HADDOCK

Melanogrammus aeglefinus

GENERAL INFORMATION

Icelandic haddock (*Melanogrammus aeglefinus*) is abundant in the coastal waters around Iceland and is mostly limited to the Icelandic continental shelf, while 0-group and juveniles from the stock are occasionally found in East Greenland waters (ICES area 14). Apart from this, larval drifts links with other areas have not been found. In addition, minimal catches have been reported in area 14 (maximum of less than 10 tons in 2016). The nearest area to the Icelandic were haddock are found in reasonable abundance are in shallow Faroese waters, an area that constitutes as a separate stock. The two grounds are separated by a wide and relatively deep ridge, an area where reporting of haddock catches is non-existent, both commercially and scientifically. Tagging studies (Jónsson 1996) conducted between 1953 and 1965 showed no migrations of juvenile and mature fish outside of Icelandic waters, with most recaptures taking place in the area of tagging (or adjacent areas) and on the spawning grounds south of Iceland. Information about stock structure (metapopulation) of haddock in Icelandic waters is limited.

The species is found all around the Icelandic coast, principally in the relatively warm waters off the west and south coast, in shallow waters (10-200 m depth). Spawning has historically been limited to the southern waters. Haddock is also found off the north coast and in warm periods a large part of the immature fish have been found north of Iceland. In recent years a larger part of the fishable stock has been found off the north coast of Iceland than the last two decades of the 20th century.

FISHERY

The fishery for haddock in 5a has not changed substantially in recent years, but the total number of boats that account for 95% of fishery have been declining steadily (Figure 1). Around 250 longliners annually report catches of haddock, around 60 trawlers and 40 demersal seine boats. Most of Haddock in 5a is caught by trawlers and the proportion caught by that gear has decreased since 1995 from around 70% to 45% in 2017. However, for the last two years this proportion has increased slightly and is now around 60%. At the same time the proportion caught by longlines has increased from around 15% in 1995 - 2000 to 40 % in 2011–2021. Catches in demersal seine have varied less and have been at around 15% of Icelandic catches of Haddock in 5a. Currently less than 2% of catches are taken by other vessel types, but historically up to 10 % of total catches were by gillnetters, but since 2000 these catches have been low (Figure 2). Most of the haddock caught in 5a by Icelandic vessels is caught at depths less than 200 m (Figure 3). The main fishing grounds for Haddock in 5a, as observed from logbooks, are in the south, southwestern and western part of the Icelandic shelf (Figure 4) and Figure 5). The main trend in the spatial distribution of haddock catches in 5a according to logbook entries is the increased proportion of catches caught in the north and northeast.

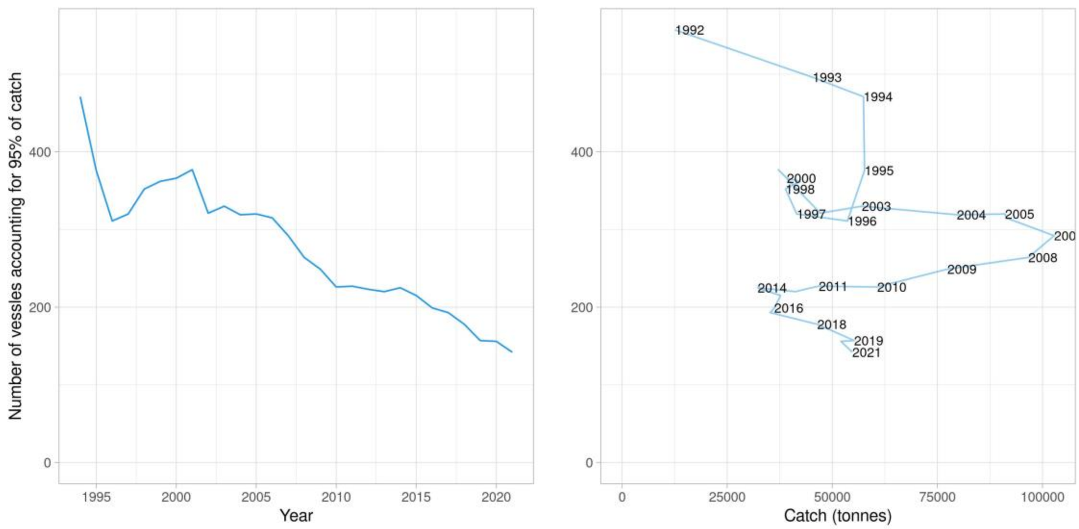

Figure 1: Haddock in 5a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

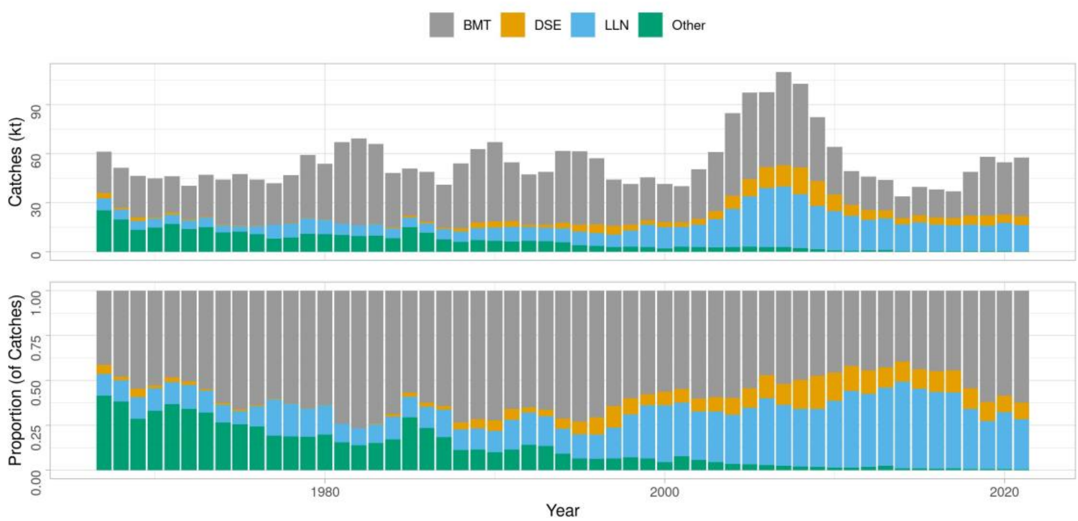

Figure 2: Haddock in 5a. Landings in tons and percent of total by gear and year

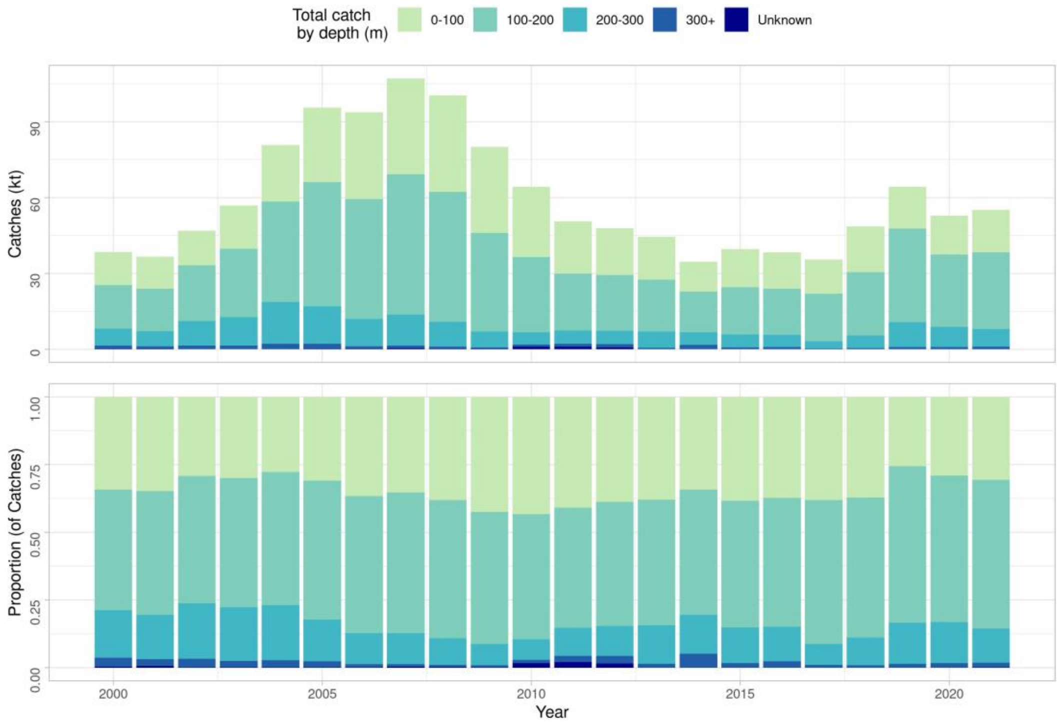

Figure 3: Haddock in 5a. Depth distribution of haddock catches from bottom trawls, longlines, trawls and demersal seine from Icelandic logbooks

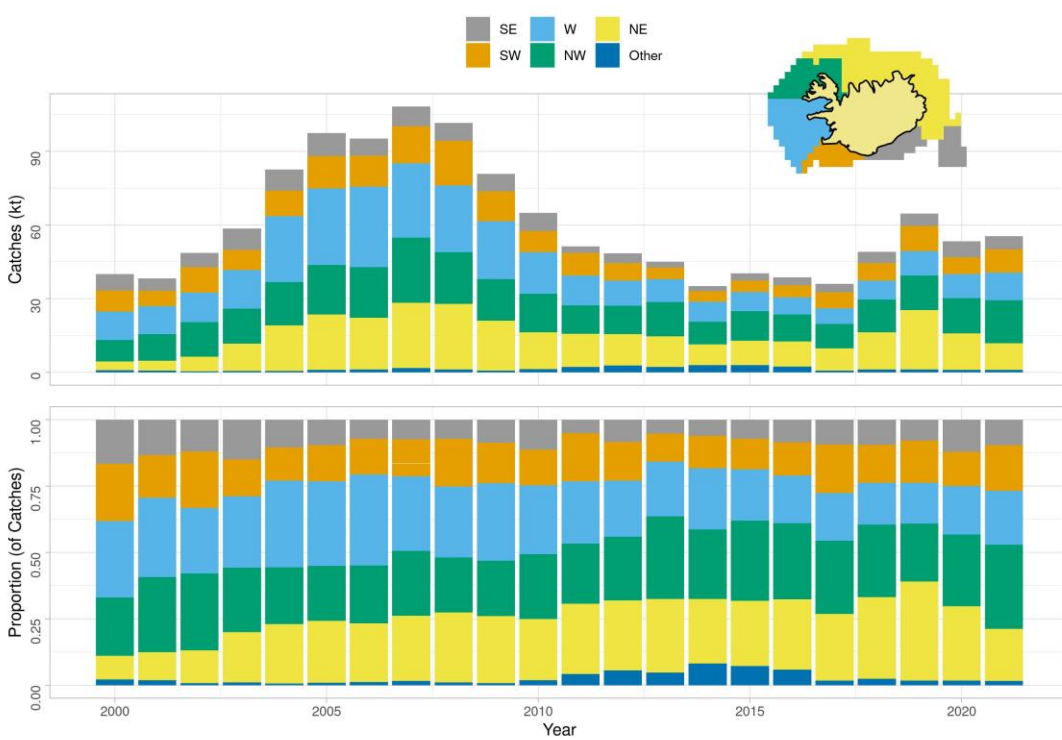

Figure 4: Haddock in 5a. Changes in spatial distribution of haddock catches as recorded in Icelandic logbooks.

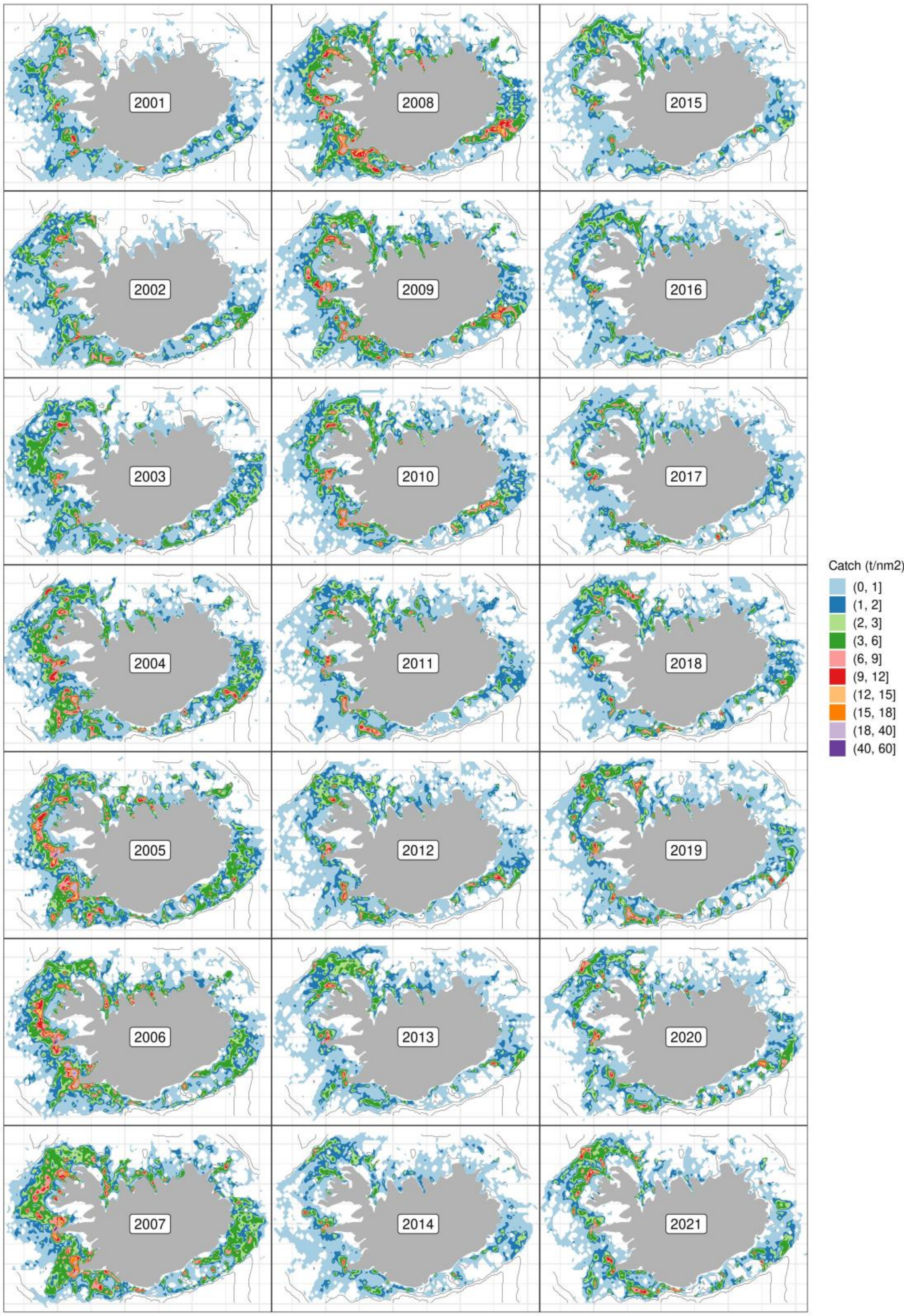

Figure 5: Haddock in 5a. Spatial distribution of catches by all gears.

