NORTHWESTERN WORKING GROUP (NWWG)

Please note: Section 16 was added to this report in September 2021, Sections 2-6 and 21-22 were added in December 2021.

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Contents

i Executive summary

This section was updated in December 2021

The North Western Working Group (NWWG) reports on the status and considerations for management of some of the demersal fish stocks (cod, haddock, saithe, plaice and Greenland halibut) around Greenland, Iceland and Faroes, as well as two pelagic fish stocks in Icelandic waters (summer spawning herring and capelin) and five redfish stocks in Greenland, Iceland and the Irminger Sea.

Capelin in the Iceland-East Greenland-Jan Mayen area

In October 2020, MFRI advised an intermediate TAC of 0 tonnes based on an acoustic survey in September. Final advice for 2020/2021.

In November 2020, ICES advised an initial quota of 400 000 tonnes for the fishing season 2021/2022.

In February 2021, MFRI advised a final TAC of 127 300 t for 2020/2021 based on an acoustic survey in January 2021. All advice was based on the HCR from the ICES Benchmark Workshop on Icelandic Stocks (WKICE - ICES, 2015).

The total landings in the fishing season 2020/2021 amounted to 129 thousand tonnes (preliminary data). All catches were caught in winter months (January–March) 2021.

The stock has been accepted to go through a benchmark in 2022.

Offshore West Greenland Cod

The West Greenland offshore stock component is currently assessed as cod in the area comprised of the NAFO subdivisions 1A–E in West Greenland. The East Greenland stock component is currently assessed as cod in the area comprised of the area NAFO Subdivision 1F in South Greenland and ICES Subarea 14 in East Greenland.

Mixing occurs between the two stocks in West Greenland which at present is considered to act as a nursing area for juveniles of the East Greenland stock component. New genetic information suggest that the mixing is more extensive than previously thought, making the geographical boundaries arbitrary. Stock mixing will be addressed at the next benchmark for the Greenland cod stocks proposed for 2023.

Fishery collapsed in the area in the beginning of the 1990s and has since only been of minor importance with average catches between 2000–4000 tonnes per year in the period 2015–2019. TAC in 2020 was zero tonnes, but 100 tonnes were fished on the inshore quota.

Both the German Groundfish survey and Greenland Shrimp and Fish survey indices show that the biomass and abundance increased in the period 2010–2015 due primarily to the 2009-year class and in part to the 2010-year class. In the period 2016–2019, the German survey did not cover the stock area. The Greenland survey showed a reduction in biomass in 2016 due to a decrease in the 2009 and 2010-year classes at age 6 and 7 years which where historically high at age 5 and 6 years in 2015. The decrease has been attributed as an effect of fishing and migration inshore and eastward. The abundance of older cod (age >7 years), however, increased since 2017 compared to previous years where older cod where almost absent indicating that not all cod has migrated out of the area and/or they returned from the inshore area. In 2019, the highest biomass in the time period was observed in the Greenland survey. The increase was based on two large hauls in the southern part of the survey area resulting in high uncertainty. Genetic samples from the 2019 survey, including the two hauls, showed that the stock composition in the southern part of the survey area is dominated by the East Greenland/Iceland offshore stock. Therefore, the increase in biomass in 2019 is not considered representative for the West Greenland offshore stock. The biomass and abundance in both the Greenland and German survey was low in 2020. No analytical assessment is available and there are no biological reference points for the stock. Information from the Greenland survey is used as basis for advice. The age structure observed in survey data indicates that the abundance of adult cod remains low. For the first time in decades, spawning was observed in 2019 in NAFO Division 1C.

The advice is biennial and the one given in 2021 is valid for 2022 and 2023. TAC in 2021 is zero tonnes.

The stock is up for benchmark in 2023 where stock identities, based on new genetic data, will be the main issue.

Inshore Greenland cod

The stock has increased since 2006 to historic high levels in 2016 and is currently above reference points. Low recruitment since 2016 has affected the spawning stock biomass, which continues to decrease since 2016. Fishing mortality has never been below F_{MSY} (0.27) and remains above.

The mixing of cod from different stocks in the West Greenland inshore area adds uncertainty to the assessment. This is most pronounced in the poor model fit to catches, which is substantial in years with large catches (>15 000 t). Managers should take this into account when relating the ICES advice to the TAC setting.

TAC has been high in the period 2016–2019 (30 000–35 000 tonnes) but has only been fished in 2016. Since then, catches have decreased to 18000 tonnes in 2020. TAC in 2021 is reduced to 21 000 tons.

The stock is up for benchmark in 2023, were stock identities, based on new genetic data, will be the main issue.

Cod in East Greenland, South Greenland

Fishing mortality ($F_{5\text{–}10}$) has been below F_{MSY} (0.46) since 1993 and was low until 2010 where F gradually increased. SSB has been declining since 2014 but is still above MSY $B_{trigger}$ (14 803 tonnes).

The assessment shows retrospective patterns with consistent underestimation of the spawning stock and corresponding overestimating of fishing mortality. The SSB peels are inside the confidence interval and as the bias is upwards in SSB. There may be several reasons for the pattern.

Tagging shows substantial spawning emigration to Iceland that is accounted for in the assessment. Given genetic and tagging studies, it is inferred that the cod in East Greenland is a mixture of cod that spawns in East Greenland and Iceland with some of immature cod from these spawning areas also growing up in West Greenland waters (north of NAFO 1F). In recent years, fishing effort on the slope south of the Dohrn Bank (northeastern part of East-Greenland) where large old cod are caught has been increasing. These factors contribute to the uncertainty of the assessment and may contribute to the observed retrospective pattern.

In 2021, East Greenland was split into two management areas, the Dohrn bank area (east of 35^{o}15W) and the remaining part. TAC in the Dohrn bank management area is set at 20 000 tonnes, whereas TAC in the remaining area is set at 6091 tonnes which equals the ICES catch advise for 2021.

The stock is up for benchmark in 2023 were stock identities, based on new genetic data, will be the main issue.

Note that the stock assessment proposed at NWWG 2021 was not accepted by the Advice Drafting Group Arctic North-Western. An inter-benchmark process will be set up in 2021 to investigate retrospective patterns and model assumption settings.

Icelandic saithe

Annual landings in the fishing year 2019/2020 are now estimated to be 53 221 tonnes or less than 70% of the TAC of 80 588. Since the fishing year 2014/2015 around 90% of the TAC has usually been caught.

The assessment has since 2010 been based on a separable model tuned with indices from the Icelandic spring survey (often referred to as SMB in this report). The assessment, benchmarked in 2019, is relatively uncertain due to fluctuations in the survey data, poor recruitment estimates and irregular changes in the fleet selectivity. This uncertainty is taken into account when evaluating the management plan.

The current assessment shows a downward revision of the stock size compared to the last three assessments but the stock size is still estimated to be large. Investigation of alternative model setup shows the adopted assessment to be in higher end of plausible values and low catches compared to TAC could be an indication that the stock is overestimated.

To the extent possible, the part of the TAC that is not caught is transferred to other species but a large part is not used at all. There are indication that overestimation will not lead to risk to the saithe stock, the fisheries will not become profitable and the TAC will not be caught, something that could change with higher saithe prices.

According to the management plan, catches in the fishing year 2021/22 should be no more than 77 691 tonnes.

Icelandic cod

The advice rule has gone through some amendments and revisions over time. The last significant change occurred in 2007, when the harvest rate multiplier upon which the TAC for the next fishing season is based was changed from 0.25 to 0.20. The current rule has in addition a catch stabilizer. When the SSB in the assessment year is estimated to be above $SSB_{trigger}$ (220 kt) the decision rule is:

$$TAC_{y/y+1} = \left(0.20 * B_{4+,y} + TAC_{y-1/y}\right)/2$$

The TAC for the current fishing year (2020/2021) based on last year's assessment was 256 593 kt.

Following the benchmark in 2021, the assessment upon which the advice is based is approximately 20% lower than based on setting prior to the benchmark. This in part is reflected in somewhat higher harvest rate than intended although it is still within the range expected in the HCR simulation.

The results of this year's assessment show that the spawning stock in 2021 is estimated to be 361 348 kt. The values estimated in recent years are higher than have been observed during the last five decades. The reference biomass B_{4+} in 2021 is estimated to be 940 767 kt. Fishing mortality is 0.43 in 2020, having declined significantly in recent decades due to management action. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around 34% lower than observed in the period 1955–1985.

Given the above HCR rule and the estimated reference biomass in the beginning of 2021, the catch for the coming fishing year (2021/2022) is predicted to be 222 373 kt based on the following:

$$TAC_{2021/2022} = \left(0.20 * 940.767_{2021} + 256.593_{2020/2021}\right)/2 = 222.373kt$$

The input in the analytical age-based assessment are catch at age 1955–2020 (age 3–14) and ages 1–14 (from the 1985–2021 Icelandic spring survey (often referred to as SMB in this report) and ages 1–13 from the 1996–2020 Icelandic fall groundfish surveys (often referred to as SMH in this report).

Icelandic summer spawning herring

The total reported landings in 2020/21 fishing season were 36.1 kt (including summer fishery 2020) but the TAC was set at 35.5 kt. Analyses of biological samples from the past fishing season indicate continuation of new infection by *Ichthyophonus* in the stock in the coming fishing year 2021/22.

In this update assessment, where the 2020/21 catch and survey data have been added to the input data, additional natural mortality was applied for 2020 because of the *Ichthyophonus* infection in the stock. The same approach was used as for 2009–2011 and 2017–2020 where the applied mortality corresponds to that 30% of infected herring died.

The results from the analytical assessment model, NFT-Adapt, indicate that the stock size has increased, due to a large 2017-year class entering the fishery at age 4 this autumn. Spawning stock biomass for 2021 is estimated 377.1 kt and the reference biomass of age 4+ (B_{Ref}) is 481.6 kt in the beginning of the year 2021. As the SSB will be above MGT $B_{trigger}$ = 200 kt, the catches in 2021/22 according to the Iceland Management Plan would be $HR_{MGT} \times B_{Ref} = 0.15 \times 481\ 594 = 72\ 239$ tonnes.

Golden redfish (*Sebastes norvegicus*) in Subareas 5, 6, 12 and 14

Annual landings increased gradually since the 2000s, when they were at low level, to 2016. Since then, landings have decreased. Total landings in 2020 were 45 893 tonnes, which is 2753 tonnes less than in 2019. About 90% of the catches were taken in Division 5.a.

The assessment results of 2021 show that the spawning stock increased from 1995 to 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 due to TAC exceeding advised catches. Analytical retrospective patterns indicates that fishing mortality has consistently been underestimated and SSB has been overestimated. Recruitment estimates after 2013 are record low for the time series.

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

The management plan is based on $F_{9–19}$ = 0.097 that is reduced linearly if the spawning stock is estimated below 220 000 tonnes ($B_{trigger}$). B_{lim} is set at 160 000 tonnes, lowest SSB in the 2012 run. The 2021 SSB was estimated at 260 093 tonnes.

Icelandic slope beaked redfish (*Sebastes mentella*) in 5.a and 14

Total landings of demersal *S. mentella* in Icelandic waters in 2020 were 11 375 tonnes, 2659 tonnes more than in 2019. No agreed analytical assessment is available and there are no biological reference points for this stock. Survey indices from the Icelandic autumn survey since 2000 are used as basis for advice.

The total biomass and abundance indices were highest in 2000 and 2001, declined in 2002 and have been at that level since then.

The East Greenland shelf is most likely a nursery area for the stock. No new recruits (<18 cm) are seen in the survey catches of the German survey and the Greenland survey conducted in the area.

Icelandic slope *S. mentella* is considered a data limited stock (DLS) and follows the ICES framework for such (Category 3.2). The stock will be benchmarked in 2022.

Greenlandic demersal *Sebastes mentella* in 14.b

Before 2009, *Sebastes mentella* was mainly a bycatch in the fishery for Greenland halibut, but afterwards, a directed mixed fishery towards demersal redfish (*S. mentella* and *S. norvegicus*) has taken place. In 2020, total landings of demersal *S. mentella* were 1677 tonnes in East Greenland. The proportion of *S. mentella* in this mixed fishery is monitored on a yearly basis, and with the exception of 2019, *S. norvegicus* has dominated the catches since 2016.

S. mentella is a slow growing, late maturing species and is therefore considered vulnerable to overexploitation. Biomass and abundance index from the Greenland Shallow Water Survey (GRL-GFS) for both adult *S. mentella* and juvenile redfish (*Sebastes* spp.) have been declining for almost a decade. For *S. mentella*, the biomass index of 2020 is the lowest in the time series. The low stock biomass of *S. mentella* is supported by the German Groundfish Survey index (GER(GRL)-GFS-Q4).

The Greenlandic demersal *S. mentella* is a data limited stock (DLS) and follows the ICES framework for category 3 stocks. The low biomass indices obtained in recent years and especially in 2020 indicate that the stock is below any candidates for biomass reference points and given the poor recruitment for a decade no catch level could be identified in accordance with the precautionary approach. For a data limited stock with extremely low biomass, ICES method 3.1.4 was applied and zero catches for 2022 are proposed. The stock will be benchmarked in 2023.

Icelandic Haddock

All the signs from commercial catch data and surveys indicate that haddock in 5.a is at present in a good state. This is confirmed in the assessment. At the ICES Workshop on evaluation of the adopted harvest control rules for Icelandic summer spawning herring, ling and tusk (WKICEMSE – ICES, 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 expected to remain at the current levels next year but it is, however, projected to increase in coming years due to strong incoming recruitment from the 2019- and 2020-year classes.

Due to this good state of the stock, and CPUE being at its highest value, the landings are expected to substantially exceed the TAC advice for the fishing year 2020/2021. To prevent a possible quota choke, the Government of Iceland increased the TAC by 8000 tonnes while stating that the TAC for 2021/2022 will be reduced by 8000 tonnes. Catch scenarios for 2021/2022 are therefore based on a catch constraint based on the remainder TAC advice.

Greenland Halibut in Subareas 5, 6, 12, and 14

Catches of Greenland halibut in subareas 5, 6, 12 and 14 have ranged between 20 and 30 kt in the last two decades and amount to 22 669 t in 2020 which is a 3% decrease in total catches compared to 2019. The biomass indices used as input to the assessment (combined survey index from Greenland and Iceland) and logbook information from Iceland trawler fishery showed a similar increasing trend, however the survey have in the past two years been outside the inter-quartile of the model estimates. The increase in survey biomass index was due to increase of fish larger than 40 cm.

A logistic production model in a Bayesian framework are used to assess stock status and for catch forecast scenarios. The model includes an extended catch series going back to the assumed virgin status of the stock at the beginning of the fishery in 1961. Estimated stock biomass showed an overall decline along with the high catches in the late 1980s and early 1990s. Since 2004/2005, the stock increased slowly and is in recent years at about 70% of B_{MSY}. Fishing mortality has since 2013 been close and above F_{MSY} but is in 2021 below F_{MSY} (0.90xF_{MSY}). The remaining available tuning indices are currently not used in the analytical assessment due to conflicting signals (log-book information from East Greenland trawl fishery, from Faroese trawl fishery and biomass index from a Faroese survey). The Greenland fishery in 14.b suggest a high but slightly declining biomass while the Faroese indices suggest a significantly lower and declining biomass in the eastern areas of the stock distribution. Survey estimates (5b) of the abundance of fish smaller than 40 cm show reduced productivity since 2014. This will likely impact the fishable stock in the near future. Stock structure and connectivity between the main fishing areas within the stock distribution area remains partly unknown and this will be an important issue in a forthcoming benchmark.

European plaice around Iceland

Icelandic plaice fishery in 5.a has been considered stable in last two decades and total landings have been between 5 and 8 thousand tonnes during this period. In 2020, landings were around 7500 tonnes which is a 675 tonnes increase from the previous year. Historical landings of plaice have fluctuated during different time periods, with highest landings registered in the 1980s, with 14 500 tonnes landed in 1985. Demersal seine is the main fishing gear for plaice (65–71% since 2011) in Iceland followed by demersal trawl (23–30%).

Results from Icelandic surveys indicate that the Icelandic plaice stock is stable, however the surveys are not adequately covering the main recruitment grounds for plaice, as recruitment takes place in shallow water in habitats unsuitable for demersal trawling. Juvenile abundance indices (<20 cm) from those surveys indicate low levels since 1998 with occasional small peaks.

Analytical age-based stock assessment model using catch in numbers and age-disaggregated indices from the spring survey has been used in by MFRI since 2016 but has not been agreed by ICES yet. The model runs from 1991 onwards and ages 3–10 are tracked by the model, where age 10 is a plus group. Natural mortality is set to 0.2 for all age groups. Considerable uncertainty is present in the model due to limited information on recruitment. The result of the assessment indicates that the stock is stable, with 2021 SSB at 33 500 tonnes. Maximum sustainable yield is the basis for the advice, and the reference point is set at F = 0.22.

Faroe Plateau cod

The stock was historically low in the period from 2006 to 2017. The spawning stock biomass increased above MSY $B_{trigger}$ in 2018 and 2019 and was expected to increase even further in the near future. However, the current assessment shows that the recruitment is markedly revised downwards, probably due to low food availability in 2019 that also was reflected in high catchabilities with longlines and extremely high fishing mortalities in 2019 and 2020. The spawning stock was below B_{lim} in 2021 and is expected to stay low for the next two years.

Faroe Haddock

The spawning-stock biomass (SSB) decreased significantly from 2003 and is estimated to have been below B_{lim} in the period 2009–2017 and since 2018, SSB has been above MSY $B_{trigger}$ = 22 843 tonnes. Nominal landings in 2020 are estimated at 7300 tonnes. Estimated fishing mortality in 2020 is F_{bar} = 0.47, which is above F_{MSY} = 0.165 and F_{pa} = 0.19 but beneath F_{lim} = 0.54. According to the MSY approach, catches in 2021 should be no more than 8600 t. The current assessment is a downward revision of last year's assessment due to a substantial downward revision of the spawning stock biomass. Short-term prediction, using status quo fishing mortality, predicts an increase of the spawning stock biomass to 70 000 tonnes in 2022.

Faroe saithe

This stock was benchmarked in 2017. SAM was adopted as basis for the advice. In 2020, the stock was inter-benchmarked.

Nominal landings in 2020 are estimated at 22 773 tonnes. Estimated fishing mortality in 2020 is F_{bar} = 0.33, which is above F_{MSY} = 0.30. SSB has been above MSY $B_{trigger}$ = 41 400 tonnes since 2017. Recruitment has fluctuated with no clear trend since 2000. According to the MSY approach, catches in 2021 should be no more than 37 444 t. The current assessment is a downward revision of last year's assessment due to lower and higher estimates of SSB and F respectively.

Capelin in the Iceland-East Greenland-Jan Mayen area

In October 2020, MFRI advised an intermediate TAC of 0 tonnes based on an acoustic survey in September.

In November 2020, ICES advised an initial quota of 400 000 tonnes for the fishing season 2021/2022.

In February 2021, MFRI advised a final TAC of 127 300 tonnes for 2020/2021 based on an acoustic survey in January 2021. All advice was based on the HCR from the ICES Benchmark Workshop on Icelandic Stocks (WKICE - ICES, 2015).

The total landings in the fishing season 2020/2021 amounted to 129 thousand tonnes (preliminary data). All catches were caught in winter months (January–March) 2021.

In October 2021, MFRI advised an intermediate TAC of 904 200 tonnes based on an acoustic survey in September.

In November 2021, ICES advised an initial quota of 400 000 tonnes for the fishing season 2022/2023.

The stock has been accepted to go through a benchmark in 2022.

ii Expert group information

Expert group name	Northwestern Working Group (NWWG)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair	Teunis Jansen, Greenland and Denmark
Meeting venues and dates	22–29 April 2021, online meeting (19 participants)
	23 August 2021, online meeting (5 participants)
	20–21 September 2021, online meeting (17 participants),
	25–29 October 2021, online meeting (11 participants)

1 Introduction

1.1 Terms of Reference (ToR)

1.1.1 Specific ToR

2020/2/FRSG05 **The North-Western Working Group** (NWWG), chaired by Teunis Jansen, Iceland, will meet by correspondence on 22–29 April 2021 to:

a) Address generic ToRs for Regional and Species Working Groups for all stocks, except stocks mentioned in ToRs c) and d)
b) Compile and review available data and information on plaice in Division 5.a and prepare a road map and issue list for a future benchmark

and on 6-8 September 2021 to:

c) Address generic ToRs for Regional and Species Working Groups for beaked redfish (*Sebastes mentella*) in ICES subareas 5, 12, and 14 (Iceland and Faroe grounds, North of Azores, East of Greenland) and NAFO subareas 1 and 2 deep pelagic (> 500m) and shallow pelagic (< 500m) stocks.

and on 25-29 October to:

d) Address generic ToRs for Regional and Species Working Groups for Capelin (*Mallotus villosus*) in subareas 5 and 14 and Division 2.a west of 5°W, Cod (*Gadus morhua*) in Subdivision 5.b.1 (Faroe Plateau), Cod in Subdivision 5.b.2 (Faroe Bank,) Haddock (*Melanogrammus aeglefinus*) in Division 5.b (Faroes grounds) and Saithe (*Pollachius virens*) in Division 5.b (Faroes grounds).

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2021 ICES data call.

NWWG will report by 19 May, 10 September and 5 November 2021 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

1.2 NWWG 2021 work in relation to the generic ToR

Because of the disruptions caused by COVID 19 in 2021 the meeting in April was held remotely.

For all stocks discussed during the meeting, the NWWG adopted the assessment which formed the basis for stock status and the premise for the forecasts. Based on the assessments the group produced a draft advice (abbreviated form) for all stocks.

European plaice around Iceland is a new stock in NWWG. The data and assessment was presented as well as the plans for a benchmark and management plan evaluation. This work was described in the report. No advice was drafted.

The fisheries overview for the Icelandic Ecoregion was published in 2019. Ecosystem overview for Greenland and Fisheries Overview for the Greenland and Faroese were published in 2020.

1.3 Mohn's Rho

Generic Term of Reference c)-viii).

Mean Mohn's Rho for category 1 stocks for F_{BAR}, spawning-stock biomass (SSB) and Recruitment for the stocks discussed so far during the this years' meetings. The plots are shown in relevant chapters.

Stock	Code	Term. year	Retro years	F_{bar}	SSB	Recr
Inshore West Greenland cod	cod.21.1	2020	5	0.027	-0.217	-0.54
East Greenland, South Greenland cod	cod.2127.1f14	2020	5	0.416	-0.214	-0.486
Icelandic Saithe	pok.27.5a	2020	5	-0.084	0.101	-0.074
Icelandic cod	Cod.27.5a	2020	5	0.035	-0.021	0.074
Icelandic haddock	had.27.5a	2020	5		-0.065	0.035
Greenland halibut	ghl.27.561214	2019	5	0.030	0.043	-
Golden redfish	reg.27.561214	2021	5	-0.0533	0.0352	0.501

1.4 NWWG 2021 work in relation to the specific ToR

The group will meet three times in 2021 (see ToR). The report will be updated with the respective stocks after each meeting.

1.5 Assessment methods applied to NWWG stocks

The methods applied to assess the stock status of the NWWG stocks covers a wide range from descriptive to age based analytical assessments as follows:

Stock	Assessment model	Input*	Advice
Faroe Bank cod	Qualitative evaluation	Survey	November 2021
Faroe Plateau cod	SAM	Survey	November 2021
Faroe haddock	SAM	Survey	November 2021
Faroe saithe	SAM	CPUE	November 2021
Iceland saithe	ADCAM (statistical catch-at-age)	Survey	June 2021
Iceland cod	ADCAM (statistical catch-at-age)	Survey	June 2021
Iceland haddock	Adapt type model	Survey	June 2021
Iceland herring	NFT-Adapt	Survey	June 2021
Capelin	Linear regression	Survey	November 2021
Inshore West Greenland cod	SAM	Survey	June 2021
East and South Greenland cod	SAM	Survey	June 2021
Offshore West Greenland cod	Descriptive	Survey	June 2021
Greenland halibut	Stock production model (Bayesian)	Survey + CPUE	June 2021

Stock	Assessment model	Input*	Advice
Golden redfish	GADGET (age-length based cohort model)	Survey	June 2021
Iceland slope *S. mentella*	DLS category 3.2	Survey	June 2021
Deep pelagic *S. mentella*	Gadget	Survey	September 2021
Shallow pelagic *S. mentella*	Qualitative evaluation	Survey	September 2021
Greenland Slope *S. mentella*	DLS category 3.2	Survey	June 2021

*** Landings or landings by age are input to all assessments**

1.6 Audits

All audits were completed. The auditors found the work of the assessment and advice satisfactory.

1.7 Recommendations

There were no recommendations to NWWG this year.

1.8 Benchmarks and workshops

Icelandic slope beaked redfish will be benchmarked in early 2022. The aim of the benchmark is to apply an analytical assessment model (Gadget) and move the stock from category 3 to category 1. Furthermore, the aim is to define reference points for the stock. Issue list has been prepared.

Benchmark of golden redfish, deep pelagic beaked redfish and Greenlandic demersal beaked redfish is recommended for benchmark in 2023.

The group recommends that East Greenland, inshore and offshore West Greenland cod stocks to be benchmarked in 2023 instead of 2022 as earlier suggested. A substantial issue lists has been prepared and work has been initiated. Main pillars of the work are expected to be presented for discussion at NWWG 2022.

The group still recommends that capelin should be benchmarked as planned at WKCAPELIN in 2022.

Furthermore, the group is aware of plans for submitting requests for intermediate benchmarks or similar evaluations of Icelandic plaice and the Faroese stocks (intermediate catch estimation and management plans).

1.9 Chair

This was first of three years for the new Chair, Teunis Jansen, Greenland/Denmark.

2 Demersal stocks in the Faroe area (Division 5.b and Subdivision 2.a4)

This section was updated in November 2021.

2.1 Overview

2.1.1 Fisheries

The main fisheries in Faroese waters are mixed-species, demersal fisheries and single species pelagic fisheries. The demersal fisheries are mainly conducted by Faroese vessels, whereas the pelagic fisheries are conducted both by Faroese vessels and by foreign vessels licensed through bilateral and multilateral fisheries agreements. The usual picture has changed, however. From 2010 there has been no full agreement between the coastal states with regards to mackerel and this also applied for Norwegian Spring Spawning herring in 2013 and blue whiting in 2016.

Pelagic Fisheries. Three main species of pelagic fish are fished in Faroese waters: blue whiting, herring and mackerel; several nations participate. The Faroese pelagic fisheries are conducted by purse-seiners, larger purse-seiners also equipped for pelagic trawling and trawlers otherwise performing demersal fisheries. The pelagic fishery by Russian vessels is conducted by large factory trawlers. Other countries use purse-seiners and factory trawlers.

Demersal Fisheries. Although they are conducted by a variety of vessels, the demersal fisheries can be grouped into fleets of vessels operating in a similar manner. Some vessels change between longlining, jigging and trawling, and they therefore can appear in different fleets. The number of licenses can be found in Table 2.3. The grouping of the vessels under the management scheme can be seen in Section 2.1.2. Fleets 4a and 4b were merged in 2021.

2.1.2 Fisheries and management measures

The fishery around the Faroe Islands has for centuries been an almost free international fishery involving several countries. Apart from a local fishery with small wooden boats, the Faroese offshore fishery started in the late 19th century. The Faroese fleet had to compete with other fleets, especially from the UK with the result that a large part of the Faroese fishing fleet became specialized in fishing in other areas. So, except for a small local fleet most of the Faroese fleet were fishing around Iceland, at Rockall, in the North Sea and in more distant waters like the Grand Bank, Flemish Cap, Greenland, the Barents Sea and Svalbard.

Up to 1959, all vessels were allowed to fish around the Faroes outside the 3 nm zone. During the 1960s, the fisheries zone was gradually expanded, and in 1977 an EEZ of 200 nm was introduced in the Faroe area. The demersal fishery by foreign nations has since decreased and Faroese vessels now take most of the catches. The fishery may be considered a multifleet and multispecies fishery as described below.

During the 1980s and 1990s the Faroese authorities have regulated the fishery and the investment in fishing vessels. In 1987, a system of fishing licenses was introduced. The demersal fishery at the Faroe Islands has been regulated by technical measures (minimum mesh sizes and closed areas). In order to protect juveniles and young fish, fishing is temporarily prohibited in areas where the number of small cod, haddock and saithe exceeds 30% (in numbers) of the catches;

after 1–2 weeks, sometimes longer, the areas are again opened for fishing. A reduction of effort has been attempted through banning of new licenses and buy-back of old licenses.

A quota system, based on individual quotas, was introduced in 1994. The fishing year started on 1 September and ended on 31 August the following year. The aim of the quota system was, through restrictive TACs for the period 1994–1998, to increase the SSBs of Faroe Plateau cod and haddock to 52 000 t and 40 000 t, respectively. The TAC for saithe was set higher than recommended scientifically. It should be noted that especially cod and haddock but also saithe are caught in a mixed fishery and any management measure should account for this. Species under the quota system were Faroe Plateau cod, haddock, saithe, redfish and Faroe Bank cod.

The catch quota management system introduced in the Faroese fisheries in 1994 was met with considerable criticism and resulted in discarding and in misreporting of portions of the catches. Reorganization of enforcement and control did not solve the problems. As a result of the dissatisfaction with the catch quota management system, the Faroese Parliament discontinued the system as from 31 May 1996. In close cooperation with the fishing industry, the Faroese government developed a new system based on individual transferable effort quotas in days within fleet categories. The new system entered into force on 1 June 1996. The fishing year from 1 September to 31 August, as introduced under the catch quota system, was maintained.

The individual transferable effort quotas applied to 1) the longliners less than 110 GRT, the jiggers, and the single trawlers less than 400 HP (Groups 4,5), 2) the pairtrawlers (Group 2) and 3) the longliners greater than 110 GRT (Group 3). The single trawlers greater than 400 HP were in 2011 included into the fishing days system and were allocated a number of fishing days (tables 1 and 2). They were not allowed to fish within the 12 nautical mile limit and the areas closed to them, as well as to the pairtrawlers, had increased in area and time. Their catch of cod and haddock was before 2011 limited by maximum bycatch allocation. This fleet started to pair-trawl, and since the fiscal year 2011/12, merged with the pairtrawlers group. The single trawlers less than 400 HP were given special licenses to target flatfish inside 12 nautical miles with a bycatch allocation of 30% cod and 10% haddock. In addition, they were obliged to use sorting devices in their trawls in order to minimize their bycatches. One fishing day by longliners less than 110 GRT was considered equivalent to two fishing days for jiggers in the same gear category. Longliners less than 110 GRT could therefore double their allocation by converting to jigging. Table 2.1 shows the allocated number of fishing days by fleet group since the fiscal year 1996/1997 and in Table 2.2 is a comparison between number of allocated days and number of actually used fishing days. From Table 2.1 it can been seen that since 1996/1997, the number of days allocated has been reduced considerable and is now around half of the originally allocated days. Despite this, there still are many unused days in the system (Table 2.2).

Holders of individual transferable effort quotas who fish outside the thick line on Figure 2.2 could fish for 3 days for each day allocated inside the line. Trawlers were generally not allowed to fish inside the 12 nautical mile limit. Inside the innermost thick line only longliners less than 110 GRT and jiggers less than 110 GRT were allowed to fish. The Faroe Bank shallower than 200 m is closed to trawling. Due to the serious decline of the Faroe Bank cod, the Bank has been closed since 1 January 2009 for all gears except for a minor jigging fishery during summertime.

The fleet segmentation used to regulate the demersal fisheries in the Faroe Islands and the regulations applied are summarized in Table 2.3.

The effort quotas are transferable within gear categories. The allocations of number of fishing days by fleet categories were made such that together with other regulations of the fishery they should result in average fishing mortalities on each of the 3 stocks of 0.45, corresponding to average annual catches of 33% of the exploitable stocks in numbers. Built into the system was also an assumption that the day system was self-regulatory, because the fishery was expected to move between stocks according to the relative availability of each of them and no stock would be overexploited. In retrospect these target fishing mortalities were substantially higher than the F_{MSY} reference points that were defined for cod, haddock and saithe in spring 2017. Also, the fishing mortality on cod was higher than for haddock and saithe, probably because the fleets targeted cod more than haddock and saithe.

The technical measures as mentioned above are still in effect. An additional measure to reduce the fishing mortality on cod and haddock and to especially reduce the mortality on the youngest age groups was introduced (See the 2013 NWWG report, Figure 2.3) in July 2011, but was terminated in August 2013.

2.1.3 The marine environment and potential indicators

The waters around the Faroe Islands are in the upper 500 m dominated by the North Atlantic current, which to the north of the islands meets the East Icelandic current. Clockwise current systems create retention areas on the Faroe Plateau (Faroe shelf) and on the Faroe Bank. In deeper waters to the north and east and in the Faroe Bank channel there is deep Norwegian Seawater, and to the south and west is Atlantic water. From the late 1980s the intensity of the North Atlantic current passing the Faroe area decreased, but it has increased again and has since been stable. The productivity of the Faroese waters was very low in the late 1980s and early 1990s. This applies also to the recruitment of many fish stocks, and the growth of the fish was poor as well. Since then, there have been several periods with high or low productivity, which has been reflected in the fish landings a couple of years afterwards.

There has been observed a clear relationship, from primary production to the higher trophic levels (including fish and seabirds), in the Faroe shelf ecosystem, and all trophic levels seem to respond quickly to variability of primary production in the ecosystem (Gaard *et al.* 2002). There is a positive relationship between primary production and the cod and haddock individual fish growth and recruitment ½–2 years later. The primary production index has been below average since 2002 except for 2004 and 2008–2010 and 2017 when it was above average (Figure 2.3). The primary production index could therefore be a candidate ecosystem and stock indicator. Another potential indicator candidate is the Subpolar Gyre Index (Hátún *et al.*, 2005, Hátún and Chafik, 2018 (Figure 2.3). The subpolar gyre index presented here is merged from these references using simple linear regression for the 1993–2003 period.

Work (Steingrund *et al*., 2012) shows that there is a moderate positive correlation between primary production on the Faroe Shelf and the subsequent production of cod (Steingrund and Gaard, 2005). There is also a moderate positive correlation for haddock and saithe. If all three species are combined, the positive correlation becomes stronger (Figure 2.4). However, the period of high productivity (2008–2010) did not lead to any marked increase in the stock size of cod/haddock, but only in saithe. The catchability of cod with longlines also increased by a factor of 2–3 in the same period. The productive period in 2016-2017 also seems not to have led to any marked recovery of cod, but probably more so for haddock.

2.1.4 Summary of the 2021 assessment of Faroe Plateau cod, haddock and saithe

A summary of selected parameters from the assessment of Faroe Plateau cod, Faroe haddock and Faroe saithe is shown in Figure 2.6. As mentioned in previous reports of this WG, landings of cod, haddock and saithe on the Faroes appear to be closely linked with the total biomass of the stocks.

For cod and haddock, the exploitation ratio and fishing mortality have remained relatively stable over time, although they have been more fluctuating since the 1980s (Figure 2.6). For saithe, the exploitation rate was low in the 1930s and 1950s and increased until the 1970s, it decreased from the early 1990s–2004 and has increased close to the highest values observed in 2009. It has since declined again.

Another main feature of the plots of landings, biomasses, mortalities and recruitment is the apparent periodicity during the time-series with cod and haddock showing almost the same fluctuations and time-trends. Moreover, while the sum of cod, haddock and saithe biomasses has been rather constant over time (varied between 300–500 thousand tonnes most years), the proportion of saithe has increased during the period from 1924 up to today whereas the proportion of cod has decreased (Figure 2.6).

2.1.5 Reference points for Faroese stocks

A benchmark assessment was held in February 2017 where the assessment model was changed from the XSA to SAM. Since the assessment model was changed, the reference points were recalculated/revised at the NWWG 2017 (ICES, 2017) meeting, according to the ICES guidelines (ICES fisheries management reference points for category 1 and 2 stocks, January 2017, http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/12.04.03.01_Reference_points_for_category_1_and_2.pdf).

These reference points are all estimated based on single-species models. Multispecies models may give different perception of F_{MSY} reference points than single-species models, and for the Faroe area this could be extra true, since there is a close relationship between the environment and the fish stocks and between fish stocks (see Section 2.1.3). For example, adding the recruitment of cod and haddock and relating them to zooplankton concentration shows a strong negative correlation (Figure 2.5). Sandeels are abundant at times with strong cod and haddock recruitment (age 1) and sandeels probably graze down the zooplankton biomass during summer when they are numerous.

Faroe saithe stock dynamics is puzzling. If the biomass estimates prior to 1961 are approximately correct (see ICES, 2016) then there has been an increase in biomass from 1925 up to now as well as in catch and exploitation rate. There might be an interaction with cod, since the cod biomass has decreased over the same period. It might be speculated that trawling activity in the deep areas (> 150 m) from the 1950s has had a negative effect on cod and a positive effect on saithe. Hence, it might not be possible to maximize cod and saithe catches at the same time.

2.1.6 Management plan

In 2011, the Faroese minister of fisheries established a group of experts to formulate a management plan for cod, haddock and saithe including a harvest control rule and a recovery plan. The group consisted of scientists from the Faroe Marine Research Institute and the Faroese University, of 1 representative from the industry (trawlers) and 1 from the Ministry of Fisheries. The results of this work was delivered to the Minister of Fisheries in spring 2012 but the outcome has not been approved by the authorities so far and not been implemented. Basically, the plan builds on the MSY framework developed by ICES.

In 2015, the Faroese minister of fisheries established a new group of experts to formulate a new fisheries management system. The reason was that all fishing licences would be withdrawn on 31 December 2017 – 10 years after the Faroese Parliament decided to do this. The group delivered its recommendations on 3 October 2016. The group recommended that the effort management system was replaced by a quota system in the new fisheries management system. The following treatment in the political system resulted in a law that was adopted by the Faroese Parliament in December 2017. In the law it was stated that the large trawlers (Group 2) and the large longliners

(Group 3) should be regulated by catch quotas whereas the rest of the fleets will be regulated in the same way as before, i.e., by fishing days and licences. This was supposed to be implemented on 1 January 2019, but that was in November 2018 postponed to 1 January 2020. The fiscal year starting on 1 September 2017 and ending 31 August 2018 was extended to 31 December 2018. From 2019 the fishing year was equal to the calendar year. As already mentioned, the fishery since 2019 has been regulated by fishing days and licences.

A committee was in September 2018 set by the Ministry of Fisheries to work on management plans for cod, haddock and saithe in Faroese waters. The committee was composed of representatives from the Ministry of Fisheries, the fishing industry, Faroe Marine Research Institute and Faroe Coastal Guard. The committee delivered its report in May 2019. There were two main outcomes in the report. Firstly, the continuation to use fishing days as the main measure of fishing effort for all fleets (i.e., abandoning the quotas for Group 2 and Group 3), and secondly, the formulation of a harvest control rule. The harvest control rule aimed to keep fishing mortalities within sustainable limits and a recovery plan was used in cases when spawning stocks were below certain limits. A buffer was applied so that the number of fishing days could only be changed by either -5%, 0% or 5% from one year to the next. The management plan was implemented in 2021. The Faroese fishery for cod, haddock and saithe on the Faroe Plateau was certified as sustainable in September 2021 by Marine Stewardship Council.

The partial F per fishing day for the fleets is not constant but varies between years. In the case of longliners this is probably a result of the varying amounts of sandeels (Figure 2.7) – cod and probably haddock prey preferably on sandeels and, if they are scarce, on other prey items like longline baits. Also, the recruitment of cod and haddock is positively correlated with sandeel abundance (Figure 2.8). When sandeels are abundant, recruitment of cod and haddock is high while the partial F per fishing day is low – this may lead to a rapid increase in the stock. Conversely, when sandeels are scarce, the opposite happens, recruitment is low while the partial F per fishing day is high and the stocks may decrease rapidly. This implies that the cod and haddock stocks may be fished too hard during periods with low sandeel abundance. The implemented management plan, especially the limits of fishing mortalities, needs to be scrutinised in the future to ensure that the management plan is sustainable. The management plan is not yet sent to ICES for evaluation.

2.1.7 Other issues

In order to put assessments into a wider context, the biomass of Faroe saithe, cod and haddock on the Faroe Plateau has been estimated over centuries (ICES, 2016). The biomass of Faroe Plateau cod was in the years 2006–2017, the lowest compared to the last 300 years. The biomass of Faroe haddock in the same time period was the lowest for a century. Saithe on the other hand, shows an opposite trend, its biomass in the same time period is well above average and it had a lower biomass prior to 1960, when there was little fishery for saithe. The stock dynamics of saithe is therefore a bit contradictory since an increase in fishing mortality is associated with increased biomass.

The stock assessment of saithe has the last five-ten years had the tendency to overestimate stock size and underestimate fishing mortality and this has led to a too high advised catch. For some reason the fishing fleet has not been able to fish the advised catch and this situation will likely be the case in 2022. There is a need to get a better biological understanding why the fleet is not able to fish the advised catch even though an effort management system is in place. It is also worth mentioning that sorting grids were introduced in the saithe fishery (Group 2) in September 2021 and at the same time two closed areas with young saithe were opened.

During the NWWG meeting in October 2021 the issue was raised whether there was a migration of cod between Faroe Plateau and Faroe Bank (since year classes have been downscaled on the Faroe Plateau and at the same time there has been an increase of cod biomass on Faroe Bank). Although there has been conducted a tagging experiment on the Faroe Plateau since 1997, there has been very little fishing activity on Faroe Bank and hence making recoveries of tagged cod originating from Faroe Plateau difficult to demonstrate. There have not been conducted any recent genetic analyses of cod from Faroe Plateau or Faroe Bank. It should be pointed out, however, that there is a positive correlation between an o-group index of cod on Faroe Bank and total survey catch per tow in March four years later indicating that a migration from Faroe Plateau is not necessary to explain the stock development of cod on Faroe Bank.

2.1.8 References

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Table 2.1. Number of allocated days since the fiscal year 1996/97. The fiscal year 2017/2018 was extended to 31 December 2018 (2017/2018 end). Group 4a and 4b were merged in 2021.

	Number of allocated days								
	Fleet group								
Fishing year	2 outer	2 inner	3	4 A	4 B	4 T	5	Total days	Total 2-4
1996/1997		8225	3040	4700	3080		22000	49585	20275
1997/1998		7199	2660	4696	4632		23625	43389	19187
1998/1999		6839	2527	4461	4400		22444	41219	18227
1999/2000		6839	2527	4461	4400		22444	41219	18227
2000/2001		6839	2527	4461	4400		22444	41219	18227
2001/2002		6839	2527	4461	4400		22444	40671	18227
2002/2003		6771	2502	4416	4356		22220	40265	18045
2003/2004		6636	2452	4328	4269		21776	39461	17685
2004/2005		6536	2415	4263	4205		21449	38868	17419
2005/2006		5752	3578	1770	2067	1766	21235	36168	14933
2006/2007		5752	3471	1717	2005	1713	20598	35256	14658
2007/2008		5637	3402	1683	1965	1679	20186	34552	14366
2008/2009		4406	2940	1323	1756	1540	17259	30762	12595
2009/2010		4406	2940	1323	1756	1540	17259	29224	11965
2010/2011	1700	5174	2852	1323	1756	1540	13259	27604	11745
2011/2012	1530	4657	2657	1058	1405	1386	10607	23210	12603
2012/2013	1530	4626	2567	1011	1533	1386	10607	23260	12653
2013/2014	1530	4441	2387	1011	1533	1386	9865	22153	12288
2014/2015	1530	4455	2887	1029	1530	1386	9865	22182	12317
2015/2016	1530	4455	2387	1029	1530	1386	9865	22182	12317
2016/2017	1530	4386	2029	859	1323	1178	8879	20660	11781
2017/2018	1530	4386	2029	859	1323	1178	8879	20660	11781
2017/2018 end	2040	5848	2705	1145	1764	1571	11839	26912	15073
2018 cal year	1530	4386	2029	859	1323	1178	8879	20184	11305
2019 cal year	1530	4386	2029	791	1436	1178	11029	22379	11350
2020 cal year	1582	4291	2571	902	1851	1581	11029	23807	12778
2021 cal year	1661	4506	2442	2615		1502	10478	23204	12726

Table 2.2. Number of used days since the fiscal year 1997/1998. The values for 2021 were based on the January 1 to October 15 period and scaled up by 12/9.5. Group 4a and 4b were merged in 2021.

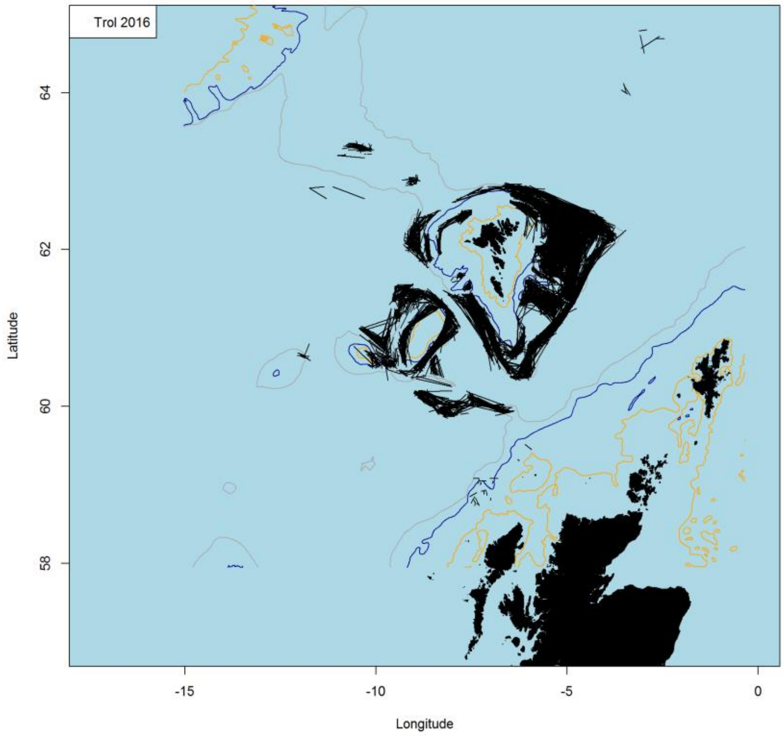
	Number of used days									
	2 outer	2 inner	3	4 A	4 B	4 T	5 A	5 B	Total days	Total 2-4
1996/1997										
1997/1998		6211	2469	2619	3983					15282
1998/1999		5907	2309	2147	3715					14078
1999/2000		6497	2207	2255	3995					14954
2000/2001		6065	2469	2733	4435					15702
2001/2002		5643	2494	2454	4450					15041
2002/2003		4688	2432	2303	4554					13977
2003/2004		5018	2186	2184	5108					14496
2004/2005		5070	2468	1647	4613					13798
2005/2006		4381	3141	1200	1717	2443				12883
2006/2007		4186	2820	961	1113	2208				11288
2007/2008		4524	2447	582	1036	1923				10512
2008/2009		4065	2273	415	1016	1434				9201
2009/2010		4585	2078	426	1158	1382				9629
2010/2011		3883	2071	405	1016	1412	2856	4525	17506	8787
2011/2012	895	4758	1986	260	657	1313	1834	3160	14862	9869
2012/2013	879	3953	1205	271	688	1166	1410	2845	12415	8162
2013/2014	797	3916	1120	272	519	895	1136	3337	11992	7519
2014/2015	1125	4308	1235	254	565	717	1297	3709	13210	8204
2015/2016	1312	3784	1452	315	699	919	810	4421	13711	8481
2016/2017	1225	3882	1075	280	556	1111	646	3440	12215	8129
2017/2018 est.	1202	4472	963	289	812	990	634	2904	12267	8729
2017/2018 end	1390	5562	1568	461	895	1518	887	5486	17719	11394
2018 cal year	1043	4077	1201	391	718	1239	785	5053	14507	8669
2019 cal year	864	3940	1665	420	818	1390	3801	5539	18320	9097
2020 cal year	845	2284	1759	284	454	1182	4022	1745	12575	6808
2021 cal year, estim.	948	3752	1432	980		1307	3408	1633	13460	8419

Table 2.2. Continued. Number of used days since the fiscal year 1997/1998 (%). Group 4a and 4b were merged in 2021.

	Percentage of used days								
	2 outer	2 inner	3	4 A	4 B	4 T	5	Total days	Total 2-4
1997/1998		86	93	56	86				
1998/1999		86	91	48	84				77
1999/2000		95	87	51	91				82
2000/2001		89	98	61	101				86
2001/2002		83	99	55	101				83
2002/2003		69	97	52	105				77
2003/2004		76	89	50	120				82
2004/2005		78	102	39	110				79
2005/2006		76	88	68	83	138			86
2006/2007		73	81	56	55	129			77
2007/2008		80	72	35	53	115			73
2008/2009		92	77	31	58	93			73
2009/2010		104	71	32	66	90			80
2010/2011		75	73	31	58	92	56	63	75
2011/2012	58	102	75	25	47	95	47	64	78
2012/2013	57	85	47	27	45	84	40	53	65
2013/2014	52	88	47	27	34	65	45	54	61
2014/2015	74	97	43	25	37	52	51	60	67
2015/2016	86	85	61	31	46	66	53	62	69
2016/2017	80	89	53	33	42	94	46	59	69
2017/2018 est.	79	102	47	34	61	84	40	59	74
2017/2018 end	68	95	58	40	51	97	54	66	76
2018 cal year	68	93	59	46	54	105	66	72	77
2019 cal year	56	90	82	53	57	118	85	82	80
2020 cal year	53	53	68	31	25	75	52	53	53
2021 cal year, estim.	57	83	59	37		87	48	58	66

Table 2.3. Main regulatory measures by fleet in the Faroese fisheries in 5.b. The fleet capacity is fixed, based on among other things no. of licenses. Number of licenses within each group (by May 2006) are as follows: 1:12; 2:29; 3:25; 4A: 25; 4B:21; 4T:19; 5A:140; 5B:453; 6:8. These licenses have been fixed in 1997, but in group 5B a large number of additional licenses can be issued upon request.

Fleet segment		Subgroups		Main regulation tools
1	Single trawlers > 400 HP	none		Fishing days, have from 2011/12 been merged with the pairtrawlers, area closures
2	Pairtrawlers > 400 HP	none		Fishing days, area closures
3	Longliners > 110 GRT	none		Fishing days, area closures
4	Coastal vessels > 15 GRT	4A	Trawlers 15-40 GRT	Fishing days
		4A	Longliners 15-40 GRT	Fishing days
		4B	Longliners > 40 GRT	Fishing days
		4T	Trawlers > 40 GRT	Fishing days
5	Coastal vessels <15 GRT	5A	Full-time fishers	Fishing days
		5B	Part-time fishers	Fishing days
6	Others		Gillnetters	Bycatch limitations, fishing depth, no. of nets
			Others	Bycatch limitations



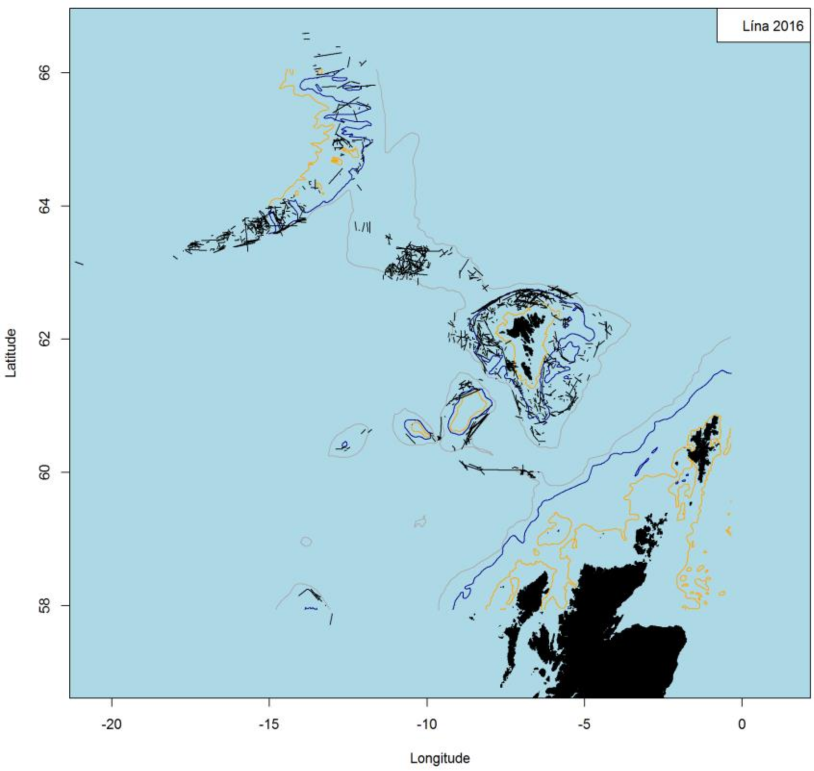


Figure 2.1. The 2016 distribution of fishing activities by some major fleets. From top: 1010HP, trap and trawl > Gillnet, longline. The longline fleet below 110 GRT is not shown here since they are not obliged to keep logbooks.

Exclusion zones for trawling

Area	Period
a	1 jan - 31 des
aa	1 jun - 31 aug
b	20 jan - 1 mar
c	1 jan - 31 des
d	1 jan - 31 des
e	1 apr - 31 jan
f	1 jan - 31 des
g	1 jan - 31 des
h	1 jan - 31 des
i	1 jan - 31 des
j	1 jan - 31 des
k	1 jan - 31 des
l	1 jan - 31 des
m	1 feb - 1 jun
n	31 jan - 1 apr
o	1 jan - 31 des
p	1 jan - 31 des
r	1 jan - 31 des
s	1 jan - 31 des
C1	1 jan - 31 des
C2	1 jan - 31 des
C3	1 jan - 31 des

Spawning closures

Area	Period
1	15 feb - 31 mar
2	15 feb - 15 apr
3	15 feb - 15 apr
4	1 feb - 1 apr
5	15 jan - 15 mai
6	15 feb - 15 apr
7	15 feb - 15 apr
8	1 mar - 1 may

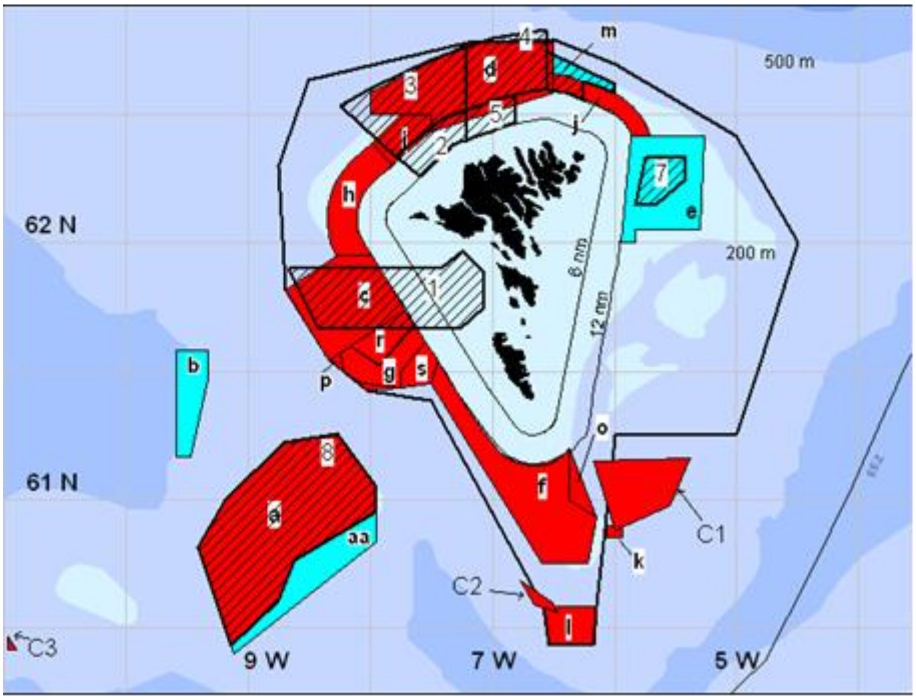


Figure 2.2. Fishing area regulations in Division 5.b. Allocation of fishing days applies to the area inside the outer thick line on the Faroe Plateau. Holders of effort quotas who fish outside this line can triple their numbers of days. Longliners larger than 110 GRT are not allowed to fish inside the inner thick line on the Faroe Plateau. If longliners change from longline to jigging, they can double their number of days. The Faroe Bank shallower than 200 m depths (a, aa) is regulated separate from the Faroe Plateau. It is closed to trawling and the longline fishery is regulated by individual day quotas.

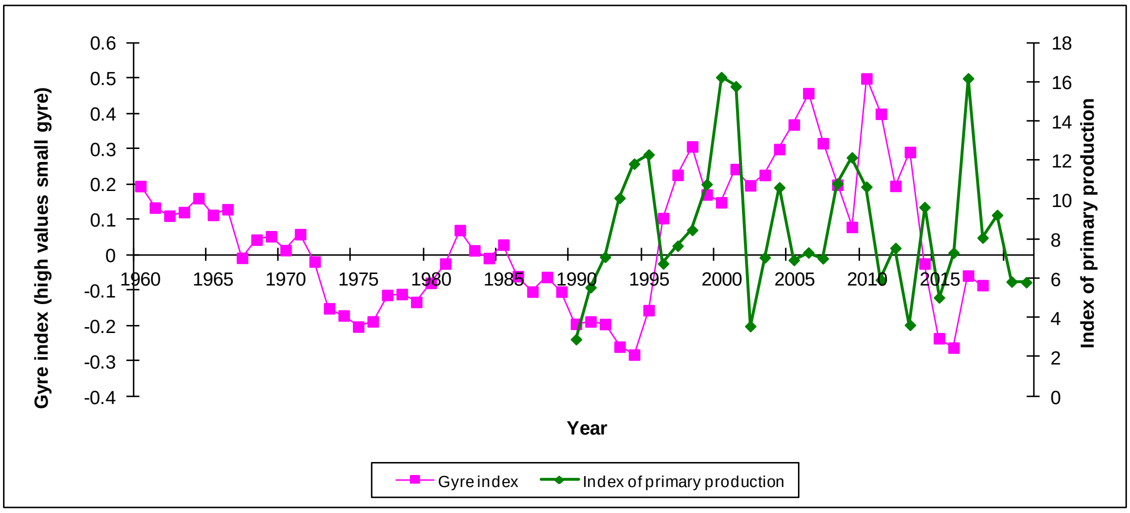


Figure 2.3. Temporal development of the phytoplankton index over the Faroe Shelf area (< 130 m) and the Subpolar Gyre index which may indicate productivity in deeper waters.

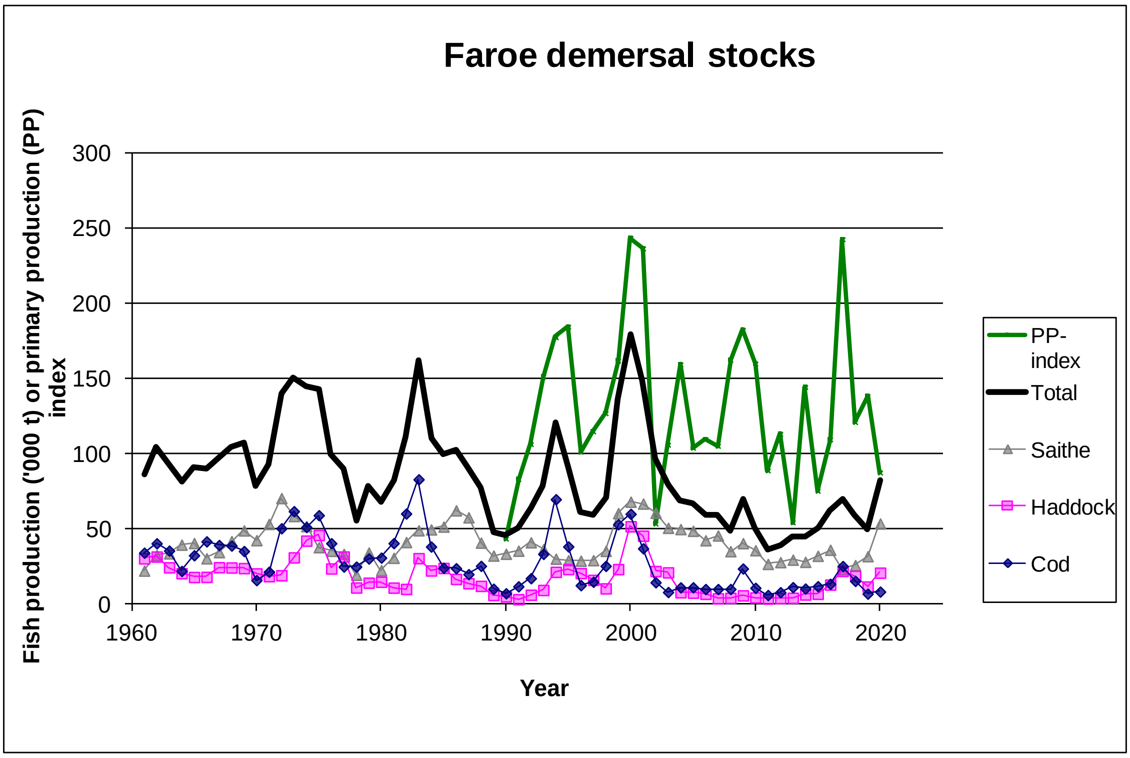


Figure 2.4. Temporal development of primary production and production of cod, haddock and saithe.

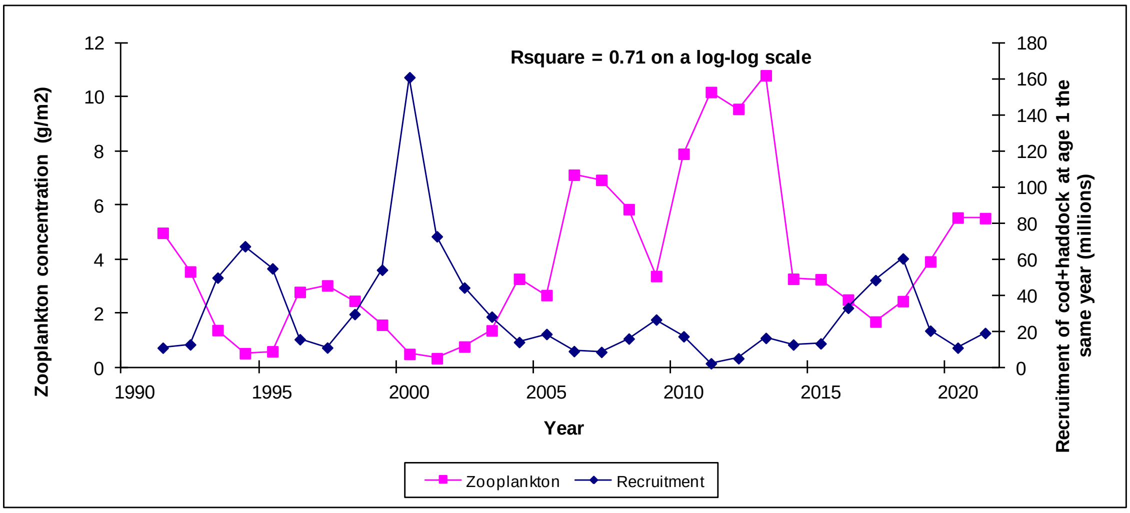


Figure 2.5. Relationship between zooplankton concentration in June/July and recruitment of cod and haddock on the Faroe Plateau.

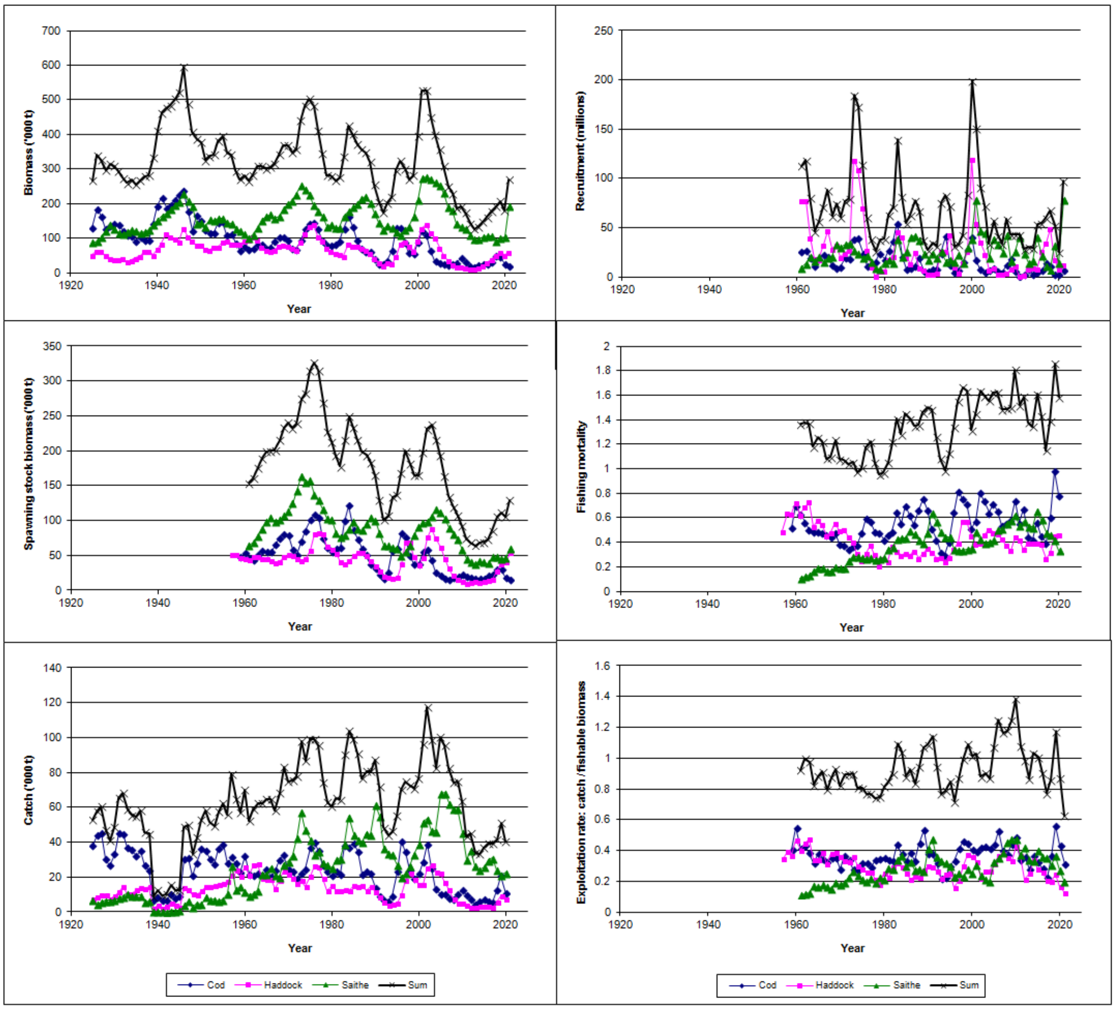


Figure 2.6. Summary of the stock dynamics for Faroe Plateau cod, Faroe haddock and Faroe saithe. Fishable biomass is age 3+ for cod and haddock and age 4+ biomass for saithe.

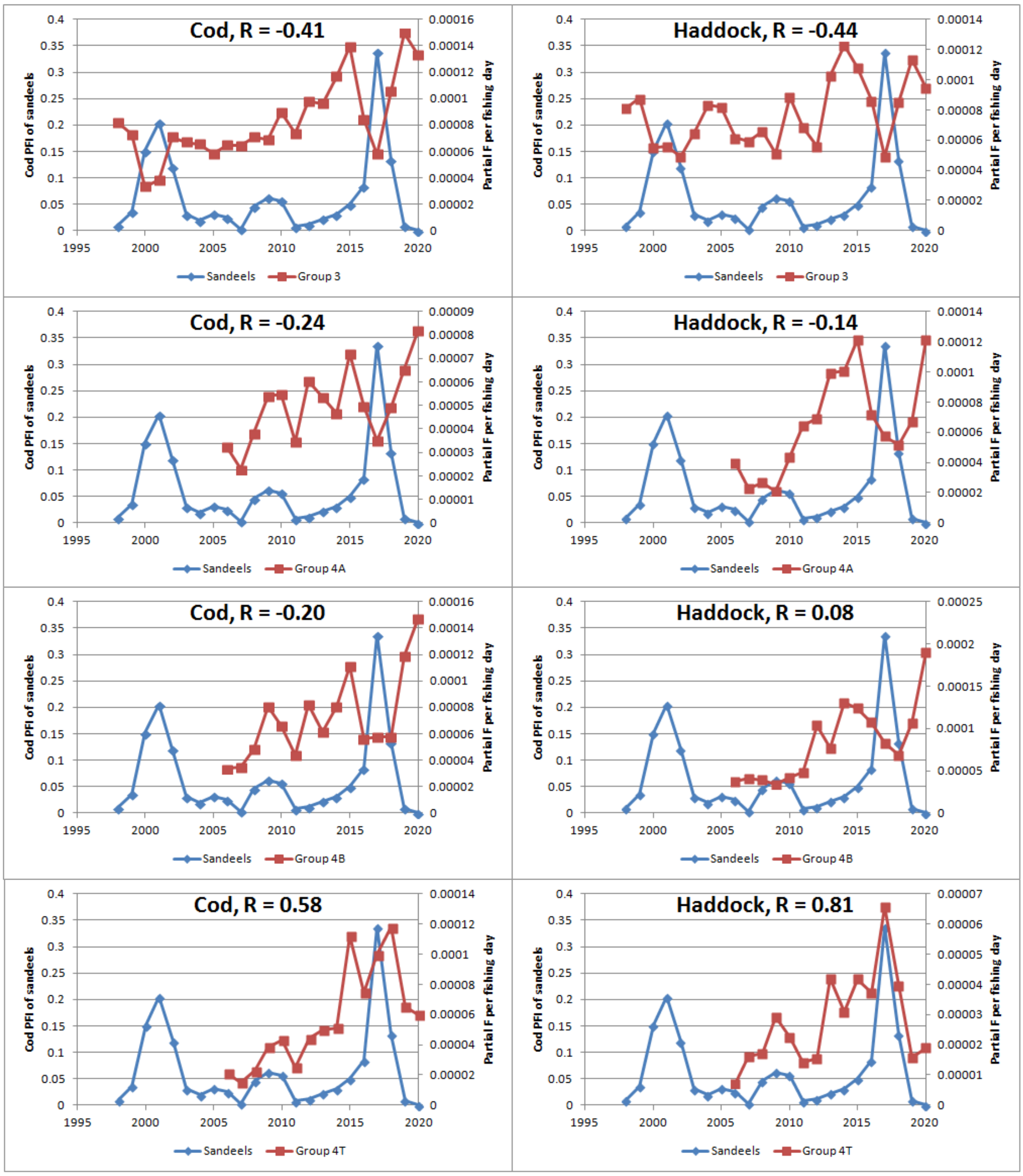


Figure 2.7. Partial F per fishing day of cod and haddock for large longliners (Group 3), medium-sized longliners (Group 4A) and small longliners (Group 4B) as well as small single trawlers (Group 4T). A comparison with sandeel abundance is made.

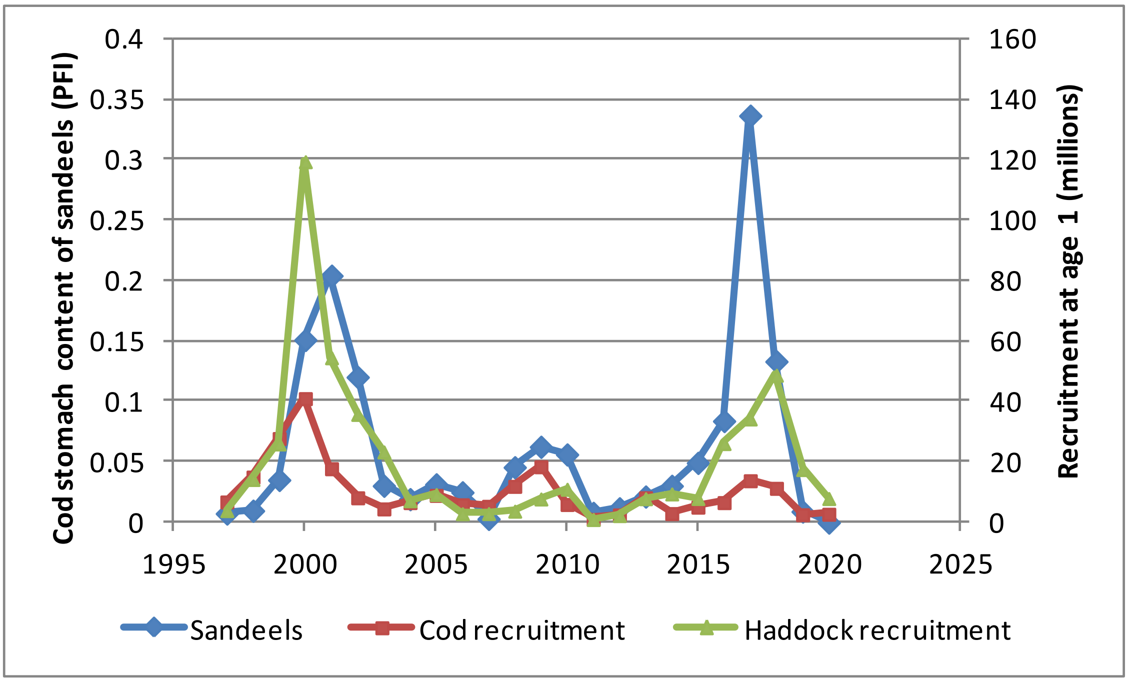


Figure 2.8. Sandeel abundance, as measured by cod stomach partial fullness index of sandeels, compared with the recruitment of cod and haddock.

3 Faroe Bank cod

This section was updated in November 2021.

3.1 State of the stock

Total nominal catches of the Faroe Bank cod from 2002 to 2020 as officially reported to ICES are given in Table 3.1 and since 1965 in Figure 3.1. UK catches reported to be taken on the Faroe Bank are all assumed to be taken on the Faroe Plateau and are therefore not used in the assessment. Landings have been highly variable from 1965 to the mid-1980s, reflecting the opportunistic nature of the cod fishery on the Bank, with peak landings slightly exceeding 5000t in 1973 and 2003. The trend of landings has been smoother since 1987, declining from about 3500 t in 1987 to only 330 t in 1992 before increasing to 3600 t in 1997. Landings have declined sharply from a peak of almost 6000 t. in 2004 to 65 in 2020. (Figure 3.1). Longline fishing effort increased substantially in 2003 and although it decreased in 2004 and 2005 the latter remains the second highest fishing effort observed since 1988 (Figure 3.1). Since 2005–2007 the effort has been reduced substantially. In the 2010/2011 and 2011/2012 fishing years a total of 61 and 100 fishing-days were allocated to the Bank.

The Faroese groundfish surveys (spring and summer) cover the Faroe Bank and cod is mainly taken within the 200 m depth contour. The catches of cod per trawl hour in depths shallower than 200 meters are shown in Figure 3.2.

Spring survey was initiated in 1983 and discontinued in 1996, 2004 and 2005. Summer survey has been carried out since 1996. The CPUE of spring survey was low during 1988–1995 varying between 73 and 95 kg per tow. Although noisy, the survey suggests higher, possibly increasing biomass during 1995–2003 and in 2013 and 2014 but it decreased rapidly from 2015 to 2019. Survey stock estimates in 2020 and 2021 are the largest since 2004.. The summer index was high from 1996 to 2003 but declined substantially in 2004 and it has remained at low levels since then. There are conflicting signals between both indices from 2013 to 2014. The agreement between summer and spring index is good during 1996 to 2001, but they diverged in the 2002–2003 and 2013—2014 periods. The summer index has remained well below average since 2004.

The figure of length distributions (figures 3.3 and 3.4) show in general good recruitment of 1 year old in summer survey from 2000–2002 (lengths 26–45 cm), corresponding to good recruitment of 2 years old in spring surveys from 2001 to 2003 (40–60 cm). The spring index shows poor recruitment from 2006–2019 reflecting the weak year classes observed in summer survey since 2004. Length composition data show relatively high numbers of individuals in the 80–100 cm range since 2019. Figure 3.5 shows the ichtoplankton survey carried out in the Faroe Bank since 1991.

A way to estimate recruitment strength is by simply counting the number of fish in length groups in the surveys. In spring index, recruitment was estimated as total number of fish below 60 cm (2-year old) and in summer index as number of fish below 45 cm (1-year old). According to the summer index the recruitment of 1 year old was good from 2000 to 2003, while the recruitment has been relatively poor since 2004 (Figure 3.6). Spring recruitment index in 2015 was the highest since 2005. Correlation between spring and summer survey recruitment indices is fairly good ($r = 0.85$). Correlation between numbers of 1-year and 2-years old cod in the age-disaggregated summer and spring surveys respectively is estimated at $r = 0.79$.

Surplus production models have been run from 2014 to 2016. The ratio of landings to the survey indices provides an exploitation ratio, which can be used as a proxy to relative changes in fishing mortality. For summer survey, the results suggest that fishing mortality has been reasonably stable during 1996 to 2002, but that it increased steeply in 2003, consistent with the 160% increase in longline fishing days in that year (Figure 3.7). The exploitation ratio has decreased since 2006 but increased in 2011 and 2016 due to the increase in catches.

3.2 Comparison with previous assessment and forecast

The status of the stock remains almost unchanged with respect to last year's assessment. Both spring and summer indices suggest the stock is well below average while there are no indications of incoming recruitment. The spring index suggested an increasing stock biomass from 2020–2021 which it was however not confirmed by the summer index.

3.3 Management plans and evaluations

None.

3.4 Management considerations

The landing estimates are uncertain because since 1996 vessels are allowed to fish both on the Plateau and on Faroe Bank during the same trip, rendering landings from both areas uncertain. Given the relative size of the two fisheries, this is a bigger problem for Faroe Bank cod than for Faroe Plateau cod, but the magnitude remains unquantified for both. The ability to provide advice depends on the reliability of input data. If the cod landings from Faroe Bank are not known, it is difficult to provide advice. If the fishery management agency intends to manage the two fisheries to protect the productive capacity of each individual unit, then it is necessary to identify the catch removed from each stock. Simple measures should make it possible to identify if the catch is originating in the Bank or from the Plateau e.g. by storing in different section of the hold and/or by tagging of the different boxes.

Consistent with the advice given in 2016 the WG suggests the closure of the fishery until the recovery of the stock is confirmed. The reopening of the fishery should not be considered until both surveys indicate a biomass at or above the average that of the period 1996–2002.

3.5 Regulations and their effects

In 1990, the decreasing trends in cod landings from Faroe Bank lead ACFM to advise the Faroese authorities to close the bank to all fishing. This advice was followed for depths shallower than 200 meters. In 1992 and 1993, longliners and jiggers were allowed to participate in an experimental fishery inside the 200 meters depth contour. For the quota year 1 September 1995 to 31 August 1996 a fixed quota of 1050 t was set. The new management regime with fishing days was introduced on 1 June 1996 allowing longliners and jiggers to fish inside the 200 m contour. The trawlers are allowed to fish outside the 200 m contour.

A total fishing ban during the spawning period (1 March–1 May) has been enforced since 2005. In 2009, fishing was restricted to all fishing gears from 1 January–31 August. However, in the 2010/2011 and 2011/2012 fishing years a total of 61 and 100 fishing-days were allocated to the Bank to jiggers in the shallow waters of the Bank. Since 2009 the number of fishing days allocated to the Bank has been negligible.

Table 3.1. Faroe Bank (subdivision Vb2) cod. Nominal catches (tonnes) by countries 2002–2018 as officially reported to ICES. From 1992 the catches by Faroe Islands and Norway are used in the assessment.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Faroe Islands	1840	5957	3607	1270	1005	471	231	81	111	393	115	40	40	26	19	14	33	73	55 *
Norway	25	72	18	37	10	7	1	4	1		0		1	0	1	1			13
France															3			3	0
Greenland	-	-	-	-	-	-	-	-	5		1								
UK (E/W/NI)	42 [3]	15 [3]	15 [3]	24 [3]	1 [3]														
UK (Scotland)	218 [3]	254 [3]	244 [3]	1129 [3]	278 [3]	53	32	38	54				45 [4]	16 [4]	60 [4]	404 [3,4]			
Total	2125	6298	3884	2460	1294	531	264	123	171	393	116	40	86	42	83	419	33	76	68
Correction of Faroese catches in Vb2	-109	-353	-214	-75	-60	-28	-14	-5	-7	-23	-7	-2	-2	-2	-1	-1	-2	-4	-3
Used in assessment	1756	5676	3411	1232	955	450	218	80	105	370	108	38	39	24	19	14	31	69	65

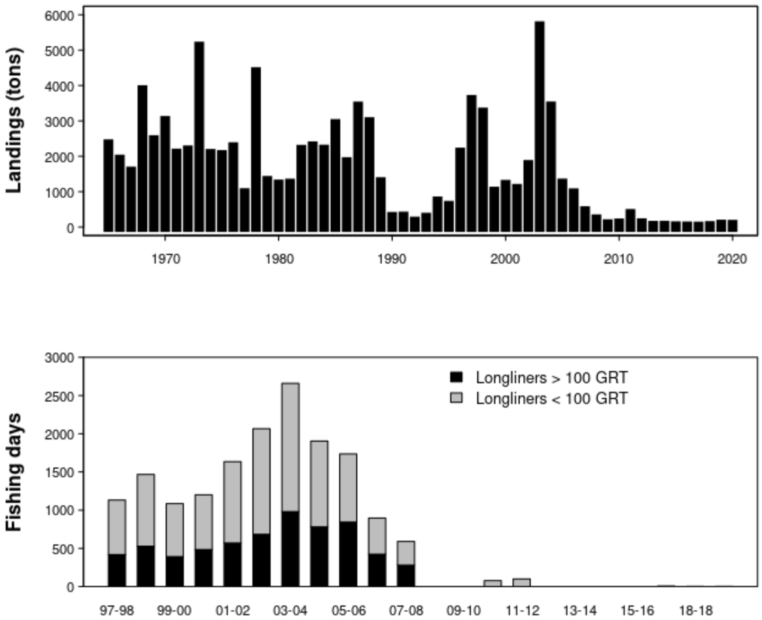


Figure 3.1. Faroe Bank (subdivision Vb2) cod. Reported landings 1965–2020. Since 1992 only catches from Faroese and Norwegian vessels are considered to be taken on Faroe Bank. Lower plot: fishing days (fishing year) 1997–2018 for long-line gear type in the Faroe Bank.

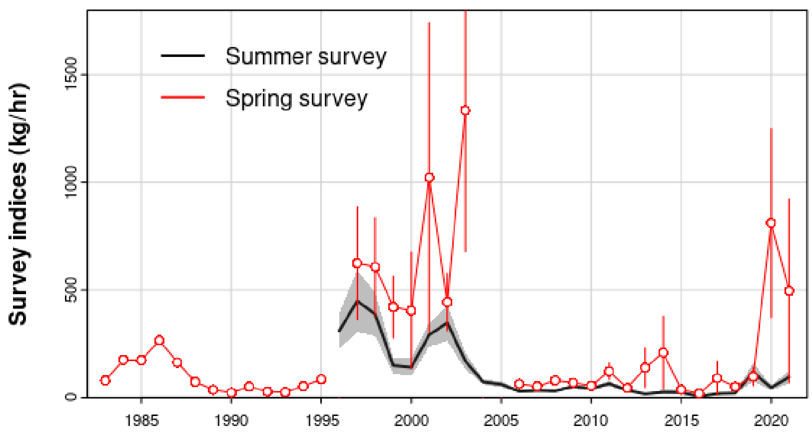


Figure 3.2. Faroe Bank (subdivision Vb2) cod. Catch per unit of effort in spring groundfish survey (1983–2019) (red line) and summer survey (1996–2019) (black line). Vertical bars and shaded areas show the standard error in the estimation of indices.

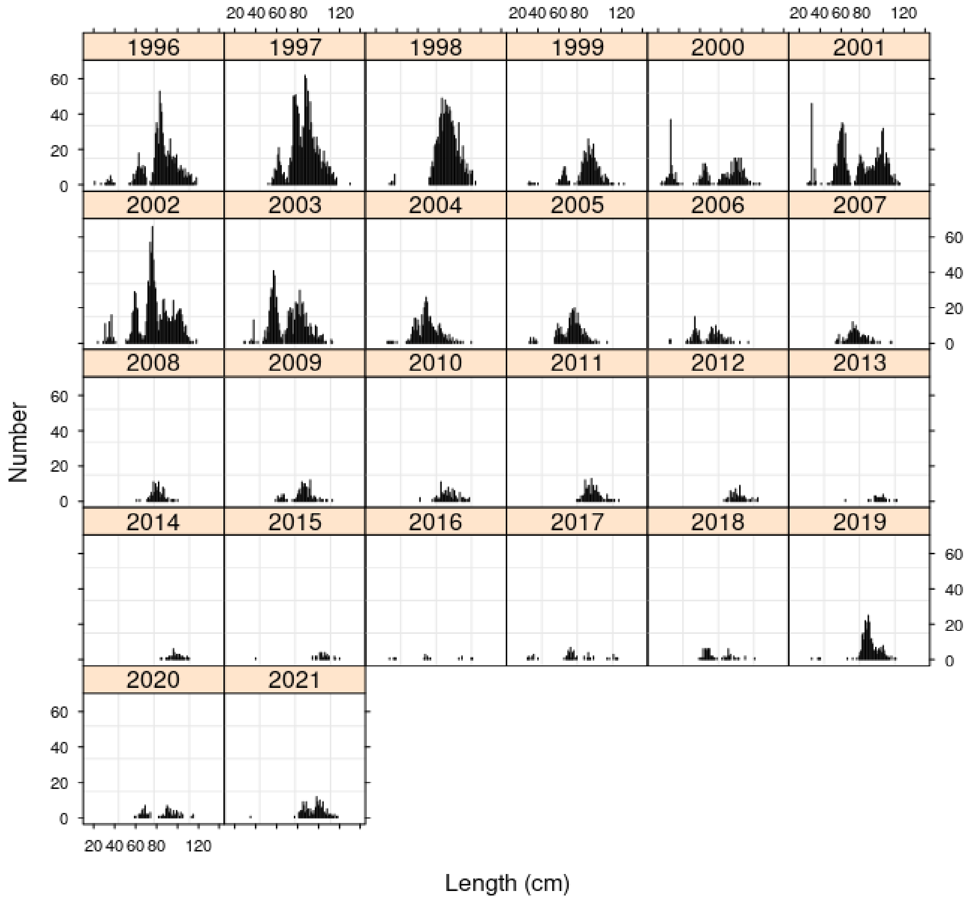


Figure 3.3. Faroe Bank (subdivision Vb2) cod. Length distributions in summer survey (1996–2021)

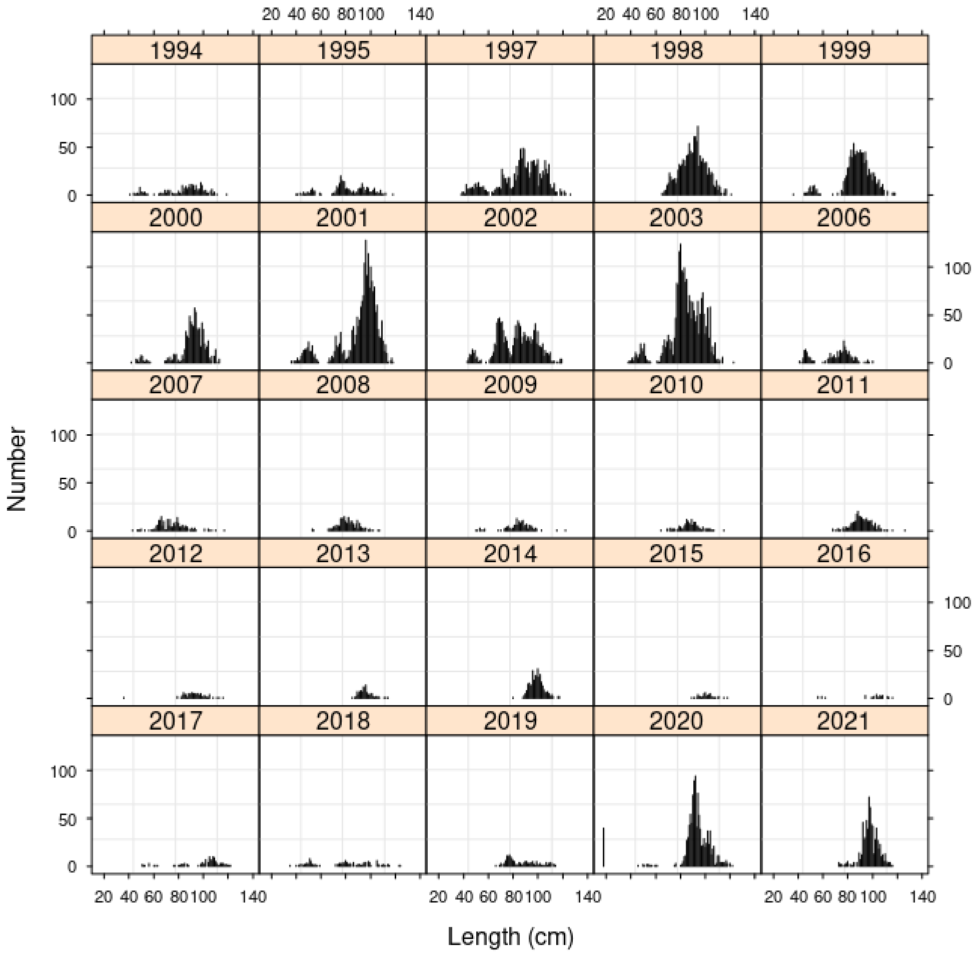


Figure 3.4. Faroe Bank (subdivision Vb2) cod. Length distributions in spring survey (1994–2021). No surveys were conducted in 1996, 2004 and 2005.

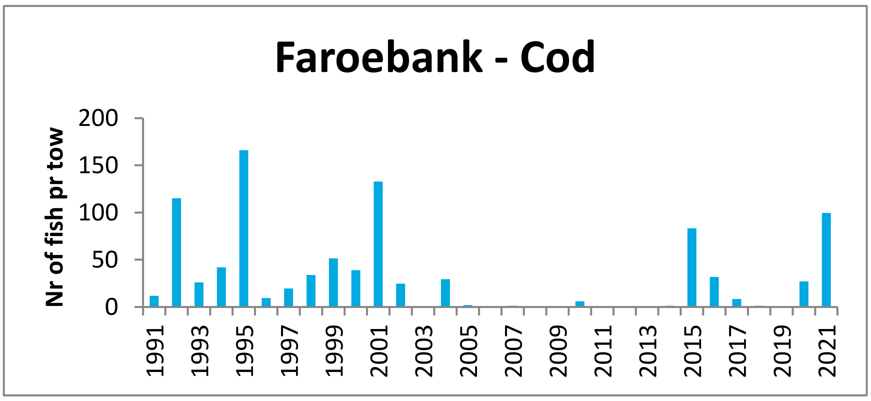


Figure 3.5. Faroe Bank (subdivision Vb2) cod. Ichtoplankton survey (1991–2021). No surveys were conducted in 2009, 2011 and 2013.

