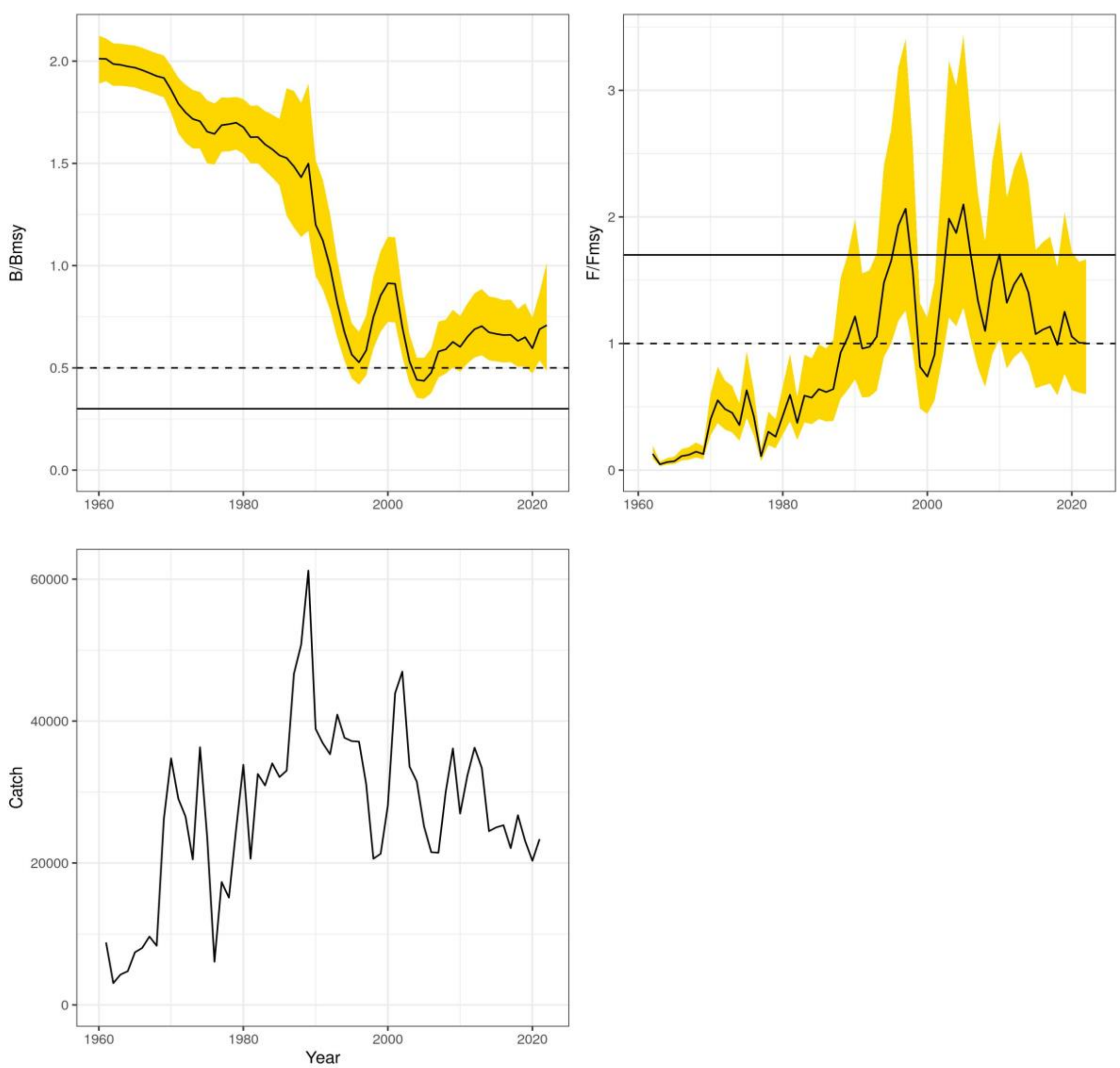

Figure 24: Greenland halibut. Stock summary, upper panel right: fishing mortality (F/Fmsy) and 95% conf limits, left: total biomass (B/Bmsy) and 95% conf limits and lower panel is landings since start of the fishery. MSY Btrigger and Fmsy (dashed line), Blim and Flim (solid lines) are indicated.