LANDING TRENDS

Landings of Icelandic haddock in 2021 are estimated to have been 57599 tonnes, see Figure 6. The landings in division 5a. have decreased from 100 thous. tonnes between 2005–2008, which historically was very near the maximum levels observed in the 1960's, to the current level which is slightly lower than observed between 1975 to early 2000's.

Foreign vessel landings were a considerable proportion of the landings, but since the expansion of the EEZ landings of foreign vessels are negligible. Currently most of the foreign catch is caught by Faeroese vessels, which in last year was 1696 tonnes, while Norwegian vessels land considerably less haddock.

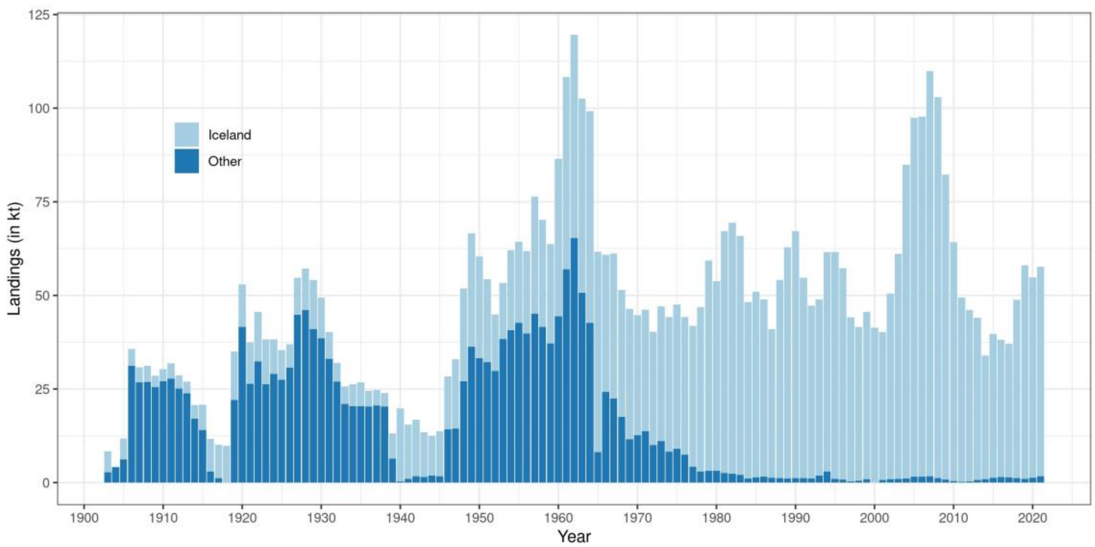

Figure 6: Haddock in 5a. Recorded landings since 1905.

DATA AVAILABLE

In general sampling is considered good from commercial catches from the main gears (demersal seines, longlines and trawls). The sampling does seem to cover the spatial and seasonal distribution of catches (see Figure 7and Figure 8. 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.

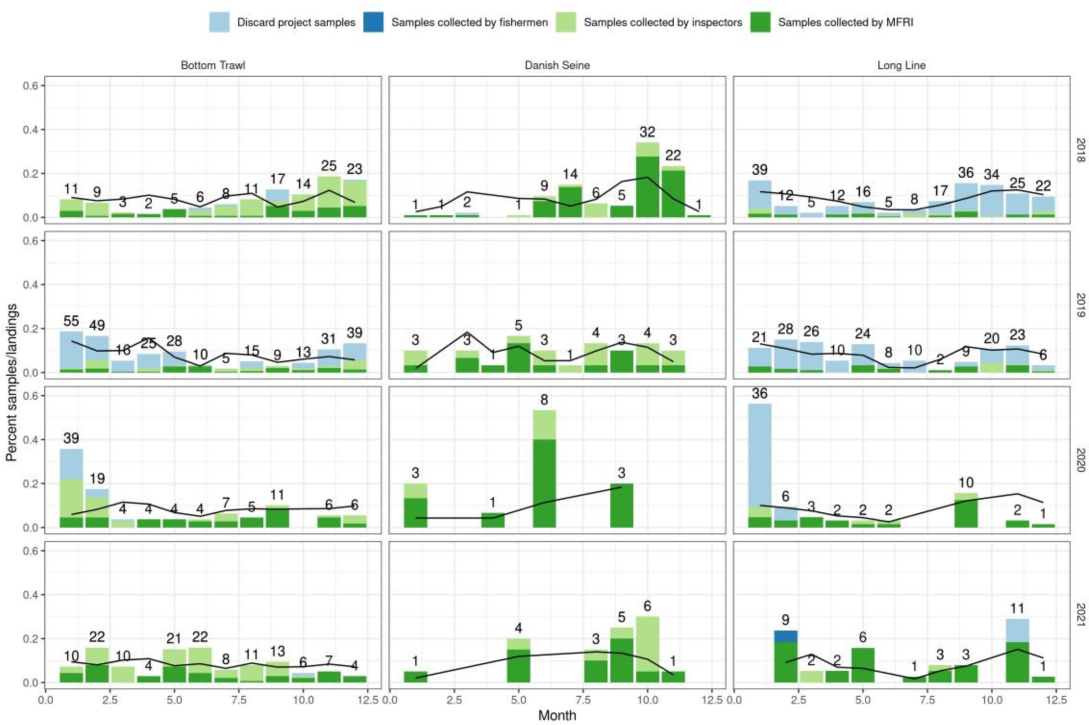

Figure 7: Haddock in 5a. Ratio of samples by month (blue bars) compared with landings by month (solid black line) split by year and main gear types. Numbers of above the bars indicate number of samples by year, month and gear.

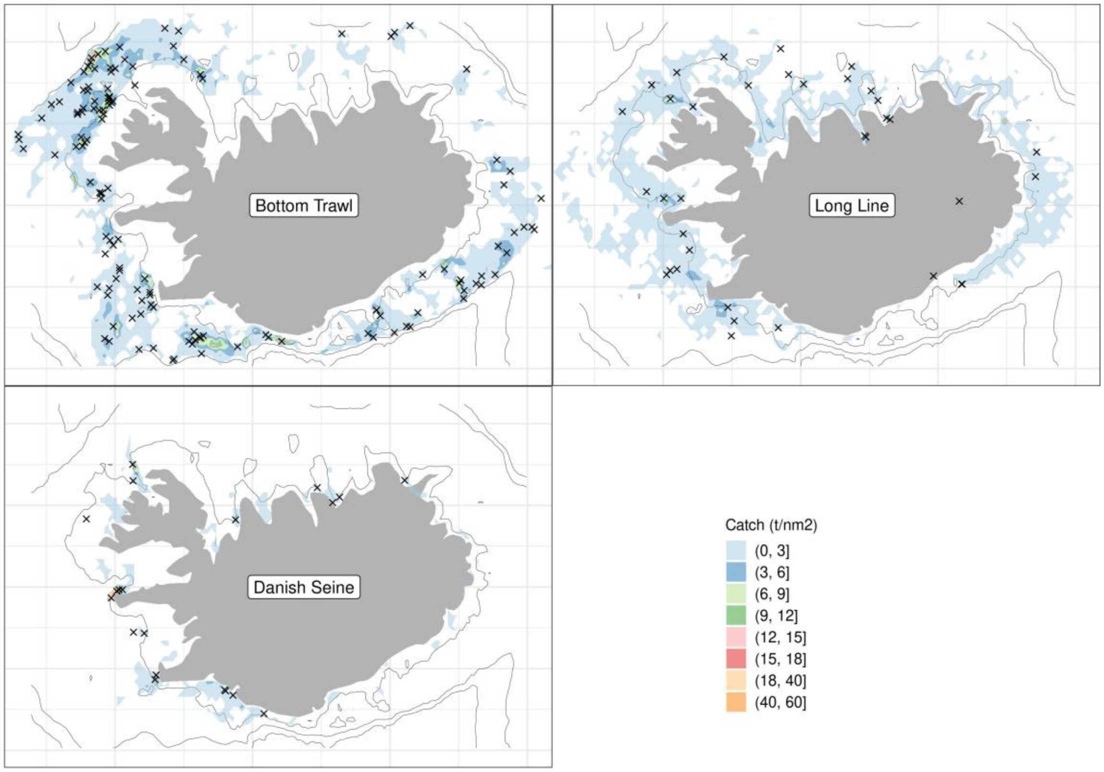

Figure 8: Haddock in 5a. Fishing grounds in 2019 as reported in logbooks (contours) and positions of samples taken from landings (crosses) by main gear types.

LANDINGS AND DISCARDS

All landings in 5a before 1982 are derived from the STATLANT database, and also all foreign landings in 5a to 2005. The years between 1982 and 1993 landings by Icelandic vessels were collected by the Fisheries Association of Iceland (Fiskifélagið). Landings after 1994 by Icelandic vessels are given by the Icelandic Directorate of Fisheries. Landings of foreign vessels (mainly Norwegian and Faroese vessels) are given by the Icelandic Coast Guard prior to 2014 but after 2014 this are also recorded by the Directorate. Discarding is banned by law in the Icelandic demersal fishery. Based on annual discards estimates since 2001, discard rates in the Icelandic fishery for haddock due to highgrading are estimated very low in recent years (<3% in either numbers or weight, see MRI (2016) for further details) while historically discards may have been substantial in the early 1990s. Measures in the management system such as converting quota share from one species to another are used by the fleet to a large extent and this is thought to discourage discarding in mixed fisheries. In addition to prevent high grading and quota mismatch the fisheries are allowed to land fish that will not be accounted for in the allotted quota, provided that the proceedings when the landed catch is sold will go to the Fisheries Project Fund (*Verkefnasjóður sjávarútvegsins*). A more detailed description of the management system can be found on https://www.responsiblefisheries.is/seafood-industry/management-and-control-system/.

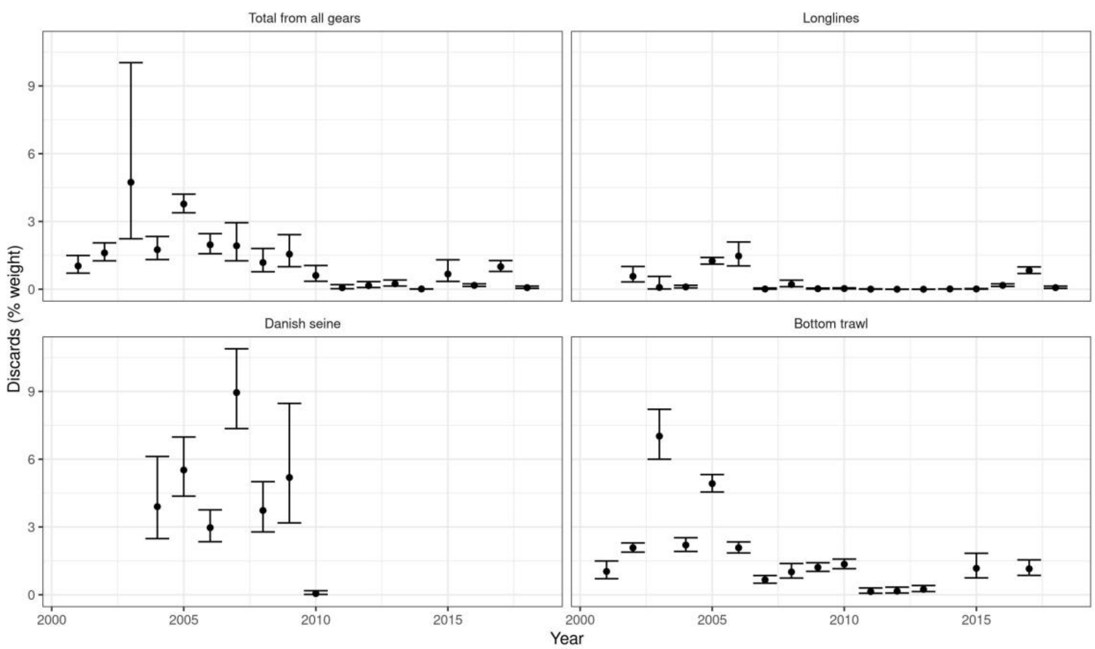

Figure 9: Haddock in 5a. Estimates of annual discards by gear. Verical lines indicate the 95 % confidence interval while dots the point estimates. No estimates are available since 2018 at this time.

LENGTH COMPOSITIONS

The bulk of the length measurements are from the three main fleet segments, i.e. trawls, longlines and demersal seine. 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 Figure 10. The sizes caught by the main gear types (bottom trawl and longlines) appear to be stable, primarily catching haddock in the size range between 40 and 70 cm. Gillnets tend to catch slightly larger fish and modes of the length distribution varies more depending on the availability of large haddock.