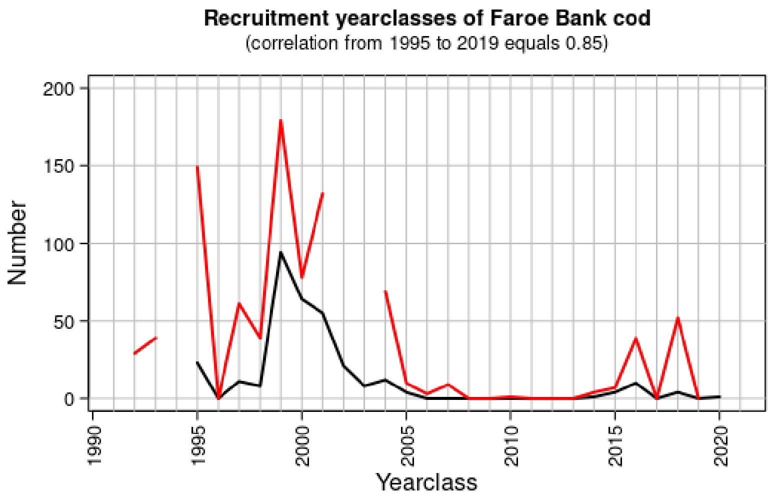


Figure 3.6. Faroe Bank (subdivision Vb2) cod. Correlation between recruitment year classes in both survey indices.

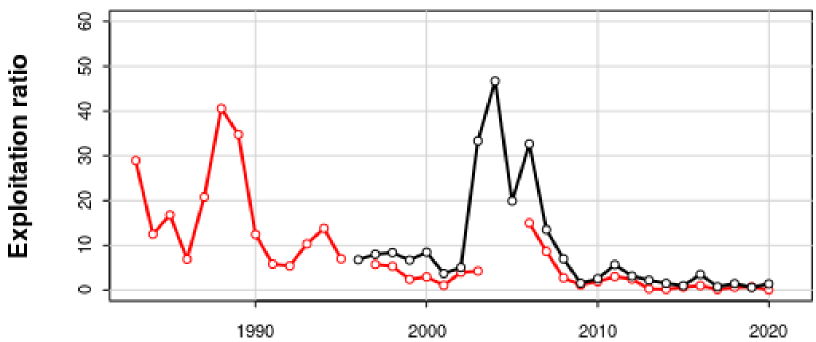


Figure 3.7. Faroe Bank (subdivision Vb2) cod. Exploitation ratios, ratio of spring index to landings (red line) and ratio of summer index to landings (black line).

4 Faroe Plateau cod

This section was updated in November 2021.

4.1 Stock description and management units

Both genetic and tagging data suggest that there are three cod stocks present in Faroese waters: on the Faroe Bank (Division 5.b.2), on the Faroe Plateau (Division 5.b.1) and on the Faroe-Iceland Ridge. Cod on the Faroe-Iceland Ridge seem to belong to the cod stock at Iceland, and the WG in 2005 decided to exclude these catches from the catch-at-age calculations. The stock annex provides more information.

4.2 Scientific data

4.2.1 Trends in landings and fisheries

The landings were obtained from the Fisheries Ministry and Statistics Faroe Islands. The landings are presented in Table 4.2.1 and the working group estimates are presented in Table 4.2.2. The catches on the Faroe-Iceland Ridge, i.e. for single trawlers and the large longliners were not included in the catch-at-age calculations (Table 4.2.3).

4.2.2 Catch-at-age

Landings-at-age for 2020 are provided for the Faroese fishery in Table 4.2.4. Faroese landings from the main fleet categories were sampled (Table 4.2.5). The catch-at-age is shown in Table 4.2.6. Catch curves are shown in Figure 4.2.1.

4.2.3 Weight-at-age

Mean weight-at-age data are provided for the Faroese fishery in Table 4.2.7. These were calculated using the length/weight relationship based on individual length/weight measurements of samples from the landings. The sum-of-products-check for 2019 showed a discrepancy of 0 %. The weights have increased in recent years, but decreased in 2020 (Figure 4.2.2).

4.2.4 Maturity-at-age

The proportion of mature cod by age during the Faroese groundfish surveys carried out during the spawning period (March) is given in Table 4.2.8 and in Figure 4.2.3. Full maturity is generally reached at age 5 or 6, but considerable changes have been observed in the proportion mature for younger ages between years. Maturities were slightly revised during the benchmark in February 2017. The maturities prior to 1983 were set to the average for 1983 to 1996.

4.2.5 Catch, effort and research vessel data

Fisheries independent CPUE series

The spring groundfish surveys in Faroese waters with the research vessel Magnus Heinason is used as a tuning series. The catch curves showed a normal pattern (Figure 4.2.4), i.e., a decreasing trend after age 5. The stratified mean catch of cod per unit effort (Figure 4.2.5) has decreased in the recent years and was amongst the lowest values in 2021.

The other tuning series used is the Summer Groundfish Survey. The new research vessel, Jákup Sverri, conducted the august survey in 2021. The stratified mean catch of cod per unit effort has also decreased in recent years to low values (Figure 4.2.5). The catch curves (Figure 4.2.6) show that the fish are fully recruited to the survey gear at an age of 4 or 5 years. Both tuning series are presented in Table 4.2.9 and they show that the 2016 and 2017 year classes initially seemed to be of average strength but were less abundant in 2020–2021 than expected. Catch per tow in the spring and summer survey shows that there were occasional large hauls in both surveys (Figure 4.2.7 and Figure 4.2.8).

Commercial CPUE series

Three commercial CPUE series (longliners and pairtrawlers) are also presented (tables 4.2.10, 4.2.11, and 4.2.12 as well as Figure 4.2.7), although they are not used as tuning series. Note that the small boats (0–25 GRT) operating with longlines and jigging reels close to land have had an extremely high CPUE in recent years relative to the fishable biomass (Figure 4.2.10, Figure 4.2.11), a feature also observed for the larger longliners (Figure 4.2.9). When that happens, the recruitment of cod tends to be low (Steingrund *et al*., 2010). However, the catchability for the large longliners came down to the average level in 2020 (Figure 4.2.11).

4.3 Information from the fishing industry

The sampling of the catches is included in the 'scientific data'. The fishing industry has since 1996 gathered data on the size composition of the landings but this information has not been used in this assessment.

4.4 Methods

The benchmark in February 2017 decided to change the traditional assessment tool from XSA to SAM although it was recognised that the results of the assessment were mainly data-driven. The SAM model had some beneficial characteristics, e.g. that it provided uncertainty estimates for the catch in numbers, surveys and the output from the assessment (biomasses and fishing mortalities).

4.5 Reference points

Since the assessment model was replaced at the benchmark in February 2017, it was necessary to recalculate reference points at the NWWG meeting in 2017 (this was not finally conducted during the benchmark).

The B_{lim} was kept unchanged at 21 thousand tonnes, since this previously defined B_{loss} was the lowest spawning biomass from which the stock had made a recovery. It was noted that the biomass had been lower afterwards but the stock had not recovered by the time when the reference point was defined.

The $B_{pa} = B_{trigger} = 29\,226$ tonnes (changed from 40 000 tonnes). The uncertainty in the SAM assessment on the final year of SSB was found to be $\sigma = 0.20$ and the B_{pa} was found by using the formula $B_{pa} = B_{lim} \times \exp(\sigma \times 1.645)$. The $B_{trigger}$ was, according to ICES guidelines, set equal to B_{pa} since the stock had not been fished at F_{MSY} for five or more years.

F_{lim} = 0.90 (changed from 0.68). F_{lim} was derived from B_{lim}. A stock was simulated with a segmented regression on the spawning stock – recruitment function having the point of inflection at B_{lim}. F_{lim} was set to the F that, in equilibrium, gave a 50% probability that SSB > B_{lim}. This simulation was based on a fixed F, i.e., without inclusion of a $B_{trigger}$ and without inclusion of assessment/advice errors.

F_{pa} = 0.69 (changed from 0.35). F_{pa} was derived from F_{lim} in the reverse of the way B_{pa} was derived from B_{lim}, i.e., $F_{pa} = F_{lim} \times \exp(-\sigma \times 1.645)$, where $\sigma = 0.16$. This year (2021), the value of Fpa was set equal to the Fp0.5 of 0.41, which is the fishing mortality that leads to probability of 5% of SSB going below Blim.

The calculations were conducted using EQSIM following ICES guidelines. Decisions made involved the spawning stock – recruitment relationship, the weights at age, the selection pattern and the level of advice error. The full time series (1959–2015) was used as basis for the spawning stock – recruitment relationship where the S-R function was based on the segmented regression (weight 0.61), Ricker (weight 0.36) and Beverton and Holt (weight 0.03). The Ricker curve was included because recruitment at very large stock sizes was low according to extension of stock biomass back to 1710 (ICES, 2016). The autocorrelation between SSB-R data points was approximately 0.55. The weights at age were based on the last 10 years (2007–2016). The selection pattern was also based on the last 10 years. The selection pattern has been very stable over time, so the use of the last 20 years would not make any big difference for the F_{MSY}. The advice error was estimated from advice sheets back to 1999: cvF = 0.44, phiF = 0.47, cvSSB = 0.38, phiSSB = 0.24. In total, 2000 iterations were performed that projected the stock 200 years into the future, of which, the last 50 years were kept to calculate 'equilibrium' values.

The result of the analyses was that F_{MSY} = 0.23 (changed from 0.32). The fishing mortality that is associated with a risk of 5% to fall below B_{lim}, Fp0.5, was estimated to be 0.41, i.e., greater than F_{MSY}.

4.6 State of the stock - historical and compared to what is now

As previous years, the two surveys were used for tuning. The commercial series showed a similar overall tendency as the surveys (Figure 4.2.9) but were not used in the tuning. At the benchmark in February 2017, the traditional XSA was replaced by a SAM assessment model. The SAM model settings and the model parameters are shown in Table 4.6.1, e.g. the fishing mortality is assumed equal for ages 7+. The variation in the catchability coefficients for the survey at age was set equal for ages 2+, although different for each survey, and age 1 was set different from the other ages, but different for the two surveys. An AR covariance structure was applied for the summer survey, eliminating year effects, but not for the spring survey. The observation residuals looked quite random (Figure 4.6.1) as well as the joint residuals (Figure 4.6.2).

The results from the SAM-run shows that fishing mortality (F3–7) has decreased in recent years albeit increasing steeply the last three years (Table 4.6.2, Table 4.6.4, Figure 4.6.3). The population numbers, total biomass and spawning stock biomass have been low compared with other years in the series, but temporarily increased around 2017 and decreased again to a level below B_{lim} (Table 4.6.3, Table 4.6.4, Figure 4.6.4, Figure 4.6.5). The poor state of the stock since 2004 was due to poor recruitment (not poor individual growth). Prior to that time, extremely weak year classes (< 5 million individuals at age 2) were only observed three times, whereas it has happened several times since 2004. In the past there has been a poor relationship between the size of the spawning stock and subsequent recruitment (Figure 4.6.6), but the increasing number of low data points in recent years have strengthened the stock-recruitment relationship. The spawning stock biomass in the terminal year was below B_{lim} and the fishing mortality around F_{lim} (Table 4.6.4). The spawning stock biomass in the assessment year was below B_{lim}.

The period of low biomass of Faroe Plateau cod since 2004 has been unprecedented over the last 300 years (Figure 4.6.4); for data and figures for the years before 1959, see ICES (2016), although there were short periods of low biomass between 1700 and 1750 and around 1813.

4.7 Short term forecast

4.7.1 Input data

The short-term prediction was performed in the SAM model. The SAM model provides predictions that carry the signals from the assessment into the short-term forecast. The forecast procedure starts from the last year's (assessment year) estimate of the state (log(N) and log(F) at age. One thousand replicates of the last state are simulated from its estimated joint distribution. Each of these replicates are then simulated forward according to the assumptions and parameter estimates found by the assessment model. In the forward simulations a 5-year average (years up to the assessment year) is used for catch mean weight, stock mean weight, proportion mature, and natural mortality. Recruitment is re-sampled from the last 10 years (up to the year before the assessment year). In each forward simulation step the fishing mortality is scaled, such that the median of the distribution is matching the requirement in the scenario (e.g. hitting a specific mean F value or a specific catch).

4.7.2 Results

The landings in 2021 were originally expected to be 9194 tonnes (Table 4.6.4) with an extremely high projected fishing mortality of 0.85. However, the landings in 2021 were estimated to be only 5454 tonnes, based on the January-September landings 2021 and comparing with 2010-2019. Therefore, (deviating from the stock annex) a catch constraint was set on the landings in 2021 of 5454 tonnes and forecasts based on this assumption (Table 4.6.4). The landings from the Faroe-Iceland Ridge should be added to this figure in order to get the total Faroese landings within the 5.b.1 area. The spawning stock biomass is expected to be 17 thousand tonnes in 2022 and 24 thousand tonnes in 2023 if the F_{MSY} is applied. This is markedly lower than expected in the last years' forecast.

4.8 Long term forecast

The yield per recruitment calculations were performed in the SAM model and were based on the last 20 years (up to the year before the assessment year). The F_{max} was estimated at 0.26 (Figure 4.8.1).

4.9 Uncertainties in assessment and forecast

Since there is no incentive to discard fish or misreport catches under the effort management system, the catch figures are considered adequate, as well as the catch-at-age.

The retrospective pattern indicates uncertainties in the assessment, especially in recruitment (Figure 4.9.1). The Mohn's rho was 353%, -20% and 17% for recruitment, F, and the spawning stock biomass, respectively. The massive downscaling of the recruitment is commented on later in this report (4.10).

Steingrund *et al.* (2010) found that the recruitment of Faroe Plateau cod (age 2) could be rather precisely estimated as there is a significant relationship between cod biomass (age 3+) and the amount of cannibalistic cod in nearshore waters in June–October the previous year. This approach showed that the recent year classes were extremely weak and that the 2016 and 2017 year classes were slightly stronger (Figure 4.9.2).

A preliminary catch-at-age for 2021 was calculated, based on the data already available (catch figures January-September scaled up to the whole year, 5454 tonnes, based on the landings in 2010-2019; age and length samples from the catch January-September). The catch-at-age figures for 2021 were (age 2 to 10+ in thousands): 3, 154, 553, 473, 131, 53, 19, 7, and 2. The fishing mortality in 2021 was much more reasonable (0.43 vs. 0.85) and the recruitment was even more downscaled leading to a more pessimistic forecast of future biomass. Question is whether an additional recruitment index should be used in future assessments that reflects the food availability in the ecosystem – much food, large recruitment, and *vice versa* (NWWG 2020, WD 23), see 4.10. The importance of food is also demonstrated in WD 30 where the downscaling of year classes from age 1 to age 3 was most severe when the condition factor of adult cod was low at the time the year classes were 2 years old.

4.10 Comparison with previous assessment and forecast

The assessment settings were according to the Stock Annex. The assessment this year showed substantial downscaling of the recruitment, a lower total stock biomass and spawning stock biomass and higher fishing mortality compared with last year's assessment (Figure 4.10.1). Reason for this downscaling of recruitment is likely either food shortage or cannibalism or both. This is indicated by a high catchability with longlines and a high abundance of age 3+ cod close to land (in the nursery areas of recruiting cod) that are easily caught by small longliners. This was observed in summer-autumn 2018 and especially in 2019 (Figure 4.2.10, Figure 4.2.11 and Figure 4.9.2). In hindsight, this has happened before (in 1997, 2002–2003) and was not surprising given the low abundance of sandeels and below-average abundance of Norway pout. For some reason, though, the weights-at-age in 2019 and 2020 were above average and this should be investigated further in the future.

4.11 Management plans and evaluations

A management plan based on the fishing day system was implemented in 2021. The management plan comprises the fishery for cod, haddock and saithe on the Faroe Plateau. Longliners and small trawlers are regulated by the status of the cod and haddock stocks whereas the large single trawlers and pair trawlers are regulated by the status of the saithe stock. The change in the allocated fishing days can be either -5%, 0% or +5% from one year to the next. Due to the management plan the fishery for cod, haddock and saithe on the Faroe Plateau was certified as sustainable by MSC in September 2021. The management plan is not yet evaluated by ICES.

4.12 Management considerations

The productivity of the Faroe Plateau cod stock seems to be less now than decades ago. It is stated in the management plan that if extraordinary situations arise there is an option to modify the management plan, although situations or actions are not explicitly specified.

4.13 Ecosystem considerations

Regarding the ecosystem effects on fishing, this issue is partly addressed in the overview section for Faroese stocks. Although the fishery has changed substantially during the last century the total biomass of cod+haddock+saithe has fluctuated around the same level. However, the proportion of saithe has increased steadily over the time period, whereas cod has decreased. This could indicate some effect of fishing on the ecosystem, although other factors cannot be ruled out.

4.14 Regulations and their effects

There seems to be a poor relationship between the number of fishing days and the fishing mortality because of large fluctuations in catchability. Area restrictions may help to reduce fishing mortality, but they cause practical problems for the fishing fleets (e.g. high concentrations of vessels in certain areas).

4.15 Changes in fishing technology and fishing patterns

Fishing effort per fishing day may have increased gradually since the effort management system was introduced in 1996, although little direct quantitative information exists. There also seems to have been substantial increases in fishing power when new vessels are replacing old vessels.

The fishing pattern in recent years has changed in comparison to previous years. The large longliners seem to have exploited the deep areas (> 200 m) to a larger extent (ling and tusk) because the catches in shallower waters of cod and haddock have been so poor – which was also observed in the beginning of the 1990s. They also have fished in other areas, e.g. in Greenland and on the Flemish Cap. This could reduce the fishing mortality on cod and haddock, but the small longliners and jiggers still exploit the shallow areas.

4.16 Changes in the environment

The primary production was low for a number of years, albeit high in 2008 to 2010 and in 2017, but it is not believed that this has any relationship with a change in the environment. Since 2002, the temperature has been about 1°C higher than in the 1990s, which may have had a negative effect on cod recruitment.

Table 4.2.1. Faroe Plateau cod (Subdivision 5.b.1). Nominal catch (t) by countries, as officially reported to ICES.

	Denmark	Faroe Islands	France	Germany	Iceland	Netherlands	Norway	Greenland	Portugal	UK	UK Scotland	Total
1986	8	34492	4	8			83	-		0	0	34595
1987	30	21303	17	12			21	-		8	0	21391
1988	10	22272	17	5			163	-		0	0	22467
1989	-	20535	-	7			285	-		0	0	20827
1990	-	12232	-	24			124	-		0	0	12380
1991	-	8203	-**	16			89	-		1	0	8309
1992	-	5938	3***	12			39	-		74	0	6066
1993	-	5744	1***	+			57	-		186	0	5988
1994	-	8724	-	2***			36	-		56	0	8818
1995	-	19079	2***	2			38	-		43	0	19164
1996	-	39406	1***	+			507	-		126	0	40040
1997	-	33556	-	+			410	-		61***	0	34027
1998	-	23308	-*	-			405	-		27***	0	23740
1999	-	19156	-*	39	-		450	-		51	0	19696
2000		0	1	2	-		374	-		18	0	395
2001		29762	9***	9	-		531	-		50	0	30361
2002		40602	20	6	5		573			42	0	41248
2003		30259	14	7	-		447	-		15	0	30742
2004		17540	2	3***			414		1	15	0	17975
2005		13556	-				201			24	0	13781
2006		11629	7	1***			49	5		0	0	11691
2007		9905	1***				71	7		0	360	10344
2008		9394	1				40			0	383	9818
2009		10736	1				14	7		0	300	11058

	Denmark	Faroe Islands	France	Germany	Iceland	Netherlands	Norway	Greenland	Portugal	UK	UK Scotland	Total
2010		13878	1				10			0	312	14206
2011		11348	-				0			0	0	11348
2012		8437	0		28		0			0	0	8466
2013		5331	0		20		0	2		0	0	5333
2014		6655					2			0	226	6883
2015		7812					33	14		0	367	8174
2016		6736					31	5		0	456	7232
2017		6215	2			0	16			0	388	6625
2018		13297	2			0	69			0	504	13872
2019		22342	1			0	219			0	238	22800
2020		10614*	2			0	163			0	683	11463

*** Preliminary, ** Included in 5.b.2, *** Reported as 5.b.**

Table 4.2.2. Faroe Plateau cod (Subdivision 5.b.1). Nominal catch (t) used in the assessment.

	Officially reported	Faroese catches				Reported as 5.b.2			Foreign catches				Used in the assessment
		in 5.b.1	Adjustment in 5.b.1	On Faroe-Iceland ridge	in 2.a within Faroe area jurisdiction	UK (E/W/NI)	UK (Scotl.)	UK	French ***	Greenland ***	Russia ***	UK ***	
1986	34595												34595
1987	21391												21391
1988	22467				715								23182
1989	20827				1229				12				22068
1990	12380				1090	-	205		17				13692
1991	8309				351	-	90						8750
1992	6066				154	+	176						6396
1993	5988					1	118						6107
1994	8818					1	227						9046
1995	19164	3330****				-	551						23045
1996	40040					-	382						40422
1997	34027					-	277						34304
1998	23740					-	265						24005
1999	19696			-661		-	210						19245
2000	395	21793*		-600		-	245						21833
2001	30361		-1766	-306		-	288						28577
2002	41248		-2409	-223		-	218	-				-	38834
2003	30742		-1795	-4034		-	254	-				-	25167
2004	17975		-1041	-4338		-	244	-				-	12840
2005	13781		-804	-3987			1129	-				-	10119
2006	11691		-690	-1435			278						9844
2007	10344		-588	-2304			53			6			7511
2008	9818		-557	-1978			32						7315

	Officially reported	Faroese catches				Reported as 5.b.2			Foreign catches				Used in the assessment
		in 5.b.1	Adjustment in 5.b.1	On Faroe-Iceland ridge	in 2.a within Faroe area jurisdiction	UK (E/W/NI)	UK (Scotl.)	UK	French ***	Greenland ***	Russia ***	UK ***	
2009	11058		-637	-510			38			26	4		9979
2010	14206		-823	-680			54			5			12762
2011	11348		-673	-986						3			9692
2012	8466		-500	-766						5			7205
2013	5333		-316	-544							0		4473
2014	6883		-395	-777									5711
2015	8174		-460	-384									7329
2016	7232		-399	-958									5876
2017	6625		-369	-896									5360
2018	13872		-789	-869									12214
2019	22800		-1326	-804									20670
2020	11463*		-630	-402									10431

*** Preliminary, ** In order to be consistent with procedures used previous years, *** Reported to Faroese Coastal Guard, **** expected misreporting/discard.**

Table 4.2.3. Faroe Plateau cod (Subdivision 5.b.1). The landings of Faroese fleets (in percentage) of total catch (t). Note that the catches on the Faroe-Iceland ridge (mainly belonging to single trawlers and longliners) are included in this table, but excluded in the catch in numbers.

	Tonnes						Percentage				
	Jigging	Longline	Gillnet	Single trawl	Pairtrawl	Sum	Jigging	Longline	Gillnet	Single trawl	Pairtrawl
1985	1686.2	19971.4	223.7	10170.5	7084.2	39422	4.3	50.7	0.6	25.8	18.0
1986	1008.6	10255.8	454.3	6834.6	15352.1	34492	2.9	29.7	1.3	19.8	44.5
1987	619.5	7366.4	113.9	4443.6	8610.3	21303	2.9	34.6	0.5	20.9	40.4
1988	1670.9	6498.5	573.2	4245.2	9115.5	22272	7.5	29.2	2.6	19.1	40.9
1989	1900.8	10498.2	647.5	3460.1	3873.9	20535	9.3	51.1	3.2	16.8	18.9
1990	1005.3	7222.0	175.8	1572.7	2150.4	12232	8.2	59.0	1.4	12.9	17.6
1991	652.4	4348.2	167.3	1236.8	1743.9	8203	8.0	53.0	2.0	15.1	21.3
1992	418.3	2497.0	1.1	757.7	1945.0	5938	7.0	42.1	0.0	12.8	32.8
1993	514.5	1768.3	0.0	1326.8	2064.9	5744	9.0	30.8	0.0	23.1	35.9
1994	1672.1	2634.1	46.7	1531.9	2787.9	8724	19.2	30.2	0.5	17.6	32.0
1995	4748.7	7751.4	58.7	2931.8	3576.2	19079	24.9	40.6	0.3	15.4	18.7
1996	7881.2	17338.6	0.0	3546.5	10639.6	39406	20.0	44.0	0.0	9.0	27.0
1997	3280.2	20531.2	162.1	4151.2	5403.4	33556	9.8	61.2	0.5	12.4	16.1
1998	1515.3	14600.3	312.9	4124.7	2720.0	23308	6.5	62.6	1.3	17.7	11.7
1999	1039.0	9305.8	439.5	4291.9	3988.2	19156	5.4	48.6	2.3	22.4	20.8
2000	2290.6	8133.9	206.0	6851.3	4259.7	21793	10.5	37.3	0.9	31.4	19.5
2001	4491.4	14349.7	48.2	5815.3	4139.4	28838	15.6	49.8	0.2	20.2	14.4
2002	3790.3	23423.1	103.4	7313.0	3717.2	38347	9.9	61.1	0.3	19.1	9.7
2003	2180.5	17654.6	445.6	6269.5	2821.4	29382	7.4	60.1	1.5	21.3	9.6
2004	1105.6	10453.9	92.1	2793.9	2324.3	16772	6.6	62.3	0.5	16.7	13.9
2005	830.3	7735.4	131.0	5518.8	1248.7	15472	5.4	50.0	0.8	35.7	8.1
2006	611.4	5689.7	20.6	1525.6	784.8	8636	7.1	65.9	0.2	17.7	9.1
2007	542.8	5788.9	25.5	1937.0	569.5	8866	6.1	65.3	0.3	21.8	6.4

	Tonnes						Percentage				
	Jigging	Longline	Gillnet	Single trawl	Pairtrawl	Sum	Jigging	Longline	Gillnet	Single trawl	Pairtrawl
2008	494.0	5086.2	51.1	1720.6	313.0	7666	6.4	66.3	0.7	22.4	4.1
2009	721.5	5113.6	21.1	624.9	663.8	7146	10.1	71.6	0.3	8.7	9.3
2010	1293.2	7075.5	4.4	547.3	1339.8	10258	12.6	69.0	0.0	5.3	13.1
2011	639.4	5895.5	8.9	577.2	2377.7	9502	6.7	62.0	0.1	6.1	25.0
2012	339.7	3777.3	0.0	547.2	1712.7	6378	5.3	59.2	0.0	8.6	26.9
2013	381.9	2901.8	10.0	505.1	944.7	4749	8.0	61.1	0.2	10.6	19.9
2014	365.2	3732.0	24.4	727.1	844.7	5699	6.4	65.5	0.4	12.8	14.8
2015	533.9	3643.2	5.6	934.7	771.5	5890	9.1	61.9	0.1	15.9	13.1
2016	521.7	3226.6	36.6	852.4	922.4	5562	9.4	58.0	0.7	15.3	16.6
2017	491.7	1966.9	26.6	1623.9	1168.8	5279	9.3	37.3	0.5	30.8	22.1
2018	1176.7	4182.7	31.1	3134.8	1852.7	10379	11.3	40.3	0.3	30.2	17.9
2019	2474.2	8959.9	25.5	1944.7	2770.6	16176	15.3	55.4	0.2	12.0	17.1
2020	1207.6	6160.6	34.2	1106.6	1203.8	9718	12.4	63.4	0.4	11.4	12.4

Table 4.2.4. Faroe Plateau cod (Subdivision 5.b.1). Catch in numbers at age per fleet in terminal year. Numbers are in thousands. LL<100: Longliners smaller than 100 GRT. LL>100: Longliners larger than 100 GRT.

	Numbers in thousands				Percent		
Age	LL < 100	LL > 100	Trawlers	Total	LL < 100	LL > 100	Trawlers
1	0	0	0	0			
2	8.2	18.1	1.2	27.4	30	66	4
3	1234.9	305.4	92.5	1632.8	76	19	6
4	647.8	348.6	223.1	1219.5	53	29	18
5	256.5	135.6	86	478.1	54	28	18
6	168.3	116.3	39.1	323.7	52	36	12
7	104.6	65.5	14	184.1	57	36	8
8	6.2	31.2	6.7	44	14	71	15
9	0	6.7	1.8	8.5	0	79	21
10+	0	0.2	1.1	1.3	0	15	85
Sum	2426.5	1027.6	465.5	3919.4	62	26	12

Table 4.2.5. Faroe Plateau cod (Subdivision 5.b.1). Number of samples, lengths, otoliths, and individual weights in terminal year.

Drift	Samples			Only lengths			Lengths and Weights			Otoliths	
	Q1-2	Q3-4		Q1-2	Q3-4		Q1-2	Q3-4		Q1-2	Q3-4
Open boats	1	1		145	88		0	0		65	60
Longliners < 100 GRT	1	2		0	272		219	0		59	120
Jiggers	1	2		158	264		0	0		60	120
Single trawlers < 400 HP	0	0		0	0		0	0		0	0
Single trawlers > 400 HP	0	0		0	0		0	0		0	0
Pair trawlers < 1000 HP	14	7		0	0		2455	938		833	416
Pair trawlers > 1000 HP	6	8		0	0		1164	1029		359	453
Longliners > 100 GRT	12	4		132	0		2170	730		680	240
Sum	35	24		435	624		6008	2697		2056	1409

Table 4.2.6. Faroe Plateau cod (Subdivision 5.b.1). Catch in numbers at age.

Year\age	1	2	3	4	5	6	7	8	9	10+
1959	0	2002	4239	858	1731	200	207	50	10	0
1960	0	4728	4027	2574	513	876	171	131	61	0
1961	0	3093	2686	1331	1066	232	372	78	29	0
1962	0	4424	2500	1255	855	481	93	94	22	0
1963	0	4110	3958	1280	662	284	204	48	30	0
1964	0	2033	3021	2300	630	350	158	79	41	0
1965	0	852	3230	2564	1416	363	155	48	63	0
1966	0	1337	970	2080	1339	606	197	104	33	0
1967	0	1609	2690	860	1706	847	309	64	27	0
1968	0	1529	3322	2663	945	1226	452	105	11	0
1969	0	878	3106	3300	1538	477	713	203	92	0
1970	0	402	1163	2172	1685	752	244	300	44	0
1971	0	328	757	821	1287	1451	510	114	179	0
1972	0	875	1176	810	596	1021	596	154	25	0
1973	0	723	3124	1590	707	384	312	227	120	97
1974	0	2161	1266	1811	934	563	452	149	141	91
1975	0	2584	5689	2157	2211	813	295	190	118	150
1976	0	1497	4158	3799	1380	1427	617	273	120	186
1977	0	425	3282	6844	3718	788	1160	239	134	9
1978	0	555	1219	2643	3216	1041	268	201	66	56
1979	0	575	1732	1673	1601	1906	493	134	87	38
1980	0	1129	2263	1461	895	807	832	339	42	18
1981	0	646	4137	1981	947	582	487	527	123	55
1982	0	1139	1965	3073	1286	471	314	169	254	122
1983	0	2149	5771	2760	2746	1204	510	157	104	102
1984	0	4396	5234	3487	1461	912	314	82	34	66
1985	0	998	9484	3795	1669	770	872	309	65	80
1986	0	210	3586	8462	2373	907	236	147	47	38
1987	0	257	1362	2611	3083	812	224	68	69	26
1988	0	509	2122	1945	1484	2178	492	168	33	25
1989	0	2237	2151	2187	1121	1026	997	220	61	9
1990	0	247	2892	1504	865	410	298	295	51	26
1991	0	192	451	2152	622	303	142	93	53	24
1992	0	205	455	466	911	293	132	53	30	34
1993	0	120	802	603	222	329	96	33	22	25
1994	0	573	788	1062	532	125	176	39	23	16
1995	0	2615	2716	2008	1012	465	118	175	44	49
1996	0	351	5164	4608	1542	1526	596	147	347	47
1997	0	200	1278	6710	3731	657	639	170	51	120

Year\age	1	2	3	4	5	6	7	8	9	10+
1998	0	455	745	1558	5140	1529	159	118	28	25
1999	0	1246	1044	840	1164	2339	461	62	18	8
2000	0	2170	2737	811	443	700	840	108	8	1
2001	0	3967	3812	2130	373	372	728	443	36	6
2002	0	2099	7354	3405	1688	474	538	417	293	7
2003	0	697	2186	4696	1979	657	182	94	118	21
2004	0	98	673	1230	2051	717	234	63	41	36
2005	0	504	604	896	1146	841	208	41	19	31
2006	0	1110	1097	469	663	801	333	76	10	3
2007	0	506	1226	723	315	289	255	85	20	3
2008	0	287	761	783	430	187	157	156	57	19
2009	0	873	2262	861	618	296	85	55	43	17
2010	0	2114	2034	861	468	481	178	58	33	38
2011	0	328	2344	1234	365	188	126	50	19	2
2012	0	49	517	1347	555	200	99	69	25	22
2013	0	55	173	333	587	175	39	25	15	5
2014	0	387	517	286	499	350	86	14	9	1
2015	0	154	1026	517	208	280	219	46	23	7
2016	0	175	374	702	214	146	143	67	18	2
2017	0	112	280	333	438	151	75	41	24	8
2018	0	929	1026	717	541	476	94	60	36	4
2019	0	576	2170	1407	1242	928	239	37	23	9
2020	0	27	1633	1220	478	324	184	44	9	1

Table 4.2.7. Faroe Plateau cod (Subdivision 5.b.1). Mean weight at age (kg) in the catches. Stock weights are set equal to catch weights.

Year\age	2	3	4	5	6	7	8	9	10+
1959	0.850	1.730	3.230	4.400	5.800	6.370	7.340	7.880	10.270
1960	1.000	2.030	3.370	4.420	6.020	6.650	8.120	11.000	10.270
1961	1.080	2.220	3.450	4.690	5.520	7.090	9.910	8.030	10.270
1962	1.000	2.270	3.350	4.580	4.930	9.080	6.590	6.660	10.270
1963	1.040	1.940	3.510	4.600	5.500	6.780	8.710	11.720	10.820
1964	0.970	1.830	3.150	4.330	6.080	7.000	6.250	6.190	14.390
1965	0.920	1.450	2.570	3.780	5.690	7.310	7.930	8.090	11.110
1966	0.980	1.770	2.750	3.510	4.800	6.320	7.510	10.340	11.650
1967	0.960	1.930	3.130	4.040	4.780	6.250	7.000	11.010	10.690
1968	0.880	1.720	3.070	4.120	4.650	5.500	7.670	10.950	9.280
1969	1.090	1.800	2.850	3.670	4.890	5.050	7.410	8.660	14.390
1970	0.960	2.230	2.690	3.940	5.140	6.460	10.310	7.390	9.340
1971	0.810	1.800	2.980	3.580	3.940	4.870	6.480	6.370	10.220
1972	0.660	1.610	2.580	3.260	4.290	4.950	6.480	6.900	11.550
1973	1.110	2.000	3.410	3.890	5.100	5.100	6.120	8.660	7.570
1974	1.080	2.220	3.440	4.800	5.180	5.880	6.140	8.630	7.620
1975	0.790	1.790	2.980	4.260	5.460	6.250	7.510	7.390	8.170
1976	0.940	1.720	2.840	3.700	5.260	6.430	6.390	8.550	13.620
1977	0.870	1.790	2.530	3.680	4.650	5.340	6.230	8.380	10.720
1978	1.112	1.385	2.140	3.125	4.363	5.927	6.348	8.715	12.229
1979	0.897	1.682	2.211	3.052	3.642	4.719	7.272	8.368	13.042
1980	0.927	1.432	2.220	3.105	3.539	4.392	6.100	7.603	9.668
1981	1.080	1.470	2.180	3.210	3.700	4.240	4.430	6.690	10.000
1982	1.230	1.413	2.138	3.107	4.012	5.442	5.563	5.216	6.707
1983	1.338	1.950	2.403	3.107	4.110	5.020	5.601	8.013	8.031
1984	1.195	1.888	2.980	3.679	4.470	5.488	6.466	6.628	10.981
1985	0.905	1.658	2.626	3.400	3.752	4.220	4.739	6.511	10.981
1986	1.099	1.459	2.046	2.936	3.786	4.699	5.893	9.700	8.815
1987	1.093	1.517	2.160	2.766	3.908	5.461	6.341	8.509	9.811
1988	1.061	1.749	2.300	2.914	3.109	3.976	4.896	7.087	8.287
1989	1.010	1.597	2.200	2.934	3.468	3.750	4.682	6.140	9.156
1990	0.945	1.300	1.959	2.531	3.273	4.652	4.758	6.704	8.689
1991	0.779	1.271	1.570	2.524	3.185	4.086	5.656	5.973	8.147
1992	0.989	1.364	1.779	2.312	3.477	4.545	6.275	7.619	9.725
1993	1.155	1.704	2.421	3.132	3.723	4.971	6.159	7.614	9.587
1994	1.194	1.843	2.613	3.654	4.584	4.976	7.146	8.564	8.796
1995	1.218	1.986	2.622	3.925	5.180	6.079	6.241	7.782	8.627
1996	1.016	1.737	2.745	3.800	4.455	4.978	5.270	5.593	7.482
1997	0.901	1.341	1.958	3.012	4.158	4.491	5.312	6.172	7.056

Year\age	2	3	4	5	6	7	8	9	10+
1998	1.004	1.417	1.802	2.280	3.478	5.433	5.851	7.970	8.802
1999	1.050	1.586	2.350	2.774	3.214	5.496	8.276	9.129	10.652
2000	1.416	2.170	3.187	3.795	4.048	4.577	8.182	11.895	13.009
2001	1.164	2.076	3.053	3.976	4.394	4.871	5.563	7.277	12.394
2002	1.017	1.768	2.805	3.529	4.095	4.475	4.650	6.244	7.457
2003	0.820	1.362	2.127	3.329	4.092	4.670	6.000	6.727	6.810
2004	1.037	1.154	1.693	2.363	3.830	5.191	6.326	7.656	9.573
2005	0.986	1.373	1.760	2.293	3.138	5.287	8.285	8.703	9.517
2006	0.839	1.304	1.988	2.386	3.330	4.691	7.635	9.524	11.990
2007	0.937	1.324	1.970	3.076	3.529	4.710	6.464	9.461	9.509
2008	1.209	1.478	2.104	2.714	3.804	4.669	5.915	7.233	9.559
2009	0.805	1.431	2.287	2.723	3.435	5.081	6.281	8.312	9.959
2010	1.049	1.642	2.400	3.212	3.678	4.774	5.973	7.094	9.800
2011	0.815	1.367	2.413	3.493	4.525	5.076	6.631	6.863	10.089
2012	1.007	1.315	1.893	3.102	4.279	5.573	5.871	7.482	9.206
2013	1.011	1.527	2.528	3.180	4.672	6.776	6.966	9.028	10.324
2014	1.099	1.653	2.466	3.000	4.148	6.489	9.394	9.236	12.120
2015	1.198	1.733	2.769	3.650	4.403	5.768	8.035	10.334	11.127
2016	1.358	1.993	2.752	3.937	4.419	5.399	7.059	10.227	10.975
2017	1.281	2.162	3.051	4.042	4.985	5.650	7.407	9.172	10.882
2018	1.278	2.095	3.392	4.249	4.919	5.553	6.987	8.530	10.099
2019	1.328	2.123	3.408	4.292	4.956	5.663	7.009	8.817	10.393
2020	0.975	1.329	2.523	4.085	4.971	6.021	8.442	11.328	14.004
2021	0.933	1.392	2.503	3.948	5.362	6.126	8.049	10.159	11.798

Table 4.2.8. Faroe Plateau cod (Subdivision 5.b.1). Proportion mature at age. The average for 1983 to 1996 is used prior to 1983.

Year	Age									
	1	2	3	4	5	6	7	8	9	10+
1959	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1960	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1961	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1962	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1963	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1964	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1965	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1966	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1967	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1968	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1969	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1970	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1971	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1972	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1973	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1974	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1975	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1976	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1977	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1978	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1979	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1980	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1981	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1982	0.00	0.18	0.64	0.87	0.95	0.99	0.99	0.99	1.00	1.00
1983	0.00	0.03	0.71	0.93	0.94	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.07	0.96	0.98	0.97	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.00	0.50	0.96	0.96	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.00	0.38	0.93	1.00	1.00	0.96	0.94	1.00	1.00
1987	0.00	0.00	0.67	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.06	0.72	0.90	0.97	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.05	0.54	0.98	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.00	0.68	0.90	0.99	0.96	0.98	1.00	1.00	1.00
1991	0.00	0.00	0.72	0.86	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.06	0.50	0.82	0.98	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.03	0.73	0.78	0.91	0.99	1.00	1.00	1.00	1.00
1994	0.00	0.05	0.33	0.88	0.96	1.00	0.96	1.00	1.00	1.00
1995	0.00	0.09	0.35	0.33	0.66	0.97	1.00	1.00	1.00	1.00
1996	0.00	0.04	0.43	0.74	0.85	0.94	1.00	1.00	1.00	1.00

Year	Age									
	1	2	3	4	5	6	7	8	9	10+
1997	0.00	0.00	0.64	0.91	0.97	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.00	0.62	0.90	0.99	0.99	1.00	1.00	1.00	1.00
1999	0.00	0.02	0.43	0.88	0.98	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.02	0.39	0.69	0.92	0.99	1.00	1.00	1.00	1.00
2001	0.00	0.07	0.47	0.86	0.94	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.04	0.37	0.76	0.97	0.93	0.97	1.00	1.00	1.00
2003	0.00	0.00	0.29	0.79	0.88	0.98	1.00	1.00	1.00	1.00
2004	0.00	0.00	0.51	0.78	0.92	0.89	0.87	1.00	1.00	1.00
2005	0.00	0.05	0.66	0.90	0.93	0.98	0.92	1.00	1.00	1.00
2006	0.00	0.04	0.59	0.80	0.99	0.99	1.00	1.00	1.00	1.00
2007	0.00	0.00	0.47	0.78	0.91	0.99	0.97	1.00	1.00	1.00
2008	0.00	0.10	0.78	0.91	0.90	0.95	1.00	1.00	1.00	1.00
2009	0.00	0.09	0.61	0.81	0.96	0.94	0.96	1.00	1.00	1.00
2010	0.00	0.08	0.61	0.77	0.94	0.97	1.00	1.00	1.00	1.00
2011	0.00	0.06	0.51	0.69	0.84	0.93	0.98	1.00	1.00	1.00
2012	0.00	0.00	0.63	0.85	0.94	0.97	1.00	1.00	1.00	0.83
2013	0.00	0.24	0.82	0.95	0.98	1.00	1.00	1.00	1.00	1.00
2014	0.00	0.24	0.73	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2015	0.00	0.28	0.48	0.70	0.95	0.97	1.00	1.00	1.00	1.00
2016	0.00	0.21	0.89	0.91	0.97	1.00	1.00	1.00	1.00	1.00
2017	0.00	0.10	0.73	0.98	0.98	0.97	1.00	1.00	1.00	1.00
2018	0.00	0.14	0.64	0.78	0.94	0.95	0.91	0.92	1.00	1.00
2019	0.00	0.07	0.55	0.83	0.98	0.97	1.00	1.00	1.00	1.00
2020	0.00	0.07	0.45	0.74	0.93	1.00	1.00	1.00	1.00	1.00
2021	0.00	0.03	0.69	0.81	0.94	1.00	0.96	1.00	1.00	1.00

Table 4.2.9. Faroe Plateau cod (Subdivision 5.b.1). Summer survey tuning series (number of individuals per 200 stations) and spring survey tuning series (number of individuals per 100 stations) used as tuning series in the assessment model. Zero values were replaced by 0.1.

Year	Effort	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
1996	200	39.0	724.2	6568.0	3719.9	1298.6	700.2	232.4	48.4	75.5
1997	200	55.0	514.5	1476.6	6647.4	1445.9	177.0	138.1	30.6	1.4
1998	200	411.5	529.2	507.9	981.8	3677.1	901.0	49.6	36.5	17.8
1999	200	121.7	374.3	1257.2	752.3	676.4	1419.0	236.8	40.0	10.0
2000	200	461.6	1374.3	1151.0	672.7	310.5	436.6	601.2	36.5	7.6
2001	200	212.2	3442.3	2446.6	1534.3	417.2	237.4	282.9	242.7	30.9
2002	200	737.1	2368.2	5574.6	1812.6	811.5	149.2	84.3	69.9	49.9
2003	200	68.3	357.4	1038.0	2211.5	566.0	123.7	17.7	12.0	18.4
2004	200	204.1	451.8	839.2	1081.3	1547.3	344.3	80.1	25.6	21.6
2005	200	218.8	616.3	736.6	871.7	1167.8	754.8	142.4	44.7	12.7
2006	200	133.5	980.1	689.3	348.3	311.5	256.3	122.8	28.0	15.5
2007	200	85.6	233.2	449.5	314.0	179.7	134.8	75.8	30.8	12.7
2008	200	181.6	70.3	370.6	328.0	400.6	159.8	52.5	27.8	33.3
2009	200	612.4	435.5	1975.0	821.1	552.9	392.3	131.5	47.2	37.6
2010	200	269.1	1247.8	1551.3	1008.4	363.2	244.2	148.9	41.8	34.2
2011	200	7.1	302.8	1374.7	1083.8	380.7	160.7	105.0	37.4	14.1
2012	200	40.9	22.2	231.1	1080.5	512.6	88.3	35.7	19.2	4.7
2013	200	394.5	105.1	205.3	209.3	888.9	541.5	104.3	44.3	30.9
2014	200	14.4	644.0	866.2	357.9	357.6	400.8	124.0	36.8	22.2
2015	200	205.8	233.0	2236.9	1694.9	412.5	361.1	241.6	66.8	15.8
2016	200	205.6	590.4	838.8	1849.4	693.1	146.5	142.7	73.2	14.6
2017	200	708.3	831.3	997.4	1591.2	1636.3	361.0	129.7	65.0	17.8
2018	200	980.3	982.0	779.4	781.5	502.9	409.8	105.8	27.7	19.8
2019	200	234.0	743.9	922.9	801.5	437.6	276.2	123.4	36.3	16.6
2020	200	83.6	164.6	857.0	685.5	212.3	86.0	48.6	29.6	4.5
2021	200	114.4	102.9	136.6	485.8	211.2	62.0	20.2	15.3	9.1

Year	Effort (hours)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
1994	100	7.8	611.1	336.9	915.0	509.3	130.1	187.3	29.0	0.0
1995	100	4.4	628.7	848.3	1524.9	1518.4	1200.4	282.5	348.3	49.5
1996	100	0.0	216.6	4042.0	3986.7	1889.7	1374.3	421.6	83.2	169.2
1997	100	2.1	74.9	841.6	5395.5	2362.7	332.6	225.4	57.4	4.9
1998	100	1.2	69.5	422.0	1568.5	4928.3	1136.3	82.0	40.6	35.0
1999	100	10.7	708.4	676.9	991.9	1227.7	2085.0	253.4	25.0	13.6
2000	100	2.0	321.5	1433.1	747.1	442.1	507.8	838.6	64.5	1.6
2001	100	1.4	945.3	2381.3	1992.4	456.6	323.9	576.9	125.2	5.3
2002	100	0.2	397.1	4559.4	2896.1	1578.3	330.5	230.8	177.9	130.7
2003	100	0.0	91.4	723.4	3915.6	1263.7	531.3	68.5	52.3	39.8
2004	100	0.5	629.8	581.8	846.8	1178.8	295.0	66.5	22.4	12.0
2005	100	0.0	382.1	440.3	1151.8	1442.4	839.5	140.1	14.0	3.8
2006	100	1.1	167.7	156.5	177.0	360.1	292.6	94.7	15.4	4.0
2007	100	0.0	41.7	271.8	286.2	154.8	170.4	105.1	38.6	14.8
2008	100	5.6	174.0	464.9	832.6	469.8	149.4	83.2	39.4	13.5
2009	100	73.7	309.3	470.5	980.0	1162.5	427.1	73.4	31.8	24.8
2010	100	36.9	699.5	1316.9	747.7	539.3	381.2	99.1	41.4	17.4
2011	100	0.0	149.5	1318.6	1241.6	562.7	300.4	237.4	84.8	21.8
2012	100	0.0	1.4	273.2	1301.5	327.5	73.7	27.1	23.9	6.2
2013	100	3.5	65.2	379.6	1694.7	2055.9	297.3	32.6	22.6	17.5
2014	100	1.0	143.6	126.2	160.3	421.2	333.2	74.8	21.9	13.4
2015	100	0.0	22.5	532.4	226.5	193.9	304.9	138.9	32.6	8.0
2016	100	6.2	82.7	279.3	697.0	152.2	73.7	77.4	27.2	7.7
2017	100	26.6	109.4	529.0	695.0	1085.1	136.0	56.3	31.7	10.3
2018	100	22.7	592.3	923.6	1002.7	730.6	714.4	155.0	50.8	35.3
2019	100	39.0	352.1	1080.5	760.0	555.5	350.7	187.4	20.2	14.2
2020	100	0.2	11.2	676.7	728.7	306.2	147.2	76.2	36.1	4.1
2021	100	35.3	84.6	224.7	629.1	242.9	86.8	17.3	9.5	4.8

Table 4.2.10. Faroe Plateau cod (Subdivision 5.b.1). Pair trawler abundance index (number of individuals per 1000 fishing hours). This series was not used in the tuning in the assessment model. The season is June–December. The otoliths are selected from deep (> 150 m) locations.

Year	Age							
	2	3	4	5	6	7	8	9
1989	1200	1638	1783	1381	928	719	297	194
1990	116	2856	2057	834	465	419	200	0
1991	8	148	1401	869	329	225	65	93
1992	84	487	696	1234	760	353	129	62
1993	51	1081	2192	746	1062	398	67	107
1994	1314	2129	1457	2208	697	1241	461	53
1995	577	3645	5178	4199	2769	543	539	106
1996	242	10608	16683	7985	4410	194	0	723
1997	28	674	6038	9375	2413	944	113	0
1998	80	731	1805	5941	4904	801	286	0
1999	444	2082	1933	3008	5136	2220	218	4
2000	3478	3956	1737	956	1003	1694	382	0
2001	3385	6700	3009	555	415	797	862	25
2002	571	6409	5019	1235	432	400	41	228
2003	63	1341	4450	3630	870	270	152	145
2004	23	0	278	2534	2831	1733	274	184
2005	42	399	655	1766	2171	860	148	70
2006	93	135	699	755	1580	612	787	71
2007	64	916	1767	1392	802	656	206	46
2008	54	295	418	573	387	456	487	182
2009	11	734	801	756	448	247	147	105
2010	1578	2917	1787	543	603	190	0	81
2011	22	1487	4078	1967	622	441	95	25
2012	0	95	1531	1789	950	223	40	107
2013	35	102	761	1583	670	103	57	36
2014	292	1631	1006	1690	1812	477	94	101
2015	43	967	1943	1019	1190	1086	320	96
2016	130	485	2227	1521	905	691	362	177
2017	158	392	855	1477	561	276	216	142
2018	620	1205	1929	1927	1466	629	176	74
2019	2170	5140	2243	1207	339	86	8	6
2020	43	1322	2504	1014	392	211	100	30

Table 4.2.11. Faroe Plateau cod (Subdivision 5.b.1). Longliner abundance index (number of individuals per 100 000 hooks). This series was not used in the tuning in the assessment model. The age composition was obtained from all longliners > 100 GRT. The area was restricted to the area west of Faroe Islands at depths between 100 and 200 m.

Year	Age							
	1	2	3	4	5	6	7	8
1993	405	2610	9306	3330	806	2754	847	258
1994	101	8105	14105	7863	4659	962	1187	71
1995	0	15249	23062	2895	2505	1568	708	1073
1996	0	2269	18658	13265	4153	8435	4513	1147
1997	0	1738	5837	26368	18089	2805	2807	402
1998	1892	4490	2025	2565	11738	2732	131	19
1999	849	10968	3811	985	1891	3759	548	109
2000	2695	10983	6710	998	780	1473	2136	109
2001	287	12999	7409	2660	515	1135	1808	2545
2002	105	6862	20902	10819	7759	1561	1945	1265
2003	16	2099	6057	15910	7778	1830	708	650
2004	59	510	1773	2438	3214	1059	293	71
2005	297	2169	1543	2313	2327	1360	170	13
2006	151	5813	5319	674	2205	2352	1148	56
2007	274	3578	6383	2778	1927	1159	1118	134
2008	1270	2243	4449	4773	2564	1133	816	716
2009	294	2670	15107	6308	3028	2491	683	132
2010	23	20287	16914	8733	2595	4780	1878	864
2011	160	2817	28218	14391	4295	2207	1252	195
2012	0	1833	9562	8309	2364	1296	403	197
2013	0	52	209	2887	5132	2654	1222	359
2014	93	5898	9602	4695	4398	3475	1289	116
2015	0	1260	10417	8202	3167	3342	2428	414
2016	157	1790	3118	5109	1985	873	1370	1548
2017	584	1624	1700	1255	1073	743	462	553
2018	0	3690	8057	7624	6613	7832	1836	1899
2019	0	5430	15027	7622	6057	2776	698	73
2020	0	91	2831	5361	2172	840	453	213

Table 4.2.12. Longliner abundance index (number of individuals per day) for longliners < 25 GRT operating mainly near shore. This series was not used in the tuning of the assessment model. The age composition was obtained from all longliners. Data were not available for 2020.

Year	Age							
	1	2	3	4	5	6	7	8
1983	0.9	7.5	4.7	3.8	1.6	0.9	0.5	0.2
1984	0.0	33.3	32.1	13.2	5.8	6.3	1.0	0.7
1985	0.0	3.7	50.1	35.0	25.3	14.1	19.6	5.8
1986	0.0	5.6	41.6	24.0	15.3	6.8	6.2	2.2
1987	0.0	6.8	11.3	16.6	27.5	12.4	5.3	0.9
1988	0.0	3.1	6.4	13.0	8.5	19.1	6.5	2.6
1989	0.1	43.7	21.3	20.5	13.9	7.5	16.1	2.2
1990	0.0	7.9	40.3	8.6	12.2	6.5	7.7	4.2
1991	0.0	0.0	5.2	27.0	8.7	3.9	2.4	0.7
1992	0.0	6.2	17.1	6.9	3.9	3.6	1.8	1.4
1993	0.4	4.6	19.2	7.3	1.4	1.3	0.3	1.3
1994	0.1	14.9	18.4	15.4	6.6	2.1	2.6	0.5
1995	0.0	53.6	47.8	12.2	8.4	5.1	2.0	3.1
1996	0.0	5.9	76.2	52.1	13.1	28.8	14.3	4.2
1997	0.0	4.6	16.6	71.8	54.5	7.9	7.6	0.9
1998	5.8	12.1	5.6	8.2	33.1	9.9	0.4	0.4
1999	0.3	29.2	10.0	4.7	7.0	15.9	2.5	0.1
2000	9.6	40.4	23.5	1.3	1.3	2.4	4.2	0.5
2001	0.6	96.6	48.7	17.1	3.0	5.7	12.6	12.9
2002	0.1	47.6	97.2	43.4	30.0	7.3	11.5	6.8
2003	0.0	17.5	37.4	106.4	59.1	12.9	4.1	1.5
2004	0.0	7.0	21.5	21.0	31.1	8.2	0.3	0.0
2005	0.6	14.7	20.5	18.5	32.9	15.6	1.5	0.0
2006	2.0	58.7	47.0	9.1	10.6	13.6	4.1	0.4
2007	0.2	11.2	23.2	8.9	4.2	4.9	3.5	0.6
2008	0.3	3.4	16.2	21.1	14.4	3.3	1.5	2.1
2009	3.1	33.3	154.6	57.5	33.9	23.5	9.6	5.9
2010	2.6	135.7	147.1	62.4	27.3	28.5	8.5	1.8
2011	0.0	19.7	156.5	65.0	25.2	15.6	8.5	1.9
2012	0.3	4.6	39.3	59.0	15.1	5.2	2.6	1.3
2013	1.2	16.6	23.8	63.6	58.0	7.8	2.9	0.0
2014	2.1	103.4	102.0	46.9	27.3	17.1	1.4	0.0
2015	0.9	25.4	148.6	65.3	23.0	17.9	10.7	0.7
2016	3.2	30.5	40.6	36.9	7.8	4.9	5.6	0.0
2017	14.6	41.2	36.0	18.8	11.6	2.1	0.1	0.0
2018	1.2	126.1	86.6	40.4	25.1	27.8	6.5	9.3
2019	0.0	60.5	148.2	83.0	63.4	46.5	7.8	1.0

Table 4.6.1. Faroe Plateau cod (Subdivision 5.b.1). Configuration in the SAM-run and the model parameters.

```
> conf
$minAge
[1] 1

$maxAge
[1] 10

$maxAgePlusGroup
[1] 1

$keyLogFsta
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1    0    1    2    3    4    5    5    5     5
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$corFlag
[1] 2

$keyLogFpar
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]    0    1    2    3    4    5    6    7    7    -1
[3,]    8    9   10   11   12   13   14   15   15    -1

$keyQpow
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$keyVarF
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$keyVarLogN
[1] 0 1 1 1 1 1 1 1 1 1

$keyVarObs
```

```
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]    1    2    2    2    2    2    2    2    2    -1
[3,]    3    4    4    4    4    4    4    4    4    -1

$obsCorStruct
[1] ID AR ID
Levels: ID AR US

$keyCorObs
     1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
[1,]  NA  NA  NA  NA  NA  NA  NA  NA   NA
[2,]   0   0   0   0   0   0   0   0   -1
[3,]  NA  NA  NA  NA  NA  NA  NA  NA   -1

$stockRecruitmentModelCode
[1] 0

$noScaledYears
[1] 0

$keyScaledYears
numeric(0)

$keyParScaledYA
<0 x 0 matrix>

$fbarRange
[1] 3 7

$keyBiomassTreat
[1] -1 -1 -1

$obsLikelihoodFlag
[1] LN LN LN
Levels: LN ALN

$fixVarToWeight
[1] 0
```

Table of model parameters: (Not updated yet)

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-8.996	0.225	0	0	0
logFpar_1	-7.726	0.132	0	0	0.001
logFpar_2	-6.639	0.127	0.001	0.001	0.002
logFpar_3	-6.137	0.124	0.002	0.002	0.003
logFpar_4	-5.912	0.122	0.003	0.002	0.003
logFpar_5	-5.802	0.12	0.003	0.002	0.004
logFpar_6	-5.655	0.115	0.004	0.003	0.004
logFpar_7	-5.519	0.117	0.004	0.003	0.005
logFpar_8	-13.047	0.39	0	0	0
logFpar_9	-8.332	0.142	0	0	0
logFpar_10	-6.633	0.135	0.001	0.001	0.002
logFpar_11	-5.747	0.132	0.003	0.002	0.004
logFpar_12	-5.435	0.13	0.004	0.003	0.006
logFpar_13	-5.378	0.129	0.005	0.004	0.006
logFpar_14	-5.443	0.128	0.004	0.003	0.006
logFpar_15	-5.576	0.099	0.004	0.003	0.005
logSdLogFsta_0	-1.375	0.118	0.253	0.2	0.32
logSdLogN_0	-0.276	0.125	0.759	0.591	0.974
logSdLogN_1	-1.266	0.117	0.282	0.223	0.356
logSdLogObs_0	-1.276	0.096	0.279	0.231	0.338
logSdLogObs_1	0.02	0.157	1.02	0.745	1.397
logSdLogObs_2	-0.634	0.085	0.531	0.448	0.629
logSdLogObs_3	0.69	0.139	1.994	1.511	2.632
logSdLogObs_4	-0.461	0.053	0.631	0.567	0.702
transfIRARdist_0	-0.62	0.223	0.538	0.345	0.84
itrans_rho_0	1.676	0.208	5.343	3.523	8.104

Model	log(L)	#par	AIC
Current	-925.72	26	1903.43
base	-925.72	26	1903.43

Table 4.6.2. Faroe Plateau cod (Subdivision 5.b.1). Fishing mortality at age from the SAM model.

Year Age	1	2	3	4	5	6	7	8	9	10
1959		0.226	0.467	0.496	0.539	0.526	0.578	0.578	0.578	0.578
1960		0.292	0.607	0.653	0.721	0.723	0.803	0.803	0.803	0.803
1961		0.252	0.528	0.582	0.656	0.671	0.749	0.749	0.749	0.749
1962		0.216	0.46	0.52	0.594	0.608	0.666	0.666	0.666	0.666
1963		0.178	0.389	0.456	0.527	0.552	0.606	0.606	0.606	0.606
1964		0.147	0.337	0.419	0.505	0.555	0.629	0.629	0.629	0.629
1965		0.128	0.311	0.403	0.501	0.57	0.66	0.66	0.66	0.66
1966		0.11	0.278	0.376	0.484	0.58	0.705	0.705	0.705	0.705
1967		0.099	0.261	0.359	0.461	0.555	0.673	0.673	0.673	0.673
1968		0.094	0.257	0.359	0.452	0.533	0.629	0.629	0.629	0.629
1969		0.093	0.266	0.38	0.479	0.575	0.687	0.687	0.687	0.687
1970		0.071	0.212	0.308	0.389	0.475	0.571	0.571	0.571	0.571
1971		0.063	0.195	0.291	0.375	0.471	0.574	0.574	0.574	0.574
1972		0.059	0.186	0.275	0.345	0.423	0.509	0.509	0.509	0.509
1973		0.062	0.201	0.296	0.363	0.436	0.538	0.538	0.538	0.538
1974		0.061	0.2	0.299	0.371	0.448	0.568	0.568	0.568	0.568
1975		0.072	0.248	0.381	0.473	0.565	0.728	0.728	0.728	0.728
1976		0.077	0.28	0.453	0.585	0.72	0.97	0.97	0.97	0.97
1977		0.071	0.273	0.45	0.573	0.682	0.887	0.887	0.887	0.887
1978		0.061	0.243	0.398	0.494	0.581	0.747	0.747	0.747	0.747
1979		0.06	0.247	0.401	0.485	0.559	0.7	0.7	0.7	0.7
1980		0.056	0.233	0.369	0.433	0.487	0.592	0.592	0.592	0.592
1981		0.06	0.255	0.406	0.476	0.54	0.663	0.663	0.663	0.663
1982		0.061	0.267	0.427	0.499	0.569	0.705	0.705	0.705	0.705
1983		0.079	0.357	0.575	0.664	0.746	0.897	0.897	0.897	0.897
1984		0.069	0.313	0.507	0.574	0.633	0.744	0.744	0.744	0.744
1985		0.073	0.348	0.598	0.711	0.834	1.022	1.022	1.022	1.022
1986		0.061	0.301	0.533	0.633	0.744	0.904	0.904	0.904	0.904
1987		0.055	0.266	0.472	0.553	0.649	0.793	0.793	0.793	0.793
1988		0.069	0.33	0.586	0.679	0.788	0.948	0.948	0.948	0.948
1989		0.082	0.383	0.684	0.787	0.895	1.048	1.048	1.048	1.048
1990		0.068	0.316	0.584	0.693	0.8	0.955	0.955	0.955	0.955
1991		0.05	0.231	0.437	0.532	0.626	0.763	0.763	0.763	0.763
1992		0.04	0.18	0.345	0.43	0.519	0.656	0.656	0.656	0.656

Year Age	1	2	3	4	5	6	7	8	9	10
1993		0.031	0.138	0.259	0.32	0.388	0.505	0.505	0.505	0.505
1994		0.032	0.135	0.245	0.296	0.354	0.464	0.464	0.464	0.464
1995		0.044	0.18	0.322	0.394	0.482	0.648	0.648	0.648	0.648
1996		0.058	0.239	0.446	0.599	0.801	1.157	1.157	1.157	1.157
1997		0.07	0.278	0.512	0.719	1.023	1.568	1.568	1.568	1.568
1998		0.076	0.284	0.486	0.656	0.924	1.437	1.437	1.437	1.437
1999		0.087	0.302	0.481	0.618	0.853	1.335	1.335	1.335	1.335
2000		0.079	0.262	0.382	0.454	0.587	0.869	0.869	0.869	0.869
2001		0.09	0.299	0.432	0.511	0.661	0.966	0.966	0.966	0.966
2002		0.119	0.404	0.597	0.735	0.956	1.34	1.34	1.34	1.34
2003		0.103	0.357	0.539	0.688	0.904	1.217	1.217	1.217	1.217
2004		0.077	0.276	0.431	0.582	0.812	1.123	1.123	1.123	1.123
2005		0.095	0.334	0.498	0.649	0.888	1.203	1.203	1.203	1.203
2006		0.105	0.358	0.499	0.614	0.795	1.013	1.013	1.013	1.013
2007		0.095	0.32	0.43	0.506	0.639	0.806	0.806	0.806	0.806
2008		0.093	0.32	0.434	0.513	0.657	0.861	0.861	0.861	0.861
2009		0.104	0.362	0.48	0.552	0.679	0.849	0.849	0.849	0.849
2010		0.117	0.427	0.583	0.698	0.885	1.108	1.108	1.108	1.108
2011		0.083	0.314	0.439	0.534	0.679	0.837	0.837	0.837	0.837
2012		0.08	0.321	0.477	0.623	0.85	1.105	1.105	1.105	1.105
2013		0.051	0.21	0.317	0.417	0.566	0.733	0.733	0.733	0.733
2014		0.05	0.213	0.317	0.409	0.532	0.648	0.648	0.648	0.648
2015		0.057	0.253	0.385	0.52	0.726	0.932	0.932	0.932	0.932
2016		0.042	0.191	0.295	0.408	0.593	0.773	0.773	0.773	0.773
2017		0.033	0.159	0.25	0.357	0.534	0.7	0.7	0.7	0.7
2018		0.051	0.255	0.399	0.561	0.809	0.993	0.993	0.993	0.993
2019		0.071	0.397	0.658	0.953	1.352	1.557	1.557	1.557	1.557
2020		0.051	0.305	0.525	0.775	1.105	1.228	1.228	1.228	1.228
2021		0.055	0.328	0.568	0.842	1.196	1.323	1.323	1.323	1.323

Table 4.6.3. Faroe Plateau cod (Subdivision 5.b.1). Stock number at age from the SAM model.

Year	1	2	3	4	5	6	7	8	9	10
1959	19919	11907	12053	2395	4214	607	503	159	25	0
1960	18377	16491	8526	5990	1191	1864	334	226	94	12
1961	26117	14174	8167	3669	2527	518	689	138	70	39
1962	26784	22368	7892	3652	1806	1112	236	222	51	42
1963	19942	22920	13761	3799	1779	759	494	123	82	39
1964	11348	16945	13513	7283	1822	866	344	222	73	54
1965	18071	8061	12850	7954	3701	873	395	135	118	55
1966	22882	15272	5219	8002	4114	1630	375	184	64	73
1967	20949	19593	12472	3471	5141	2117	719	124	67	56
1968	12515	18193	15832	8486	2367	3083	987	302	36	51
1969	8890	10004	13891	10742	4577	1218	1632	399	164	38
1970	10175	6815	6665	8490	6046	2267	566	773	135	84
1971	19280	7771	5136	3923	4696	3561	1174	244	422	104
1972	18145	17387	7309	3745	2351	2531	1622	506	89	277
1973	38472	13280	15208	5819	2550	1401	1010	705	280	215
1974	39524	34813	9188	9268	3536	1591	900	445	353	236
1975	24205	34756	25556	6650	6193	2136	850	398	225	292
1976	11337	20565	24120	13946	3569	3350	1103	472	149	199
1977	12971	8205	14942	17630	7598	1638	1567	388	203	43
1978	15684	10539	6680	8840	9238	2981	642	450	130	96
1979	24140	12421	8277	4932	4625	4743	1344	273	161	80
1980	17869	21866	10655	5135	2757	2251	2224	679	115	68
1981	26664	13280	17915	6830	2788	1473	1074	1105	312	104
1982	36177	22120	10053	10651	3867	1385	683	421	475	209
1983	54788	29173	18080	6759	5874	2156	734	271	183	231
1984	20566	54385	20406	9394	3272	2428	808	219	83	148
1985	8149	16713	37586	10784	4110	1415	1188	378	98	112
1986	8767	5812	13486	20903	5034	1689	451	315	96	65
1987	11345	6997	5837	7694	9005	2064	601	140	111	51
1988	19496	8932	6964	4346	3749	4324	928	276	50	47
1989	5951	20263	6954	4411	2128	1699	1632	330	100	22
1990	5820	4149	12460	3706	1793	809	558	465	95	41
1991	7964	4549	2706	6457	1611	685	302	183	130	46
1992	8547	6743	3562	1690	2874	721	270	123	70	73

Year	1	2	3	4	5	6	7	8	9	10
1993	23392	6149	6365	2873	908	1297	297	93	56	65
1994	41296	20347	6168	5042	2116	511	708	139	38	60
1995	11725	43595	16603	5874	3689	1533	340	525	91	76
1996	5173	8934	31473	12682	3447	2482	932	180	368	74
1997	6824	4524	6504	21685	6890	1116	921	266	38	138
1998	15085	6492	3437	4515	11684	2805	286	145	48	31
1999	27862	12735	5536	2524	2734	4968	759	81	23	12
2000	41091	24652	10221	2994	1369	1687	1949	154	18	4
2001	17848	42763	15757	6500	1413	921	1167	718	51	9
2002	8214	16432	26433	8433	3429	787	600	511	283	14
2003	4528	6355	8537	12652	3689	1175	260	150	149	46
2004	6622	3403	3851	4277	4948	1264	331	80	53	54
2005	9014	6040	2612	2540	2705	1842	385	79	23	32
2006	5897	9091	3684	1425	1361	1242	556	103	21	8
2007	5389	4961	4706	2111	824	634	454	169	43	7
2008	12006	3939	3864	2456	1341	479	275	182	87	25
2009	18506	8185	5632	2300	1500	749	221	102	75	36
2010	5992	15719	6694	2611	1078	783	336	94	43	40
2011	1058	4579	9096	3559	997	437	281	96	37	10
2012	2534	714	2416	4609	1533	362	169	100	30	23
2013	8224	1818	1076	1373	2140	596	109	51	26	11
2014	2978	7632	2353	896	1078	965	228	45	23	6
2015	5111	2479	5348	1743	562	620	413	96	25	11
2016	6619	4359	2366	3110	858	303	270	123	32	7
2017	13868	5229	2854	2010	1864	444	171	104	37	15
2018	11354	12595	4547	2540	1542	1073	225	83	50	12
2019	2596	8743	6853	2951	1613	1022	393	67	26	13
2020	2757	1319	5613	3169	1019	456	225	81	13	3
2021	6562	2161	1143	3057	1263	360	101	50	22	4

Table 4.6.4. Faroe Plateau cod (Subdivision 5.b.1). Summary table from the SAM model (catch is also provided) and forecast with F_{MSY} fishing mortality.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	Catch	TSB	Low	High
1959	19919	10026	39575	47528	37481	60268	0.521	0.401	0.678	22415	65346	51836	82376
1960	18377	9645	35014	52884	42921	65159	0.701	0.553	0.889	32255	75677	61261	93485
1961	26117	13707	49763	46615	37860	57394	0.637	0.498	0.815	21598	68024	54802	84435
1962	26784	14007	51218	43770	35375	54158	0.569	0.442	0.734	20967	70656	55731	89579
1963	19942	10421	38165	50650	40336	63602	0.506	0.391	0.655	22215	82036	63908	105308
1964	11348	5888	21871	56446	44508	71587	0.489	0.378	0.634	21078	82295	64578	104872
1965	18071	9386	34794	54740	43406	69033	0.489	0.377	0.634	24212	70975	56309	89460
1966	22882	11856	44163	54436	43134	68699	0.484	0.372	0.631	20418	73732	58439	93028
1967	20949	10849	40452	64625	51554	81010	0.462	0.353	0.603	23562	91319	72287	115362
1968	12515	6464	24231	74973	59740	94091	0.446	0.343	0.58	29930	102000	80828	128716
1969	8890	4567	17306	79513	63181	100067	0.478	0.367	0.621	32371	102448	81206	129245
1970	10175	5204	19896	78025	62035	98136	0.391	0.3	0.51	24183	93133	74224	116858
1971	19280	9892	37578	58066	46418	72637	0.381	0.293	0.496	23010	69129	55471	86150
1972	18145	9348	35222	51044	41358	62998	0.348	0.267	0.453	18727	66551	53575	82669
1973	38472	19843	74592	69306	55367	86753	0.367	0.286	0.471	22228	95584	75312	121313
1974	39524	20458	76360	84633	67724	105764	0.377	0.297	0.48	24581	127963	100287	163276
1975	24205	12552	46675	100337	80904	124439	0.479	0.383	0.599	36775	143416	113865	180637
1976	11337	5849	21975	108465	87605	134291	0.601	0.484	0.748	39799	145337	116470	181360
1977	12971	6712	25068	104149	82940	130780	0.573	0.457	0.718	34927	127012	101247	159333
1978	15684	8112	30325	73701	58964	92121	0.493	0.389	0.623	26585	90741	73036	112737
1979	24140	12478	46700	61553	50097	75629	0.478	0.376	0.608	23112	78081	63520	95979

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	Catch	TSB	Low	High
1980	17869	9262	34475	54654	44896	66534	0.423	0.332	0.538	20513	78897	63323	98302
1981	26664	13883	51214	58766	47794	72255	0.468	0.371	0.59	22963	82539	66008	103209
1982	36177	18848	69440	60594	49296	74480	0.493	0.394	0.618	21489	91694	72923	115297
1983	54788	28249	106260	99269	79831	123439	0.648	0.522	0.805	38133	126167	99544	159910
1984	20566	10708	39500	120968	96088	152289	0.554	0.446	0.69	36979	162424	124565	211789
1985	8149	4195	15829	85740	68198	107795	0.703	0.57	0.867	39484	133716	104363	171324
1986	8767	4545	16910	73510	57013	94781	0.623	0.501	0.775	34595	95483	75329	121028
1987	11345	5923	21731	59460	47288	74763	0.547	0.439	0.681	21391	71702	57782	88976
1988	19496	10022	37925	50161	41316	60898	0.666	0.542	0.819	23182	61812	50943	75000
1989	5951	3061	11572	36798	30573	44290	0.759	0.619	0.931	22068	61890	49208	77840
1990	5820	2989	11335	30507	24600	37832	0.67	0.538	0.833	13692	40361	32143	50682
1991	7964	4058	15629	21799	17202	27625	0.518	0.408	0.658	8750	26792	21323	33664
1992	8547	4363	16742	16550	13171	20795	0.426	0.33	0.549	6396	26925	21142	34291
1993	23392	12273	44583	25584	20055	32637	0.322	0.247	0.419	6107	35673	27535	46216
1994	41296	21741	78439	55813	43906	70949	0.299	0.233	0.382	9046	64277	49912	82776
1995	11725	6400	21479	59462	48918	72279	0.405	0.328	0.501	23045	130603	102109	167048
1996	5173	2845	9407	81529	67286	98786	0.648	0.536	0.784	40422	130909	106284	161239
1997	6824	3768	12359	75744	61143	93831	0.82	0.686	0.98	34304	87404	70953	107668
1998	15085	8515	26726	49425	39889	61242	0.757	0.632	0.908	24005	58971	48444	71787
1999	27862	15636	49647	37848	31257	45829	0.718	0.593	0.868	19245	56820	47495	67976
2000	41091	23020	73346	37912	31915	45037	0.511	0.414	0.63	21833	89092	71822	110515
2001	17848	10049	31698	55412	46207	66452	0.574	0.472	0.698	28577	122156	97473	153091

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	Catch	TSB	Low	High
2002	8214	4614	14622	57522	47681	69393	0.806	0.669	0.972	38834	109352	88873	134551
2003	4528	2533	8094	43579	35341	53737	0.741	0.612	0.896	25167	64266	52663	78425
2004	6622	3738	11733	25905	21320	31476	0.645	0.531	0.784	12840	34896	29056	41910
2005	9014	5086	15975	21150	17743	25211	0.715	0.59	0.866	10119	29187	24617	34605
2006	5897	3328	10449	16404	13880	19388	0.656	0.536	0.802	9844	26336	21998	31530
2007	5389	3032	9581	14335	12097	16987	0.54	0.438	0.666	7511	23516	19608	28202
2008	12006	6725	21435	17874	14982	21324	0.557	0.455	0.682	7315	24337	20257	29239
2009	18506	10231	33476	18807	15797	22391	0.584	0.479	0.713	9979	29309	24304	35345
2010	5992	3339	10754	21764	18243	25965	0.74	0.606	0.904	12762	42956	34590	53345
2011	1058	579	1934	19636	16153	23871	0.56	0.451	0.696	9692	32623	26525	40123
2012	2534	1418	4526	17317	14144	21201	0.675	0.548	0.832	7205	20888	17085	25537
2013	8224	4540	14898	15979	13012	19622	0.449	0.356	0.565	4473	17981	14736	21941
2014	2978	1635	5425	16438	13757	19642	0.424	0.339	0.53	5711	23907	19508	29298
2015	5111	2859	9138	16786	14103	19978	0.563	0.455	0.697	7329	25377	20889	30827
2016	6619	3694	11861	20567	16792	25191	0.452	0.363	0.563	5876	26634	21676	32727
2017	13868	7648	25146	22955	18703	28174	0.4	0.32	0.5	5360	30990	25210	38095
2018	11354	6092	21159	29670	24752	35566	0.604	0.495	0.737	12214	50357	40768	62202
2019	2596	1342	5022	29764	24678	35899	0.983	0.809	1.195	20670	45612	37246	55857
2020	2757	1282	5928	17732	14085	22323	0.787	0.604	1.026	10431	25400	19930	32371
2021	6562	1778	24213	15240	10369	22399	0.852	0.528	1.375	9194	19466	13403	28274

F_{MSY} projection. TAC in 2021 of 5454 tonnes													
Year	**R(age 1)**	**Low**	**High**	**SSB**	**Low**	**High**	**Fbar(3-7)**	**Low**	**High**	**Catch**	**TSB**	**Low**	**High**
2021	6763	1780	26087	15540	10659	22431	0.428	0.273	0.661	5454	19896	13938	28685
2022	2978	1058	13868	17289	10851	28248	0.136	0.072	0.271	2206	25666	15335	48185
2023	5111	1058	13868	23848	12965	48049	0.136	0.062	0.31	3098	33556	18204	65915
2024	2978	1058	13868	30416	15341	71624	0.136	0.055	0.329	3956	40802	21324	90861

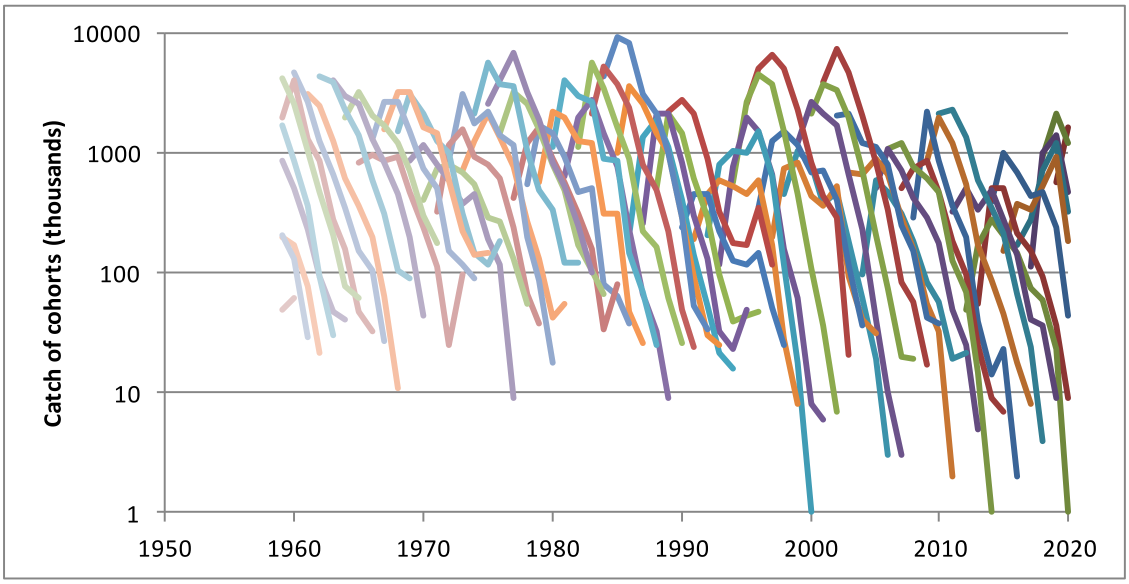


Figure 4.2.1. Faroe Plateau cod (Subdivision 5.b.1). Catch in numbers at age shown as catch curves.

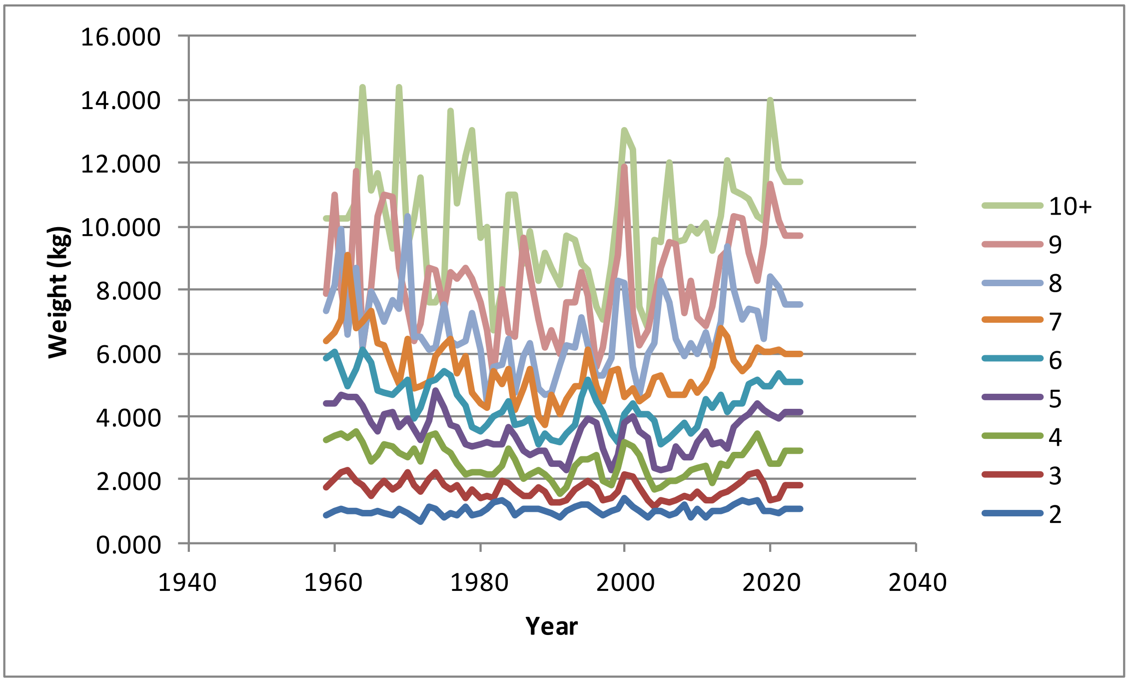


Figure 4.2.2. Faroe Plateau cod (Subdivision 5.b.1). Mean weight at age in the catches. The last three years are based on a previous 5 year average.

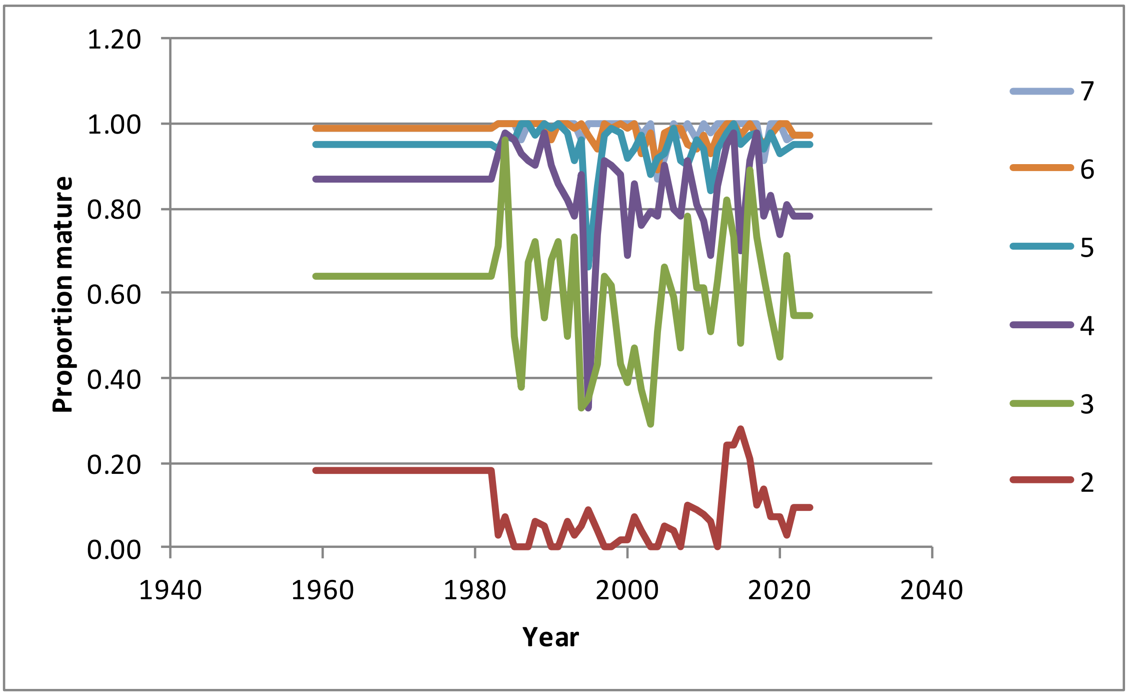


Figure 4.2.3. Faroe Plateau cod (Subdivision 5.b.1). Proportion mature at age as observed in the spring groundfish survey. The last three years are based on a previous 5 year average.

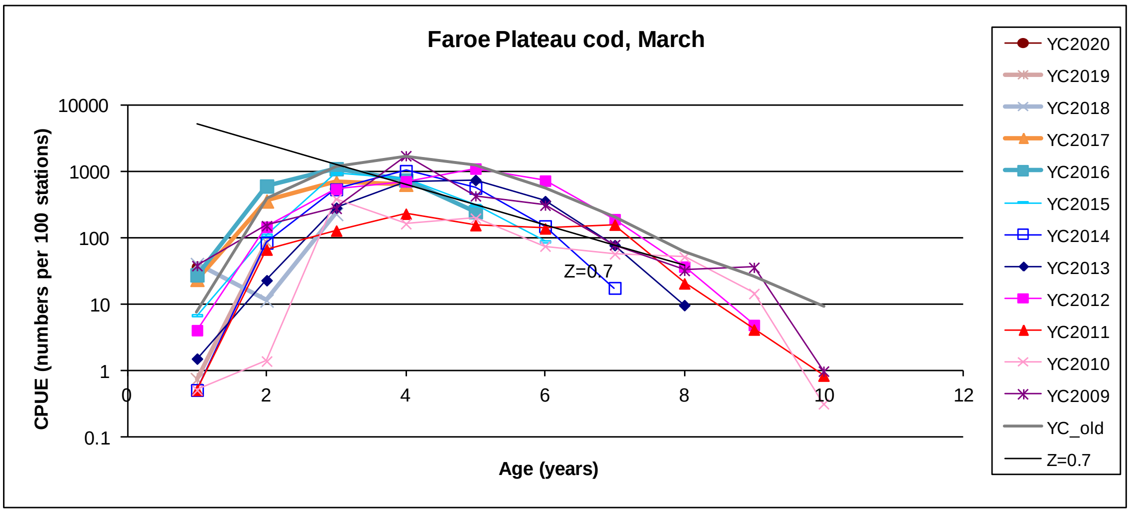


Figure 4.2.4. Faroe Plateau cod (Subdivision 5.b.1). Catch curves from the spring groundfish survey.

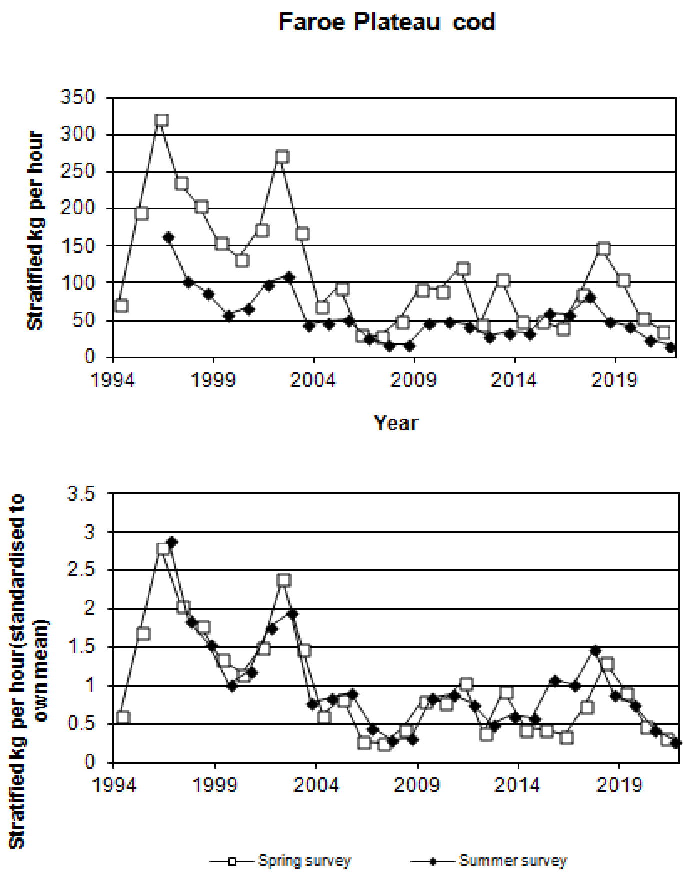


Figure 4.2.5. Faroe Plateau cod (Subdivision 5.b.1). Stratified kg/hour in the spring and summer surveys.