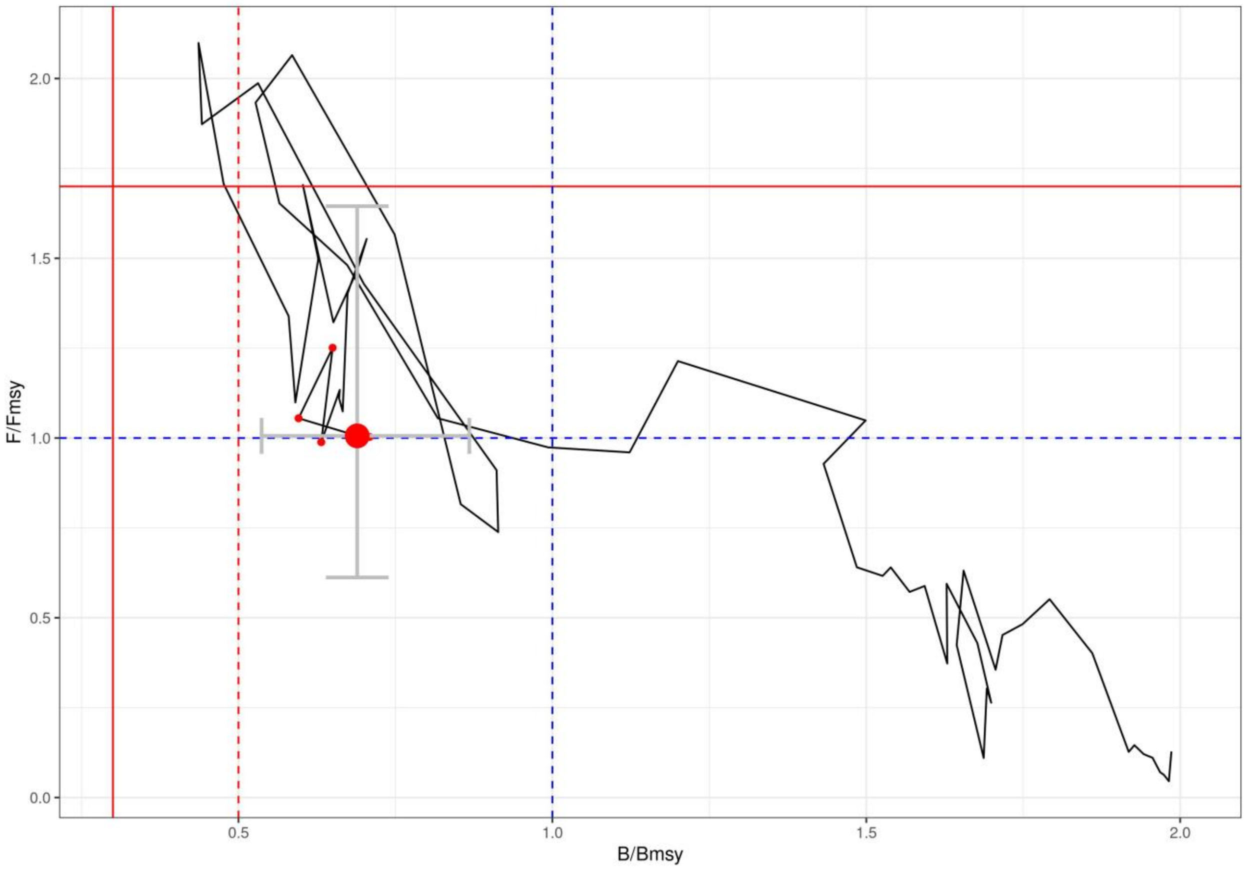

Figure 25: Greenland halibut. Stock trajectory from 1960 onwards. Estimated annual median biomass-ratio (B/B_{MSY}) and fishing mortality-ratio (F/F_{MSY}). B_{lim}, MSY $B_{trigger}$ and F_{lim} are indicated. Last five years are indicated with red dots, current assessment the largest. The gray cross indicates the uncertainty in the assessment year

MANAGEMENT

Figure 26 shows the Icelandic national TAC, and catches since the 1991/1992 fishing year. In 2014, the Greenland and Iceland entered a five-year bilateral agreement to limit the fishing pressure of the Greenland halibut stock in East-Greenland, Iceland and Faroes to F_{msy}. According to this agreement 56.4% of the TAC is allocated to Iceland and 37.6% to Greenland. The Faroe Islands were not party to the agreement. Currently no agreement exists between the parties but it is expected that Greenland and Iceland will maintain the TAC split for this fishing year.

In recent fishing years, landings have been similar to the advised TAC. Figure 27 shows the net transfers in the Icelandic ITQ-system since 1991. In this period, transfers to Greenland halibut from other species (positive values) and transfers from Greenland halibut to other species (negative values) have fluctuated. Since 2002/03, transfers have been negative, apart from 2009/10 and the past two fishing years, when a small amount was transferred to Greenland halibut quota.