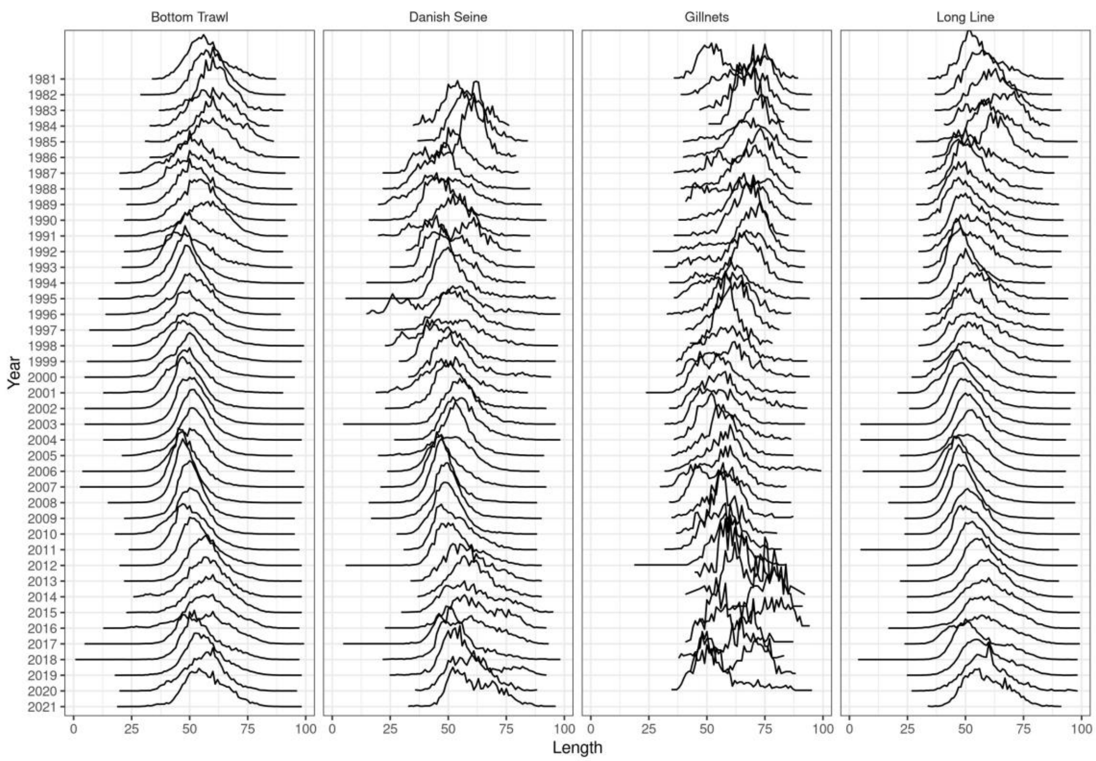

Figure 10: Haddock in 5a. Commercial length distributions by gear and year

AGE COMPOSITIONS

Catch in numbers-at-age is shown in Figure 11. The catches in 2021 are mainly composed with the 2014-2017 year classes. The number of year classes contributing to the catches is unusually many; the result of low fishing mortality in recent years and the last year class contributing with more that 1% of total is 11 years old (fig. 12).

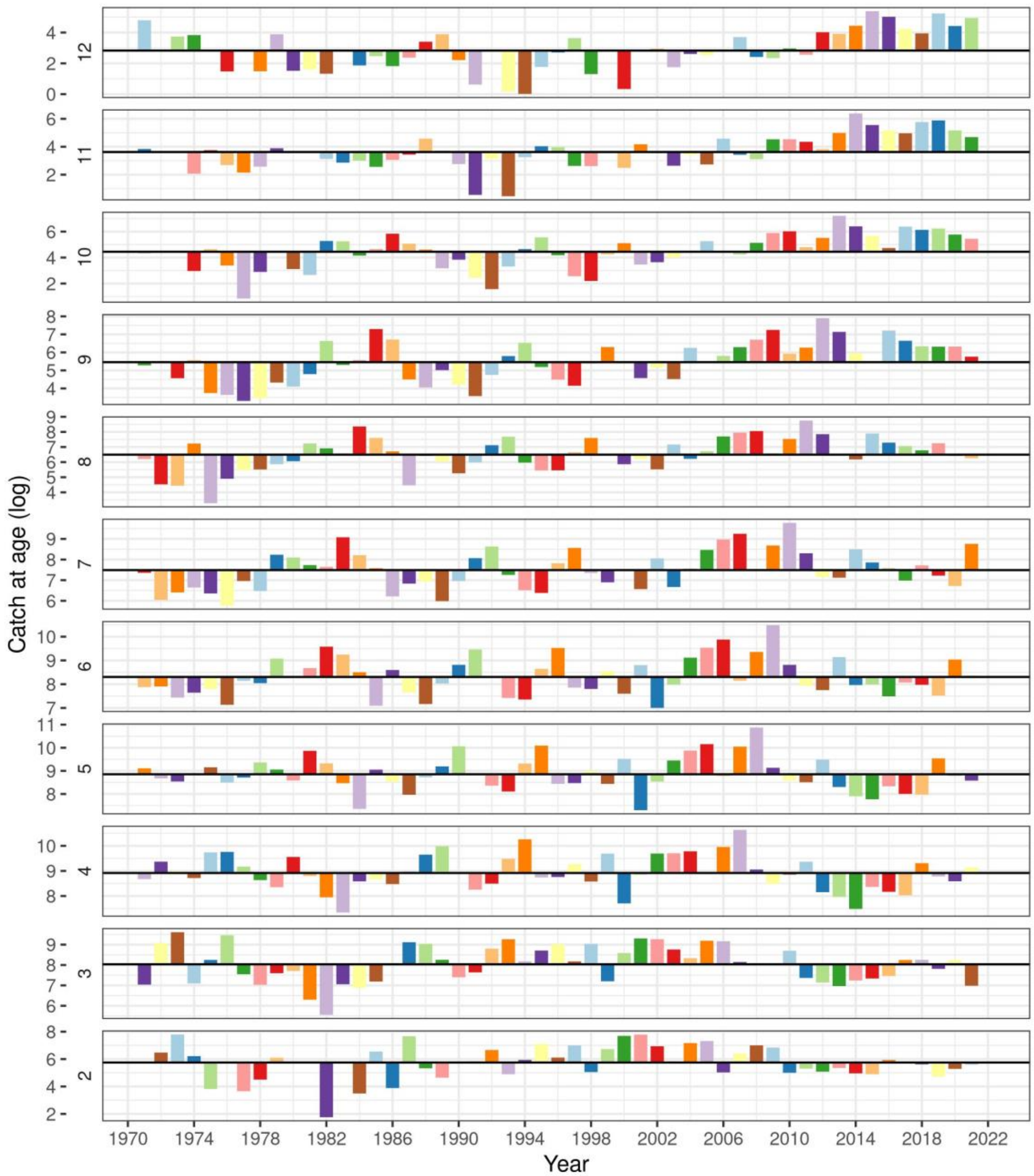

Figure 11: Haddock in 5a. Catch at age from the commercial fishery in Iceland waters. Bar size is indicative of the catch in numbers and bars are colored by cohort.

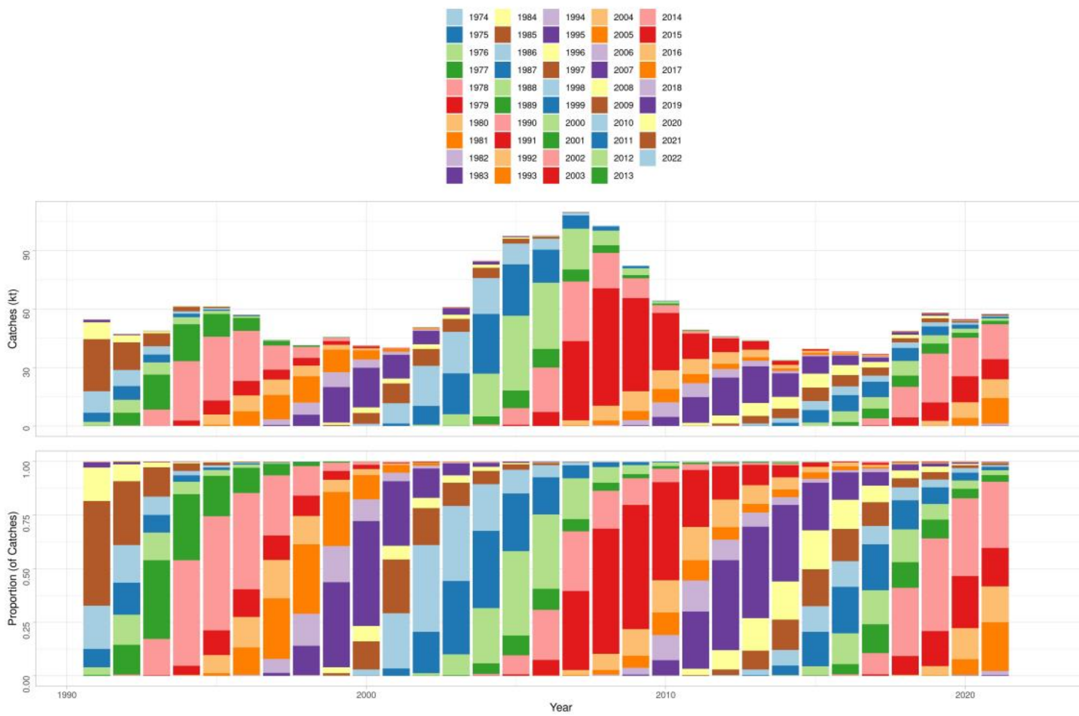

Figure 12: Haddock in 5a. Catch at age from the commercial fishery in Iceland waters. Biomass caught by year and age, bars are colored by cohort.

WEIGHT AT AGE IN THE CATCH

Mean weight at age in the catch is shown in Figure 13. Catch weights of the older year classes have been increasing in recent years, after being very low when the stock was large between 2005 and 2009. Higher mean weight at age is most apparent for the younger haddock from the small cohorts (2008–2013), which has resulted in a mean weight of the old fish above average. Mean weight of younger year classes in the catches has decreased but is still above average.

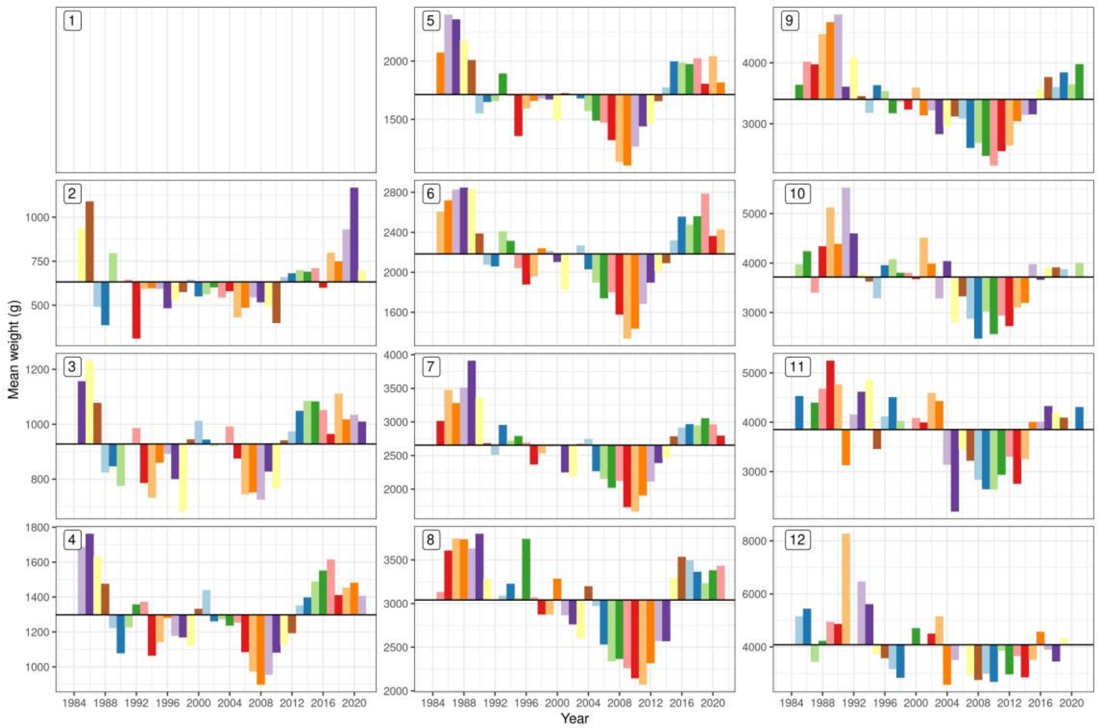

Figure 13: Haddock in 5a. Catch weights from the commercial fishery in Icelandic waters. Bars are coloured by cohort.

NATURAL MORTALITY

No information is available on natural mortality. For assessment and advisory purpose, the natural mortality is set to 0.2 for all age groups.

CATCH, EFFORT AND RESEARCH VESSEL DATA

CATCH PER UNIT OF EFFORT FROM COMMERCIAL FISHERIES

Catch per unit of effort data (Figure 14 shows that for hauls where the catch is composed of more than 50 % haddock the CPUE has been steadily increasing since 1990 for the main gear types. The CPUE from all catches from bottom trawls and demersal seine is amongst the highest recorded while for longlines it is fairly low. This is in-line with fishermen's perception that it is easy to catch haddock. This gives a different picture of the development of the stock than that which is observed in surveys and assessment, much less increase after 2000 and much less decrease in recent years. However, it is worth noting that there is also a considerable change in the size composition of the stock, where the biomass of 60 cm and above is at the highest observed in the time series, while the total biomass is close to it average value, suggesting that the CPUE may be more representative of larger fish.

There are also considerable differences in the CPUE by area, where the area north of Iceland has seen a continuous increase while the southern regions are more consistent with the total biomass index from the spring survey. Bycatch is of little concern as the haddock is commonly targeted in specific catch mixtures.