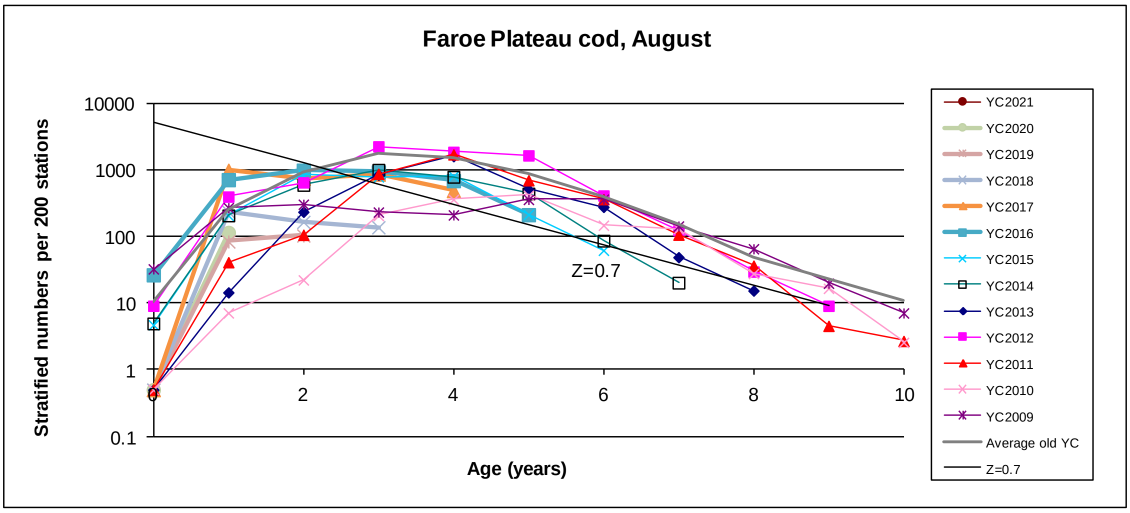


Figure 4.2.6. Faroe Plateau cod (Subdivision 5.b.1). Catch curves from the summer groundfish survey.

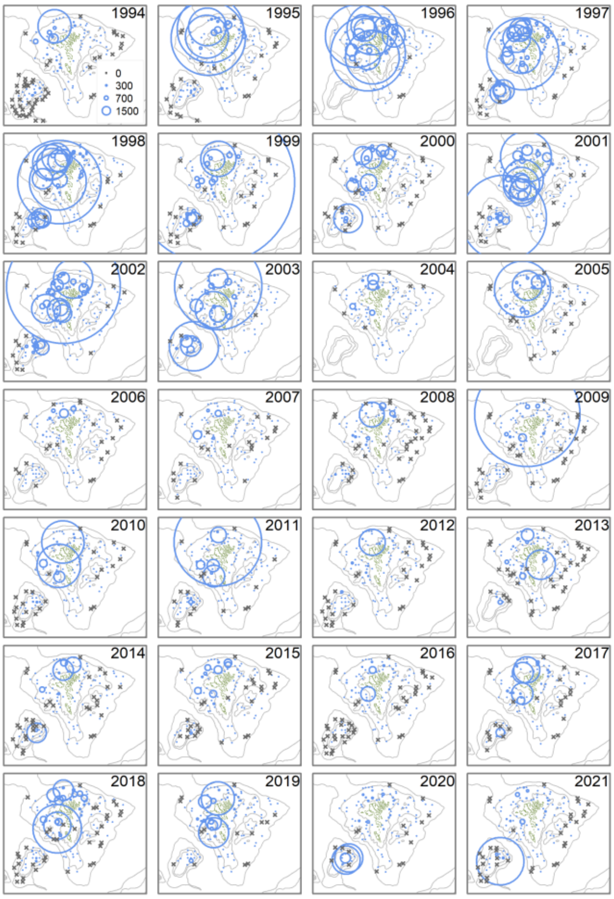


Figure 4.2.7. Faroe Plateau cod (Subdivision 5.b.1). Catch per tow in the spring groundfish survey.

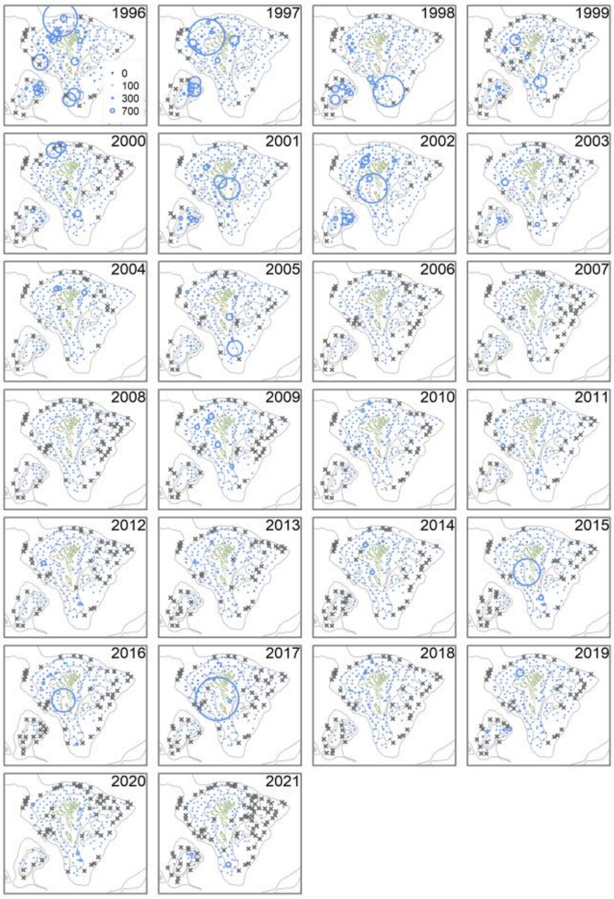


Figure 4.2.8. Faroe Plateau cod (Subdivision 5.b.1). Catch per tow in the summer groundfish survey.

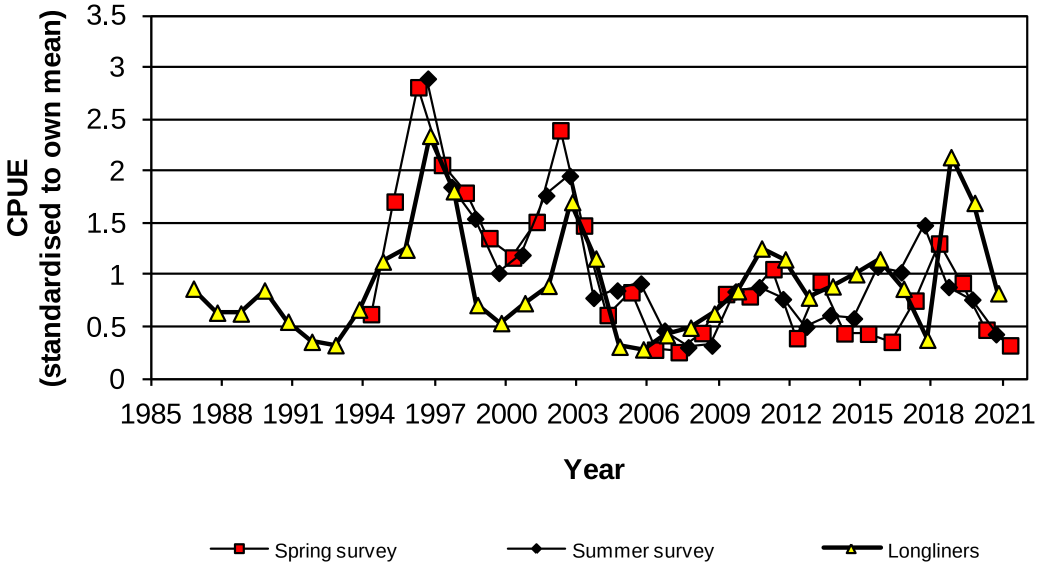


Figure 4.2.9. Faroe Plateau cod (Subdivision 5.b.1). Standardised catch per unit effort for pair trawlers and longliners. The two surveys are shown as well.

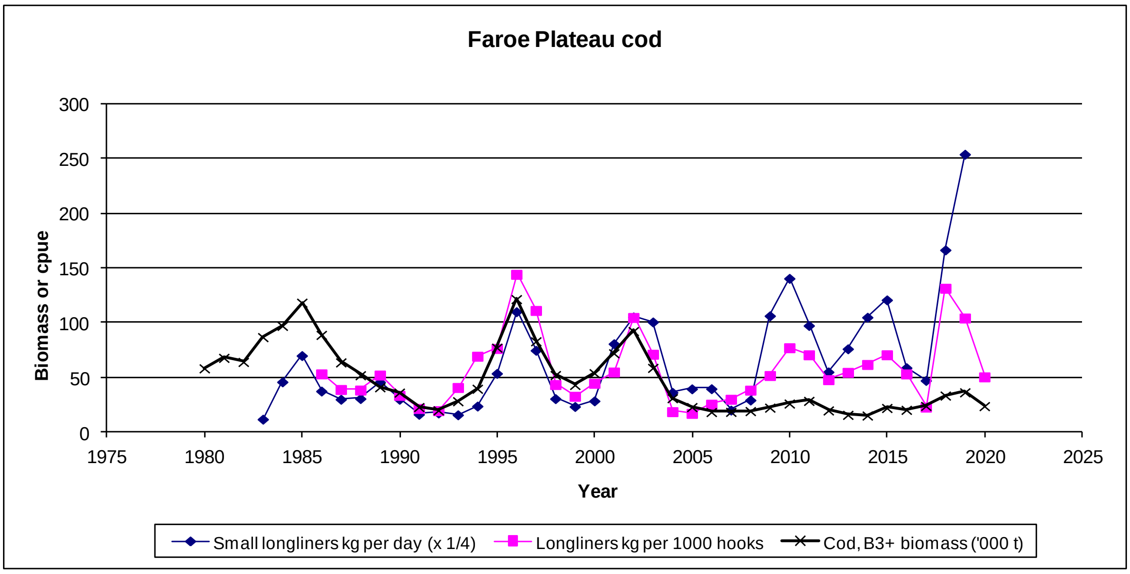


Figure 4.2.10. Faroe Plateau cod (Subdivision 5.b.1). Catch per unit effort for small and large longliners compared with the fishable (age 3+) biomass. No data for small longliners were available for 2020.

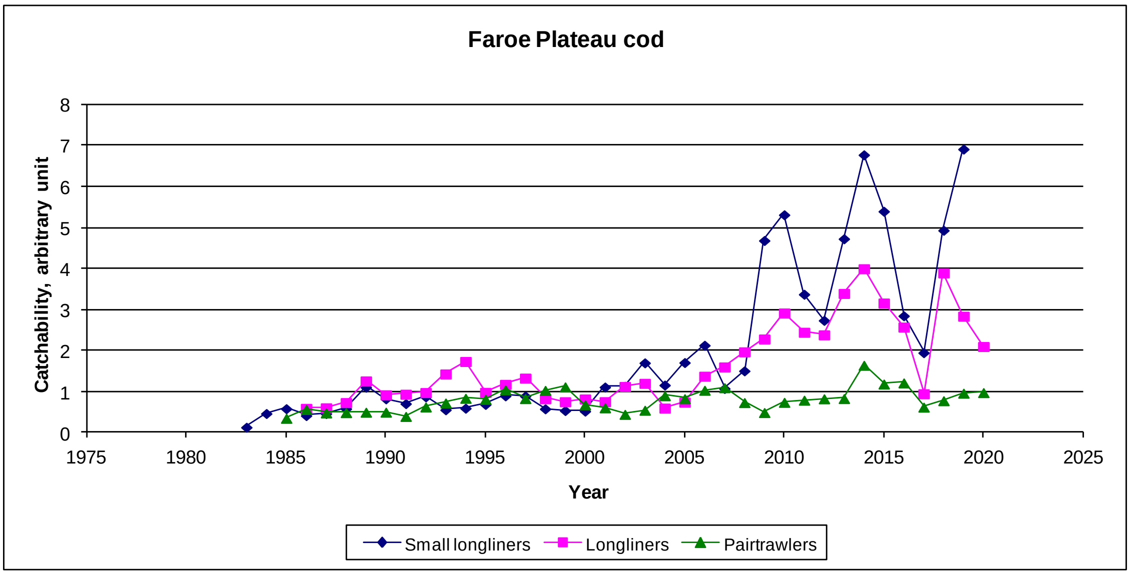


Figure 4.2.11. Faroe Plateau cod (Subdivision 5.b.1). Catchability (cpue divided by age 3+ biomass) for small and large longliners and pair trawlers. No data for small longliners were available for 2020.

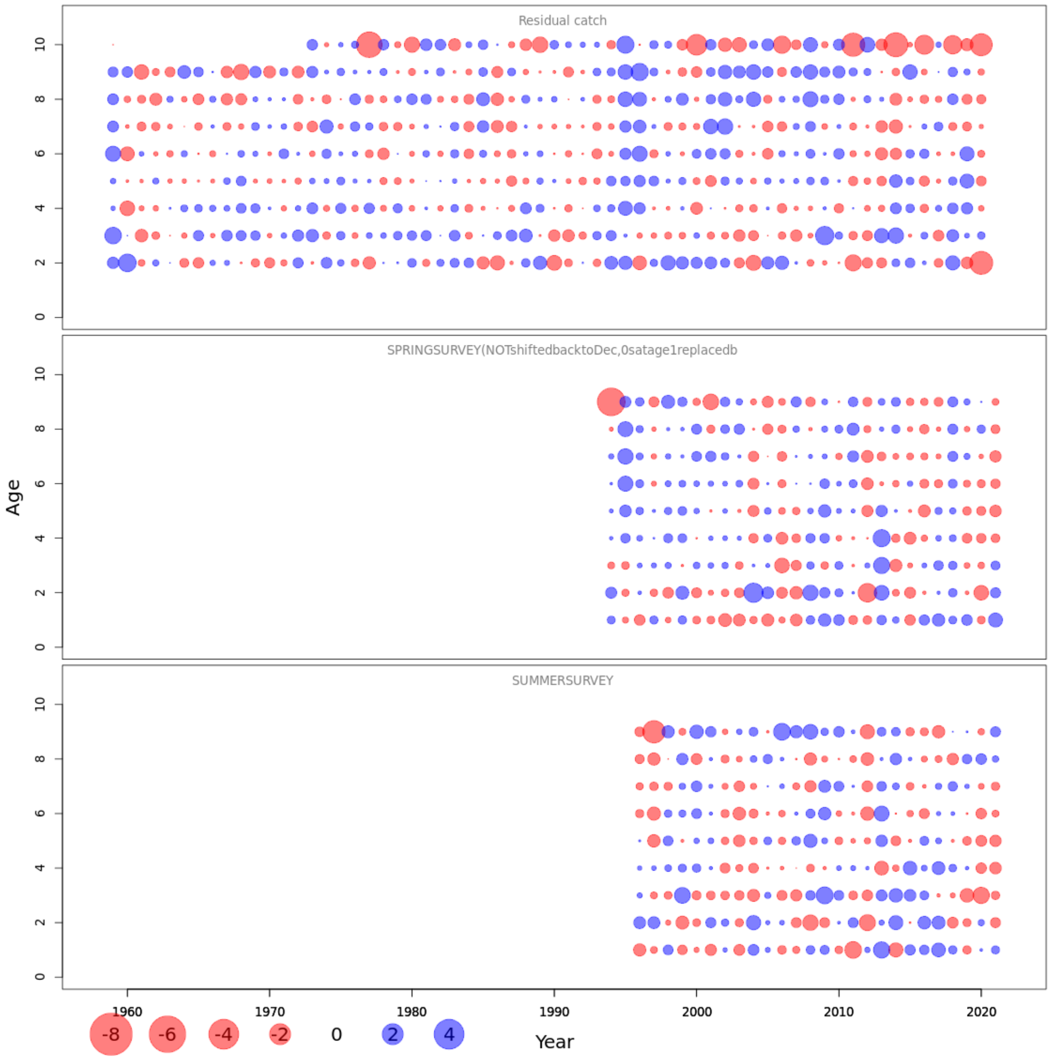


Figure 4.6.1. Faroe Plateau cod (Subdivision 5.b.1). Observation residuals for the catch, spring survey and the summer survey as estimated by the SAM model.

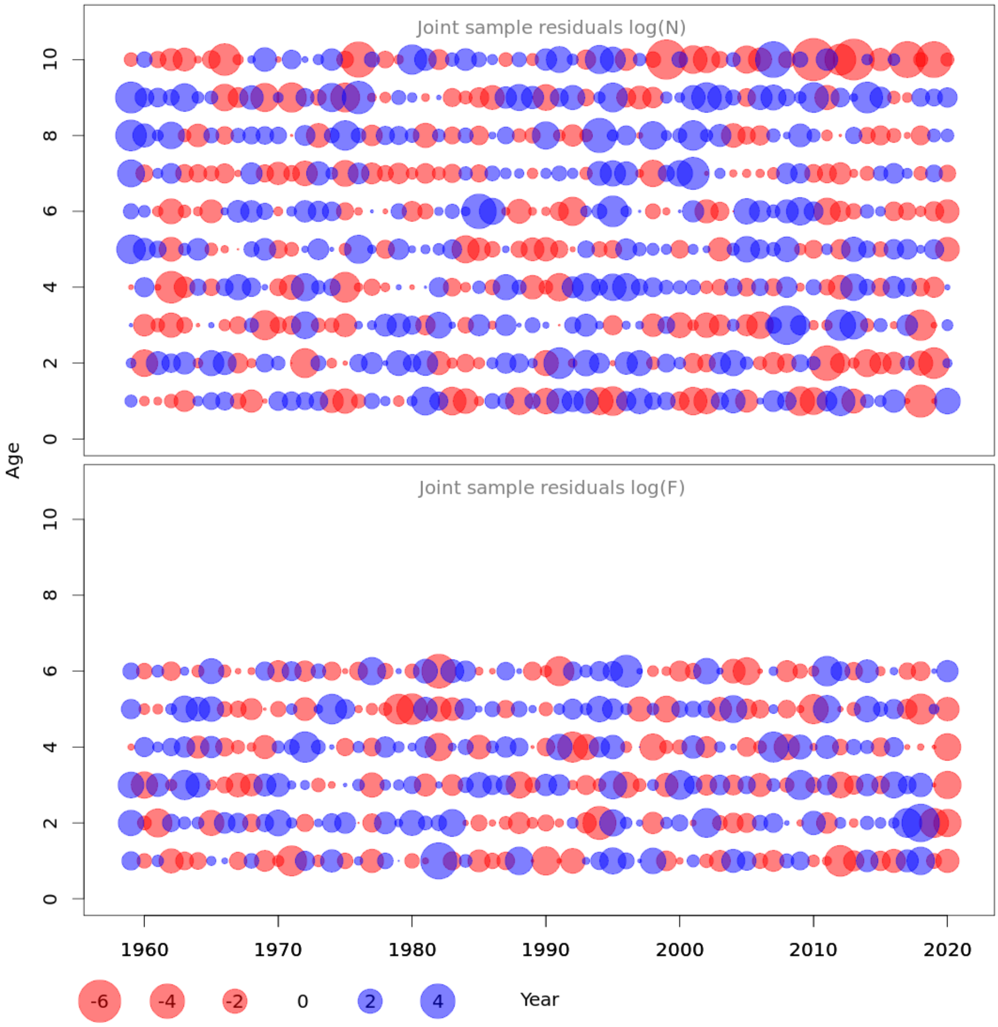


Figure 4.6.2. Faroe Plateau cod (Subdivision 5.b.1). Joint sample residuals for the population numbers and fishing mortality as estimated by the SAM model.

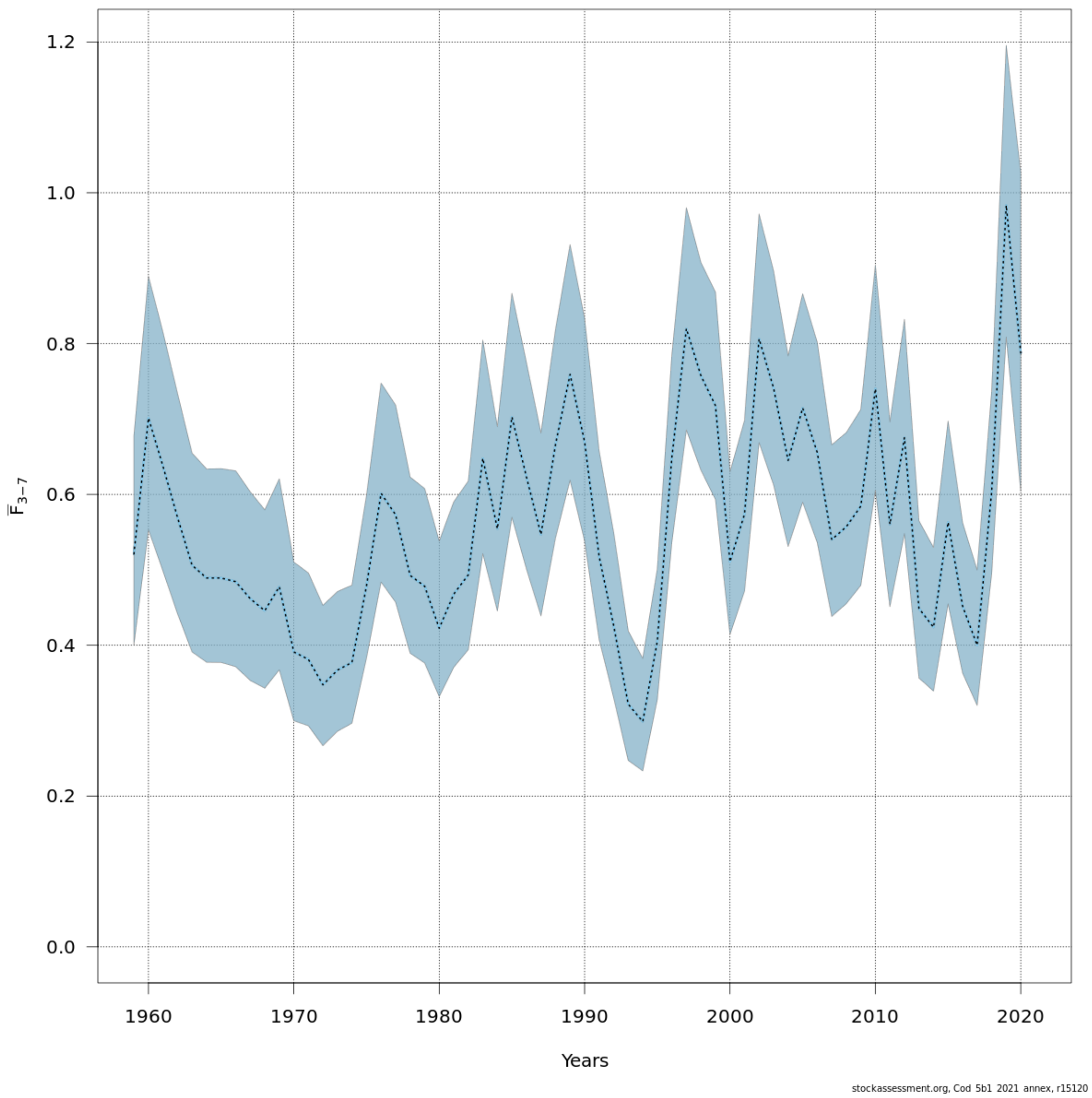


Figure 4.6.3. Faroe Plateau cod (Subdivision 5.b.1). Development of fishing mortality over time.

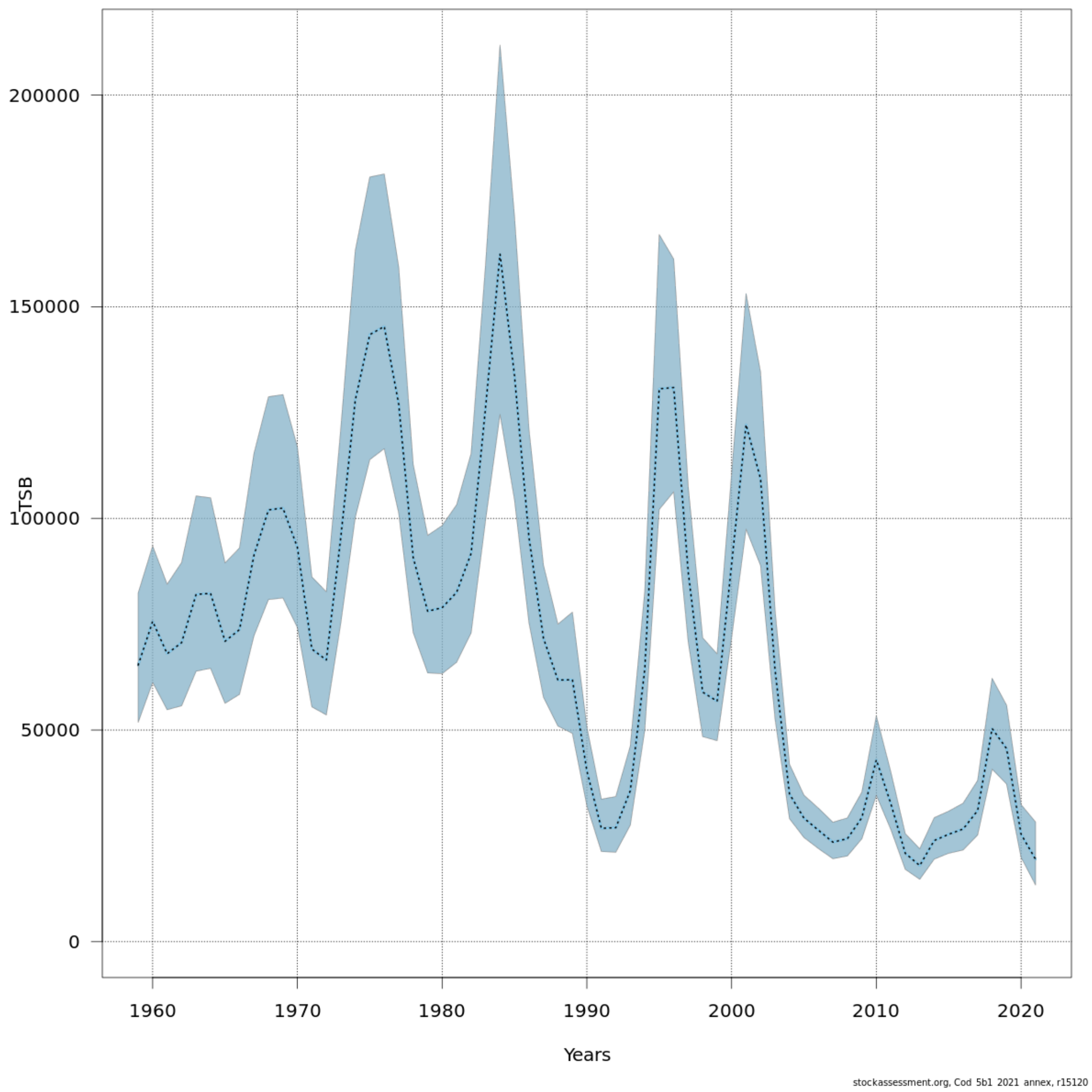


Figure 4.6.4. Faroe Plateau cod (Subdivision 5.b.1). Development of the total stock over time.

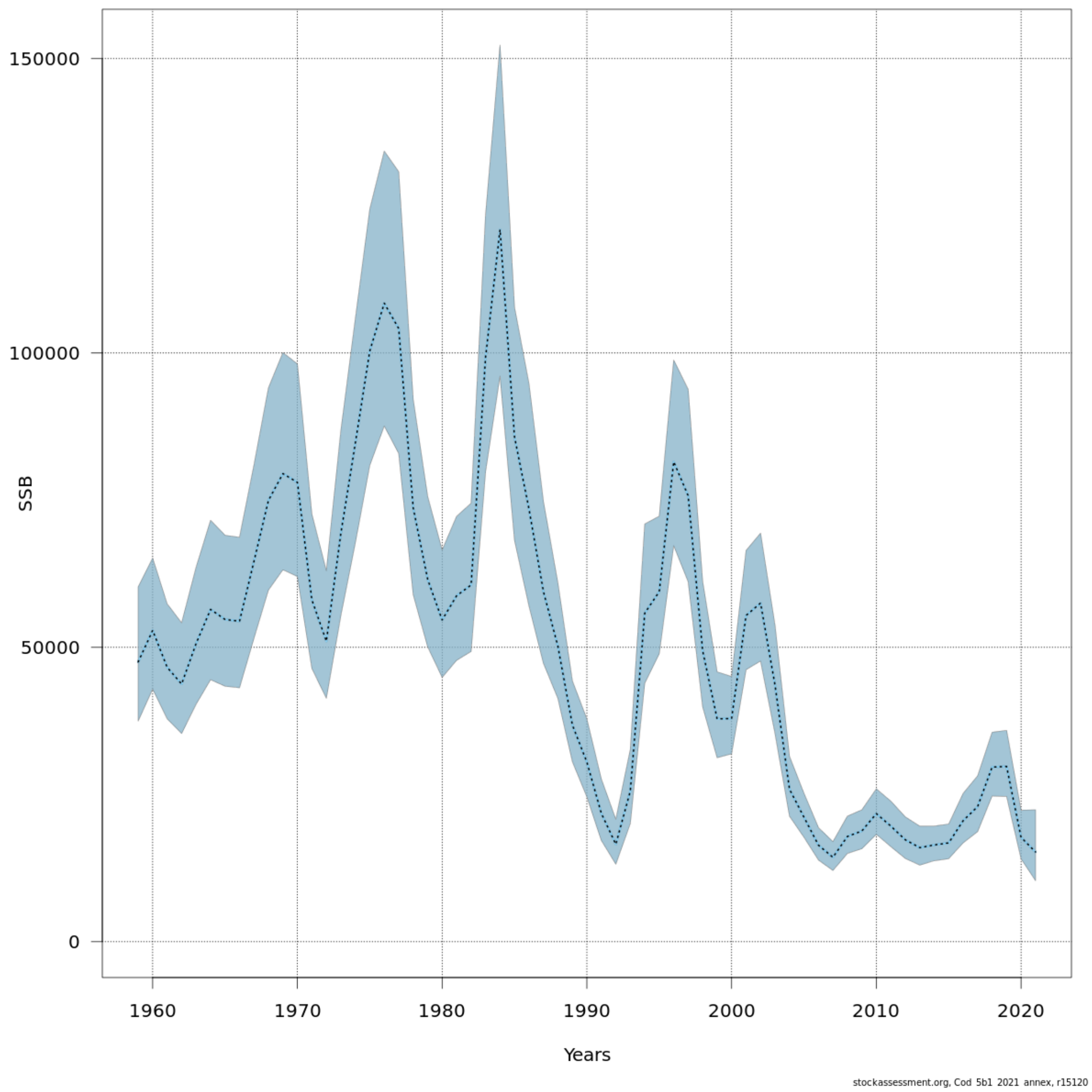


Figure 4.6.5. Faroe Plateau cod (Subdivision 5.b.1). Development of the spawning stock biomass over time.

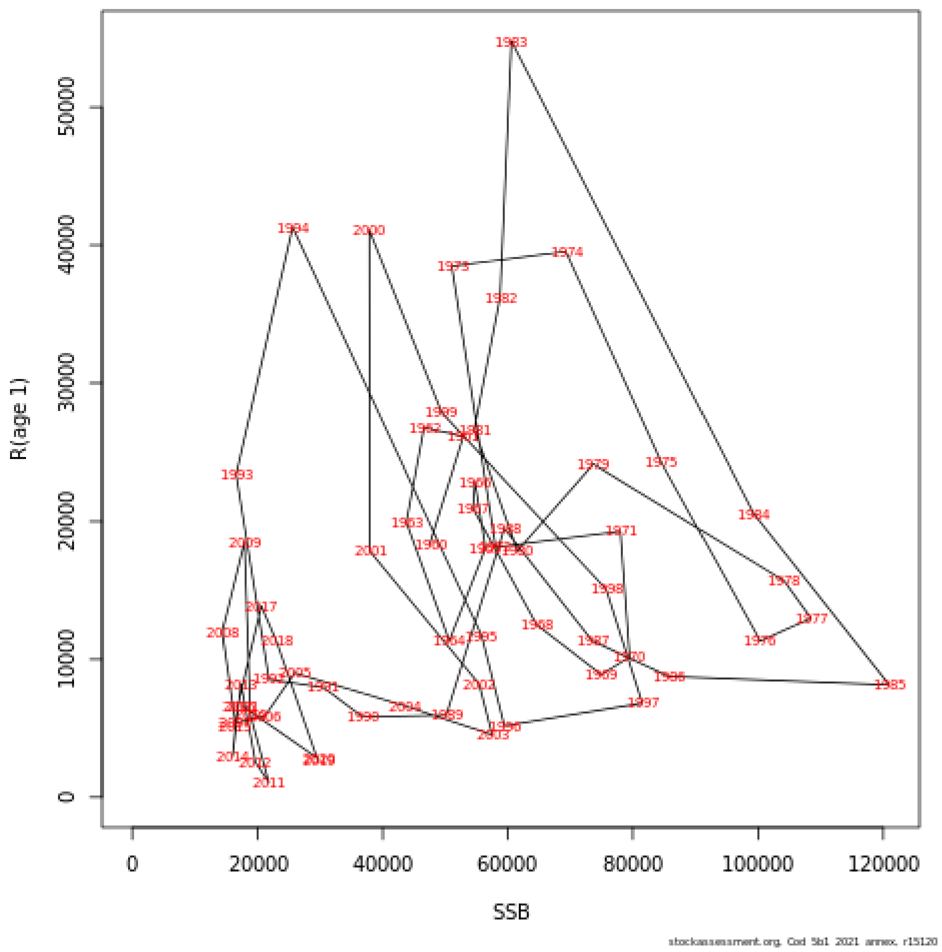


Figure 4.6.6. Faroe Plateau cod (Subdivision 5.b.1). Spawning stock (tons) – recruitment (thousands) relationship. Years are shown at each data point.

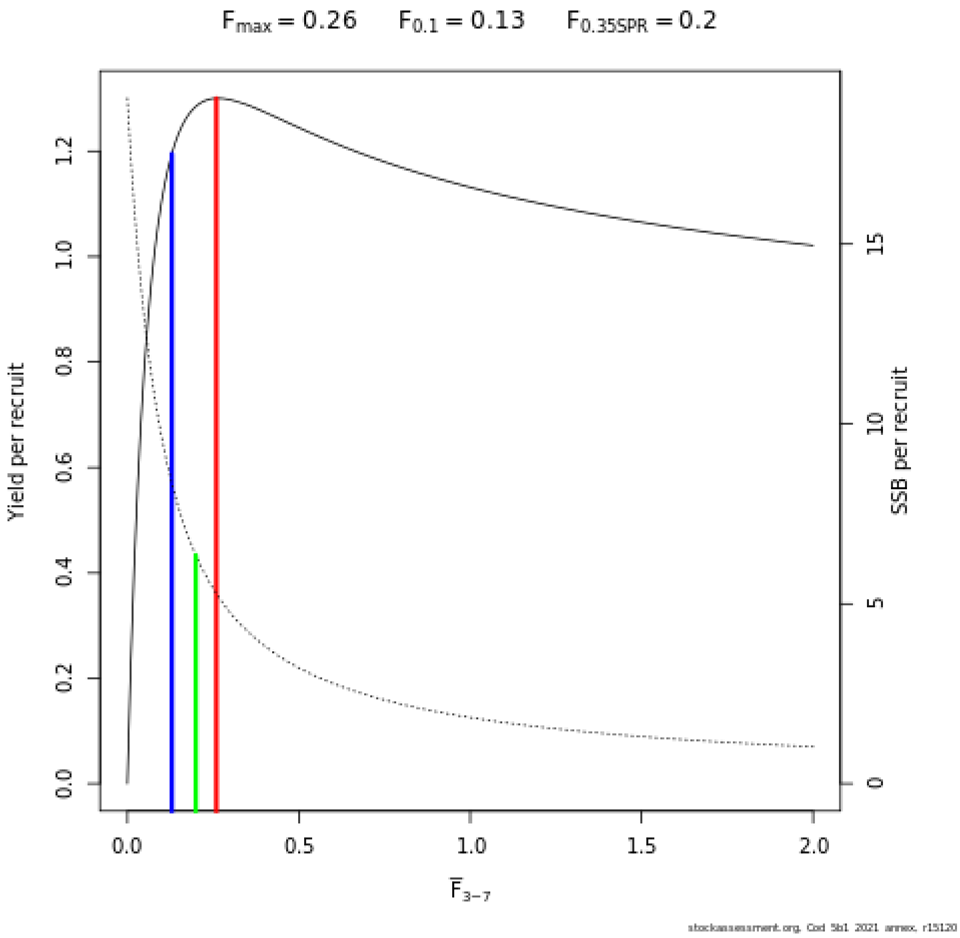


Figure 4.8.1. Faroe Plateau cod (Subdivision 5.b.1). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality.

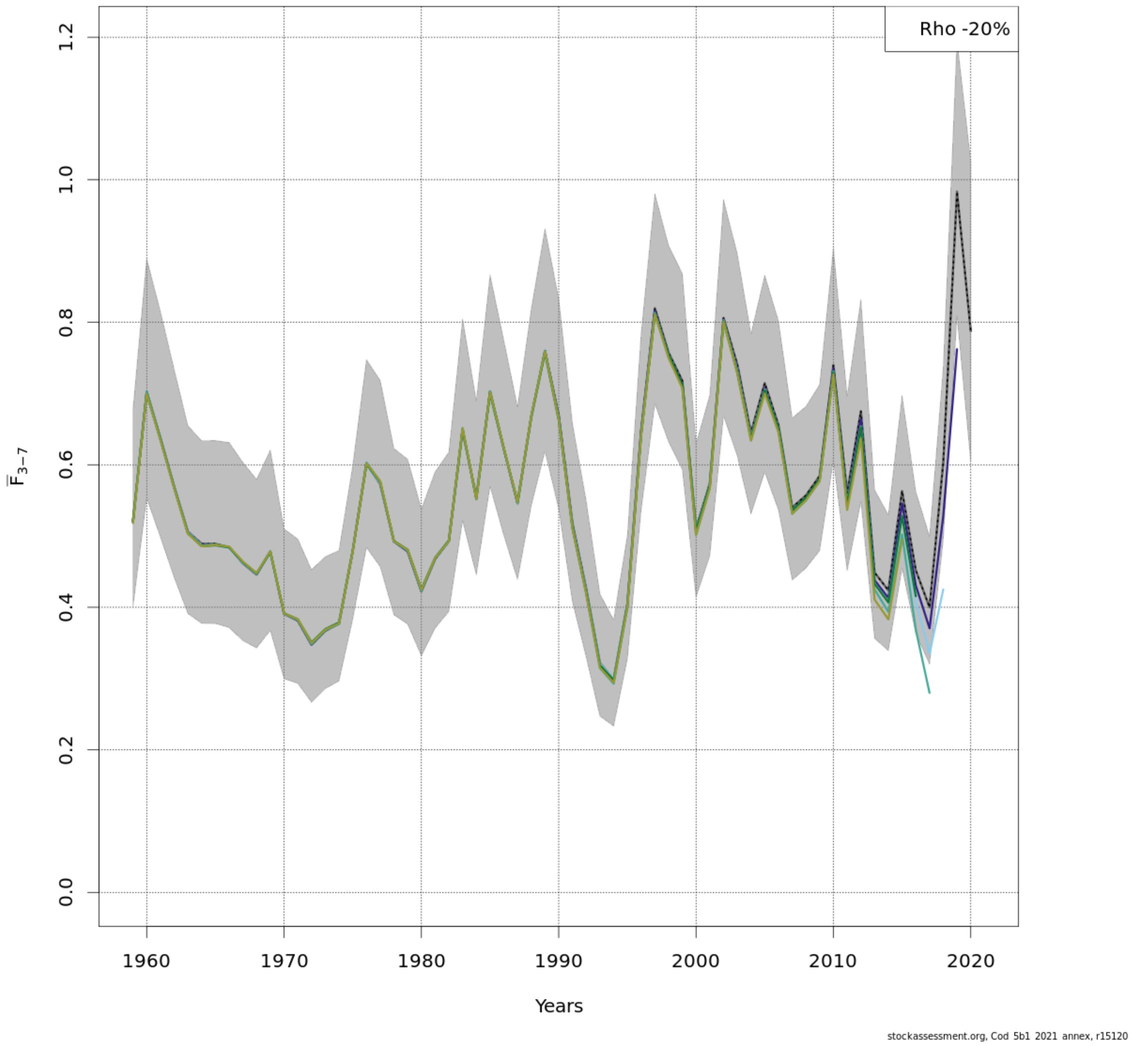


Figure 4.9.1. Faroe Plateau cod (Subdivision 5.b.1). Results from the SAM retrospective analysis of fishing mortality (ages 3-7).

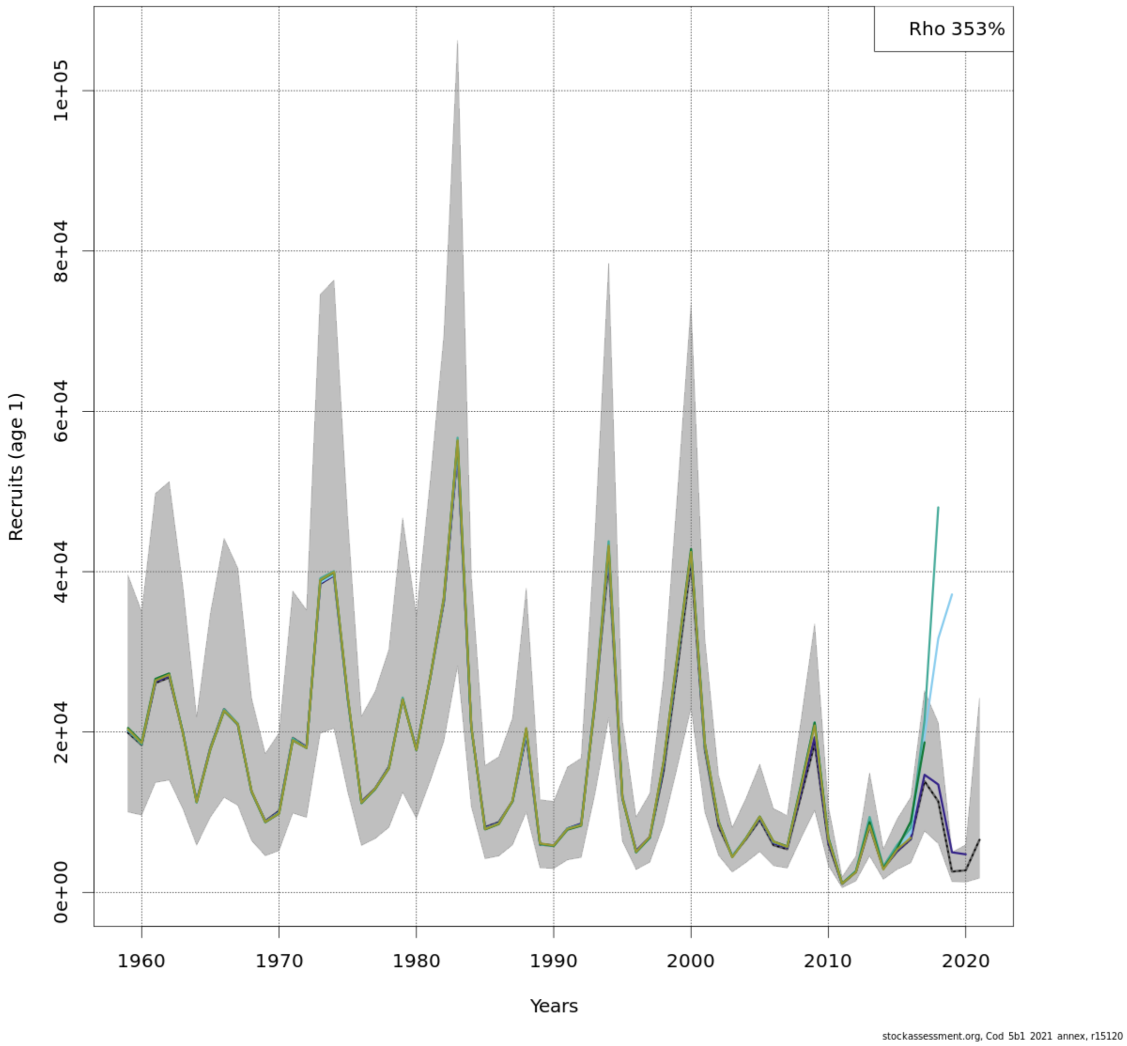


Figure 4.9.1. Faroe Plateau cod (Subdivision 5.b.1). Results from the SAM retrospective analysis (continued). Recruitment at age 1.

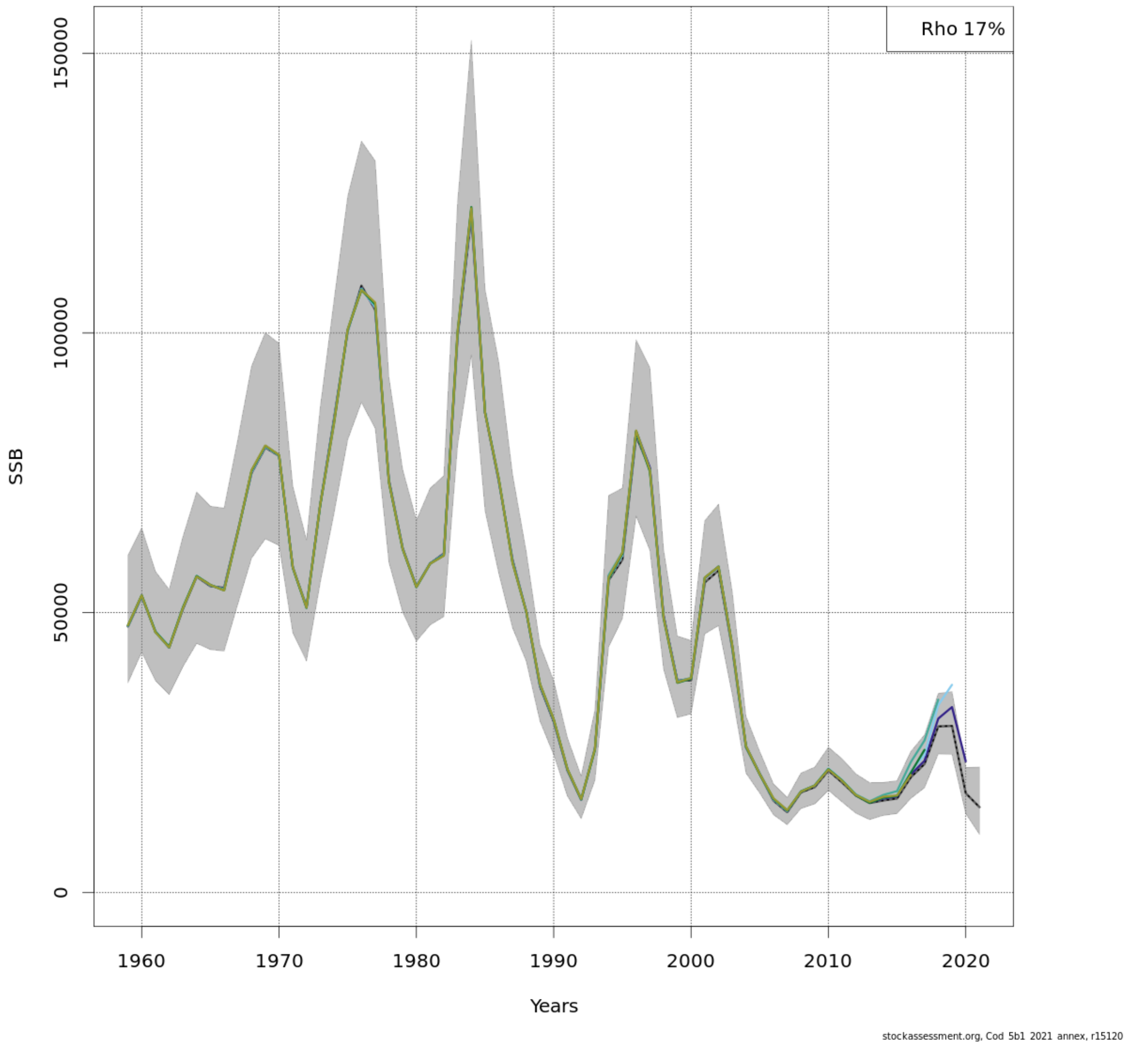


Figure 4.9.1. Faroe Plateau cod (Subdivision 5.b.1). Results from the SAM retrospective analysis (continued). Spawning stock biomass.

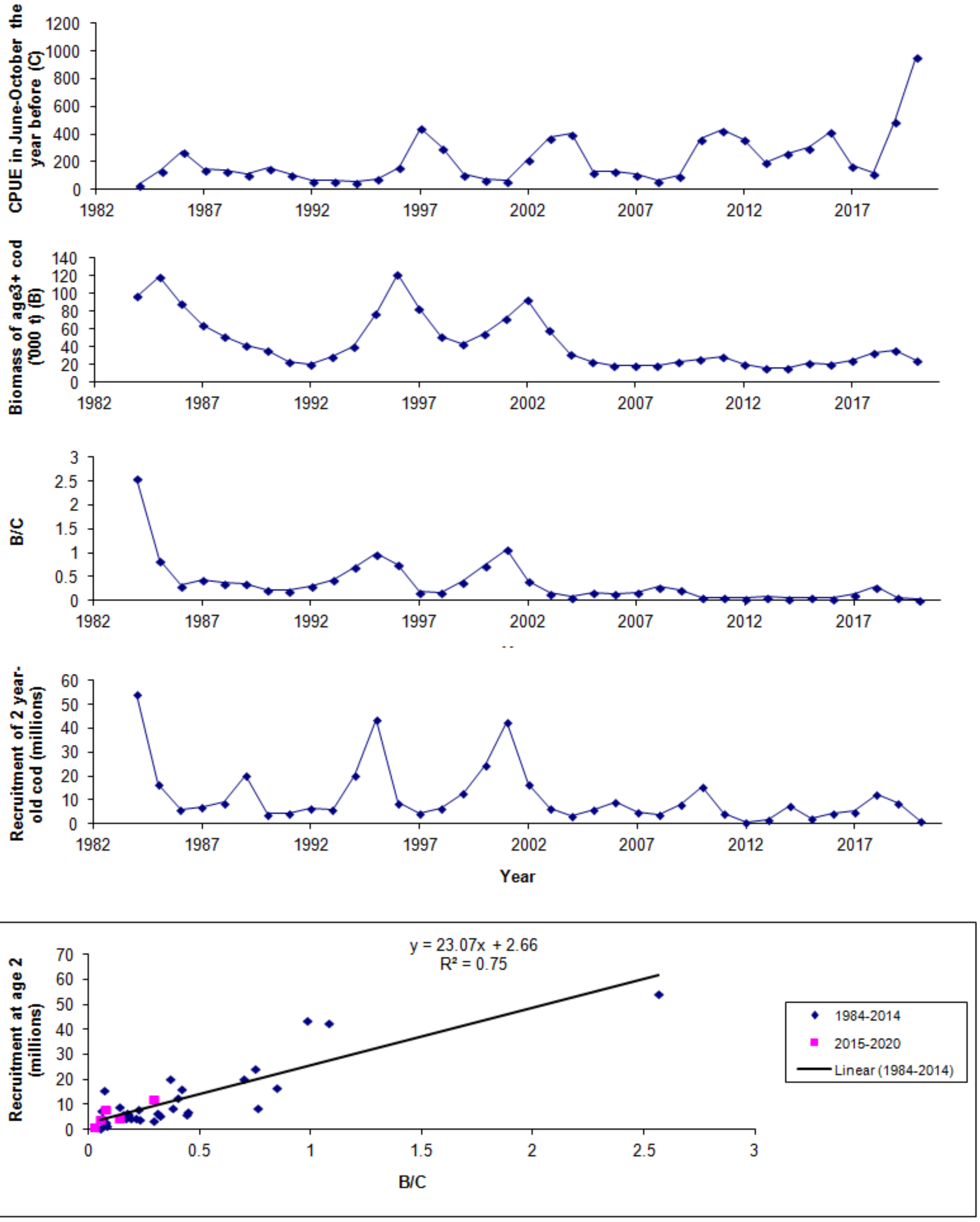


Figure 4.9.2. Faroe Plateau cod (Subdivision 5.b.1). Modelling cod recruitment in three steps. First, the catch-per-unit-effort of cod (C) for small boats operating close to land, as being indicative of the amount of cannibalistic cod. Second, the amount of cod (older than the recruiting cod) (B), as being indicative of e.g. culling-down of potential predators/competitors of recruiting cod. Third, the ratio between B and C, as indicative of recruitment success. Fourth and fifth, a comparison with observed recruitment. No cpue data were available for 2020.

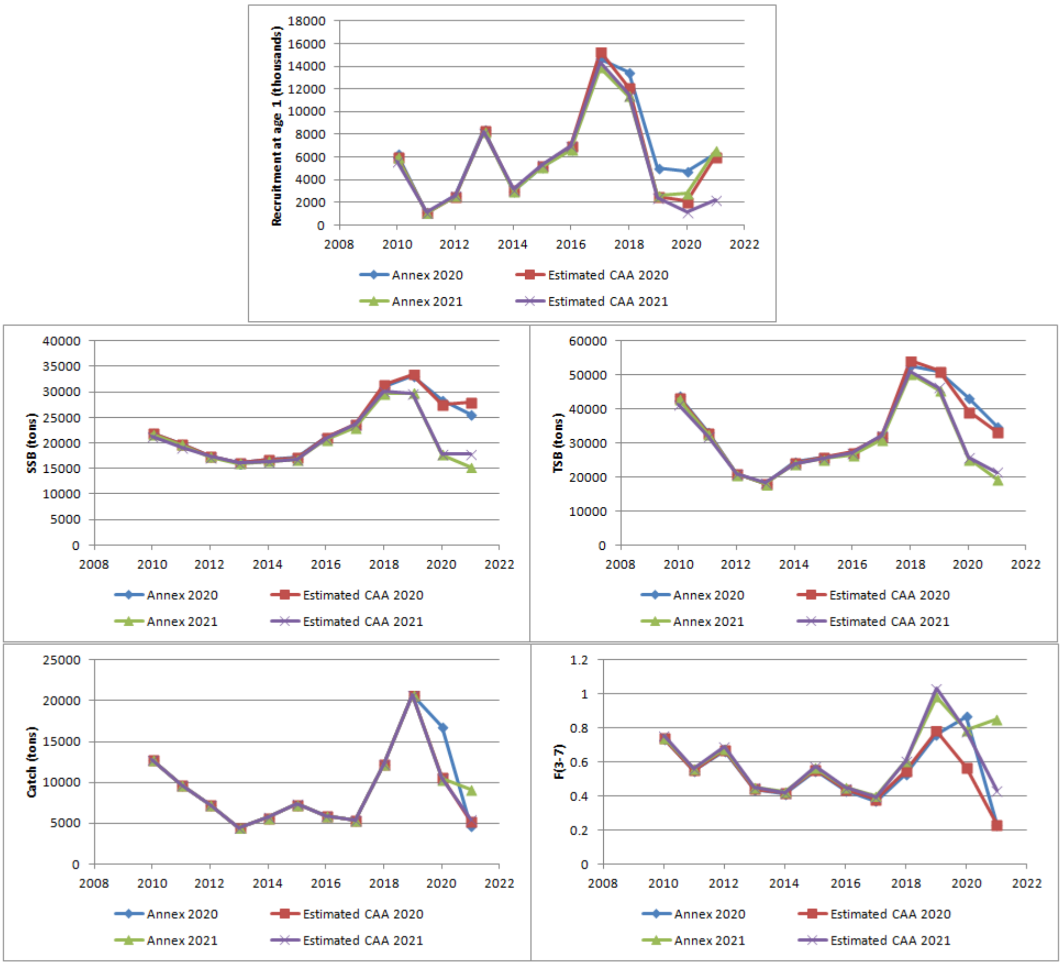


Figure 4.9.3. Faroe Plateau cod (Subdivision 5.b.1). The current assessment (Annex 2021) compared with an assessment that included a preliminary catch-at-age for 2021 (Estimated CAA 2021). The results from the 2020 assessment are shown for comparison..

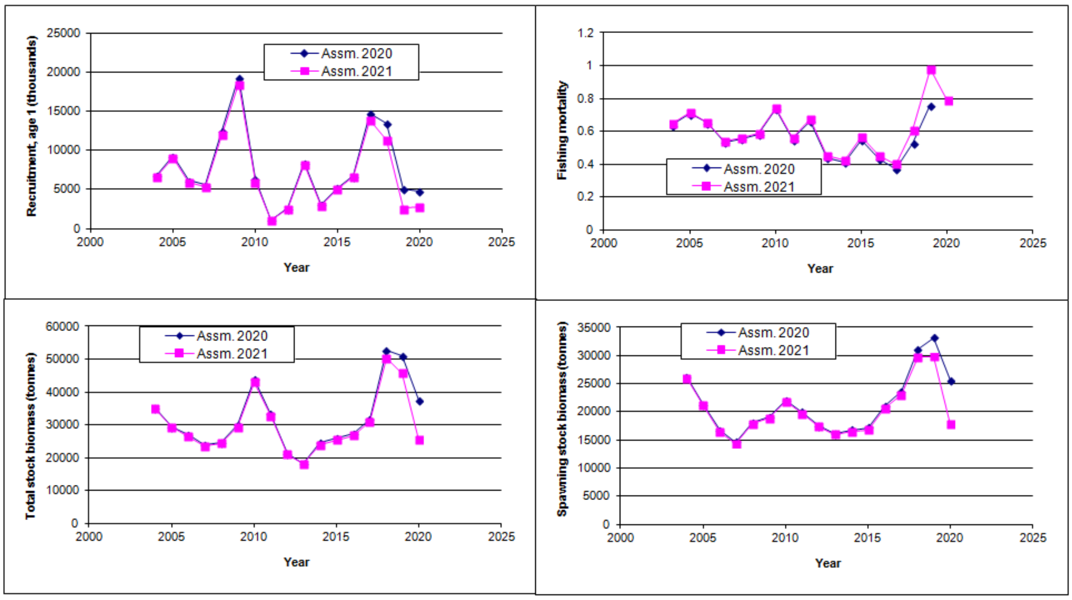


Figure 4.10.1. Faroe Plateau cod (Subdivision 5.b.1). Comparison between the results from the current autumn assessment compared with last year's assessment.

5 Faroe haddock

This section was updated in November 2021.

5.1 Stock description and management units

Haddock in Faroese Waters, i.e. ICES subdivisions 5.b.1 and 5.b.2 and in the southern part of ICES Division 2.a, close to the border of Subdivision 5.b.1, are generally believed to belong to the same stock and are treated as one management unit named Faroe haddock. Haddock is distributed all over the Faroe Plateau and the Faroe Bank from shallow water down to more than 450 m. A more detailed description of haddock in Faroese waters is given in the stock annex. The spatial distribution of the haddock in the summer survey and in the spring survey is shown in Figure 5.8.

5.2 Scientific data

5.2.1 Trends in landings and fisheries

Nominal landings of Faroe haddock gradually decreased since its peak in 2003 with 27 000 t and were at lowest in 2017 where the nominal catch was 2800 t. Since 2017 the nominal catch increased and was at its highest in 2019, 9334 t. In 2020 the nominal catch was 7300 t. Most of the landings are taken from the Faroe Plateau; the 2020 landings from the Faroe Bank (Subdivision 5.b.2), where the area shallower than 200 m depths has been closed to the bulk of fisheries since the fiscal year 2008–2009, amounted to 410 t (tables 5.1 and 5.2).

Faroese vessels have taken the bulk of the catch since the late 1970s (Figure 5.1). Most of the catch is caught by longliners and in recent years, and in 2020 the share of longliners was 62% and share of trawlers was 12%. Small open boats and jiggers, which mainly fish near shore, caught 26% of the total catch of 2020 (Figure 5.2).

5.2.2 Catch-at-age

Landings-at-age for 2020 are provided for the Faroese fishery in Table 5.4. Faroese landings from the main fleet categories were sampled and the sampling intensity in the terminal year is shown in Table 5.3. The most recent data were revised according to the final catch figures and the results are shown in Table 5.4. Catch-at-age in numbers is shown in Figure 5.3.

5.2.3 Weight-at-age

Mean weight-at-age data are provided for the Faroese fishery (Table 5.5). Figure 5.4 shows the mean weights-at-age in the landings for age groups 2–8 since 1977. During this period, weights have shown cyclical changes. They were at a minimum in 2007–2009, but have increased in recent years, but decreased for age 2–6 in 2020. The mean weights at age in the stock are assumed equal to those in the landings.

5.2.4 Maturity-at-age

Maturity-at-age data is available from the Faroese Spring Groundfish Surveys from 1982 and onwards. The survey is carried out in February–March. This means the maturity-at-age is determined just prior to the spawning of haddock in Faroese waters happening in April and the determination of the different maturity stages is relatively easy.

In order to reduce year-to-year variation, the routine by the WG has been to use a 3-year running average in the assessment. For the years prior to 1982, average maturity-at-age from the surveys 1982–1995 was adopted (Table 5.6 and Figure 5.5).

5.3 Information from the fishing industry

There exists a considerable amount of data on fish size in the fishing industry. No such information was used directly in the current assessment but catch per unit effort for some selected fleets (logbook data) is used as additional information on the status of the stock (see Section 5.3.1.1).

5.3.1 Methods

The benchmark in February 2017 decided to change the traditional assessment tool from XSA to SAM although it was recognized that the results of the assessment were mainly data-driven. The SAM model has some beneficial characteristics as compared to XSA, e.g. it provides uncertainty estimates for the catch in numbers, surveys and the output from the assessment (biomasses and fishing mortalities). See the stock annex for more information.

In the NWWG meeting in 2018, it was proposed to change the settings for the model (Table 5.9). Default settings used the same sdLogN for all ages (1–7/8 years) in the two tuning series, but different for each survey. Comparisons of the results from the two different settings were presented in the first version of the NWWG report 2018 (June 2018). The Advice Drafting Group 2018 (May 2018) adopted the revised model settings for future assessments and advice.

From mid-1990s to 2017/2018 the fishing year was from September 1st to August 31th and the ICES advice to Faroese authorities provided in June. The assessment was based on catch data up to the year before the interim year and the last tuning data point was from spring in the interim year. This was the situation when the benchmark assessment was performed in February 2017. However, the fishing year was changed to be equal to the calendar year and this change was first applied to the calendar year 2018. Faroese authorities needed the ICES advice in November and this implied that the tuning data point in August in the interim year could be added as input in the assessment. These settings were applied for the first time in the stock assessment performed in November 2019, i.e. using catch data up to 2018 and tuning data (both surveys) up to 2019.

The 2021 assessment was done in October at an online NWWG-meeting. Comparison between the 2021 assessment and the latest assessments is shown in Figure 5.9.

5.3.1.1 Tuning and estimates of fishing mortality

Commercial CPUE series

The age-aggregated CPUE series for longliners and pair trawlers are presented in Figure 5.6. In general, the two series show the same trends although in some periods the two series are conflicting; this has been explained by variations in catchability of the longlines due to changes in productivity of the Faroe Shelf ecosystem. Both series, however, show that the total stock biomass has been low, but is now increasing, yet the catchability reduced for both fleets in 2021.

Fisheries independent CPUE series

Two annual groundfish surveys are available, one carried out in February–March since 1982 (100 stations per year down to 500 m depth), and the other in August-September since 1996 (200 stations per year down to 500 m depth). The new research vessel, Jákup Sverri, conducted the august survey in 2021. Survey catch at age data is presented in Table 5.7. The main trends from the surveys are the same but the summer survey indicates a more depleted stock in recent years than the summer survey; both surveys indicate a slow increase in recent years. Age disaggregated data are available for the whole summer series, but due to problems with the database (see earlier reports), age disaggregated data for the spring survey are only available since 1994. The calculation of indices at age is based on age-length keys with a Gaussian smoother applied. This is a useful method but some artefacts may be introduced since the smoothing can assign wrong ages to some lengths, especially for the youngest and oldest specimen. As in recent years, the length distributions have been used more directly for calculation of indices at age (ages 0–2), since these ages have length distributions almost without overlap. LN (numbers at age) for the surveys is presented in Figures 5.9–5.10. The distribution of haddock catches for spring and summer survey is shown in Figure 5.8.

These surveys have shown similar signal through the time series, however, since 2019, the signal has been conflicting, showing highly above average in the spring survey and the opposite, beneath average, in the summer survey. This is presented in Figure 5.7. This conflicting signal is furthermore exposed in the residual plot, see Figure 5.11, where SAM delimits the signal from the summer survey, especially for the older ages. This inconsistency reduced in 2021, nevertheless, the reasons behind this conflicting signal are yet unclear and urge for further investigations.

5.4 Reference points

Since the assessment model was replaced at the benchmark in February 2017, it was necessary to recalculate reference points at the NWWG meeting in 2017 (this was not finally conducted during the benchmark).

The B_{lim} was changed from 22 thousand tonnes to 16 780 tonnes, the lowest spawning biomass from which the stock had made a recovery. The biomass was lower later in the time series, but the stock had not recovered by the time of the determination of this reference point.

The $B_{pa} = B_{trigger} = 22\,843$ tonnes (changed from 35 000 tonnes). The uncertainty in the SAM assessment in the final year of SSB was found to be $\sigma = 0.188$ and the B_{pa} was found by using the formula $B_{pa} = B_{lim} \times \exp(\sigma \times 1.645)$. The $B_{trigger}$ was, according to ICES guidelines, set equal to B_{pa} since the stock had not been fished at F_{MSY} for five or more years.

$F_{lim} = 0.54$ (changed from 0.4). F_{lim} was derived from B_{lim}. A stock was simulated with a segmented regression on the spawning stock – recruitment function having the point of inflection at B_{lim}. F_{lim} was set to the F that, in equilibrium, gave a 50% probability that SSB > B_{lim}. This simulation was based on a fixed F, i.e., without inclusion of a $B_{trigger}$ and without inclusion of assessment/advice errors.

$F_{pa} = 0.40$ (changed from 0.25). F_{pa} was derived from F_{lim} in the reverse of the way B_{pa} was derived from B_{lim}, i.e., $F_{pa} = F_{lim} \times \exp(-\sigma \times 1.645)$, where $\sigma = 0.185$. This year (2021), the value of F_{pa} was set equal to the $F_{p0.5}$ of 0.19, which is the fishing mortality that leads to probability of 5% of SSB going below B_{lim}.

The calculations were conducted using EQSIM following ICES guidelines. Decisions made involved the spawning stock–recruitment relationship, the weights at age, the selection pattern and the level of advice error. The period since 1978 was used as basis for the spawning stock–recruitment relationship where the S-R function was based on the segmented regression (weight

0.7), Ricker (weight 0.24), and Beverton and Holt (weight 0.06). The autocorrelation between SSB-R data points was approximately 0.52. The weights at age were based on the last 20 years. The selection pattern was based on the last 5 years. The advice error was estimated from advice sheets back to 1999: cvF = 0.48, phiF = 0.37, cvSSB = 0.40, phiSSB = 0.43. In total, 2000 iterations were performed that projected the stock 200 years into the future, of which, the last 50 years were kept to calculate 'equilibrium' values.

The result of the analyses was that F_{MSY} = 0.165 (changed from 0.25). The fishing mortality that is associated with a risk of 5% to fall below B_{lim}, $F_{p0.5}$, was estimated to be 0.19. The value was in the first simulations 0.13 assuming autocorrelation in the recruitment. At a web-ex meeting in June 2017 it was assumed there was no autocorrelation in the recruitment that led to F_{MSY} = 0.165.

5.5 State of the stock - historical and compared to what is now.

At the benchmark in February 2017 the traditional XSA was replaced by a SAM assessment model. The SAM model settings and the model parameters are shown in Table 5.8. AR covariance structure has been applied for both surveys, eliminating year effects. The observation residuals look quite random (Figure 5.11) as well as the process residuals (Figure 5.12).

The results from the SAM-run show that fishing mortality (F3–7) has decreased in recent years, albeit increasing steeply the last two years, and is above both F_{MSY} and F_{pa} in 2020. (Table 5.13, Figure 5.14). The spawning stock biomass was beneath MSY $B_{trigger}$ from 2008–2017 but has increased slowly since 2018. (Table 5.13, Figure 5.16). The poor state of the stock since 2008 has been due to poor recruitment combined with high F but with above average year classes in 2016 and 2017, the state of the stock has improved and the spawning stock biomass is above all reference points in 2020 (Table 5.13, Figure 5.17).

5.6 Short term forecast

Input data

The SAM model provides predictions that carry the signals from the assessment into the short-term forecast. The forecast procedure starts from the assessment year's estimate of the state (log(N) and log(F) at age. One thousand replicates of the last state are simulated from its estimated joint distribution. Each of these replicates are then simulated forward according to the assumptions and parameter estimates found by the assessment model. In the forward simulations, a 5-year average (years up to and including the assessment year) is used for catch mean weight, stock mean weight, proportion mature, and natural mortality. Recruitment is re-sampled from the period 2001 to terminal year. In each forward simulation step the fishing mortality is scaled so that the median of the distribution is matching the requirement in the scenario (e.g. hitting a specific mean F value or a specific catch).

Results

The landings in 2021 were originally expected to be 20 thousand tonnes with status quo fishing mortality. However, the landings in 2021 were estimated to be only 6 634 tonnes, based on the January-September landings 2021 and comparing with 2015-2020. Therefore, (deviating from the stock annex) a catch constraint was set on the landings in 2021 of 6 634 tonnes and forecasts based on this assumption (Table 5.14). The spawning stock biomass is expected to be 68 000 tonnes in 2022, 70 000 tonnes in 2023 and eventually 71 000 tonnes in 2024, if the F_{MSY} is applied. This is markedly lower than expected in the last years' forecast.

5.7 Yield per recruit

The yield-per-recruit calculations were performed in the SAM model based on the last 20 years. The F_{max} was estimated at 0.67, but due to the very flat topped curve this value is poorly defined. $F_{0.1}$ was estimated at 0.1 and $F_{0.35SPR}$ at 0.3 (Figure 5.13).

5.8 Uncertainties in assessment and forecast

Since there is no incentive to discard fish or misreport catches under the effort management system, the catch figures are considered adequate, as well as the catch-at-age.

Retrospective analyses indicate periods with tendencies to overestimate recruitment and underestimate fishing mortality (Figures 5.14–5.16). Mohn´s Rho was 37% for SSB, 80% for recruitment and -33% for F(ages 3–7). The massive downscaling of the recruitment is commented on later in this report (5.9).

A preliminary catch-at-age for 2021 was calculated, based on the data already available (catch figures January-September scaled up to the whole year, 6634 tonnes, based on the landings in 2015-2020; age and length samples from the catch January-September). The catch-at-age figures for 2021 were (age 2 to 10+ in thousands): 54, 2515, 2481, 588, 238, 100, 62, 24, and 3. The fishing mortality in 2021 was much more reasonable (0.216 vs. 0.798) and the recruitment was even more downscaled leading to a more pessimistic forecast of future biomass.

5.9 Comparison with previous assessment and forecast

The assessment settings were according to the Stock Annex. The assessment this year showed substantial downscaling of the recruitment, a lower total stock biomass and spawning stock biomass and higher fishing mortality compared with last year's assessment (Figure 5.19). One possible reason for this downscaling of the stock is a variable natural mortally (m) on younger ages of haddock in some years. WD30 (NWWG2021) demonstrates that the downscaling of year classes from age 1 to age 3 is most severe, when the condition factor of adult haddock is low, which is often the case in years when primary production index is low. Thus, the younger year classes experience higher natural mortality in these years, due to either food shortage or/and higher predation. Further investigations should be done to investigate these findings and optimise the assessments settings to avoid these inconsistencies and downscaling between assessment years.

5.10 Management plans and evaluations

A management plan based on the fishing day system was implemented in 2021. The management plan comprises the fishery for cod, haddock and saithe on the Faroe Plateau. Longliners and small trawlers are regulated by the status of the cod and haddock stocks whereas the large single trawlers and pair trawlers are regulated by the status of the saithe stock. The change in the allocated fishing days can be either -5%, 0% or +5% from one year to the next. Due to the management plan the fishery for cod, haddock and saithe on the Faroe Plateau was certified as sustainable by MSC in September 2021. The management plan is not yet evaluated by ICES.

5.11 Ecosystem considerations

Since on average about 75% of the catches are taken by longliners and the remaining by trawls, effects of the haddock fishery on the bottom is moderate (Figure 5.2).

5.12 Regulations and their effects

As explained in the overview (Section 2), the fishery for haddock in 5.b is regulated through a maximum number of allocated fishing days, gear specifications, closed areas during spawning times, closed areas for longlining close to land and large areas closed to trawling. As a consequence, around 75% of the haddock landings derive from long line fisheries. Since there is no incentive to discard fish or misreport catches under the effort management system, the catch figures are considered adequate.

5.13 Changes in fishing technology and fishing patterns

Fishing effort per fishing day may have increased gradually since the effort management system was introduced in 1996, although little direct quantitative information exists. There also seems to have been substantial increases in fishing power when new vessels are replacing old vessels.

The fishing pattern in recent years has changed in comparison to previous years. The large longliners seem to have exploited the deep areas (> 200 m) to a larger extent (ling and tusk) because the catches in shallower waters of cod and haddock have been so poor – which was also observed in the beginning of the 1990s. They also have fished in other areas, e.g. in Greenland and on the Flemish Cap. This could reduce the fishing mortality on cod and haddock, but the small longliners and jiggers still exploit the shallow areas.

5.14 Changes in the environment

The primary production was low for a number of years, albeit high in 2008 to 2010 and in 2017, but it is not believed that this has any relationship with a change in the environment. Since 2002, the temperature has been about 1 °C higher than in the 1990s.

Table 5.1. Faroe Plateau (Sub-division 5b1) HADDOCK. Nominal catches (tonnes) by countries 2000-2020 and Working group estimates in 5b.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Faroe Islands	13620	13457	20776	21615	18995	18172	15600	11689	6728	4895	4932	3350	2490	2877	2756	2919	3090	2575	5192	8679	6688
France	6	8	2	4	+		12	4	3	2	1	2	1	+	+	1	+	1	+	+	1
Germany	1	2	6	1	6		1														
Greenland							1	9		6											
Iceland			4										2								
Ireland																+					
Norway	355	257	227	265	229	212	57	61	31	8	6				+	5	11	1	21	41	49
Russia					16				10	0											
Spain					49																
UK (Engl. And Wales)	19	4	11	14	8	1	1														
UK (Scotland)	185	148	177	185	186	1,070	106	35	60	65	40										
United Kingdom														+	350	428	237	72	121	283	183
Total (tonnes)	14186	13876	21203	22084	19489	19455	15778	11798	6832	4976	4979	3352	2493	2877	3105	3352	3339	2649	5334	9003	6921
Used in the assessment in 5b	**15799**	**15891**	**24929**	**26941.97**	**23100**	**21944**	**17154**	**12631**	**7393**	**5197**	**5203**	**3546**	**2634**	**2924**	**3252**	**3421**	**3470**	**2863**	**5549**	**9334**	**7329**

Table 5.2 Faroe Bank (Sub-division 5b2) HADDOCK. Nominal catches (tonnes) by countries, 2000–2020.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Faroe Islands	1565	1948	3698	4804	3594	2444	1374.84	810	556	192	178	194	141	47	71	48	111	196	192	330	407
France	+									1							5				
Greenland											12										
Norway	48	66	28	54	17	45	1	8	+	3	1				2	1	+	5	1	1	1
UK (Scotland)								15	5	26	33										
United Kingdom															74	21	15	14	22		
Total (tonnes)	1613	2014	3726	4858	3611	2489	1376	833	561	222	224	194	141	47	147	69	131	214	215	332	408

Table 5.3. Faroe Plateau (Subdivision 5.b) haddock. Catch at age and sampling intensity of terminal year.

Fleet	Size	Samples	Lengths	Otoliths	Weights
Open boats		2	400	120	400
Longliners	< 100 GRT	2	205	60	205
Longliners	> 100 GRT	8	1682	475	1682
Jiggers		0	0	0	0
Gillnetters		0	0	0	0
Single trawlers	< 400 HP	0	0	0	0
Single trawlers	400-1000 HP	0	0	0	0
Single trawlers	> 1000 HP	0	0	0	0
Pair trawlers	< 1000 HP	0	0	0	0
Pair trawlers	> 1000 HP	19	3766	1139	6053
Total		30	6053	1794	6053

Table 5.4. Faroe haddock. Catch in numbers at age per fleet in terminal years.

	27.5.b - Faroese fleet		
	Longliners, open boats, jiggers	**Longliners**	**Trawlers**
Age	**< 100 GRT**	**> 100 GRT**	
0	0	0	0
1	0	0	0
2	272	164	10,876
3	1,519,175	778,357	356,645
4	1,401,856	521,254	308,936
5	430,433	262,405	66,064
6	162,764	117,069	27,522
7	77,298	96,273	4,673
8	46,688	67,034	2,253
9	23,676	23,090	1,018
10	0	2,559	0
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
15	0	0	0
Total no.	3,662,162	1,868,205	777,988
Catch, t.	3354	2291	734

Numbers in 1000'

Catch, gutted weight in tonnes

Table 5.4. Faroe haddock. Catch in numbers at age 1957–2020.

Year \ age	0	1	2	3	4	5	6	7	8	9	10
1957	0	45	4133	7130	8442	1615	894	585	227	94	58
1958	0	116	6255	8021	5679	3378	1299	817	294	125	105
1959	0	525	3971	7663	4544	2056	1844	721	236	98	47
1960	0	854	6061	10659	6655	2482	1559	1169	243	85	28
1961	0	941	7932	7330	5134	1937	1305	838	236	59	13
1962	0	784	9631	13977	5233	2361	1407	868	270	72	22
1963	0	356	13552	8907	7403	2242	1539	860	257	75	23
1964	0	46	2284	7457	3899	2360	1120	728	198	49	7
1965	0	39	1368	4286	5133	1443	1209	673	1345	43	8
1966	0	90	1081	3304	4804	2710	1112	740	180	54	9
1967	0	70	1425	2405	2599	1785	1426	631	197	52	13
1968	0	49	5881	4097	2812	1524	1526	923	230	68	12
1969	0	95	2384	7539	4567	1565	1485	1224	378	114	20
1970	0	57	1728	4855	6581	1624	1383	1099	326	68	10
1971	0	55	717	4393	4727	3267	1292	864	222	147	102
1972	0	43	750	3744	4179	2706	1171	696	180	113	95
1973	0	665	3311	8416	1240	2795	919	1054	150	68	11
1974	0	253	5633	2899	3970	451	976	466	535	68	147
1975	0	94	7337	7952	2097	1371	247	352	237	419	187
1976	0	40	4396	7858	6798	1251	1189	298	720	258	318
1977	0	0	255	4039	5168	4918	2128	946	443	731	855
1978	0	0	32	1022	4248	4054	1841	717	635	243	312
1979	0	1	1	1162	1755	3343	1851	772	212	155	74
1980	0	0	143	58	3724	2583	2496	1568	660	99	86
1981	0	0	74	455	202	2586	1354	1559	608	177	36
1982	0	0	539	934	784	298	2182	973	1166	1283	214
1983	0	0	441	1969	383	422	93	1444	740	947	795
1984	0	25	1195	1561	2462	147	234	42	861	388	968
1985	0	0	985	4553	2196	1242	169	91	61	503	973
1986	0	0	230	2549	4452	1522	738	39	130	71	712
1987	0	0	283	1718	3565	2972	1114	529	83	48	334
1988	0	0	655	444	2463	3036	2140	475	151	18	128
1989	0	0	63	1518	658	2787	2554	1976	541	133	81
1990	0	0	105	1275	1921	768	1737	1909	885	270	108
1991	0	0	77	1044	1774	1248	651	1101	698	317	32
1992	0	0	40	154	776	1120	959	335	373	401	162
1993	0	43	113	298	274	554	538	474	131	201	185
1994	0	1	277	191	307	153	423	427	383	125	301
1995	0	0	804	452	235	226	132	295	290	262	295

Year \ age	0	1	2	3	4	5	6	7	8	9	10
1996	0	1	326	5234	1019	179	163	161	270	234	394
1997	0	0	77	2913	10517	710	116	123	93	220	516
1998	0	0	106	1055	5269	9856	446	99	87	95	502
1999	0	9	174	1142	942	4677	6619	226	26	20	192
2000	0	73	1461	3061	210	682	2685	2846	79	1	71
2001	0	19	4380	3128	2423	173	451	1151	1375	17	18
2002	0	0	1515	14039	2879	1200	133	239	843	1095	33
2003	0	0	132	3419	13486	2213	944	162	332	854	920
2004	0	3	243	2007	4802	10425	1163	409	89	166	811
2005	0	0	91	1793	4132	7245	6573	581	158	30	165
2006	0	0	247	446	2566	3949	5423	3278	136	63	70
2007	0	0	76	982	547	2732	3309	2758	1117	89	9
2008	0	6	66	204	919	424	1472	1707	1255	320	39
2009	0	0	27	329	402	555	514	1133	739	285	48
2010	0	0	389	445	426	279	484	553	718	444	159
2011	0	0	170	774	325	198	186	280	354	368	187
2012	0	0	8	960	513	156	114	123	94	171	114
2013	0	0	82	506	1108	217	94	77	87	70	118
2014	0	0	236	392	637	1133	101	61	32	15	48
2015	0	0	387	1153	320	564	324	49	27	23	20
2016	0	8	280	982	638	220	454	116	22	24	12
2017	0	1	156	391	812	321	113	143	70	14	10
2018	0	0	583	1809	768	583	213	85	78	28	9
2019	0	0	312	2396	2664	1135	560	139	91	38	4
2020	0	0	11	2659	2236	760	308	179	116	48	3

Table 5.5 Faroe Haddock. Mean weight at age (kg) in the catches, 1957–2020.

Year \ age	1	2	3	4	5	6	7	8	9	10
1957	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1958	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1959	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1960	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1961	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1962	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1963	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1964	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1965	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1966	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1967	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1968	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55

Year \ age	1	2	3	4	5	6	7	8	9	10
1969	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1970	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1971	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1972	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1973	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1974	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1975	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1976	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
1977	0	0.311	0.633	1.044	1.426	1.825	2.241	2.205	2.57	2.591
1978	0	0.357	0.79	1.035	1.398	1.87	2.35	2.597	3.014	2.92
1979	0.3	0.357	0.672	0.894	1.156	1.59	2.07	2.525	2.696	3.519
1980	0	0.643	0.713	0.941	1.157	1.493	1.739	2.095	2.465	3.31
1981	0	0.452	0.725	0.957	1.237	1.651	2.053	2.406	2.725	3.25
1982	0	0.7	0.896	1.15	1.444	1.498	1.829	1.887	1.961	2.856
1983	0	0.47	0.74	1.01	1.32	1.66	2.05	2.26	2.54	3.04
1984	0.359	0.681	1.011	1.255	1.812	2.061	2.059	2.137	2.368	2.686
1985	0	0.528	0.859	1.391	1.777	2.326	2.44	2.401	2.532	2.686
1986	0	0.608	0.887	1.175	1.631	1.984	2.519	2.583	2.57	2.922
1987	0	0.605	0.831	1.126	1.462	1.941	2.173	2.347	3.118	2.933
1988	0	0.501	0.781	0.974	1.363	1.68	1.975	2.344	2.248	3.295
1989	0	0.58	0.779	0.923	1.207	1.564	1.746	2.086	2.424	2.514
1990	0	0.438	0.699	0.939	1.204	1.384	1.564	1.818	2.168	2.335
1991	0	0.547	0.693	0.884	1.086	1.276	1.477	1.574	1.93	2.153
1992	0	0.525	0.724	0.817	1.038	1.249	1.43	1.564	1.633	2.126
1993	0.36	0.755	0.982	1.027	1.192	1.378	1.643	1.796	1.971	2.24
1994	0	0.754	1.103	1.254	1.465	1.593	1.804	2.049	2.225	2.423
1995	0	0.666	1.054	1.489	1.779	1.94	2.182	2.357	2.49	2.678
1996	0.36	0.534	0.858	1.459	1.993	2.33	2.351	2.469	2.777	2.582
1997	0	0.519	0.771	1.066	1.799	2.27	2.34	2.475	2.501	2.676
1998	0	0.622	0.846	1.016	1.283	2.08	2.556	2.572	2.452	2.753
1999	0.278	0.504	0.624	0.974	1.22	1.49	2.456	2.658	2.598	2.953
2000	0.28	0.661	0.936	1.166	1.483	1.616	1.893	2.821	3.749	3.196
2001	0.28	0.608	0.94	1.374	1.779	1.971	2.119	2.373	2.75	3.966
2002	0	0.584	0.857	1.405	1.799	1.974	2.301	2.37	2.626	3.13
2003	0	0.571	0.715	1.008	1.537	1.911	2.091	2.301	2.406	2.535
2004	0.367	0.574	0.77	0.887	1.159	1.638	1.87	2.438	2.357	2.417
2005	0	0.538	0.649	0.797	1.02	1.245	1.843	2.061	2.263	2.579
2006	0	0.475	0.601	0.768	0.911	1.126	1.374	2.158	2.211	2.569
2007	0	0.628	0.669	0.859	0.969	1.06	1.245	1.475	2.266	2.256
2008	0.491	0.636	0.754	0.86	0.991	1.082	1.151	1.379	1.727	2.435

Year \ age	1	2	3	4	5	6	7	8	9	10
2009	0	0.482	0.734	0.985	1.13	1.264	1.357	1.545	1.792	2.154
2010	0	0.692	0.87	1.149	1.308	1.386	1.429	1.568	1.74	1.841
2011	0	0.553	0.815	1.086	1.303	1.387	1.469	1.538	1.702	1.862
2012	0	0.619	0.786	1.069	1.405	1.616	1.656	1.675	1.727	1.905
2013	0	0.576	0.83	1.149	1.465	1.71	1.827	1.886	1.856	2.085
2014	0	0.547	0.902	1.165	1.354	1.693	1.841	1.872	1.856	1.823
2015	0.424	0.533	0.889	1.353	1.64	1.729	2.424	2.003	2.218	2.302
2016	0.396	0.645	0.934	1.22	1.571	1.908	2.066	2.187	2.276	2.789
2017	0.343	0.79	0.904	1.169	1.595	2.137	2.291	2.666	2.697	3.791
2018	0	0.642	1	1.584	1.944	2.281	2.544	2.597	2.818	3.288
2019	0	0.626	0.775	1.133	1.807	2.096	2.677	2.461	2.872	2.505
2020	0	0.574	0.673	1.028	1.731	2.129	2.874	3.069	3.013	2.596

Table 5.6 Faroe haddock. Proportion mature at age 1957–2020.

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1957	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1958	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1959	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1960	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1961	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1962	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1963	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1964	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1965	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1966	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1967	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1968	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1969	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1970	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1971	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1972	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1973	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1974	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1975	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1976	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1977	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1978	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1979	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1980	0	0	0.06	0.48	0.91	1	1	1	1	1	1
1981	0	0	0.06	0.48	0.91	1	1	1	1	1	1

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1982	0	0	0.08	0.62	0.89	1	1	1	1	1	1
1983	0	0	0.08	0.62	0.89	1	1	1	1	1	1
1984	0	0	0.08	0.76	0.98	1	1	1	1	1	1
1985	0	0	0.03	0.62	0.96	1	1	1	1	1	1
1986	0	0	0.03	0.43	0.95	0.99	1	1	1	1	1
1987	0	0	0.05	0.32	0.91	0.98	1	1	1	1	1
1988	0	0	0.05	0.24	0.89	0.98	1	1	1	1	1
1989	0	0	0.02	0.22	0.87	0.99	1	1	1	1	1
1990	0	0	0.08	0.37	0.9	1	1	1	1	1	1
1991	0	0	0.16	0.58	0.93	1	1	1	1	1	1
1992	0	0	0.18	0.65	0.91	1	1	1	1	1	1
1993	0	0	0.11	0.5	0.85	0.97	0.99	1	1	1	1
1994	0	0	0.05	0.42	0.86	0.96	0.99	1	1	1	1
1995	0	0	0.03	0.47	0.91	0.96	0.99	1	1	1	1
1996	0	0	0.03	0.47	0.93	0.98	1	1	1	1	1
1997	0	0	0.01	0.47	0.91	1	1	1	1	1	1
1998	0	0	0.01	0.36	0.87	0.99	1	1	1	1	1
1999	0	0	0.01	0.35	0.86	0.99	1	1	1	1	1
2000	0	0	0.02	0.36	0.87	0.99	1	1	1	1	1
2001	0	0	0.09	0.54	0.93	1	1	1	1	1	1
2002	0	0	0.08	0.49	0.97	1	1	1	1	1	1
2003	0	0	0.07	0.45	0.97	0.99	1	1	1	1	1
2004	0	0	0	0.35	0.94	0.99	1	1	1	1	1
2005	0	0	0.01	0.34	0.91	0.99	1	1	1	1	1
2006	0	0	0.01	0.42	0.91	1	1	1	1	1	1
2007	0	0	0.02	0.52	0.91	1	1	1	1	1	1
2008	0	0	0.01	0.64	0.95	1	1	1	1	1	1
2009	0	0	0.01	0.61	0.93	1	1	1	1	1	1
2010	0	0	0.03	0.65	0.96	1	1	1	1	1	1
2011	0	0	0.09	0.74	0.97	1	1	1	1	1	1
2012	0	0	0.13	0.79	0.99	1	1	1	1	1	1
2013	0	0	0.17	0.83	0.99	1	1	1	1	1	1
2014	0	0	0.17	0.83	1	1	1	1	1	1	1
2015	0	0	0.19	0.9	1	1	1	1	1	1	1
2016	0	0	0.14	0.89	1	1	1	1	1	1	1
2017	0	0	0.12	0.9	1	1	1	1	1	1	1
2018	0	0	0.08	0.80	0.99	1	1	1	1	1	1
2019	0	0	0.21	0.76	0.97	1	1	1	1	1	1
2020	0	0	0.24	0.69	0.95	1	1	1	1	1	1

Table 5.7. Faroe haddock. Spring survey tuning series (number of individuals per 100 stations) and summer survey tuning series (numbers of individuals per 200 stations) used as tuning series in the assessment model.