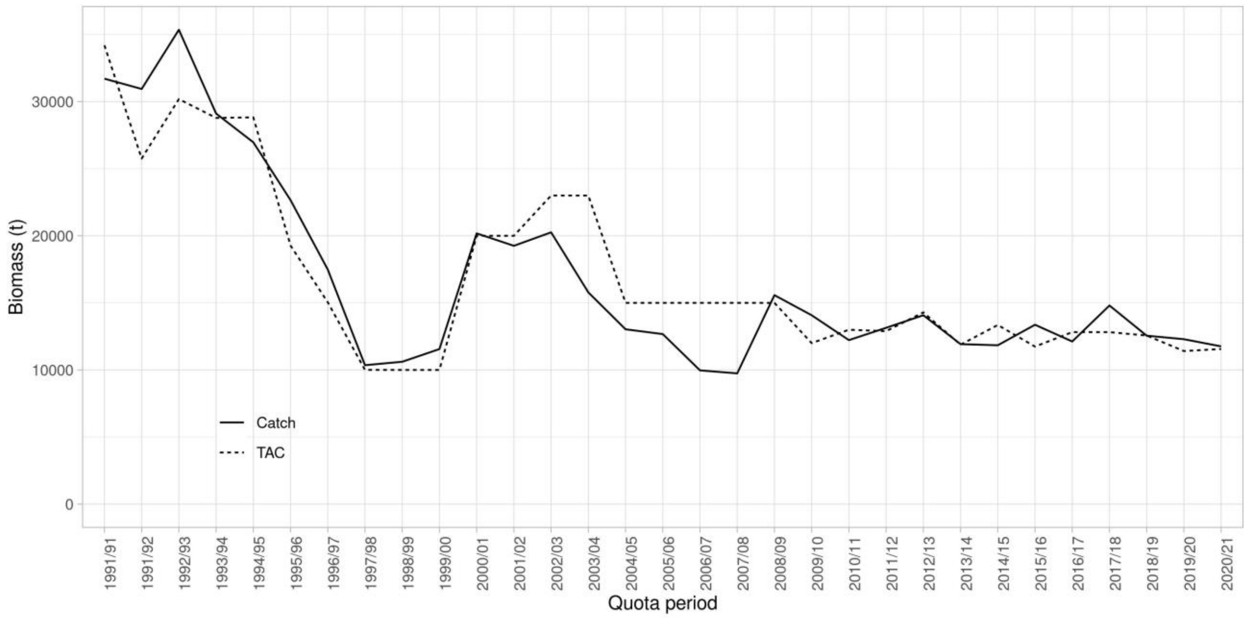

Figure 26: Greenland halibut. Recommended Icelandic national total allowable catch (TAC) compared with catches in Icelandic waters.

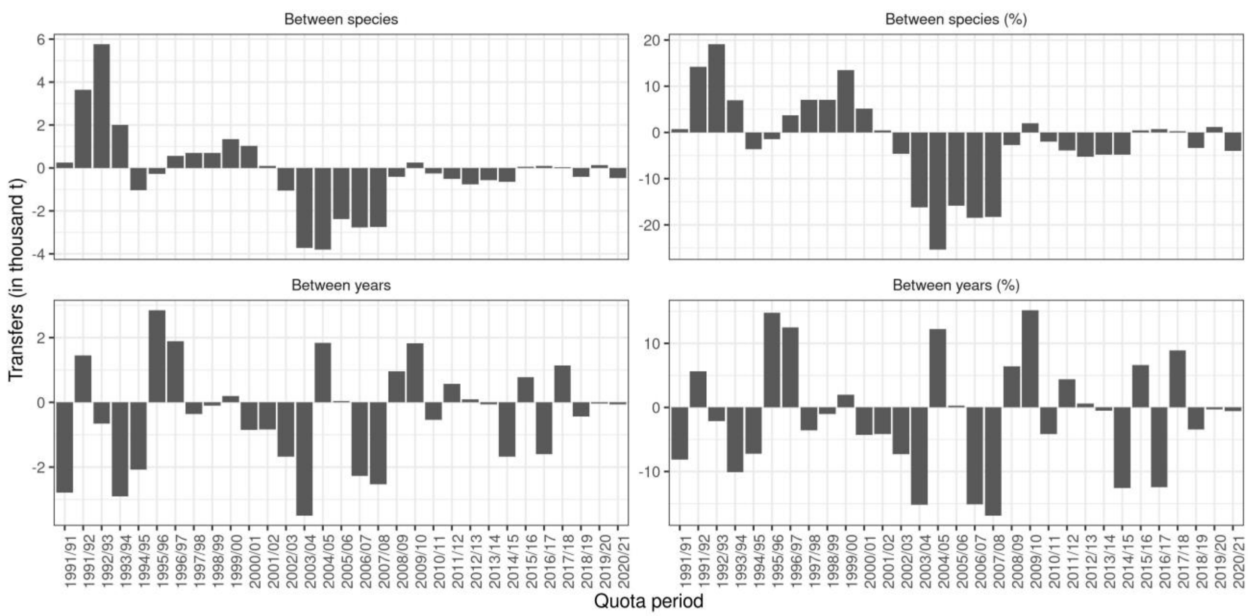

Figure 27: Greenland halibut. Net transfers of quota to and from Greenland halibut in the Icelandic ITQ system by fishing year. Between species (upper): Positive values indicate a transfer of other species to Greenland halibut, but negative values indicate a transfer of Greenland halibut quota to other species. Between years (lower): Net transfer of quota for a given fishing year.