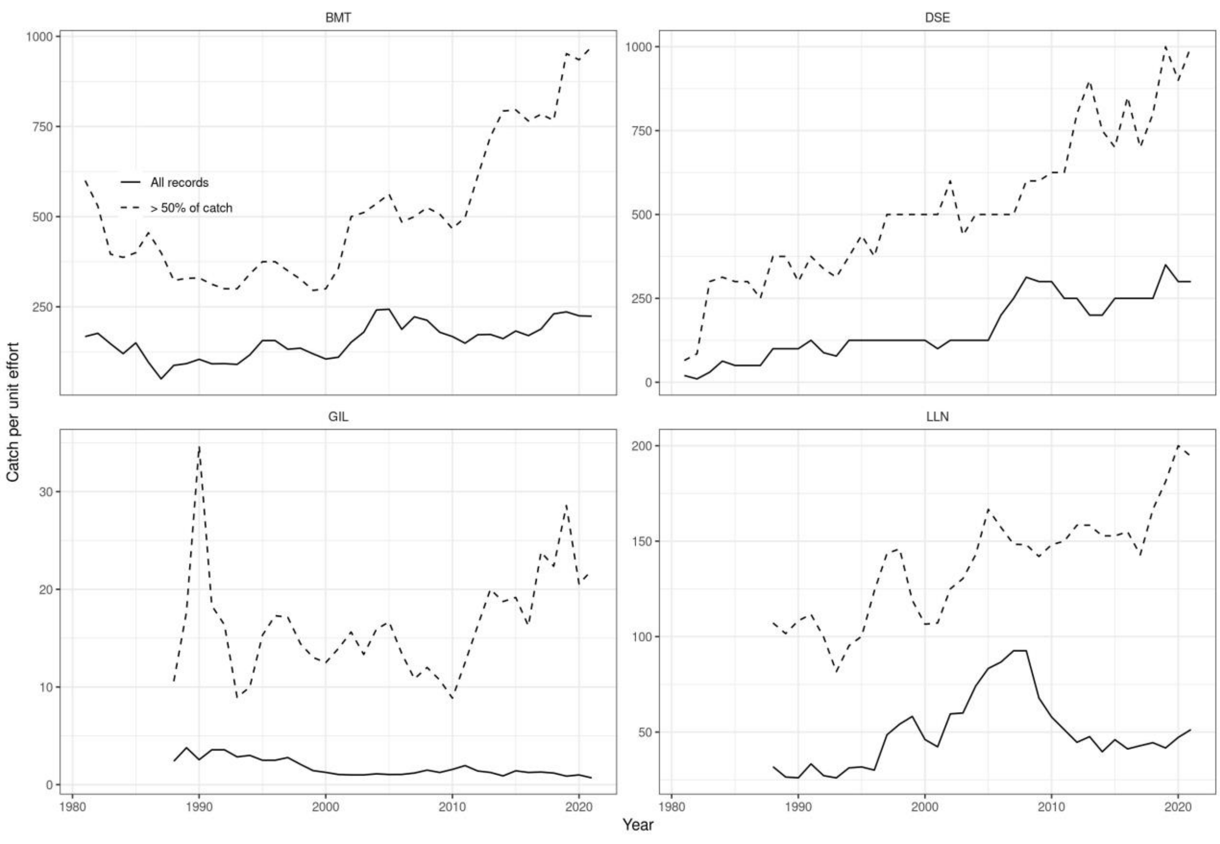

Figure 14: Haddock in 5a. Catch per unit of effort in the most important gear types. The dashed lines are based on locations where more than 50% of the catch is haddock and solid lines on all records where haddock is caught. A change occurred in the longline fleet starting September 1999. Earlier only vessels larger than 10 BRT were required to return logbooks but later all vessels were required to return logbooks.

ICELANDIC SURVEY DATA

Information on abundance and biological parameters from Haddock in 5a is available from two surveys, the Icelandic groundfish survey in the spring and the Icelandic autumn survey.

The Icelandic groundfish survey in the spring, which has been conducted annually since 1985, covers the most important distribution area of the haddock fishery. The autumn survey commenced in 1996 and expanded in 2000 to include deep water stations. It provides additional information on the development of the stock. The autumn survey has been conducted annually except for 2011 when a full autumn survey could not be conducted due to a fisherman strike. Although both surveys were originally designed to monitor the Icelandic cod stock, the surveys are considered to give a good indication of the haddock stock, both the juvenile population and the fishable biomass. A detailed description of the Icelandic spring and autumn groundfish surveys is given in the Stock Annex. Figure 15 shows both a recruitment index and the trends in various biomass indices. Changes in spatial distribution observed in the spring survey are shown in Figure 16. The figure shows that a larger proportion of the observed biomass now resides in the north (areas NW and NE). Survey length distributions are shown in Figure 18 (abundance) and changes in spatial distribution in Figure 17.

Both surveys show much increase total biomass between 2002 and 2005 but considerable decrease from 2007–2010. The difference in perception of the stock between the surveys is that the autumn survey shows less contrast between periods of large and small stock. The 2015 estimate from the autumn survey exhibited substantially lower biomass compared to adjacent years. The contrast between the surveys appears to be starker when looking at the biomass of 60 cm and larger, but both surveys show that the 60 cm$^+$ is at its maximum in recent years.

Age disaggregated indices from the March survey are shown in Figure 19. Similar to the biomass of 60 cm$^+$ the index of age 11^+ higher than seen before in March survey. This is assumed to be related to lower fishing mortality after the establishment of a management plan for haddock in 5a. After a period of low recruitment, the biomass for other age groups is near the geometric mean in both surveys.

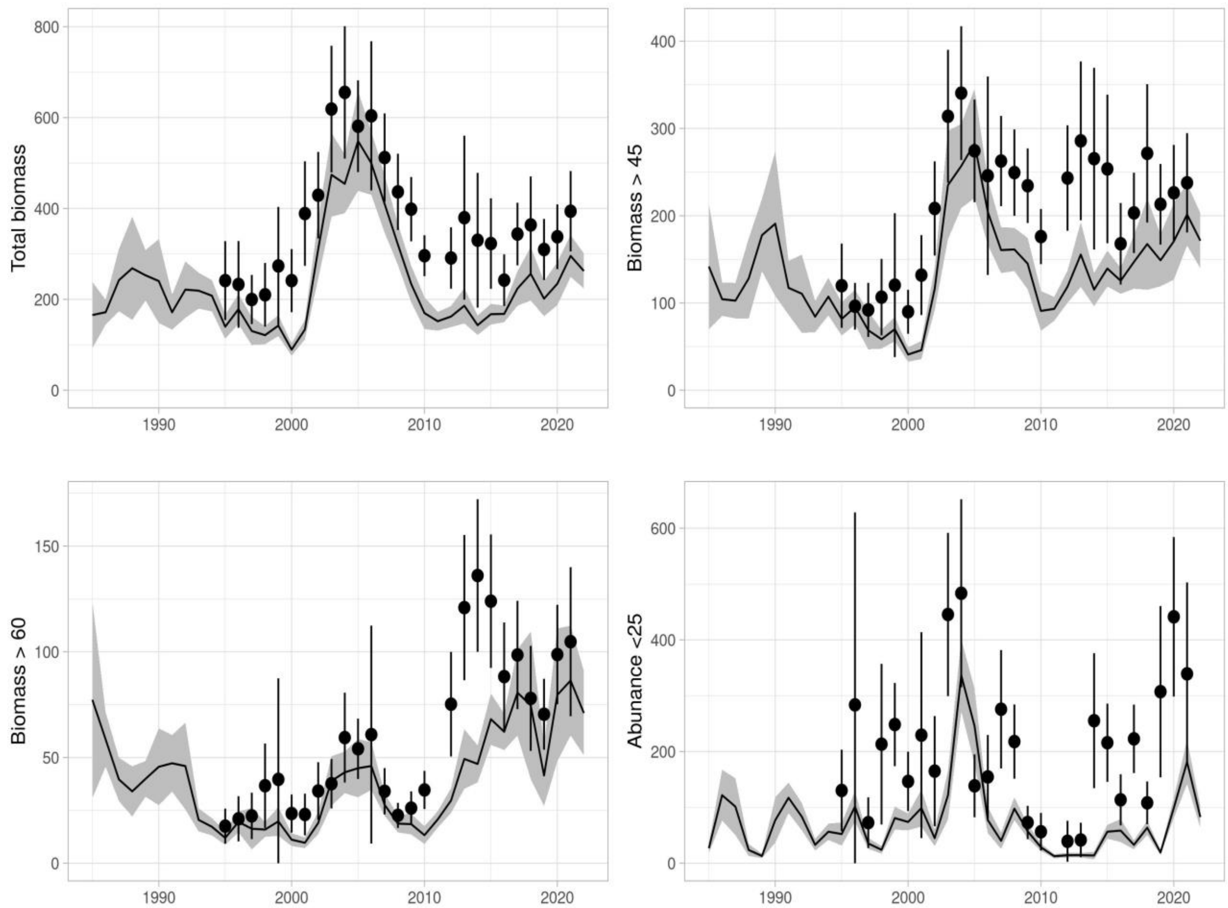

Figure 15: Haddock in 5a. Indices in the Spring Survey (March) 1985 and onwards (line shaded area) and the autumn survey (point ranges).

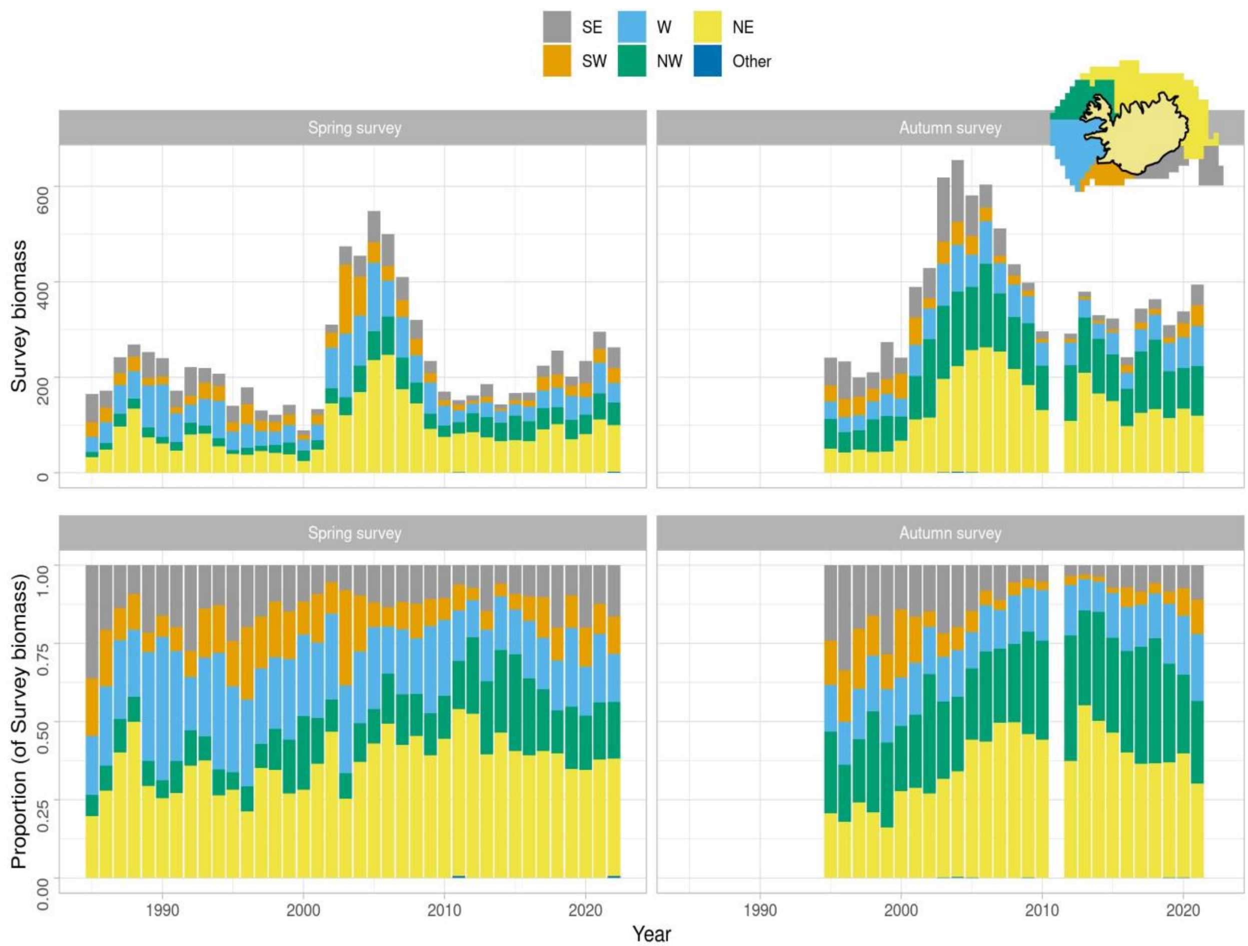

Figure 16: Haddock in 5a. Changes in geographical distribution of the survey biomass.

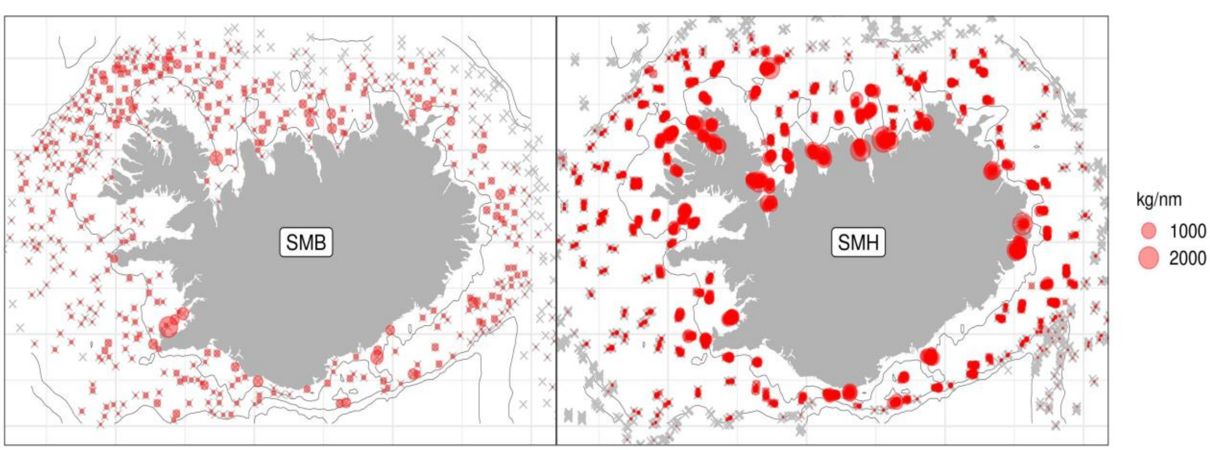

Figure 17: Haddock in 5a. Location of haddock in the March (SMB) and the Autumn (SMH) survey, bubble sizes are relative to catch sizes.