Spring survey							
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
1994	19585	2381	208	323	170	308	414
1995	53979	21906	748	235	164	54	158
1996	5982	35320	20186	716	102	77	59
1997	273	7908	15994	26431	689	156	40
1998	3534	1360	3410	9793	13430	372	16
1999	4555	6953	113	1499	4402	3362	54
2000	29968	8695	5247	222	455	1686	2036
2001	27317	37139	3549	1126	28	112	448
2002	21041	17601	26398	2089	718	42	107
2003	9110	22710	13017	13606	855	241	20
2004	1699	15554	10921	7158	12092	560	90
2005	5860	5455	7921	6402	4678	5304	269
2006	733	6207	1514	4485	3327	3450	1756
2007	1258	1403	3056	816	2900	3079	2363
2008	691	2145	783	1711	612	1706	1534
2009	4157	2082	1073	407	941	376	970
2010	6529	5192	652	419	198	287	277
2011	103	6360	1894	463	268	221	257
2012	439	368	4957	908	228	143	293
2013	3513	1254	264	3987	674	132	116
2014	3643	4175	830	918	2286	295	101
2015	1598	3363	4090	1079	2087	1373	204
2016	14093	4497	2471	1382	279	461	115
2017	60511	15358	2763	2352	714	170	340
2018	85580	24603	3849	1010	734	267	66
2019	14548	38587	21130	7091	1382	768	218
2020	2521	47592	24449	16663	2197	869	301
2021	4319	7993	8306	17356	988	161	65

				Summer Survey					
Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
1996	375	47,759	42,901	64,257	1,278	214	299	248	425
1997	27	7,738	14,052	25,104	49,758	977	183	87	176
1998	1,485	20,209	2,763	2,502	14,017	19,433	321	99	82
1999	1,441	24,141	9,549	6,383	1,620	8,473	10,331	235	6
2000	5,148	169,563	19,483	7,956	390	1,300	4,696	6,007	105
2001	1,913	96,784	98,147	13,072	4,632	181	647	2,714	3,429
2002	2,047	95,407	53,532	62,498	6,158	1,974	170	412	1,336
2003	261	45,045	38,177	21,476	37,994	4,370	667	110	466
2004	670	7,951	33,766	10,718	15,151	17,822	1,003	207	27
2005	6	14,510	7,191	12,563	16,713	12,085	12,958	592	43
2006	76	2,504	8,700	1,790	8,009	8,237	6,980	3,494	129
2007	24	3,986	6,587	1,744	1,565	4,322	5,364	2,731	630
2008	684	4,798	1,877	1,135	2,505	1,001	3,183	3,287	1,513
2009	4,063	10,597	1,337	411	1,303	1,273	948	2,300	1,304
2010	21	24,891	3,636	1,457	1,072	576	828	776	1,329
2011	32	670	12,059	2,108	530	486	294	319	424
2012	2,733	2,454	357	5,617	1,176	223	149	161	105
2013	157	9,447	212	1,330	5,021	1,129	224	114	176
2014	247	13,910	3,989	891	1,034	2,944	428	94	84
2015	131	7,676	9,320	4,086	873	1,449	1,094	129	74
2016	3,861	36,511	3,303	3,101	1,989	284	567	378	46
2017	4,182	144,745	16,698	1,813	2,529	1,115	293	302	134
2018	4,675	135,364	54,716	12,800	4,557	3,435	1,106	528	598
2019	540	38,266	6,902	13,595	9,889	2,665	1,322	510	356
2020	44	13,005	3,652	11,020	12,442	1,024	463	126	36
2021	196	34,543	4,883	5,470	21,531	2,699	343	87	26

Table 5.8 Faroe haddock. Configuration in the SAM-run and the model parameters.

```
$minAge
[1] 1

$maxAge
[1] 10

$maxAgePlusGroup
[1] 1

$keyLogFsta
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    1    2    3    4    5    6    7    8     8
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$corFlag
[1] 2

$keyLogFpar
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]    0    1    2    3    4    5    6    6   -1    -1
[3,]    7    8    9   10   11   12   12   -1   -1    -1

$keyQpow
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$keyVarF
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1
[3,]   -1   -1   -1   -1   -1   -1   -1   -1   -1    -1

$keyVarLogN
 [1] 0 1 1 1 1 1 1 1 1 1

$keyVarObs
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]    1    1    1    1    1    1    1    1   -1    -1
[3,]    2    2    2    2    2    2    2   -1   -1    -1

$obsCorStruct
[1] ID AR AR
Levels: ID AR US

$keyCorObs
     1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
[1,]  NA  NA  NA  NA  NA  NA  NA  NA   NA
[2,]   0   0   0   0   0   0   0  -1   -1
[3,]   1   1   1   1   1   1   1  -1   -1

$stockRecruitmentModelCode
[1] 0

$noScaledYears
[1] 0

$keyScaledYears
numeric(0)
```

```
$keyParScaledYA
<0 x 0 matrix>

$fbarRange
[1] 3 7

$keyBiomassTreat
[1] -1 -1 -1

$obsLikelihoodFlag
[1] LN LN LN
Levels: LN ALN

$fixVarToWeight
[1] 0
```

Table 5.9 Faroe haddock 2018. Changes in the SAM settings to incorporate the different variance on age 1–2 in summer survey and age 1 in spring survey.

Default settings:

```
$keyVarObs
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]    1    1    1    1    1    1    1    1   -1    -1
[3,]    2    2    2    2    2    2    2   -1   -1    -1
```

Revised settings:

```
$keyVarObs
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10]
[1,]    0    0    0    0    0    0    0    0    0     0
[2,]    1    1    2    2    2    2    2    2   -1    -1
[3,]    3    4    4    4    4    4    4   -1   -1    -1
```

Table 5.10 Faroe haddock. Model parameters, model fitting and selected sd from SAM run.

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-4.701	0.171	0.009	0.006	0.013
logFpar_1	-5.439	0.159	0.004	0.003	0.006
logFpar_2	-5.548	0.114	0.004	0.003	0.005
logFpar_3	-5.346	0.11	0.005	0.004	0.006
logFpar_4	-5.403	0.108	0.005	0.004	0.006
logFpar_5	-5.335	0.105	0.005	0.004	0.006
logFpar_6	-5.19	0.091	0.006	0.005	0.007
logFpar_7	-5.502	0.213	0.004	0.003	0.006
logFpar_8	-4.956	0.144	0.007	0.005	0.009
logFpar_9	-5.488	0.134	0.004	0.003	0.005
logFpar_10	-5.458	0.128	0.004	0.003	0.006
logFpar_11	-5.639	0.123	0.004	0.003	0.005
logFpar_12	-5.687	0.113	0.003	0.003	0.004
logSdLogFsta_0	-0.957	0.111	0.384	0.308	0.48
logSdLogN_0	-0.066	0.11	0.936	0.751	1.168
logSdLogN_1	-1.27	0.09	0.281	0.235	0.336
logSdLogObs_0	-1.065	0.082	0.345	0.293	0.407
logSdLogObs_1	-0.415	0.124	0.66	0.516	0.846
logSdLogObs_2	-0.892	0.082	0.41	0.348	0.483
logSdLogObs_3	-0.032	0.163	0.969	0.699	1.343
logSdLogObs_4	-0.518	0.081	0.596	0.507	0.7
transfIRARdist_0	0.656	0.295	1.928	1.068	3.48
transfIRARdist_1	-0.211	0.228	0.809	0.513	1.278
itrans_rho_0	1.204	0.121	3.334	2.62	4.244

Model	log(L)	#par	AIC
Current	-1010.37	24	2068.73
base	-1010.37	24	2068.73

Year	sd(log(R))	sd(log(SSB))	sd(log(Fbar))
2020	0.371	0.152	0.198
2021	0.518	0.202	0.313

Table 5.11. Faroe haddock (Division 5.b.). Fishing mortality at age from the SAM model.

Year \ Age	1	2	3	4	5	6	7	8	9	10
1957	0.003	0.122	0.344	0.494	0.392	0.484	0.744	0.752	0.853	0.853
1958	0.005	0.172	0.444	0.605	0.495	0.638	1.020	1.076	1.284	1.284
1959	0.007	0.190	0.448	0.576	0.474	0.630	1.034	1.133	1.405	1.405
1960	0.010	0.230	0.530	0.668	0.543	0.716	1.187	1.300	1.589	1.589
1961	0.010	0.217	0.477	0.580	0.466	0.607	0.999	1.131	1.317	1.317
1962	0.010	0.237	0.534	0.650	0.516	0.661	1.089	1.341	1.559	1.559
1963	0.008	0.217	0.528	0.689	0.564	0.707	1.183	1.647	2.010	2.010
1964	0.004	0.110	0.313	0.469	0.422	0.550	0.883	1.366	1.618	1.618
1965	0.003	0.092	0.280	0.449	0.431	0.625	1.112	1.721	1.801	1.801
1966	0.003	0.088	0.278	0.443	0.417	0.588	1.004	1.341	1.509	1.509
1967	0.002	0.071	0.233	0.364	0.342	0.492	0.851	1.074	1.311	1.311
1968	0.002	0.088	0.280	0.412	0.368	0.508	0.853	0.987	1.231	1.231
1969	0.003	0.096	0.324	0.482	0.432	0.588	0.975	1.031	1.282	1.282
1970	0.003	0.082	0.303	0.445	0.409	0.518	0.800	0.704	0.762	0.762
1971	0.002	0.072	0.305	0.451	0.441	0.523	0.797	0.737	0.891	0.891
1972	0.002	0.072	0.329	0.441	0.418	0.427	0.610	0.576	0.755	0.755
1973	0.004	0.111	0.420	0.479	0.394	0.342	0.380	0.329	0.359	0.359
1974	0.003	0.077	0.293	0.364	0.306	0.283	0.309	0.316	0.386	0.386
1975	0.002	0.057	0.226	0.295	0.261	0.245	0.258	0.309	0.424	0.424
1976	0.001	0.042	0.202	0.312	0.324	0.343	0.361	0.448	0.586	0.586
1977	0.001	0.018	0.125	0.268	0.388	0.506	0.593	0.811	1.129	1.129
1978	0.000	0.008	0.072	0.183	0.295	0.408	0.546	0.815	1.149	1.149
1979	0.000	0.006	0.061	0.151	0.221	0.269	0.334	0.491	0.679	0.679
1980	0.000	0.014	0.119	0.258	0.315	0.320	0.339	0.446	0.576	0.576
1981	0.001	0.019	0.140	0.273	0.299	0.271	0.243	0.276	0.341	0.341
1982	0.001	0.033	0.238	0.428	0.452	0.397	0.335	0.389	0.474	0.474
1983	0.001	0.030	0.198	0.363	0.388	0.378	0.328	0.418	0.503	0.503
1984	0.001	0.029	0.171	0.317	0.334	0.352	0.289	0.404	0.492	0.492
1985	0.001	0.028	0.164	0.311	0.356	0.406	0.332	0.483	0.594	0.594
1986	0.000	0.022	0.126	0.252	0.318	0.395	0.369	0.588	0.720	0.720
1987	0.001	0.025	0.134	0.259	0.339	0.451	0.481	0.705	0.798	0.798
1988	0.000	0.021	0.112	0.214	0.281	0.363	0.397	0.536	0.637	0.637
1989	0.000	0.017	0.106	0.211	0.300	0.414	0.511	0.676	0.818	0.818
1990	0.000	0.022	0.143	0.264	0.337	0.452	0.567	0.713	0.923	0.923
1991	0.000	0.029	0.171	0.292	0.324	0.389	0.438	0.464	0.540	0.540

Year \ Age	1	2	3	4	5	6	7	8	9	10
1992	0.000	0.026	0.146	0.256	0.283	0.321	0.351	0.360	0.423	0.423
1993	0.001	0.037	0.192	0.307	0.298	0.297	0.298	0.288	0.321	0.321
1994	0.000	0.018	0.122	0.240	0.265	0.290	0.308	0.308	0.336	0.336
1995	0.000	0.017	0.125	0.269	0.314	0.340	0.363	0.356	0.366	0.366
1996	0.000	0.013	0.119	0.288	0.377	0.442	0.495	0.478	0.452	0.452
1997	0.000	0.015	0.132	0.284	0.404	0.526	0.655	0.652	0.588	0.588
1998	0.000	0.025	0.222	0.388	0.516	0.731	1.028	1.151	0.913	0.913
1999	0.000	0.030	0.277	0.428	0.514	0.681	0.948	1.339	0.963	0.963
2000	0.001	0.040	0.299	0.425	0.456	0.515	0.573	0.725	0.576	0.576
2001	0.000	0.033	0.241	0.383	0.427	0.454	0.440	0.491	0.438	0.438
2002	0.000	0.025	0.194	0.350	0.444	0.511	0.502	0.552	0.561	0.561
2003	0.000	0.014	0.125	0.280	0.458	0.675	0.771	0.834	0.906	0.906
2004	0.000	0.015	0.122	0.263	0.446	0.721	0.984	1.140	1.318	1.318
2005	0.000	0.019	0.135	0.264	0.420	0.655	0.946	1.146	1.417	1.417
2006	0.001	0.025	0.162	0.280	0.401	0.604	0.902	1.103	1.582	1.582
2007	0.001	0.030	0.187	0.295	0.376	0.521	0.765	0.974	1.268	1.268
2008	0.001	0.030	0.186	0.287	0.328	0.435	0.646	0.885	1.279	1.279
2009	0.001	0.025	0.185	0.288	0.310	0.378	0.507	0.631	0.901	0.901
2010	0.001	0.036	0.275	0.414	0.423	0.490	0.615	0.720	1.044	1.044
2011	0.000	0.025	0.221	0.367	0.403	0.478	0.633	0.736	1.103	1.103
2012	0.000	0.019	0.165	0.282	0.337	0.408	0.529	0.626	0.962	0.962
2013	0.000	0.032	0.243	0.337	0.383	0.449	0.578	0.699	1.115	1.115
2014	0.000	0.036	0.269	0.365	0.408	0.431	0.499	0.563	0.965	0.965
2015	0.000	0.037	0.274	0.371	0.415	0.443	0.479	0.549	1.046	1.046
2016	0.000	0.029	0.235	0.348	0.417	0.461	0.482	0.591	1.215	1.215
2017	0.000	0.011	0.117	0.214	0.286	0.335	0.386	0.555	1.320	1.320
2018	0.000	0.011	0.140	0.266	0.358	0.396	0.435	0.663	1.936	1.936
2019	0.000	0.008	0.136	0.334	0.537	0.615	0.663	0.949	2.759	2.759
2020	0.000	0.003	0.078	0.230	0.481	0.661	0.877	1.371	3.701	3.701
2021	0.000	0.004	0.109	0.344	0.798	1.164	1.572	2.299	5.700	5.700

Table 5.12 Faroe haddock (Division 5.b). Stock number at age from the SAM model.

Year Age	1	2	3	4	5	6	7	8	9	10
1957	27174	36643	25426	20827	5416	2606	1226	470	202	118
1958	32279	30697	25236	14228	9549	2980	1334	480	182	127
1959	58842	29225	23239	12848	6300	4397	1275	390	134	68
1960	77199	39354	24213	13354	6228	3300	1794	379	104	39
1961	78120	54399	23945	12857	5727	3040	1350	415	89	22
1962	77730	51062	35473	12356	6534	3018	1364	399	108	27
1963	40281	60653	26885	16395	5481	3587	1266	369	84	25
1964	18343	28808	33018	11484	6536	2585	1716	303	60	11
1965	17748	16865	20935	17234	5227	3103	1147	806	63	11
1966	32740	15250	14016	13567	8411	2725	1275	300	98	11
1967	47072	25019	12615	9268	7085	4140	1212	360	68	19
1968	28708	48283	19003	8972	5598	4222	1930	418	102	19
1969	32460	26350	33328	11956	5274	3437	2141	670	130	29
1970	20126	25984	20776	19531	5791	3196	1628	682	201	29
1971	24173	13964	20097	13479	9964	3198	1601	515	279	120
1972	27389	19334	10391	13209	7264	5079	1493	580	186	140
1973	119111	24399	19965	4760	7724	3595	3244	594	310	83
1974	109345	80346	15449	11950	2272	4155	1961	2007	316	330
1975	70056	91827	49120	9372	6724	1463	2424	1119	1258	440
1976	27258	68033	53626	28161	5824	4266	1111	1833	698	927
1977	10248	20029	44146	29454	14925	3911	2410	765	1020	931
1978	993	9474	16774	29167	17271	6788	1673	1090	309	488
1979	5908	561	13902	13556	18690	9794	3277	641	363	186
1980	6140	6115	653	14414	10016	11589	6204	1814	271	212
1981	18045	4576	4227	744	10598	6094	7177	3753	839	184
1982	21351	16027	3416	2752	628	7302	3807	4490	2958	612
1983	45886	16553	12536	1624	1444	349	4562	2253	2636	2018
1984	40814	40646	12533	8534	759	791	220	2644	1186	2561
1985	20070	34534	31961	9037	4659	443	424	171	1354	2061
1986	13519	15963	26042	21420	5673	2486	207	261	108	1546
1987	24628	10115	15138	18937	12918	3356	1279	131	109	670
1988	9587	23158	6303	12872	12866	7782	1736	540	48	296
1989	7179	7397	16194	4428	9538	8241	4606	1005	264	154
1990	3239	6150	8178	10222	3120	5632	4618	2115	391	159
1991	2752	2504	5735	6745	5953	2013	3000	2158	854	132
1992	3971	2148	1669	3926	4394	3690	1158	1492	1153	484
1993	26187	2834	1893	1200	2533	2654	2237	661	856	843
1994	25691	11235	1709	1420	760	1641	1740	1486	441	1108
1995	42977	40640	5098	1089	898	503	1092	1104	937	991

Year Age	1	2	3	4	5	6	7	8	9	10
1996	10231	35336	55237	3079	577	487	379	719	685	1204
1997	3972	7913	30068	50047	1821	332	225	243	437	1159
1998	14285	3263	6033	21668	32527	962	127	123	128	838
1999	26062	12826	2437	3712	13891	16823	408	26	33	351
2000	119639	23686	13036	872	2142	7236	7951	148	4	138
2001	54635	107580	17697	7510	441	1236	3701	4339	58	63
2002	35862	45176	90173	10034	3691	310	742	2234	2624	72
2003	23410	24292	33629	56537	5824	1676	204	550	1272	1467
2004	7234	21324	21465	23927	35033	2607	607	98	214	1019
2005	9297	5617	17157	18713	18535	17434	1051	187	32	273
2006	2940	8756	3703	12477	13085	11828	6266	321	58	69
2007	2985	2641	5804	2562	8431	8439	5592	1732	117	18
2008	3774	2542	1880	3928	1828	5060	4291	2170	480	40
2009	7819	2262	1785	1473	2350	1479	3088	1814	648	105
2010	11040	6740	1888	1325	914	1306	1141	1611	770	257
2011	1014	10254	4136	1028	696	551	601	647	609	295
2012	2315	884	9050	2099	535	339	337	232	279	231
2013	7910	1983	1561	6075	1080	296	192	163	106	172
2014	9492	6661	1745	1753	3386	450	157	92	45	77
2015	7983	8021	5646	1145	1680	1248	177	81	40	36
2016	26193	6719	5950	2993	673	1060	432	67	38	21
2017	34349	17512	4562	4076	1590	427	508	168	27	15
2018	48855	34608	13581	3751	2645	897	310	254	52	10
2019	17577	35240	24196	8455	2546	1341	423	209	71	6
2020	7967	11927	29432	14991	2788	1003	426	155	60	4
2021	12325	6998	10192	29467	6926	1184	372	140	32	1

Table 5.13 Faroe haddock (Division 5.b). Summary table from the SAM model (catch is also provided).

Year	Recruitment			SSB			Total	F		
	Age 1	97.5%	2.5%		97.5%	2.5%	Catch	Ages 3–7	97.5%	2.5%
	thousands			tonnes			tonnes			
1957	27174	51861	14239	50178	66116	38083	20995	0.49	0.67	0.36
1958	32279	58859	17702	50561	64505	39631	23871	0.64	0.84	0.49
1959	58842	105643	32774	45408	57354	35950	20239	0.63	0.82	0.49
1960	77199	138673	42977	45306	56831	36118	25727	0.73	0.94	0.56
1961	78120	141371	43168	42764	53823	33977	20831	0.63	0.82	0.48
1962	77730	140898	42882	47465	59683	37748	27151	0.69	0.89	0.53
1963	40281	73342	22124	47968	60870	37801	27571	0.73	0.95	0.57
1964	18343	33635	10003	44608	57225	34773	19490	0.53	0.70	0.40
1965	17748	32617	9658	44968	58133	34784	18479	0.58	0.76	0.44
1966	32740	60070	17844	41937	54381	32341	18766	0.55	0.72	0.41
1967	47072	86435	25635	37987	48742	29606	13381	0.46	0.61	0.34
1968	28708	52589	15671	40423	50866	32124	17852	0.48	0.64	0.37
1969	32460	59356	17751	47170	59549	37365	23272	0.56	0.74	0.43
1970	20126	36894	10979	49895	64545	38570	21361	0.50	0.66	0.37
1971	24173	44273	13199	49604	63918	38496	19393	0.50	0.68	0.37
1972	27389	50319	14908	45299	58757	34923	16485	0.45	0.61	0.32
1973	119111	225416	62939	42339	54620	32818	18035	0.40	0.56	0.29
1974	109345	207403	57648	44081	56553	34359	14773	0.31	0.44	0.22
1975	70056	133991	36628	57097	73782	44185	20715	0.26	0.36	0.183
1976	27258	52820	14066	80267	105735	60933	26211	0.31	0.43	0.22
1977	10248	22794	4607	82309	109632	61796	25555	0.38	0.53	0.27
1978	993	2244	439	79992	108957	58728	19200	0.30	0.44	0.21
1979	5908	11644	2997	62737	85442	46066	12424	0.21	0.30	0.141
1980	6140	12926	2917	57653	77130	43094	15016	0.27	0.39	0.189
1981	18045	38013	8566	52061	70010	38714	12233	0.25	0.35	0.174
1982	21351	45045	10120	40441	52698	31035	11937	0.37	0.51	0.27
1983	45886	97280	21644	37594	49125	28770	12894	0.33	0.47	0.24
1984	40814	80036	20813	41135	53112	31859	12378	0.29	0.41	0.21
1985	20070	42661	9442	49355	65278	37316	15143	0.31	0.44	0.22
1986	13519	28834	6339	54218	73052	40239	14477	0.29	0.41	0.21
1987	24628	52883	11469	54152	72552	40419	14882	0.33	0.47	0.24
1988	9587	20522	4478	48956	65190	36765	12178	0.27	0.38	0.196
1989	7179	15232	3383	41868	54632	32087	14325	0.31	0.43	0.22
1990	3239	6846	1532	34805	44958	26945	11726	0.35	0.50	0.25
1991	2752	5798	1307	26865	35003	20619	8429	0.32	0.46	0.23
1992	3971	8410	1875	19977	26385	15125	5476	0.27	0.39	0.190
1993	26187	51687	13268	17197	22762	12992	4026	0.28	0.39	0.198

Year	Recruitment			SSB			Total	F		
	Age 1	97.5%	2.5%		97.5%	2.5%	Catch	Ages 3–7	97.5%	2.5%
	thousands			tonnes			tonnes			
1994	25691	47904	13778	16252	21143	12492	4252	0.25	0.34	0.176
1995	42977	82815	22303	17282	21818	13688	4948	0.28	0.39	0.21
1996	10231	17567	5959	36959	47959	28481	9642	0.34	0.46	0.26
1997	3972	7227	2183	68838	91008	52069	17924	0.40	0.53	0.30
1998	14285	25487	8006	67586	87351	52294	22210	0.58	0.75	0.44
1999	26062	43826	15498	47742	61022	37352	18482	0.57	0.74	0.44
2000	119639	202066	70835	36352	45257	29199	15799	0.45	0.60	0.34
2001	54635	92494	32272	46237	55831	38292	15891	0.39	0.51	0.29
2002	35862	64729	19869	75018	94655	59455	24929	0.40	0.53	0.30
2003	23410	42046	13034	87604	113294	67740	26942	0.46	0.61	0.35
2004	7234	12352	4236	74544	94933	58533	23100	0.51	0.67	0.39
2005	9297	16593	5209	60910	75558	49102	21944	0.48	0.63	0.37
2006	2940	5253	1645	44543	54570	36358	17154	0.47	0.62	0.36
2007	2985	5325	1673	30993	37708	25474	12631	0.43	0.56	0.33
2008	3774	6537	2179	20277	24411	16842	7393	0.38	0.50	0.29
2009	7819	13921	4392	15064	18051	12571	5197	0.33	0.44	0.25
2010	11040	19852	6140	11646	13766	9852	5203	0.44	0.58	0.34
2011	1014	1886	545	9223	10985	7743	3546	0.42	0.56	0.32
2012	2315	4180	1281	11081	14033	8749	2634	0.34	0.46	0.26
2013	7910	14130	4428	11484	14719	8960	2924	0.40	0.53	0.30
2014	9492	16904	5330	9998	12500	7997	3252	0.40	0.53	0.30
2015	7983	14334	4446	12554	15523	10154	3421	0.40	0.53	0.29
2016	26193	45264	15157	13468	16756	10825	3470	0.39	0.52	0.29
2017	34349	61021	19335	15325	19104	12293	2863	0.27	0.36	0.197
2018	48855	90614	26341	27339	34857	21443	5549	0.32	0.44	0.23
2019	17577	33410	9247	37451	48262	29062	9334	0.46	0.63	0.33
2020	7967	16746	3790	40342	54674	29767	7329	0.47	0.69	0.31
2021	12325	34727	4374	53186	79601	35537				

Table 5.14 Faroe haddock (Division 5.b). Prediction tables with different F scenarios.

Forecast table 1. TAC 6634 in 2021, then Fmsy=0.165.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.216	0.120	0.400	12623	4377	36843	54123	37104	79690	6634	3077	14781	59876	41097	86488
2022	0.165	0.062	0.399	9297	1014	119639	68037	41574	112196	8639	3258	24047	77218	47680	124312
2023	0.165	0.050	0.559	7983	1014	119639	70117	40044	127000	11374	3885	30807	82134	45827	153367
2024	0.165	0.042	0.653	9297	1014	119639	71326	34026	148638	12186	3763	33759	82168	39897	168915

Forecast table 2. TAC 6634 in 2021, then zero.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.216	0.120	0.400	12623	4377	36843	54123	37104	79690	6634	3077	14781	59876	41097	86488
2022	0.000	0.000	0.000	9297	1014	119639	68037	41574	112196	0	0	0	77218	47680	124312
2023	0.000	0.000	0.000	7983	1014	119639	82225	47678	146496	0	0	0	93490	52902	170089
2024	0.000	0.000	0.000	9297	1014	119639	96151	52257	183792	0	0	1	108508	57918	205522

Forecast table 3. SQ all years.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.811	0.451	1.503	12623	4377	36843	54123	37104	79690	19738	10037	38899	59876	41097	86488
2022	0.826	0.312	2.000	9297	1014	119639	51160	29708	87275	21851	9899	49160	60511	35965	100072
2023	0.814	0.246	2.760	7983	1014	119639	38164	16959	78015	15698	6989	33702	49157	22136	112635
2024	0.850	0.217	3.361	9297	1014	119639	32891	11129	96235	11630	4224	28443	44566	16460	124033

Forecast table 6. TAC 6634 in 2021, then Fpa=0.19.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.216	0.120	0.400	12623	4377	36843	54123	37104	79690	6634	3077	14781	59876	41097	86488
2022	0.190	0.072	0.460	9297	1014	119639	68037	41574	112196	9761	3709	26893	77218	47680	124312
2023	0.190	0.057	0.644	7983	1014	119639	68674	39054	124965	12518	4349	32828	80512	44608	152127
2024	0.190	0.049	0.751	9297	1014	119639	68739	32183	145952	12776	4156	34004	79860	37726	165767

Forecast table 7. TAC 6634 in 2021, then Flim=0.54.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.216	0.120	0.400	12623	4377	36843	54123	37104	79690	6634	3077	14781	59876	41097	86488
2022	0.540	0.204	1.307	9297	1014	119639	68037	41574	112196	22946	9520	55772	77218	47680	124312
2023	0.540	0.163	1.831	7983	1014	119639	53762	26335	102834	19188	8306	42325	64947	32940	131970
2024	0.540	0.138	2.135	9297	1014	119639	44591	16447	115641	14053	5376	33213	56476	21833	136273

Forecast table 4. TAC 6634 in 2021, then Fsq=0.216.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.216	0.120	0.400	12623	4377	36843	54123	37104	79690	6634	3077	14781	59876	41097	86488
2022	0.216	0.082	0.523	9297	1014	119639	68037	41574	112196	10928	4166	29801	77218	47680	124312
2023	0.216	0.065	0.732	7983	1014	119639	67143	37895	122768	13603	4826	35092	79125	43856	151383
2024	0.216	0.055	0.854	9297	1014	119639	65873	30131	142996	13358	4486	34686	77276	36227	162589

Forecast table 5. TAC 6634 in 2021, then F2020=0.465.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.216	0.120	0.400	12623	4377	36843	54123	37104	79690	6634	3077	14781	59876	41097	86488
2022	0.465	0.176	1.126	9297	1014	119639	68037	41574	112196	20575	8344	51158	77218	47680	124312
2023	0.465	0.140	1.577	7983	1014	119639	56513	28686	107326	18568	7902	42075	67518	35476	133916
2024	0.265	0.068	1.048	9297	1014	119639	48118	18347	119755	9646	3488	23744	60060	24243	140379

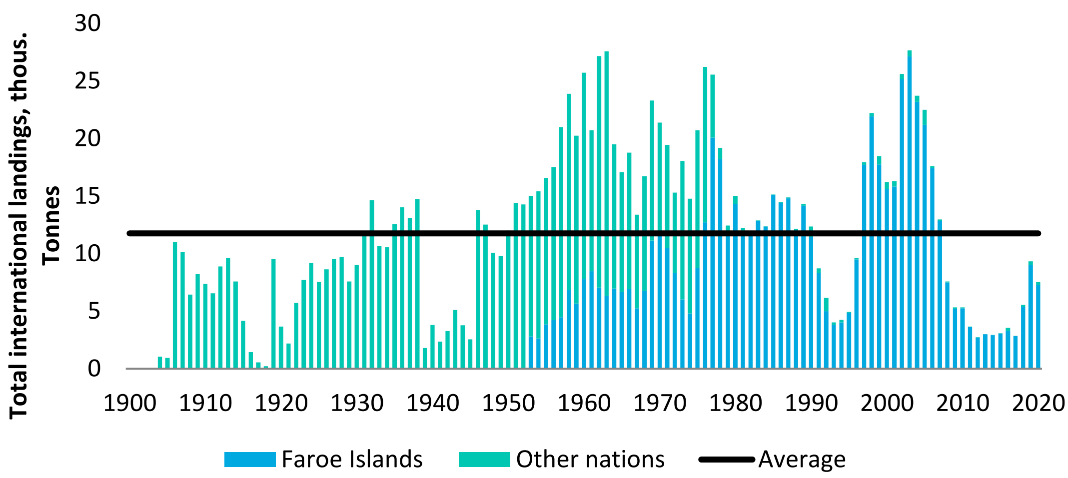


Figure 5.1. Haddock in ICES Division 5.b. Landings by all nations 1904–2020.

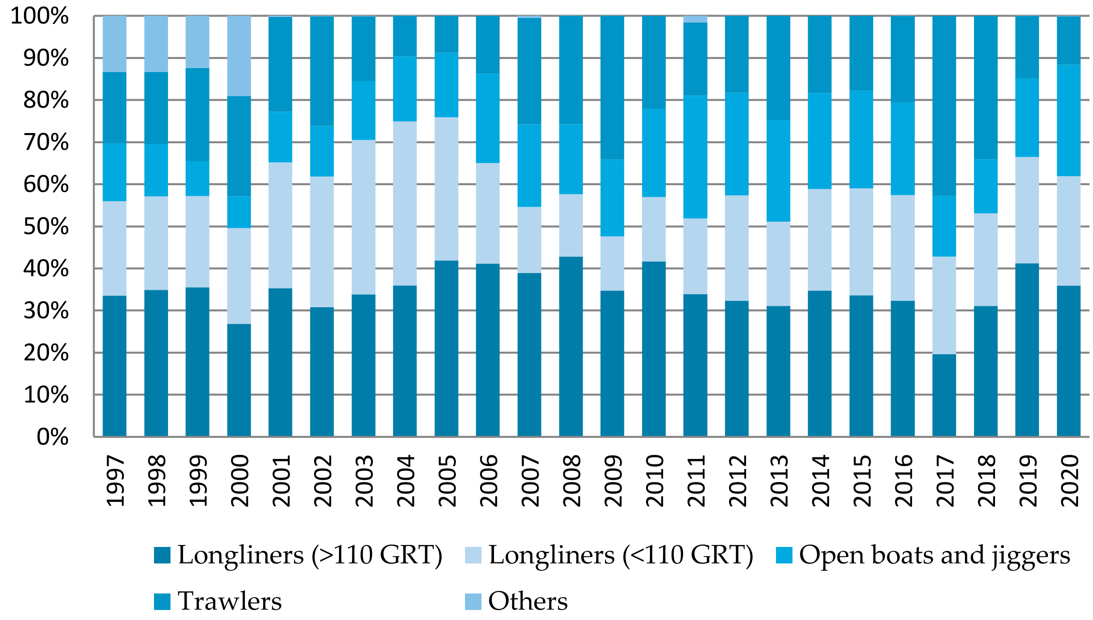


Figure 5.2. Faroe haddock. Catch distribution (%) between main fleets of the total Faroese landings 1997–2020.

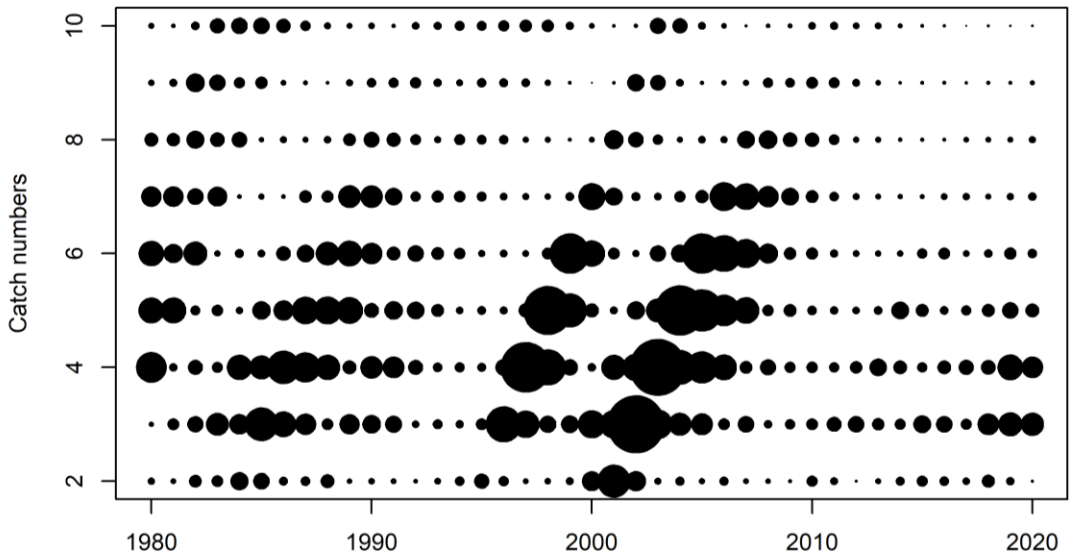


Figure 5.3. Faroe Haddock. Cath-at-age numbers in the commercial catches (ages 2–10) (1980–2020).

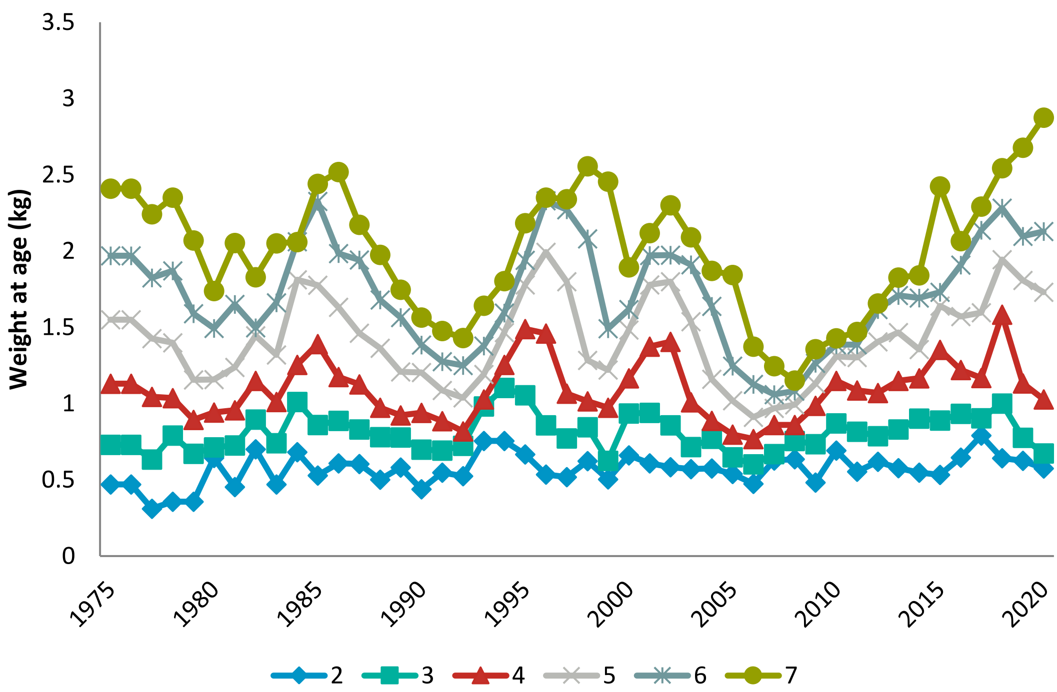


Figure 5.4. Faroe haddock. Mean weight (kg) at age (2–7).

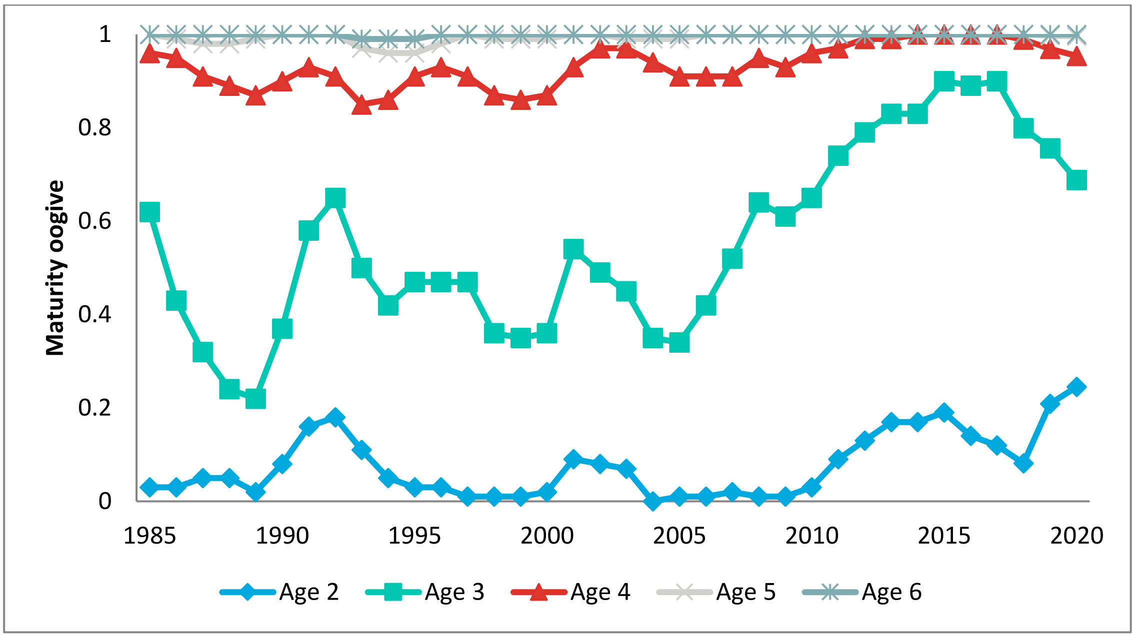


Figure 5.5. Faroe haddock. Maturity at age since 1985. Running 3-years average of spring survey observations for ages 2–6.

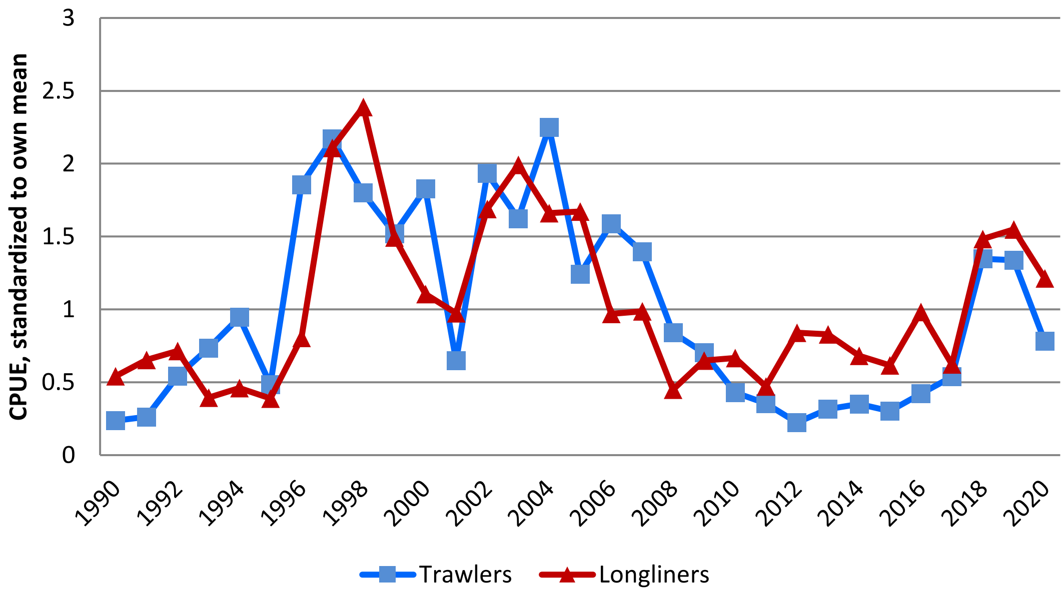


Figure 5.6. Commercial CPUEs of Faroe haddock for trawlers and longliners.

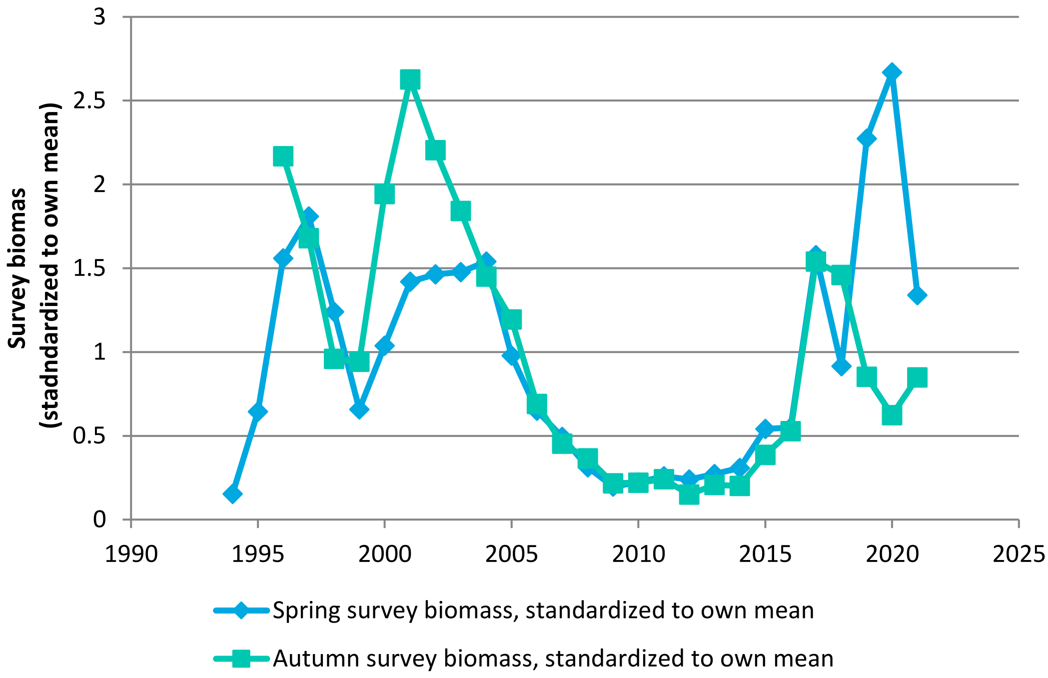


Figure 5.7. Tuning series biomass for spring surveys (1994–2021) and summer surveys (1996–2021). Surveys biomass is standardised to series mean biomass.

Figure 5.8a. Distribution of Faroe haddock catches in the spring survey.

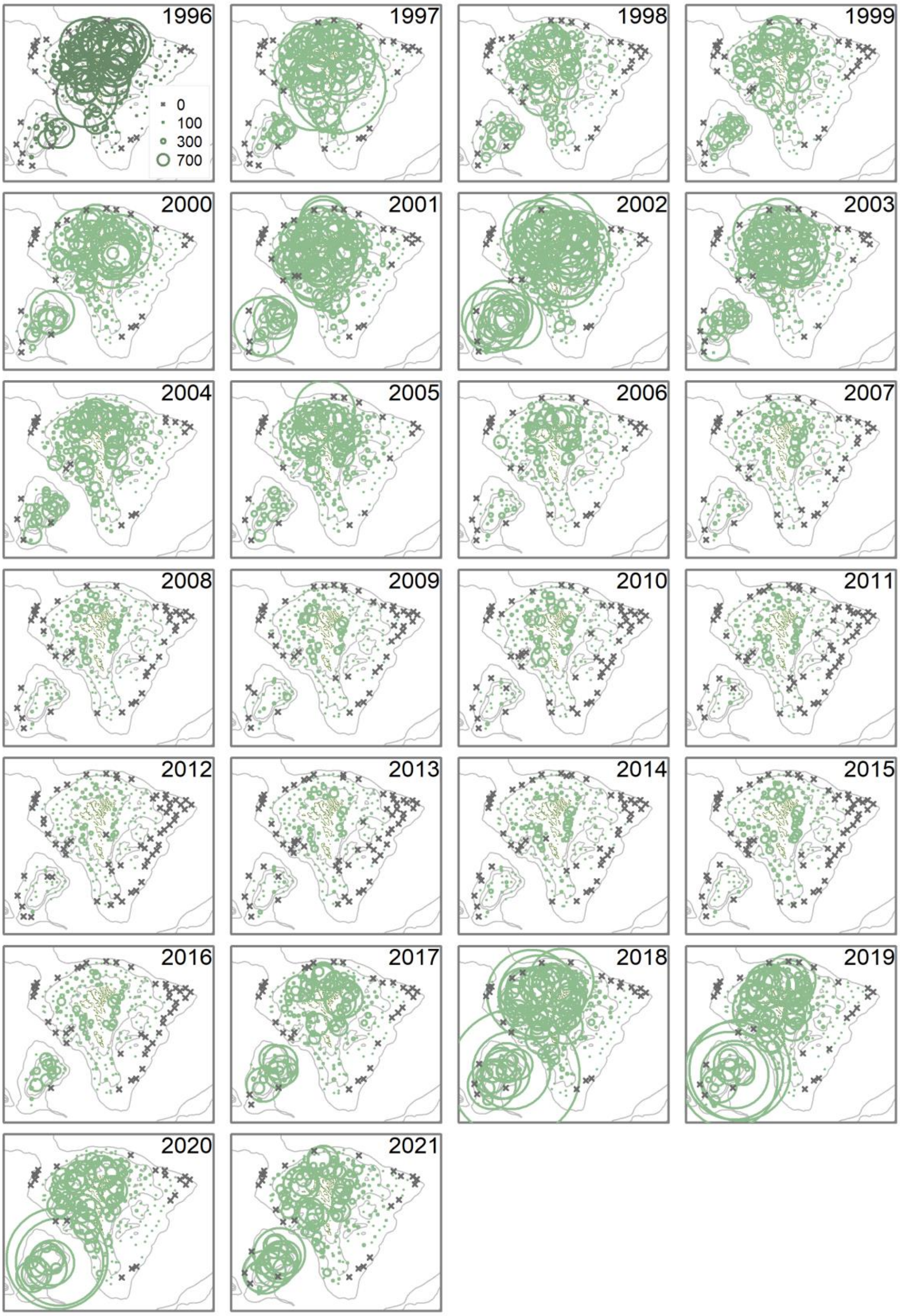


Figure 5.8b. Distribution of Faroe haddock catches in the summer survey.

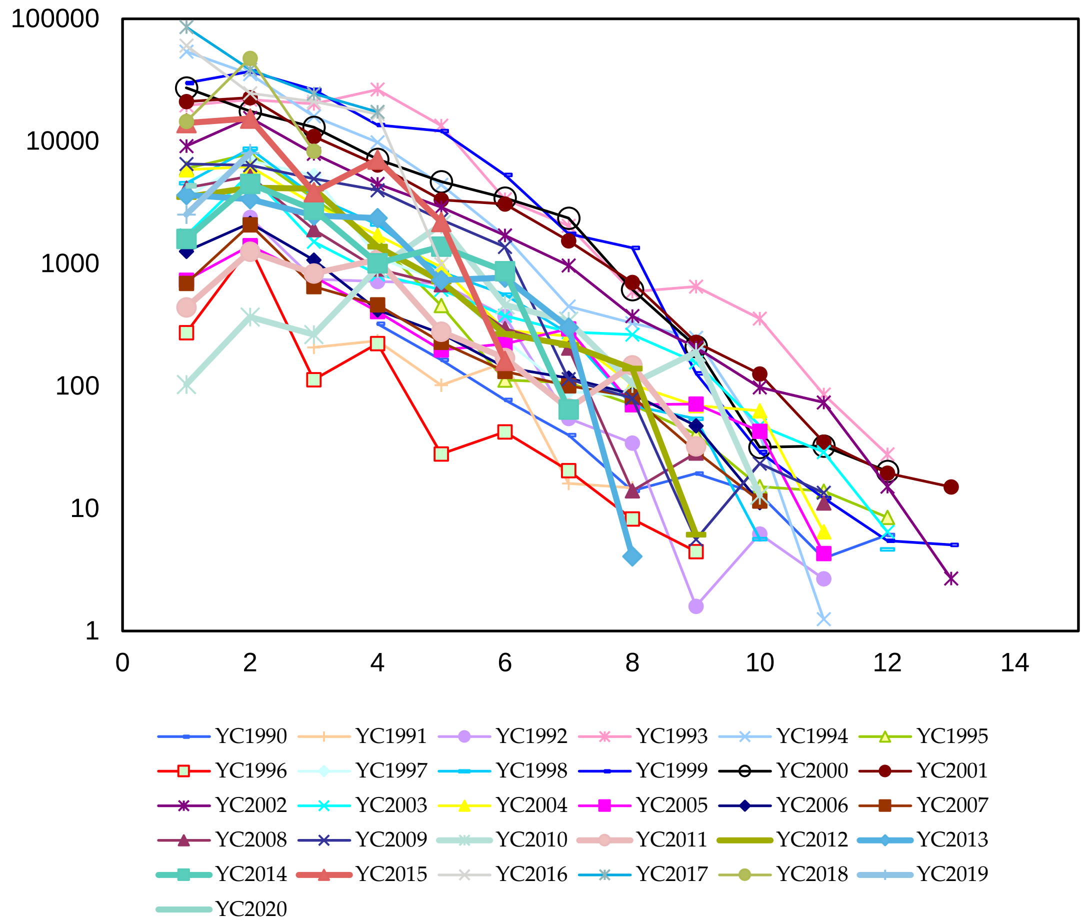


Figure 5.9. Faroe haddock. LN (catch at age in numbers) in the spring survey 1994–2020.

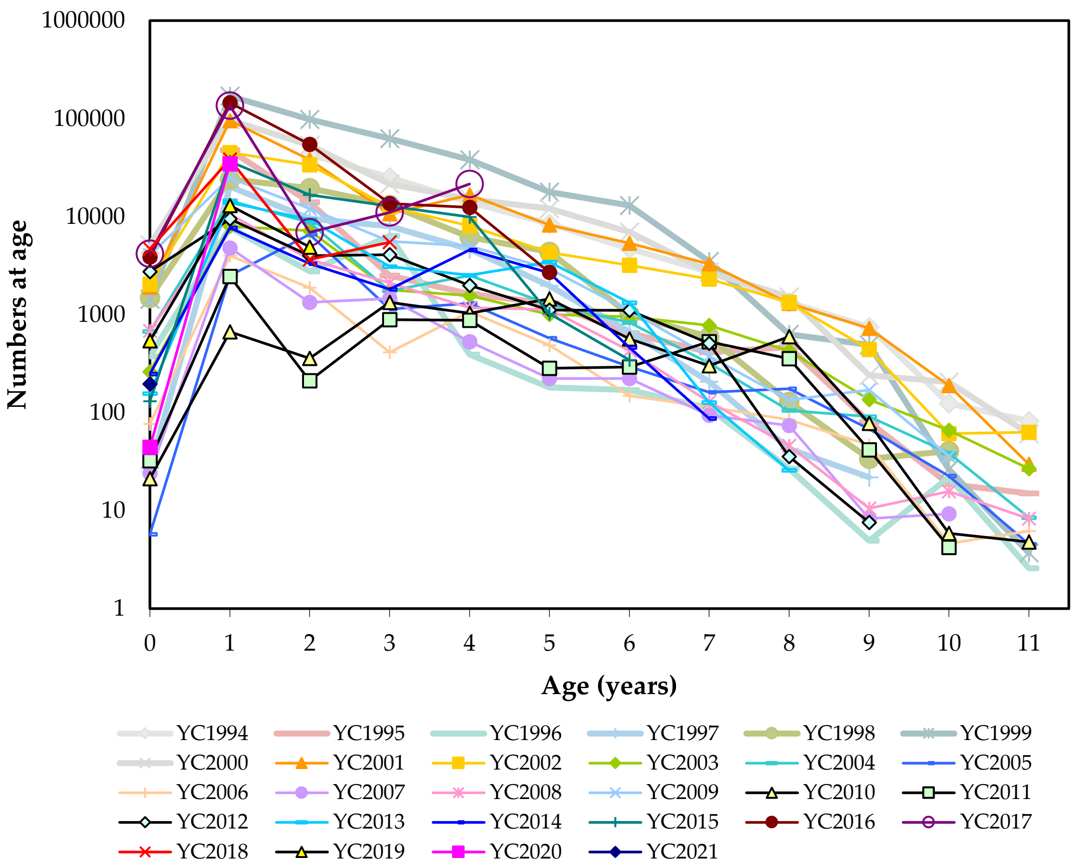


Figure 5.10. Faroe haddock. LN (catch at age in numbers) in the summer survey 1996–2021.

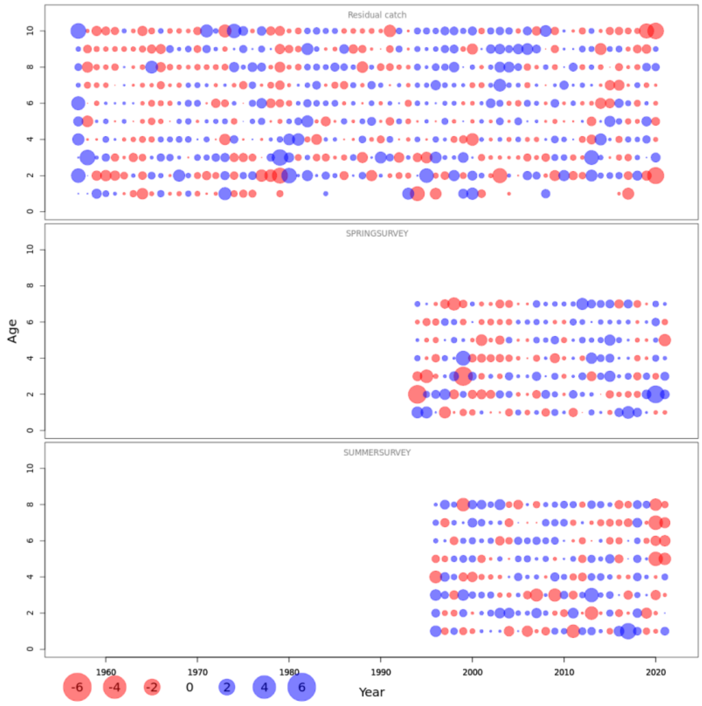


Figure 5.11. Faroe haddock (Division 5.b). Observation residuals for the catch, spring survey and the summer survey as estimated by the SAM model.

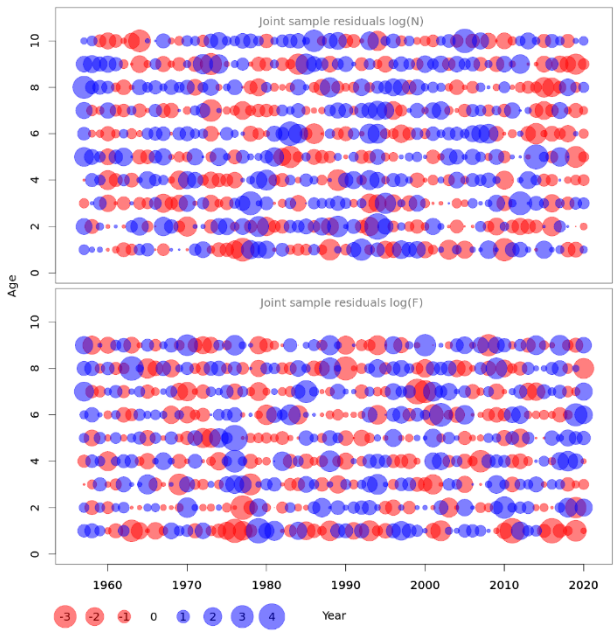


Figure 5.12. Faroe haddock (Division 5.b). Joint sample residuals for the population numbers and fishing mortality as estimated by the SAM model.

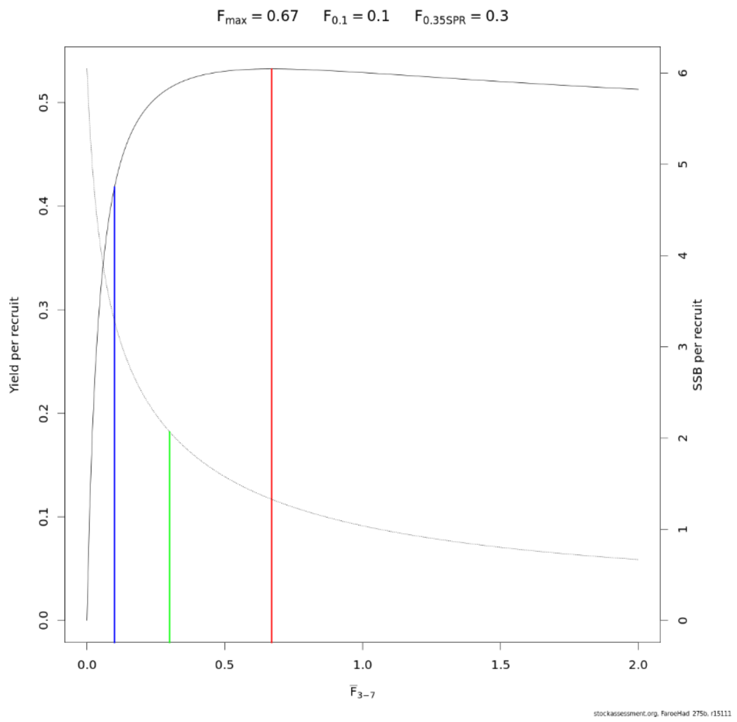


Figure 5.13. Faroe haddock (Division 5.b). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality.

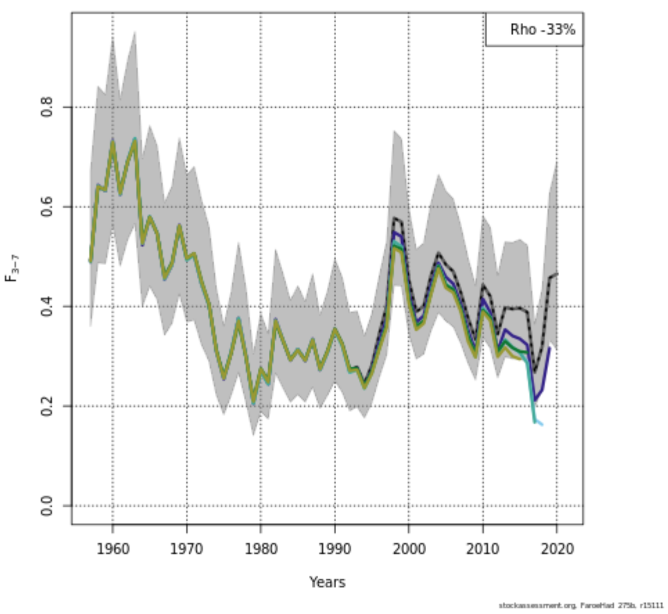


Figure 5.14. Faroe haddock (Division 5.b). Results from the SAM retrospective analysis of fishing mortality (ages 3–7).

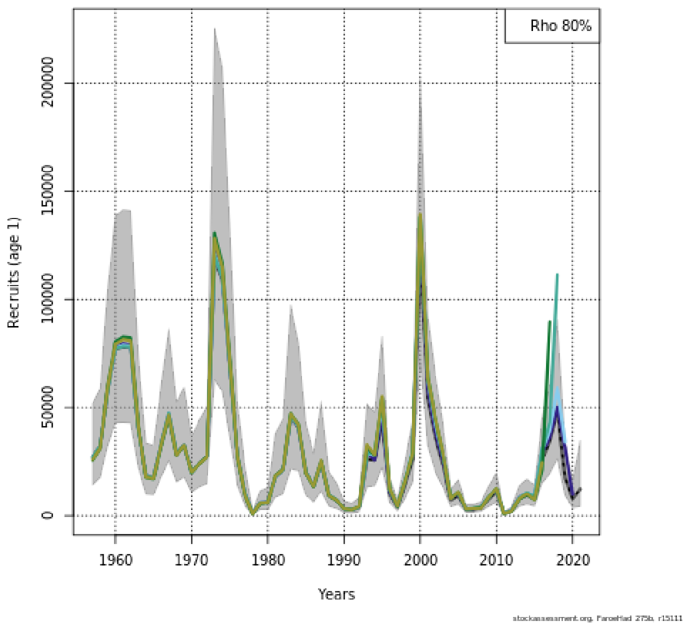


Figure 5.15. Faroe haddock (Division 5.b). Results from the SAM retrospective analysis. Recruitment at age 1.

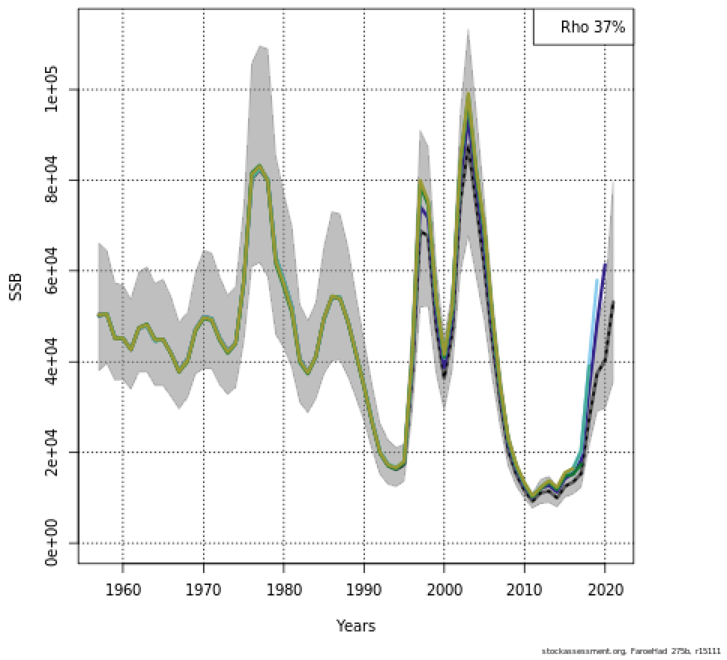


Figure 5.16. Faroe haddock (Division 5.b). Results from the SAM retrospective analysis (continued). Spawning stock biomass.

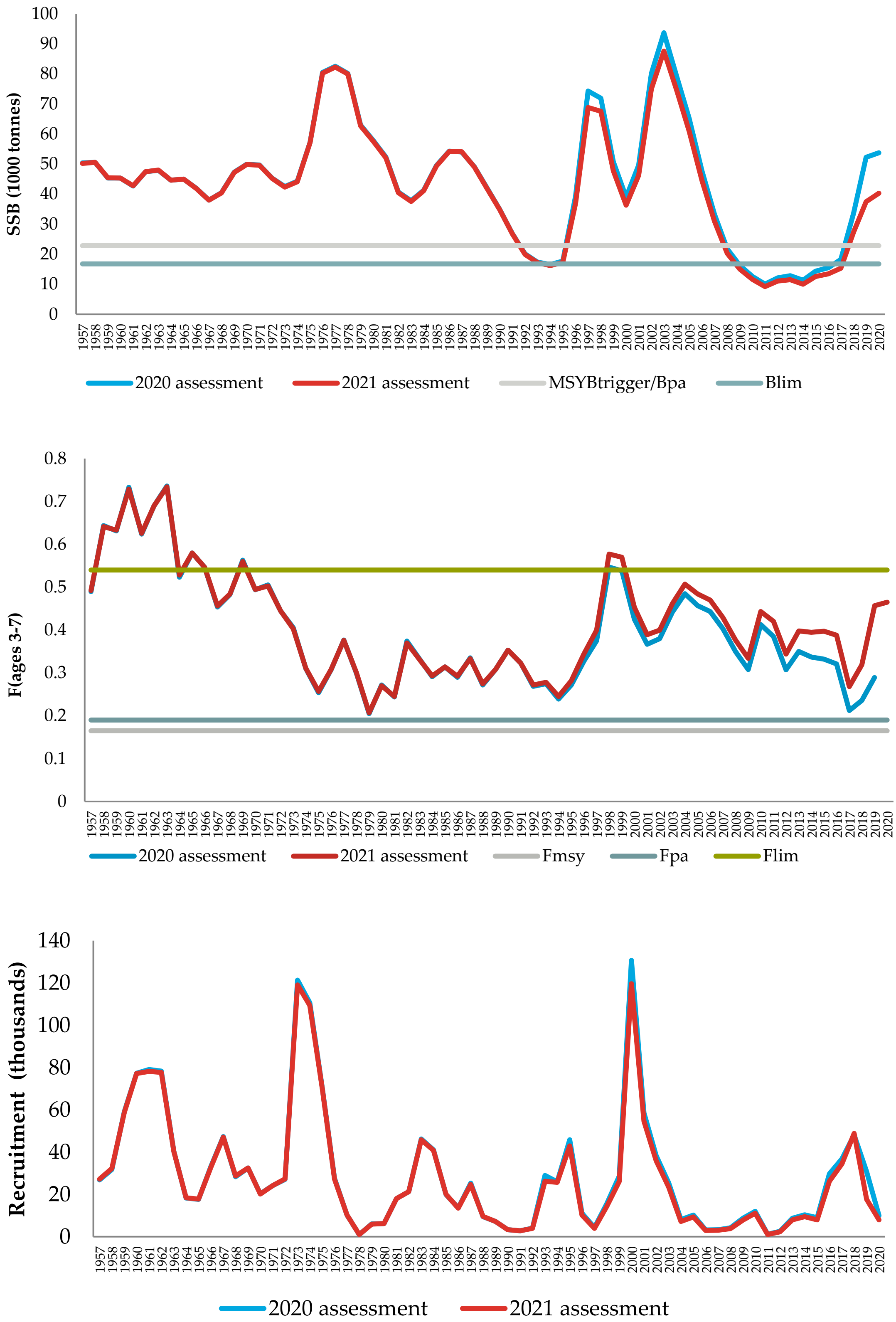


Figure 5.19. Faroe haddock (Division 5.b). Comparison between the November 2020 assessment (blue line) with the assessment (red) in the terminal year.

6 Faroe saithe

This section was updated in November 2021.

6.1 Stock description and management units.

See the stock annex.

6.2 Scientific data

6.2.1 Trends in landings and fisheries

Nominal landings of saithe from Faroese grounds (Division 5.b) have varied cyclically between 10 000 tonnes and 68 000 tonnes since 1961. After a third high of about 60 000 tonnes in 1990, landings declined steadily to 20 000 t in 1996. Since then landings have increased to 68 000 tonnes in 2005 (Table 6.2.1.1, Figure 6.2.1.1) but has declined to 57 000 tonnes in 2008 and 2009. After a substantial drop in landings in 2011 which was the lowest observed since 1999 (33 000 tonnes) landings increased by 20% in 2012 up to 35 000 tonnes. Since 2011, landings have remained below historical average (37 000 tonnes.) The total tonnage has decreased from 30 853 tonnes in 2017 to 22 773 tonnes in 2020.

Since the introduction of the 200 miles EEZ in 1977, the saithe fishery has been prosecuted mostly by Faroese vessels. The principal fleet consists of large pairtrawlers (>1000 HP), which have a directed fishery for saithe, about 50–77% of the reported landings in 1992–2011 (Table 6.2.1.2). The smaller pairtrawlers (<1000 HP) and single trawlers (400–1000HP) have a more mixed fishery and they have accounted for about 10–20% of the total landings of saithe in the 1997–2011 period while the percentage of total landings by large single trawlers (>1000 HP) has declined drastically to just 1%. Historically the catch composition by the pairtrawler fleet has accounted for about 75% of the total tonnage for saithe but since 2007 it has increased gradually up to 95% in 2020 due mainly to the gear-shifting of single-trawlers to pair-trawling. The share of catches by the jigger fleet was about 8% in the 1985–1998 period but has decreased to less than 0.5 % since 2000 and it now accounts for only 1% of the total domestic landings for saithe in 2020. Foreign catches that have been reported to the Faroese Authorities but not officially reported to ICES are also included in the Working Group estimates. Catches in Subdivision 2.a, which lies immediately north of the Faroes, have also been included. Little or no discarding is thought to occur in this fishery. Effort (measured as the ratio of nominal to used fishing days by the pair-trawl fleet segment) has diminished considerably in recent years. In the 2013/2014 fishing year, only 58% and 41% of fishing days were utilized in the inner and outer areas respectively while in the 2014/2015 fishing year these ratios went up to 97% and 74%, i.e. 29% of fishing days were not used. In the 2015/2016 and 2016/2017 fishing seasons 20% and 31% of the allocated days for the trawl fleet were not used respectively. In the 2017/2018 fishing year 19% of allocated days were not used. Around 10% of total fishing days were not activated in 2019.

Cumulative landings of saithe for the domestic fleets are shown in Figure 6.2.1.2. The period from 2011 to 2019 is among the poorest in the time-series. The progression of landings from January to August of 2021 is well below monthly averages.

6.2.2 Catch-at-age

Catch-at-age is based on length, weight and otoliths samples from Faroese landings of small and large single and pairtrawlers, and landing statistics by fleet provided by the Faroese Authorities. Catch-at-age is calculated for each fleet by four-month periods and the total is raised by the foreign catches. Minor adjustments were made to the catch-at-age matrix for 2014 due to revised final catch statistics (tables 6.2.2.1 and 6.2.2.2). Most of the age-disaggregated catch matrix is comprised of catches of the pair-trawl fleet (Figure 6.2.2.2). Since 2010, catch numbers is mostly comprised of age groups 4 to 6 whereas in the period from 2005 to 2009 it is mainly composed of age groups 4 to 8. The progression of the strong 2012 and 2016 year classes (age 3 in 2015 and 2019, respectively) can be easily tracked in the catch matrix. Numbers of aged 3, 5, 6 and 7 to 6 are lower in 2020 compared to 2019 whereas individuals aged 4 are the most numerous in the catch since 2016.

The sampling program and sampling intensity in as well as the approach used in compiling catch numbers is the same as in preceding years. A summary of sampling levels since 2011 is illustrated in table 6.2.2.3.

6.2.3 Weight at age

Mean weights at age have varied by a factor of about 2 during since 1961. Mean weights at age were generally high during the early 1980s and they subsequently decreased from the mid-1980s to the early 1990s (Table 6.2.3.1 and Figures 6.2.3.1.a and 6.2.3.1.b). Mean weights increased again in the period 1992–1996 but have shown a general decrease thereafter. With the exception of 3-years old saithe, all age groups were showing signs of increasing size since 2006. In 2011, age classes 4 to 6 were close or at long-term average. From 2012 to 2014, weight was below average for age groups 3 to 7. Age classes 7 and older are above historical average since 2014 whereas younger age groups (4–6) are lower than average. Mean weight of 3 years old saithe increased from 1.07 kg in 2016 to 1.57 kg in 2018 (50% increase) and it's 1.37 kg in 2020. Weights for all age groups but age 6 and 7 are estimated above historical average since 2019. For the short-term forecast, weights are predicted according to the following model:

$\log(CWy, a) = \beta 0 + \beta 1*\log(CWy\text{-}1, a\text{-}1) + \beta 2*\log(SWy, a)$ (Eq.1)

where CWy,a is catch-weight-at age *a* and year *y* and SWy, a is stock-weight-at age *a* and year *y*

Mean weights at age in the stock are assumed equal to those in the catch.

6.2.4 Maturity-at-age

Maturity-at-age data from the spring survey is available from 1983 onward (Steingrund, 2003.) Due to poor sampling in 1988, the proportion mature for that year was calculated as the average of the two adjacent years. At the benchmark workshop (WKFAROE) in 2017, maturity ogives were smoothed via a 10-year running average. The time period for averaging was chosen as a compromise between retaining long-term trends and reducing noise in the data. For 1962–1982, the average maturity of estimated maturities of the 1983–1996 period was used. Maturity decreased from the mid-1990s to 2006 and it shows an increasing trend for all age groups since 2010. (Table 6.2.4.1 and Figure 6.2.4.1.)

Faroe saithe begins to mature at 3 years old, approximately 20% are mature at age 4, 50% at 5 years old and 100% are mature at age 9 and onwards.

6.2.5 Indices of stock size

6.2.5.1 Surveys

There are two annual groundfish surveys conducted in Faroese waters.

The surveys design is a classical random stratified design with fixed stations. The number of stations in the spring survey are 100 and the number of stations in the summer are 200. Both survey cover depths from 60 to 500 meters. The coverage of both surveys is however very poor for juvenile saithe, which is largely distributed in coastal areas very close to shore and therefore the surveys do not provide reliable measurements of incoming recruits. Moreover, as a result of the schooling nature of saithe variability in indices is higher than that for species like cod and haddock. The spring survey consists of time series data since 1994 while the summer series were initiated in 1996. Historical data dating back to early 1980s exist but are unfortunately not available for analysis although work is in progress to recover and compile these data in upcoming meetings. Both time series cover to a large degree the traditional fishing grounds of saithe in the Faroe shelf.

Standardized biomass and abundance indices from both surveys are shown Figure 6.2.5.1.1.
In addition, abundances of fish 50 cm and smaller as a proxy for recruitment is calculated from the surveys. Catch rates (kg/hour) is also presented in figure 6.2.5.1.2. There are seasonal effects in the series but both surveys suggest low abundances of saithe in the 1990s, followed by an increase in stock biomass until 2004 and a decline from 2005 to around 2010. Since 2010, both indices are in good agreement and indicate that stock abundance is quite stable. The summer survey index decreased from 2016 to 2021. The spring survey suggests a drop in stock biomass from 2017 to 2018 with a substantial increase of the stock in 2019 to the second highest level since 2001. Both surveys indicate an increase in stock size from 2020 to 2021. The coefficient of variation (CV) of the summer index (CV = 18%, log-scale) is higher than the spring survey (CV = 13%, log-scale). The agreement between the survey indices measured by their correlation is estimated at $R^2 = 0.37$.
The progression of the 2012 year-class in the fishery is also confirmed in both age-disaggregated indices (Figure 6.2.5.1.3 and Table 6.2.5.1.1). There is conflicting signals regarding recruitment estimates in survey indices. The recruitment index for 2019 from the spring survey (numbers of aged 3 individuals) is estimated to be the largest since 1994 whereas the summer survey indicates that recruitment strength is very low. In general, both surveys suggest poor incoming recruitment and a general lack of year classes in the stock. Length compositions support the trends observed in the age-disaggregated indices (figures 6.2.5.1.4 and 6.2.5.1.5)

The internal consistency of the summer survey measured as the correlation between the indices for the same year class in two adjacent years is good with R^2 ranging from 0.5 to 0.7 for the best-defined age groups, and R^2 varying between 0.2 and 0.4 for other age classes (figures 6.2.5.1.6 and 6.2.5.1.7). The internal consistency of the summer index is overall inferior to the spring index. The spring survey shows a stronger internal consistency with R^2 ranging from 0.70 to 0.9 for the best-defined ages.

6.2.5.2 Commercial CPUE

The CPUE data from pair-trawlers have been used for tuning the assessment of saithe from 2000 to 2016. At the benchmark working group (WKFAROE, 2017), the series were replaced by fisheries-independent survey indices. A description of the commercial CPUE data can be found in the stock annex. The commercial CPUE data have not been compiled since 2016.

6.2.5.3 Information from the fishing industry

No additional information beyond the landings from the commercial fleet was presented for incorporation in the assessment.

6.3 Methods

Faroe saithe was benchmarked in 2017 (WKFAROE). The SAM (state-space assessment model) framework was adopted as the basis for advice. Input data for the assessment was revised, e.g., maturity ogives (Section 6.2.4) and survey indices (Section 6.2.5.1). Configuration of the SAM model was slightly modified at the NWWG meeting in 2017. Some changes were incorporated into the SAM model in 2020. These modifications were carried out by correspondence in an intersessional process and agreed by external experts (see Annex 7 in the 2020 NWWG report). The changes caused improvements in the model performance and diagnostics. See stock annex (https://www.ices.dk/sites/pub/Publication%20Reports/Stock%20Annexes/2020/pok.27.5b_SA.pdf) for detailed information on the configuration options for the adopted SAM model. Biological reference points were re-calculated but the adopted reference points from the benchmark in 2017 are still used.

6.4 Reference points

6.4.1 Biological reference points and MSY framework

At the NWWG in 2017, reference points were revised according to the ICES guidelines (ICES fisheries management reference points for category 1 and 2 stocks, January 2017. The software used to implement the calculations was EqSim. The procedure was as follows:

$B_{pa} = B_{trigger}$ was set to 41 4000 t (lowest historical SSB).

B_{lim} was calculated according the equation: $B_{pa} = B_{lim} \times \exp(\sigma \times 1.645) = 29\ 571$ t. where $\sigma = 0.20$ (as suggested by ACOM)

The F_{MSY} estimation process consisted of 3 simulations:

1. Simulation 1. Get F_{lim}

F_{lim} is derived from B_{lim} by simulating the stock with segmented regression S-R function with the point of inflection at B_{lim}.

F_{lim} is the F that, in equilibrium, gives a 50% probability of SSB > B_{lim}

The simulation was conducted with:

- fixed F (i.e. without inclusion of a $B_{trigger}$)
- without inclusion of assessment/advice errors.

2. Simulation 2. Get initial F_{MSY}

F_{MSY} should initially be calculated based on:

- a constant F evaluation
- with the inclusion of stochasticity in population and exploitation as well as assessment/advice error.
- SRRs (using all; Ricker, Beverton-Holt, Segmented)
- Uncertainty parameters used:

Assessment error

sigmaF <- 0.18 # SAM value of uncertainty from 2016

sigmaSSB <- 0.2 # 0.23 SAM value of uncertainty from 2017, changed to default=0.2 (ACOM)

Advice error

cvF <- 0.39 ; phiF <- 0.81

cvSSB <- 0.28 ; phiSSB <- 0.82

Biological parameters and selectivity

numAvgYrsB <- 20 # Biological

numAvgYrsS <- 20 # Selection

To ensure consistency between the precautionary and MSY frameworks, F_{MSY} is not allowed to be above F_{pa}, i.e., F_{MSY} is set to F_{pa} if this initial F_{MSY} estimate is higher than F_{pa}.

3. Simulation 3. Get final F_{MSY}

MSY $B_{trigger}$ should be selected to safeguard against an undesirable or unexpected low SSB when fishing at F_{MSY}. The ICES MSY advice rule should be evaluated to check that the F_{MSY} and MSY $B_{trigger}$ combination adheres to precautionary considerations; in the long term, P(SSB < B_{lim}) < 5%

The evaluation includes:

- realistic assessment/advice error (see above)
- stochasticity in population biology and fishery exploitation.
- SRRs (using all; Ricker, Beverton-Holt, Segmented)

The new reference points are illustrated in the table below:

Biological reference points	NWWG 2017	Basis
$B_{trigger}$	41 400 t.	B_{loss}
B_{lim}	29 571 t.	B_{pa}/1.4
B_{pa}	41 400 t.	B_{loss}
F_{lim}	0.7	Stochastic simulations (ICES, 2017) F50% F that gives a 50% probability of SSB > B_{lim}
F_{pa}	0.30	Fp05, P(SSB<Blim)<5%
F_{MSY}	0.30	Stochastic simulations (ICES, 2017).

Graphical output of the simulations are presented in figures 6.4.1.1 and 6.4.1.2.

6.5 State of the stock

Recruitment of saithe (numbers of 3-years old individuals) oscillated between 9 to 38 million from 1961 to 2000 with higher numbers than the historical average (26 millions) from late 1960s to early 1970s and in late 1980s followed by a period of low recruitment from 1988 to 1997 (Figure 6.5.1). Estimated recruitment increased substantially to 66 million in 2001 as the strong 1998 year-class entered the fishery. Recruitment has fluctuated with no clear trend around an average of 35 million since 2000. Average fishing mortality (F_{bar} = average F for ages 4–8) increased steadily from F_{bar} = 0.28 in 1973 to F_{bar} = 0.64 in 1991 causing a decrease in spawning stock biomass (SSB) from 163 kt to 81 kt. Although fishing mortality dropped substantially in the mid and late 1990s SSB continued to be low coupled with a period of poor incoming year classes. The spawning stock biomass (SSB) was estimated at its highest in the mid-1970s due to low fishing mortality (~F_{bar} = 0.26) and higher than average recruitment. Estimated F in 1991 (F_{bar} = 0.64) was the highest in the time series and although it went down to 0.35 in 2000 this did not prevent the SSB to decrease at around 50 kt in 1996. SSB increased substantially from 1997 to 2005 due to the maturation of the strongest observed 1998 year class (age 3 in 2001). F increased from F_{bar} = 0.42 in 2005 to F_{bar} = 0.63 in 2010 resulting in the largest landings of the whole time period (above 60 kt). SSB has been below MSY $B_{trigger}$ (41 400 tonnes) in 2015 and 2016. The 2016 year-class (age 3 in 2019) is estimated at around 4 million. SSB has increased since 2013 as a result of low catches and subsequently low Fs. The saithe fishery is characterised with significant changes in the selection pattern (Figure 6.5.1.a).

Patterns in landings follow approximately a cycle of three distinctive peaks. Catches have remained below historical average (37 000 tonnes) since 2010. Nominal landings of saithe were 22 773 tonnes in 2020. Catches are assumed equal to landings.

Age-disaggregated fishing mortalities and stock numbers are presented in tables 6.5.1 and 6.5.2, respectively. The stock summary table is shown in Table 6.5.3 and a summary of the model parameter estimates is presented in Table 6.5.4. The residuals plots show a reasonably random distribution in all the series (Figure 6.5.2). The relation between SSB and recruitment of saithe is shown in Figure 6.5.3.

6.6 Short-term forecast

6.6.1 Input data

SAM provides a forecast module which can simulate the stock in the period following the assessment year under certain assumptions and taking into account the uncertainty estimated in the model fit. The input data for the short-term forecast are described in the stock annex. The main features of the input for prognosis is the estimation of catch-weights in the assessment year by the model described in Section 6.2.3 and assuming mean maturity ogives over the previous five years. Recruitment is taken randomly from the last five years and therefore the uncertainty in the recruitment pattern is captured in the forecast. The exploitation pattern used is a 3 year average.

Input data for the prediction are presented in Table 6.6.1.1 and the stock projection in Figure 6.6.2.1.

6.6.2 Projection of catch and biomass

Results from predictions with management option is presented in Table 6.6.2.1 and Figure 6.6.2.1. Catch options are presented for five different scenarios, F_{MSY}, F_{pa}, F_{lim}, F-status-quo and F = 0. All scenarios assume landings of 15 663 t. in 2021. These are estimated catches from January to September extrapolated to the entire year.

According to the F_{MSY} advice (F_{MSY} = 0.30) catches are projected to 37 444 t in 2022 resulting in a SSB of 89 084 t. assuming a recruitment estimate of 81 mill. in 2021 and 15 mill. in 2022, respectively. In these conditions, SSB will go up to 110 756 t in 2023.

Landings in 2021 are predicted to rely on the 2013, 2016, 2017 and 2018 year classes (75%) while these year classes will contribute to around 70% of the spawning stock biomass in the same year (Figure 6.6.2.2.)

6.7 Yield-per-recruit

Input data to yield-per-recruit

For the yield-per-recruit calculations the average of last 15 years are assumed both in the selection pattern and in the biological parameters. F_{max} and $F_{0.1}$ are estimated at F_{max} = 0.36 and $F_{0.1}$= 0.14, respectively.

Results from the yield-per-recruit analysis are shown in Table 6.7.1 and Figure 6.7.1.

6.8 Uncertainties in assessment and forecast

Historically, the assessment of saithe was based on an XSA model calibrated with fisheries-dependent data (see Section 6.2.5.2). In 2017, the assessment framework adopted was SAM using fisheries-independent indices (see Section 6.2.5.1).

The assessment of Faroe saithe is relatively uncertain due to lack of good tuning data. Survey data for saithe are not as reliable of stock trends as for other gadoid species like cod and haddock. Saithe is a highly schooling, widely migrating and partly pelagic species. Moreover, saithe shows up in surveys with few year classes (usually one or two) dominating the entire haul composition making difficult to assess the true state of the stock. There are also indications of time-varying selectivity, so changes in the commercial catch at age may not reflect changes in the age distribution of the population

The retrospective pattern of the SAM model shows that F is underestimated and subsequently SSB is overestimated. (Figure 6.8.1). The retrospective pattern in recruitment estimates has stabilised in comparison with the historical XSA model. Recruitment estimates for saithe stocks are notoriously unreliable as no measurements of juveniles are available until they reach age 3 or older and therefore forecasts are rather uncertain. Time-varying selectivity leads to high uncertainty in the estimates of current and future SSB and fishing mortality. Mohn's rho parameter (in percentage) are estimated at 33%, -13% and 98% for the spawning stock biomass, F and recruitment, respectively. The group investigated different settings regarding the bias calculation. Given that the assessment lacks catch-at-age data for 2021, a one-year lag was assumed in the Mohn's rho calculation. This change caused a reduction in the assessment bias. The incorporation of dissagregated catch-at-age in 2021 also resulted in lower bias (See table below)

rho	**SPALY (lag=0)**	**NEW2 (lag=1)**	**Catch-at-age 2021 (lag=0)**
R(age 3)	0.98	0.53	0.85
SSB	0.33	0.16	0.22
Fbar(4-8)	0.005	-0.14	-0.15

6.9 Comparison with previous assessment and forecast

The Faroe saithe assessment was benchmarked in 2017 (WKFAROE). Input data (new maturity ogives and adoption of survey indices) and assessment method were modified and therefore the historical stock perception of the stock has changed to some extent. Some changes were incorporated into the SAM model in 2020. The modifications were carried out in an intersessional benchmark (IBP Faroese stocks) and agreed by external experts (see Stock Annex). The updated assessment suggests a downwards revision in SSB with respect to the 2020 assessment and subsequently higher estimates in F (Figure 6.9.1). The 2020 assessment estimated $F_{4\text{-}8}$=0.36 while the 2021 assessment suggests that fishing mortality was higher ($F_{4\text{-}8}$=0.42). Recruitment for the 2016 year class (age 3 in 2019) were 38% lower in last year assessment compared to the newest assessment estimate.

Predictions of the 2020 forecast were very closed to 2021 estimates in terms of $F_{4\text{–}8}$ and landings but somehow they diverged in SSB (See table below)

Forecast comparison	Forecast NWWG2020	NWWG2021	Diff
Fages 4–8 (2020)	0.34	0.331	2.72%
Landings (2020)	23659	22773	3.89%
SSB2021	73012	60300	21.08%

6.10 Management plans and evaluations

Currently, no management plan exists for saithe in Division 5.b. An effort management system has been in place since 1996. Work on a new management system started in 2018 and will continue in 2019. A reform in the current management system establishes the fishing year to start on 1 January.

6.11 Management considerations

Management consideration for saithe is under the general section for Faroese stocks.

From 2019, advice for saithe will be issued in June and fall as a consequence of the availability of the summer index to the WG before the end of the assessment year.

Biological reference points were revised in 2017 (see Section 6.4). F_{MSY} was estimated at the current F_{MSY} = 0.30 while F_{lim} = 0.7 and B_{lim} = 29 571 tonnes were defined (see Section 6.4.1.). Other biological reference points were estimated as follows; F_{pa} = 0.52, B_{pa} = MSY $B_{trigger}$ = 41 400 t. In 2020, the SAM model configuration was adjusted. The modifications were carried out by correspondence in an intersessional process and agreed by external experts (see Annex 7 in the 2020 NWWG report). The changes caused improvements in the model performance. Reference points were re-calculated but there were negligible differences with the current estimates. The decision was to maintain reference points from the 2017 benchmark assessment. The Faroese authorities implemented in 2021 a management plan (Anon. 2019) that regulates the number of fishing days in the fishery for cod, haddock and saithe on the Faroe Plateau. The plan is supposed to be used for the years to come. Due to this management plan, this fishery was in September 2021 certified as sustainable by the Marine Stewardship Council. The management plan has not yet been evaluated by ICES and therefore ICES bases its advice on the MSY approach.

6.12 Ecosystem considerations

No evidence is available to indicate that the fishery is impacting the marine environment.

6.13 Regulations and their effects

It seems to be no relationship between number of fishing days and fishing mortality, probably because of large fluctuations in catchability. Seasonal area restriction is an alternative to reduce fishing mortality and additional real-time closures are also implemented to protect small saithe in Faroese waters. In 2021, areas closed to trawling activities were opened to trawlers.

6.14 Changes in fishing technology and fishing patterns

See Section 6.2.