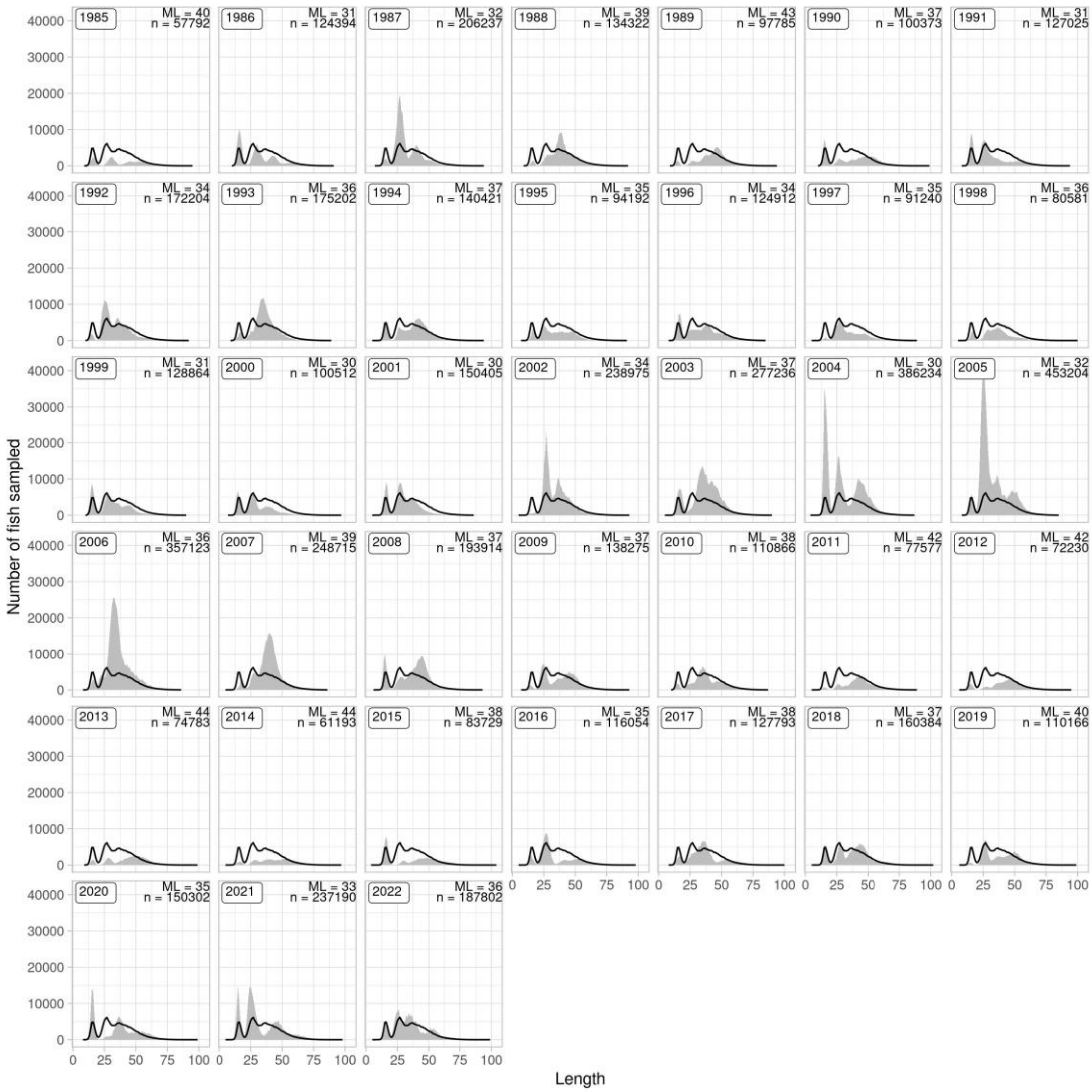

Figure 18:: Haddock in 5a. Length disaggregated abundance indices from the March survey 1985 and onwards.

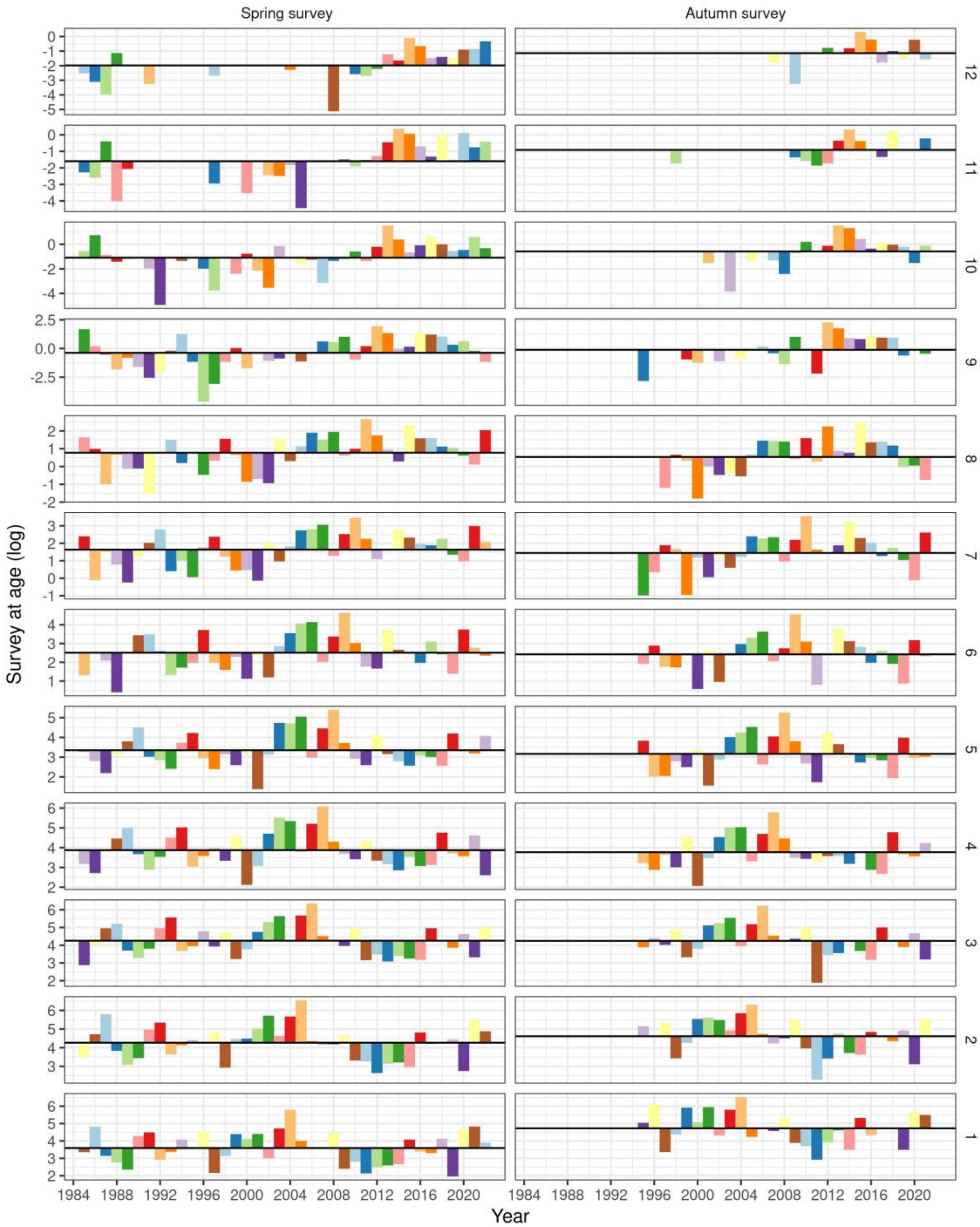

Figure 19: Haddock in 5a. Age disaggregated indices in the Spring Survey (left) and the autumn survey (rights). Bars indicated the deviation from the log mean index, fill colors indicate cohorts. Note different scales on y-axes.

STOCK WEIGHT AT AGE

Mean weight at age in the catch is shown in Figure 13. Stock weights are obtained from the groundfish survey in March and are also used as mean weight at age in the spawning stock. Both stock and catch weights of the older year classes have been increasing in recent years, after being very low when the stock was large between 2005 and 2009. Higher mean weight at age is most apparent for the younger haddock from the small cohorts (2008–2013), which has resulted in a mean weight of the old fish above average. Mean weight of younger year classes has decreased but is still above average.

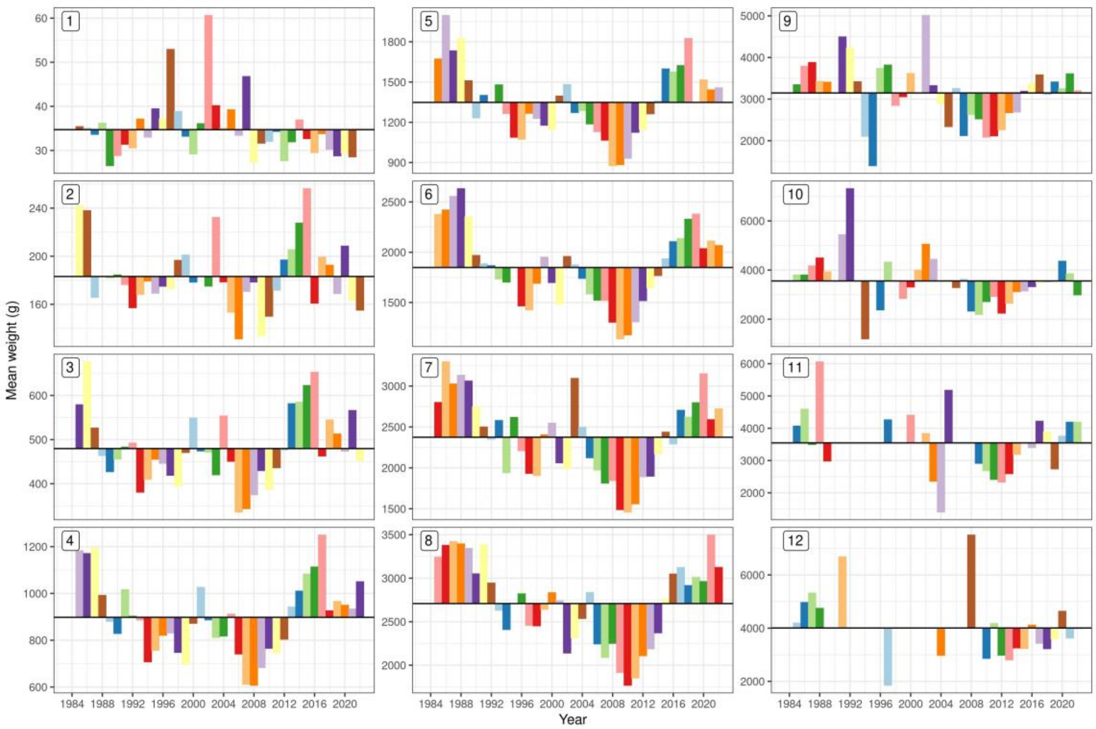

Figure 20: Haddock in 5a. Stock weights from the March survey in Icelandic waters. Bars are coloured by cohort.

STOCK MATURITY AT AGE

Maturity-at-age data are shown Figure 21. Those data are obtained from the groundfish survey in March. Maturity-at-age of the youngest age groups has been decreasing in recent years which is likely to be related to the distributional shift towards the north. Maturity by size has been decreasing and the most likely explanation is large proportion of those age groups north of Iceland where proportion mature has always been low, as illustrated in figure 22.

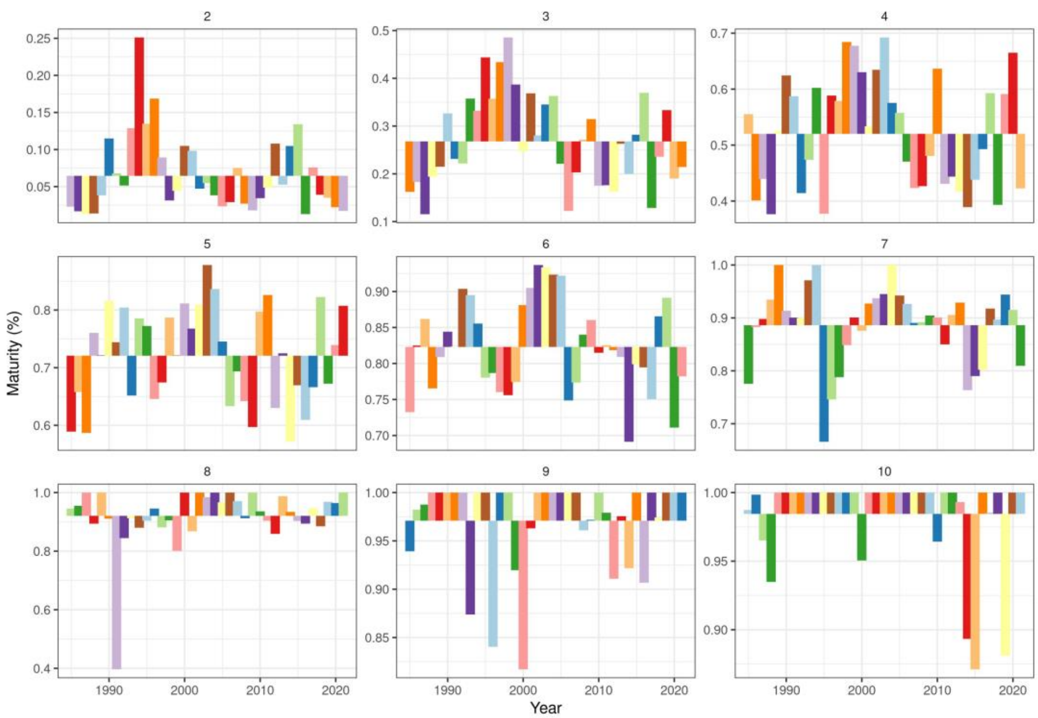

Figure 21: Haddock in division 5a. Maturity at age in the survey. Bars are coloured by cohort. The values are used to calculate the spawning stock.

Figure 22: Haddock in 5a. Geographical differences in proportion mature by year and age (top), and stock weights (below).

DATA ANALYSES

ANALYTICAL ASSESSMENT

This stock was last benchmarked in 2019 (WKICEMSE 2019), but the model had been used in parallel to the previous assessment since 2013. A management plan for haddock in 5a based on this assessment was tested at the same meeting and subsequently implemented by the government of Iceland in the same year.

The assessment model used is a statistical catch–at-age model described in Björnsson, Hjörleifsson, and Elvarsson (2019). The model runs from 1979 onwards and ages 1 to 10 are tracked by the model, where the age of 10 is a plus group. Natural mortality is set to 0.2 for all age groups. Selection pattern of the commercial fleet is defined in terms of mean stock weights at age, rather than age, based on a logit selection function:

$$S_{a,y} = \frac{1}{1 + e^{-\alpha\left(\log(sW_{a,y}) - \log(W_{50})\right)}}$$

The rationale for this choice, compared to a more traditional age-based selection, is to account for observed changes in growth between year classes. Larger year classes tend to have lower mean weight compared to smaller year classes, as observed in Figure 13. As fishery selection is mainly size based, the assessment model using a size-based selection only requires two parameters to estimate the selection pattern. In contrast an age-based selection pattern would require parameter based on multiple selection time periods.

The weights to the survey data are based on a common multiplier to the variance estimates of each age group and survey obtained from a backwards calculation model (described in Björnsson, Hjörleifsson, and Elvarsson 2019), shown in Figure 23.

The ratio of fishing and natural mortality before spawning was set at 0.4 and 0.3 respectively as haddock is known to spawn in the period between April till the end of May.

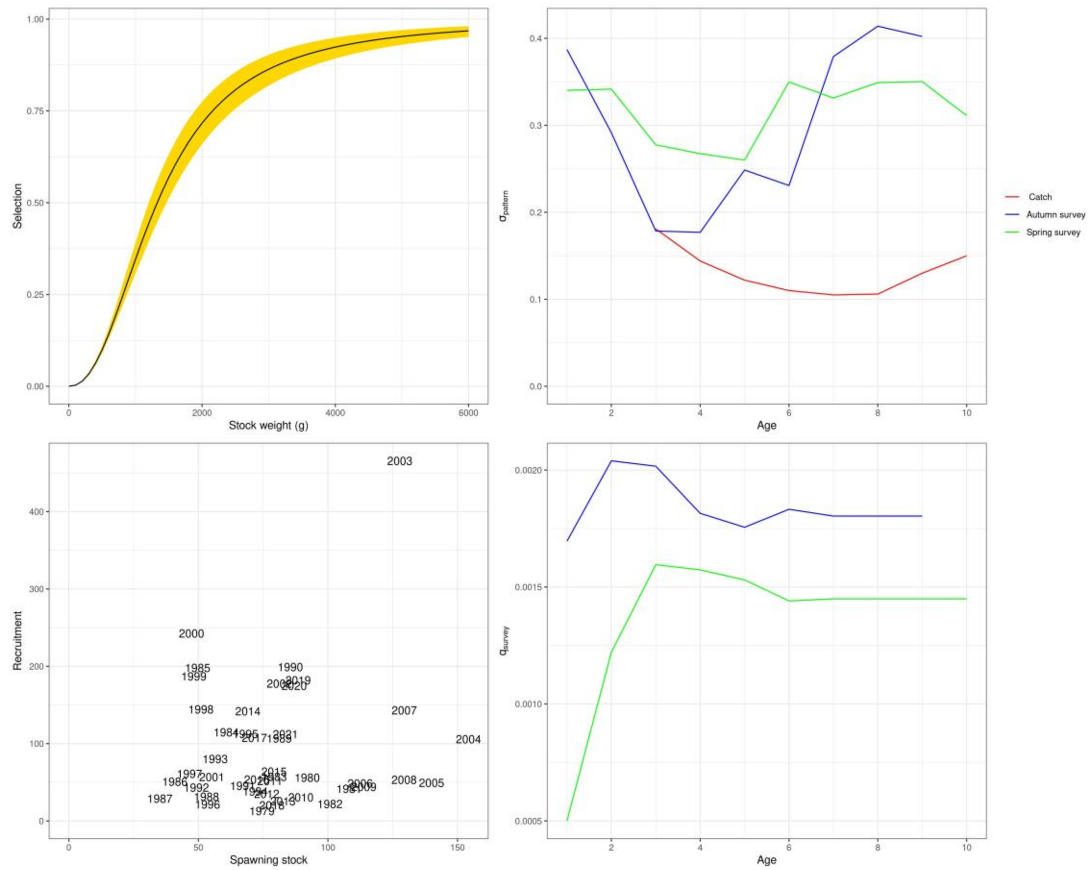

Figure 23: Haddock in 5a. Estimated selection by weight, CV pattern, stock recruitment relationship and survey catchability.

DATA USED BY THE ASSESSMENT

The assessment relies on four sources of data, that are described above. These are the two surveys, commercial samples, and landings. The commercial data is used to compile catch at age data that enter the likelihood along with the survey at age from both surveys. Stock weights and catch weights at age are derived from the spring survey and catches respectively. The maturity data is similarly collected in the spring survey. Prior to 1985, when the spring survey started, stock weights and maturity at age were assumed constant at the 1985 values. A full description of the preparation of the data used for tuning and as input is given in the stock annex (see ICES (2019)).

DIAGNOSTICS

The fit to data is illustrated in Figure 25 where no concerning residual patterns are observed. When looking at the combined fit (Figure 24) the figure shows the observed vs. predicted biomass from the surveys and it indicates that historically the autumn survey biomass has been closer to the prediction than corresponding values from the March survey, where the contrast in observed biomass is more than predicted from the assessment. The model accounts for this by estimating a stronger residual correlation for the spring survey (0.527) compared with the autumn survey (0.193). When contrasting the biomass levels before and after the mid 2000's peak, the autumn survey suggests that the biomass level after the peak biomass is higher while the spring survey is at similar levels. Thus, the model appears to fall in a region between the two surveys. The discrepancy appears to be in the largest age groups where the age indices from the autumn survey are overpredicted in recent years, suggesting that older age groups observed in the March survey are not observed to the same degree in the October survey. Related to this figure, Figure 23 shows the estimated "catchability" and CV as a function of age for the surveys, showing that estimated CV is lower is generally lower for ages 2–6, whereas the CV increases faster by age for the autumn survey compared with the spring survey.

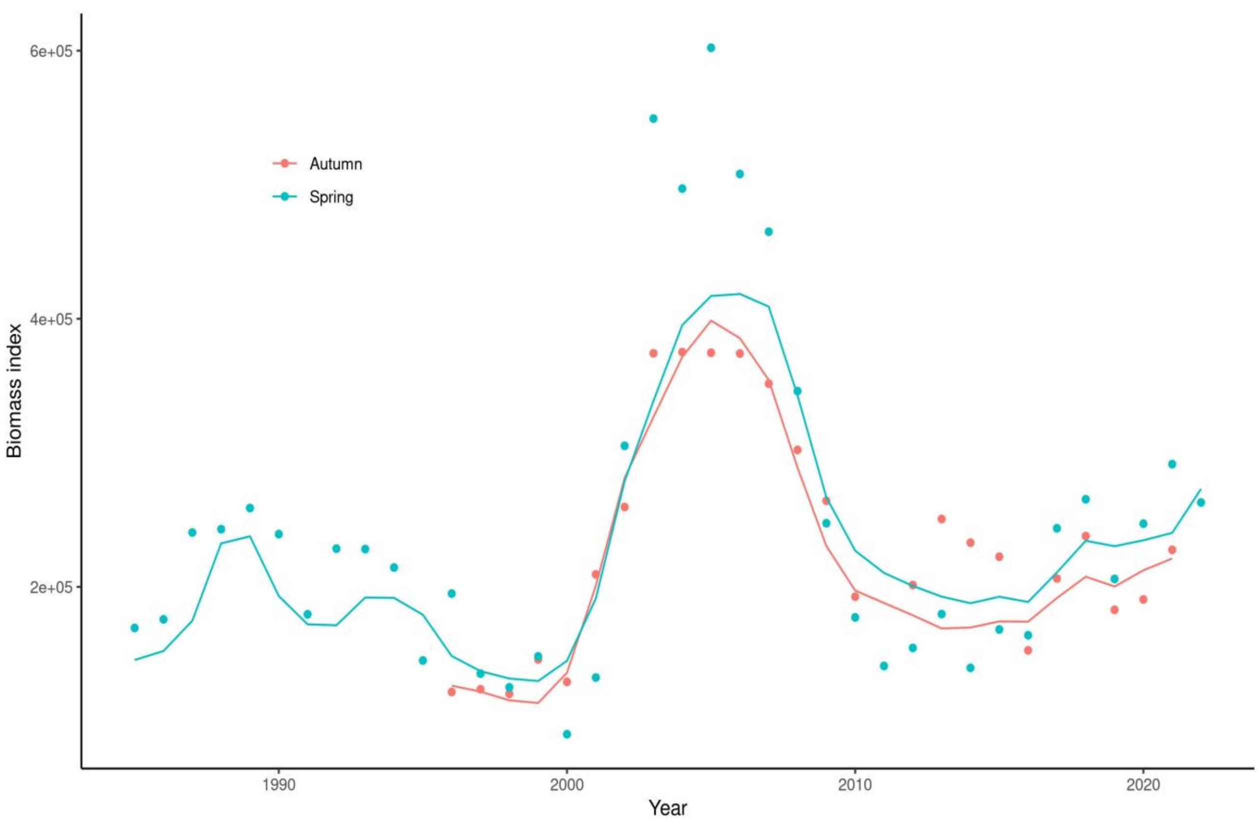

Figure 24: Haddock in division 5a. Aggregated model fit to the total biomass indices.

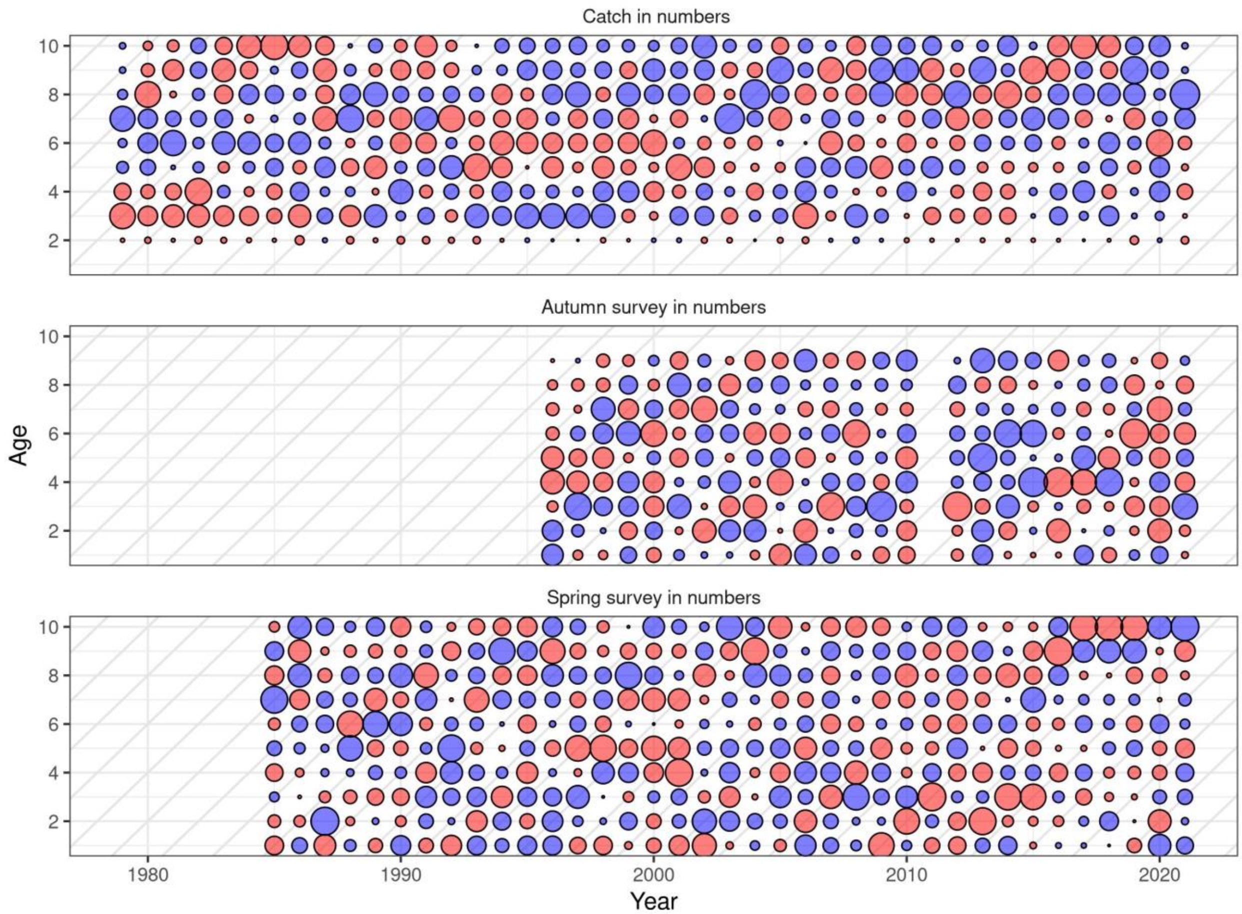

Figure 25: Haddock in division 5a. Residuals from the model fit to survey and catch data based on the both the surveys. Red circles indicate negative residuals (observed < modelled), while blue positive. Residuals are proportional to the area of the circles.

MODEL RESULTS

The results of the assessment indicate that the stock decreased from 2008–2011 when large year classes disappeared from the stock and were replaced by smaller year classes (Figure 26). Since 2011 the rate of reduction has slowed down as fishing mortality has been low. The spawning stock has, however, decreased more than the reference biomass as the proportion mature by age/size has been decreasing. Fishing mortality is now estimated to be low and is in line with the overall goal of the currently implemented HCR. The baseline assessment does indicate that a bottom has been reached and the stock size will increase in the coming years. The main features of the baseline assessment are the same as in the assessments used between 2011 to 2018. The analytical retrospective (Figure 28) indicates a slight upwards revision in the most recent years. The assessment can however be considered fairly stable and the estimated 5-year Mohns's ρ are within acceptable range as illustrated in Figure 28.

Assessment in recent years has shown some difference between model runs where either or both of the two different tuning series, i.e. March and the October surveys, are omitted from the estimation, but currently this difference is mostly within the estimated uncertainty (Figure 27) but that has not always been the case. When the model is fitted with catch data the reference biomass is estimated to be increasing a much faster rate than the baseline assessment suggest.

Estimated selection is illustrated in Figure 29, where substantial variations in selection at age is estimated by the model. Haddock in Icelandic waters has exhibited substantial density dependence in growth, as illustrated in Figure 32.