6.15 Changes in the environment

According to existing literature, the productivity of the ecosystem clearly affects both cod and haddock recruitment and growth (Gaard *et al.*, 2002), a feature outlined in Steingrund and Gaard (2005). The primary production on the Faroe Shelf (< 130 m depth), over the period May through June, varied interannually by a factor of five, giving rise to low- or high-productive periods of 2–5 years duration (Steingrund and Gaard, 2005). The productivity over the outer areas seems to be negatively correlated with the strength of the Subpolar Gyre (Hátún *et al.*, 2005; Hátún *et al.*, 2009; Steingrund *et al.*, 2010), which may regulate the abundance of saithe in Faroese waters (Steingrund and Hátún, 2008). When comparing a gyre index (GI) to saithe in Faroese waters there was a marked positive relationship between annual variations in GI and the total biomass of saithe lagged 4 years (figures 6.15.1 and 6.15.2)

There is a negative relationship between mean weight-at-age and the stock size of saithe in Faroese waters. This could be due to simple density-dependence, where there is a competition for limited food resources. Stomach content data show that the food of saithe is dominated by blue whiting, Norway pout, and krill, and the annual variations in the stomach fullness are mainly attributable to variations in the feeding on blue whiting. There seems to be no relationship between stomach fullness and weights-at-age for saithe (í Homrum *et al.* WD 2009).

6.16 References

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6.17 Tables

Table 6.2.1.1. Faroe saithe (Division 5.b). Nominal catches (tonnes round weight) by countries 1988–2020 as officially reported to ICES.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Denmark	94	-	2	-	-	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	-	16	-	-	-	-
Faroe Islands	44402	43,624	59,821	53,321	35,979	32,719	32,406	26,918	19,267	21,721	25,995	32,439		49,676
France [3]	313	-	-	-	120	75	19	10	12	9	17	-	273	934
Germany	-	-	-	32	5	2	1	41	3	5	-	100	230	667
German Dem.Rep.	-	9	-	-	-	-	-	-	-	-	-	-	-	-
German Fed. Rep.	74	20	15	-	-	-	-	-	-	-	-	-	-	5
Greenland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-	-	0	0	0
Netherlands	-	22	67	65	-	-	-	-	-		-	160	72	60
Norway	52	51	46	103	85	32	156	10	16	67	53	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	20	1
UK (Eng. & W.)	-	-	-	5	74	279	151	21	53	-	19	67	32	80
UK (Scotland)	92	9	33	79	98	425	438	200	580	460	337	441	534	708
USSR/Russia [2]	-	-	30	-	12	-	-	-	18	28	-	-	-	-
Total	45027	43,735	60,014	53,605	36,373	33,532	33,171	27,200	19,949	22,306	26,065	33,207	1,161	52,131
Working Group estimate [4,5]	45285	44,477	61,628	54,858	36,487	33,543	33,182	27,209	20,029	22,306	26,421	33,207	39,020	51,786

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020 [1]
Denmark	-	-	-	-	34	-	-	-	-	-	-	-	-	-	-	-	-	-	
Estonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Faroe Islands	55,165	47,933	48,222	71,496	72,169	66,319	63,424	63,339	48,279	32,357	38,278	28,655	25,655	27,496	30,849	32,966	25,692	22,698	24,217
France	607	370	147	123	315	108	97	68	46	135	40	31	28	122	336	40			
Germany	422	281	186	1	49	3	3	0	-	-		-	-	-	-	-	-	-	-
Greenland	125	-			73	239	0	1			1	-	-	-	-	-	1	-	-
Irland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	-	148	-	-	-	-	-	-	-	-	-	2	
Netherlands	0	0	0	0	0	3	0	0	-	-	-	-	-	-	1	-	-	-	-
Norway	77	62	82	82	35	81	38	23	28	-	-	-	4	40	198	27	40	38	35
Portugal	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Russia	10	32	71	210	104	160	38	44	3	-	-	1	-	-	-	-	-	0	-
UK (E/W/NI)	58	89	85	32	88	4	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	540	610	748	4,322	1,011	408	400	685	-	-	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	706	19		1	340	304	601	292	214	73	337
Total	57,004	49,377	49,546	76,266	73,878	67,325	64,000	64,308	49,062	32,511	38,319	28,688	26,027	27,962	31,985	33,325	25,947	22,811	24,589
Working Group estimate [4,5,6,7]	53,546	46,555	46,355	67,967	68,465	62,351	59,243	59,558	45,441	30,084	35,448	26,539	24,103	25,900	29,671	30,853	24,019	21,109	22,773

Table 6.2.1.2. Faroe saithe (Division 5.b). Total Faroese landings (rightmost column) and the contribution (%) by each fleet category (1985–2019).

	Open boats	LL <100	LL >100	Gillnet	Jigger	ST <400	ST 400-1000	ST >1000	PT <1000	PT >1000	IT	Other	Total
1985	0.2	0.1	0.1	0	2.6	0.1	6.6	33.7	28.2	28.2	0.2	0.2	38377
1986	0.3	0.2	0.1	0.1	3.6	0.1	2.8	27.3	27.5	36.5	0.7	0.9	36130
1987	0.7	0.1	0.1	0.4	5.6	0.3	4.1	20.4	22.8	44.3	1.1	0	35671
1988	0.4	0.3	0.1	0.3	6.5	0.1	6.8	20.8	19.6	43.7	1.3	0.1	39486
1989	0.9	0.1	0.1	0.2	9.3	0.3	5.4	17.7	23.5	41.1	1.3	0	40132
1990	0.6	0.2	0.2	0.2	7.4	0.2	3.9	19.6	24	42.8	0.9	0	54722
1991	0.6	0.1	0.1	0.6	9.8	0.1	1.3	13.9	26.5	46.2	0.8	0	48911
1992	0.4	0.4	0.1	0	10.5	0	0.5	7.1	24.4	55.6	1	0	31473
1993	0.6	0.2	0.1	0	9.3	0.1	0.6	6.5	21.4	60.6	0.7	0	29110
1994	0.4	0.4	0.2	0	12.6	0.1	1.1	6.8	18.5	59.1	0.7	0	29194
1995	0.2	0.1	0.3	0	9.6	0.4	0.9	9.9	17.7	60.9	0	0	24246
1996	0	0	0.2	0	9.2	0.1	1.2	6.8	23.7	58.6	0	0	17353
1997	0	0.1	0.4	0	8.9	0.1	2.5	10.7	17.8	58.9	0.4	0	19561
1998	0.1	0.4	0.3	0	7.5	0.1	2.6	19.3	15.4	53.9	0.4	0	23417
1999	0	0.1	0.2	0	5.7	0.1	1.2	12.6	18.5	60	1.6	0	29781
2000	0.1	0.1	0.1	0	3.7	0.2	0.3	15	17.5	62.3	0.7	0	33736
2001	0.1	0.1	0.2	0	2.8	0.1	0.3	20.2	16.5	58.8	0.8	0.1	41896
2002	0.1	0.2	0.1	0	1.6	0.1	0.1	26.5	10.5	60.8	0	0	48377
2003	0	0	0.1	0	0.9	1.9	0.4	17.4	14.7	64.7	0	0	35778
2004	0.1	0.2	0.2	0	1.9	3.7	0.4	15.1	14.4	63.8	0	0	34622
2005	0.2	0.1	0.2	0	2.4	4.4	0.2	12.7	20.6	59.2	0	0	47349
2006	0.2	0.4	0.6	0	3.9	0.3	0.1	19.8	20.6	54.1	0	0	41997
2007	0.2	0.2	0.3	0	2	0.2	0.1	30.4	16	50.6	0	0	33553
2008	0.2	0.3	0.5	0	3.2	1.5	0.2	20.4	16	57.7	0	0	24752
2009	0.4	0.2	0.2	0	4.3	3.3	0.1	9.6	15.1	66.8	0	0	42452
2010	0.1	0.1	0.6	0	3.9	1.2	2.4	8.3	15.1	68.3	0	0	34498
2011	0.1	0.1	0.5	0	3.6	0.5	1.3	2.6	14.1	77.1	0	0	24193
2012	0.2	0.1	1	0	2.4	1.9	0.1	2.2	18.6	73.5	0	0	28498
2013	0.1	0.3	0.5	0	3.2	1	0.2	0.6	24.9	69	0	0.1	20125
2014	0.2	0.3	0.3	0	1.9	0.5	0.2	0.2	15.6	80.7	0	0.1	18732
2015	0.2	0.4	0.3	0	2.3	1.1	0	2	18	75.5	0	0	18879
2016	0.1	0.1	0.3	0	1.6	1.7	0.2	0.2	21.7	73.8	0	0.4	20282
2017	0.1	0	0.1	0.1	0.7	0.7	0.3	0.2	20.6	76.9	0	0.1	22682
2018	0.2	0	0.1	0	0.8	0.9	0.2	0.8	20.5	76.3	0	0	17780
2019	0.1	0.1	0.3	0	0.3	0.4	0.4	1.3	18.4	78.6	0	0	15294
2020	0.1	0.2	0.4	0	1.9	0.9	0.3	1.1	19.1	75.7	0	0	22805

Table 6.2.2.1. Faroe saithe (Division 5.b). Catch number-at-age by fleet categories in 2020.

Age	Jiggers	Single trawlers >1000 HP	Pair trawlers <1000 HP	Pair trawlers >1000HP	Others	Total Division Vb
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	1	0	1
3	0	0	75	316	0	392
4	0	0	1280	5171	0	6450
5	0	0	96	387	0	484
6	0	0	180	690	0	870
7	0	0	201	737	0	939
8	0	0	65	275	0	340
9	0	0	12	60	0	73
10	0	0	10	37	0	47
11	0	0	0	1	0	1
12	0	0	0	0	0	0
13	0	0	1	3	0	4
14	0	0	0	0	0	0
15	0	0	0	0	0	0
Total No.	0	0	1922	7680	0	9601
Catch, t.	0	0	4873	19480	0	24353

Table 6.2.2.2. Faroe saithe (Division 5.b). Catch number-at-age (thousands) from the commercial fleet (1961–2020)

Year-Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	183	379	483	403	216	129	116	82	45	27	6	1	48
1962	562	542	617	495	286	131	129	113	71	29	13	16	47
1963	614	340	340	415	406	202	174	158	94	169	61	8	36
1964	684	1908	1506	617	572	424	179	150	100	83	47	30	14
1965	996	850	1708	965	510	407	306	201	156	120	89	30	46
1966	488	1540	1201	1686	806	377	294	205	156	94	52	34	45
1967	595	796	1364	792	1192	473	217	190	97	75	38	11	16
1968	614	1689	1116	1095	548	655	254	128	89	59	40	29	59
1969	1191	2086	2294	1414	1118	589	580	239	115	100	36	30	24
1970	1445	6577	1558	1478	899	730	316	241	86	48	46	15	23
1971	2857	3316	5585	1005	828	469	326	164	100	54	13	18	15
1972	2714	1774	2588	2742	1529	1305	1017	743	330	133	28	28	21
1973	2515	6253	7075	3478	1634	693	550	403	215	103	25	21	37
1974	3504	4126	4011	2784	1401	640	368	340	197	124	45	44	52
1975	2062	3361	3801	1939	1045	714	302	192	193	126	64	41	67
1976	3178	3217	1720	1250	877	641	468	223	141	96	60	54	77
1977	1609	2937	2034	1288	767	708	498	338	272	129	80	57	64
1978	611	1743	1736	548	373	479	466	473	407	211	146	95	83
1979	287	933	1341	1033	584	414	247	473	368	206	136	98	251
1980	996	877	720	673	726	284	212	171	196	156	261	133	236
1981	411	1804	769	932	908	734	343	192	92	128	176	310	407
1982	387	4076	994	1114	380	417	296	105	88	56	49	110	687
1983	2483	1103	5052	1343	575	339	273	98	98	99	25	127	289
1984	368	11067	2359	4093	875	273	161	52	65	59	18	25	151
1985	1224	3990	5583	1182	1898	273	103	38	26	72	41	8	154
1986	1167	1997	4473	3730	953	1077	245	104	67	33	56	7	62
1987	1581	5793	3827	2785	990	532	333	81	43	5	11	15	66
1988	866	2950	9555	2784	1300	621	363	159	27	43	15	1	1
1989	451	5981	5300	7136	793	546	185	83	55	10	2	11	16
1990	294	3833	10120	9219	5070	477	123	61	60	18	19	9	33
1991	1030	5125	7452	5544	3487	1630	405	238	128	77	22	8	11
1992	521	4067	3667	2679	1373	894	613	123	63	37	52	8	11
1993	1316	2611	4689	1665	858	492	448	245	54	34	10	6	2
1994	690	3961	2663	2368	746	500	307	303	150	28	19	1	1
1995	398	1019	3468	1836	1177	345	241	192	104	73	25	14	5
1996	297	1087	1146	1449	1156	521	132	77	64	45	29	1	7

Year-Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1997	344	832	2440	1767	1335	624	165	71	29	48	29	15	8
1998	163	1689	1934	3475	1379	683	368	77	32	28	24	14	7
1999	322	655	3096	2551	4113	915	380	147	24	27	5	23	14
2000	811	2830	1484	4369	2226	2725	348	186	56	18	2	3	2
2001	1125	2452	8437	2155	3680	1539	1334	293	90	24	19	13	0
2002	302	8399	5962	9786	862	1280	465	362	33	36	8	1	0
2003	330	2432	11152	3994	4287	417	419	304	91	40	3	0	0
2004	76	2011	8544	8762	2125	1807	265	293	146	100	10	2	0
2005	454	2948	9486	16606	7099	843	810	32	102	27	3	0	0
2006	1509	5163	7963	7892	10537	3848	655	289	33	12	12	5	0
2007	852	3406	11596	6640	3878	4405	1578	416	83	11	9	3	0
2008	4968	3228	3737	9731	3733	2309	2127	461	165	12	6	0	0
2009	472	7618	5116	1893	5310	2065	1743	1099	300	42	3	1	0
2010	2406	3019	5486	1165	1045	2172	1292	861	389	53	23	0	0
2011	1924	2783	1968	1830	484	538	714	529	446	140	34	4	0
2012	863	9870	4157	1257	905	305	308	401	230	137	91	21	0
2013	723	5186	4231	2249	512	210	122	97	146	85	39	33	3
2014	887	2344	3172	1696	873	333	100	93	71	55	16	1	0
2015	2201	2338	2656	1988	889	292	185	89	71	34	32	9	6
2016	889	10550	1984	1924	723	293	113	67	93	9	19	1	1
2017	487	3638	8927	1074	555	462	121	25	1	10	17	2	1
2018	329	1419	4067	3585	370	201	90	41	22	4	12	5	3
2019	3262	829	1178	2145	1316	179	117	47	6	4	3	0	0
2020	402	6625	497	894	964	350	75	49	1	0	4	0	0

Table 6.2.2.3. Faroe saithe (Division 5.b). Sampling intensity in 2007–2020.

Year		Jiggers	Single trawlers >1000 HP	Pair trawlers <1000 HP	Pair trawlers >1000 HP	Others	Total
2007	Lengths	683	10525	10593	18045	381	40227
	Otoliths	120	748	960	1977	0	3805
	Weights	120	697	5603	9884	120	16424
2008	Lengths	0	6892	3694	13995	234	24815
	Otoliths	0	690	600	1500	0	2790
	Weights	0	0	2517	12914	234	15665
2009	Lengths	511	5273	3695	23352	0	32831
	Otoliths	97	301	599	2519	0	3516
	Weights	511	0	3494	19060	0	23065
2010	Lengths	209	1442	3663	25793	151	31258
	Otoliths	5	119	480	2459	0	3063
	Weights	5	0	3060	18749	151	21965
2011	Lengths	583	18	1874	19990	753	23218
	Otoliths	60	0	300	2459	60	2879
	Weights	583	18	1458	14256	753	17068
2012	Lengths	6	0	1060	24924	211	26201
	Otoliths	6	0	120	2516	0	2642
	Weights	6	0	1060	17593	211	18870
2013	Lengths	0	0	1465	18015	920	20400
	Otoliths	0	0	360	1979	120	2459
	Weights	0	0	1465	13544	1325	16334
2014	Lengths	0	201	0	22131	920	23252
	Otoliths	0	0	0	2542	120	2662
	Weights	0	0	0	15448	920	16368
2015	Lengths	0	0	173	22455	753	23381
	Otoliths	0	0	20	2169	90	2279
	Weights	0	0	173	17199	753	18125
2016	Lengths	479	0	671	20282	2613	24045
	Otoliths	120	0	179	3118	776	4193
	Weights	479	0	671	15512	2613	19275
2017	Lengths	0	0	225	16874	1824	18923
	Otoliths	0	0	60	2253	538	2851
	Weights	0	0	225	11222	1824	13271
2018	Lengths	799	0	2284	14559	196	17838
	Otoliths	239	0	478	2931	60	3708
	Weights	799	0	2284	10922	196	14201
2019	Lengths	616	0	7748	6062	264	14690
	Otoliths	180	0	1645	1257	124	3206
	Weights	616	0	5720	5261	264	11861
2020	Lengths	0	0	5314	2980	0	8294
	Otoliths	0	0	1555	896	0	2451
	Weights	0	0	5314	2980	0	8294

Table 6.2.3.1. Faroe saithe (Division 5.b). Catch weights at age (kg) (equal to stock-weights) from the commercial fleet (1961–2020). Catch weights in 2021 used for short-term prediction.

Year-Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	1.43	2.302	3.348	4.287	5.128	6.155	7.06	7.265	7.497	8.198	9.154	9.6	10
1962	1.273	2.045	3.293	4.191	5.146	5.655	6.469	6.706	7.15	7.903	8.449	8.654	10
1963	1.28	2.197	3.212	4.568	5.056	5.932	6.259	8	7.265	8.551	9.02	9	10
1964	1.175	2.055	3.266	4.255	5.038	5.694	6.662	6.837	7.686	8.348	8.123	9.154	10
1965	1.181	2.125	2.941	4.096	4.878	5.932	6.321	7.288	8.074	7.878	9.479	9.617	10
1966	1.361	2.026	3.055	3.658	4.585	5.52	6.837	7.265	7.662	8.123	10.21	9.728	10
1967	1.273	1.78	2.534	3.572	4.368	5.313	5.812	6.554	7.806	7.591	8.551	7.878	10
1968	1.302	1.737	2.036	3.12	4.049	5.183	6.238	7.52	8.049	8.654	8.298	9.234	10
1969	1.188	1.667	2.302	2.853	3.673	5.002	5.714	6.405	6.554	7.591	7.951	8.373	10
1970	1.244	1.445	2.249	2.853	3.515	4.418	5.444	5.733	6.662	7.31	9.047	9.073	10
1971	1.101	1.316	1.818	2.978	3.702	4.271	5.388	5.972	6.49	7.173	7.38	9.288	10
1972	1.043	1.485	2.055	2.829	3.791	4.175	4.808	5.294	6.948	6.727	7.591	9.315	10
1973	1.306	1.754	1.899	2.7	4.426	5.264	6.156	6.334	8.076	8.777	9.782	9.546	12.006
1974	1.615	1.723	2.493	2.824	3.524	5.197	6.279	6.454	7.07	7.773	8.763	10.279	11.296
1975	1.293	1.924	2.623	3.621	4.128	4.754	5.952	7.073	8.352	9.032	9.984	10.225	11.607
1976	1.162	1.79	3.074	3.291	4.579	4.648	5.116	6.314	7.069	7.069	7.808	8.337	10.68
1977	1.223	1.641	2.66	3.79	4.239	5.597	5.35	5.912	6.837	6.727	6.948	8.424	10
1978	1.493	2.324	3.068	3.746	4.913	4.368	5.276	5.832	6.053	6.706	7.686	7.219	10
1979	1.22	1.88	2.62	3.4	4.18	4.95	5.69	6.38	7.02	7.26	8.15	8.64	10
1980	1.23	2.12	3.32	4.28	5.16	6.42	6.87	7.09	7.93	8.07	8.59	9.79	10.34
1981	1.31	2.13	3	3.81	4.75	5.25	5.95	6.43	7	7.47	8.14	8.55	10.1
1982	1.337	1.851	2.951	3.577	4.927	6.243	7.232	7.239	8.346	8.345	8.956	9.584	10.33
1983	1.208	2.029	2.965	4.143	4.724	5.901	6.811	7.051	7.248	8.292	9.478	10.893	10.34
1984	1.431	1.953	2.47	3.85	5.177	6.347	7.825	6.746	8.636	8.467	8.556	11.127	10.748
1985	1.401	2.032	2.965	3.596	5.336	7.202	6.966	9.862	10.67	10.46	10.202	9.644	13.232
1986	1.718	1.986	2.618	3.277	4.186	5.589	6.05	6.15	9.536	9.823	7.303	11.869	12.875
1987	1.609	1.835	2.395	3.182	4.067	5.149	5.501	6.626	6.343	10.245	8.491	11.634	10.22
1988	1.5	1.975	1.978	2.937	3.798	4.419	5.115	6.712	9.04	9.364	9.142	10.346	10.086
1989	1.309	1.735	1.907	2.373	3.81	4.667	5.509	5.972	6.939	8.543	9.514	11.73	9.627

Year-Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	1.223	1.633	1.83	2.052	2.866	4.474	5.424	6.469	6.343	8.418	7.383	5.822	9.408
1991	1.24	1.568	1.864	2.211	2.648	3.38	4.816	5.516	6.407	7.395	8.079	7.187	9.756
1992	1.264	1.602	2.069	2.554	3.057	4.078	5.012	6.768	7.754	8.303	7.786	9.575	9.102
1993	1.408	1.86	2.323	3.131	3.73	4.394	5.209	6.54	8.403	7.275	9.414	9.281	10.715
1994	1.503	1.951	2.267	2.936	4.214	4.971	5.657	5.95	6.891	8.752	9.752	8.629	7.349
1995	1.456	2.177	2.42	2.895	3.651	5.064	5.44	6.167	7.08	7.736	7.295	5.885	10.518
1996	1.432	1.875	2.496	3.229	3.744	4.964	6.375	6.745	7.466	7.284	8.47	10.001	10.143
1997	1.476	1.783	2.032	2.778	3.598	4.766	5.982	7.658	7.882	8.539	9.488	10.355	10.523
1998	1.388	1.711	1.954	2.405	3.3	4.22	4.999	6.391	6.665	8.214	8.485	8.668	9.2
1999	1.374	1.712	1.905	2.396	2.845	4.124	5.256	5.526	6.956	8.03	8.349	8.083	10.262
2000	1.477	1.606	2.077	2.36	2.977	3.48	4.851	5.268	6.523	4.727	8.807	8.002	10.427
2001	1.33	1.59	1.785	2.586	3.059	3.871	4.374	5.565	6.703	5.776	7.745	7.773	10
2002	1.142	1.46	1.652	1.969	3.13	3.589	4.513	5.138	6.422	8.026	4.759	11.357	10
2003	1.123	1.304	1.614	1.977	2.532	3.97	4.834	5.499	6.099	6.987	5.961	9.044	10
2004	1.143	1.333	1.45	1.789	2.56	3.159	4.154	5.167	6.015	6.186	7.056	9.391	10
2005	1.148	1.325	1.516	1.672	2.087	2.975	3.79	6.087	6.134	6.651	7.424	9.113	10
2006	1.126	1.218	1.462	1.79	2.035	2.436	3.861	4.222	5.149	6.437	6.905	5.365	10
2007	1.058	1.391	1.413	1.824	2.361	2.682	3.278	4.104	4.998	6.331	7.844	7.971	10
2008	1.146	1.312	1.672	1.816	2.395	2.902	3.1	3.728	4.769	6.072	6.451	7.96	10
2009	0.938	1.485	1.893	2.411	2.601	3.147	3.634	4.024	5.014	5.828	6.308	9.011	10
2010	1.429	1.706	2.166	2.551	3.172	3.411	3.972	4.352	5.083	4.941	5.305	9.011	10
2011	1.111	1.693	2.253	2.918	3.609	4.204	4.531	5.087	5.416	6.087	6.763	7.916	10
2012	1.029	1.334	1.626	2.709	3.785	4.448	4.799	5.207	5.562	6.018	7.143	6.247	10
2013	1.208	1.466	1.778	2.069	3.553	4.292	5.191	5.742	5.919	6.417	7.941	7.154	6.963
2014	1.369	1.724	2.163	2.868	3.325	5.903	5.899	6.877	6.784	7.467	7.121	11.31	10
2015	0.932	1.555	2.091	3.17	4.208	5.032	6.715	7.858	7.428	7.565	7.629	9.87	8.613
2016	1.07	1.246	2.091	2.613	3.98	4.927	5.876	7.426	6.967	8.153	7.89	7.36	8.233

Year-Age	3	4	5	6	7	8	9	10	11	12	13	14	15
2017	1.472	1.534	1.689	3.083	3.977	5.92	6.415	6.833	8.192	9.013	8.314	9.036	8.545
2018	1.574	1.849	2.055	2.452	3.95	4.879	6.138	7.481	8.217	7.567	7.924	8.179	8.09
2019	1.297	1.737	2.377	2.776	3.325	5.462	5.938	7.409	7.902	9.981	8.808	8.808	8.808
2020	1.369	1.814	2.411	2.846	3.751	4.687	7.553	7.336	8.821	8.821	8.88	8.88	8.88
2021	1.413	1.786	2.516	3.174	4.027	4.861	6.543	7.409	8.313	8.790	8.537	8.622	8.593

Table 6.2.4.1. Faroe saithe (Division 5.b). Proportion mature at age (1983–2021). Maturities for ages 11 to 15 are set to 1.00

Year-Age	3	4	5	6	7	8	9	10
1983	0.04	0.25	0.55	0.84	0.92	0.98	1	1
1984	0.03	0.26	0.58	0.85	0.93	0.98	1	1
1985	0.04	0.26	0.57	0.86	0.93	0.99	1	1
1986	0.04	0.28	0.6	0.87	0.94	0.99	1	1
1987	0.05	0.28	0.58	0.86	0.95	0.99	1	1
1988	0.06	0.28	0.57	0.86	0.95	0.98	1	1
1989	0.06	0.27	0.58	0.85	0.94	0.97	1	1
1990	0.05	0.26	0.58	0.82	0.92	0.97	1	1
1991	0.05	0.26	0.57	0.82	0.91	0.97	1	1
1992	0.04	0.24	0.54	0.81	0.91	0.98	1	1
1993	0.04	0.25	0.56	0.79	0.91	0.98	1	1
1994	0.05	0.22	0.54	0.78	0.9	0.97	1	1
1995	0.05	0.22	0.57	0.79	0.91	0.97	1	1
1996	0.04	0.18	0.54	0.77	0.9	0.97	1	1
1997	0.02	0.17	0.55	0.77	0.89	0.97	1	1
1998	0.01	0.16	0.53	0.73	0.88	0.98	1	1
1999	0.01	0.16	0.5	0.71	0.86	0.99	0.99	1
2000	0.02	0.17	0.48	0.72	0.87	0.98	0.99	1
2001	0.02	0.16	0.47	0.72	0.87	0.98	0.99	1
2002	0.02	0.18	0.48	0.68	0.84	0.96	0.98	1
2003	0.02	0.17	0.47	0.67	0.82	0.96	0.98	1
2004	0.02	0.16	0.42	0.62	0.79	0.94	0.98	1
2005	0.01	0.16	0.39	0.59	0.77	0.92	0.98	1
2006	0.01	0.18	0.38	0.58	0.75	0.91	0.97	1
2007	0.01	0.19	0.37	0.57	0.74	0.9	0.97	1
2008	0.01	0.2	0.39	0.59	0.75	0.9	0.97	1
2009	0.01	0.19	0.38	0.61	0.77	0.9	0.98	1
2010	0.01	0.18	0.41	0.63	0.79	0.91	0.98	1
2011	0.01	0.19	0.44	0.64	0.8	0.91	0.98	1
2012	0.01	0.2	0.43	0.65	0.81	0.91	0.98	1
2013	0.01	0.19	0.42	0.64	0.83	0.91	0.97	1
2014	0.02	0.25	0.48	0.69	0.86	0.94	0.97	1
2015	0.03	0.24	0.47	0.7	0.88	0.94	0.98	1
2016	0.04	0.26	0.5	0.73	0.91	0.96	0.98	1
2017	0.05	0.26	0.53	0.75	0.91	0.97	0.99	1
2018	0.07	0.25	0.5	0.74	0.89	0.97	0.99	1
2019	0.07	0.28	0.53	0.76	0.91	0.98	0.99	1
2020	0.07	0.28	0.52	0.75	0.9	0.98	0.99	1

Table 6.2.5.1. Faroe saithe (Division 5.b). Effort (hours) and catch in number-at-age for the survey indices used in the SAM model. Summer index (ages 3–10, years 1996–2021). Spring index (ages 3–10, years 1994–2021)

Summer Survey									
Year/age	**Effort**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1996	200	293	818	403	334	166	84	31	26
1997	200	1266	981	1614	644	459	236	77	19
1998	200	223	843	798	1101	220	110	56	19
1999	200	302	418	1298	918	1235	206	80	39
2000	200	1621	5005	1338	2958	1198	1325	171	95
2001	200	27060	14830	28221	1878	2494	783	799	192
2002	200	4640	13148	4691	5021	334	419	208	144
2003	200	15749	21047	14624	2277	1986	162	105	93
2004	200	1372	14471	32436	11964	1619	711	51	49
2005	200	4693	5808	6037	6801	1787	262	168	32
2006	200	8986	20294	8842	3767	3057	791	72	57
2007	200	1647	2081	5559	2046	1007	722	252	69
2008	200	6864	2415	965	2373	690	378	233	72
2009	200	2350	2339	6939	938	1690	669	431	359
2010	200	2790	1240	1461	213	134	245	126	98
2011	200	5895	1713	519	388	107	88	163	94
2012	200	6457	6018	3012	393	193	86	58	86
2013	200	1086	3777	3931	1853	202	86	30	31
2014	200	2481	1484	1251	550	235	39	26	20
2015	200	5882	2177	2122	847	333	88	38	23
2016	200	4357	11484	1620	669	205	110	39	44
2017	200	2435	4588	3680	423	315	170	58	22
2018	200	264	699	1549	1352	77	54	17	7
2019	200	4343	813	874	1113	622	107	59	41
2020	200	378	1140	151	287	252	74	34	23
2021	200	6314	519	977	136	172	224	92	31
Spring Survey									
Year/age	**Effort**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1994	100	127	847	470	423	108	68	51	54
1995	100	157	527	914	916	357	85	58	24
1996	100	63	270	115	131	105	57	34	16
1997	100	79	107	252	131	94	63	23	26
1998	100	335	941	805	1358	323	145	104	23
1999	100	218	208	699	557	662	89	39	19
2000	100	215	381	310	1256	503	568	28	12
2001	100	797	363	1112	291	427	163	130	23
2002	100	419	6989	2717	2574	206	211	79	39
2003	100	838	927	3306	964	585	76	49	46
2004	100	531	5326	7993	4765	297	120	13	28
2005	100	1417	1208	2774	4592	1497	218	83	26
2006	100	2726	1145	1991	1470	1480	457	41	25
2007	100	254	410	1401	536	226	242	111	13
2008	100	5922	648	481	1333	334	343	223	27
2009	100	1292	7699	978	274	466	217	206	16
2010	100	146	401	674	180	200	297	194	14
2011	100	3723	647	210	235	65	46	92	60
2012	100	255	2305	602	140	73	43	58	64
2013	100	281	2203	1130	524	89	82	32	31
2014	100	488	1215	1434	447	238	65	55	26
2015	100	2343	988	1067	538	139	88	20	6
2016	100	1001	6118	176	189	59	47	19	12
2017	100	1126	4372	5213	190	83	72	27	21
2018	100	216	517	1228	803	56	32	33	5
2019	100	13608	1772	828	771	442	90	74	46
2020	100	733	2724	247	224	191	113	29	14
2021	100	9587	588	910	130	184	230	52	24

Table 6.3.2. Faroe saithe (Division 5.b). Parameter estimates of the SAM model.

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-7.605	0.233	0.000	0.000	0.001
logFpar_1	-7.043	0.189	0.001	0.001	0.001
logFpar_2	-6.721	0.179	0.001	0.001	0.002
logFpar_3	-6.779	0.117	0.001	0.001	0.001
logFpar_4	-6.954	0.126	0.001	0.001	0.001
logFpar_5	-7.022	0.127	0.001	0.001	0.001
logFpar_6	-7.027	0.141	0.001	0.001	0.001
logFpar_7	-8.265	0.252	0.000	0.000	0.000
logFpar_8	-7.444	0.199	0.001	0.000	0.001
logFpar_9	-7.191	0.129	0.001	0.001	0.001
logFpar_10	-7.080	0.091	0.001	0.001	0.001
logFpar_11	-7.246	0.091	0.001	0.001	0.001
logFpar_12	-7.129	0.099	0.001	0.001	0.001
logFpar_13	-7.068	0.120	0.001	0.001	0.001
logSdLogFsta_0	-1.385	0.114	0.250	0.199	0.314
logSdLogN_0	-0.493	0.139	0.611	0.463	0.806
logSdLogN_1	-1.368	0.108	0.255	0.205	0.316
logSdLogObs_0	-0.919	0.047	0.399	0.363	0.438
logSdLogObs_1	0.025	0.147	1.026	0.765	1.376
logSdLogObs_2	-0.211	0.150	0.810	0.600	1.093
logSdLogObs_3	-0.276	0.146	0.759	0.567	1.016
logSdLogObs_4	-0.856	0.158	0.425	0.309	0.583
logSdLogObs_5	-0.783	0.147	0.457	0.341	0.614
logSdLogObs_6	-0.846	0.153	0.429	0.316	0.583
logSdLogObs_7	-0.764	0.156	0.466	0.341	0.636
logSdLogObs_8	-0.465	0.171	0.628	0.447	0.884
logSdLogObs_9	0.216	0.138	1.242	0.942	1.636
logSdLogObs_10	-0.023	0.125	0.978	0.761	1.255
logSdLogObs_11	-0.523	0.127	0.593	0.460	0.765
logSdLogObs_12	-1.024	0.137	0.359	0.273	0.472
logSdLogObs_13	-1.016	0.136	0.362	0.276	0.476
logSdLogObs_14	-0.896	0.143	0.408	0.307	0.543
logSdLogObs_15	-0.654	0.156	0.520	0.380	0.711
logSdLogObs_16	-0.036	0.145	0.965	0.722	1.289
transfIRARdist_0	-1.512	0.274	0.221	0.127	0.382
transfIRARdist_1	-0.619	0.208	0.538	0.355	0.816
itrans_rho_0	1.350	0.153	3.858	2.842	5.236

Table 6.5.1. Faroe saithe (Division 5.b). Estimated fishing mortality-at-age (1961–2021) from the SAM model (median F).

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	0.029	0.063	0.099	0.117	0.127	0.120	0.133	0.160	0.198	0.198	0.198	0.198	0.198
1962	0.034	0.073	0.112	0.133	0.145	0.140	0.157	0.192	0.238	0.238	0.238	0.238	0.238
1963	0.033	0.072	0.114	0.139	0.159	0.162	0.187	0.234	0.295	0.295	0.295	0.295	0.295
1964	0.042	0.094	0.149	0.178	0.201	0.202	0.222	0.264	0.317	0.317	0.317	0.317	0.317
1965	0.044	0.103	0.164	0.199	0.233	0.244	0.274	0.330	0.398	0.398	0.398	0.398	0.398
1966	0.043	0.104	0.166	0.201	0.236	0.252	0.282	0.336	0.393	0.393	0.393	0.393	0.393
1967	0.039	0.095	0.146	0.171	0.197	0.211	0.232	0.267	0.297	0.297	0.297	0.297	0.297
1968	0.042	0.104	0.155	0.174	0.195	0.210	0.234	0.271	0.302	0.302	0.302	0.302	0.302
1969	0.053	0.134	0.193	0.207	0.221	0.234	0.255	0.288	0.308	0.308	0.308	0.308	0.308
1970	0.061	0.151	0.204	0.204	0.203	0.204	0.212	0.230	0.236	0.236	0.236	0.236	0.236
1971	0.068	0.162	0.213	0.200	0.186	0.177	0.176	0.182	0.178	0.178	0.178	0.178	0.178
1972	0.085	0.202	0.274	0.268	0.254	0.244	0.241	0.244	0.228	0.228	0.228	0.228	0.228
1973	0.107	0.262	0.341	0.311	0.268	0.240	0.222	0.213	0.194	0.194	0.194	0.194	0.194
1974	0.117	0.286	0.356	0.311	0.256	0.223	0.202	0.192	0.181	0.181	0.181	0.181	0.181
1975	0.113	0.285	0.345	0.293	0.234	0.202	0.179	0.168	0.162	0.162	0.162	0.162	0.162
1976	0.106	0.277	0.331	0.285	0.228	0.199	0.174	0.158	0.152	0.152	0.152	0.152	0.152
1977	0.094	0.265	0.330	0.301	0.252	0.229	0.201	0.179	0.169	0.169	0.169	0.169	0.169
1978	0.071	0.216	0.281	0.276	0.253	0.250	0.232	0.211	0.201	0.201	0.201	0.201	0.201
1979	0.057	0.192	0.268	0.289	0.284	0.292	0.280	0.252	0.240	0.240	0.240	0.240	0.240
1980	0.050	0.181	0.261	0.302	0.308	0.323	0.315	0.278	0.271	0.271	0.271	0.271	0.271
1981	0.045	0.187	0.296	0.379	0.404	0.437	0.431	0.367	0.369	0.369	0.369	0.369	0.369
1982	0.042	0.185	0.307	0.404	0.426	0.460	0.454	0.375	0.398	0.398	0.398	0.398	0.398
1983	0.045	0.210	0.371	0.492	0.517	0.551	0.548	0.448	0.500	0.500	0.500	0.500	0.500
1984	0.041	0.213	0.391	0.515	0.524	0.535	0.522	0.429	0.490	0.490	0.490	0.490	0.490
1985	0.040	0.207	0.395	0.517	0.517	0.521	0.509	0.437	0.525	0.525	0.525	0.525	0.525
1986	0.037	0.205	0.430	0.599	0.604	0.628	0.627	0.551	0.653	0.653	0.653	0.653	0.653
1987	0.034	0.193	0.417	0.584	0.577	0.581	0.567	0.492	0.554	0.554	0.554	0.554	0.554
1988	0.029	0.169	0.376	0.533	0.518	0.498	0.456	0.378	0.396	0.396	0.396	0.396	0.396
1989	0.027	0.165	0.366	0.508	0.482	0.447	0.401	0.344	0.384	0.384	0.384	0.384	0.384
1990	0.032	0.202	0.460	0.628	0.589	0.523	0.472	0.436	0.535	0.535	0.535	0.535	0.535
1991	0.043	0.270	0.612	0.825	0.784	0.712	0.675	0.657	0.825	0.825	0.825	0.825	0.825
1992	0.039	0.239	0.535	0.716	0.700	0.655	0.652	0.671	0.874	0.874	0.874	0.874	0.874
1993	0.037	0.211	0.458	0.601	0.595	0.556	0.542	0.545	0.666	0.666	0.666	0.666	0.666
1994	0.033	0.183	0.397	0.535	0.558	0.533	0.510	0.494	0.553	0.553	0.553	0.553	0.553
1995	0.027	0.151	0.356	0.515	0.591	0.604	0.602	0.598	0.681	0.681	0.681	0.681	0.681
1996	0.019	0.106	0.255	0.392	0.475	0.504	0.500	0.487	0.535	0.535	0.535	0.535	0.535
1997	0.016	0.091	0.225	0.363	0.463	0.518	0.537	0.546	0.618	0.618	0.618	0.618	0.618
1998	0.014	0.084	0.213	0.350	0.464	0.547	0.588	0.605	0.696	0.696	0.696	0.696	0.696
1999	0.014	0.083	0.216	0.360	0.481	0.582	0.636	0.668	0.783	0.783	0.783	0.783	0.783
2000	0.014	0.088	0.231	0.380	0.491	0.570	0.594	0.601	0.679	0.679	0.679	0.679	0.679
2001	0.015	0.103	0.292	0.510	0.690	0.823	0.894	0.938	1.135	1.135	1.135	1.135	1.135
2002	0.013	0.089	0.260	0.457	0.613	0.724	0.768	0.790	0.967	0.967	0.967	0.967	0.967
2003	0.011	0.076	0.228	0.410	0.562	0.681	0.755	0.757	0.959	0.959	0.959	0.959	0.959

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
2004	0.011	0.079	0.229	0.407	0.572	0.727	0.860	0.868	1.164	1.164	1.164	1.164	1.164
2005	0.017	0.111	0.288	0.453	0.574	0.665	0.742	0.684	0.902	0.902	0.902	0.902	0.902
2006	0.028	0.169	0.392	0.558	0.654	0.734	0.823	0.762	0.993	0.993	0.993	0.993	0.993
2007	0.037	0.217	0.451	0.582	0.628	0.696	0.802	0.758	1.033	1.033	1.033	1.033	1.033
2008	0.051	0.288	0.551	0.644	0.632	0.654	0.746	0.712	0.979	0.979	0.979	0.979	0.979
2009	0.057	0.330	0.605	0.684	0.646	0.636	0.706	0.667	0.890	0.890	0.890	0.890	0.890
2010	0.065	0.372	0.660	0.746	0.684	0.663	0.716	0.681	0.895	0.895	0.895	0.895	0.895
2011	0.055	0.315	0.553	0.644	0.598	0.590	0.642	0.648	0.889	0.889	0.889	0.889	0.889
2012	0.057	0.329	0.561	0.666	0.645	0.648	0.711	0.753	1.088	1.088	1.088	1.088	1.088
2013	0.055	0.312	0.525	0.613	0.597	0.607	0.644	0.683	0.989	0.989	0.989	0.989	0.989
2014	0.054	0.301	0.508	0.611	0.594	0.604	0.594	0.576	0.716	0.716	0.716	0.716	0.716
2015	0.061	0.347	0.599	0.759	0.751	0.799	0.784	0.723	0.774	0.774	0.774	0.774	0.774
2016	0.057	0.322	0.556	0.698	0.678	0.696	0.665	0.553	0.452	0.452	0.452	0.452	0.452
2017	0.052	0.282	0.473	0.576	0.546	0.534	0.488	0.370	0.251	0.251	0.251	0.251	0.251
2018	0.054	0.281	0.449	0.545	0.528	0.514	0.490	0.385	0.241	0.241	0.241	0.241	0.241
2019	0.055	0.280	0.416	0.491	0.471	0.439	0.399	0.305	0.171	0.171	0.171	0.171	0.171
2020	0.046	0.237	0.339	0.386	0.362	0.333	0.285	0.211	0.111	0.111	0.111	0.111	0.111
2021	0.048	0.250	0.356	0.404	0.375	0.341	0.289	0.214	0.112	0.112	0.112	0.112	0.112

Table 6.5.2. Faroe saithe (Division 5.b). Stock number-at-age (start of year) (Thousands) (1961–2021).

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	8643	7267	5762	3506	1929	1349	1018	679	314	120	59	6	291
1962	13775	6918	5737	4305	2416	1371	1008	728	495	222	71	49	199
1963	20527	9752	4872	4128	3085	1643	1050	735	496	377	178	41	143
1964	16837	17964	8459	3777	3084	2167	1144	747	472	330	207	114	94
1965	20715	11869	13294	5900	2640	2068	1366	796	502	297	214	116	131
1966	15505	16272	8588	9435	3922	1731	1329	792	499	291	152	112	133
1967	19788	11995	11788	5819	6258	2442	1081	826	433	288	163	74	119
1968	20388	17101	9601	8406	4003	3909	1488	671	505	251	175	101	138
1969	33304	16122	13328	7581	6093	2872	2439	926	421	337	145	108	125
1970	30123	31950	11035	9215	5473	4187	1921	1370	518	243	206	82	128
1971	33503	23444	22838	7555	6416	3994	2880	1341	808	323	148	127	122
1972	34041	22554	16227	13369	5667	4892	3282	2263	1053	541	204	119	160
1973	26788	25919	18027	11408	7536	3595	3113	2096	1349	637	307	138	208
1974	24011	19120	15612	10663	7055	4226	2319	2046	1323	848	398	238	273
1975	19773	15222	11640	8775	6315	4672	2671	1583	1360	867	547	283	392
1976	21990	13323	8231	6147	5350	4271	3379	1973	1187	917	563	382	487
1977	15070	14617	7340	4624	3596	3661	3102	2561	1590	933	677	398	560
1978	9219	10266	8472	3715	2503	2129	2465	2278	2030	1173	726	528	660
1979	7886	6456	6293	5005	2335	1614	1208	1652	1537	1455	810	506	968
1980	14817	6070	4163	3669	3059	1395	958	688	944	925	1140	570	1068
1981	17848	10486	4194	2708	2297	1847	874	581	374	537	597	847	1209
1982	14064	18841	6200	2848	1456	1165	901	452	312	196	297	343	1366
1983	38943	10027	15047	3837	1565	807	546	435	268	167	102	203	882
1984	20487	33513	7254	9305	1984	769	382	211	246	140	66	56	523
1985	26063	18471	18793	4211	4631	928	381	177	101	151	68	29	308
1986	40912	17575	12800	8789	2408	2205	479	219	106	52	81	27	152
1987	41413	37087	11796	6837	3315	1288	889	206	111	44	20	32	73
1988	37757	30487	29030	6299	3122	1441	698	390	98	56	33	7	28

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1989	24080	33559	22885	17868	2809	1451	629	358	179	52	23	25	30
1990	17874	20796	23484	15227	9282	1438	686	306	217	80	34	15	40
1991	24166	15975	14466	11069	6762	3948	740	412	175	123	38	16	25
1992	19128	19818	9570	6141	3666	2537	1561	302	185	59	49	13	14
1993	25634	15195	13040	4380	2419	1499	1185	685	129	80	18	14	7
1994	15852	19277	10197	6704	1942	1142	759	623	345	57	43	6	7
1995	17972	10338	10100	6679	3217	863	579	397	292	164	25	25	7
1996	15484	16759	6548	4439	2974	1234	399	246	193	125	69	7	16
1997	22729	12434	14357	4436	3100	1653	537	185	103	105	63	33	13
1998	14021	20402	11340	13258	3355	1580	809	227	87	45	51	29	18
1999	29761	10214	17881	8709	11763	1852	766	348	87	38	16	23	19
2000	38328	34133	7175	14935	6300	7069	796	364	131	35	13	6	11
2001	78929	27770	33433	5097	8157	3133	2719	426	154	50	15	8	7
2002	46907	76633	21226	24917	2346	2820	1277	772	122	39	13	3	4
2003	44712	50055	55340	12135	10739	1103	858	588	245	46	10	4	2
2004	19715	41566	54881	39625	6014	3730	387	393	222	78	15	3	2
2005	38919	25312	31973	45528	17485	2444	1268	149	132	55	15	4	1
2006	32742	40607	24273	19656	23256	7960	944	505	64	38	19	6	2
2007	25217	18925	36820	14872	9344	8325	2936	553	142	21	12	5	2
2008	43191	17574	9674	22090	7767	5444	3803	1075	242	30	7	4	2
2009	16460	22332	11804	4355	9551	4245	3109	1744	455	79	8	2	2
2010	25965	10993	12710	2908	2424	4132	2322	1367	802	149	29	3	1
2011	40754	16664	5336	4159	1326	1045	1802	1023	576	308	58	9	1
2012	23475	28166	11898	2540	1584	712	588	785	426	171	127	22	3
2013	13905	19659	12459	6919	1162	728	312	283	287	120	37	41	6
2014	16480	11314	10622	4772	2577	557	350	203	142	87	34	7	14
2015	40185	9813	7748	4818	2033	822	310	195	115	67	31	13	9
2016	21912	39789	4686	3673	1469	770	241	117	115	49	30	8	6
2017	11286	19466	22511	2162	1401	812	286	107	30	62	37	14	6

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
2018	7446	8021	12981	10842	980	656	305	121	69	21	45	24	14
2019	32492	4759	4790	6465	3813	628	344	134	59	42	15	29	24
2020	14498	24596	2519	3057	3410	1271	387	225	45	41	32	11	37
2021	78889	8637	13375	1397	1943	2233	735	244	149	33	30	24	35

Table 6.5.3. Faroe saithe (Division 5.b). Summary table (1961–2020).

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–8)	Low	High	TSB	Low	High
1961	8643	4661	16030	64278	48613	84991	0.105	0.07	0.158	100581	75571	133867
1962	13775	7762	24447	68566	52477	89588	0.12	0.083	0.174	108514	82552	142642
1963	20527	11655	36150	77425	60158	99647	0.129	0.091	0.184	130225	99561	170333
1964	16837	9635	29423	88327	69061	112968	0.165	0.117	0.232	151054	115250	197981
1965	20715	11860	36181	98654	76662	126956	0.189	0.134	0.265	163371	124993	213531
1966	15505	8846	27176	103409	79495	134517	0.192	0.136	0.271	167366	127645	219449
1967	19788	11341	34527	98651	75114	129565	0.164	0.116	0.232	157938	120145	207620
1968	20388	11774	35304	100367	76717	131308	0.168	0.119	0.237	162822	124425	213067
1969	33304	19367	57270	106736	81779	139310	0.198	0.14	0.278	183995	140744	240537
1970	30123	17687	51304	112261	85974	146586	0.193	0.137	0.271	199905	153134	260961
1971	33503	19828	56610	124526	95616	162177	0.188	0.134	0.263	207149	160641	267123
1972	34041	20264	57182	142683	110784	183766	0.248	0.179	0.344	225039	177098	285959
1973	26788	15980	44904	162637	126713	208747	0.284	0.206	0.392	253508	200966	319788
1974	24011	14223	40534	153868	120025	197254	0.286	0.208	0.395	240306	191043	302273
1975	19773	11697	33423	156771	122383	200821	0.272	0.197	0.376	224624	179263	281464
1976	21990	12937	37379	137380	108083	174618	0.264	0.191	0.365	196681	157900	244987
1977	15070	8885	25559	128961	102729	161892	0.275	0.199	0.381	177736	143914	219506
1978	9219	5444	15612	115725	93538	143175	0.255	0.186	0.35	161569	131418	198637
1979	7886	4646	13386	103021	83763	126707	0.265	0.195	0.36	132429	108919	161015
1980	14817	8767	25043	100796	82710	122837	0.275	0.205	0.369	138183	114289	167072
1981	17848	10516	30294	81676	67584	98705	0.34	0.256	0.452	129092	105821	157481
1982	14064	8284	23875	76353	63336	92045	0.356	0.27	0.47	130703	105583	161800
1983	38943	22824	66445	78741	63895	97037	0.428	0.328	0.559	162466	127112	207654
1984	20487	12111	34655	87601	69720	110067	0.436	0.334	0.567	178187	137901	230241
1985	26063	15497	43833	97713	77760	122785	0.432	0.332	0.561	188417	148158	239617
1986	40912	24188	69202	88049	70696	109663	0.493	0.38	0.64	198533	152853	257864
1987	41413	24526	69925	85551	68690	106550	0.471	0.361	0.613	213504	162039	281314
1988	37757	22334	63828	94659	74678	119986	0.419	0.318	0.551	219249	167617	286786
1989	24080	14291	40574	103672	81406	132029	0.394	0.3	0.517	201340	156880	258402
1990	17874	10634	30043	99641	79214	125335	0.48	0.372	0.621	171533	136897	214933
1991	24166	14472	40355	81219	65801	100250	0.641	0.499	0.823	146235	118111	181055
1992	19128	11468	31906	64738	53117	78902	0.569	0.443	0.731	125381	100722	156078
1993	25634	15323	42882	63658	52182	77659	0.484	0.376	0.624	136655	108172	172639
1994	15852	9593	26194	61567	50952	74393	0.441	0.341	0.571	129488	102958	162855
1995	17972	10805	29891	59737	49254	72452	0.444	0.34	0.579	117909	94183	147613
1996	15484	9439	25399	49742	40918	60471	0.346	0.264	0.454	108907	85015	139514
1997	22729	13944	37048	54950	44865	67303	0.332	0.256	0.431	123654	96047	159196
1998	14021	8582	22908	64367	52743	78552	0.332	0.256	0.429	133441	106128	167782
1999	29761	17865	49576	78723	64500	96083	0.345	0.267	0.445	161779	128785	203224
2000	38328	23570	62327	90452	74865	109286	0.352	0.271	0.457	212017	167274	268728
2001	78929	48609	128159	96009	79197	116392	0.483	0.375	0.624	274900	211240	357746
2002	46907	28306	77732	98139	80342	119878	0.428	0.329	0.557	278009	214641	360085
2003	44712	27304	73217	105892	85154	131679	0.391	0.299	0.512	269684	209469	347208
2004	19715	11634	33410	115508	93232	143106	0.403	0.31	0.522	261198	207158	329335
2005	38919	24164	62683	111374	90846	136540	0.418	0.323	0.541	253626	205161	313541
2006	32742	20517	52251	102718	84841	124362	0.501	0.393	0.64	230238	188227	281626
2007	25217	15973	39810	89012	73980	107099	0.515	0.406	0.652	189447	155936	230160
2008	43191	26369	70744	80132	67041	95778	0.554	0.438	0.7	180477	146918	221701
2009	16460	10385	26089	73427	61619	87497	0.58	0.458	0.735	140799	116729	169833
2010	25965	16503	40852	58594	49296	69646	0.625	0.49	0.797	132760	108154	162965
2011	40754	25543	65023	45371	38516	53447	0.54	0.424	0.688	125666	99445	158801
2012	23475	14885	37020	39614	33386	47003	0.57	0.45	0.722	108503	86377	136296
2013	13905	8828	21902	36675	30445	44180	0.531	0.415	0.678	95683	76643	119452
2014	16480	10422	26058	41739	34484	50520	0.524	0.406	0.675	96125	77233	119639
2015	40185	25269	63907	39882	33022	48168	0.651	0.507	0.836	102293	80614	129803
2016	21912	13797	34800	38492	31226	47449	0.59	0.457	0.762	105883	81394	137741

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–8)	Low	High	TSB	Low	High
2017	11286	6977	18254	47312	37408	59839	0.482	0.365	0.636	105391	81753	135865
2018	7446	4457	12440	48242	38107	61072	0.463	0.344	0.624	91056	71192	116463
2019	32492	17469	60435	44350	34269	57396	0.419	0.297	0.592	100381	70605	142715
2020	14498	6814	30851	46920	33374	65964	0.331	0.217	0.506	104021	67152	161132
2021	78889	23213	268097	60300	36056	100848	0.345	0.187	0.639	192554	81361	455715

Table 6.6.1.1. Faroe saithe (Division 5.b). Input data for short-term forecast for the SAM assessment. Natural mortality (nm), maturity (mat), catch weights (cw), selection pattern(sel), stock weights (sw). Units for catch and stock weights are kg.

"age"	"N"	"nm"	"mat"	"pf"	"pm"	"sw"	"sel"	"cw"
3	78889	0.2	0.066	0	0	1.413	0.187	1.413
4	8637	0.2	0.272	0	0	1.786	0.974	1.786
5	13375	0.2	0.524	0	0	2.516	1.468	2.516
6	1397	0.2	0.75	0	0	3.174	1.724	3.174
7	1943	0.2	0.902	0	0	4.027	1.633	4.027
8	2233	0.2	0.976	0	0	4.861	1.538	4.861
9	735	0.2	0.99	0	0	6.543	1.377	6.543
10	244	0.2	1	0	0	7.409	1.044	7.409
11	149	0.2	1	0	0	8.313	0.611	8.313
12	33	0.2	1	0	0	8.79	0.611	8.79
13	30	0.2	1	0	0	8.537	0.611	8.537
14	24	0.2	1	0	0	8.622	0.611	8.622
15	35	0.2	1	0	0	8.593	0.611	8.593

Table 6.6.2.1. Faroe saithe (Division 5.b). Output of the SAM short-term-forecast including confidence intervals (low and high columns). Units for ssb and catch are tonnes, thousands for recruitment. F_{MSY} advice.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	tsb:median	tsb:low	tsb:high
2021	0.200	0.112	0.354	81151	23230	287493	62409	38575	107106	15663	9047	28277	199263	90635	514630
2022	0.300	0.169	0.532	14498	7446	32492	89084	44494	196649	37444	18079	91592	210860	100568	545248
2023	0.300	0.169	0.532	14498	7446	32492	110756	48073	297456	43405	19459	119655	203480	97527	543985

Table 6.7.1. Faroe saithe (Division 5.b). Input data for the yield-per-recruit calculations of the SAM assessment. Natural mortality (nm), maturity (mat), catch weights (cw), selection pattern(sel), stock weights (sw). Units for catch and stock weights are kg.

"age"	"nm"	"mat"	"pf"	"pm"	"sw"	"sel"	"cw"
3	0.2	0.033	0	0	1.228	0.119	1.228
4	0.2	0.23	0	0	1.575	0.644	1.575
5	0.2	0.461	0	0	2.013	1.056	2.013
6	0.2	0.68	0	0	2.619	1.252	2.619
7	0.2	0.843	0	0	3.468	1.202	3.468
8	0.2	0.937	0	0	4.45	1.185	4.45
9	0.2	0.981	0	0	5.305	1.169	5.305
10	0.2	1	0	0	6.058	1.029	6.058
11	0.2	1	0	0	6.626	1.069	6.626
12	0.2	1	0	0	7.27	1.069	7.27
13	0.2	1	0	0	7.524	1.069	7.524
14	0.2	1	0	0	8.489	1.069	8.489
15	0.2	1	0	0	9.115	1.069	9.115

6.18 Figures

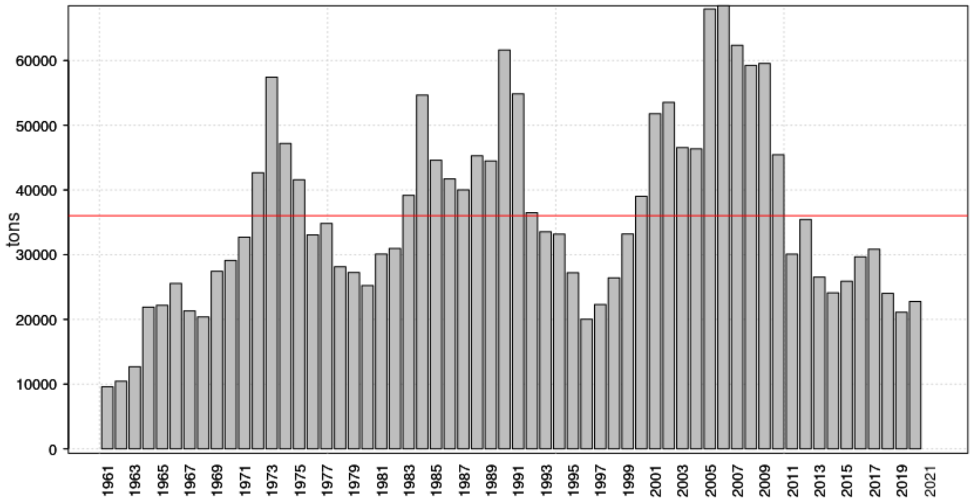

Figure 6.2.1.1. Faroe saithe (Division 5.b). Landings (tonnes) (1961–2020). Horizontal red line represents average landings.

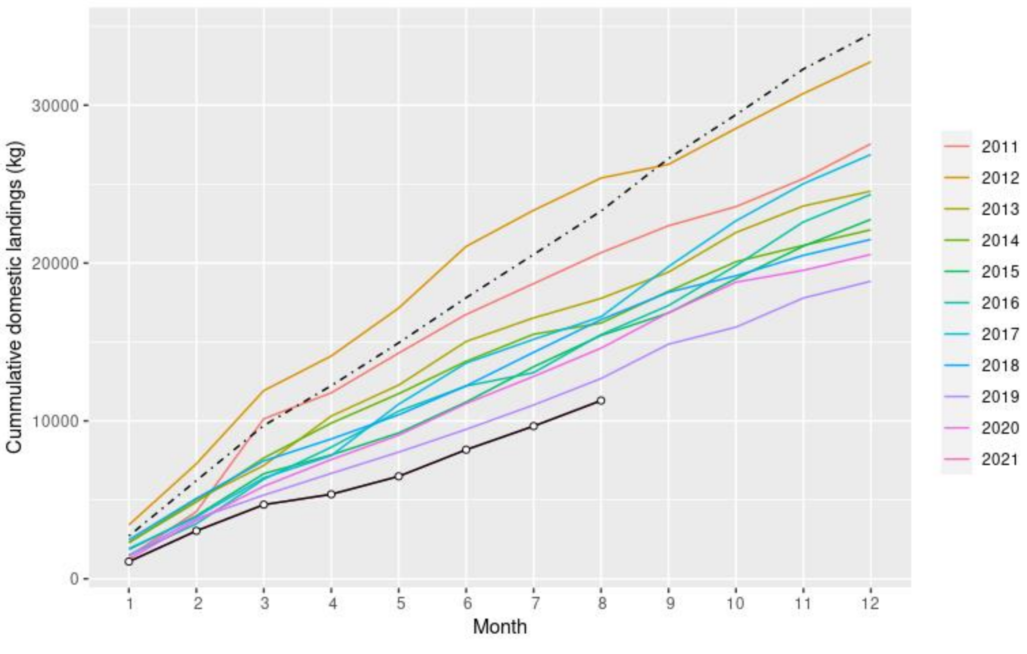

Figure 6.2.1.2. Saithe in the Faroes (Division 5.b). Cumulative domestic landings (2011–2021). Black line shows the first quarter of 2020.

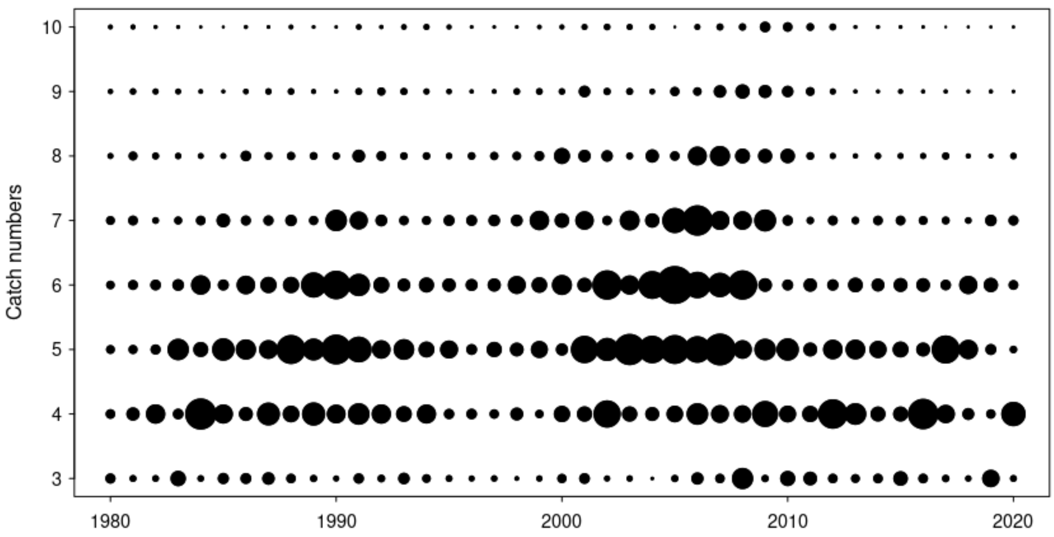

Figure 6.2.2.2. Faroe saithe (Division 5.b). Cath-at-age numbers in the commercial catches (ages 3–10) (1961–2020).

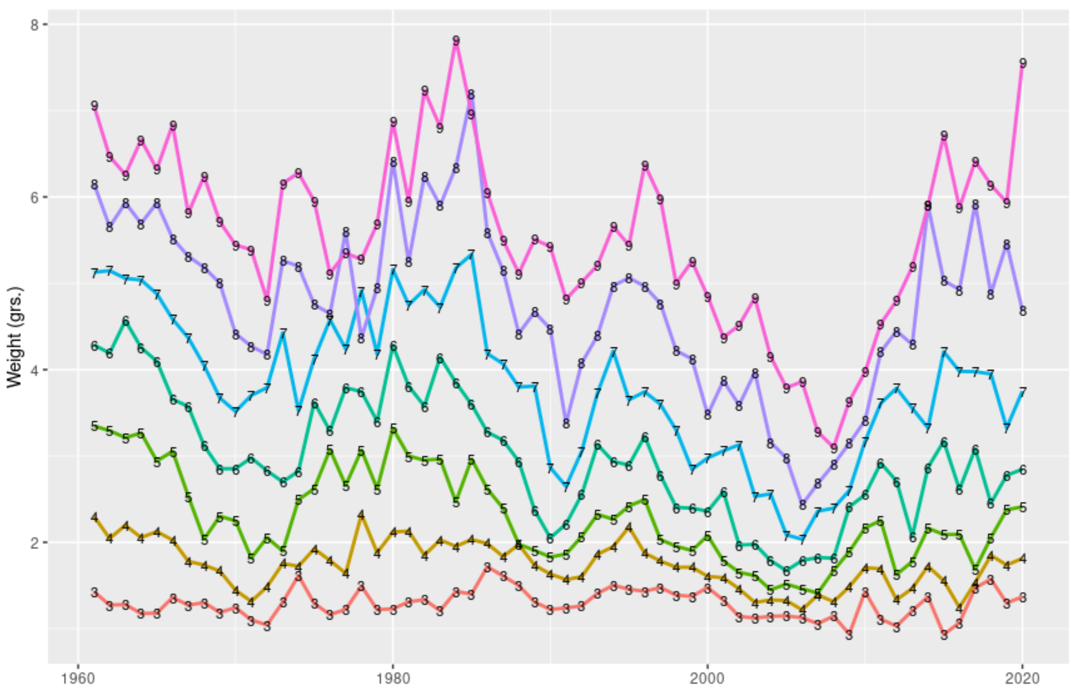

Figure 6.2.3.1.a Faroe saithe (Division 5.b). Mean weight at age (kg) in commercial catches (ages 3–9) (1961–2020).

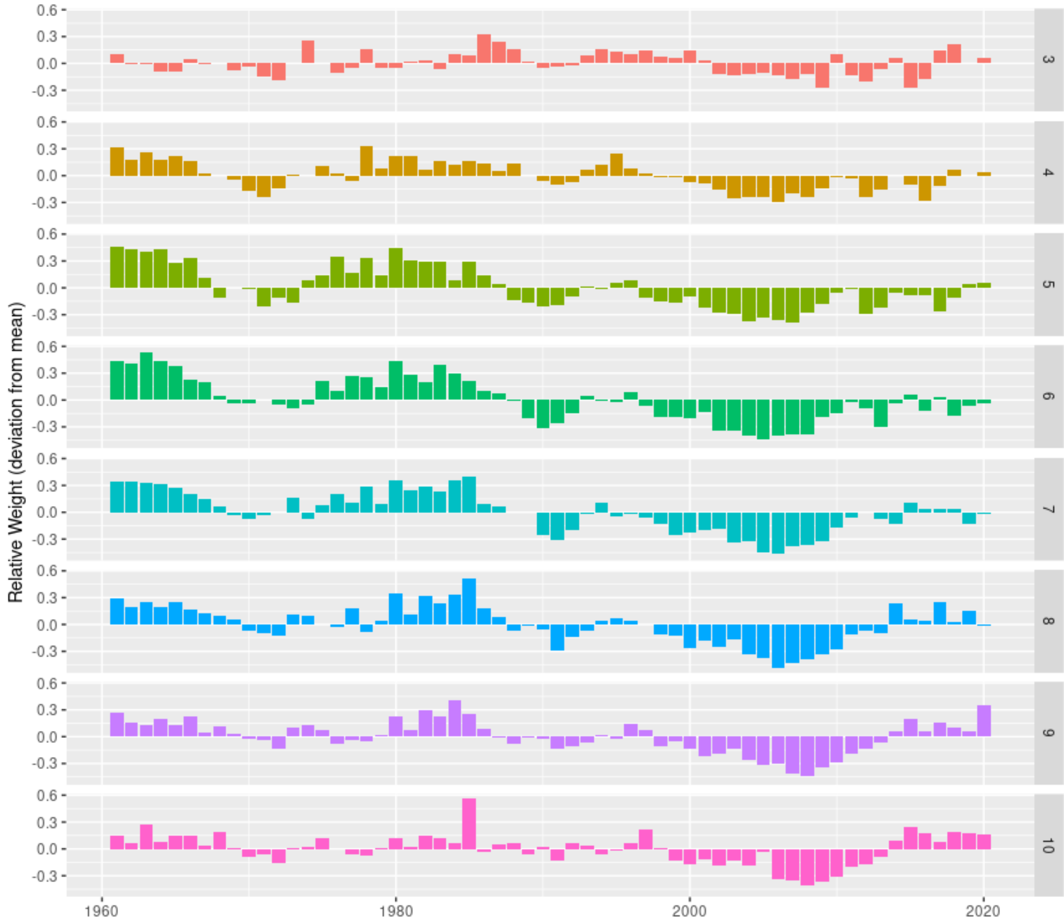

Figure 6.2.3.1.b Faroe saithe (Division 5.b). Deviations of mean weight at age (kg) from historical average in commercial catches (ages 3–10) (1961–2021). Weights in 2021 are estimated.

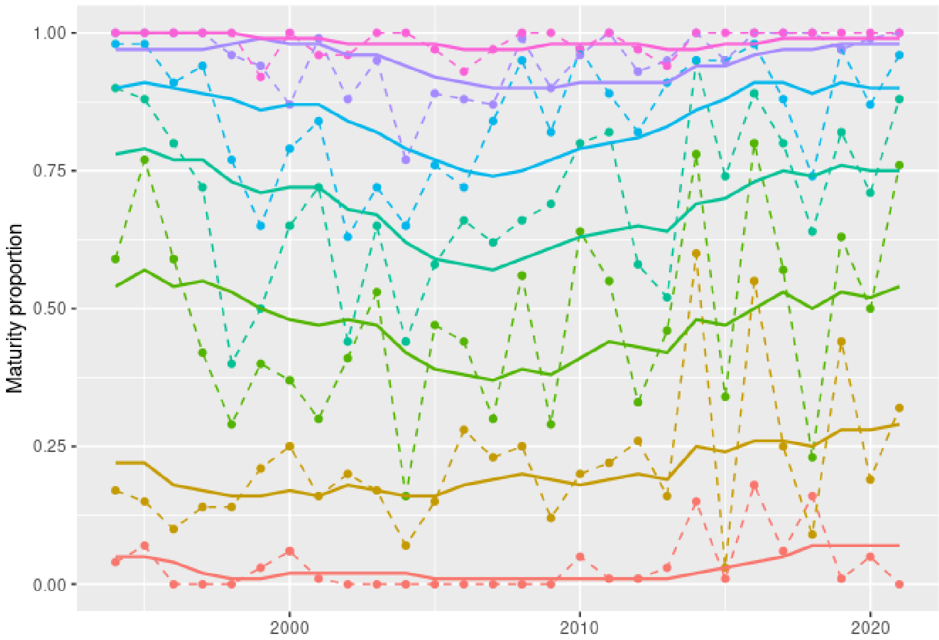

Figure 6.2.4.1. Faroe saithe (Division 5.b). Observed and smoothed maturity ogives (ages 3–9) (1994–2021) from FGFS1 (spring survey).

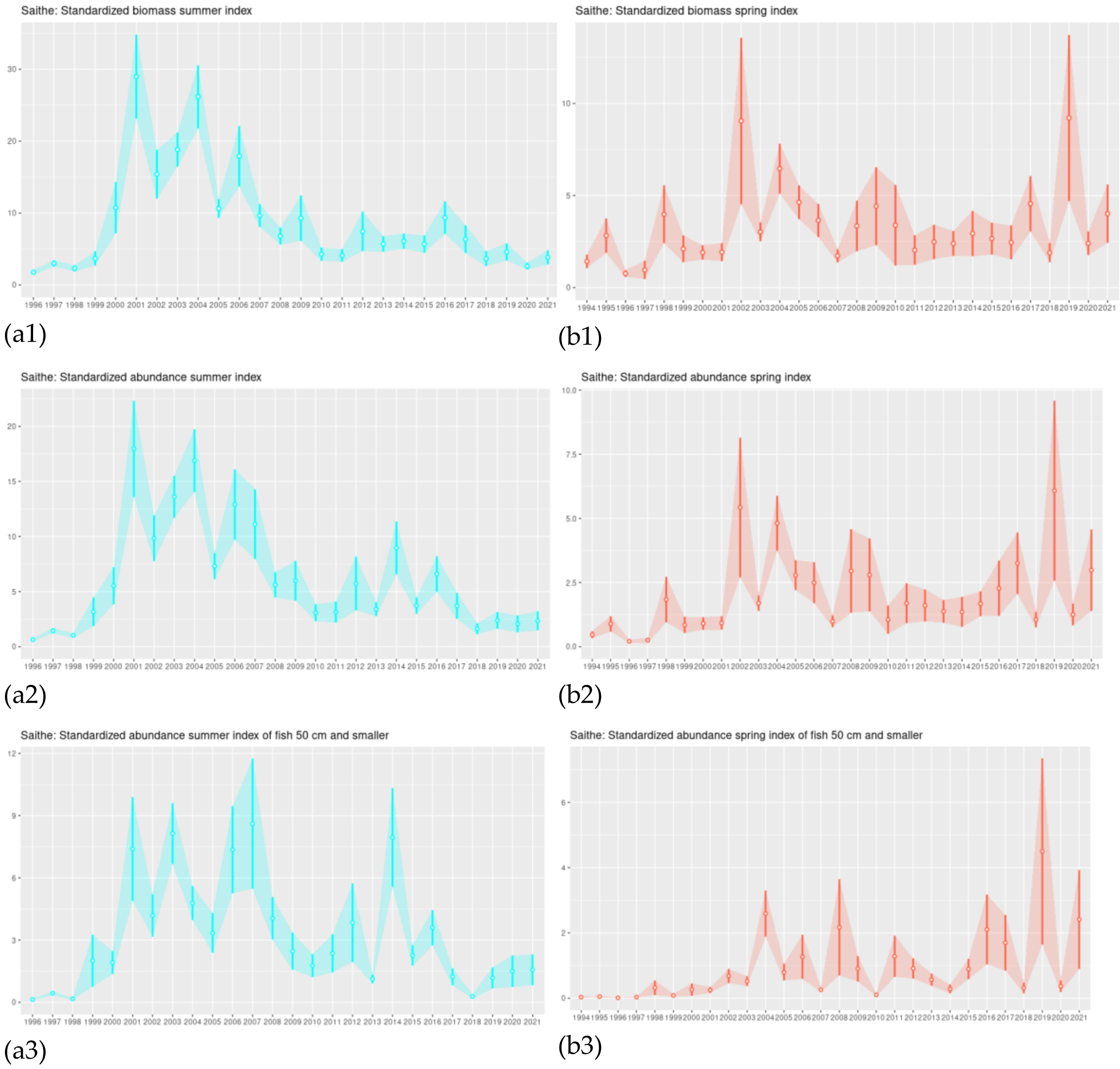

Figure 6.2.5.1.1. Faroe saithe (Division 5.b). Standardised biomass (a1) (b1) and abundance (a2)(b2) indices from the Faroese bottom-trawl summer FGFS1 (1996–2021) and spring surveys FGFS2 (1994–2021). Abundance indices of fish 50 cm and smaller are proxies for recruitment strength (a3) (b3). Shade areas show standard errors in the estimation of indices.

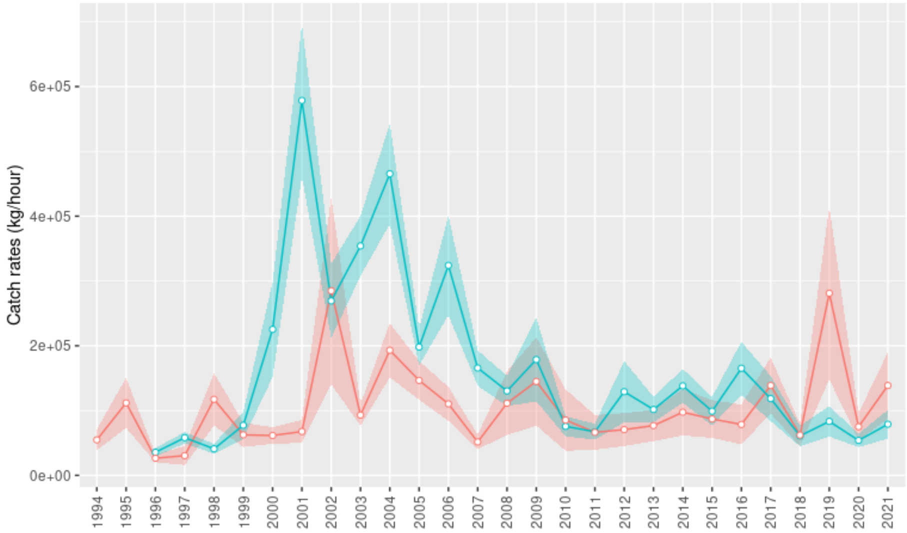

Figure 6.2.5.1.2. Faroe saithe (Division 5.b). Catch rates (kg/hour) from the Faroese bottom-trawl spring FGFS1 (1994–2021) (red line) and summer survey FGFS2 (1996–2021) (cyan line). Shade areas show standard errors in the estimation of indices.

Figure 6.2.5.1.3. Faroe saithe (Division 5.b). Age-disaggregated (ages 3-10) numbers from the commercial fleet (left panel), the Faroese bottom-trawl spring FGFS1 (middle panel) and summer survey FGFS2 (right panel) since 1995.

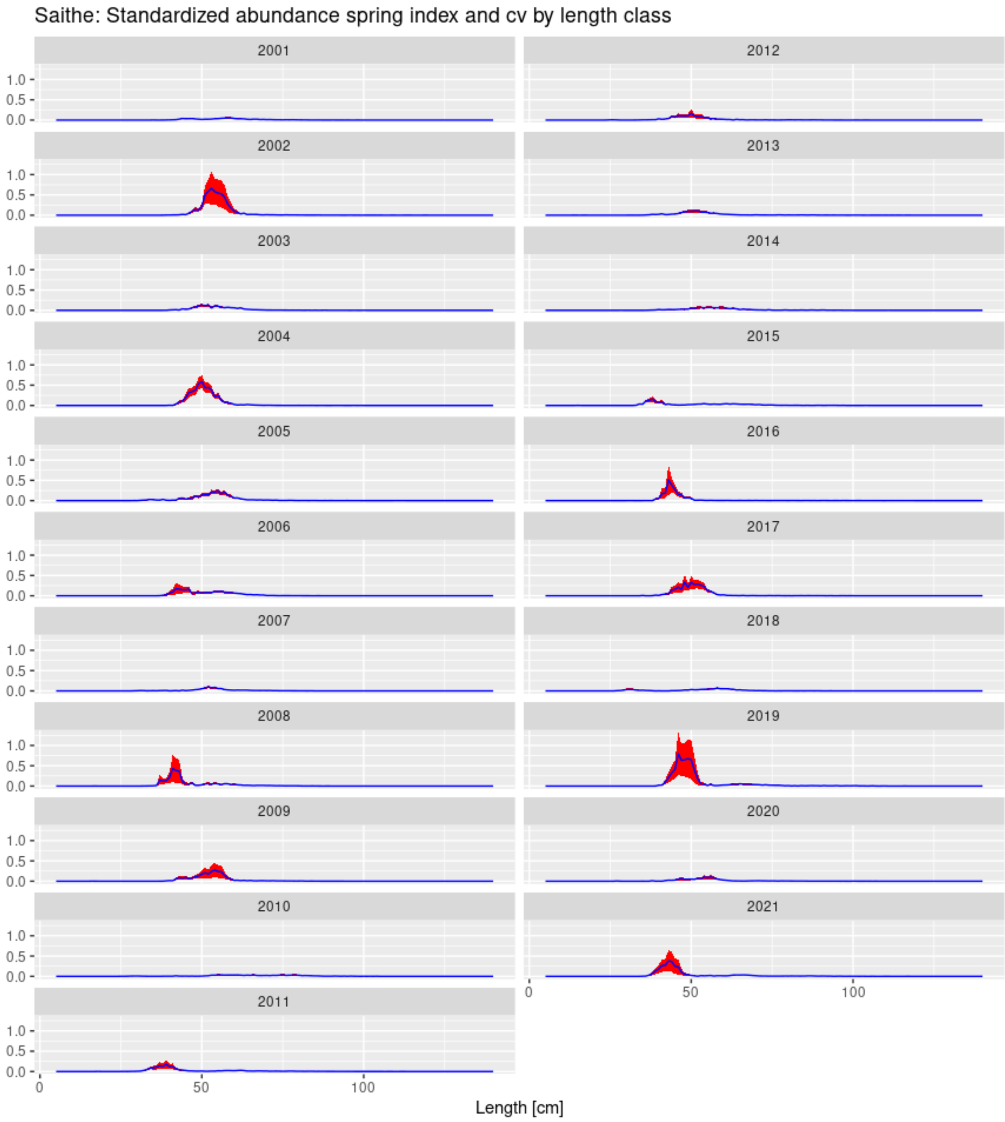

Figure 6.2.5.1.4. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl spring survey FGFS1 (2001–2021).

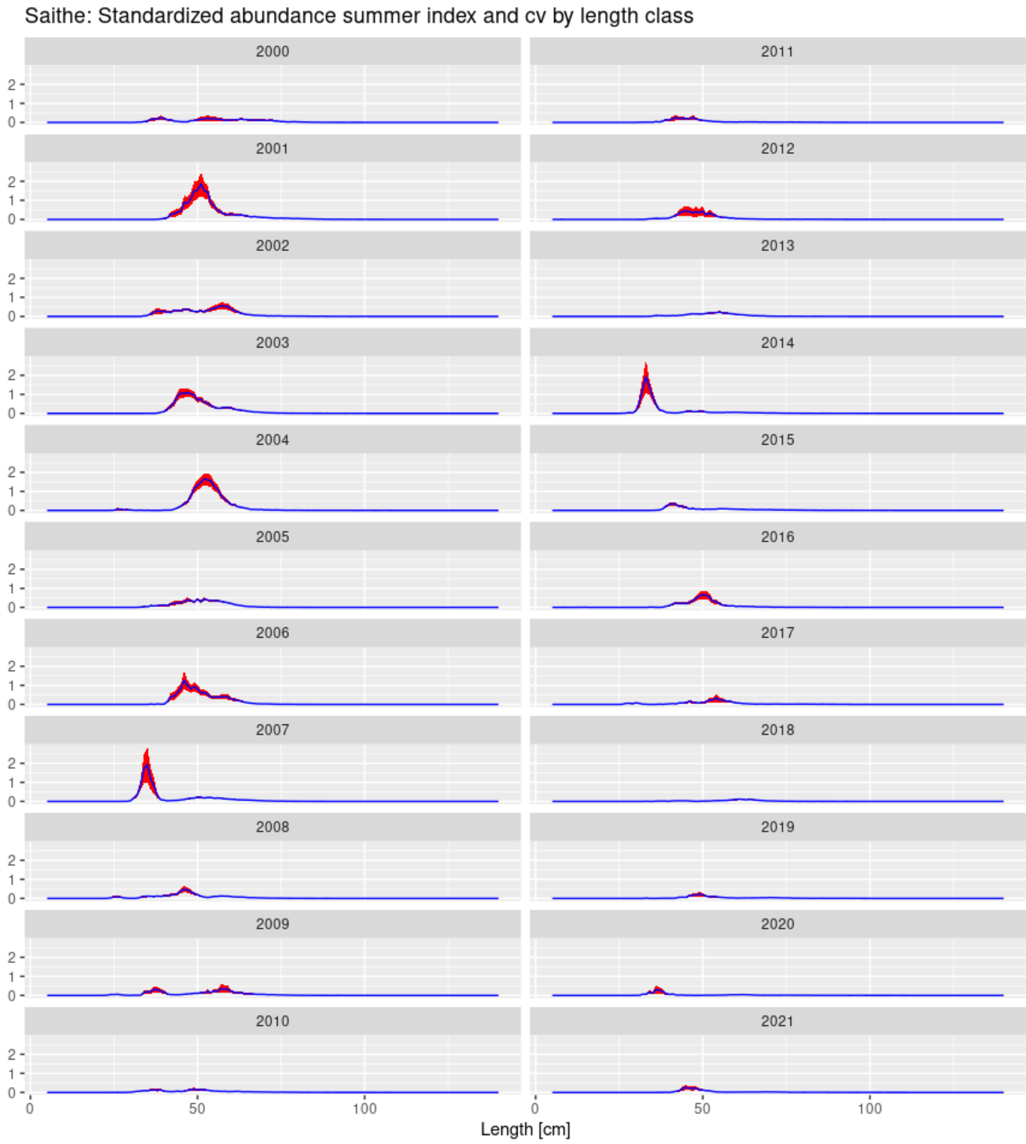

Figure 6.2.5.1.5. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl summer survey FGFS2 (2000–2021).

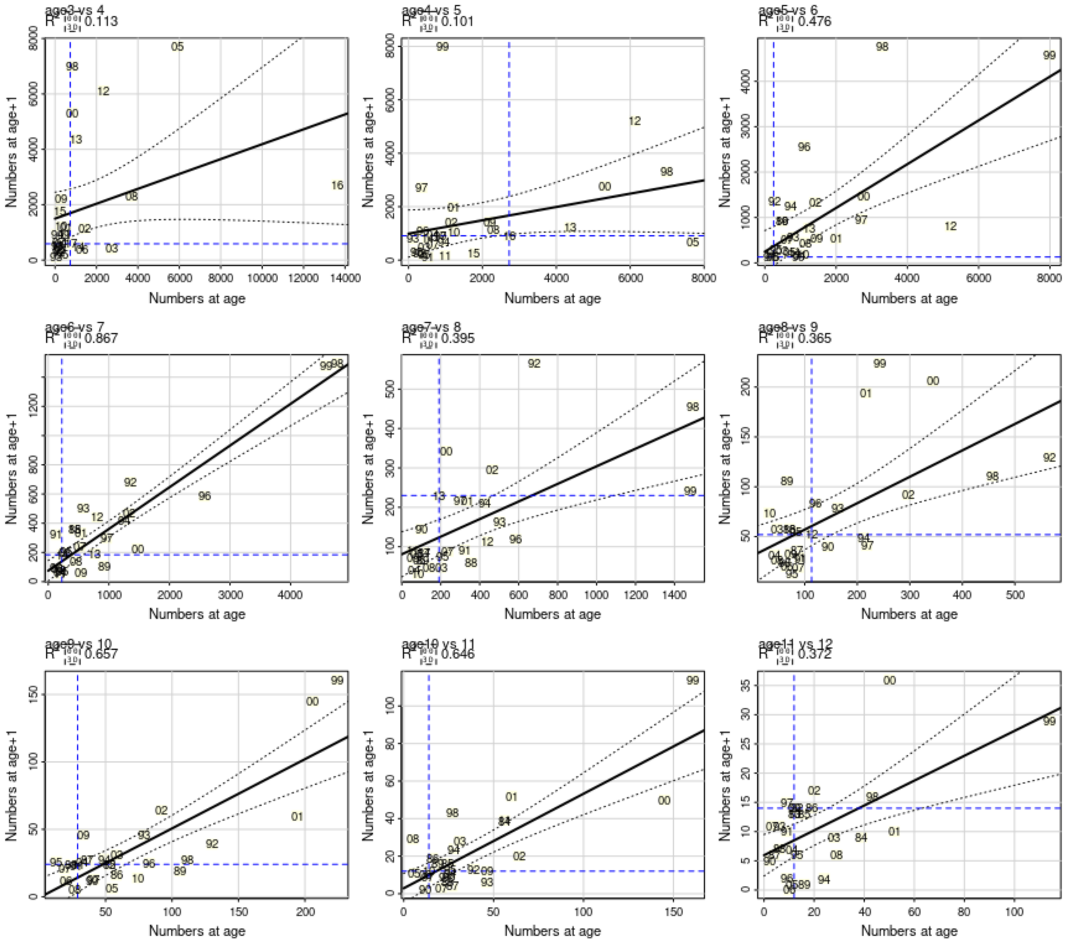

Figure 6.2.5.1.6. Faroe saithe (Division 5.b). Numbers from spring survey (FGFS1) plotted against numbers of the same year class one year later. Letters in the figures represent year classes. Horizontal and vertical lines crossing is the most recent pair.

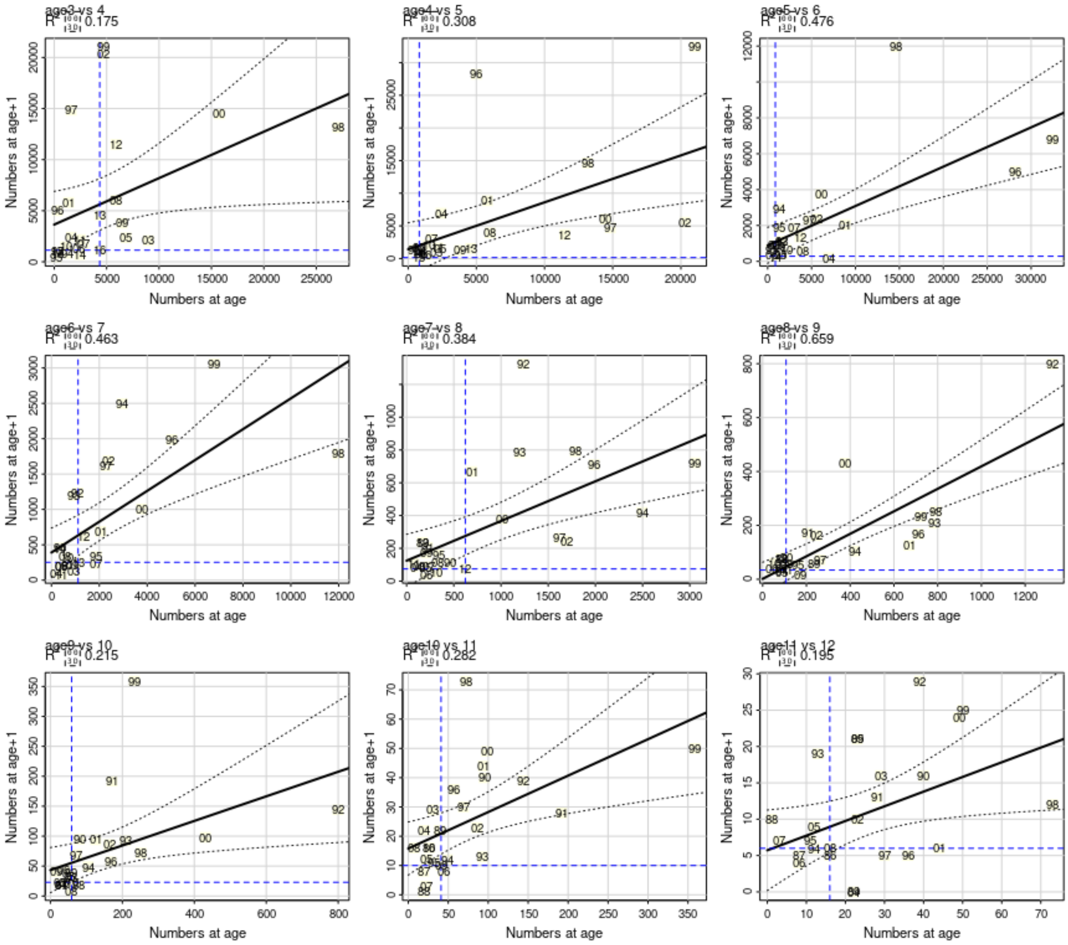

Figure 6.2.5.1.7. Faroe saithe (Division 5.b). Numbers from summer survey (FGFS2) plotted against numbers of the same year class one year later. Letters in the figures represent year classes. Horizontal and vertical lines crossing is the most recent pair.