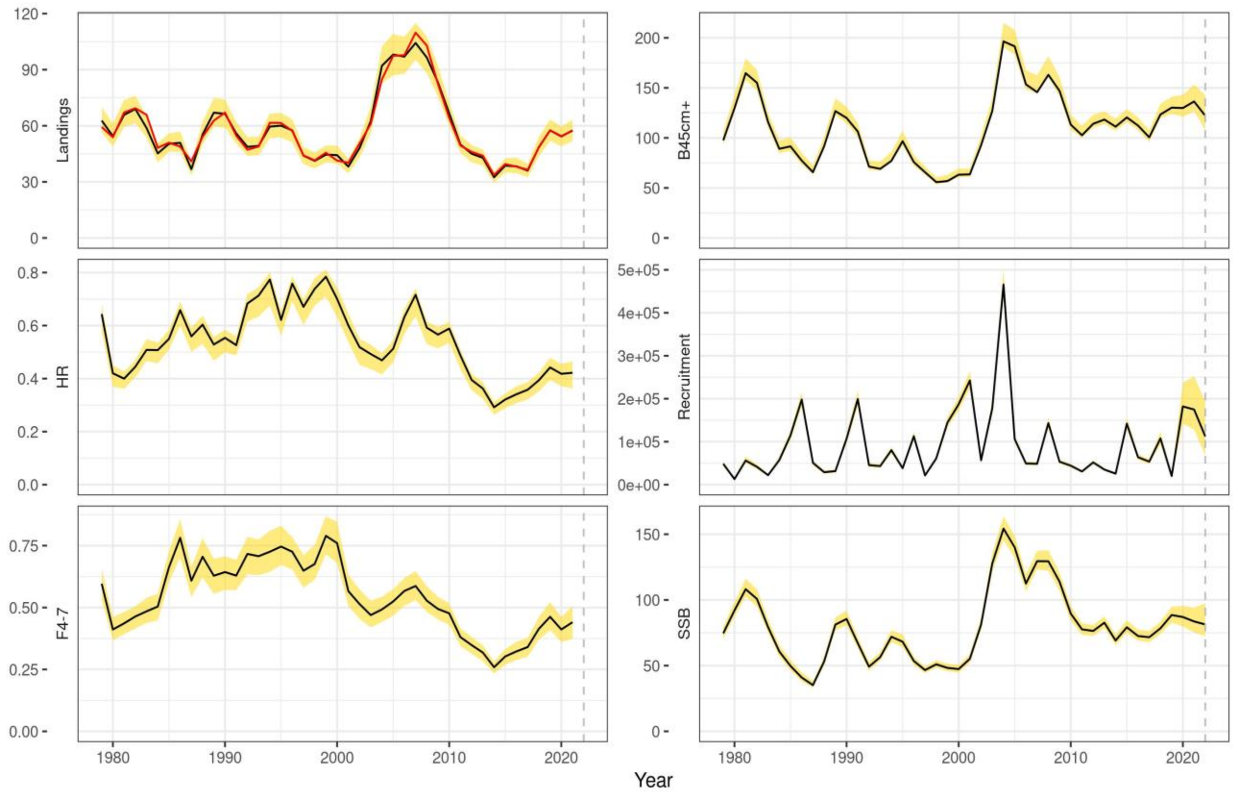

Figure 26: Haddock in division 5a. Summary from assessment. Dashed vertical line indicates the assessment year and yellow shaded region the uncertainty as estimated by the model.

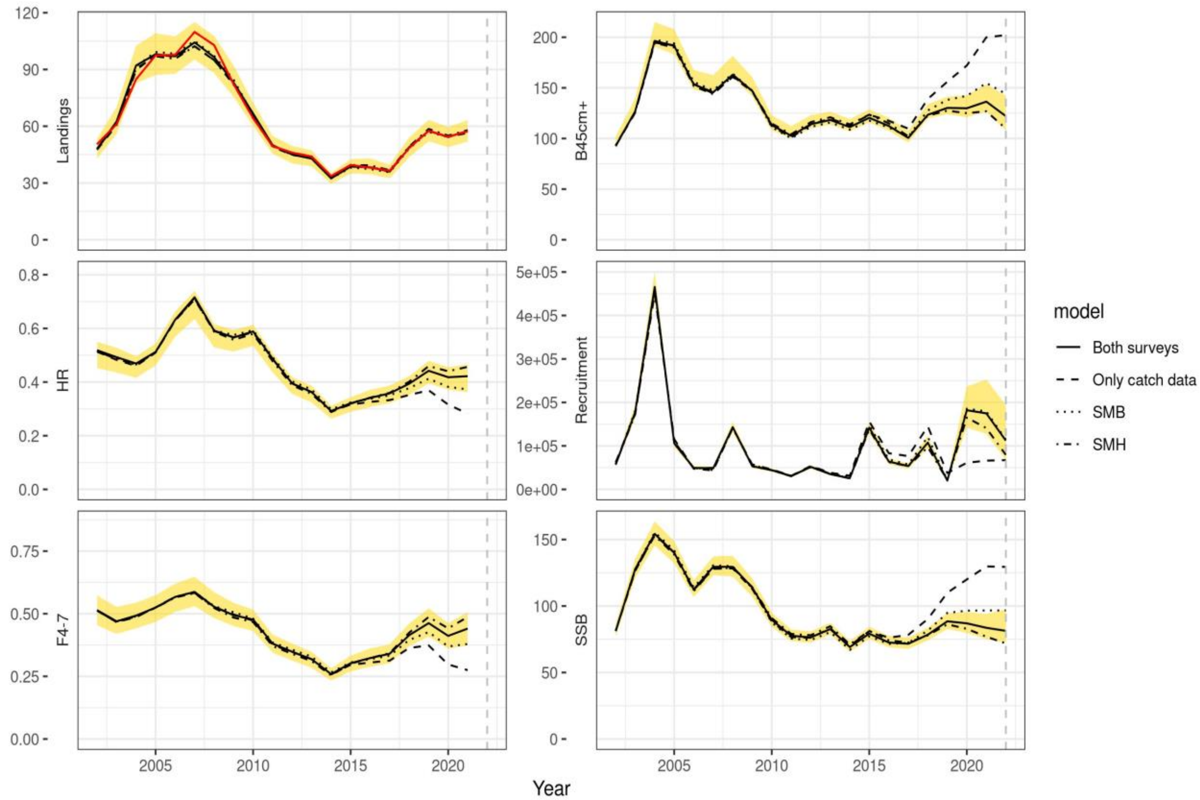

Figure 27: Haddock in 5a. Comparison of assessment results where either the spring survey or the autumn survey is omitted from the estimation.

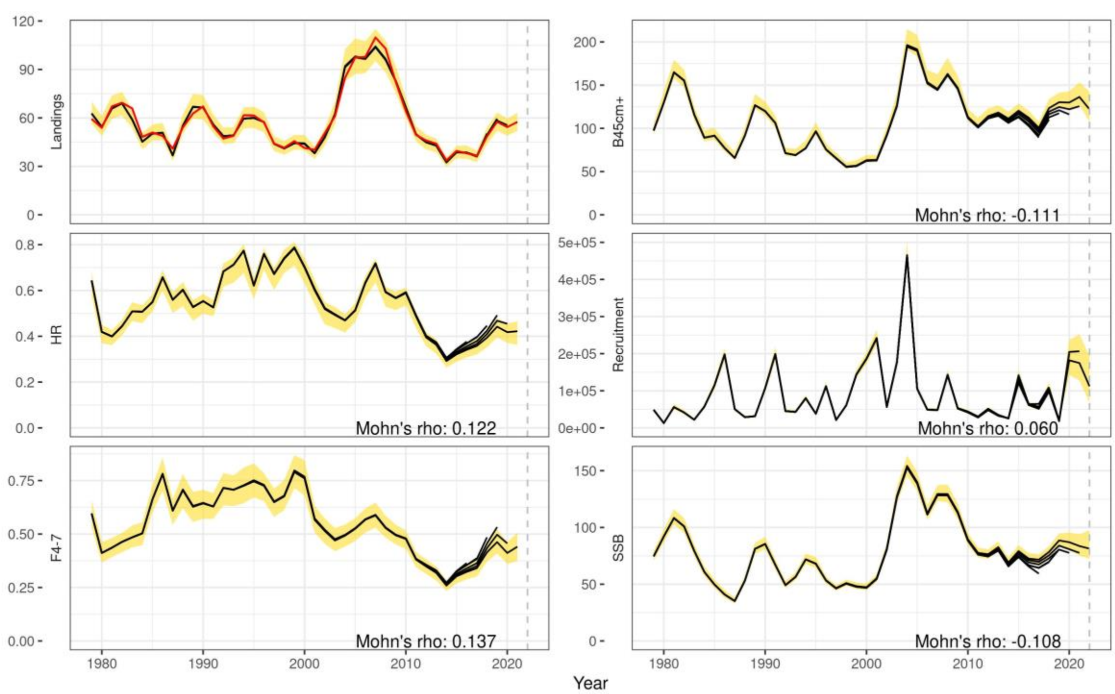

Figure 28: Haddock in division 5a. Analytical retrospective analysis of the assessment of haddock with a 5 year peel.

Figure 29: Haddock in 5a. Estimated selection at age.

SHORT TERM PROJECTIONS

Following the management plan the advice for the coming fishing year (2022/2023) is based in the biomass of 45 cm$^+$ at the beginning the next calendar year (2023). To arrive at this prediction a deterministic projection of the growth in weight and changes in maturity in the coming calendar year is needed. Growth in 2023 is predicted by the equation:

$$log\left(\frac{W_{a+1,y+1}}{W_{a,y}}\right) = \alpha + \beta log(W_{a,y0}) + \delta_y$$

where according to the stock annex the factor δ_y for the assessment year (Figure 32) is the average of the points estimates of the growth factor in the two preceding years. Growth has been high but somewhat variable in recent years but was much less in when the stock was larger. Maturity, selection, catch weights at age and proportion of the biomass above 45cm$^+$ are then predicted from stock weights in 2022. When those values have been estimated the prediction is done by the same model as used in the assessment. The model works iteratively as the estimated TAC for the fishing year 2022/2023 has some effect of the biomass at the beginning of 2023, which the TAC is based on. This procedure is described in the detail in the stock annex.

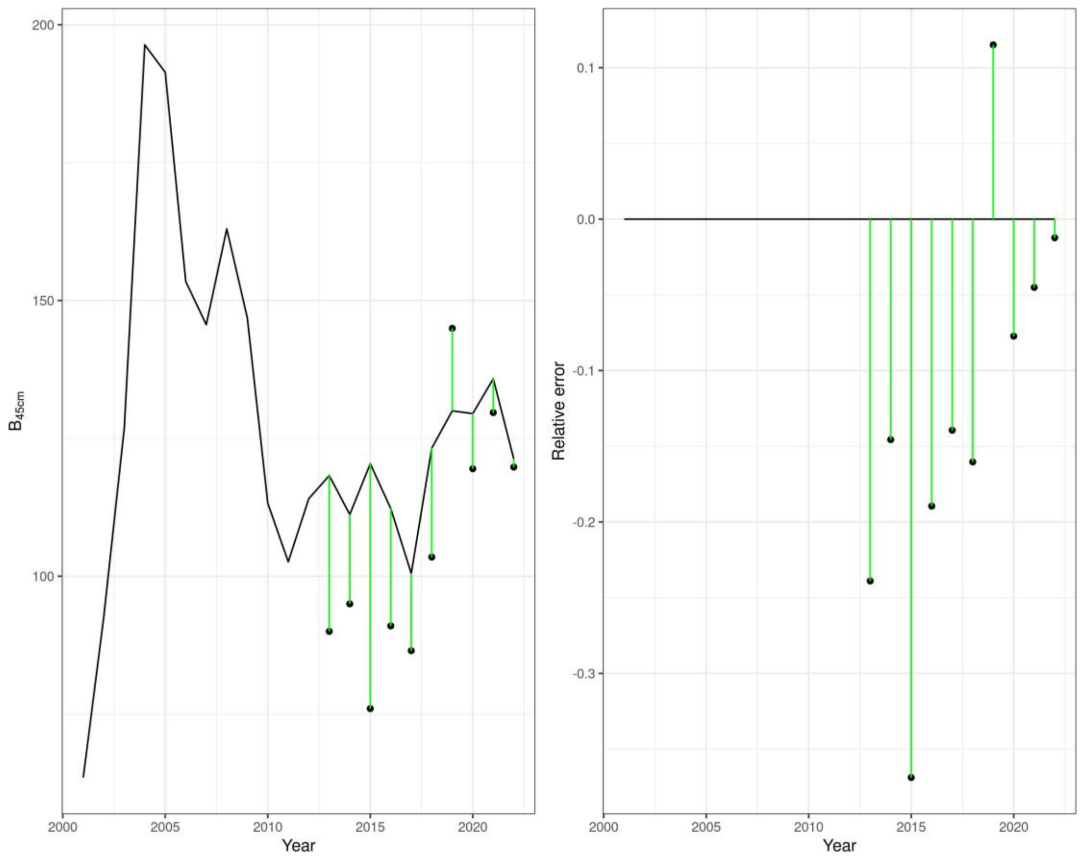

Figure 30: Haddock in 5a. Comparison of the short-term prediction of reference biomass to the realised value a year later.