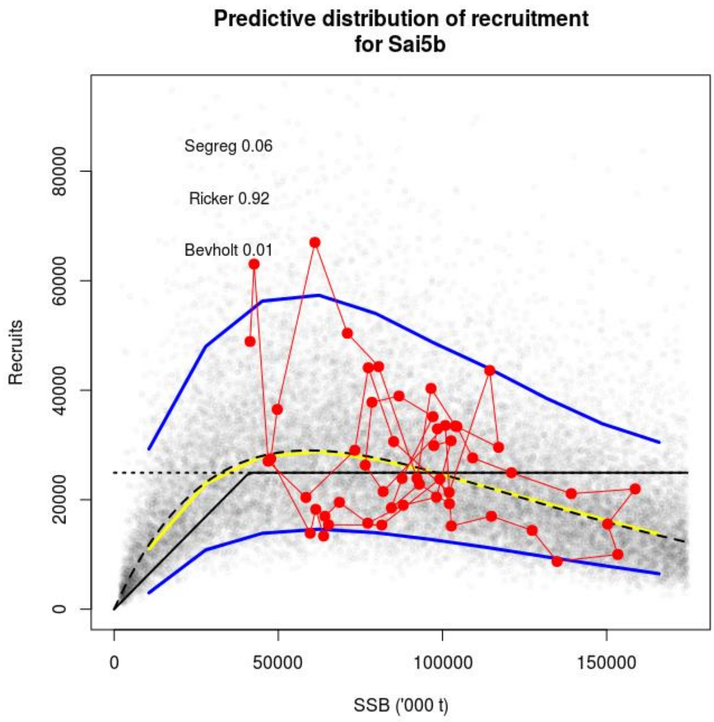

Figure 6.4.1.1. Faroe saithe (Division 5.b). EqSim simulations. Stock–recruitment functions used in the simulations (Ricker, Beverton-Holt and Segmented).

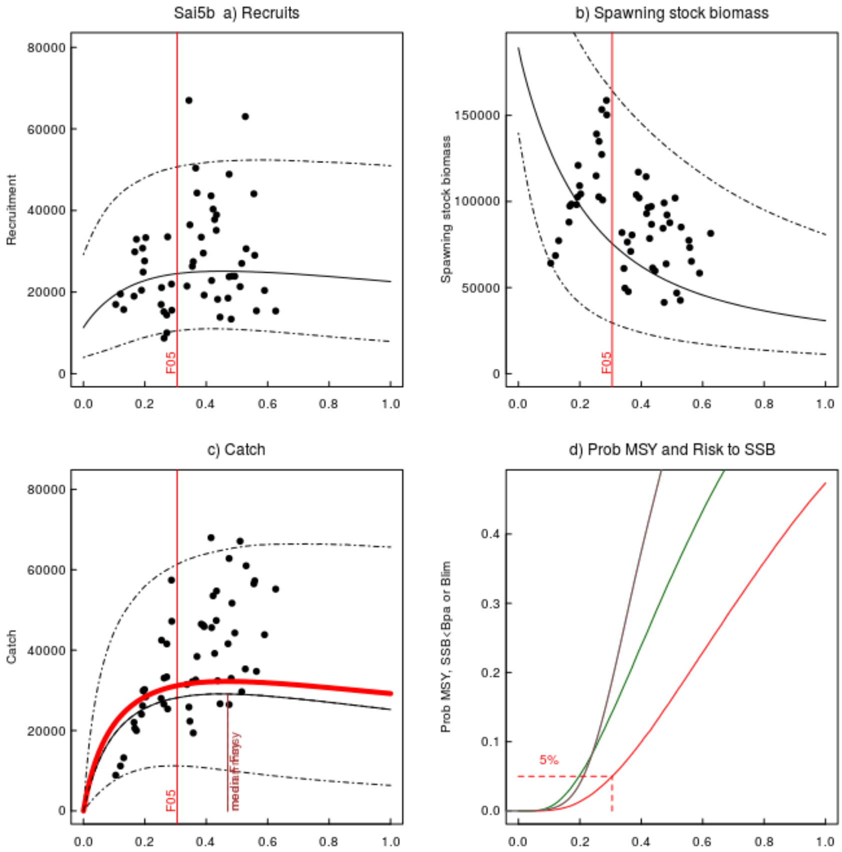

Figure 6.4.1.2. Faroe saithe (Division 5.b). EqSim simulation results. F_{MSY} = 0.30 is the vertical red line in the bottom-left graph.

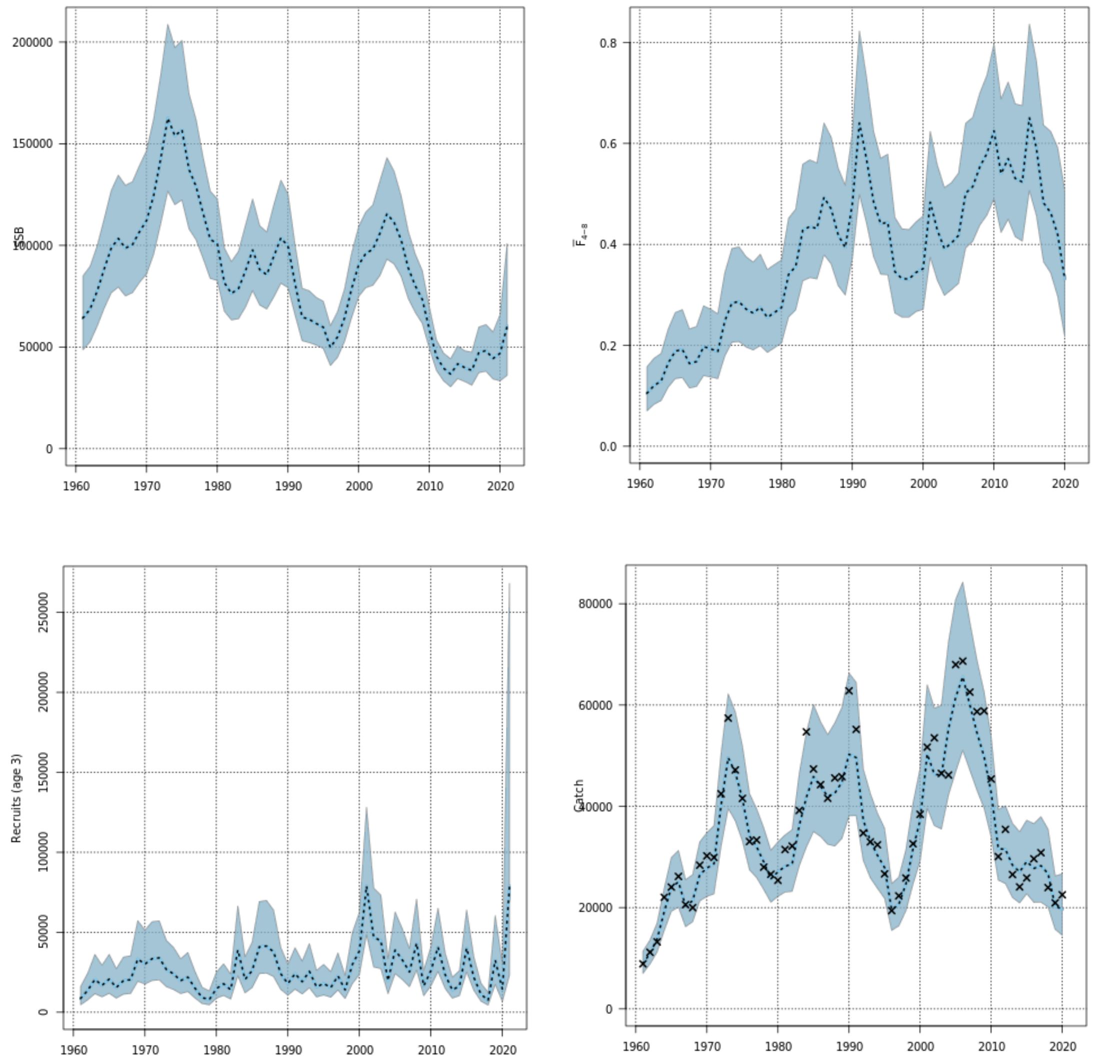

Figure 6.5.1. Faroe saithe (Division 5.b). Spawning-stock biomass (tonnes) (top-left), recruitment (age 3) in millions (bottom-left), F_{bar} (ages 4 to 8) (top-right) and landings (tonnes) (bottom-right) from the SAM assessment. Reference points ($B_{trigger} = B_{pa}$ = 41 400 t and F_{MSY} = 0.30 respectively).

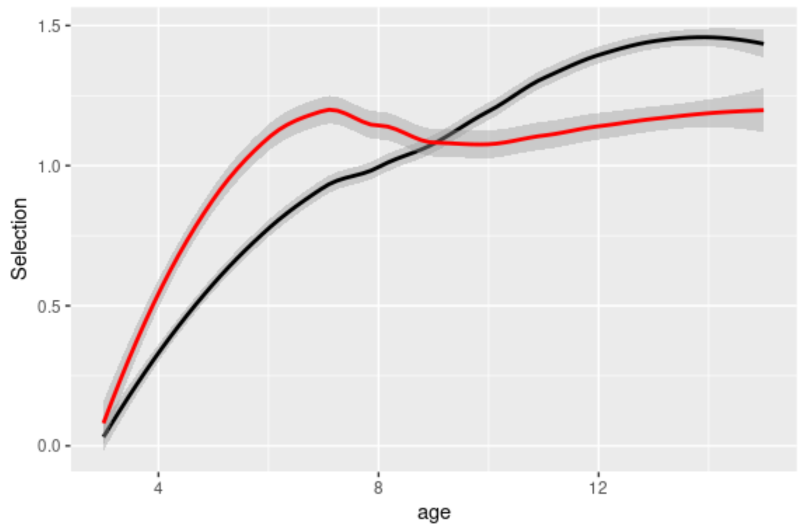

Figure 6.5.1.a Faroe saithe (Division 5.b). Selection pattern by periods in the fishery. Average selection from 2000 to 2014 (black line) and from 2015 to 2019 (red line).

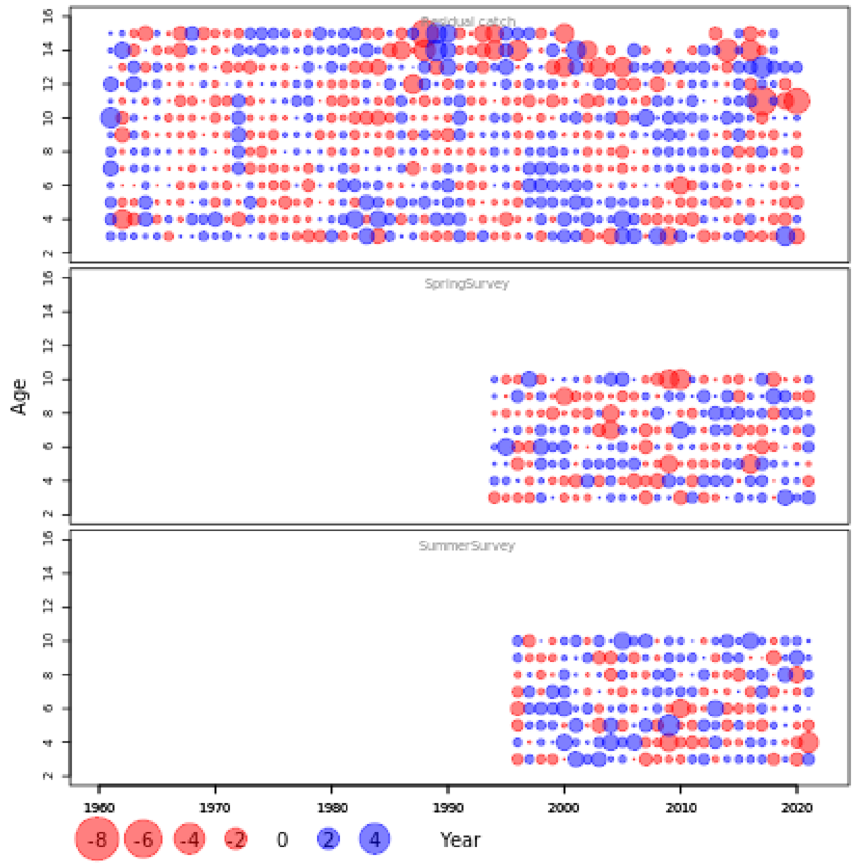

Figure 6.5.2. Faroe saithe (Division 5.b). Residuals of the SAM assessment calibrated with both survey indices. Blue and red bubbles represent positive and negative residuals respectively.

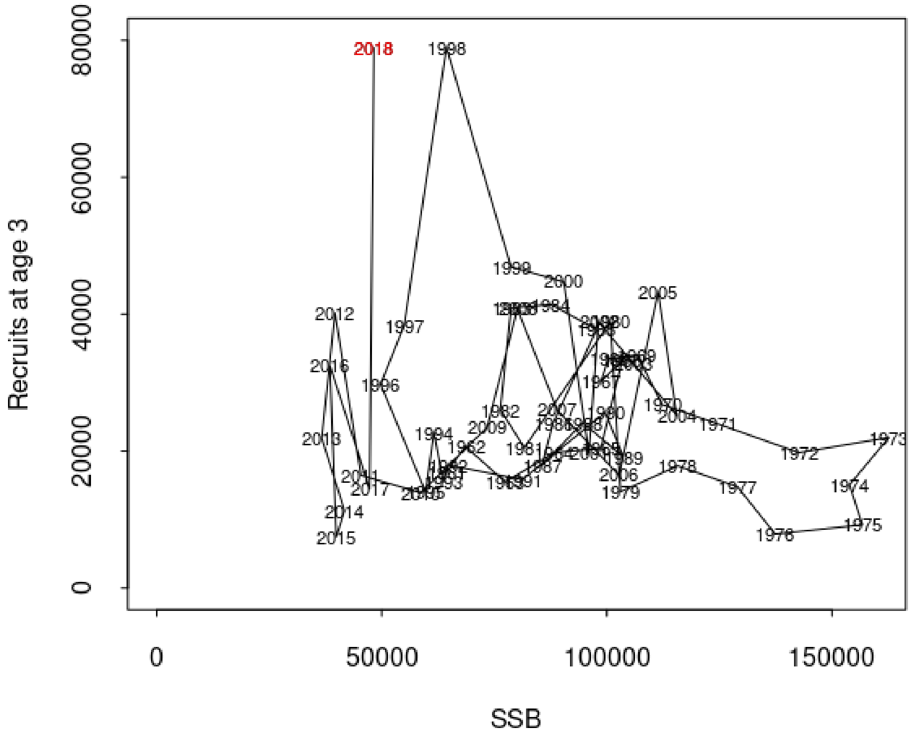

Figure 6.5.3. Faroe saithe (Division 5.b). Relation between SSB and recruitment (age 3). Numbers represent year-classes. The most recent year-class (2018) is highlighted in red.

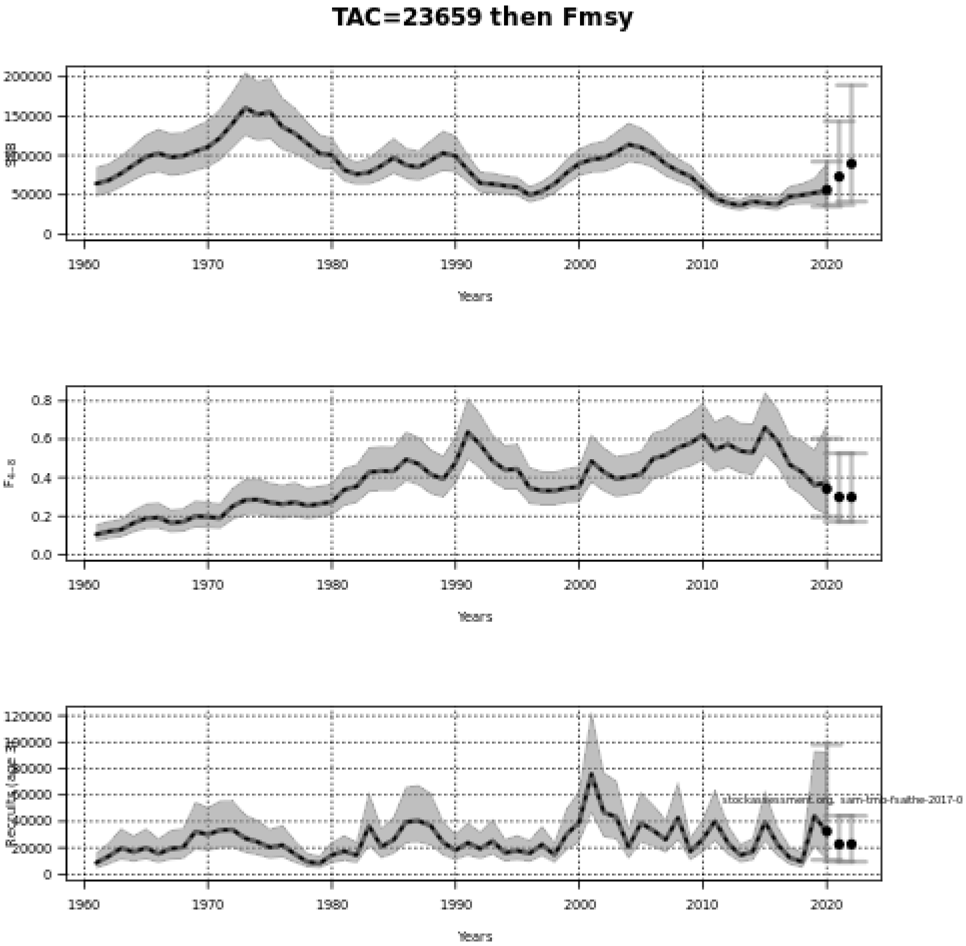

Figure 6.6.2.1. Faroe saithe (Division 5.b). Short-term forecast based on the F_{MSY} advice including historical assessment. Spawning stock biomass (top, red line represents $B_{trigger}$), average fishing mortality (F_{4-8}) (middle) and recruitment (numbers age 3, bottom).

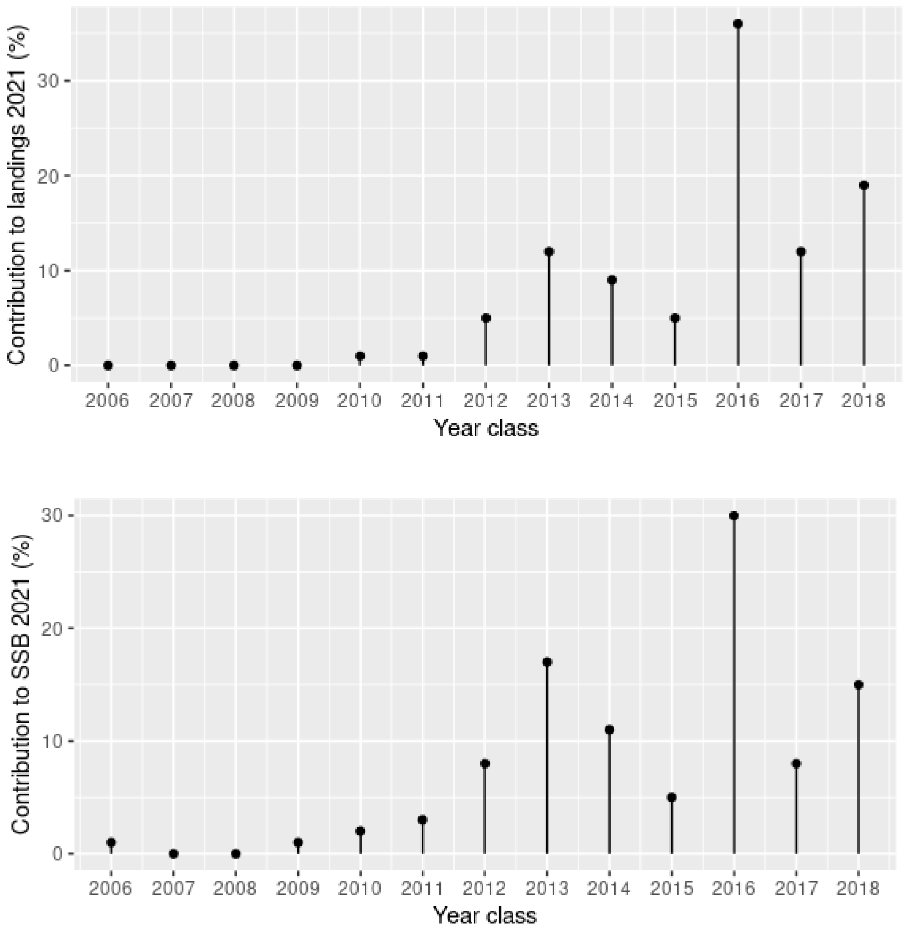

Figure 6.6.2.2. Faroe saithe (Division 5.b). Contribution of year classes to landings (top) and spawning stock biomass (bottom) in 2021.

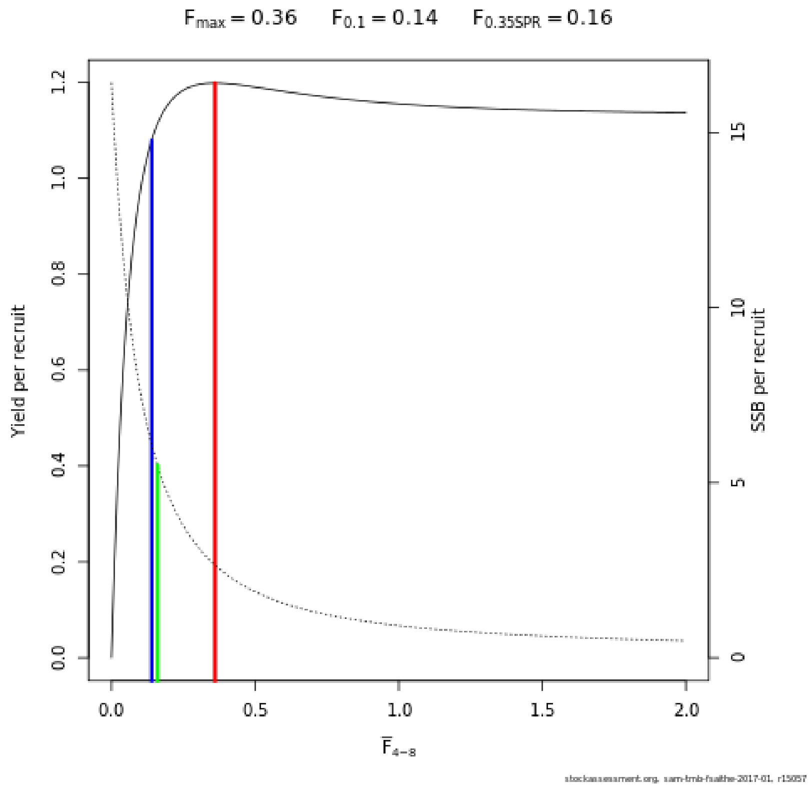

Figure 6.7.1. Faroe saithe (Division 5.b). Yield-per-recruit analysis.

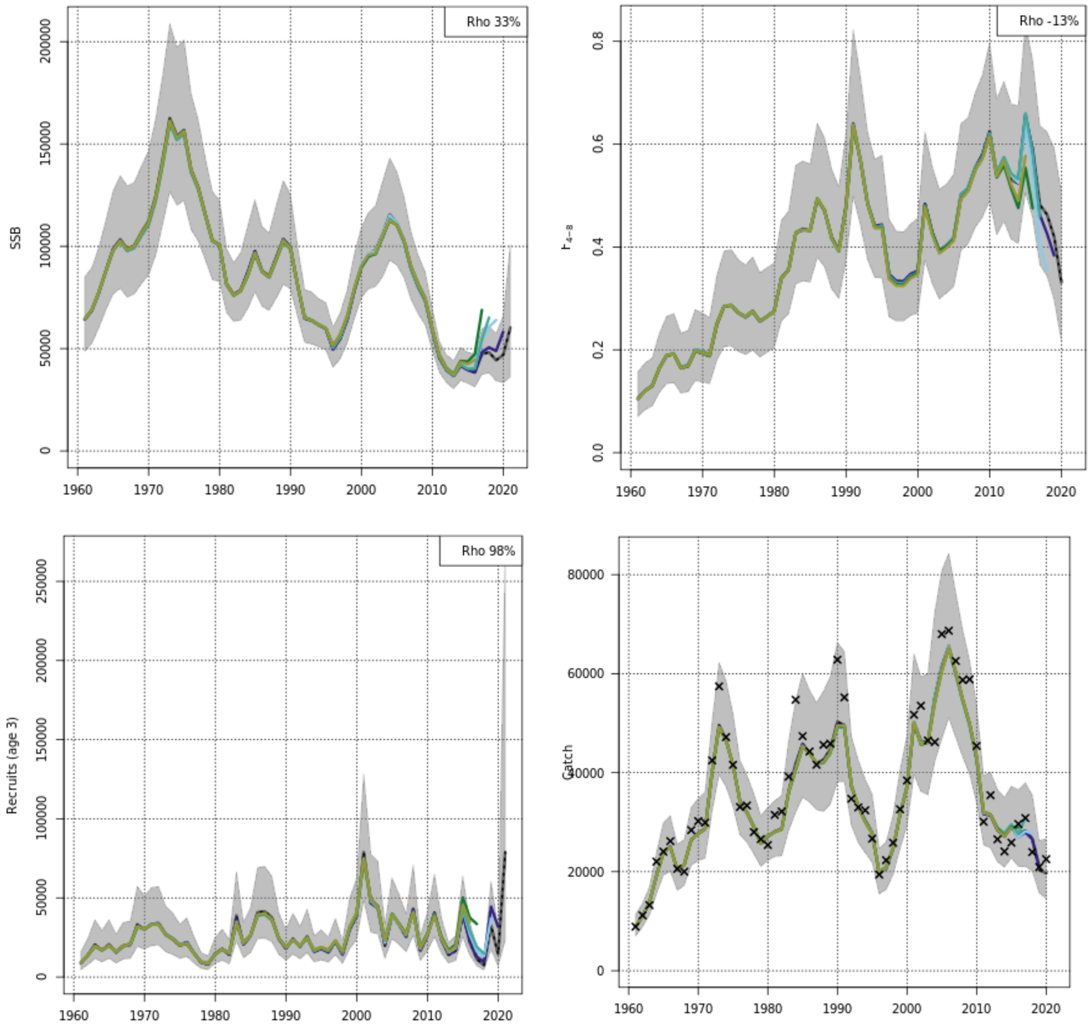

Figure 6.8.1. Faroe saithe (Division 5.b). Retrospective analysis of spawning-stock biomass (tonnes)(top-left), average fishing mortality over age groups 4–8 (top-right), recruitment-at-age 3 ('000) (bottom-left) and total landings (tons)(bottom-right) from the SAM assessment.

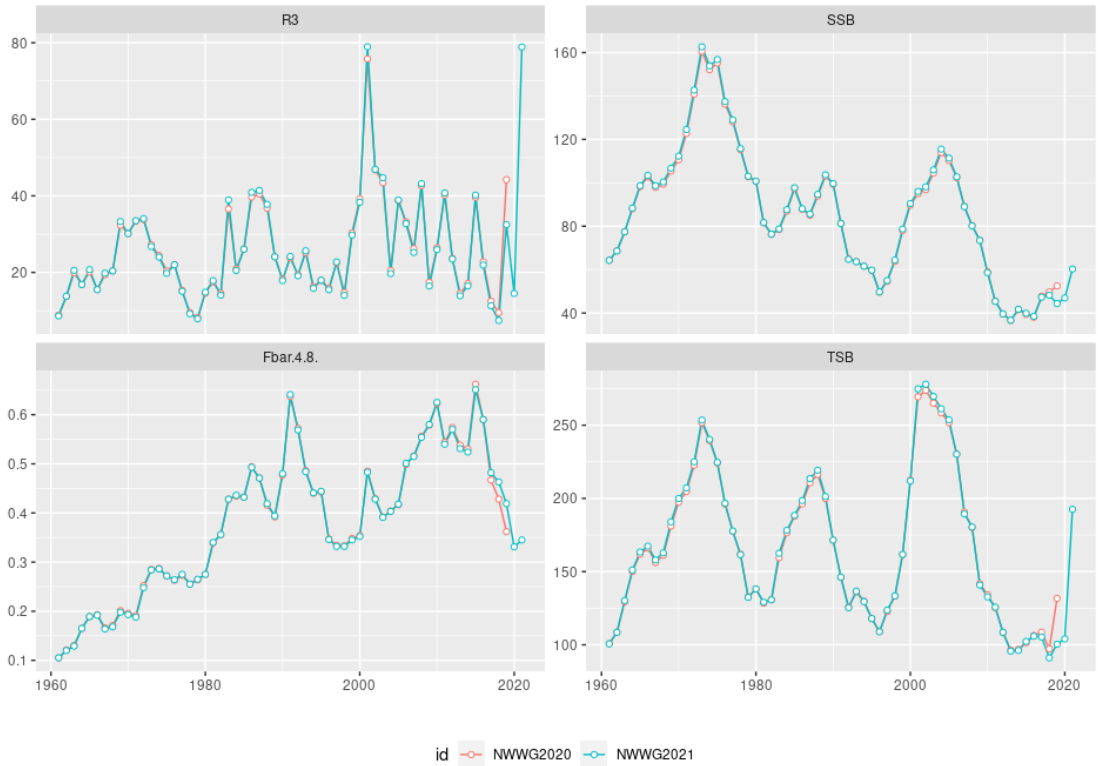

Figure 6.9.1. Faroe saithe (Division 5.b). Comparison with previous assessment. Recruitment-at-age 3 ('000) (top-left), spawning-stock biomass (tonnes)(top-right), average fishing mortality over age groups 4–8 (bottom-left) and total biomass (tonnes) (bottom-right) from the 2020 (red) and 2021 (cyan) assessments

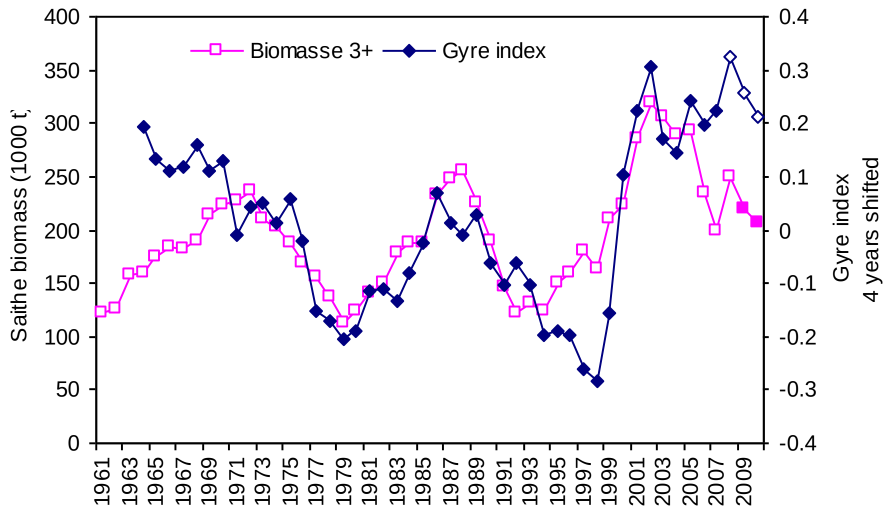

Figure 6.15.1. Faroe saithe (Division 5.b). Relationship between the Gyre index (4 years shifted) and saithe biomass (age 3+) in Faroese waters.

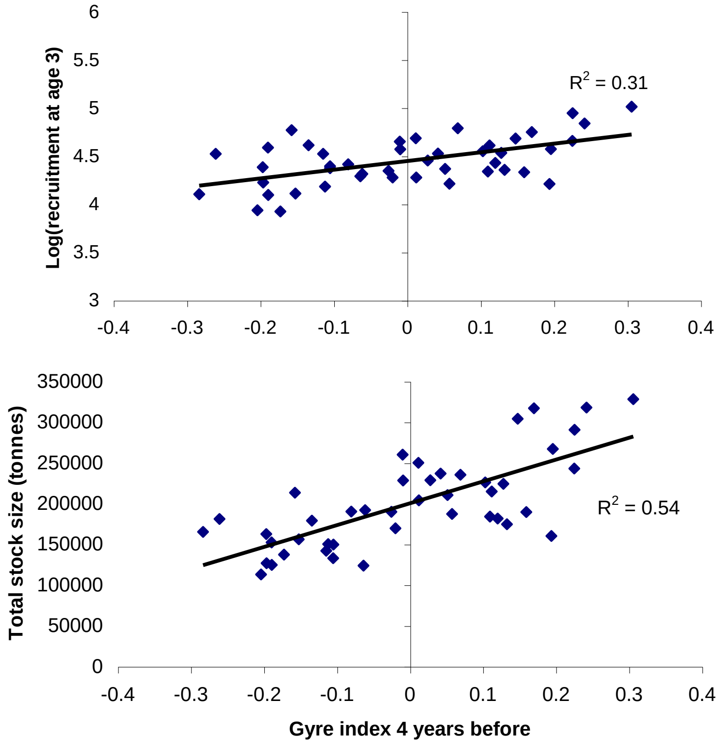

Figure 6.15.2. Relationship between the gyre index and both recruitment (top figure) and total stock biomass estimates (bottom figure.) Note that a large gyre index indicates a small subpolar gyre, and, consequently, a large influx of plankton-rich warmer-than-average water to the outer areas (bottom depth > 150 m) around the Faroes, where saithe typically are found.

7 Overview on ecosystem, fisheries and their management in Icelandic waters

The most recent Icelandic Waters ecoregion – Ecosystem overview is available as an ICES advice:

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/EcosystemOverview_IcelandicWaters_2020.pdf

The most recent Icelandic Waters ecoregion – Fisheries overview is available as an ICES advice:

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/FisheriesOverview_IcelandicWaters_2020.pdf

These contain the information previously given in this section.

8 Icelandic saithe

8.1 Stock description and management units

Description of the stock and management units is provided in the stock annex.

The stock was benchmarked and the management plan evaluated in March 2019 (ICES, 2019a). The result was no change in assessment setup. A minor change in the management plan was introduced as $MGMTB_{trigger}$ was decreased from 65 to 61 thous. tonnes to be in line with ICES MSY $B_{trigger}$. Other reference points were unchanged except HR_{lim} and $HR_{pa.}$ were introduced to replace F_{lim} and F_{pa}.

8.2 Fisheries-dependent data

Landings of saithe in Icelandic waters in 2020 are estimated to have been 50 252 t (Table 8.1 and Figure 8.1). This is considerable reduction from earlier year and not in accordance with the TAC that has been around 80 thous. tonnes for the current and last fishing year. (Figure 8.4)

Of the landings, 43 842 t were caught by trawl, 1794 t by gillnets, and the rest caught by other fishing gear. Most of the catch is taken by bottom trawl (83% in 2010–2017, 90% in 2018–2020, with gillnet and jiggers taking the majority of the rest, 5% each fleet. The share taken by the gillnet fleet was larger in the past, 26% in 1987–1996 compared to 9% in 1998–2020 (Figure 8.1). The reduction in the gillnet fisheries is caused by general reduction in gillnet boats that are mostly targeting cod and increased mesh size in gillnet fisheries targeting cod.

The reduction in the gillnet fleet was driven by boats changing from gillnets (another types of gear) to longlines, a change driven by cod and haddock fisheries. Price of large gillnet cod sold for bacalau reduced compared to “normal size” so it became more economical to operate long-liners that supply fish evenly through the year. Increase in the haddock stock in the early 2000’s and progress in automatic baiting were also an important factor.

For saithe fisheries the important factor is that saithe is rarely caught by longliners so the fleet has become much less of saithe fleet than before. The share of longlines has though gradually been increasing from 0.8% before 2000 to 2.2% in 2013–2016 reducing to 1.5% in 2020.

The fleet using demersal trawl can be divided in two parts, those that freeze the catch and those that land it fresh. The trend in last decade has been that the proportion of the trawler fleet that land the catch fresh has increased. Freezing trawlers have taken large proportion of the catch of saithe and redfish but much less of cod and haddock (Figure 16). The main reason for this is relative price of frozen vs fresh fish for each species, but mixed fisheries issues like avoiding redfish when landing fresh fish can be a factor (redfish scratches the bycatch).

Spatial distribution of the saithe fisheries changed much from 2002–2014. (Figures 8.5 and 8.7). Before 2002 most of the saithe was caught south and west of Iceland but since 2012 40–50% of the catch have been taken north west of Iceland. Comparable percentage before 2002 was 3–8%. Similar increase can be seen for golden redfish but redfish and saithe have for a long time been caught by the same vessels, not necessarily in the same hauls, rather as night and day fish. The area where saithe is caught now (Hali Figure 8.7) has since early in the 20th century been the most important cod fishing ground for trawlers.

8.2.1 Logbook data

CPUE from the fleet show increasing trend over time (Figure 8.16 and 8.17). Considerable variability can be seen on top of this trend and all measures of CPUE show substantial reduction since 2018.

The GLM indices shown in 8.17 are compiled by a model of the form .

$$C = T^{\gamma} \times \delta_{year}$$

$$C = T^{\gamma} \times \delta_{year}\delta_{freeze}$$

Where C is catch of saithe, T hours trawled. $\delta_{year}$is an estimated year factor δ_{freeze} a factor indicating if the catch is frozen aboard the vessel. γ is an estimated parameter showing relationship between hours trawled and catch.

Those models give similar trend as the indices compiled directly but the interesting observation of those models is that the models predict inverse relationship between hours trawled and saithe catch ($\gamma = -0.25$) (the models are run on all hauls where saithe is registered).

8.2.2 Landings, advice and TAC

For all Icelandic stocks that are managed by a TAC system the TAC is given for fishing year where fishing year **y/y+1** is from September 1st in the year **y** to August 31st in year **y+1**. Assessment done in the spring of year **y**, is used to give advice for the fishing year starting September 1st the same year. For most stocks the survey conducted in March is the most influential data source and the most recent survey from March in the assessment year is used in the advice.

The management plan and assessment for Icelandic saithe have been identical since 2010 and both advice and TAC based on the 20% harvest control rule. Since 2014/2015 the TAC has not been caught (Figure 8.4) but in the period 1997/1998 to 2013/2014 the TAC was caught in all years except 2007/2008 and 2008/2009. The catch in the fishing year 2019/2020 is estimated to have been 53 thous. tonnes, while the set TAC was 80 000 tonnes.

The Icelandic Fisheries management system allows some transfer between species based on cod-equivalence factors that are supposed to reflect the price of the species compared to cod (see ICES, 2021). Cod is though not included in the system that is quite limited. In recent years saithe has been converted to other species (Figure 8.2) that are probably more economical to catch than saithe. But considerable part of the saithe quota has not been used that might be a signal of over-estimation of the stock or that catching saithe is not economical. As described before, the fleet has been less of a saithe fleet in recent years and historical assessment shows that fishing mortality of Icelandic saithe was never really high (the same applies to other saithe stocks ref).

8.2.3 Landings by age

Compilation of catch in numbers is based on age and length distributions from the catches where the number aged is usually considerably less than number length measured. Discarding is not considered to be a problem in the Icelandic saithe fisheries, with an estimated discard proportion of 0.1% (annual reports by Palsson *et al.*, 2003 and later). Recently, the fleet does also seem to have difficulty in catching the set TAC making discards more unlikely. Since the amount discarded is likely to be small, not taking discards into account in the total catches and catch in numbers is not considered to have major effect on the stock assessment.

Foreign landings that are 194 tonnes are included in the landings above. They are mostly caught by longlines (99 tonnes) and handlines (95 tonnes). All the foreign landings have in recent years been taken by the Faroese fleet.

Catch in numbers are compiled based on 2 fleets, bottom trawl and gillnets, 1 region and 1 season. Bottom trawl accounts for 90% of the landings and other fleets than bottom trawl and gillnet are included with the bottom trawl.

The samples used to derive catch in numbers are both taken by observers at sea and from shore samples. The trawlers that freeze the catch account for majority of sea samples while all shore samples are from fresh fish trawlers. In additions relatively few fishes from sea samples are sampled for otoliths but the age-length keys are most likely similar.

Length distributions from sea and shore samples show some difference in recent years, the shore samples show more of large fish (Figure 8.8). This difference might be reflecting the difference in composition of the catch of the trawlers that freeze the catch and those that land the catch fresh. Excluding sea sampled when compiling catch in number for the year 2020 leads to more of 9 years and older fish but less of other age groups (green and red bars in Figure 8.9).

Length distributions from bottom trawl show tendency to catch smaller fish from 2003–2017 but again larger fish in 2018–2020 (Figure 8.10). In 2020 the +110 cm group is especially abundant.

Numbers sampled in 2018–2020 is shown in Tables 8.2 and 8.3. Sampling effort was low in 2020, mostly due to Covid. In recent years sea samples account on the average for about 77% of the length measured fish that is used in the calculation of the catch in number and 67% of the length samples. On the other hand, 25% of the aged otoliths come from sea samples. These numbers are different in 2020 when no aged fish and 50% of length measured fish come from sea samples.

90% of the length samples are taken from trawl that accounts for ~90% of the catches.

The sampling program has been revised in last decades, the number of age samples reduced and the number of fish per sample has also reduced (Figure 8.3 and stock annex).

Two age-length keys are used to calculate catch at age, one key for the gillnet catch and another key for other gears combined. The same length-weight relationship ($W = 0.02498 * L^{2.75674}$) is applied to length distributions from both fleets.

Catch in numbers by age are listed in Table 8.4 and Figure 8.9 where they are compared to prediction from last year, not fitting too well (red and blue bars).

In recent decade increased proportion of saithe catches has been caught north-west of Iceland (Figure 8.5). This situation could lead to potential problem, if the sampling effort does not follow distribution in the catches. To look at this problem catch in numbers were recompiled using 12 cells, 3 gear (bottom trawl, gillnets and handlines), 2 areas (north and south) and 2 time periods (Jan–May and June–Dec). The resulting catch in numbers are nearly identical (Figure 8.11) and using it in assessment leads to less than 1% difference of reference biomass.

8.2.4 Mean weight and maturity at age

Weights of ages 3–6 have been low in recent years, but older ages are close to average weight (Table 8.5 and Figures 8.12–8.14). The large 2012 year class has the lowest mean weight of all year classes, both in catches and in the survey. This is in line with density dependent growth that has been observed in this stock and can for example be seen for year classes 1984 and 2000 that are both large. Year classes 2013 and 2014 that seem to be above average have higher mean weight at age than the 2012 year class. The long-term trend since 1980 has been a gradual decline in the weight of all ages.

Weight at age in the landings are used to compile the reference biomass (B4+) that is the basis for the catch advice. Catch weights are also used to compile the spawning stock. Catch weights for the assessment year are predicted by applying a linear model using survey weights in the assessment year and the weight of the same year class in catches in the previous year as predictors (Magnusson, 2012 and stock annex).

Maturity at ages 4–9 has decreased in recent years and is currently around average since 1985 (Table 8.6 and Figure 8.11). A model using maturity at age from the Icelandic groundfish spring survey is used to derive smoothed trends in maturity by age and year (see stock annex).

8.3 Scientific surveys

In the benchmarked assessments from 2010 and 2019, only spring survey data are used to calibrate the assessment. Compared to the autumn survey the spring survey has larger number of stations (lower CV) and longer time series. Saithe is among the most difficult demersal fishes to get reliable information from bottom trawl surveys. In the spring survey, which has 500–600 stations, a large proportion of the saithe is caught in relatively few hauls and there seems to be considerable inter-annual variability in the number of these hauls.

The biomass indices from the spring survey (Figure 8.12) fluctuated greatly from 1985–1995 but were consistently low from 1995–2001. Since 1995 the indices have been variable but compared to the period 1985–1995 the variability seems “real” rather than noise. This difference is also seen by the estimated confidence intervals of the indices that are smaller after 1995. In 2018 the indices were the highest in the series and had tripled since 2014. (Table 8.7 and Figure 8.12). Most of the increase was caused by year class 2012 that was strong in the surveys 2015–2018 (Figure 8.14). The biomass index from the March survey shows lower index in 2019 than recent years (Figure 8.12). The reduction since 2018 that was the highest value in the series (the 1986 value is considered an outlier) is around 50%. Similar reduction in survey biomass has been seen before.

Estimated CV from the survey is often relatively high and many relatively low values appear in the survey matrix, both for the youngest and oldest age groups. The youngest age group (age 3–4 and younger) are considered to inhabit waters shallower than the survey covers and the older age groups are reducing in numbers and could also be pelagic.

To take this into account the survey residuals are compiled as $\frac{log(I+\epsilon)}{log(\hat{I}+\epsilon)}$ where ϵ is a number that should avoid giving low values too much weight as they do in log-log fit. Typical value of ϵ is the value that 3–4 otoliths will give, that would be 0.15 for saithe. Higher values are used for saithe 0.3 for the older ages, 0.5 for ages 3–5 and 0.7 for age 2, a value giving age 2 very low weight except the index if very high.

Looking at the CV large part of the high biomass in 2018 was caused by age 6, a value with relatively high CV.

The autumn survey shows similar trend as the spring survey and the index is at high level in 2017 (2004 and 2018 are outliers due to large CV). The values before 2000 might be underestimate due to stations added in 2000 (Figure 8.6) where large schools of saithe are sometimes found. Excluding these stations leads to lower but more stable index.

Catchcurves from the survey indicate that Z ~ 0.5 assuming similar q with age (Figure 8.22).

Indices from the gillnet survey conducted south and west of Iceland since 1996 were high from 2015–2020 but the 2021 value is lower. (Figure 8.13). The gillnet survey is mostly targeting large saithe (mean weight in 2021 was 6.7 kg).

To summarize, survey indices and CPUE from last 2–4 years indicate decreasing stock.

The high index in March 1986 (Figure 8.18) is mostly the result of one large haul that is scaled down to the second largest haul when compiling indices for tuning. The scaling is from 16 tonnes to 1 tonne.

Internal consistency in the March survey measured by the correlation of the indices for the same year class in 2 adjacent surveys is relatively poor, with R^2 close to 0.46 where it is highest (Figure 8.21).

8.4 Assessment method

In accordance with the recommendation from the benchmark (ICES, 2019a), a separable forward-projecting statistical catch-age model Muppet (Björnsson 2019), developed in AD Model Builder, is used to fit commercial catch at age (ages 3–14 from 1980 onwards) and survey indices at age (ages 2–10 from 1985 onwards). The selectivity pattern is constant within each of 3 periods (Figure 8.23). Natural mortality is set at 0.2 for all ages. The survey residuals ($\frac{log(I+\epsilon)}{log(\hat{I}+\epsilon)}$) are modelled as multivariate normal distribution with the correlation estimated (one coefficient).

The assessment model is also used for short term forecast, the Muppet model can't be run without prediction.

The input for the short-term forecast is shown in Tables 8.3, 8.4 and 8.7. Future weights, maturity, and selectivity are assumed to be the same as in the assessment year, as described in the stock annex. Recruitment predictions are based on the segmented stock-recruitment function estimated in the assessment model which is essentially geometric mean when the stock is above estimated break point that is near B_{loss}.

8.5 Reference points and HCR

In April 2013, the Icelandic government adopted a management plan for managing the Icelandic saithe fishery (Ministry of Industries and Innovation, 2013). ICES evaluated this management plan and concluded that it was precautionary and in conformity with ICES MSY framework.

The management plan for the Icelandic saithe fishery, adopted for the first time in 2013 was reevaluated by ICES in March 2019 and found to be precautionary and in conformity with ICES MSY approach (ICES, 2019a).

The TAC set in year *t* is for the upcoming fishing year, from 1 September in year *t*, to 31 August in year *t*+1. The TAC according to the management plan is calculated as follows.

If $SSB_y \geq MGMTB_{trigger}$

$$Tac_{y/y+1} = \frac{Tac_{y-1/y} + 0.2 \times B_{4+,y}}{2}$$

If $SSB_y \leq MGMTB_{trigger}$

$$Tac_{y/y+1} = \alpha \times Tac_{y-1/y} + (1-\alpha) \times \frac{SSB_y}{MGMTB_{trigger}} \times 0.2 \times B_{4+,y}$$

$$\alpha = 0.5 \times \frac{SSB_y}{MGMTB_{trigger}}$$

Where $Tac_{y/y+1}$ is the TAC for the fishing year starting 1 September in year y ending 31 August in year $y+1$. $B_{4+,y}$ the biomass of age 4 and older in the beginning of the assessment year compiled from catch weights. The latter equation shows that the weight of the last years Tac does gradually reduce from 0.5 to 0.0 when estimated SSB changes from $MGMTB_{trigger}$ to 0.

Reference points were also reevaluated at WKICEMSE 2019 (See table below and ICES, 2019a). B_{lim}, B_{pa}, $MSYB_{trigger}$, HR_{MSY} and HR_{Mgt} were unchanged, $MGMTB_{trigger}$ changed from 65 to 61 thous. tonnes and HR_{lim} and HR_{pa} were defined but earlier F_{lim} and F_{pa} had been defined.

Item	B_{lim}	B_{pa}	$MSYB_{trigger}$	$MGTB_{trigger}$	HR_{MSY}	HR_{Mgt}	HR_{lim}	HR_{pa}
Value	44	61	61/65	61	0.2	0.2	0.36	0.26/0.25
Basis	B_{loss}/1.4	B_{loss}	B_{pa}	B_{pa}	Stochastic simulations.			

The recipe to evaluate MSY $B_{trigger}$ and HR_{pa} has changed since 2019 so those reference points were evaluated based on the same simulations as in 2019, leading to MSY $B_{trigger}$ = 65 thousand tonnes and HR_{pa} = 0.25.

8.6 State of the stock

The results of the principal stock quantities (Table 8.8 and Figure 8.24) show that the reference biomass (B4+) has historically ranged from 130 to 410 kt (in 1999 and 1988), but this range has been narrower since 2003, between 220 and 410 kt. The current estimated stock size of $B4+_{2021}$ = 382 kt is among the highest values in the time series. Spawning biomass is estimated as 221 kt, among highest in the timeseries.

The harvest rate peaked around 28% in the mid 1990's but has since 2013 been below HR_{Mgt} target of 20%. The explanations for lower than intended harvest rate since 2013 are that the allocated TAC has not been fished and the stabilizer was reducing the TAC when the stock was increasing. Fishing mortality has been low since 2004 compared to before that. Part of the difference is caused by change in selection pattern (Figure 8.23) that leads to F before and after 2004 not being comparable measures of fishing pressure. SSB has been at a relatively high level during the last ten years.

Recruitment has been relatively stable since year class 2006, above average. Year class 2012 is estimated to be strong and year classes 2013 and 2014 above average. Year class 2015 is estimated as poor but year classes 2016–2018 around geometric mean. Geometric mean is the first guess in the model for each year class. Deviations from the mean are then driven by the survey and catches but survey indices for ages 3 and 4 have been around average in recent years, except for year class 2015 where all survey indices have been low and the year class estimated poor since in the 2018 assessment.

The details of the fishing mortality and stock in numbers are presented in Tables 8.9 and 8.10.

The commercial catch-at-age residuals in 2020 (Figure 8.28) are positive age 9 and older except for age 10. The more or less positive residuals for old fish are not unexpected as unusually much large fish was caught in 2020 (Figure 8.10), and proportion of age 9 and older in 2020 is higher than expected (Figure 8.9). The survey residuals (Figure 8.27) show large positive values in 2018 for ages 4–7, the age groups accounting for most of the biomass, therefore the survey biomass in 2018 exceeds prediction by large margin (Figure 8.26). The 2019–2021 residuals are relatively small with both positive and negative values leading to similar observed and predicted survey biomass.

Assumptions about catch in the assessment year deviate from the stock annex that specifies the catch in the calendar year 2021 as the remaining TAC from the fishing year 2020/2021 at 1 January 2021 plus 1/3 of the catch in the fishing year 2021/2022. 63 thousand tonnes of the catch for the fishing year 2020/2021 were remaining 1 January and the total catch for the year 2021 will be 90 thousand. tonnes following this procedure. Development of landings indicate that the catch for 2021 will not be higher than 70 thousand tonnes so the parameter "remaining TAC" in the model is set to 43 thousand tonnes. The advice for next fishing year is based on biomass in the beginning of the assessment year so assumptions about catch in the assessment year do not affect the advice.

8.7 Uncertainties in assessment and forecast

The assessment of Icelandic saithe is relatively uncertain due to fluctuations in the survey data, poor recruitment estimates and irregular changes in the fleet selectivity. The internal consistency in the spring bottom trawl surveys is low for saithe (Figure 8.21). This is not surprising, considering the nature of the species that is partly pelagic, schooling, and relatively widely migrating. Uncertainties base on the hessian matrix in the assessment model indicate that CV of the biomass 4+ is around 16%, rather high value for this kind of estimate that is usually underestimation of the real uncertainty.

The retrospective pattern (Figure 8.21) reveals some of the assessment uncertainty. The harvest control rule evaluations incorporated uncertainties in assessment as well as other sources of uncertainty (ICES, 2019).

Using retrospective pattern based on the assessment years 2017–2021 Mohns rho is -0.04 for the reference biomass, -0.054 for the Harvest rate, 0.10 for SSB and -0.07 for recruitment (Table 8.11 called Oldsettings) . Those values are mostly generated by the very high 2018 survey biomass.

Looking at metrics from converged assessment (assessment year < 2018, year <= assessment the values are shown in Table 8.12 based on assessment years 2000–2017. Bias is defined as $\overline{log(\frac{B_{y,y}}{B_{y,assY}})}$ and CV as $\sigma^{log(\frac{B_{y,y}}{B_{y,assY}})}$. Mohns rho is really another way to present bias. The selection of years to use is the difference between Tables 8.11 and 8.12, in 8.12 the results are based on the assessment years that are not used when compiling results for Table 8.11.

CV of B4+ from the adopted model is 0.2 and the bias -0.07 compared to Mohns rho of 0.043 based on the 5 years peel (5 last assessments). The 2018 assessment has here large effect but the pattern since 2000 has been periods of over and underestimation.

Alternative settings of the Muppet model and one SAM run were tested (Figure 8.30) compared to the results. The result show very low estimated biomass when the survey data are down-weighted, the same result is obtained with the leaveout run in SAM, both indicating that catch in numbers indicate smaller stock compared to survey indices. Winchorised survey results lead to less noise and more weight on the survey in the assessment. The Adapt model used is just the Muppet model, using N of the oldest fish from the forward running model. The backwards running model is selected by changing one number in the main input file. A major advantage with the adapt approach that CV of survey can be estimated independently for each age group , if attempted in a catch at age model the survey CV of one age will be set to zero. The table below show $B4+_{2021}$, the number that matters for the advice. The values are in thousand tonnes.

Std settings	Winchorised survey	Adapt	LessWeight On survey	2020 Std settings	SAM
382	424	339	277	377	347

If all the models would be taken as equally plausible configurations (which they are not) the average B4+2020 is 357 and CV 0.15.

The SAM settings are correlated random walk, 3 observation variance blocks for the catches and 4 for the survey.

One problem in the assessment is the fact that the TAC has not been fished in some recent years (Figure 8.4). The assessment models indicate substantial reduction of fishing mortality and harvest rate in last 4 years (Figure 8.24), mostly because the TAC has not been fished. The selection pattern observed since 2004 (Figure 8.15) indicates that the fisheries are targeting younger fish than before, something that could be interpreted as lack of large fish. This trend is even greater than observed in the figure as mean weight at age of ages 4–5 have been low in recent years (Figure 8.12). The gillnet survey that is an indicator of the amount of large saithe has shown sharp decrease from a high level in 2019 (Figure 8.19) and the autumn survey shows decreasing trend.

The problem seen in recent years is not new and the fact that fishing mortality of saithe was never high, indicates that it is difficult to catch saithe. One reason is that most of the gear is demersal while saithe is partly pelagic. Change of fleet and fishing practice in recent 20 years might also have effects. But the summary of the investigations in earlier section, reduction in CPUE, TAC not caught, gillnet survey showing decrease is that the TAC is too high and the biomass most likely overestimated.

The effect of too high TAC is increased catch of some other species through the transfer system, something that could change with higher price of saithe. Overestimation of the saithe stock leads to overestimation of the predation on capelin by saithe, leading to more precautionary capelin advice.

8.8 Ecosystem considerations

Changes in the distribution of large pelagic stocks (blue whiting, mackerel, Norwegian spring-spawning herring, Icelandic summer-spawning herring) may affect the tendency of saithe to migrate off shelf and between management units. Saithe is a migrating species and makes both vertical and long-distance feeding and spawning migrations (Armannsson *et al.*, 2007, Armannsson and Jonsson, 2012, i Homrum *et al.*, 2013). The evidence from tagging experiments (ICES, 2008) show some migrations along the Faroe-Iceland Ridge, as well as onto the East Greenland shelf.

Saithe is an important predator of capelin and is included in the predation model used to compile advice for Icelandic capelin.

8.9 Possible changes in assessment setup.

Earlier this winter the assessment of Icelandic cod was benchmarked and a number of changes done in the model formulation that lead to substantial downward revision of the biomass (ICES 2021). All the changes had to do with treatment of survey indices in the model.

1. With lower fishing effort the abundance of old age groups increased. For some of those age groups (10+) the number caught had been so low that sampling error related to few otoliths had been the most important uncertainty. Ages 11 and older in the surveys were earlier not used in the tuning as they were minor part of the stock (1–2%). Not including them in the survey lead to "ghostfish" i.e dome shaped selection pattern of the fleet, not an impossible pattern but not acceptable without some proofs, especially when the older fish becomes larger part of the stock.
2. For ages 6–9 abundance increased, and nonlinear relationships started to show up, that was not apparent when range of values was smaller.

3. The relationship between abundance indices of ages 1–3 and older fish changed. The change can either be related to increased mortality or changed behaviour or less coastal spatial distribution.
4. The VPA version of Muppet was run and CV in the survey estimated for each age group using a VPA model. That pattern was then used in the separable model with one estimated multiplier.

Looking at saithe only factor 4 was relevant. Estimating power curves turned out to lead to no improvement of fit and the power coefficients were not far from 1 and quite variable in retrospective runs. Age composition of saithe has not been changing dramatically in recent years but old saithe has always been common compared to old cod. Looking at all aged fish since 1980 number of cod otoliths is 3.5 times the number of saithe otoliths but for all ages > 12 years the number of saithe is larger than number of cod. Changes in spatial distribution of recruits could be relevant for saithe but the recruitment indices are of too low quality to easily detect changes. The common perception about saithe is that the nursery areas are close to shore while the nursery areas of cod are both close to shore and in deeper waters.

What was then left was to re estimate the survey CV pattern with age (like redefining observation error blocks in SAM) and increase the number of age groups in the tuning fleet. In addition, a version of the model that uses the estimated survey CV was run.

To revise the pattern of survey CV with age the VPA model is used, estimating CV in the survey for each age group. The VPA model used is just the Muppet model, first the model is run in the forward model but then the number of fish in the oldest age group is used for VPA. If large changes in the CV pattern are observed the procedure might be reiterated.

To look again at the value of ϵ in survey residuals in ($\frac{log(I+\epsilon)}{log(\hat{I}+\epsilon)}$) the number of aged saithe in the survey is 900 and the average total index around 20. 4 otoliths do therefore correspond to ϵ = 0.15 which would be the suggested value to use for all age groups based only on this consideration. Other factors like poor spatial coverage of recruits might be used to justify higher values. In some of the alternative tested, age 2 was not included in the tuning fleet.

When doing the reweighting scheme, the pattern of ϵ must be exactly the same in the linked separable and VPA model. In principle the objective function for models using the same pattern of ϵ can be compared but if ϵ is different the comparison might be quest

When compiling the survey indices, relative standard error in the estimation of the indices is also compiled $CV_{s,y,a} = \frac{\sigma_{I_{y,a}}}{I_{y,a}}$ where $\sigma_{I_{y,a}}$ is standard error in the indices. High value indicates that few stations are responsible for large part of the index, it is the part of the uncertainty that can be improved by increasing the number of stations. There are other uncertainties that cannot be reduced by increasing the number of stations in the same area, like the proportion of fish that is pelagic or closer to coast that the survey covers. The model setup is to use $CV_{s,y,a}$ but add to that an estimated CV by age called $CV_{2,a}$ $CV_{s,y,a} = \frac{\sigma_{I_{y,a}}}{I_{y,a}}$. $CV_{tot,y,a} = \sqrt{\left(CV_{s,y,a}^2 + CV_{2,a}^2\right)}$.

$CV_{2,a}$ can here be estimated for each age group as $CV_{tot,y,a}$ is never going to be 0.

Using this approach the variance-covariance matrix (approximately 9x9) must be recalculated and inverted at every timestep, not a difficult task for today's computers.

In Figures 8.29 and 8.31 and the Tables 8.11 and 8.12 the results of 5 settings are compared. All the settings are based on the same data except the number of age groups in the survey varies.

1. Oldsettings. The adopted model from the benchmark 2019.
2. Sameepsreweight. Same pattern of ϵ but CV pattern be age re estimated.
3. eps01reweight. ϵ = 0.1 for all age groups. Age 2 not included.

4. surveyCV. Model uses estimated $CV_{y,a}$ in survey as described above.
5. SurAge314eps01. ϵ = 0.1 for all age groups. Survey indices age 3–14.

Models 1 and 2 tuned with ages 2–10, 3 and 5 with ages 3–10 and 5 with 3–14. Models 1–4 are based on constant q by age for ages 7 and older but model 5 with constant q for ages 10 and older. Assumptions about age above which q does not change is an important factor in the settings.

Looking at Mohns rho, model 4 performs best, not unexpected as the "overestimation in 2018" was caused by survey value with high CV something easily taken care of by that model. Looking over assessment years 2001–2017 model 4 performs best but the metrics for models 1 and 3 are similar.

Comparing models 1 and 2 B4+2021 is 381 vs 311 thousand tonnes, and the objective function -752.7 vs -821.9. Model 2 fits the data much better (it is reweighted in 2021) and indicates much smaller stock. Retrospective performance of model 2 is on the other hand worse than of model 1 but here the inference might be different if the end value of model 2 was different.

In summary model 3 seems to be most feasible alternative if a new model was adopted today. The table below shows the estimated B4+ in 2021 by the different models.

Oldsettings	Sameepsreweight	eps01reweight	surveyCV	SurAge314eps01
381.8	310.6	318.2	328.3	383

An interesting factor to look at in the models is estimated q from the surveys (Figure 8.32). Model 5 uses all ages and q in constrained to be identical for ages 9 and older but ages 7 and older for the other models that use age groups until 10. This assumption when does q become constant has considerable effect on stock size, reducing q by age as in model 5 leads to larger stock.

Estimated selection (since 2004) in the model is also somewhat different (Figure 8.33). Models 1 and 5 have different selection pattern for older fish and do therefore not converge to exactly the same biomass in the period after 2003.

8.10 References

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Table 8.1. Saithe in Division 5.a. Nominal catch (t) by countries, as officially reported to ICES.

	belgium	faroes	france	germany	iceland	norway	uk (e/w/ni)	uk (scot)	uk	total
1980	980	4930			52 436	1				58 347
1981	532	3545			54 921	3				59 001
1982	201	3582	23		65 124	1				68 931
1983	224	2138			55 904					58 266
1984	269	2044			60 406					62 719
1985	158	1778			55 135	1	29			57 101
1986	218	2291			63 867					66 376
1987	217	2139			78 175					80 531
1988	268	2596			74 383					77 247
1989	369	2246			79 796					82 411
1990	190	2905			95 032					98 127
1991	236	2690			99 811					102 737
1992	195	1570			77 832					79 597
1993	104	1562			69 982					71 648
1994	30	975		1	63 333					64 339
1995		1161		1	47 466	1				48 629
1996		803		1	39 297					40 101
1997		716			36 548					37 264
1998		997		3	30 531					31 531
1999		700		2	30 583	6	1	1		31 293
2000		228		1	32 914	1	2			33 146
2001		128		14	31 854	44	23			32 063
2002		366		6	41 687	3	7	2		42 071
2003		143		56	51 857	164			35	52 255
2004		214		157	62 614	1	105			63 091
2005		322		224	67 283	2			312	68 143
2006		415		33	75 197	2			16	75 663
2007		392			64 008	3			30	64 433
2008		196			69 992	2				70 190
2009		269			61 391	3				61 663
2010		499			53 772	1				54 272
2011		735			50 386	2				51 123
2012		940			50 843					51 783
2013		925			57 077					58 002
2014		746			45 733	4				46 483
2015		499			47 973	3				48 473
2016		287			48 920	5				49 212
2017		261			48 786	4			4	49 057
2018		270			65 090					65 360

	belgium	faroes	france	germany	iceland	norway	uk (e/w/ni)	uk (scot)	uk	total
2019		237			64 295					64 532
2020		194			50 058					50 253

Table 8.2. Saithe in Division 5.a. Samping from catches 2018–2020

Year	Fleet	Landings (t)	No. of otolith samples	No. of otoliths aged	No. of length samples	No. of length measurements	No. of sea length samples
2018	Long lines	787	0	0	1	1	1
2018	Gillnets	1715	3	75	5	464	1
2018	Jiggers	1250	1	25	5	598	0
2018	Danish seine	969	3	75	5	461	2
2018	Bottom trawl	60975	62	1604	143	25486	96
2018	Other gear	553	0	0	0	0	0
2018	Total	66248	69	1779	159	27010	100
2019	Long lines	966	0	0	5	19	5
2019	Gillnets	1405	0	0	0	0	0
2019	Jiggers	1843	4	100	8	467	2
2019	Danish seine	1451	8	198	11	901	3
2019	Bottom trawl	58339	51	1269	159	28296	118
2019	Other gear	528	0	0	0	0	0
2019	Total	64532	63	1567	183	29683	128
2020	Long lines	745	0	0	1	8	1
2020	Gillnets	2573	3	75	9	630	6
2020	Jiggers	1794	4	87	8	365	0
2020	Danish seine	980	3	75	4	410	1
2020	Bottom trawl	43842	31	775	57	8181	26
2020	Other gear	319	0	0	0	0	0
2020	Total	50252	41	1012	79	9594	34

Table 8.3. Saithe in Division 5.a. Sampling from catches 2020. No age samples were taken at sea.

Gear	Length sea-samples	Length shore-samples	Age shore-samples
Bottom trawl	26	31	31
Demersal seine	2	3	3
Gillnets	6	3	3
Handlines	0	8	4

Table 8.4. Saithe in Division 5.a. Commercial catch at age (thousands).

Year	3	4	5	6	7	8	9	10	11	12+
1980	275	2540	5214	2596	2169	1341	387	262	155	209
1981	203	1325	3503	5404	1457	1415	578	242	61	417
1982	508	1092	2804	4845	4293	1215	975	306	59	129
1983	107	1750	1065	2455	4454	2311	501	251	38	18
1984	53	657	800	1825	2184	3610	844	376	291	546
1985	376	4014	3366	1958	1536	1172	747	479	74	166
1986	3108	1400	4170	2665	1550	1116	628	1549	216	95
1987	956	5135	4428	5409	2915	1348	661	496	498	133
1988	1318	5067	6619	3678	2859	1775	845	226	270	132
1989	315	4313	8471	7309	1794	1928	848	270	191	221
1990	143	1692	5471	10112	6174	1816	1087	380	151	168
1991	198	874	3613	6844	10772	3223	858	838	228	51
1992	242	2928	3844	4355	3884	4046	1290	350	196	125
1993	657	1083	2841	2252	2247	2314	3671	830	223	281
1994	702	2955	1770	2603	1377	1243	1263	2009	454	428
1995	1573	1853	2661	1807	2370	905	574	482	521	154
1996	1102	2608	1868	1649	835	1233	385	267	210	447
1997	603	2960	2766	1651	1178	599	454	125	95	234
1998	183	1289	1767	1545	1114	658	351	265	120	251
1999	989	732	1564	2176	1934	669	324	140	72	75
2000	850	2383	896	1511	1612	1806	335	173	57	57
2001	1223	2619	2184	591	977	943	819	186	94	69
2002	1187	4190	3147	2970	519	820	570	309	101	53
2003	2284	4363	6031	2472	1942	285	438	289	196	72
2004	952	7841	7195	5363	1563	1057	211	224	157	124
2005	2607	3089	7333	6876	3592	978	642	119	149	147
2006	1380	10051	2616	5840	4514	1989	667	485	118	229
2007	1244	6552	8751	2124	2935	1817	964	395	190	99
2008	1432	3602	5874	6706	1155	1894	1248	803	262	307
2009	2820	5166	2084	2734	2883	777	1101	847	555	373
2010	2146	6284	3058	997	1644	1571	514	656	522	409
2011	2004	4850	4006	1502	677	1065	1145	323	433	469
2012	1183	4816	3514	2417	903	432	883	1015	354	549
2013	1163	5538	6366	2963	1610	664	375	537	460	320
2014	668	3499	4867	2805	1276	725	347	241	312	401
2015	781	2712	6461	2917	1509	694	589	249	133	347
2016	1588	6230	2653	2838	1648	1059	526	337	148	131
2017	750	3333	7542	1806	1449	813	648	229	127	237
2018	689	6681	4267	7908	1446	962	455	258	192	175

Year	3	4	5	6	7	8	9	10	11	12+
2019	1292	1585	6325	2752	4543	693	675	339	242	231
2020	1333	2310	1496	3228	1334	1700	710	351	379	666

Table 8.5. Saithe in Division 5.a. Mean weight at age (g) in the catches and in the spawning stock, with predictions in gray.

Year	3	4	5	6	7	8	9	10	11	12+
1980	1428	1983	2667	3689	5409	6321	7213	8565	9147	9979
1981	1585	2037	2696	3525	4541	6247	6991	8202	9537	9523
1982	1547	2194	3015	3183	5114	6202	7256	7922	8924	10021
1983	1530	2221	3171	4270	4107	5984	7565	8673	8801	9445
1984	1653	2432	3330	4681	5466	4973	7407	8179	8770	10520
1985	1609	2172	3169	3922	4697	6411	6492	8346	9401	10767
1986	1450	2190	2959	4402	5488	6406	7570	6487	9616	11080
1987	1516	1715	2670	3839	5081	6185	7330	8025	7974	10886
1988	1261	2017	2513	3476	4719	5932	7523	8439	8748	9823
1989	1403	2021	2194	3047	4505	5889	7172	8852	10170	11194
1990	1647	1983	2566	3021	4077	5744	7038	7564	8854	11284
1991	1224	1939	2432	3160	3634	4967	6629	7704	9061	9547
1992	1269	1909	2578	3288	4150	4865	6168	7926	8349	10181
1993	1381	2143	2742	3636	4398	5421	5319	7006	8070	9842
1994	1444	1836	2649	3512	4906	5539	6818	6374	8341	10388
1995	1370	1977	2769	3722	4621	5854	6416	7356	6815	8799
1996	1229	1755	2670	3802	4902	5681	7182	7734	9256	9601
1997	1325	1936	2409	3906	5032	6171	7202	7883	8856	9865
1998	1347	1972	2943	3419	4850	5962	6933	7781	8695	10043
1999	1279	2106	2752	3497	3831	5819	7072	8078	8865	10872
2000	1367	1929	2751	3274	4171	4447	6790	8216	9369	10443
2001	1280	1882	2599	3697	4420	5538	5639	7985	9059	10419
2002	1308	1946	2569	3266	4872	5365	6830	7067	9240	10190
2003	1310	1908	2545	3336	4069	5792	7156	8131	8051	10825
2004	1467	1847	2181	2918	4017	5135	7125	7732	8420	9547
2005	1287	1888	2307	2619	3516	5080	6060	8052	8292	8569
2006	1164	1722	2369	2808	3235	4361	6007	7166	8459	9583
2007	1140	1578	2122	2719	3495	4114	5402	6995	7792	9848
2008	1306	1805	2295	2749	3515	4530	5132	6394	7694	9589
2009	1412	1862	2561	3023	3676	4596	5651	6074	7356	9237
2010	1287	1787	2579	3469	4135	4850	5558	6289	6750	8785
2011	1175	1801	2526	3680	4613	5367	5685	6466	6851	7739
2012	1160	1668	2369	3347	4430	5486	6161	6448	7220	8236
2013	1056	1675	2219	3244	4529	5628	6397	7055	7378	8342

Year	3	4	5	6	7	8	9	10	11	12+
2014	1211	1575	2229	2983	4378	5598	6773	8023	7875	9020
2015	1072	1639	2141	3122	4262	5555	6633	7697	8269	8773
2016	1105	1468	2260	3071	4127	5272	6379	7247	8566	8969
2017	1282	1674	2199	3255	4314	5718	6361	7630	8590	9238
2018	1346	1724	2335	3005	4178	5319	6544	7773	8530	9324
2019	1485	2054	2449	3128	4104	5694	6483	7750	8563	9488
2020	1285	2015	2386	3131	4065	5059	6284	7025	8285	9175
2021	1372	1802	2708	3299	4149	5340	6202	7516	8459	9344
2022	1372	1802	2708	3299	4149	5340	6202	7516	8459	9344

Table 8.6. Saithe in Division 5.a. Maturity at age, with predictions in gray.

Year	3	4	5	6	7	8	9	10	11	12
1980	0	0.083	0.189	0.374	0.606	0.798	0.91	1	1	1
1981	0	0.083	0.189	0.374	0.606	0.798	0.91	1	1	1
1982	0	0.083	0.189	0.374	0.606	0.798	0.91	1	1	1
1983	0	0.083	0.189	0.374	0.606	0.798	0.91	1	1	1
1984	0	0.083	0.189	0.374	0.606	0.798	0.91	1	1	1
1985	0	0.083	0.189	0.374	0.606	0.798	0.91	1	1	1
1986	0	0.075	0.173	0.349	0.579	0.779	0.901	1	1	1
1987	0	0.068	0.158	0.325	0.553	0.76	0.891	1	1	1
1988	0	0.062	0.146	0.305	0.529	0.743	0.881	1	1	1
1989	0	0.058	0.136	0.288	0.51	0.727	0.873	1	1	1
1990	0	0.055	0.129	0.276	0.495	0.716	0.866	1	1	1
1991	0	0.053	0.126	0.27	0.487	0.709	0.862	1	1	1
1992	0	0.053	0.126	0.27	0.487	0.709	0.862	1	1	1
1993	0	0.055	0.13	0.277	0.496	0.716	0.866	1	1	1
1994	0	0.059	0.139	0.293	0.515	0.732	0.875	1	1	1
1995	0	0.066	0.154	0.319	0.546	0.755	0.888	1	1	1
1996	0	0.078	0.177	0.356	0.587	0.785	0.904	1	1	1
1997	0	0.093	0.208	0.403	0.634	0.816	0.919	1	1	1
1998	0	0.111	0.243	0.452	0.679	0.845	0.933	1	1	1
1999	0	0.131	0.278	0.498	0.718	0.867	0.944	1	1	1
2000	0	0.148	0.308	0.533	0.745	0.883	0.951	1	1	1
2001	0	0.158	0.325	0.553	0.76	0.891	0.954	1	1	1
2002	0	0.162	0.331	0.56	0.766	0.893	0.956	1	1	1
2003	0	0.16	0.329	0.557	0.764	0.892	0.955	1	1	1
2004	0	0.155	0.321	0.548	0.757	0.889	0.954	1	1	1
2005	0	0.149	0.31	0.535	0.747	0.884	0.951	1	1	1
2006	0	0.142	0.299	0.522	0.737	0.878	0.949	1	1	1
2007	0	0.137	0.29	0.512	0.729	0.873	0.947	1	1	1

Year	3	4	5	6	7	8	9	10	11	12
2008	0	0.133	0.282	0.502	0.722	0.869	0.945	1	1	1
2009	0	0.129	0.275	0.494	0.715	0.865	0.943	1	1	1
2010	0	0.125	0.268	0.484	0.707	0.861	0.941	1	1	1
2011	0	0.12	0.258	0.472	0.697	0.855	0.938	1	1	1
2012	0	0.113	0.247	0.457	0.684	0.847	0.934	1	1	1
2013	0	0.107	0.234	0.44	0.669	0.838	0.93	1	1	1
2014	0	0.1	0.222	0.423	0.653	0.829	0.925	1	1	1
2015	0	0.095	0.212	0.408	0.639	0.82	0.921	1	1	1
2016	0	0.091	0.204	0.396	0.628	0.812	0.917	1	1	1
2017	0	0.088	0.199	0.389	0.621	0.808	0.915	1	1	1
2018	0	0.087	0.197	0.386	0.618	0.806	0.914	1	1	1
2019	0	0.087	0.197	0.386	0.618	0.806	0.914	1	1	1
2020	0	0.088	0.198	0.388	0.62	0.807	0.915	1	1	1
2021	0	0.089	0.2	0.391	0.623	0.809	0.916	1	1	1
2022	0	0.089	0.2	0.391	0.623	0.809	0.916	1	1	1

Table 8.7. Saithe in Division 5.a. Survey indices by age.

Year	2	3	4	5	6	7	8	9	10
1985	0.59	0.57	3.1	5.32	1.81	1.1	0.52	1.43	0.16
1986	2.34	2.46	2.15	2.21	1.5	0.65	0.3	0.19	0.32
1987	0.38	11.84	13.22	6.61	4.09	3.19	0.82	0.37	0.27
1988	0.31	0.47	2.74	2.86	1.76	0.98	0.42	0.07	0.08
1989	1.42	4.01	5.08	6.68	2.65	1.74	0.89	0.37	0.01
1990	0.73	1.32	4.96	6.42	12.53	3.38	1.23	0.65	0.12
1991	0.22	1.38	1.7	2.18	1.12	2.49	0.31	0.02	0.04
1992	0.14	0.91	5.91	5.67	2.84	2.69	1.93	0.28	0.06
1993	1.27	11	1.93	6.61	2.33	2.2	1.02	3.92	0.66
1994	0.83	0.72	1.96	1.79	2.07	0.72	1.13	1.2	2.77
1995	0.49	1.98	1.12	0.52	0.29	0.34	0.1	0.15	0.15
1996	0.13	0.49	3.78	1.16	1.03	0.59	0.98	0.06	0.09
1997	0.32	0.91	4.73	3.98	0.95	0.4	0.16	0.1	0.05
1998	0.13	1.66	2.36	2.55	1.27	0.72	0.3	0.09	0.07
1999	0.73	3.74	0.94	1.27	1.7	0.59	0.16	0.02	0.02
2000	0.38	2.01	2.55	0.61	0.86	0.54	0.45	0.08	0.03
2001	0.92	2.06	2.73	1.68	0.22	0.23	0.4	0.14	0.07
2002	1.02	2.23	3.01	3.11	2.19	0.42	0.47	0.32	0.22
2003	0.05	9.79	5.14	2.98	1.37	0.78	0.21	0.05	0.1
2004	0.9	1.39	9.6	6.27	4.52	1.52	0.84	0.17	0.17
2005	0.25	4.29	2.41	7.5	4.73	2.36	0.88	0.45	0.13
2006	0	2.19	6.77	1.98	8.86	3.5	1.21	0.29	0.25
2007	0.06	0.31	1.75	3.27	0.82	1.64	0.71	0.29	0.16
2008	0.08	2.26	1.81	2.88	4.05	0.62	0.79	0.34	0.15
2009	0.21	2.45	1.85	0.69	0.91	0.84	0.12	0.26	0.15
2010	0.07	1.24	5.07	2.55	0.64	0.61	0.47	0.07	0.12
2011	0.15	3.84	4.24	3.1	1.17	0.41	0.39	0.44	0.17
2012	0.02	1.77	12.01	6.75	2.76	0.63	0.17	0.38	0.5
2013	0.11	4.28	7.57	6.85	4.67	2.58	1.12	0.3	0.43
2014	0.03	0.39	3.89	3.74	2.02	0.87	0.42	0.15	0.11
2015	0.04	1.08	1.93	3.22	1.73	0.82	0.72	0.66	0.43
2016	0.05	3.17	16.21	2.75	2.27	1.08	0.53	0.44	0.28
2017	0.02	1.48	6.67	14.64	3.03	1.68	0.87	0.45	0.3
2018	0.03	0.5	17.92	10.51	15.28	1.51	0.84	0.43	0.32
2019	0.08	3.75	1.22	3.46	2.61	4.07	0.82	0.61	0.14
2020	0.09	1.89	2.57	0.7	2.14	1.19	2.36	0.35	0.18
2021	0.36	2.55	4.53	3.42	1.06	2.69	0.67	1.17	0.23

Table 8.8. Saithe in Division 5.a. Main population estimates.

Year	B4+	SSB	N3	Yield	f4–9	HR
1980	313	114	28	58	0.29	0.18
1981	306	121	20	58	0.26	0.21
1982	296	138	22	68	0.3	0.2
1983	271	138	32	57	0.24	0.22
1984	288	141	42	60	0.23	0.19
1985	300	139	35	54	0.24	0.2
1986	319	137	67	65	0.28	0.24
1987	336	129	91	80	0.35	0.23
1988	416	126	51	77	0.32	0.19
1989	398	129	32	82	0.31	0.23
1990	378	136	21	98	0.35	0.27
1991	337	146	29	102	0.37	0.26
1992	289	138	15	80	0.37	0.26
1993	232	114	20	72	0.4	0.29
1994	188	95	18	64	0.45	0.28
1995	154	71	30	48	0.46	0.27
1996	151	62	26	39	0.4	0.25
1997	158	64	17	37	0.36	0.21
1998	157	70	9	31	0.29	0.2
1999	135	75	31	31	0.3	0.24
2000	147	77	32	33	0.32	0.22
2001	168	83	55	32	0.26	0.23
2002	226	100	64	42	0.29	0.22
2003	289	124	73	52	0.28	0.21
2004	330	144	26	65	0.25	0.2
2005	296	156	73	69	0.27	0.25
2006	321	164	42	75	0.3	0.21
2007	292	161	19	64	0.27	0.23
2008	261	159	26	69	0.32	0.24
2009	234	147	38	60	0.3	0.24
2010	232	135	37	54	0.28	0.22
2011	235	126	44	51	0.26	0.22
2012	240	121	41	51	0.26	0.23
2013	246	120	42	58	0.29	0.2
2014	243	119	30	46	0.22	0.2
2015	244	124	93	48	0.21	0.2
2016	313	135	43	49	0.2	0.16
2017	347	156	58	49	0.16	0.17
2018	389	181	17	66	0.2	0.16

Year	B4+	SSB	N3	Yield	f4–9	HR
2019	370	203	38	63	0.19	0.15
2020	356	206	48	50	0.16	0.18
2021	382	221	43			
Average	276	130	39	59	0.29	0.22

Table 8.9. Saithe in Division 5.a. Stock in numbers. Shaded area is input to prediction.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1980	32.2	24.7	28.2	46.9	31	10.3	8.2	3.7	1.3	0.7	0.7	0.5	0.3	0.1
1981	48	26.4	20.2	22.7	35.3	21.3	6.3	4.7	2	0.7	0.4	0.4	0.3	0.2
1982	62.5	39.3	21.6	16.3	17.2	24.7	13.4	3.7	2.6	1.1	0.4	0.2	0.2	0.2
1983	52.7	51.2	32.2	17.4	12.2	11.8	14.9	7.5	2	1.4	0.6	0.2	0.1	0.1
1984	100.2	43.2	41.9	26	13.3	8.6	7.6	9.1	4.3	1.1	0.8	0.4	0.1	0.1
1985	136	82	35.4	33.9	19.9	9.4	5.6	4.6	5.3	2.6	0.7	0.5	0.2	0.1
1986	75.5	111.3	67.2	28.6	25.8	14.1	6.1	3.4	2.6	3.1	1.5	0.4	0.3	0.1
1987	47.9	61.8	91.2	54.1	21.5	17.8	8.7	3.5	1.8	1.5	1.7	0.9	0.2	0.2
1988	31.1	39.2	50.6	73.2	40	14.3	10.3	4.6	1.7	0.9	0.7	0.9	0.5	0.1
1989	44	25.5	32.1	40.7	54.6	27	8.5	5.6	2.3	0.9	0.5	0.4	0.5	0.3
1990	22.2	36	20.8	25.8	30.5	37.1	16.2	4.7	2.9	1.3	0.5	0.3	0.2	0.3
1991	29.7	18.2	29.5	16.7	19.1	20.2	31.4	8.6	2.3	1.5	0.6	0.3	0.1	0.1
1992	26.6	24.3	14.9	23.6	12.3	12.5	11.4	16.2	4.1	1.1	0.7	0.3	0.1	0.1
1993	44.9	21.7	19.9	11.9	17.4	8.1	7.1	5.9	7.7	2	0.5	0.4	0.2	0.1
1994	38.7	36.7	17.8	16	8.7	11.2	4.4	3.6	2.7	3.7	0.9	0.3	0.2	0.1
1995	25.5	31.7	30.1	14.2	11.5	5.4	5.9	2.1	1.5	1.2	1.5	0.4	0.1	0.1
1996	13.2	20.9	25.9	24	10.2	7.1	2.8	2.7	0.9	0.7	0.5	0.7	0.2	0.1
1997	46.3	10.8	17.1	20.8	17.5	6.6	3.9	1.4	1.2	0.4	0.3	0.3	0.4	0.1
1998	47.7	37.9	8.9	13.5	14.7	11.4	3.9	2.1	0.7	0.6	0.2	0.1	0.1	0.2
1999	82.1	39	31	7	9.9	10	7.3	2.3	1.2	0.4	0.3	0.1	0.1	0.1
2000	96.2	67.2	31.9	24.7	5.1	6.7	6.3	4.2	1.2	0.6	0.2	0.2	0.1	0
2001	108.4	78.7	55	25.4	17.8	3.4	4.2	3.6	2.2	0.6	0.3	0.1	0.1	0
2002	38.5	88.7	64.5	43.9	18.7	12.3	2.2	2.5	2	1.2	0.4	0.2	0.1	0.1
2003	108.3	31.5	72.6	51.3	32	12.7	7.9	1.3	1.4	1.1	0.7	0.2	0.1	0

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2004	62.5	88.7	25.8	57.8	37.5	21.9	8.2	4.7	0.7	0.7	0.6	0.4	0.1	0.1
2005	27.8	51.2	72.6	20.3	39.4	23.5	13.5	5.2	3	0.5	0.5	0.4	0.2	0.1
2006	39.1	22.7	41.9	57	13.6	24.1	14.2	8.3	3.3	1.8	0.3	0.3	0.2	0.1
2007	57.3	32	18.6	32.7	37.5	8.1	14.1	8.5	5.1	1.9	1.1	0.2	0.2	0.1
2008	54.8	46.9	26.2	14.6	21.9	22.9	4.9	8.7	5.4	3.2	1.2	0.6	0.1	0.1
2009	65.7	44.9	38.4	20.4	9.5	12.8	13.1	2.9	5.3	3.1	1.8	0.7	0.4	0.1
2010	61	53.8	36.8	30	13.4	5.6	7.4	7.8	1.8	3.1	1.9	1	0.4	0.2
2011	63	49.9	44	28.8	20	8.1	3.4	4.6	4.9	1.1	1.9	1.1	0.6	0.2
2012	45.3	51.6	40.9	34.6	19.5	12.4	5	2.1	2.9	3.1	0.7	1.1	0.6	0.4
2013	139.1	37.1	42.2	32.2	23.5	12.2	7.6	3.1	1.3	1.8	1.9	0.4	0.7	0.4
2014	64.1	113.8	30.3	33.1	21.3	14.1	7.2	4.6	1.9	0.8	1.1	1.1	0.2	0.4
2015	86.6	52.5	93.2	24	23	13.8	9	4.7	3.1	1.3	0.5	0.7	0.7	0.1
2016	24.9	70.9	42.9	73.8	16.8	15	8.9	5.9	3.1	2	0.8	0.3	0.4	0.4
2017	57.1	20.4	58	34.1	52.3	11.1	9.9	5.9	4	2.1	1.3	0.5	0.2	0.3
2018	71.1	46.7	16.7	46.3	24.9	36.1	7.6	6.8	4.2	2.8	1.4	0.9	0.4	0.1
2019	64.1	58.3	38.2	13.2	32.9	16.5	23.8	5.1	4.6	2.8	1.9	0.9	0.6	0.2
2020	53	52.4	47.7	30.4	9.4	21.9	10.9	15.9	3.5	3.1	1.9	1.2	0.6	0.4
2021	52.4	43.4	42.9	38.1	22.2	6.5	15	7.6	11.2	2.4	2.2	1.3	0.8	0.4
2022	52.4	43.4	42.9	38.1	22.2	6.5	15	7.6	11.2	2.4	2.2	1.3	0.8	0.4
2023	53.2	43.6	35.7	28.3	35.8	6.8	14.2	8.3	11.5	2.4	2.2	1.2	0.8	0.4

Table 8.10. Saithe in Division 5.a. Fishing mortality rate. Shaded areas show predictions i.e. where catches are unknown.

Year	3	4	5	6	7	8	9	10	11	12	13	14
1980	0.016	0.085	0.177	0.294	0.362	0.434	0.403	0.434	0.337	0.356	0.356	0.356
1981	0.015	0.076	0.158	0.263	0.323	0.388	0.36	0.388	0.301	0.318	0.318	0.318
1982	0.017	0.088	0.183	0.303	0.373	0.448	0.415	0.448	0.347	0.367	0.367	0.367
1983	0.014	0.07	0.146	0.243	0.299	0.359	0.333	0.359	0.278	0.294	0.294	0.294
1984	0.013	0.067	0.14	0.231	0.285	0.342	0.317	0.342	0.265	0.28	0.28	0.28
1985	0.014	0.071	0.148	0.245	0.302	0.363	0.337	0.363	0.282	0.297	0.297	0.297
1986	0.016	0.082	0.171	0.283	0.348	0.418	0.388	0.418	0.324	0.342	0.342	0.342
1987	0.02	0.102	0.212	0.352	0.434	0.521	0.483	0.521	0.404	0.426	0.426	0.426
1988	0.018	0.094	0.195	0.323	0.398	0.478	0.443	0.478	0.371	0.391	0.391	0.391
1989	0.017	0.089	0.185	0.307	0.378	0.454	0.421	0.454	0.352	0.372	0.372	0.372
1990	0.019	0.101	0.211	0.35	0.432	0.518	0.481	0.518	0.402	0.424	0.424	0.424
1991	0.021	0.108	0.226	0.374	0.461	0.554	0.514	0.554	0.43	0.454	0.454	0.454
1992	0.02	0.106	0.221	0.366	0.452	0.542	0.503	0.542	0.42	0.444	0.444	0.444
1993	0.022	0.115	0.239	0.397	0.489	0.587	0.544	0.587	0.455	0.481	0.481	0.481
1994	0.025	0.13	0.271	0.45	0.554	0.665	0.617	0.665	0.516	0.545	0.545	0.545
1995	0.025	0.133	0.276	0.458	0.564	0.678	0.628	0.678	0.525	0.555	0.555	0.555
1996	0.022	0.116	0.241	0.399	0.492	0.591	0.548	0.591	0.458	0.483	0.483	0.483
1997	0.035	0.144	0.229	0.309	0.41	0.511	0.545	0.515	0.519	0.471	0.471	0.471
1998	0.028	0.116	0.185	0.249	0.331	0.413	0.44	0.416	0.42	0.381	0.381	0.381
1999	0.03	0.121	0.192	0.259	0.344	0.429	0.457	0.433	0.436	0.396	0.396	0.396
2000	0.031	0.127	0.202	0.272	0.361	0.451	0.481	0.455	0.458	0.416	0.416	0.416
2001	0.026	0.106	0.169	0.228	0.302	0.377	0.402	0.38	0.383	0.348	0.348	0.348
2002	0.028	0.115	0.184	0.248	0.329	0.41	0.437	0.414	0.417	0.378	0.378	0.378
2003	0.028	0.113	0.18	0.242	0.321	0.401	0.428	0.405	0.408	0.37	0.37	0.37
2004	0.039	0.184	0.268	0.28	0.261	0.238	0.264	0.267	0.301	0.317	0.317	0.317

Year	3	4	5	6	7	8	9	10	11	12	13	14
2005	0.042	0.201	0.292	0.306	0.286	0.26	0.289	0.291	0.329	0.346	0.346	0.346
2006	0.046	0.218	0.318	0.333	0.311	0.283	0.314	0.317	0.358	0.376	0.376	0.376
2007	0.043	0.202	0.294	0.307	0.287	0.261	0.29	0.292	0.33	0.347	0.347	0.347
2008	0.05	0.234	0.341	0.357	0.333	0.303	0.337	0.34	0.384	0.403	0.403	0.403
2009	0.047	0.223	0.324	0.34	0.317	0.288	0.32	0.323	0.365	0.383	0.383	0.383
2010	0.043	0.203	0.296	0.31	0.289	0.263	0.292	0.295	0.333	0.35	0.35	0.35
2011	0.04	0.19	0.276	0.289	0.27	0.246	0.273	0.275	0.311	0.327	0.327	0.327
2012	0.04	0.188	0.274	0.287	0.268	0.244	0.271	0.273	0.308	0.324	0.324	0.324
2013	0.045	0.211	0.308	0.322	0.301	0.273	0.304	0.306	0.346	0.364	0.364	0.364
2014	0.034	0.162	0.235	0.247	0.23	0.209	0.232	0.234	0.265	0.278	0.278	0.278
2015	0.033	0.157	0.228	0.239	0.223	0.203	0.225	0.227	0.257	0.27	0.27	0.27
2016	0.031	0.145	0.211	0.221	0.206	0.187	0.208	0.21	0.237	0.249	0.249	0.249
2017	0.025	0.116	0.17	0.178	0.166	0.151	0.168	0.169	0.191	0.201	0.201	0.201
2018	0.03	0.144	0.21	0.22	0.205	0.186	0.207	0.209	0.236	0.248	0.248	0.248
2019	0.03	0.14	0.204	0.213	0.199	0.181	0.201	0.203	0.229	0.241	0.241	0.241
2020	0.025	0.117	0.17	0.178	0.166	0.151	0.168	0.169	0.191	0.201	0.201	0.201
2021	0.034	0.159	0.231	0.242	0.226	0.205	0.228	0.23	0.26	0.274	0.274	0.274
2022	0.038	0.181	0.263	0.275	0.257	0.234	0.26	0.262	0.296	0.311	0.311	0.311

Table 8.11. Mohns rho for the 5 models compared as candidate assessment model. The value is based on assessment years 2017–2021. Oldsetting is the adopted model today.

model	B4+	ssb	N3	hr	f4-9
Oldsettings	0.043	0.101	-0.074	-0.054	-0.084
Sameepsreweight	0	0.079	-0.086	-0.031	-0.064
eps01reweight	0.056	0.146	-0.085	-0.073	-0.106
surveyCV	0	0.068	-0.122	-0.029	-0.059
SurAge314eps01	0.02	0.076	-0.135	-0.039	-0.067

Table 8.12. Bias, CV and Mohns rho for the 5 models compared as candidate assessment model based on “converged assessment” i.e. results from assessment years 2000–2017 compared to results for same years from the 2021 assessment.

Parameter	Model	Bias	CV	Mohns rho
B4+	Oldsettings	-0.071	0.2	-0.051
B4+	Sameepsreweight	-0.113	0.22	-0.087
B4+	eps01reweight	-0.053	0.253	-0.022
B4+	surveyCV	0.028	0.222	0.053
B4+	SurAge314eps01	-0.17	0.232	-0.136
F4-9	Oldsettings	0.042	0.224	0.068
F4-9	Sameepsreweight	0.069	0.248	0.104
F4-9	eps01reweight	0.013	0.283	0.053
F4-9	surveyCV	-0.034	0.219	-0.01
F4-9	SurAge314eps01	0.136	0.265	0.185
hr	Oldsettings	0.035	0.187	0.053
hr	Sameepsreweight	0.057	0.199	0.079
hr	eps01reweight	0.009	0.232	0.035
hr	surveyCV	-0.036	0.195	-0.018
hr	SurAge314eps01	0.108	0.213	0.139
N3	Oldsettings	-0.302	0.383	-0.211
N3	Sameepsreweight	-0.352	0.323	-0.261
N3	eps01reweight	-0.328	0.333	-0.242
N3	surveyCV	-0.217	0.353	-0.147
N3	SurAge314eps01	-0.398	0.332	-0.293
ssb	Oldsettings	-0.087	0.25	-0.057
ssb	Sameepsreweight	-0.112	0.286	-0.072
ssb	eps01reweight	-0.054	0.326	-0.005
ssb	surveyCV	0.016	0.267	0.05
ssb	SurAge314eps01	-0.198	0.306	-0.145

Table 8.13. Saithe in Division 5.a. Output from short-term projections.

2021			
B4+	SSB	Fbar	Landings
382	221	0.215	69.8

2022				**2023**		
B4+	SSB	F_{bar}	Landings	B4+	SSB	Rationale
374	213	0.245	77.1	343	193	20% HCR

20% HCR = average between 0.2 B4+ (current year) and last year's TAC

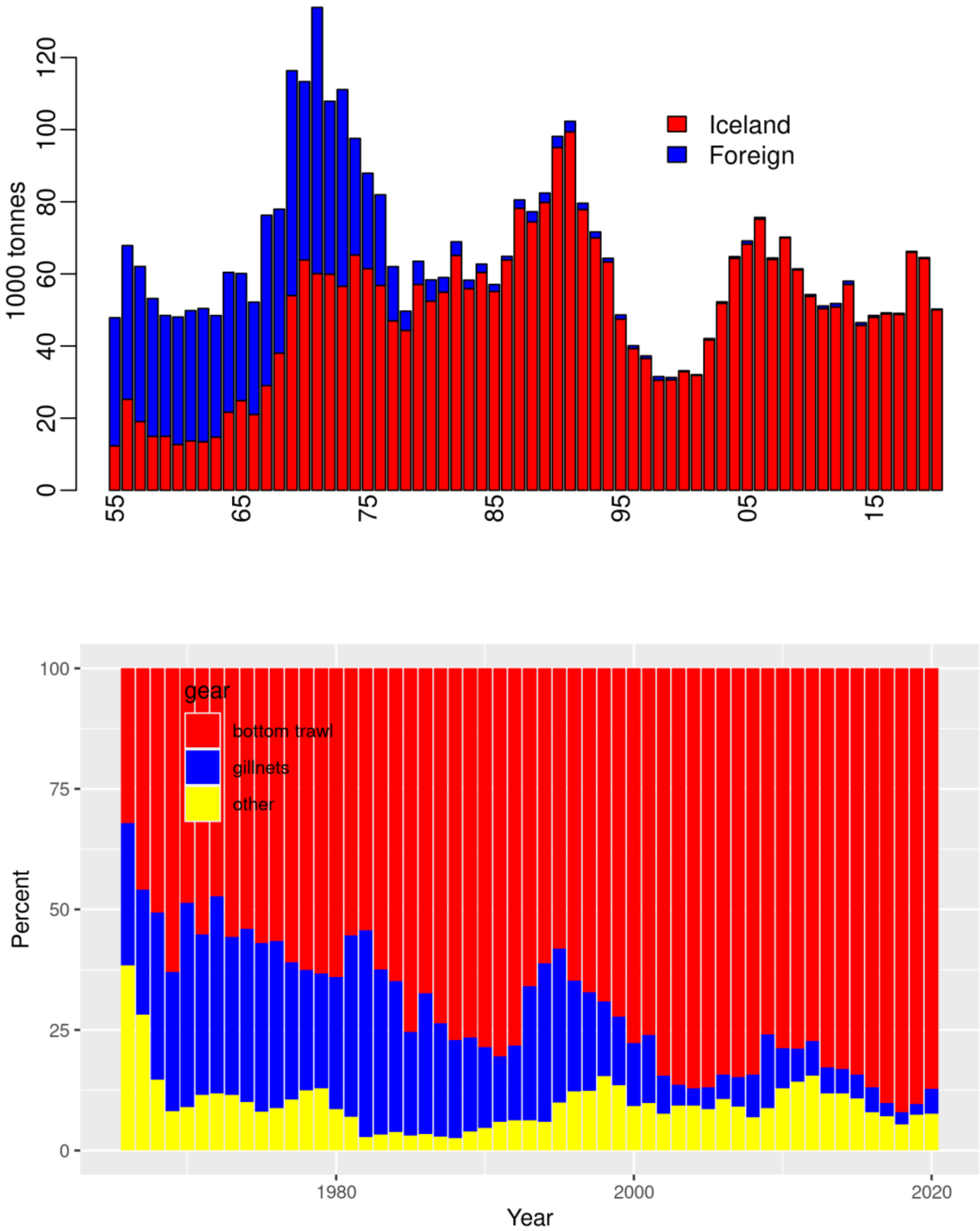


Figure 8.1 Saithe in Division 5.a. Total landings and percent by gear.

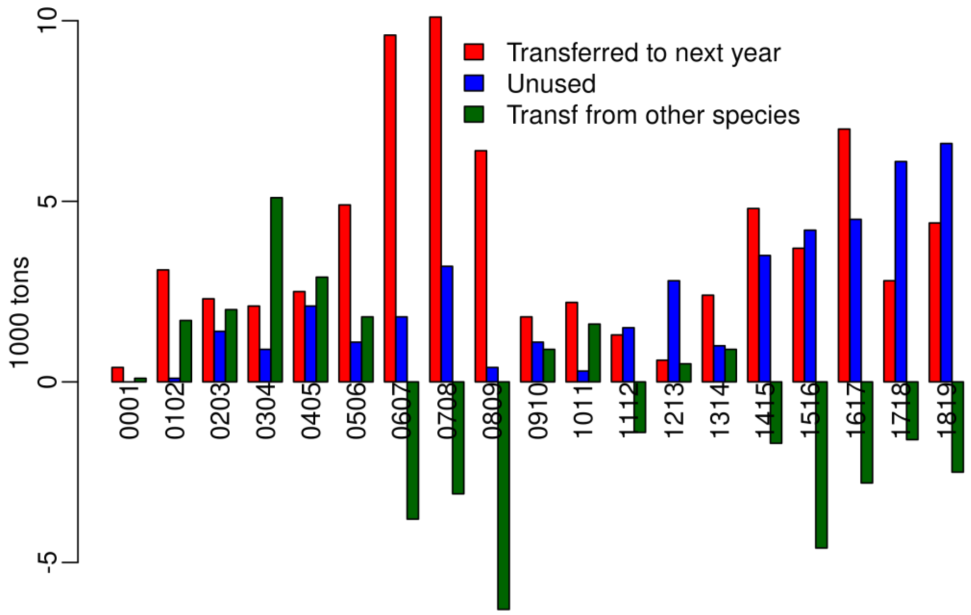


Figure 8.2 Saithe in Division 5.a. Upper figure. Cumulative landings in the current fishing year (left) and calendar year (right). The vertical (green line) in the left figure shows the quota for the current fishing year. Lower figure. Transfer of quota to next fishing year, unused quota and transfer from other species (negative transfer from other species means transfer to other species).

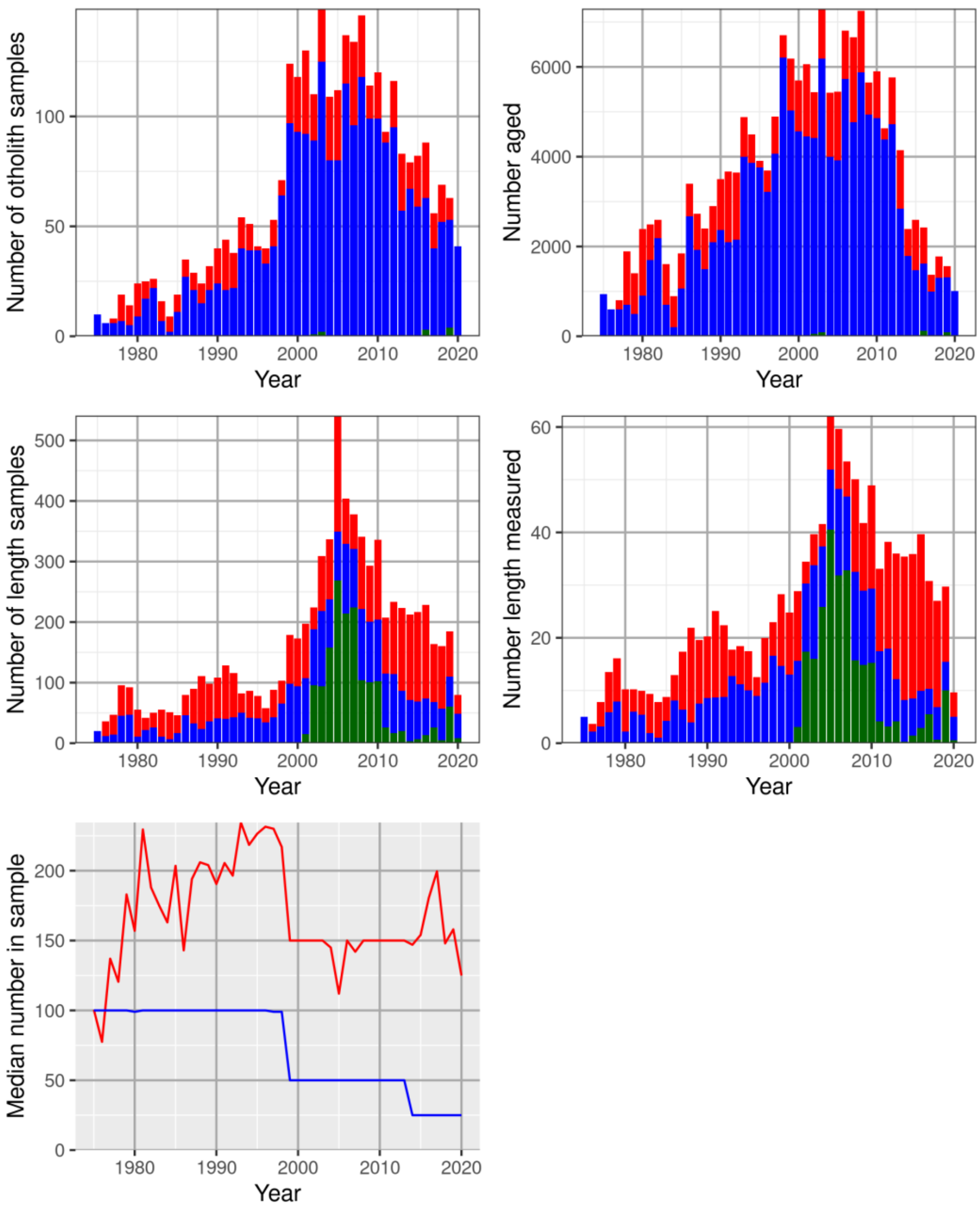


Figure 8.3 Saithe in Division 5.a. Development of sampling intensity from catches.

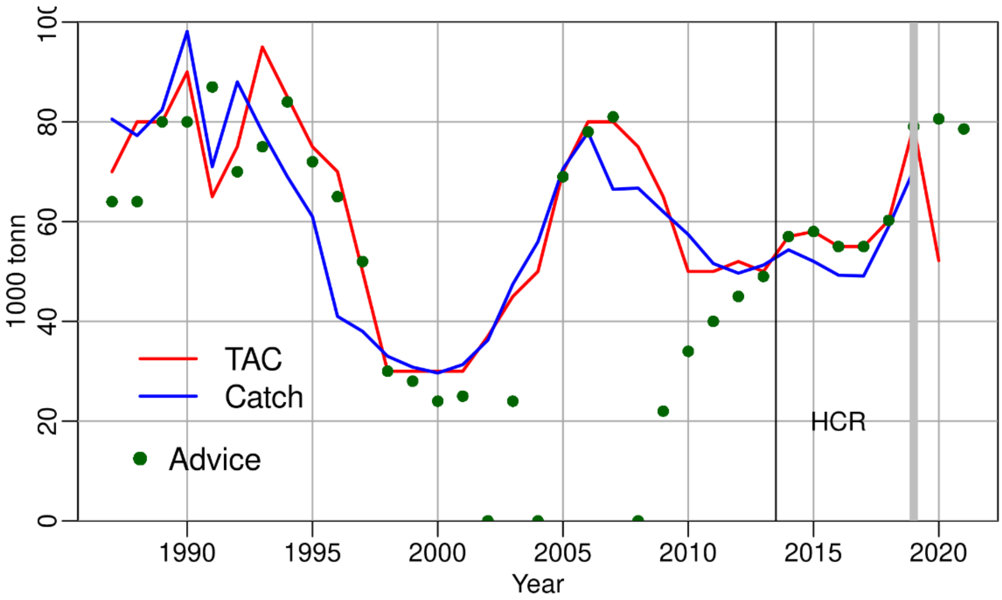
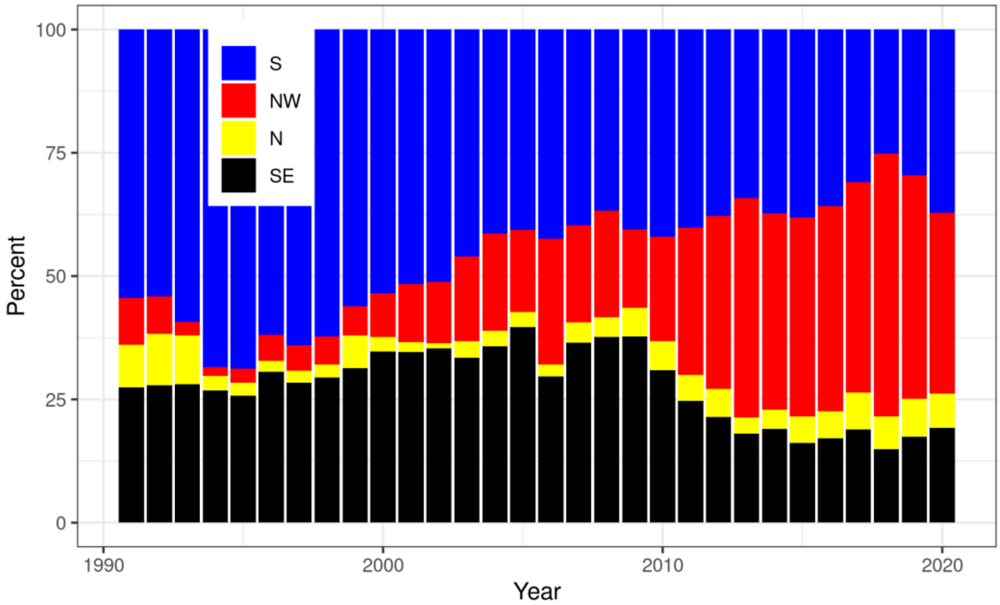


Figure 8.4. Advice, TAC and catch of saithe since 1987.



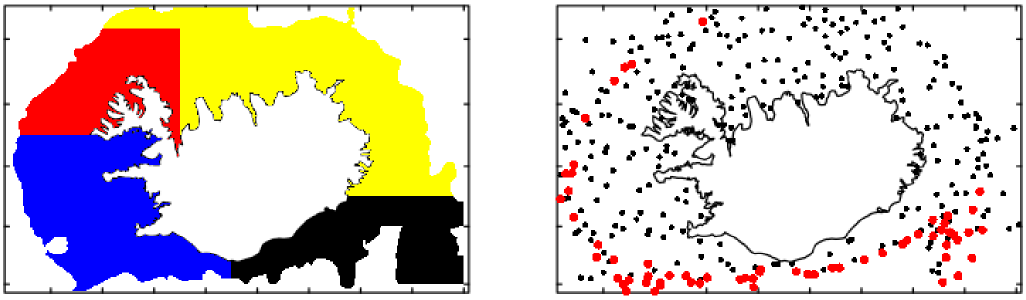


Figure 8.5. Saithe in Division 5.a. Upper figure percent of landings by regions defined in the lower figure to the left. Lower right, stations added in the autumn survey in 2000 (red dots).

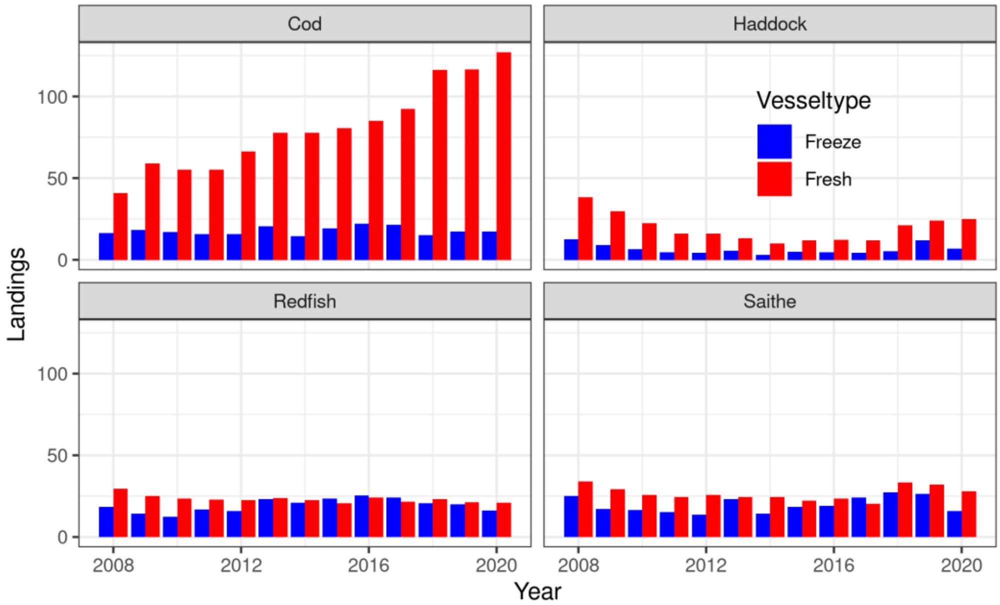


Figure 8.6 Saithe in Division 5.a. Catch by trawlers divided between those that freeze the catch and those that do not. Number of trawlers landing more than 500 tonnes has been reducing gradually from 42 in 2008 to 33 in 2020. Freezing trawlers landing > 500 tonnes were 26 in 2008 but 9 in 2020.

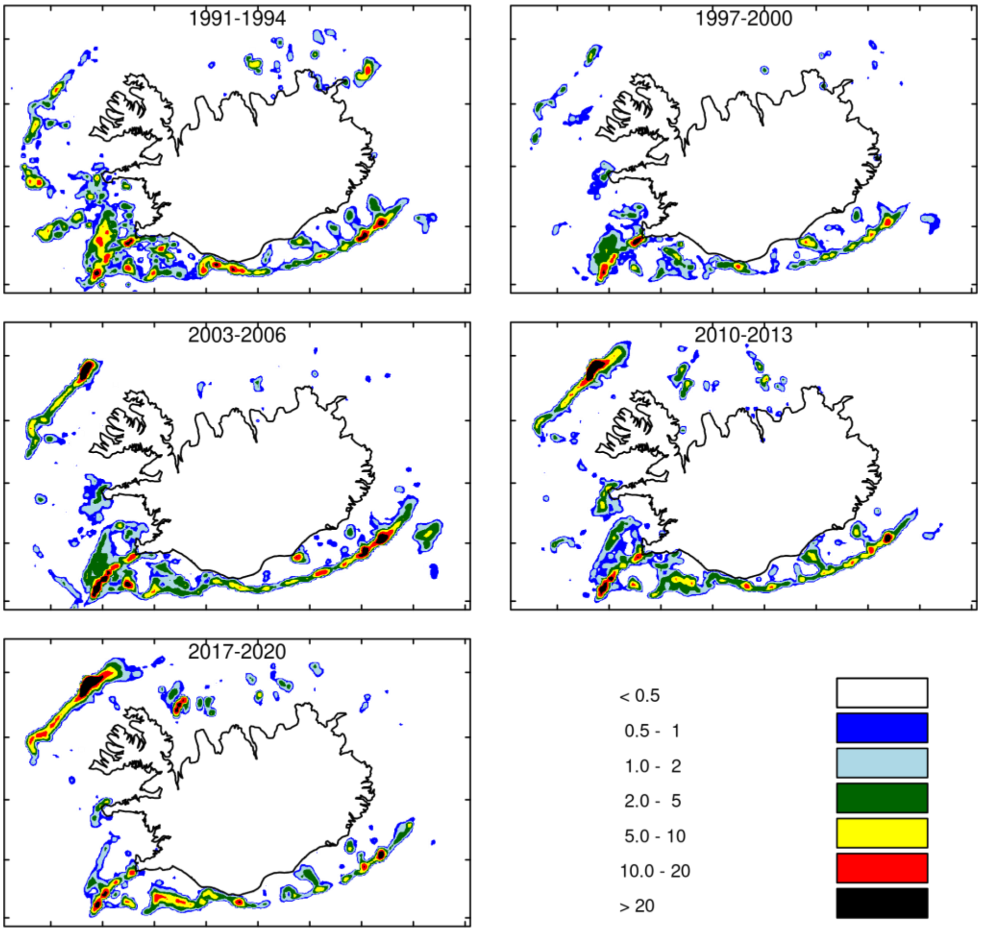


Figure 8.7. Spatial distribution of saithe catch as tonnes per square nautical mile per year.

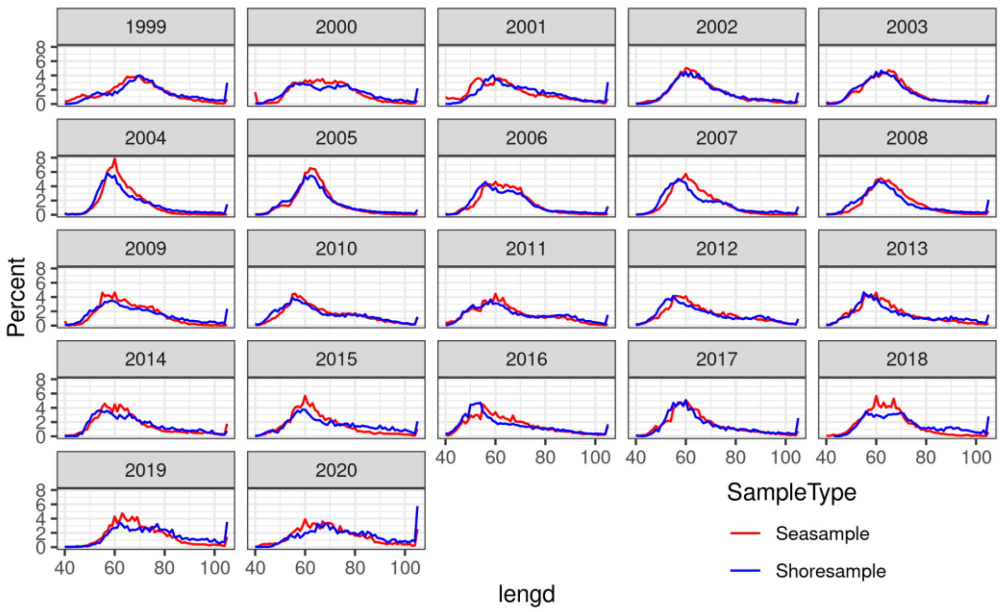


Figure 8.8. Length distributions from sea and shore samples.

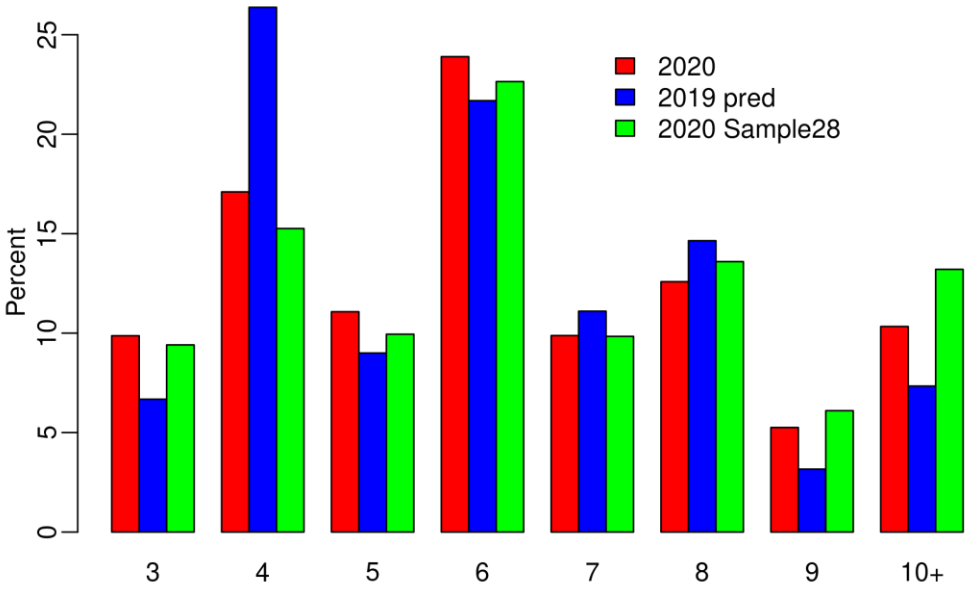


Figure 8.9. Catch in numbers 2020 compared to last year's prediction. The green bars show catch in numbers only based on shore samples.

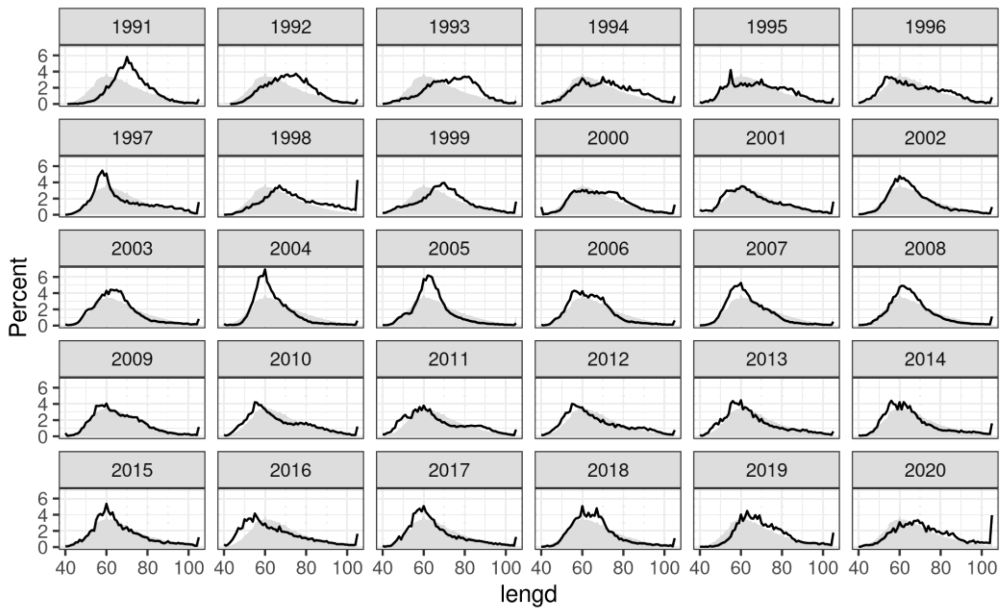


Figure 8.10. Length distributions from bottom trawl catches (lines) compared to average (grey shading).

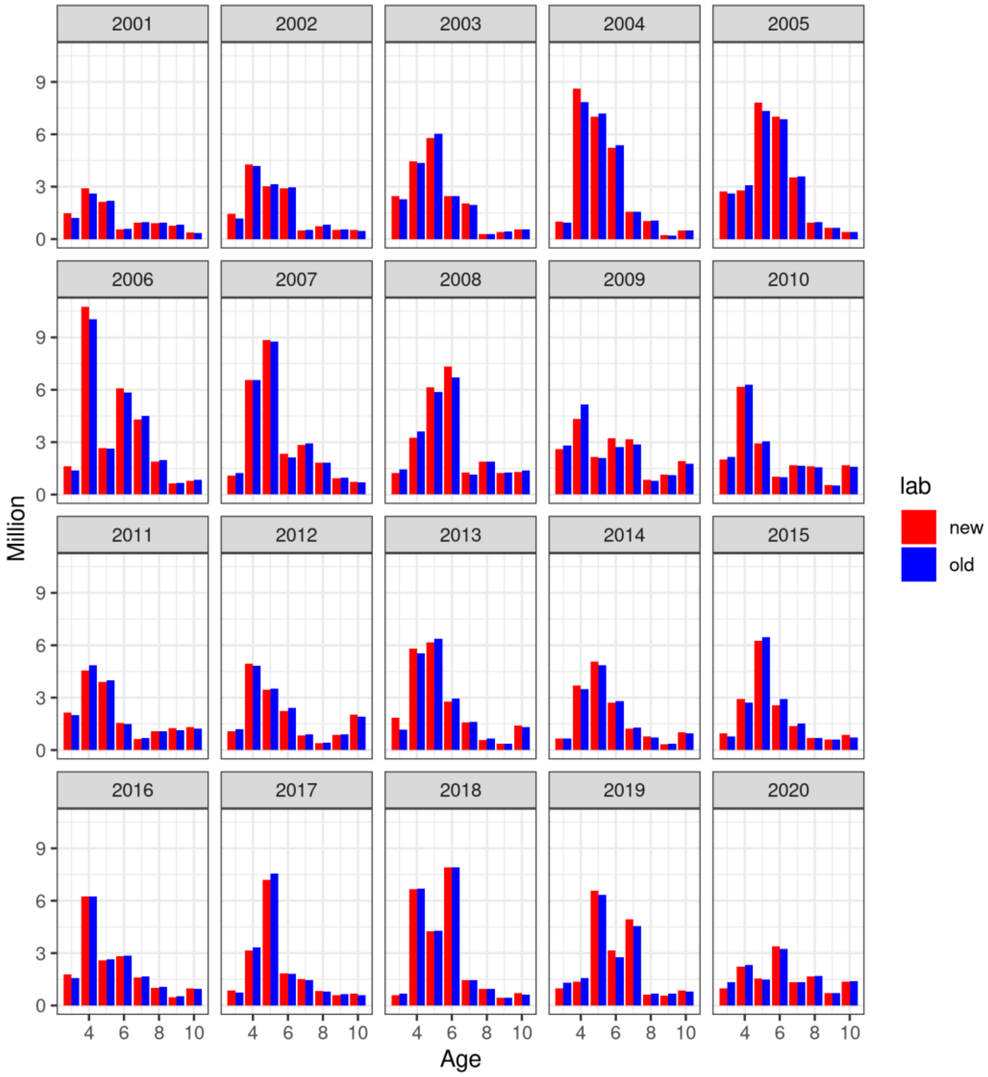


Figure 8.11. Catch in numbers 2000–2020 compiled by 1 region and 1 time interval (old) compared to catch in numbers compiled by 2 regions and 2 time interval (new). The regions are shown in Figure 8.6, north red and yellow and south blue and black.

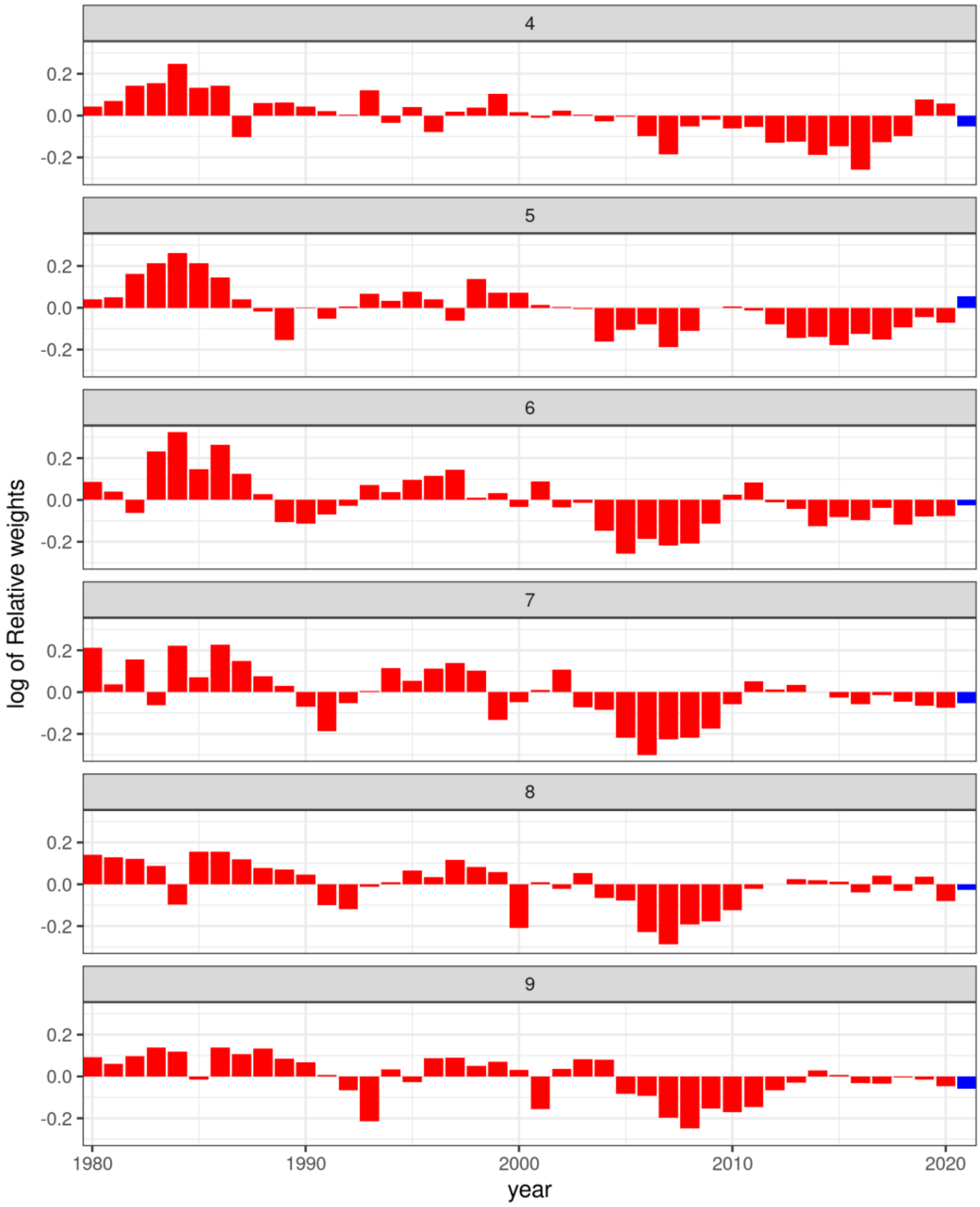


Figure 8.12. Saithe in Division 5.a. Weight at age in the catches, as relative deviations from the mean. Blue bars show prediction.

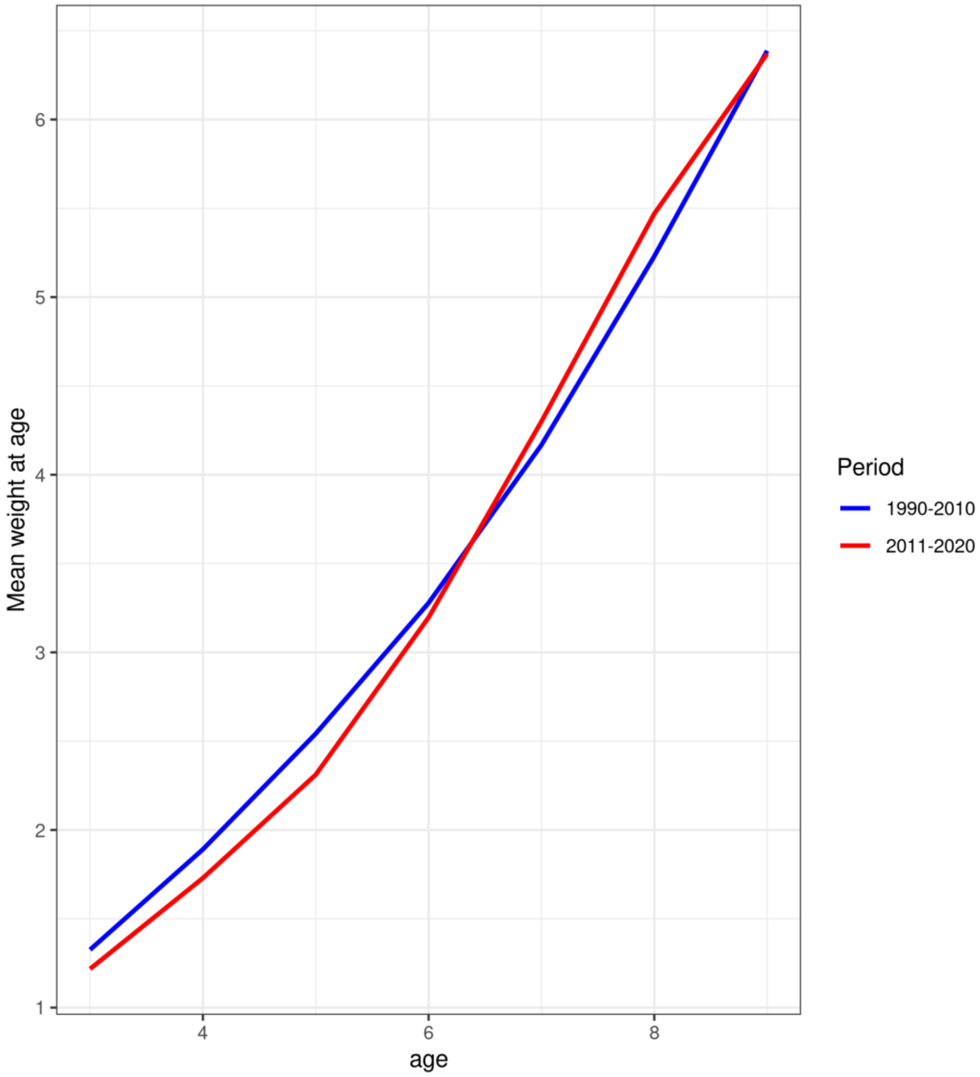


Figure 8.13. Saithe in Division 5.a. Weight at age in the catches shown as average for 2 periods.

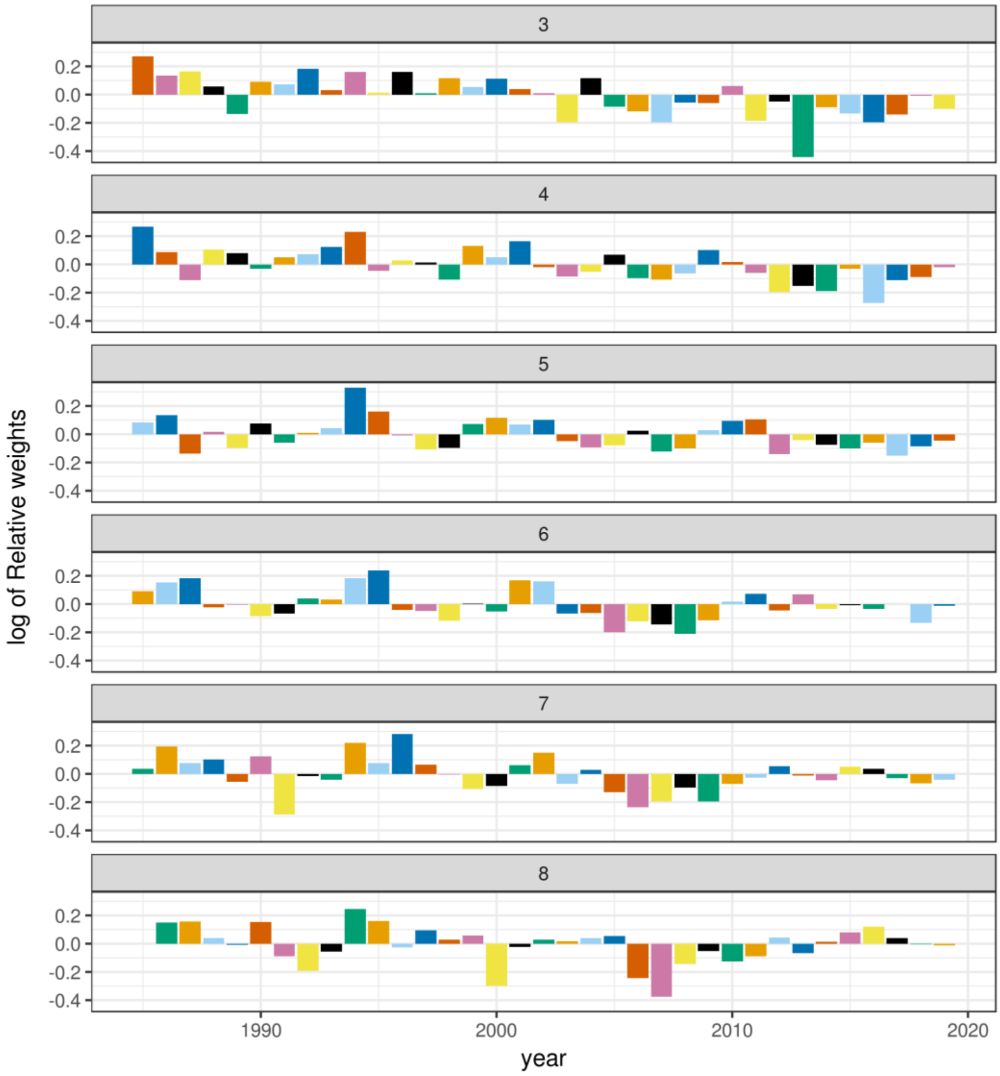


Figure 8.14 Saithe in Division 5.a. Weight at age in the survey, as relative deviations from the mean. Colours can be used to follow year classes.

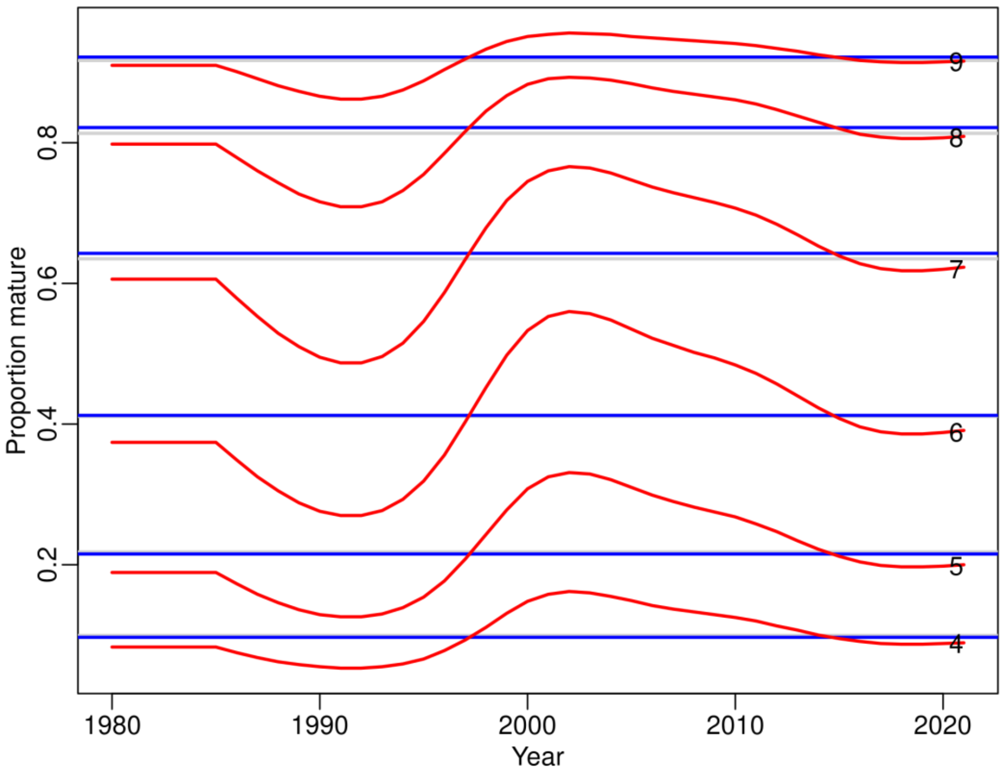


Figure 8.15. Saithe in Division 5.a. Maturity at age used for calculating the SSB. The horizonal lines show the average of last 10 years (blue one) and the average since 1985.

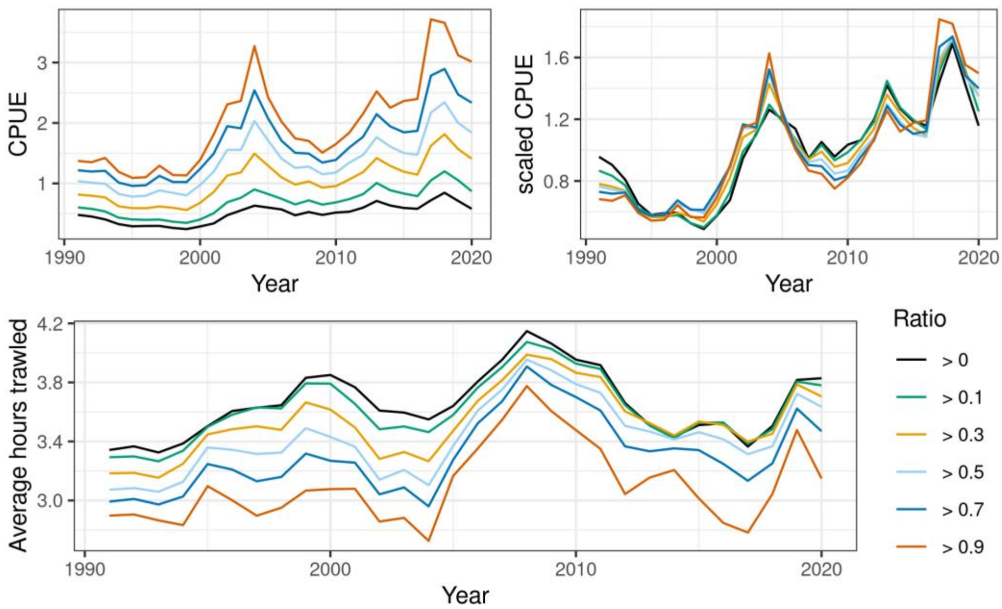


Figure 8.16. CPUE, CPUE scaled to an average of 1 and average numbers of hour trawled. Different colours indicate selection of tows where proportion of saithe of the total catch exceeds certain specified value.

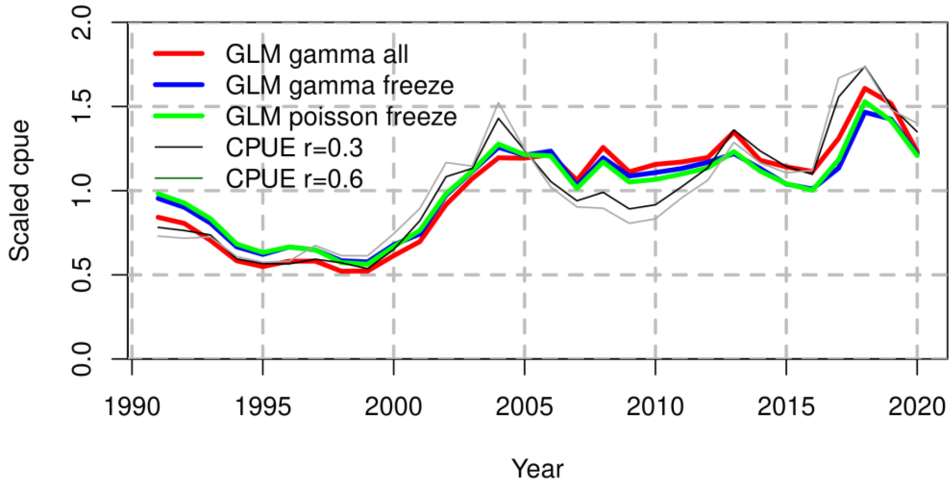


Figure 8.17. CPUE compiled from 3 different models compared to CPUE compiled in similar way as shown in figure 8.16. All curves scaled to an average of 1.

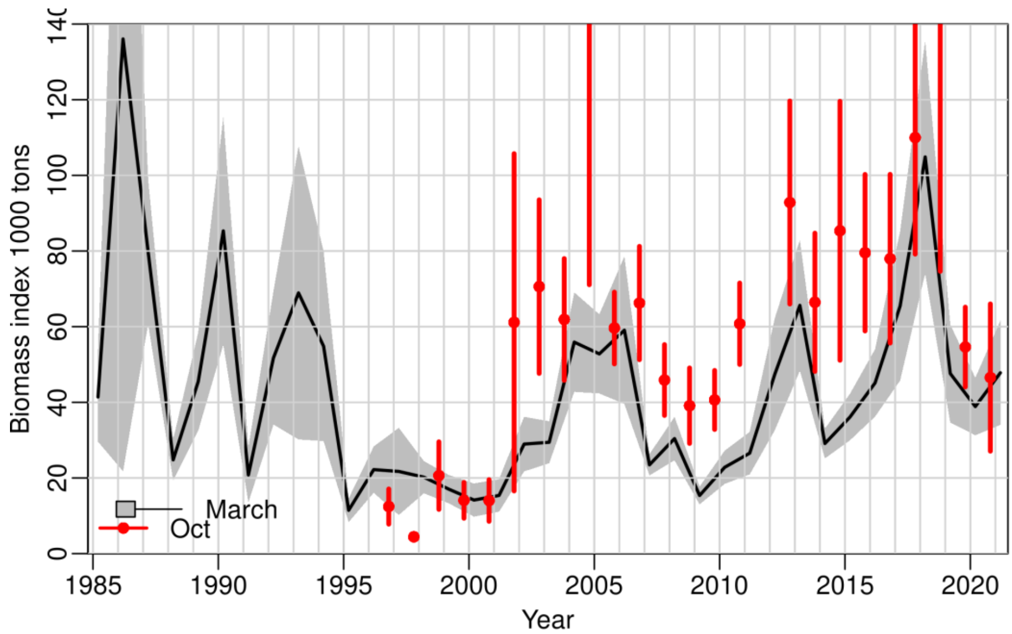


Figure 8.18. Saithe in Division 5.a. Biomass index from the groundfish surveys in March and October.

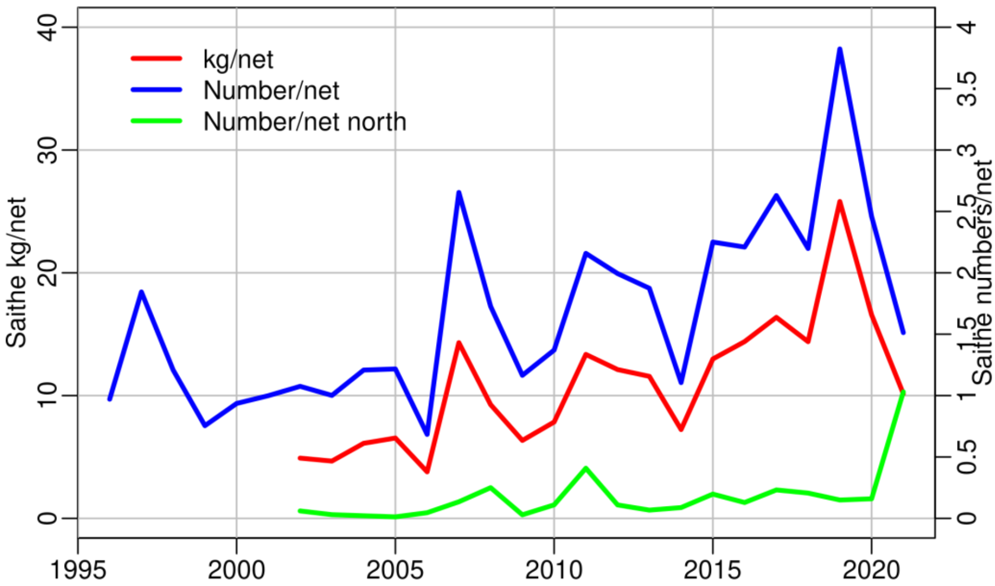


Figure 8.19. Saithe in Division 5.a. Indices from the gillnet survey in April 1996–2018. Saithe was not length measured in the survey before 2002 so catch in kg cannot be compiled. (add 2018)

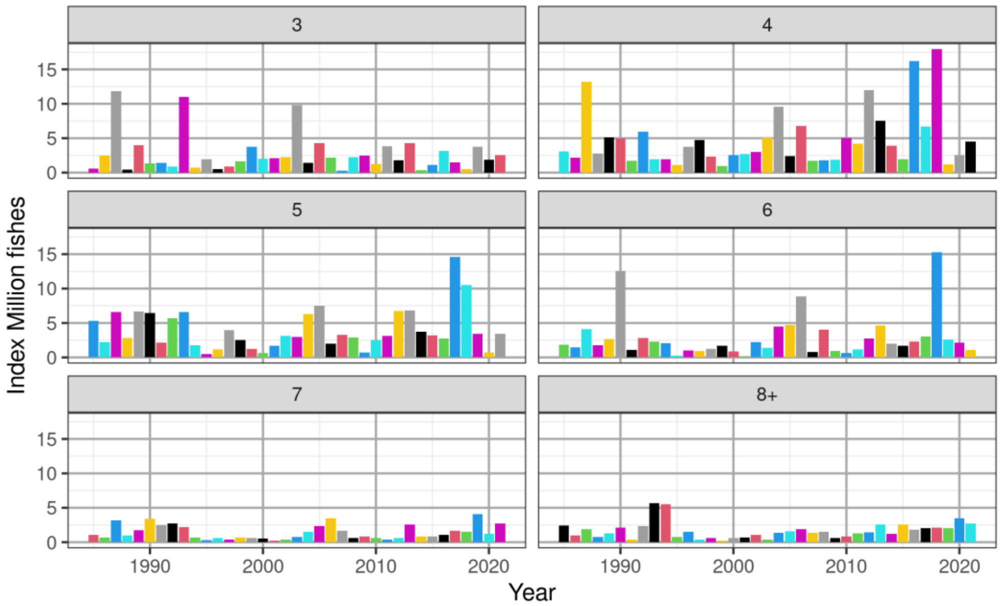


Figure 8.20. Saithe in Division 5.a. Survey indices by age from the spring survey. The colours follows year classes except of course for age 8+.

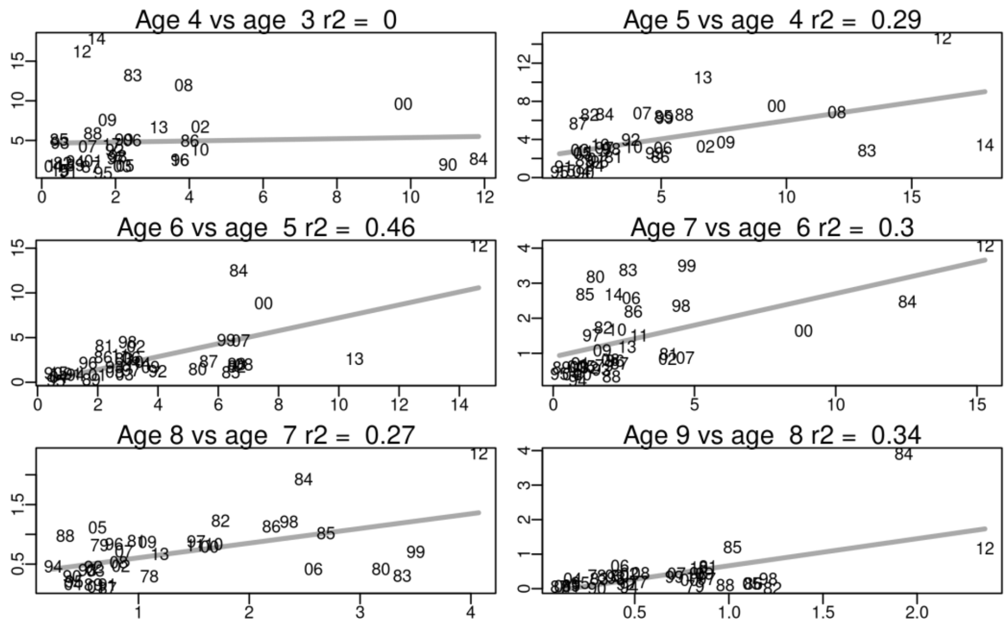


Figure 8.21. Saithe in Division 5.a. Survey indices by age from the spring survey plotted against indices of the same cohort one year earlier.

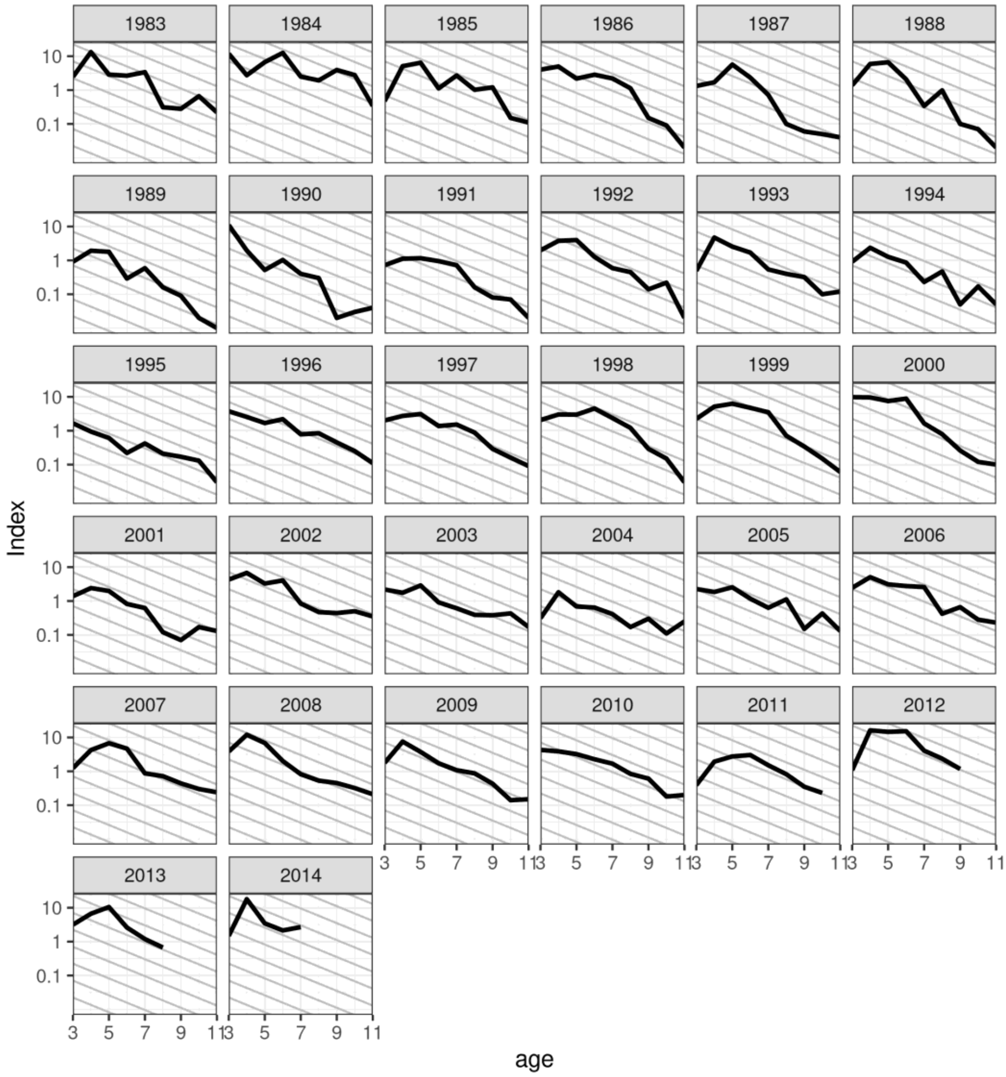


Figure 8.22. Saithe in Division 5.a. Survey indices by age from the spring survey plotted as catch curves for each yearclass. The grey lines correspond to Z=0.5.

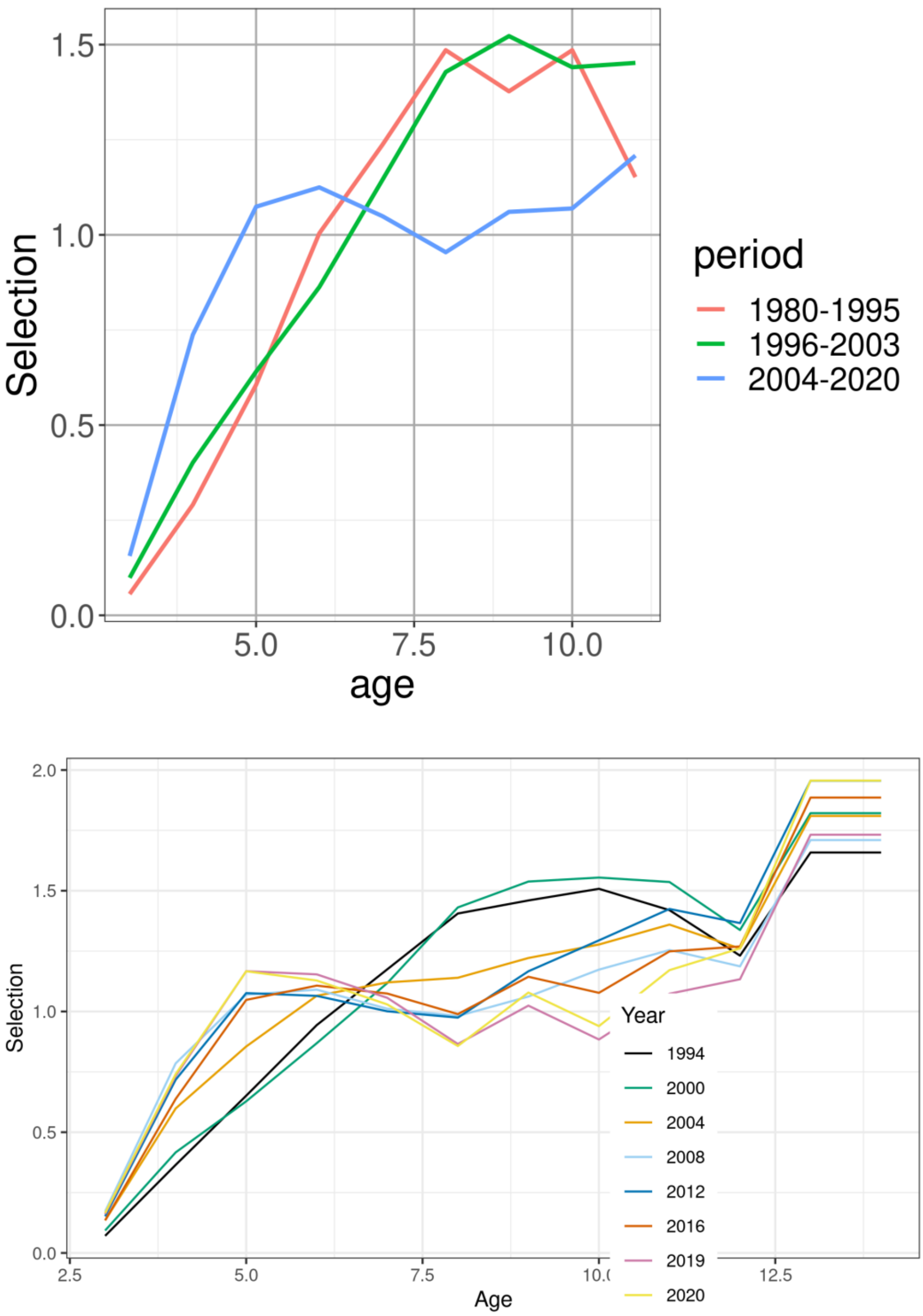


Figure 8.23. Upper figure. Estimated selectivity patterns for the 3 periods, 1980–1996, 1997–2003 and 2004–2020. Lower figure estimated selection from the SAM model. The timing of selection change around 2004 is also evident in the SAM model results.

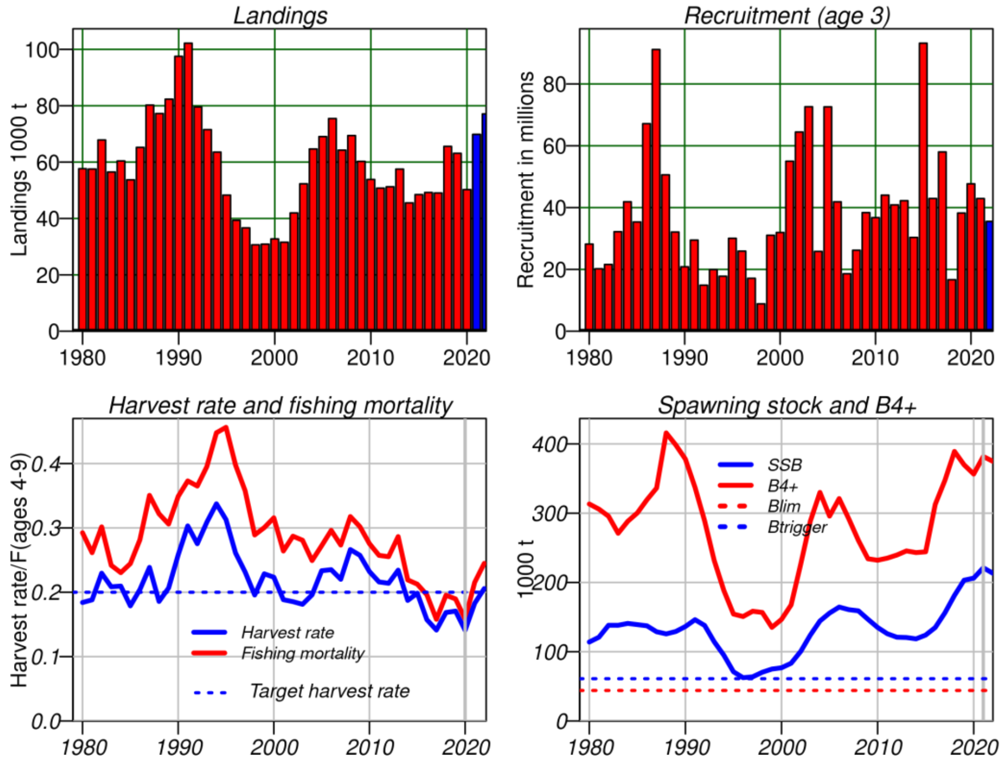


Figure 8.24. Saithe in Division 5.a. Results from the adopted benchmark (SPALY) model and short-term forecast.

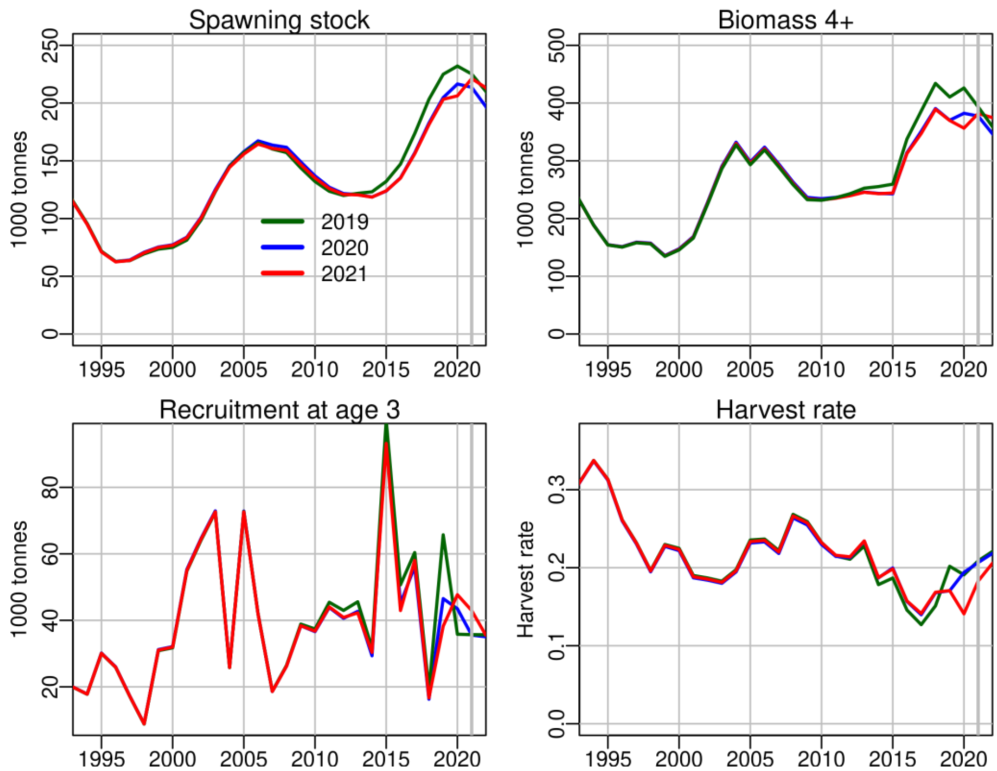


Figure 8.25. Saithe in Division 5.a. Comparison of this year's assessment and short term forecast with results from two earlier years.

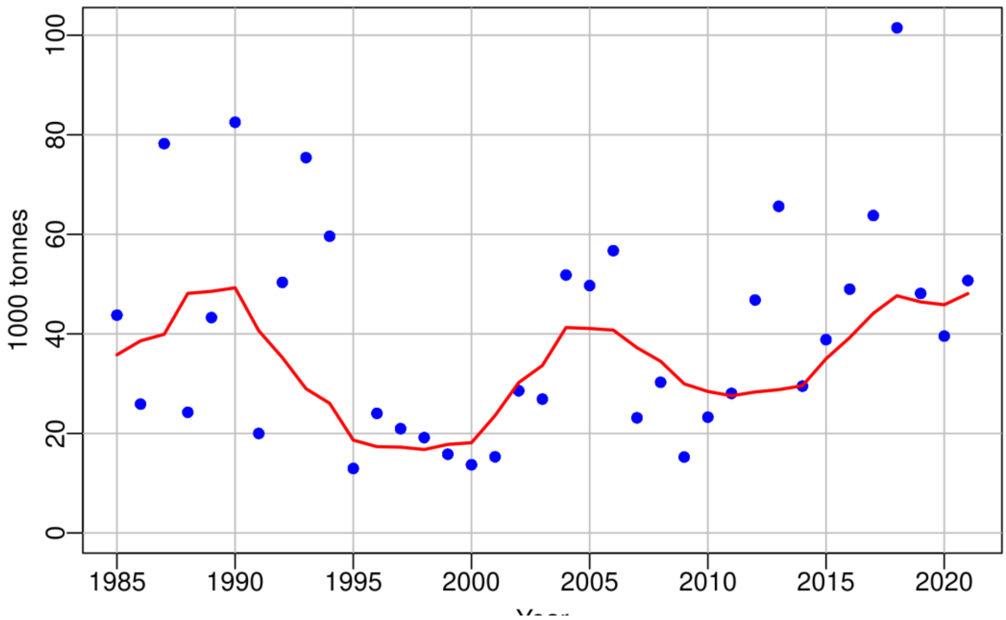


Figure 8.26. Saithe in Division 5.a. Observed and predicted survey biomass from the "SPALY model".

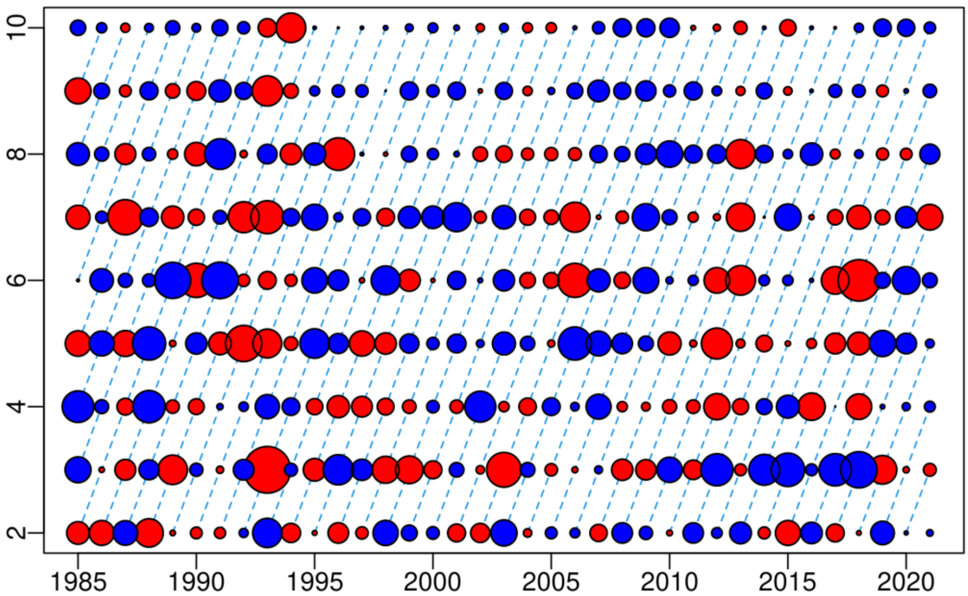


Figure 8.27. Saithe in Division 5.a. Survey residuals from the "SPALY model". The residuals are standardised.

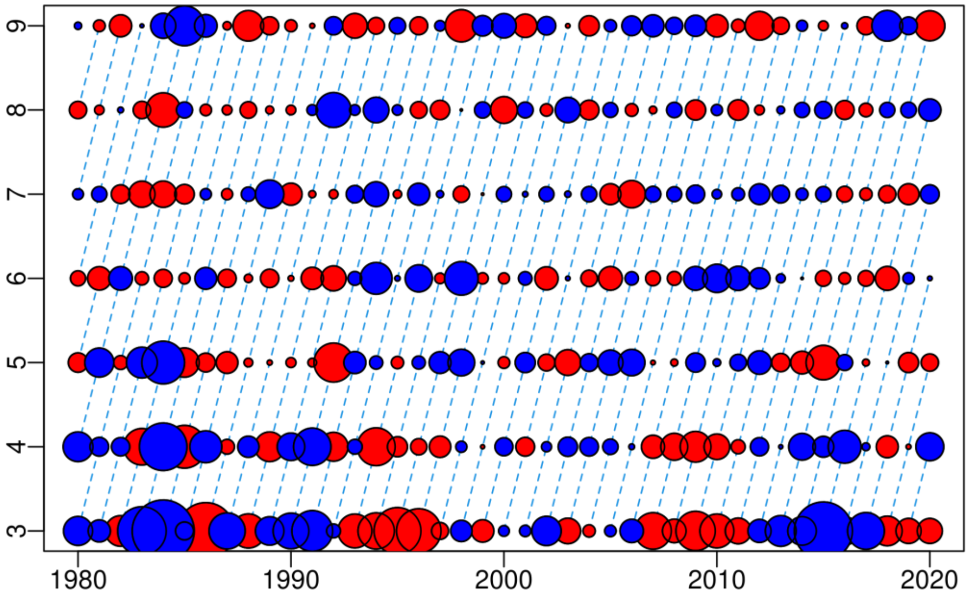


Figure 8.28. Saithe in Division 5.a. Catch residuals from the "SPALY model".

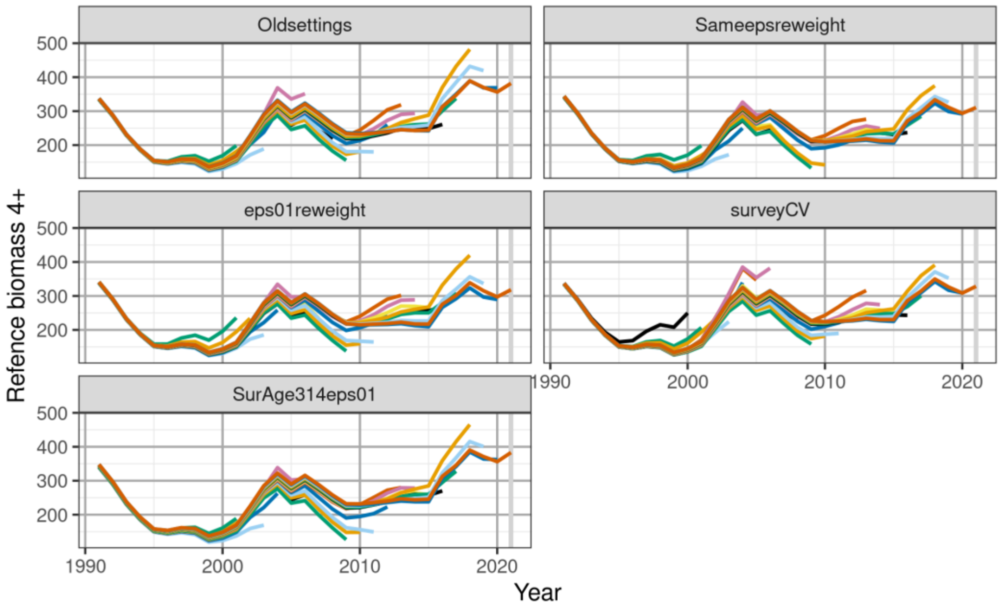


Figure 8.29. Saithe in Division 5.a. Retrospective pattern for the adopted assessment model (Oldsettings) and alternative configurations of the model. The figure shows estimate of B4+, the metric affecting advised catch. The grey vertical lines show the year 2021.

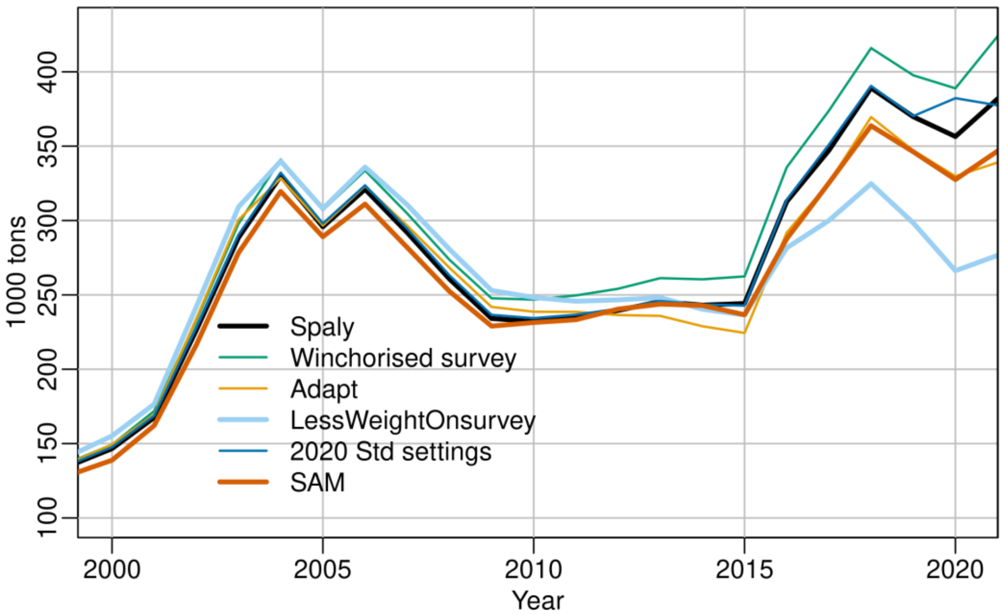


Figure 8.30. Saithe in Division 5.a. Comparison between the default separable model (Muppet) and alternative assessment model settings.

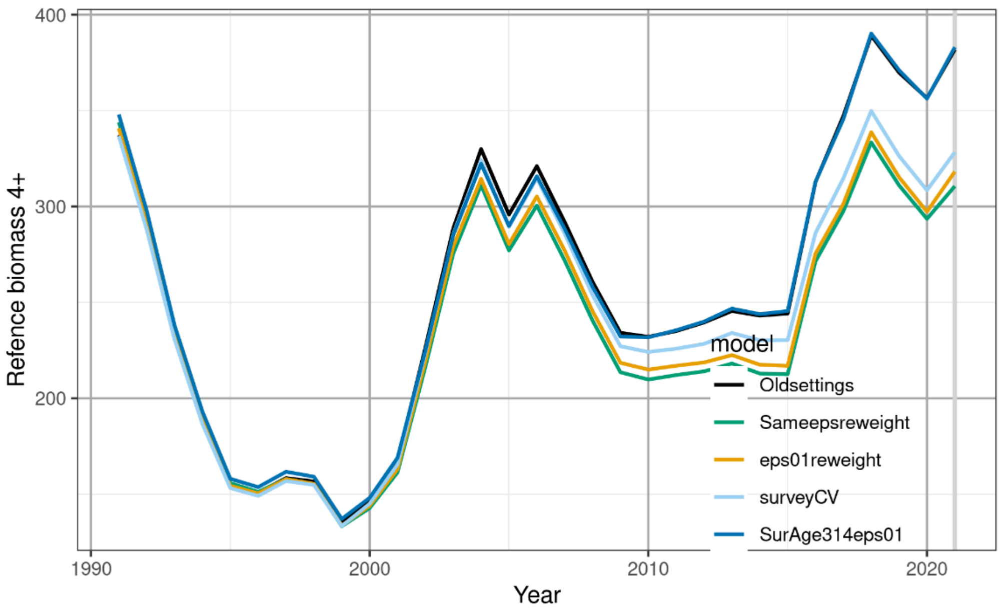


Figure 8.31. Saithe in Division 5a. Comparison between 2021 assessment results of the models shown in Figure 8.29.

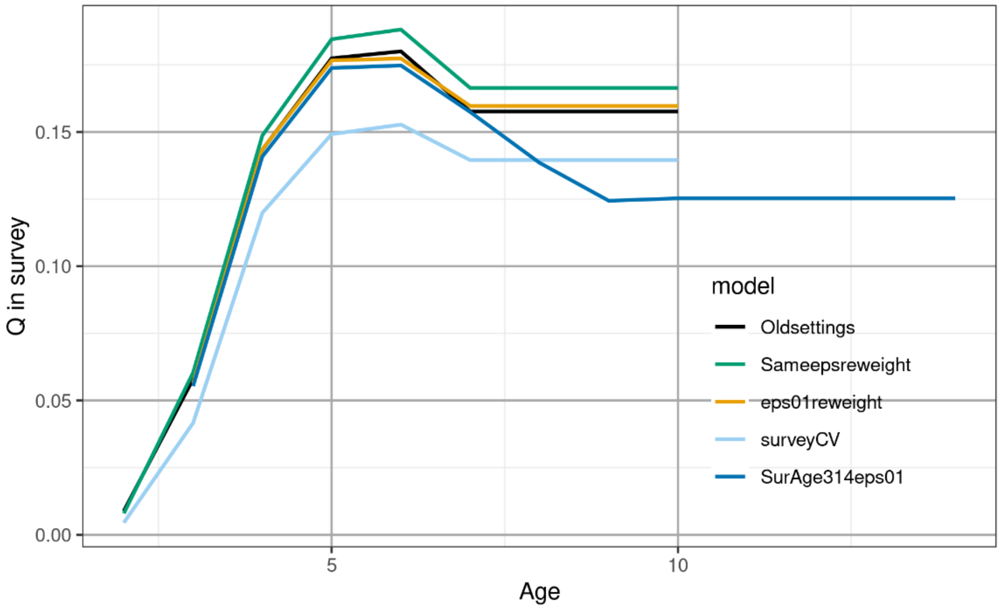


Figure 8.32. Saithe in Division 5a. Q by age in the March survey for the different models.

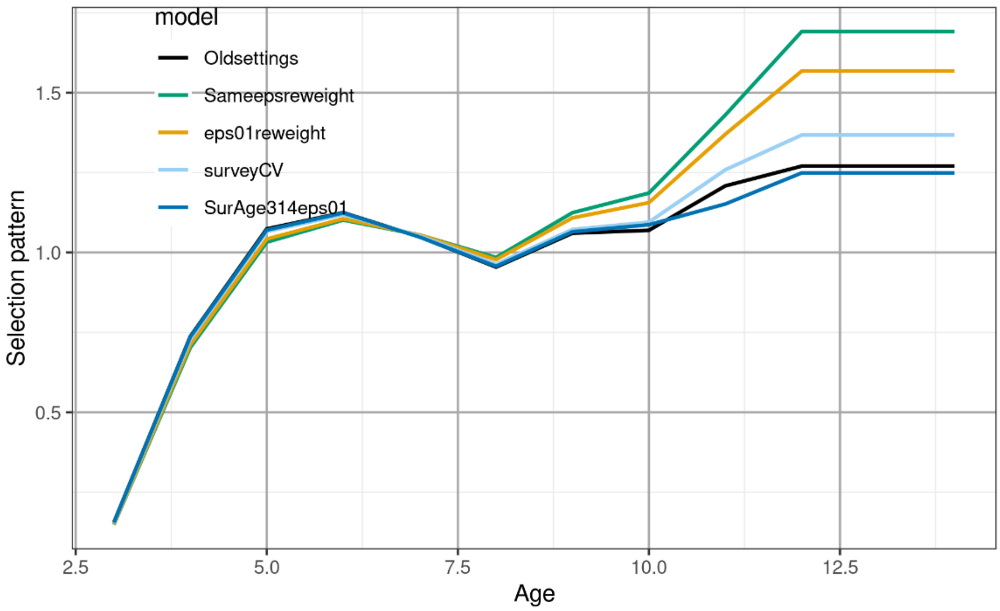


Figure 8.33. Saithe in Division 5a. Selection by age 2004–2021 for the different models.