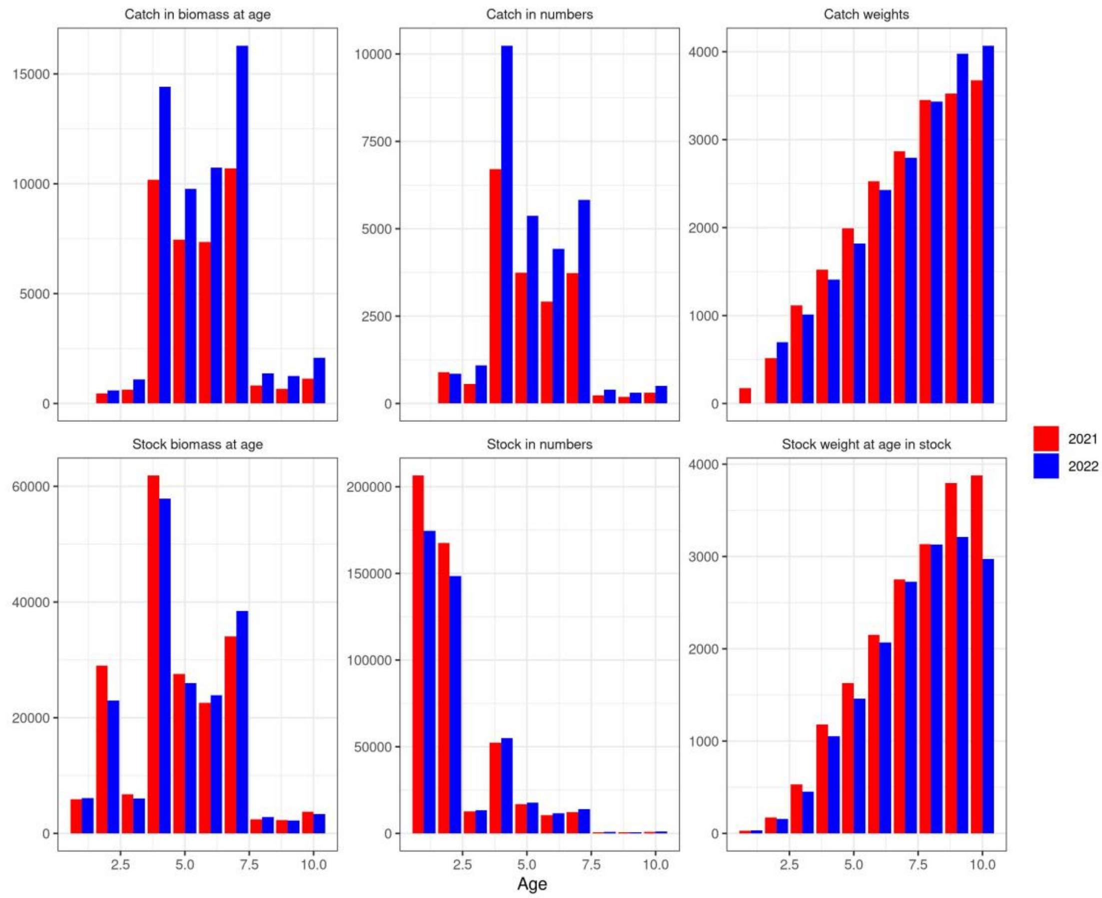

Figure 31: Haddock in 5a. Comparison of some of the results of 2019 assessment based on different tuning data and 2017 assessment tuned with both the surveys

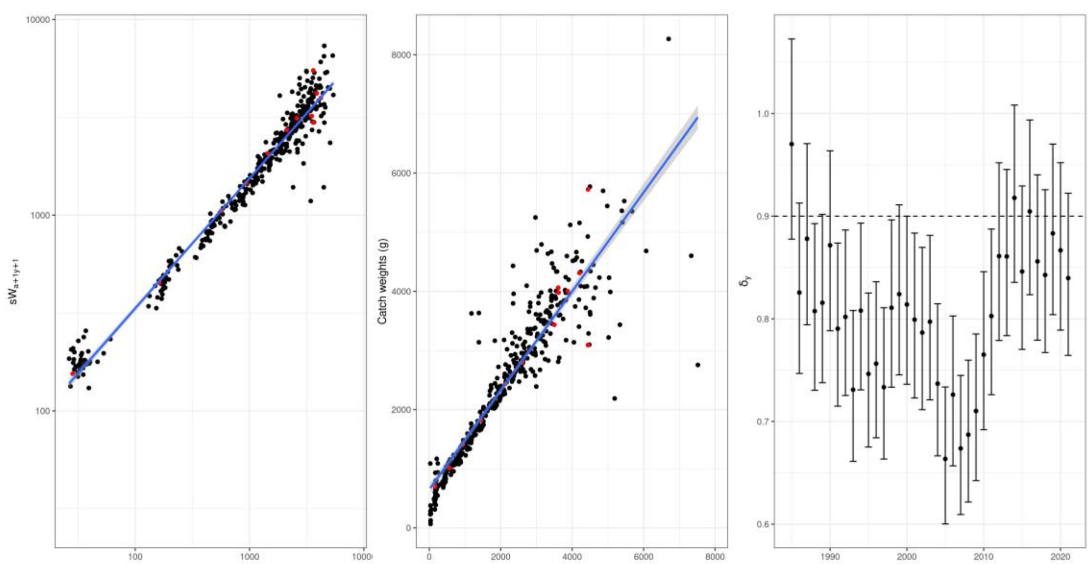

Figure 32: Haddock in 5a. Input data to prediction model, where the exponent of the yearfactor (growth multiplier) is estimated to derive the reference biomass in the advisory year, as described in the text.

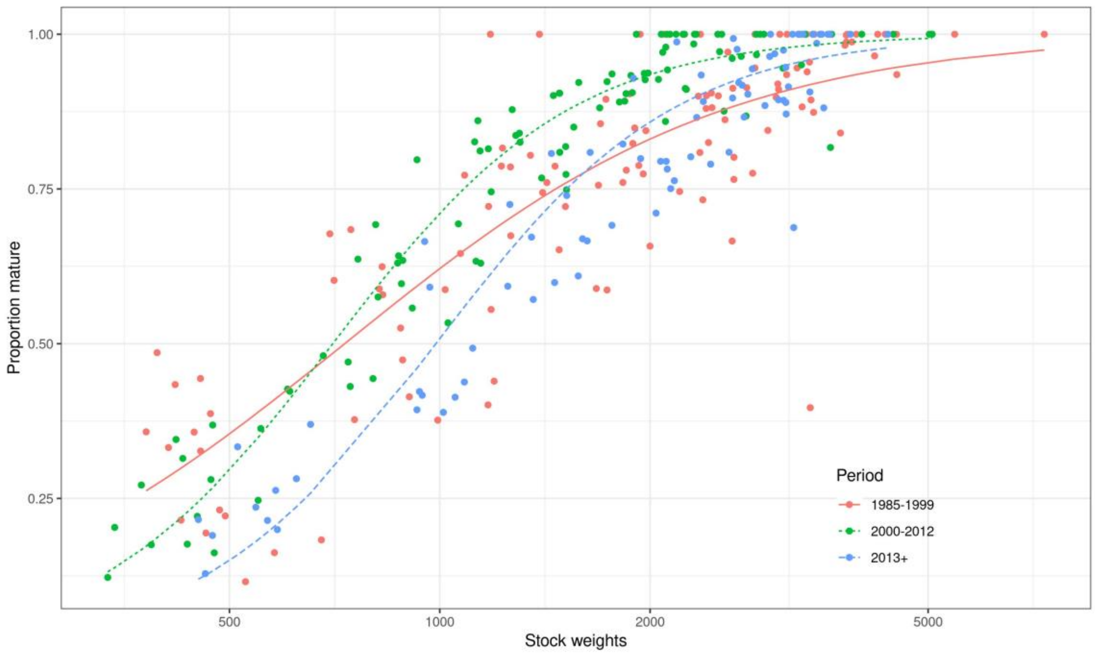

Figure 33: Haddock in 5a. Maturity at weight as used in the projections.

MANAGEMENT

The Icelandic Ministry of Food, Agriculture and Fisheries is responsible for management of the Icelandic fisheries and implementation of legislation. The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including an allocation of the TAC for each stock subject to such limitations. Haddock in 5a has been managed by TAC since the 1987. Landings have roughly followed the advice given by MFRI and the set TAC in all fishing years (Figure 34) . Since the 2001/2002 the catches have exceeded more that 5% the set TAC in seven fishing years. The largest overshoot in landings in relation to advice/TAC was observed in the fishing year 2007/2008 when the landings of haddock exceeded the advice by 11%. 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 (species transformation).

The TAC system does not include catches taken by Norway and the Faroe Islands by bilateral agreement. The level of those catches is known in advance but has until recently not been taken into consideration by the Ministry when allocating TAC to Icelandic vessels. There is no minimum landing size for Haddock in 5a. There are agreements between Iceland, Norway and the Faroe Islands relating to a fishery of vessels in restricted areas within the Icelandic EEZ. Faroese vessels are allowed to fish 5600 t of demersal fish species in Icelandic waters which includes maximum 1200 tonnes of cod and 40 t of Atlantic halibut.

The effect of these species transformations and quota transfers is illustrated in Figure 35. The figure illustrates that when the biomass of haddock was high in the years between 2002 to 2007 the net transfers to haddock from other species increased. This may in part be explained by shifts in distribution of haddock, as illustrated in Figure 5, as the fisheries that traditionally target the northern area had lower amounts of haddock in their quota portfolio. However, looking over longer period quota transfer towards/from haddock has on the average been close to zero. With the establishment a management plan in 2013 the transfers between quota years have decreased substantially, while at the same time transfers from other species have increased. This is likely due to the fact that haddock is easy to catch, as demonstrated by high CPUE in recent years. The haddock quota may also be limiting in some mixed fisheries and that haddock may have been underestimated in last years could also contribute to transfer towards haddock. These effects were considered when the management plan was tested.

Figure 34 illustrates the difference between national TAC and landed catch in 5a. The difference can be attributed to species transformation (in both directions), while for the 1999/2000 and 2020/2021 fishing years the government of Iceland increased TAC mid-season.

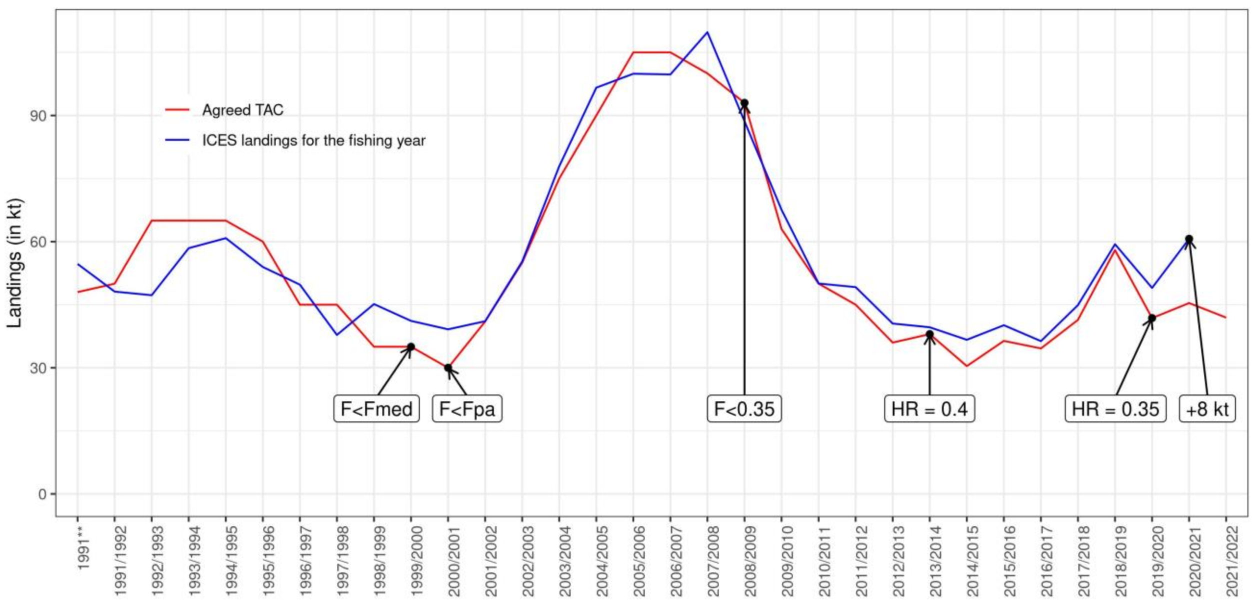

Figure 34: Haddock in 5a. Comparison of the realised catches and the set TAC for the fishing operations in Icelandic waters. Note that in the 1999/2000 fishing year the government of Iceland increased TAC mid-season

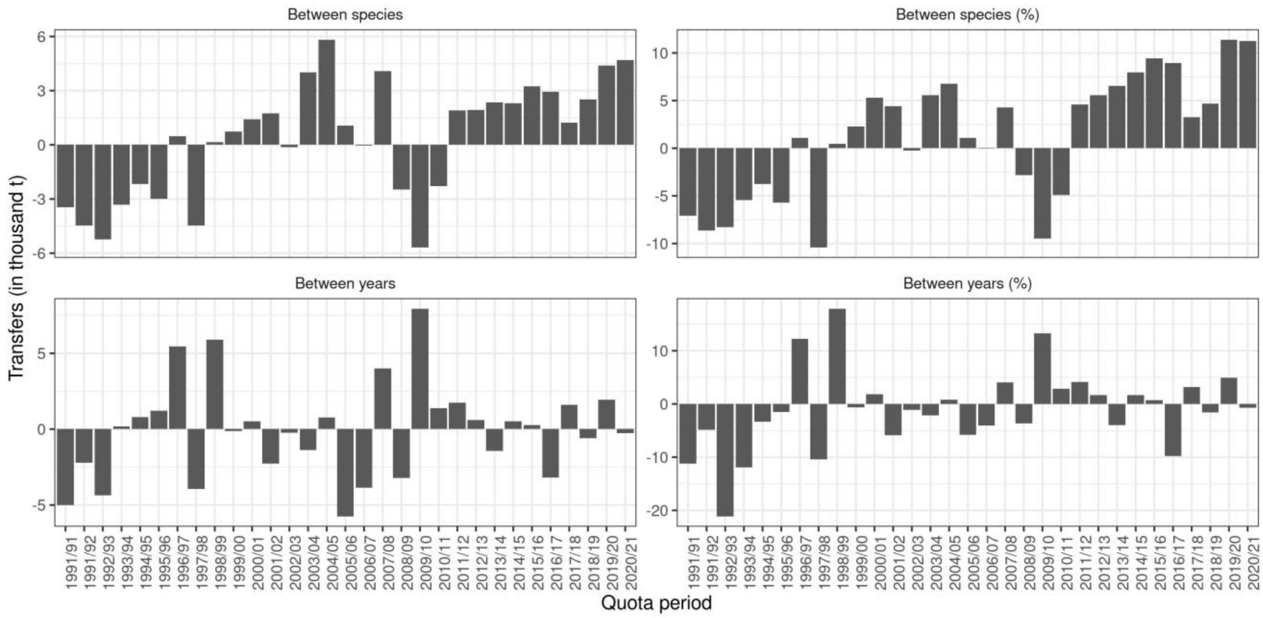

Figure 35: Haddock in 5a. An overview of the net transfers of quota between years and species transformations in the fishery in 5a.

MANAGEMENT CONSIDERATIONS

All the signs from commercial catch data and surveys indicate that Haddock in 5a is at present in a good state. This is confirmed in the assessment. At WKICEMSE 2019 the harvest rate target applied by the HCR in the period between 2013 and 2018 was estimated to be no longer precautionary while a rate of 0.35 was in-line with both the precautionary and ICES' MSY approach. As the 2018 year class is fairly small the stock has remained at the current levels however it is projected to increase in coming years due to strong incoming recruitment from the 2019 and 2020 year classes.

For the 2020/2021 fishing year the Government of Iceland increased the TAC by 8000 tons while lowering the TAC for 2021/2022 by the same amount. This was done to prevent a quota choke. The advice for 2022/2023 is therefore based on catch constraint with this lowered TAC.

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