9 Icelandic cod in 5.a

9.1 Overview

A formal HCR to set the TAC has been in place for this stock since 1994. The primary essence of the rule is that the TAC for the next fishing year (starting 1 September in the assessment year and ending 31 August next year) is based on a multiplier on the reference biomass of four years and older in the assessment year (B_{4+}).

The rule has gone through some amendments and revisions over time. The last significant change occurred in 2007, when the harvest rate multiplier upon which the TAC for the next fishing season is based was changed from 0.25 to 0.20. The current rule has in addition a catch stabilizer. When the SSB in the assessment year is estimated to be above $SSB_{trigger}$ (220 kt) the decision rule is:

$$TAC_{y/y+1} = (0.20 * B_{4+,y} + TAC_{y-1/y})/2$$

The TAC for the current fishing year (2020/2021) based on last year's assessment was 256.593 kt.

The results of this year's assessment show that the spawning stock in 2021 is estimated to be 361.348 kt. The values estimated in recent years are higher than have been observed during the last five decades. The reference biomass B_{4+} in 2021 is estimated to be 940.767 kt. Fishing mortality is 0.43 in 2020 having declined significantly in recent decades due to management action. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around 34% lower than observed in the period 1955 to 1985.

Given the above HCR rule and the estimated reference biomass in the beginning of 2021 the catch for the coming fishing year (2021/2021) is 222.373 kt based on the following:

$$TAC_{2021/2022} = (0.20 * 940.767_{2021} + 256.593_{2020/2021})/2 = 222.373kt$$

Following the benchmark 2021 the assessment upon which the advice is based is approximately 20% lower than based on setting prior to the benchmark. This in part is reflected in somewhat higher harvest rate than intended although it is still within the range expected in the HCR simulation.

The input in the analytical age-based assessment are catch at age 1955–2020 (age 3 to 14) and ages 1 to 14 (from the 1985–2021 spring (often referred to as SMB in this report) and ages 1 to 13 from the 1996–2020 fall groundfish surveys (often referred to as SMH in this report).

9.2 Some elaborations

9.2.1 Data

The data used for assessing Icelandic cod are landings and catch-at-age composition since 1955 and indices from two standardized bottom trawl surveys. The spring survey (SMB) was instigated in 1985, the fall survey (SMH) in 1996.

The sampling programs i.e log books, surveys, sampling from landings etc. have been described in previous reports.

9.2.1.1 Landings

Landings of Icelandic cod in 2020 are estimated to have been 270.303 kt, the bulk taken by the Icelandic fleet.

The share of the catch by different gears in 2020 is according to the following in-text table:

gear	p
Long line	0.26
Gill net	0.07
Jiggers	0.06
Scottish seine	0.06
Bottom trawl	0.55

The estimates of landings for the current calendar year of 247 kt is based on the remainder of the quota from the current fishing year (2020/21, 257 kt) on 1 January 2021 (170 kt), the catch that is expected to be taken from 1. September to 31. December 2021 (74 kt, 1/3rd of the advised TAC of 222 kt) and the expected catch of the foreign fleet (3 kt).

Mean annual discard of cod over the period 2001–2012 is around 1% of landings in weight (Ólafur Pálsson *et al*., 2013). More recent (unpublished) data indicate that discarding may have increased. The method used for deriving these estimates assumes that discarding only occurs as high grading.

9.2.1.2 Catch in numbers and weight at age

Catch in numbers by age: The method for deriving the catch at age (Table 3.1) is based on 20 metiers: two areas (north and south), two seasons (January–May and June–December) and five fleets (bottom trawl, longline, hooks (jiggers), gillnet and Danish seine).

In recent decades, the composition of the catch in weights has shifted towards older ages, e.g. age 8 and older where generally less than 25% of the catch prior to 2007 while in the last 4 years it has been above 40% of the catch. The increase in ages 11 to 14 have increased even more, being less than 2.5% of the caches prior to 2010 to above 10% of the catches in the last two years.

Mean weight at age in the landings: The mean weight age in the catch (Table 3.2 and Figure 3.2) declined from 2001 to 2007, reaching then a historical low in many age groups. The weight at age have been increasing in recent years and are in 2020 just under the average weights observed over the period from 1985 and close to the long term mean (1955–2020) in the most important age groups. The variation in the pattern of weight at age in the catches is in part a reflection of the variation in the weight in the stock as seen in the measurements from the spring survey (Table 3.3 and Figure 3.3).

Prediction of catch weights in 2021: The reference biomass (B_{4+}) upon which the TAC in the fishing year is set is derived from population numbers and catch weights in the beginning of the assessment year. In recent years, the estimates of mean weights in the catch of age groups 3–9 in the assessment years (y) have been based on a prediction from the spring survey weight measurements in that year using the slope (β) and the intercept (α) from a linear relationship between survey and catch weights in preceding year ($y-1$}. The same approach was used this year for predicting weight at age in the catches for 2021 (Figure 9.3). I.e. the α and β were estimated from:

$$cW_{a,y-1} = \alpha + \beta * sW_{a,y-1}$$

and the catch weights for 2021 then from:

$$cW_{a,y} = alpha + beta * sW_{a,y}$$

Based on this the mean weights at age in the catches in 2021 are predicted to be around average (Figure 9.1.b. and Table 3.2). For ages 10 and older, the weights from the previous year are used.

Weight and maturity at age used in the calculation of SSB are presented in Tables 3.4 and 3.5.

9.2.1.3 Surveys

Length based indices: The total spring (SMB) and fall survey (SMH) measurements decreased significantly from the highest value observed in 2017 to the 2020 measurement (Figure 3.5). The 2021 spring survey measurement was however more optimistic, being on par with that observed in 2018 and 2019.

The 2020 spring survey measurement indicate that the abundance in 2020 is below the average of the last 6 years for length classes 35 to 90 cm (Figure 3.6). Although the 2016 year-class (approximately 50 cm mean length in year 2020) was expected to be low and although year effects in survey measurements are known, the 2020 survey measurements are substantially below for size classes that constitute the bulk of the fish-able biomass. The 2021 measurements were more in line with the expectations indicating that the spring survey in 2020 may have been a large negative anomaly.

Age based indices: Abundance indices by age from the spring and the fall surveys (Tables 3.6 and 3.7). Indices of older fish are all relatively high in recent decade despite the indices of these year classes when younger are low or moderate in size (Figure 3.7). The 2020 spring survey anomaly are clearly apparent, e.g. for year-classes 2014 and 2015 that are around the long term average in 2019 (then ages 4 and 5) but roughly half of that in 2020 (then ages 5 and 6). In the 2021 survey these year classes are however more on par with the 2019 measurement.

The log ratio of spring survey indices principal age groups (Figure 3.8) over time illustrate the anomaly in the measurements in 2019 through 2021 for some selected age groups. Although noisy, the overall pattern over time show a decline in the log-ratio (consistent with long term reduction in mortality), but the between years 2019 and 2020 there is an increase in the ratio, even in the younger age groups that normally are not yet fully selected in to the survey.

9.2.2 The 2020 assessment and the 2021 benchmark

The 2020 domestic assessment: Only domestic advice was provided for this stock in 2020. The advice was bases on an assessment that deviated from the ICES 2015 benchmark by including survey age groups older than 10 in the tuning. This resulted in lower stock estimates and hence advice than the 2015 benchmark setup, largely because the inclusion of the older indices shifted the fisheries selection pattern from being dome shaped to a more logistic type. This interim change however lead to larger retrospective patterns (although within the ICES 0.2 Mohn's rho criterion).

The 2021 benchmark: In conjunction with a 5-year re-evaluation of the HCR the stock was benchmarked in the beginning of 2021 based on data available in 2020 (ICES, 2021).

All the changes had to do with treatment of survey indices in the model:

1. With lower fishing effort the abundance of old age groups increased. For some of those age groups (10+) the number caught had been so low that sampling error related to few otoliths had been the most important uncertainty. Ages 11 and older in the surveys were earlier not used in the tuning as they were minor part of the stock (1-2%). Not including them in the survey lead to "ghostfish" i.e dome shaped selection pattern of the fleet, not an impossible pattern but not acceptable without some proofs, especially when the older fish becomes larger part of the stock. Inclusion of survey indices age 11 and above was already done in the 2020 domestic assessment.

2. For ages 6–9 abundance increased, and nonlinear relationships started to show up, that was not apparent when range of values was smaller. This resulted in ~95 kt (~8%) reduction in biomass in 2020.
3. The relationship between abundance indices of ages 1–3 and older fish changed. The change can either be related to increased mortality or changed behaviour or less coastal spatial distribution. Inclusion of ages 1 and 2 in the survey correlation model (were treated separately before. This resulted in ~50kt (4.1%) reduction in biomass in 2020.
4. The VPA version of Muppet was run and CV in the survey estimated for each age group using a VPA model. That pattern was then used in the separable model with one estimated multiplier. Updated estimates of the survey CV-profile by age. This resulted in ~35 kt (2.8%) reduction in biomass in 2020.
5. An improvement in retrospective pattern was observed when dropping ages 1 and 2 from the fall survey. This resulted in ~30 kt (2.5%) reduction in biomass in 2020.

The sum of the changes itemized in 2.–5. resulted in a change in biomass estimates from 1205 kt to 996 kt in 2020, a reduction of 209 kt or 17%.

Additional information are found in the benchmark report (ICES, 2021)

9.2.3 The 2021 assessment

The framework: A separable statistical catch at age model (sometimes referred to as MUPPET) with four periods where the selection pattern is assumed to be constant. The last separable period is from 2007 to the present. The survey residuals are modeled as multivariate normal distribution to account for potential survey "year effects" - this being a feature in place since 2002. The same framework is used to carry the stock dynamics forward to evaluate reference points and HCR.

Diagnostics: The diagnostic (see Tables 3.8, 3.9 and 3.9 and Figure 3.9) manifest the large negative residuals in the spring survey 2020 for the most important age groups (ages 4 to 8) as observed in the 2020 assessment, while residuals in these age groups in the 2021 are much closer to that observed historically. The spring survey residuals are however anomalously high for age groups 10 years and older in the last two years. As in the spring survey the fall survey residuals in 2020 are generally negative. A summarised diagnostic of the observed vs predicted survey biomass (Figure 3.10) illustrate deviation between the model estimates and the point estimates. There are indication that interannual variability in survey measurements in both surveys has increased in recent years compared with that observed in the past.

Results: The detailed result by age of the assessment are provided in Tables 3.11 and 3.12 and the stock summary in Table 3.13 and Figure 3.11. The reference biomass is estimated to be 940.767 kt in 2021 and the fishing mortality 0.43 in 2020. The first estimates of the 2019 and 2020 year classes indicate that they may be above the average since 2000 although this may not be manifested with future measurements.

Mohn's rho: One of the ToR for this year was to evaluate the retrospective pattern of the assessment (Figure 3.12) and calculate the Mohn's rho values. The default 5-year peels resulted in the following values:

variable	value
fbar	0.035
bio	0.018
ssb	-0.021
rec	0.074

Calculation of Mohn's rho over only a 5-year period **may** not be the best indicator of potential bias in the assessment because:

- The metrics over the short period may be just a reflection of autocorrelation.
- When mortality is low the assessment converges slowly and the metrics using only the most recent years may be heavily influence by the terminal year estimates.

A longer-term metric for the Icelandic cod based on a retrospective going back to 2002 is as follows:

variable	value
fbar	0.020
bio	0.018
ssb	0.010
rec	0.018

Comparison with last year (Figure 3.13)

The reference stock (B_{4+}) in 2020 is now estimated to be 982 kt compared to 1205 kt last year. The SSB in 2020 is now estimated to be 385 kt compared to 486 kt estimated last year. Fishing mortality in 2019 is now estimated 0.39 compared to 0.33 estimated last year. Year classes 2017–2019 were estimated to be 162, 142 and 192 million in last year's assessment and are now estimated to be 143, 131 and 190 million.

9.2.3.1 On reference points

Prior to the 2021 benchmark the ICES reference points that matter for the advice (ICES $B_{trigger}$ and HR_{msy}) were set the same as in the HCR. Other (redundant) fishing pressure reference points were set based on the conventional F (i.e. F_{lim} and F_{pa}). In the 2021 there was a requirement that ICES $B_{trigger}$ should be set in accordance with the guidelines and that fishing pressure reference points should be set in the same units as used in the HCR.

Since this stock has been fished for quite a while at a rate that is closed to that resulting in MSY the ICES $B_{trigger}$ was based on the 5% percentile of SSB with the stabilizer in the HCR was ignored. The resulting value was 265 kt. This may not be the most optimum approach because the influence of incoming age 4 weigh quite high in the B_{4+} reference biomass, something that is actually ameliorated in the HCR that uses a buffer. If an advice is based on no buffer it may be better to base the reference biomass not on catch weights but stock weights, because then the influence of age four would be reduced.

More problematic is however the derivation of HR_{pa} (same would a apply to any F_{pa} derivation), which according to the guidelines is defined based on using the $B_{trigger}$ (265 kt) in the simulation. The actual value became $HR_{pa} = 0.39$. This value is higher than $HR_{lim} = 0.35$, the reason being that the latter is derived in the absence of a $B_{trigger}$ (which was hence conveniently left undefined). On its own, a $HR_{pa} = 0.39$ is quite high, in particular if is going to be presented as a horizontal line on a summary plot. This is said because the value is conditional on the $B_{trigger} = 265kt$ and if applied will result in the stock going frequently below this value, resulting attenuated inter-annual variability in yield. The simulation showed that the median realized value of fishing pressure given the trigger was ~0.30.

9.2.3.2 On measure of fishing pressure

Given the push to define fishing pressure in the same units as used in the HCR one may need to consider how one should derive the harvest rate. For the Icelandic cod, this is more cumbersome that normally because the advice is not for a calendar year but fishing year. It was decided to use the following metric in the summary (3.13) as well as the table in the advice sheet:

$$HR_y = (1/3 * Y_y + 2/3 * Y_{y+1})/B_{4+,y}$$

where Y is the yield and the fractions represent the proportion of the catch of the fishing year taken in the different calendar year. This measure of fishing pressure is by no means the best one but reflects best the “intended” harvest rate as stipulated in the HCR.

9.3 Reference

ICES 2021. ICES. 2021. Workshop on the re-evaluation of management plan for the Icelandic cod stock (WKICECOD). ICES Scientific Reports, 3:30. https://doi.org/10.17895/ices.pub.7987.

Table 3.1: Icelandic cod in Division 5.a. Estimated catch in numbers (millions) by year and age in millions of fish in 1955–2020.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	4.790	25.164	46.566	28.287	10.541	5.224	2.467	25.182	2.101	1.202	1.668	0.665
1956	6.709	17.265	31.030	27.793	14.389	4.261	3.429	2.128	16.820	1.552	1.522	1.545
1957	13.240	21.278	17.515	24.569	17.634	12.296	3.568	2.169	1.171	6.822	0.512	1.089
1958	25.237	30.742	14.298	10.859	15.997	15.822	12.021	2.003	2.125	0.771	3.508	0.723
1959	18.394	37.650	23.901	7.682	5.883	8.791	13.003	7.683	0.914	0.990	0.218	1.287
1960	14.830	28.642	27.968	14.120	8.387	6.089	6.393	11.600	3.526	0.692	0.183	0.510
1961	16.507	21.808	19.488	15.034	7.900	6.925	3.969	3.211	6.756	1.202	0.089	0.425
1962	13.514	28.526	18.924	14.650	12.045	4.276	8.809	2.664	1.883	2.988	0.405	0.324
1963	18.507	28.466	19.664	11.314	15.682	7.704	2.724	6.508	1.657	1.030	1.372	0.246
1964	19.287	28.845	18.712	11.620	7.936	18.032	5.040	1.437	2.670	0.655	0.370	1.025
1965	21.658	29.586	24.783	11.706	9.334	6.394	11.122	1.477	0.823	0.489	0.118	0.489
1966	17.910	30.649	20.006	13.872	5.942	7.586	2.320	5.583	0.407	0.363	0.299	0.311
1967	25.945	27.941	24.322	11.320	8.751	2.595	5.490	1.392	1.998	0.109	0.030	0.106
1968	11.933	47.311	22.344	16.277	15.590	7.059	1.571	2.506	0.512	0.659	0.047	0.098
1969	11.149	23.925	45.445	17.397	12.559	14.811	1.590	0.475	0.340	0.064	0.024	0.021
1970	9.876	47.210	23.607	25.451	15.196	12.261	14.469	0.567	0.207	0.147	0.035	0.050
1971	13.060	35.856	45.577	21.135	17.340	10.924	6.001	4.210	0.237	0.069	0.038	0.020
1972	8.973	29.574	30.918	22.855	11.097	9.784	10.538	3.938	1.242	0.119	0.031	0.001
1973	36.538	25.542	27.391	17.045	12.721	3.685	4.718	5.809	1.134	0.282	0.007	0.001
1974	14.846	61.826	21.824	14.413	8.974	6.216	1.647	2.530	1.765	0.334	0.062	0.028
1975	29.301	29.489	44.138	12.088	9.628	3.691	2.051	0.752	0.891	0.416	0.060	0.046
1976	23.578	39.790	21.092	24.395	5.803	5.343	1.297	0.633	0.205	0.155	0.065	0.029
1977	2.614	42.659	32.465	12.162	13.017	2.809	1.773	0.421	0.086	0.024	0.006	0.002
1978	5.999	16.287	43.931	17.626	8.729	4.119	0.978	0.348	0.119	0.048	0.015	0.027
1979	7.186	28.427	13.772	34.443	14.130	4.426	1.432	0.350	0.168	0.043	0.024	0.004
1980	4.348	28.530	32.500	15.119	27.090	7.847	2.228	0.646	0.246	0.099	0.025	0.004
1981	2.118	13.297	39.195	23.247	12.710	26.455	4.804	1.677	0.582	0.228	0.053	0.068
1982	3.285	20.812	24.462	28.351	14.012	7.666	11.517	1.912	0.327	0.094	0.043	0.011
1983	3.554	10.910	24.305	18.944	17.382	8.381	2.054	2.733	0.514	0.215	0.064	0.037
1984	6.750	31.553	19.420	15.326	8.082	7.336	2.680	0.512	0.538	0.195	0.090	0.036
1985	6.457	24.552	35.392	18.267	8.711	4.201	2.264	1.063	0.217	0.233	0.102	0.038
1986	20.642	20.330	26.644	30.839	11.413	4.441	1.771	0.805	0.392	0.103	0.076	0.044
1987	11.002	62.130	27.192	15.127	15.695	4.159	1.463	0.592	0.253	0.142	0.046	0.058
1988	6.713	39.323	55.895	18.663	6.399	5.877	1.345	0.455	0.305	0.157	0.114	0.025
1989	2.605	27.983	50.059	31.455	6.010	1.915	0.881	0.225	0.107	0.086	0.038	0.005
1990	5.785	12.313	27.179	44.534	17.037	2.573	0.609	0.322	0.118	0.050	0.015	0.020
1991	8.554	25.131	15.491	21.514	25.038	6.364	0.903	0.243	0.125	0.063	0.011	0.012
1992	12.217	21.708	26.524	11.413	10.073	8.304	2.006	0.257	0.046	0.032	0.009	0.008
1993	20.500	33.078	15.195	13.281	3.583	2.785	2.707	1.181	0.180	0.034	0.011	0.013

year	3	4	5	6	7	8	9	10	11	12	13	14
1994	6.160	24.142	19.666	6.968	4.393	1.257	0.599	0.508	0.283	0.049	0.018	0.006
1995	10.770	9.103	16.829	13.066	4.115	1.596	0.313	0.184	0.156	0.141	0.029	0.008
1996	5.356	14.886	7.372	12.307	9.429	2.157	0.837	0.208	0.076	0.065	0.055	0.005
1997	1.722	16.442	17.298	6.711	7.379	5.958	1.147	0.493	0.126	0.028	0.037	0.021
1998	3.458	7.707	25.394	20.167	5.893	3.856	2.951	0.500	0.196	0.055	0.033	0.013
1999	2.525	19.554	15.226	24.622	12.966	2.795	1.489	0.748	0.140	0.046	0.010	0.005
2000	10.493	6.581	29.080	11.227	11.390	5.714	1.104	0.567	0.314	0.074	0.022	0.006
2001	13.553	26.000	9.111	20.213	5.850	3.760	2.028	0.508	0.199	0.137	0.013	0.031
2002	6.019	17.776	24.030	7.160	9.424	2.451	1.555	0.738	0.150	0.058	0.041	0.004
2003	5.490	16.313	22.045	16.628	4.840	4.933	1.201	0.507	0.211	0.046	0.026	0.033
2004	1.784	17.960	24.043	17.901	10.166	2.880	1.978	0.499	0.162	0.087	0.019	0.008
2005	5.271	5.302	26.183	16.922	8.543	4.890	1.292	0.790	0.216	0.096	0.037	0.005
2006	3.446	13.108	8.834	22.063	10.540	4.683	2.164	0.471	0.240	0.040	0.016	0.010
2007	2.054	11.639	15.937	8.599	9.894	5.680	2.281	1.139	0.332	0.088	0.067	0.006
2008	3.104	5.126	12.849	11.641	5.153	4.708	2.139	0.880	0.280	0.067	0.043	0.004
2009	3.458	7.926	9.626	17.895	10.503	3.888	2.295	0.742	0.315	0.089	0.022	0.012
2010	3.511	7.730	9.591	8.448	10.922	5.546	1.566	0.924	0.299	0.144	0.063	0.017
2011	4.001	7.845	10.576	10.820	6.287	6.292	2.429	0.680	0.419	0.134	0.040	0.016
2012	4.056	11.249	10.814	9.560	8.918	5.009	3.213	1.152	0.292	0.227	0.081	0.026
2013	5.778	12.224	15.347	11.414	7.594	5.792	2.571	1.832	0.653	0.209	0.146	0.036
2014	4.630	8.365	14.898	13.262	8.426	4.930	2.816	1.395	0.964	0.376	0.127	0.107
2015	5.229	13.361	10.350	13.897	9.409	5.616	2.441	1.552	0.953	0.407	0.125	0.036
2016	2.667	11.179	11.886	10.989	12.746	7.345	3.232	1.590	0.847	0.537	0.184	0.056
2017	5.174	8.033	13.630	13.590	7.632	7.459	3.904	2.005	0.761	0.517	0.251	0.143
2018	4.905	12.805	8.403	14.206	11.364	7.124	4.418	2.047	0.852	0.506	0.176	0.105
2019	2.916	8.467	13.461	9.095	8.974	7.801	4.182	3.973	2.033	0.748	0.354	0.184
2020	3.284	10.770	18.092	18.630	7.373	6.139	4.384	2.468	1.511	0.912	0.458	0.270

Table 3.2: Icelandic cod in Division 5.a. Estimated mean weight at age in the catch (kg) in period the 1955–2020. The weights for age groups 3 to 9 in 2021 are based on predictions from the 2021 spring survey measurements. The weights in the catches are used to calculate the reference biomass (B_{4+}).

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.827	1.307	2.157	3.617	4.638	5.657	6.635	6.168	8.746	8.829	10.086	14.584
1956	1.080	1.600	2.190	3.280	4.650	5.630	6.180	6.970	6.830	9.290	10.965	12.954
1957	1.140	1.710	2.520	3.200	4.560	5.960	7.170	7.260	8.300	8.290	10.350	13.174
1958	1.210	1.810	3.120	4.510	5.000	5.940	6.640	8.290	8.510	8.840	9.360	13.097
1959	1.110	1.950	2.930	4.520	5.520	6.170	6.610	7.130	8.510	8.670	9.980	11.276
1960	1.060	1.720	2.920	4.640	5.660	6.550	6.910	7.140	7.970	10.240	10.100	12.871
1961	1.020	1.670	2.700	4.330	5.530	6.310	6.930	7.310	7.500	8.510	9.840	14.550
1962	0.990	1.610	2.610	3.900	5.720	6.660	6.750	7.060	7.540	8.280	10.900	12.826
1963	1.250	1.650	2.640	3.800	5.110	6.920	7.840	7.610	8.230	9.100	9.920	11.553
1964	1.210	1.750	2.640	4.020	5.450	6.460	8.000	9.940	9.210	10.940	12.670	15.900
1965	1.020	1.530	2.570	4.090	5.410	6.400	7.120	8.600	12.310	10.460	10.190	17.220
1966	1.170	1.680	2.590	4.180	5.730	6.900	7.830	8.580	9.090	14.230	14.090	17.924
1967	1.120	1.820	2.660	4.067	5.560	7.790	7.840	8.430	9.090	10.090	14.240	16.412
1968	1.170	1.590	2.680	3.930	5.040	5.910	7.510	8.480	10.750	11.580	14.640	16.011
1969	1.100	1.810	2.480	3.770	5.040	5.860	7.000	8.350	8.720	10.080	11.430	13.144
1970	0.990	1.450	2.440	3.770	4.860	5.590	6.260	8.370	10.490	12.310	14.590	21.777
1971	1.090	1.570	2.310	2.980	4.930	5.150	5.580	6.300	8.530	11.240	14.740	17.130
1972	0.980	1.460	2.210	3.250	4.330	5.610	6.040	6.100	6.870	8.950	11.720	16.000
1973	1.030	1.420	2.470	3.600	4.900	6.110	6.670	6.750	7.430	7.950	10.170	17.000
1974	1.050	1.710	2.430	3.820	5.240	6.660	7.150	7.760	8.190	9.780	12.380	14.700
1975	1.100	1.770	2.780	3.760	5.450	6.690	7.570	8.580	8.810	9.780	10.090	11.000
1976	1.350	1.780	2.650	4.100	5.070	6.730	8.250	9.610	11.540	11.430	14.060	16.180
1977	1.259	1.911	2.856	4.069	5.777	6.636	7.685	9.730	11.703	14.394	17.456	24.116
1978	1.289	1.833	2.929	3.955	5.726	6.806	9.041	10.865	13.068	11.982	19.062	21.284
1979	1.408	1.956	2.642	3.999	5.548	6.754	8.299	9.312	13.130	13.418	13.540	20.072
1980	1.392	1.862	2.733	3.768	5.259	6.981	8.037	10.731	12.301	17.281	14.893	19.069
1981	1.180	1.651	2.260	3.293	4.483	5.821	7.739	9.422	11.374	12.784	12.514	19.069
1982	1.006	1.550	2.246	3.104	4.258	5.386	6.682	9.141	11.963	14.226	17.287	16.590
1983	1.095	1.599	2.275	3.021	4.096	5.481	7.049	8.128	11.009	13.972	15.882	18.498
1984	1.288	1.725	2.596	3.581	4.371	5.798	7.456	9.851	11.052	14.338	15.273	16.660
1985	1.407	1.971	2.576	3.650	4.976	6.372	8.207	10.320	12.197	14.683	16.175	19.050
1986	1.459	1.961	2.844	3.593	4.635	6.155	7.503	9.084	10.356	15.283	14.540	15.017
1987	1.316	1.956	2.686	3.894	4.716	6.257	7.368	9.243	10.697	10.622	15.894	12.592
1988	1.438	1.805	2.576	3.519	4.930	6.001	7.144	8.822	9.977	11.732	14.156	13.042
1989	1.186	1.813	2.590	3.915	5.210	6.892	8.035	9.831	11.986	10.003	12.611	16.045
1990	1.290	1.704	2.383	3.034	4.624	6.521	8.888	10.592	10.993	14.570	15.732	17.290
1991	1.309	1.899	2.475	3.159	3.792	5.680	7.242	9.804	9.754	14.344	14.172	20.200
1992	1.289	1.768	2.469	3.292	4.394	5.582	6.830	8.127	12.679	13.410	15.715	11.267

year	3	4	5	6	7	8	9	10	11	12	13	14
1993	1.392	1.887	2.772	3.762	4.930	6.054	7.450	8.641	10.901	12.517	14.742	16.874
1994	1.443	2.063	2.562	3.659	5.117	6.262	7.719	8.896	10.847	12.874	14.742	17.470
1995	1.348	1.959	2.920	3.625	5.176	6.416	7.916	10.273	11.022	11.407	13.098	15.182
1996	1.457	1.930	3.132	4.141	4.922	6.009	7.406	9.772	10.539	13.503	13.689	16.194
1997	1.484	1.877	2.878	4.028	5.402	6.386	7.344	8.537	10.797	11.533	10.428	12.788
1998	1.230	1.750	2.458	3.559	5.213	7.737	7.837	9.304	10.759	14.903	16.651	18.666
1999	1.241	1.716	2.426	3.443	4.720	6.352	8.730	9.946	11.088	12.535	14.995	15.151
2000	1.308	1.782	2.330	3.252	4.690	5.894	7.809	9.203	10.240	11.172	13.172	17.442
2001	1.484	2.017	2.629	3.362	4.555	6.187	7.124	8.445	9.311	9.566	10.242	9.503
2002	1.309	1.947	2.664	3.638	4.551	5.927	7.083	8.100	9.276	11.660	11.221	14.029
2003	1.350	1.866	2.459	3.391	4.380	4.756	6.141	7.138	9.580	10.260	11.479	10.720
2004	1.139	1.754	2.413	3.373	4.288	5.185	5.741	7.376	10.038	10.322	12.428	11.452
2005	1.196	1.735	2.421	3.395	4.292	5.059	6.233	6.124	7.964	10.075	12.776	13.719
2006	1.088	1.622	2.205	3.052	4.265	4.978	5.287	6.028	8.455	11.154	12.608	15.381
2007	1.063	1.595	2.179	2.791	3.861	5.159	5.871	6.405	7.182	9.506	10.406	10.532
2008	1.098	1.598	2.364	3.140	3.990	5.264	6.483	7.367	7.784	10.505	11.621	18.092
2009	1.096	1.666	2.206	3.187	4.059	5.024	6.649	8.354	9.529	11.193	11.761	14.918
2010	1.100	1.824	2.355	3.213	4.481	5.463	6.740	8.026	8.969	10.419	11.648	12.205
2011	1.109	1.660	2.512	3.443	4.404	5.783	6.526	7.828	8.806	9.662	12.941	11.649
2012	1.180	1.625	2.442	3.744	4.707	5.925	7.369	7.988	9.111	10.720	12.042	11.608
2013	1.132	1.743	2.451	3.612	4.936	6.125	7.367	8.137	9.173	10.121	10.421	12.702
2014	1.118	1.741	2.522	3.518	4.677	6.158	7.486	8.586	8.967	10.518	10.286	12.354
2015	1.196	1.643	2.663	3.599	4.643	5.919	7.589	8.600	9.686	11.208	11.328	10.392
2016	1.101	1.791	2.510	3.749	4.659	5.967	7.188	8.535	10.130	10.719	11.421	13.899
2017	1.011	1.760	2.501	3.459	4.789	5.929	7.190	8.467	9.496	11.025	11.535	12.853
2018	1.181	1.797	2.808	3.768	4.591	6.126	7.102	8.723	9.471	10.127	10.422	11.617
2019	1.155	1.662	2.480	3.773	4.783	5.504	6.604	8.095	8.842	10.596	11.687	12.003
2020	1.001	1.779	2.434	3.250	4.375	5.451	6.608	7.838	8.484	9.631	9.601	11.945
2021	1.001	1.742	2.566	3.322	4.075	5.405	6.969	7.838	8.484	9.631	9.601	11.945

Table 3.3: Icelandic cod in Division 5.a. Estimated survey weight (kg) at age in the spring survey (SMB).

year	1	2	3	4	5	6	7	8	9
1985	0.014	0.137	0.388	1.124	1.743	2.601	3.264	4.757	6.009
1986	0.015	0.159	0.619	1.225	2.264	3.006	4.362	5.595	7.186
1987	0.014	0.117	0.469	1.202	1.763	3.004	4.229	6.301	6.876
1988	0.011	0.122	0.496	1.082	1.977	3.119	3.622	4.482	8.046
1989	0.022	0.151	0.547	1.159	1.973	3.081	4.404	6.212	6.942
1990	0.019	0.135	0.462	1.042	1.832	2.643	3.870	5.871	7.746
1991	0.018	0.147	0.555	1.170	1.859	2.636	3.344	5.675	7.316
1992	0.024	0.134	0.500	1.017	1.863	2.619	3.766	5.101	7.355
1993	0.012	0.173	0.576	1.170	1.954	3.043	4.048	5.410	6.080
1994	0.013	0.174	0.686	1.417	2.055	3.230	4.193	6.229	8.156
1995	0.010	0.133	0.606	1.380	2.297	3.009	4.466	5.350	8.035
1996	0.011	0.155	0.551	1.352	2.084	3.322	4.044	5.257	7.460
1997	0.018	0.139	0.546	1.194	2.170	3.211	4.858	5.501	6.463
1998	0.015	0.154	0.482	1.193	2.041	3.017	4.249	5.417	6.333
1999	0.014	0.140	0.578	1.070	1.849	2.869	3.826	4.993	5.657
2000	0.016	0.124	0.486	1.195	1.817	2.771	4.068	5.345	8.472
2001	0.017	0.149	0.530	1.184	1.845	2.625	3.781	5.491	6.472
2002	0.013	0.131	0.510	1.206	1.998	2.920	3.784	5.791	6.321
2003	0.016	0.131	0.466	1.179	1.919	2.786	4.136	4.672	6.246
2004	0.021	0.142	0.480	1.073	1.896	2.791	3.413	4.866	5.069
2005	0.011	0.118	0.440	1.033	1.771	2.669	3.680	4.365	7.207
2006	0.013	0.106	0.412	0.980	1.710	2.624	4.039	4.709	5.587
2007	0.014	0.100	0.412	0.970	1.665	2.382	3.694	5.052	6.052
2008	0.011	0.121	0.376	0.943	1.811	2.612	3.586	4.919	6.301
2009	0.012	0.111	0.411	0.847	1.616	2.646	3.690	4.698	5.836
2010	0.013	0.098	0.386	1.010	1.706	2.593	4.052	4.931	6.235
2011	0.012	0.102	0.392	1.128	2.127	3.003	4.258	5.866	6.638
2012	0.012	0.143	0.467	1.144	1.936	3.210	4.281	5.812	7.897
2013	0.014	0.110	0.495	1.053	1.790	3.033	4.781	6.372	8.078
2014	0.011	0.114	0.359	1.076	1.713	2.641	3.992	6.138	8.025
2015	0.013	0.150	0.417	0.897	2.062	3.029	4.405	6.058	8.606
2016	0.010	0.119	0.478	1.007	1.583	3.164	4.000	5.510	7.192
2017	0.014	0.091	0.418	1.223	1.938	2.726	5.160	6.445	7.570
2018	0.020	0.133	0.383	0.974	2.141	3.167	3.978	6.540	7.593
2019	0.010	0.094	0.468	0.908	1.796	3.407	4.389	5.319	7.434
2020	0.012	0.137	0.398	1.159	1.741	2.941	4.752	5.846	7.305
2021	0.010	0.111	0.489	1.014	2.096	3.090	4.078	5.825	7.879

Table 3.4: Icelandic cod in Division 5.a. Estimated weight at age in the spawning stock (kg) in period the 1955–2021. These weights are used to calculate the spawning stock biomass (SSB).

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.645	1.019	1.833	3.183	4.128	5.657	6.635	6.168	8.746	8.829	10.086	14.584
1956	0.645	1.248	1.862	2.886	4.138	5.630	6.180	6.970	6.830	9.290	10.965	12.954
1957	0.645	1.334	2.142	2.816	4.058	5.960	7.170	7.260	8.300	8.290	10.350	13.174
1958	0.645	1.412	2.652	3.969	4.450	5.940	6.640	8.290	8.510	8.840	9.360	13.097
1959	0.645	1.521	2.490	3.978	4.913	6.170	6.610	7.130	8.510	8.670	9.980	11.276
1960	0.645	1.342	2.482	4.083	5.037	6.550	6.910	7.140	7.970	10.240	10.100	12.871
1961	0.645	1.303	2.295	3.810	4.922	6.310	6.930	7.310	0.750	8.510	9.840	14.550
1962	0.645	1.256	2.218	3.432	5.091	6.660	6.750	7.060	7.540	8.280	10.900	12.826
1963	0.645	1.287	2.244	3.344	4.548	6.920	7.840	7.610	8.230	9.100	9.920	11.553
1964	0.645	1.365	2.244	3.538	4.850	6.460	8.000	9.940	9.210	10.940	12.670	15.900
1965	0.645	1.193	2.184	3.599	4.815	6.400	7.120	8.600	12.310	10.460	10.190	17.220
1966	0.645	1.310	2.202	3.678	5.100	6.900	7.830	8.580	9.090	14.230	14.090	17.924
1967	0.645	1.420	2.261	3.579	4.948	7.790	7.840	8.430	9.090	10.090	14.240	16.412
1968	0.645	1.240	2.278	3.458	4.486	5.910	7.510	8.480	10.750	11.580	14.640	16.011
1969	0.645	1.412	2.108	3.318	4.486	5.860	7.000	8.350	8.720	10.080	11.430	13.144
1970	0.645	1.131	2.074	3.318	4.325	5.590	6.260	8.370	10.490	12.310	14.590	21.777
1971	0.645	1.225	1.964	2.622	4.388	5.150	5.580	6.300	8.530	11.240	14.740	17.130
1972	0.645	1.139	1.878	2.860	3.854	5.610	6.040	6.100	6.870	8.950	11.720	16.000
1973	0.645	1.108	2.100	3.168	4.361	6.110	6.670	6.750	7.430	7.950	10.170	17.000
1974	0.645	1.334	2.066	3.362	4.664	6.660	7.150	7.760	8.190	9.780	12.380	14.700
1975	0.645	1.381	2.363	3.309	4.850	6.690	7.570	8.580	8.810	9.780	10.090	11.000
1976	0.645	1.388	2.252	3.608	4.512	6.730	8.250	9.610	11.540	11.430	14.060	16.180
1977	0.645	1.491	2.428	3.581	5.142	6.636	7.685	9.730	11.703	14.394	17.456	24.116
1978	0.645	1.430	2.490	3.480	5.096	6.806	9.041	10.865	13.068	11.982	19.062	21.284
1979	0.645	1.526	2.246	3.519	4.938	6.754	8.299	9.312	13.130	13.418	13.540	20.072
1980	0.645	1.452	2.323	3.316	4.681	6.981	8.037	10.731	12.301	17.281	14.893	19.069
1981	0.645	1.288	1.921	2.898	3.990	5.821	7.739	9.422	11.374	12.784	12.514	19.069
1982	0.645	1.209	1.909	2.732	3.790	5.386	6.682	9.141	11.963	14.226	17.287	16.590
1983	0.645	1.247	1.934	2.658	3.645	5.481	7.049	8.128	11.009	13.972	15.882	18.498
1984	0.645	1.346	2.207	3.151	3.890	5.798	7.456	9.851	11.052	14.338	15.273	16.660
1985	1.312	1.399	1.766	2.738	3.483	4.762	7.301	10.320	12.197	14.683	16.175	19.050
1986	1.312	1.612	2.915	3.279	4.591	5.803	7.199	9.084	10.356	15.283	14.540	15.017
1987	1.718	1.598	2.439	3.532	4.886	6.408	7.499	9.243	10.697	10.622	15.894	12.592
1988	0.931	1.486	2.281	3.287	4.423	4.678	8.147	8.822	9.977	11.732	14.156	13.042
1989	0.823	1.526	2.364	3.426	4.702	7.273	8.436	9.831	11.986	10.003	12.611	16.045
1990	0.733	1.044	2.199	2.841	4.367	6.177	8.919	10.592	10.993	14.570	15.732	17.290
1991	0.114	1.288	2.069	2.799	3.477	6.007	8.823	9.804	9.754	14.344	14.172	20.200
1992	0.449	1.349	2.117	3.086	3.861	5.196	7.429	8.127	12.679	13.410	15.715	11.267
1993	0.773	1.374	2.316	3.276	4.179	5.729	6.441	8.641	10.901	12.517	14.742	16.874

year	3	4	5	6	7	8	9	10	11	12	13	14
1994	1.618	1.733	2.259	3.384	4.563	6.471	9.803	8.896	10.847	12.874	14.742	17.470
1995	0.514	1.639	2.353	3.197	4.493	5.544	8.579	10.273	11.022	11.407	13.098	15.182
1996	0.542	1.756	2.490	3.530	4.251	5.621	8.263	9.772	10.539	13.503	13.689	16.194
1997	1.111	1.346	2.267	3.723	5.415	5.963	6.964	8.537	10.797	11.533	10.428	12.788
1998	1.111	1.605	2.262	3.262	4.461	5.759	6.793	9.304	10.759	14.903	16.651	18.666
1999	1.311	1.471	1.936	2.999	3.968	5.132	6.522	9.946	11.088	12.535	14.995	15.151
2000	0.497	1.355	1.916	2.881	4.318	5.573	8.464	9.203	10.240	11.172	13.172	17.442
2001	0.816	1.583	2.080	2.676	4.112	6.236	6.926	8.445	9.311	9.566	10.242	9.503
2002	0.782	1.591	2.260	3.120	3.991	5.991	9.225	8.100	9.276	11.660	11.221	14.029
2003	1.150	1.326	2.241	3.049	4.226	5.051	6.823	7.138	9.580	10.260	11.479	10.720
2004	1.150	1.456	2.095	3.011	3.678	5.192	5.400	7.376	10.038	10.322	12.428	11.452
2005	0.648	1.123	1.908	2.979	3.901	4.789	7.238	6.124	7.964	10.075	12.776	13.719
2006	0.907	1.407	2.016	2.913	4.351	5.057	6.472	6.028	8.455	11.154	12.608	15.381
2007	1.439	1.261	2.023	2.640	4.116	5.697	6.632	6.405	7.182	9.506	10.406	10.532
2008	0.912	1.845	2.232	2.911	3.897	5.400	6.927	7.367	7.784	10.505	11.621	18.092
2009	0.644	1.465	2.041	2.887	3.943	4.923	7.044	8.354	9.529	11.193	11.761	14.918
2010	0.644	1.590	2.154	3.149	4.207	5.207	6.460	8.024	8.968	10.419	11.647	12.208
2011	0.794	2.467	2.666	3.216	4.546	5.989	6.851	7.828	8.805	9.662	12.941	11.649
2012	1.404	1.702	2.606	3.717	4.516	6.016	8.038	7.988	9.111	10.720	12.042	11.608
2013	0.944	2.323	2.991	3.834	5.207	6.532	8.260	8.137	9.173	10.121	10.421	12.702
2014	0.944	1.332	2.549	3.316	4.459	6.390	8.178	8.586	8.967	10.518	10.286	12.354
2015	0.704	1.043	3.320	3.836	4.895	6.218	8.677	8.600	9.687	11.205	11.330	10.360
2016	0.972	2.247	3.042	4.213	4.614	6.000	7.351	8.486	10.111	10.701	11.362	13.899
2017	1.773	2.582	3.513	3.936	5.698	6.716	7.636	8.486	9.509	11.095	11.575	12.800
2018	1.029	2.372	3.230	3.862	4.574	6.671	7.711	8.699	9.445	10.072	10.269	11.638
2019	0.599	3.044	3.260	4.221	4.700	5.498	7.481	8.095	8.842	10.596	11.687	12.003
2020	0.874	1.697	3.150	3.941	5.140	5.998	7.342	7.838	8.484	9.631	9.601	11.945
2021	0.449	1.348	2.943	3.817	4.523	6.061	7.879	7.838	8.484	9.631	9.601	11.945

Table 3.5: Icelandic cod in Division 5.a. Estimated maturity at age in period the 1955–2021.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.019	0.022	0.033	0.181	0.577	0.782	0.834	0.960	1.000	1.000	1.000	1
1956	0.019	0.025	0.033	0.111	0.577	0.782	0.818	0.980	0.980	1.000	1.000	1
1957	0.019	0.026	0.043	0.100	0.549	0.801	0.842	0.990	1.000	1.000	1.000	1
1958	0.019	0.028	0.086	0.520	0.682	0.801	0.834	1.000	1.000	1.000	1.000	1
1959	0.019	0.029	0.070	0.535	0.772	0.818	0.834	0.990	1.000	1.000	1.000	1
1960	0.019	0.026	0.066	0.577	0.782	0.826	0.834	0.990	1.000	1.000	1.000	1
1961	0.019	0.025	0.053	0.450	0.772	0.818	0.834	0.990	0.990	1.000	1.000	1
1962	0.019	0.025	0.048	0.281	0.791	0.834	0.834	0.990	0.990	1.000	1.000	1
1963	0.019	0.025	0.048	0.237	0.706	0.834	0.849	1.000	1.000	1.000	1.000	1
1964	0.019	0.026	0.048	0.329	0.762	0.826	0.849	1.000	1.000	1.000	1.000	1
1965	0.019	0.025	0.045	0.354	0.751	0.826	0.842	1.000	1.000	1.000	1.000	1
1966	0.019	0.026	0.045	0.394	0.791	0.849	0.849	1.000	1.000	1.000	1.000	1
1967	0.019	0.028	0.051	0.341	0.772	0.842	0.849	1.000	1.000	1.000	1.000	1
1968	0.019	0.025	0.051	0.292	0.682	0.801	0.842	1.000	1.000	1.000	1.000	1
1969	0.019	0.028	0.043	0.227	0.682	0.801	0.842	1.000	1.000	1.000	1.000	1
1970	0.019	0.023	0.041	0.227	0.644	0.772	0.818	1.000	1.000	1.000	1.000	1
1971	0.019	0.025	0.037	0.074	0.657	0.706	0.772	0.979	0.994	0.982	0.993	1
1972	0.019	0.023	0.035	0.106	0.450	0.772	0.809	0.979	0.994	0.982	0.993	1
1973	0.022	0.028	0.163	0.382	0.697	0.801	0.834	0.996	0.996	1.000	1.000	1
1974	0.020	0.031	0.085	0.346	0.636	0.790	0.818	0.989	1.000	1.000	1.000	1
1975	0.020	0.035	0.118	0.287	0.715	0.809	0.839	1.000	1.000	1.000	1.000	1
1976	0.025	0.026	0.086	0.253	0.406	0.797	0.841	1.000	1.000	1.000	1.000	1
1977	0.019	0.024	0.060	0.382	0.742	0.817	0.842	1.000	1.000	1.000	1.000	1
1978	0.025	0.025	0.052	0.192	0.737	0.820	0.836	1.000	1.000	1.000	1.000	1
1979	0.019	0.021	0.053	0.282	0.635	0.790	0.836	0.919	1.000	1.000	1.000	1
1980	0.026	0.021	0.047	0.225	0.653	0.777	0.834	0.977	1.000	0.964	1.000	1
1981	0.019	0.022	0.030	0.090	0.448	0.751	0.811	0.962	0.988	1.000	1.000	1
1982	0.021	0.025	0.038	0.065	0.297	0.705	0.815	0.967	1.000	1.000	1.000	1
1983	0.019	0.030	0.047	0.116	0.264	0.530	0.715	0.979	0.985	1.000	1.000	1
1984	0.019	0.024	0.053	0.169	0.444	0.620	0.716	0.949	0.969	0.948	1.000	1
1985	0.000	0.021	0.186	0.414	0.495	0.730	0.580	0.746	1.000	1.000	1.000	1
1986	0.001	0.023	0.154	0.398	0.681	0.727	0.936	0.667	1.000	1.000	1.000	1
1987	0.001	0.033	0.094	0.359	0.487	0.879	0.777	0.805	1.000	1.000	1.000	1
1988	0.006	0.029	0.220	0.498	0.446	0.677	0.932	0.890	1.000	1.000	1.000	1
1989	0.008	0.026	0.141	0.363	0.621	0.639	0.619	1.000	1.000	1.000	1.000	1
1990	0.006	0.012	0.154	0.428	0.576	0.781	0.774	0.714	1.000	1.000	1.000	1
1991	0.000	0.055	0.149	0.368	0.629	0.787	0.654	0.901	1.000	1.000	1.000	1
1992	0.002	0.062	0.265	0.407	0.813	0.916	0.880	1.000	1.000	1.000	1.000	1
1993	0.006	0.085	0.267	0.462	0.684	0.795	0.843	0.834	1.000	1.000	1.000	1

year	3	4	5	6	7	8	9	10	11	12	13	14
1994	0.008	0.109	0.338	0.590	0.706	0.921	0.694	0.830	1.000	1.000	1.000	1
1995	0.005	0.109	0.383	0.527	0.747	0.790	0.859	1.000	1.000	1.000	1.000	1
1996	0.002	0.032	0.186	0.501	0.653	0.733	0.810	0.774	1.000	1.000	1.000	1
1997	0.006	0.037	0.247	0.427	0.686	0.786	0.804	0.539	1.000	1.000	1.000	1
1998	0.000	0.061	0.208	0.486	0.782	0.807	0.809	0.852	1.000	1.000	1.000	1
1999	0.012	0.044	0.239	0.517	0.650	0.836	0.691	0.974	1.000	1.000	1.000	1
2000	0.001	0.065	0.248	0.512	0.611	0.867	0.998	0.999	1.000	1.000	1.000	1
2001	0.003	0.046	0.286	0.599	0.761	0.766	0.883	1.000	1.000	1.000	1.000	1
2002	0.006	0.086	0.321	0.656	0.759	0.920	0.559	0.724	1.000	1.000	1.000	1
2003	0.005	0.048	0.222	0.532	0.873	0.798	0.879	0.833	1.000	1.000	1.000	1
2004	0.000	0.040	0.249	0.549	0.631	0.833	0.807	0.854	1.000	1.000	1.000	1
2005	0.003	0.108	0.281	0.494	0.795	0.808	0.949	0.904	1.000	1.000	1.000	1
2006	0.002	0.023	0.298	0.446	0.749	0.874	0.739	0.741	1.000	1.000	1.000	1
2007	0.012	0.031	0.156	0.504	0.696	0.797	0.836	0.926	1.000	1.000	1.000	1
2008	0.001	0.042	0.275	0.546	0.728	0.833	0.850	0.958	1.000	1.000	1.000	1
2009	0.002	0.015	0.134	0.451	0.684	0.884	0.752	0.631	1.000	1.000	1.000	1
2010	0.000	0.015	0.057	0.380	0.821	0.868	0.927	0.813	1.000	1.000	1.000	1
2011	0.002	0.012	0.136	0.427	0.732	0.923	0.941	0.961	1.000	1.000	1.000	1
2012	0.004	0.031	0.127	0.414	0.730	0.884	0.963	0.850	1.000	1.000	1.000	1
2013	0.003	0.008	0.062	0.344	0.738	0.922	0.965	1.000	1.000	1.000	1.000	1
2014	0.000	0.026	0.069	0.238	0.615	0.893	0.967	0.956	1.000	1.000	1.000	1
2015	0.003	0.007	0.110	0.353	0.636	0.907	0.978	0.988	1.000	1.000	1.000	1
2016	0.001	0.009	0.025	0.289	0.543	0.731	0.941	0.986	1.000	1.000	1.000	1
2017	0.005	0.008	0.089	0.262	0.765	0.906	0.979	0.987	1.000	1.000	1.000	1
2018	0.002	0.013	0.147	0.434	0.605	0.935	0.953	1.000	1.000	1.000	1.000	1
2019	0.004	0.004	0.062	0.452	0.707	0.898	0.987	0.993	1.000	1.000	1.000	1
2020	0.001	0.037	0.065	0.298	0.763	0.878	0.976	1.000	1.000	1.000	1.000	1
2021	0.002	0.005	0.111	0.432	0.612	0.873	1.000	1.000	1.000	1.000	1.000	1

Table 3.6: Icelandic cod in Division 5.a. Survey indices of the spring bottom trawl survey (SMB).

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	17.18	111.13	35.39	48.27	64.86	23.21	15.46	5.21	3.56	1.94	0.31	0.32	0.09	0.08
1986	15.61	61.09	96.43	22.57	21.74	27.73	7.36	2.85	0.97	0.85	0.31	0.08	0.06	0.04
1987	3.66	28.17	104.43	82.67	21.47	12.83	13.01	2.81	0.99	0.41	0.45	0.23	0.13	0.13
1988	3.45	7.08	73.15	103.77	69.57	8.47	6.57	7.28	0.70	0.29	0.12	0.27	0.06	0.05
1989	4.02	16.39	21.28	75.16	71.44	38.41	4.82	1.71	1.41	0.27	0.19	0.06	0.01	0.01
1990	5.47	11.74	26.44	14.30	27.98	35.30	16.78	1.76	0.58	0.47	0.13	NA	0.04	0.04
1991	3.95	15.97	18.11	30.13	15.44	18.90	22.46	4.93	0.94	0.31	0.22	NA	0.08	0.08
1992	0.71	16.96	33.51	18.78	16.44	6.80	6.33	5.75	1.48	0.23	0.04	0.04	0.04	NA
1993	3.55	4.66	30.75	36.67	13.49	10.59	2.42	2.02	1.39	0.41	0.13	0.03	0.03	0.01
1994	14.22	14.72	9.02	26.93	22.47	6.08	3.95	0.79	0.53	0.50	0.18	0.02	0.03	0.01
1995	1.08	29.27	24.77	9.07	24.56	18.47	4.04	1.92	0.39	0.20	0.24	0.14	0.03	NA
1996	3.70	5.42	42.50	29.69	13.25	15.43	15.22	4.21	1.16	0.21	0.07	0.22	0.10	0.05
1997	1.20	22.39	13.61	56.71	29.74	9.98	9.46	7.30	0.62	0.25	0.19	0.04	0.15	0.10
1998	8.04	5.46	30.11	16.08	63.24	29.99	7.01	5.78	3.33	0.76	0.20	NA	0.02	NA
1999	7.38	33.15	6.99	42.29	13.27	24.77	12.00	2.61	1.47	0.83	0.19	0.07	NA	NA
2000	18.79	27.69	55.16	7.01	30.86	8.71	8.85	4.60	0.56	0.35	0.08	0.03	0.04	0.01
2001	12.24	23.59	36.46	38.18	5.07	15.70	3.53	2.15	0.90	0.34	0.12	0.09	0.05	0.02
2002	0.96	38.56	41.31	40.59	37.26	7.47	8.99	1.66	0.81	0.35	0.07	0.01	NA	NA
2003	11.16	4.20	46.55	36.90	29.21	17.76	4.13	4.79	1.13	0.23	0.13	0.01	0.09	NA
2004	7.34	27.62	8.24	66.84	41.29	30.95	17.60	3.27	3.56	0.57	0.32	0.01	NA	0.01
2005	2.69	17.79	41.72	9.95	46.31	24.99	12.10	6.45	1.01	1.03	0.27	0.24	0.03	NA
2006	9.09	7.43	25.05	40.53	11.74	31.64	11.66	4.11	1.62	0.28	0.16	0.02	NA	NA
2007	5.65	19.04	9.07	22.77	29.88	10.06	11.37	6.10	2.44	0.86	0.30	0.13	0.01	NA
2008	6.75	12.41	23.00	9.84	22.36	22.94	9.44	8.00	3.03	0.77	0.44	0.09	0.05	NA
2009	22.14	12.75	16.46	22.41	15.49	25.86	16.60	4.81	3.15	1.16	0.28	0.11	0.07	0.03
2010	18.62	21.51	18.89	18.10	24.64	14.14	18.35	9.87	3.24	1.93	0.58	0.26	0.05	0.02
2011	3.55	22.96	27.54	20.10	23.07	26.66	14.70	13.37	5.02	1.01	1.01	0.21	0.07	0.02
2012	20.36	11.03	39.37	56.70	41.89	31.20	28.41	10.88	7.06	3.21	0.97	0.48	0.36	0.13
2013	10.89	33.70	18.22	44.39	47.10	25.89	17.15	14.44	7.19	3.47	1.68	0.71	0.16	0.25
2014	3.29	24.25	39.05	23.75	47.55	38.29	17.83	8.45	4.37	2.24	0.84	0.52	0.12	0.12
2015	21.06	10.98	28.05	42.23	21.22	41.98	29.41	17.09	5.13	3.18	1.48	0.60	0.17	0.10
2016	31.71	31.65	15.21	37.62	54.80	28.19	38.46	19.05	7.00	2.33	1.24	0.85	0.26	0.12
2017	3.83	24.95	33.72	18.16	36.43	40.35	23.63	22.55	11.86	5.15	2.09	0.88	0.54	0.09
2018	11.48	14.52	29.97	36.88	16.11	28.81	26.66	15.32	7.85	3.72	1.24	0.59	0.25	0.10
2019	7.99	22.09	14.63	30.72	31.46	14.13	20.34	17.31	9.43	5.98	2.56	0.95	0.38	0.04
2020	29.45	13.21	19.32	10.07	18.48	15.32	7.49	10.27	7.34	4.13	3.56	2.04	0.48	0.02
2021	19.23	40.30	26.90	34.21	18.08	33.56	21.40	6.79	6.01	5.30	3.19	2.48	1.17	0.38

Table 3.7: Icelandic cod in Division 5.a. Survey indices of the fall bottom trawl survey (SMH).

year	3	4	5	6	7	8	9	10	11	12	13
1996	19.59	14.19	5.57	7.70	6.49	1.65	0.31	0.08	0.02	0.05	0.01
1997	6.65	29.25	16.34	5.40	3.74	2.13	0.31	0.14	0.01	0.03	0.04
1998	15.34	7.29	16.10	16.16	5.24	2.25	1.27	0.20	0.05	0.02	0.01
1999	5.58	23.16	7.45	10.04	4.08	0.59	0.34	0.37	0.03	NA	0.06
2000	15.24	3.76	11.55	3.65	2.71	1.14	0.34	0.28	0.11	0.02	0.01
2001	19.32	21.27	3.40	6.93	1.65	0.79	0.18	0.03	0.10	0.02	NA
2002	15.84	23.39	16.21	5.53	4.86	1.13	0.63	0.08	0.17	0.02	0.04
2003	26.05	17.31	13.47	9.11	1.92	2.59	0.37	0.10	0.09	0.02	0.02
2004	6.91	30.29	19.38	12.07	7.60	1.92	1.68	0.23	0.11	0.07	NA
2005	19.96	6.77	26.10	11.30	4.00	1.96	0.31	0.32	0.03	0.06	0.02
2006	15.88	22.85	7.78	14.45	6.31	2.12	1.05	0.17	0.11	NA	0.01
2007	4.90	12.10	16.26	6.53	6.10	3.21	0.80	0.53	0.04	0.08	NA
2008	15.08	8.06	17.95	18.81	5.89	5.59	1.41	0.74	0.28	0.09	0.02
2009	13.73	17.71	12.76	16.89	10.57	3.29	2.76	0.92	0.30	0.16	0.01
2010	16.44	15.97	18.08	9.89	11.31	6.76	2.26	1.24	0.55	0.07	0.11
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	24.85	21.58	12.81	11.13	9.59	5.41	3.25	1.43	0.55	0.16	0.11
2013	14.07	26.05	21.29	12.62	7.88	6.01	3.06	1.87	0.99	0.46	0.21
2014	30.52	15.92	24.26	19.85	8.46	5.72	3.68	2.11	1.38	0.69	0.31
2015	34.96	43.59	18.98	27.61	16.14	5.39	3.10	1.10	0.58	0.47	0.19
2016	8.66	17.91	22.24	11.00	11.96	6.71	2.67	1.53	0.76	0.46	0.17
2017	32.34	16.86	31.31	31.99	12.13	9.74	4.37	1.53	0.97	0.46	0.35
2018	21.84	21.00	8.40	13.43	12.87	7.42	4.99	2.31	0.85	0.40	0.14
2019	19.38	26.60	18.01	9.07	8.66	5.30	2.46	1.68	0.74	0.26	0.16
2020	14.99	8.78	12.79	11.51	4.01	4.04	2.34	1.49	0.90	0.36	0.17

Table 3.8: Icelandic cod in Division 5.a. Catch at age residuals from the ADCAM model tuned with the spring (SMB) and the fall (SMH) surveys.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	-0.49	-0.21	0.18	0.23	0.28	-0.09	-0.14	-0.09	-0.13	-0.25	-0.15	-0.01
1956	-0.14	0.01	0.10	0.07	-0.17	-0.21	-0.03	0.10	0.11	0.23	0.37	0.29
1957	0.28	0.16	0.03	0.17	-0.21	-0.06	-0.02	-0.09	0.04	-0.06	-0.06	0.47
1958	0.52	0.31	-0.20	-0.12	-0.06	-0.02	-0.06	-0.13	0.32	0.21	-0.03	0.37
1959	0.00	0.35	0.32	-0.24	-0.27	-0.11	-0.02	0.14	-0.08	0.38	0.03	-0.05
1960	0.35	-0.36	0.09	0.13	0.03	0.04	0.00	-0.13	-0.03	0.18	-0.07	0.46
1961	0.28	0.11	-0.54	-0.02	-0.06	0.30	0.21	-0.06	0.09	-0.09	-0.16	0.43
1962	0.51	0.12	0.09	-0.39	0.06	-0.24	0.01	0.30	0.06	0.15	-0.20	0.32
1963	0.38	0.44	-0.22	-0.09	-0.12	-0.07	-0.23	0.13	0.34	0.17	0.08	-0.06
1964	0.18	0.04	0.09	-0.36	-0.18	0.36	0.01	-0.30	-0.04	0.22	0.03	0.36
1965	0.12	-0.12	0.03	0.08	-0.24	0.05	0.48	-0.44	-0.08	-0.39	-0.06	0.40
1966	-0.05	-0.11	-0.21	0.07	-0.09	0.15	-0.14	0.55	-0.48	0.10	-0.04	0.37
1967	0.07	-0.21	-0.08	-0.20	0.06	-0.29	0.50	0.04	0.38	-0.27	-0.11	-0.02
1968	-0.22	-0.14	-0.37	-0.11	0.35	0.20	-0.24	0.24	-0.11	0.15	-0.13	0.08
1969	-0.41	0.00	0.22	0.09	0.22	-0.07	-0.29	-0.32	-0.25	-0.15	-0.17	-0.03
1970	-0.44	0.14	-0.02	-0.05	0.14	-0.06	0.34	-0.53	-0.25	-0.13	-0.06	-0.02
1971	-0.41	0.02	0.18	0.27	-0.13	0.23	-0.15	-0.21	-0.34	-0.11	-0.08	-0.02
1972	-0.46	-0.22	0.17	0.13	0.15	-0.03	-0.11	0.25	-0.25	-0.07	-0.03	-0.04
1973	0.19	-0.10	-0.05	0.16	0.03	-0.27	0.04	0.12	0.07	-0.20	-0.06	-0.02
1974	-0.33	0.09	0.03	-0.06	0.04	0.00	-0.18	0.25	0.05	0.08	-0.10	0.02
1975	0.02	-0.24	0.08	0.11	0.10	-0.10	-0.15	-0.04	0.24	0.02	-0.01	0.01
1976	0.41	0.11	-0.10	0.06	-0.15	0.14	-0.17	-0.15	0.03	0.07	-0.03	0.02
1977	-0.54	-0.06	0.04	-0.16	0.20	0.08	0.21	-0.07	-0.21	-0.07	-0.05	-0.05
1978	-0.03	0.10	0.04	-0.15	0.16	-0.09	0.08	-0.12	-0.06	-0.08	-0.02	0.03
1979	0.13	0.26	-0.16	0.01	0.06	0.08	-0.25	-0.03	-0.02	-0.06	-0.04	-0.02
1980	0.06	0.11	0.14	-0.01	-0.01	-0.06	0.07	-0.25	0.09	-0.02	-0.03	-0.04
1981	-0.77	-0.33	0.07	-0.20	0.05	0.18	0.07	0.30	0.08	0.15	-0.02	0.06
1982	-0.50	-0.04	0.07	-0.08	-0.26	0.18	0.22	0.03	-0.10	-0.22	-0.02	-0.04
1983	-0.86	-0.56	0.12	0.19	0.09	0.09	0.00	-0.08	-0.05	0.07	-0.07	0.03
1984	0.26	0.04	-0.01	0.01	-0.04	0.06	0.02	-0.18	-0.36	-0.07	0.04	-0.01
1985	0.12	0.18	-0.03	0.11	-0.10	-0.03	-0.19	-0.01	-0.08	-0.30	-0.02	0.01
1986	0.31	-0.16	0.05	0.01	0.11	-0.07	0.03	-0.20	-0.01	-0.05	-0.21	-0.02
1987	-0.17	0.13	0.09	-0.13	0.04	0.04	0.01	0.06	-0.07	-0.02	-0.01	-0.04
1988	-0.30	-0.15	0.04	0.15	-0.21	0.07	0.14	0.05	0.19	0.05	0.08	0.01
1989	-0.41	0.04	0.28	0.07	-0.05	-0.20	-0.24	-0.04	0.02	0.06	0.01	-0.02
1990	-0.01	-0.20	-0.03	0.12	0.10	-0.03	-0.16	-0.11	0.06	0.02	0.00	0.01
1991	0.33	0.05	-0.14	-0.03	0.09	-0.09	-0.03	-0.06	-0.03	0.04	-0.01	0.01
1992	0.20	-0.03	0.06	-0.06	-0.06	-0.02	0.00	-0.02	-0.07	-0.05	-0.01	0.00
1993	1.00	0.01	-0.29	-0.09	-0.29	-0.15	0.26	0.56	0.20	0.02	-0.01	0.02

year	3	4	5	6	7	8	9	10	11	12	13	14
1994	0.61	0.32	-0.13	-0.27	-0.07	0.01	-0.04	0.16	0.39	0.09	0.04	0.01
1995	0.81	0.20	0.11	-0.07	-0.09	-0.13	-0.16	-0.09	0.01	0.26	0.07	0.02
1996	0.09	0.16	-0.33	0.01	0.08	-0.02	0.02	0.09	-0.02	0.04	0.13	0.01
1997	-0.47	0.14	-0.10	-0.28	-0.09	0.24	0.07	0.20	0.15	-0.01	0.05	0.05
1998	-0.50	-0.25	0.03	0.07	-0.13	-0.20	0.18	0.00	0.08	0.07	0.05	0.01
1999	-0.25	0.01	-0.06	0.11	0.05	-0.17	-0.29	-0.17	-0.08	-0.02	0.00	0.00
2000	0.36	-0.34	0.09	-0.06	-0.03	0.13	-0.06	-0.09	0.06	0.05	0.02	0.01
2001	0.75	0.33	-0.26	0.11	-0.01	-0.15	0.18	0.20	0.04	0.13	0.00	0.06
2002	0.12	0.21	0.10	-0.08	0.07	0.09	0.06	0.28	0.12	0.03	0.06	0.00
2003	-0.05	0.09	0.07	-0.05	0.02	0.15	0.18	-0.06	0.07	0.04	0.03	0.07
2004	-0.48	0.03	0.06	0.01	-0.12	0.15	0.03	0.14	-0.09	0.05	0.02	0.01
2005	0.04	-0.45	0.08	-0.05	-0.19	-0.07	0.20	0.08	0.16	0.06	0.04	0.00
2006	-0.18	-0.05	-0.28	0.15	0.00	-0.04	-0.01	0.13	-0.01	-0.01	-0.02	0.01
2007	-0.31	0.04	-0.16	-0.07	-0.14	0.12	0.08	0.23	0.38	0.01	0.16	-0.01
2008	-0.24	-0.36	0.06	-0.09	0.09	-0.05	0.14	0.18	0.05	0.07	0.05	-0.01
2009	-0.11	-0.26	-0.02	0.20	0.09	0.15	-0.13	-0.25	-0.06	-0.17	0.00	-0.01
2010	-0.03	-0.03	-0.13	-0.01	0.22	0.01	0.08	-0.22	-0.20	-0.08	0.01	0.03
2011	-0.11	-0.05	0.12	0.01	0.07	0.09	-0.11	-0.08	-0.21	-0.25	-0.12	-0.04
2012	-0.17	0.01	0.02	-0.05	0.10	0.16	0.01	-0.27	-0.16	-0.25	-0.11	-0.04
2013	0.40	-0.04	0.02	-0.04	-0.04	-0.05	0.05	-0.04	-0.20	-0.09	-0.09	-0.07
2014	0.03	0.01	0.03	-0.07	0.07	-0.02	-0.03	0.10	0.08	-0.15	0.04	0.07
2015	0.33	0.23	0.03	-0.06	-0.08	0.03	-0.08	-0.04	0.31	-0.16	-0.21	-0.05
2016	0.05	0.19	-0.14	-0.01	0.11	-0.03	0.04	0.00	-0.03	0.16	-0.17	-0.15
2017	0.25	0.25	0.15	-0.08	-0.08	-0.09	-0.06	0.09	-0.06	-0.05	0.09	0.02
2018	0.11	0.20	-0.01	0.06	-0.03	0.11	-0.08	-0.21	-0.12	-0.07	-0.21	0.00
2019	-0.18	-0.30	-0.05	-0.05	-0.15	-0.12	0.13	0.29	0.32	0.09	0.11	0.07
2020	-0.38	0.11	0.13	0.15	-0.01	-0.22	-0.11	0.13	-0.01	0.01	0.18	0.23

Table 3.9: Icelandic cod in Division 5.a. Spring survey (SMB) at age residuals from the ADCAM model, assessment tuned with both the spring and the fall survey.

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	-0.61	-0.02	0.25	0.49	0.08	0.34	0.47	0.22	0.19	0.40	-0.05	-0.32	-0.10	0.09
1986	0.35	-0.18	-0.47	-0.21	-0.05	-0.11	-0.11	-0.27	-0.26	-0.13	-0.16	-0.12	-0.33	-0.04
1987	0.61	-0.11	0.02	-0.53	0.06	-0.02	-0.01	-0.01	-0.06	-0.05	0.15	0.12	0.17	0.09
1988	-0.24	-0.09	0.46	0.10	-0.11	-0.30	0.16	0.53	-0.07	-0.08	-0.04	0.26	0.02	0.08
1989	0.29	0.03	0.55	0.51	0.23	0.12	-0.04	-0.10	0.18	0.01	0.15	0.02	-0.07	-0.02
1990	-0.55	0.03	0.10	0.09	-0.15	-0.36	0.04	-0.13	-0.08	0.05	0.07	-0.10	0.05	0.06
1991	-0.02	-0.59	0.05	0.22	0.33	0.03	0.00	-0.14	0.22	0.08	0.13	-0.09	0.14	0.16
1992	-0.29	0.15	-0.23	0.08	-0.03	-0.01	-0.13	-0.11	0.04	0.02	-0.08	-0.02	0.07	-0.01
1993	-0.50	-0.10	0.34	-0.08	0.10	0.14	-0.08	-0.02	-0.01	0.03	0.14	0.02	0.04	0.02
1994	0.54	-0.31	0.08	0.18	-0.17	-0.22	0.03	-0.10	-0.03	0.09	0.12	0.00	0.05	0.01
1995	-0.33	0.14	-0.19	-0.05	0.22	0.02	-0.09	0.02	0.01	-0.08	0.13	0.19	0.05	-0.01
1996	-0.70	-0.28	0.12	-0.11	0.20	-0.01	0.29	0.49	0.23	0.03	-0.05	0.30	0.18	0.11
1997	0.21	-0.09	0.17	0.33	-0.05	0.00	-0.06	0.21	-0.38	-0.20	0.22	0.01	0.26	0.21
1998	-0.05	0.18	-0.19	0.20	0.55	0.30	0.10	0.13	0.31	0.28	0.09	-0.07	0.02	-0.02
1999	0.09	0.24	-0.03	0.10	0.02	0.09	0.02	-0.06	-0.13	0.02	0.07	0.05	-0.02	-0.01
2000	0.87	0.24	0.36	-0.14	0.00	-0.07	-0.20	0.03	-0.31	-0.24	-0.26	-0.03	0.06	0.02
2001	0.15	-0.02	0.12	-0.04	-0.47	-0.17	-0.27	-0.58	-0.31	0.05	-0.06	0.06	0.09	0.04
2002	-0.27	0.22	0.15	0.16	0.10	0.04	-0.10	-0.21	-0.42	-0.18	-0.05	-0.09	-0.05	-0.01
2003	-0.11	-0.38	0.03	-0.04	-0.07	-0.26	-0.08	-0.01	0.16	-0.45	-0.08	-0.06	0.16	-0.02
2004	-0.12	0.24	-0.18	0.33	0.18	0.34	0.25	0.30	0.55	0.21	0.17	-0.12	-0.03	0.01
2005	-0.23	0.12	0.25	-0.14	0.12	0.08	-0.04	0.03	0.05	0.23	0.23	0.30	0.02	-0.01
2006	0.15	-0.07	0.05	0.14	-0.05	0.15	-0.15	-0.36	-0.33	-0.17	-0.17	-0.06	-0.06	-0.02
2007	-0.01	0.24	-0.31	-0.15	-0.09	-0.08	-0.37	-0.10	0.00	-0.10	0.24	0.06	-0.02	-0.02
2008	-0.09	0.05	0.02	-0.38	-0.18	-0.07	0.21	-0.09	0.01	-0.24	0.04	0.06	0.02	-0.02
2009	0.24	-0.12	-0.09	-0.12	-0.06	-0.04	-0.09	-0.03	-0.27	-0.21	-0.32	-0.16	0.10	0.03
2010	-0.12	-0.26	-0.15	-0.12	-0.06	-0.10	-0.06	-0.10	0.24	-0.05	-0.14	0.01	-0.08	0.02
2011	-0.74	-0.34	-0.40	-0.22	0.02	0.12	0.16	0.07	-0.08	-0.22	-0.04	-0.24	-0.10	-0.05
2012	0.11	-0.30	-0.19	0.21	0.43	0.38	0.41	0.24	0.10	0.11	0.20	-0.09	0.26	0.14
2013	-0.02	0.15	-0.22	-0.16	0.05	0.07	0.03	0.17	0.46	0.08	0.10	0.36	-0.18	0.29
2014	-0.03	0.20	-0.09	-0.09	-0.04	0.07	-0.04	-0.23	-0.29	0.00	-0.49	-0.23	-0.10	-0.01
2015	0.48	0.33	-0.06	-0.11	-0.28	0.06	0.05	0.31	-0.08	0.03	0.16	-0.24	-0.30	0.03
2016	0.84	0.35	0.21	0.11	0.16	0.10	0.21	0.05	0.08	-0.20	-0.23	0.18	-0.23	-0.12
2017	-0.36	0.08	0.02	0.22	0.04	0.06	0.15	0.12	0.27	0.40	0.23	-0.01	0.27	-0.23
2018	0.05	0.21	-0.13	0.00	-0.05	-0.04	-0.10	0.13	-0.20	-0.16	-0.28	-0.22	-0.25	-0.11
2019	-0.04	0.12	-0.20	-0.20	-0.16	-0.16	-0.11	-0.04	0.36	0.25	0.10	0.04	-0.01	-0.32
2020	0.14	-0.17	-0.41	-0.69	-0.68	-0.65	-0.49	-0.27	-0.10	0.27	0.40	0.48	0.10	-0.31
2021	0.16	0.07	0.12	0.07	-0.17	0.15	0.03	-0.10	0.00	0.36	0.68	0.69	0.60	0.32

Table 3.10: Icelandic cod in Division 5.a. Fall survey (SMH) at age residuals from the ADCAM model, assessment tuned with both the spring and the fall survey.

year	3	4	5	6	7	8	9	10	11	12	13
1996	-0.17	-0.32	-0.13	-0.11	0.21	0.26	-0.11	0.00	-0.05	0.06	0.01
1997	-0.14	0.19	0.04	-0.07	-0.21	-0.16	-0.24	-0.04	-0.04	0.03	0.08
1998	-0.37	-0.05	-0.05	0.40	0.52	0.08	0.23	0.03	-0.01	0.03	0.01
1999	0.11	0.09	0.11	-0.02	-0.10	-0.43	-0.34	0.12	-0.04	-0.04	0.14
2000	-0.41	-0.20	-0.18	-0.26	-0.40	-0.30	0.00	0.15	0.06	0.01	0.02
2001	-0.03	-0.04	-0.29	-0.25	-0.25	-0.54	-0.49	-0.18	0.10	-0.02	-0.01
2002	-0.32	0.15	-0.01	0.24	0.08	0.08	0.01	-0.23	0.26	0.00	0.07
2003	-0.05	-0.25	-0.14	-0.24	-0.17	0.18	-0.04	-0.24	0.03	0.01	0.02
2004	0.02	0.10	0.16	0.10	0.27	0.46	0.56	0.13	0.05	0.11	-0.01
2005	-0.01	-0.02	0.29	-0.02	-0.28	-0.24	-0.14	0.03	-0.05	0.07	0.04
2006	0.04	0.10	0.09	0.07	0.05	-0.17	0.01	-0.01	0.01	-0.05	0.01
2007	-0.51	-0.27	-0.02	0.02	-0.16	0.07	-0.21	0.12	-0.06	0.09	-0.02
2008	0.04	-0.12	0.16	0.31	0.32	0.29	-0.04	0.20	0.12	0.14	0.00
2009	0.16	0.14	0.25	0.15	0.22	0.28	0.26	0.16	0.07	0.14	0.00
2010	0.15	0.22	0.18	0.03	0.19	0.27	0.46	0.13	0.21	-0.11	0.14
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	-0.15	-0.26	-0.19	-0.11	0.05	0.25	0.03	0.00	0.21	-0.18	0.04
2013	-0.04	-0.18	-0.10	-0.08	-0.03	0.08	0.29	0.13	0.19	0.40	0.15
2014	0.15	-0.02	-0.08	0.02	-0.07	0.10	0.18	0.48	0.35	0.35	0.38
2015	0.61	0.40	0.15	0.25	0.22	-0.08	0.07	-0.29	-0.05	0.04	0.01
2016	0.04	-0.15	-0.12	-0.28	-0.15	-0.19	-0.17	0.00	-0.09	0.18	-0.07
2017	0.44	0.58	0.46	0.44	0.20	0.09	-0.02	-0.09	0.11	0.03	0.29
2018	0.02	-0.08	-0.21	-0.20	-0.02	0.19	0.06	0.02	-0.04	-0.01	-0.11
2019	0.49	0.15	-0.10	-0.08	-0.18	-0.36	-0.21	-0.25	-0.30	-0.21	-0.05
2020	-0.19	-0.33	-0.41	-0.30	-0.40	-0.34	-0.41	0.02	-0.13	-0.16	-0.02

Table 3.11: Icelandic cod in Division 5.a. Estimates of fishing mortality 1955–2020 based on ACAM using catch at age and spring and fall bottom survey indices.

year	3	4	5	6	7	8	9	10	11	12	13	14
1955	0.06	0.18	0.24	0.25	0.31	0.37	0.41	0.50	0.56	0.53	0.53	0.53
1956	0.06	0.18	0.24	0.25	0.31	0.37	0.41	0.50	0.56	0.52	0.52	0.52
1957	0.07	0.20	0.27	0.28	0.34	0.41	0.46	0.56	0.62	0.59	0.59	0.59
1958	0.08	0.22	0.30	0.31	0.39	0.47	0.52	0.63	0.70	0.66	0.66	0.66
1959	0.07	0.20	0.26	0.28	0.34	0.41	0.46	0.55	0.62	0.58	0.58	0.58
1960	0.08	0.22	0.30	0.31	0.38	0.46	0.51	0.62	0.69	0.65	0.65	0.65
1961	0.07	0.20	0.28	0.29	0.36	0.43	0.48	0.58	0.65	0.61	0.61	0.61
1962	0.07	0.21	0.28	0.29	0.36	0.43	0.48	0.58	0.65	0.61	0.61	0.61
1963	0.08	0.23	0.32	0.33	0.41	0.49	0.55	0.66	0.74	0.70	0.70	0.70
1964	0.09	0.27	0.36	0.38	0.46	0.56	0.62	0.75	0.84	0.79	0.79	0.79
1965	0.10	0.29	0.39	0.41	0.50	0.60	0.67	0.81	0.91	0.85	0.85	0.85
1966	0.09	0.26	0.36	0.37	0.46	0.56	0.62	0.75	0.84	0.79	0.79	0.79
1967	0.09	0.25	0.33	0.35	0.43	0.52	0.58	0.69	0.78	0.73	0.73	0.73
1968	0.10	0.29	0.39	0.41	0.50	0.60	0.67	0.81	0.91	0.86	0.86	0.86
1969	0.08	0.23	0.32	0.33	0.41	0.49	0.54	0.66	0.74	0.69	0.69	0.69
1970	0.10	0.29	0.39	0.41	0.50	0.60	0.67	0.81	0.91	0.86	0.86	0.86
1971	0.12	0.34	0.47	0.49	0.60	0.72	0.80	0.97	1.09	1.02	1.02	1.02
1972	0.12	0.34	0.46	0.48	0.60	0.72	0.80	0.97	1.08	1.02	1.02	1.02
1973	0.13	0.36	0.49	0.51	0.63	0.76	0.84	1.02	1.14	1.07	1.07	1.07
1974	0.13	0.37	0.50	0.53	0.65	0.78	0.87	1.05	1.18	1.10	1.10	1.10
1975	0.13	0.37	0.50	0.52	0.64	0.77	0.86	1.04	1.17	1.09	1.09	1.09
1976	0.05	0.23	0.41	0.59	0.74	0.87	0.85	0.81	0.68	0.71	0.71	0.71
1977	0.04	0.19	0.33	0.48	0.60	0.70	0.69	0.66	0.55	0.58	0.58	0.58
1978	0.03	0.15	0.27	0.38	0.49	0.57	0.56	0.53	0.44	0.46	0.46	0.46
1979	0.03	0.14	0.25	0.36	0.46	0.54	0.53	0.50	0.42	0.44	0.44	0.44
1980	0.03	0.16	0.28	0.40	0.51	0.59	0.58	0.55	0.46	0.49	0.49	0.49
1981	0.04	0.20	0.36	0.51	0.65	0.76	0.74	0.71	0.59	0.62	0.62	0.62
1982	0.05	0.23	0.41	0.58	0.74	0.86	0.84	0.80	0.67	0.71	0.71	0.71
1983	0.04	0.22	0.38	0.55	0.69	0.81	0.79	0.75	0.63	0.66	0.66	0.66
1984	0.04	0.20	0.36	0.51	0.64	0.75	0.74	0.70	0.59	0.62	0.62	0.62
1985	0.05	0.23	0.40	0.57	0.72	0.84	0.82	0.79	0.66	0.69	0.69	0.69
1986	0.06	0.28	0.49	0.69	0.88	1.02	1.00	0.96	0.80	0.84	0.84	0.84
1987	0.06	0.29	0.51	0.74	0.93	1.09	1.06	1.01	0.85	0.89	0.89	0.89
1988	0.06	0.30	0.52	0.75	0.95	1.11	1.08	1.03	0.87	0.91	0.91	0.91
1989	0.05	0.25	0.43	0.62	0.78	0.91	0.89	0.85	0.71	0.75	0.75	0.75
1990	0.05	0.25	0.44	0.63	0.79	0.92	0.90	0.86	0.72	0.76	0.76	0.76
1991	0.06	0.30	0.52	0.75	0.94	1.10	1.08	1.03	0.86	0.90	0.90	0.90
1992	0.07	0.33	0.58	0.83	1.05	1.23	1.20	1.15	0.96	1.00	1.00	1.00
1993	0.07	0.32	0.57	0.81	1.03	1.20	1.18	1.12	0.94	0.98	0.98	0.98

year	3	4	5	6	7	8	9	10	11	12	13	14
1994	0.04	0.22	0.39	0.55	0.70	0.82	0.80	0.76	0.64	0.67	0.67	0.67
1995	0.04	0.14	0.30	0.45	0.58	0.66	0.73	0.78	0.79	0.78	0.78	0.78
1996	0.03	0.13	0.29	0.42	0.55	0.63	0.70	0.74	0.75	0.74	0.74	0.74
1997	0.03	0.13	0.29	0.43	0.56	0.64	0.71	0.75	0.77	0.75	0.75	0.75
1998	0.04	0.16	0.35	0.53	0.68	0.78	0.86	0.91	0.93	0.91	0.91	0.91
1999	0.05	0.19	0.42	0.62	0.80	0.92	1.01	1.07	1.10	1.07	1.07	1.07
2000	0.05	0.19	0.42	0.63	0.81	0.93	1.03	1.09	1.11	1.09	1.09	1.09
2001	0.05	0.18	0.39	0.58	0.75	0.86	0.95	1.01	1.03	1.00	1.00	1.00
2002	0.04	0.15	0.32	0.48	0.62	0.71	0.78	0.83	0.85	0.83	0.83	0.83
2003	0.04	0.14	0.32	0.47	0.61	0.69	0.76	0.81	0.83	0.81	0.81	0.81
2004	0.04	0.15	0.33	0.50	0.64	0.74	0.81	0.86	0.88	0.86	0.86	0.86
2005	0.04	0.14	0.32	0.48	0.62	0.71	0.78	0.83	0.85	0.83	0.83	0.83
2006	0.04	0.14	0.30	0.45	0.58	0.67	0.74	0.78	0.80	0.78	0.78	0.78
2007	0.03	0.13	0.28	0.42	0.54	0.62	0.68	0.72	0.74	0.72	0.72	0.72
2008	0.04	0.11	0.20	0.31	0.38	0.48	0.48	0.51	0.49	0.61	0.61	0.61
2009	0.04	0.12	0.21	0.34	0.41	0.51	0.51	0.55	0.53	0.65	0.65	0.65
2010	0.03	0.10	0.18	0.29	0.35	0.44	0.44	0.47	0.45	0.55	0.55	0.55
2011	0.03	0.10	0.17	0.27	0.33	0.41	0.41	0.44	0.42	0.52	0.52	0.52
2012	0.03	0.10	0.17	0.27	0.33	0.42	0.41	0.44	0.43	0.53	0.53	0.53
2013	0.03	0.10	0.18	0.29	0.36	0.45	0.45	0.48	0.46	0.57	0.57	0.57
2014	0.03	0.09	0.16	0.26	0.32	0.40	0.40	0.43	0.42	0.51	0.51	0.51
2015	0.03	0.09	0.16	0.25	0.31	0.39	0.39	0.41	0.40	0.49	0.49	0.49
2016	0.03	0.09	0.16	0.26	0.32	0.40	0.40	0.42	0.41	0.50	0.50	0.50
2017	0.03	0.09	0.16	0.26	0.32	0.40	0.40	0.43	0.41	0.50	0.50	0.50
2018	0.03	0.10	0.18	0.28	0.34	0.43	0.43	0.46	0.45	0.55	0.55	0.55
2019	0.03	0.11	0.19	0.31	0.38	0.47	0.47	0.50	0.49	0.60	0.60	0.60
2020	0.04	0.12	0.22	0.35	0.42	0.53	0.53	0.57	0.55	0.67	0.67	0.67

Table 3.12: Icelandic cod in Division 5.a. Estimates of numbers at age in the stock 1955–2021 (in millions) based on ACAM using catch at age and spring and fall bottom survey indices.

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1955	161.466	143.753	151.013	211.538	199.648	110.944	31.895	20.439	9.572	77.118	6.371	4.706	5.491	1.819
1956	215.103	161.466	143.752	116.169	145.111	128.588	70.707	19.157	11.537	5.181	38.311	2.975	2.276	2.655
1957	304.213	215.103	161.466	110.614	79.752	93.561	82.043	42.526	10.831	6.256	2.580	17.937	1.442	1.103
1958	153.622	304.213	215.103	123.337	74.375	49.990	57.962	47.578	34.749	5.594	2.937	1.131	8.173	0.657
1959	195.931	153.623	304.213	162.880	80.900	45.079	29.901	32.185	39.722	16.937	2.449	1.190	0.479	3.459
1960	125.111	195.930	153.622	232.505	109.691	50.818	27.989	17.388	17.477	31.618	7.987	1.079	0.545	0.219
1961	173.200	125.111	195.930	116.474	153.060	66.811	30.553	15.641	9.001	8.591	13.983	3.273	0.461	0.233
1962	197.565	173.200	125.111	149.273	77.737	94.981	40.958	17.490	25.151	4.569	3.950	5.986	1.459	0.206
1963	219.616	197.565	173.200	95.289	99.542	48.184	58.157	23.411	9.302	12.742	2.096	1.686	2.661	0.649
1964	233.050	219.616	197.565	130.583	61.737	59.333	28.323	31.605	11.719	4.408	5.387	0.817	0.688	1.086
1965	320.419	233.050	219.616	147.332	82.017	35.281	33.376	14.577	14.821	5.161	1.707	1.902	0.304	0.256
1966	171.116	320.419	233.050	162.545	90.576	45.528	19.253	16.545	6.535	6.208	1.881	0.563	0.664	0.106
1967	239.593	171.116	320.419	173.839	102.168	51.813	25.637	9.922	7.771	2.883	2.409	0.666	0.210	0.247
1968	179.438	239.593	171.116	240.565	111.296	59.922	29.947	13.645	4.844	3.579	1.178	0.904	0.262	0.083
1969	192.968	179.438	239.593	126.604	147.748	61.699	32.655	44.935	6.104	2.024	1.301	0.388	0.315	0.091
1970	141.824	192.968	179.438	180.708	82.116	88.196	36.323	31.391	22.546	2.898	0.858	0.509	0.159	0.129
1971	277.781	141.824	192.968	132.759	110.979	45.518	48.059	17.973	14.042	9.421	1.053	0.282	0.177	0.055
1972	186.988	277.781	141.824	139.982	77.093	57.020	22.913	21.560	23.525	5.147	2.923	0.290	0.083	0.052
1973	259.329	186.988	277.781	102.947	81.435	39.707	28.777	10.312	8.606	8.660	1.605	0.809	0.086	0.025
1974	370.981	259.329	186.988	200.362	58.822	40.933	19.536	12.549	3.964	3.038	2.567	0.420	0.227	0.024
1975	143.961	370.982	259.329	134.338	113.198	29.117	19.819	8.352	4.710	1.363	0.872	0.648	0.114	0.062
1976	225.108	143.962	370.982	186.526	76.148	56.285	14.165	8.523	3.157	1.632	0.395	0.222	0.178	0.031
1977	239.218	225.108	143.962	289.738	120.856	41.327	25.616	5.514	2.931	1.106	0.594	0.164	0.089	0.071
1978	140.994	239.218	225.107	113.444	196.241	70.907	21.022	11.480	2.235	1.206	0.470	0.281	0.076	0.041
1979	145.929	140.994	239.218	178.701	79.698	122.778	39.536	10.582	5.328	1.050	0.581	0.247	0.144	0.039
1980	139.250	145.930	140.994	190.213	126.564	50.578	75.326	20.421	5.062	2.578	0.520	0.313	0.130	0.076
1981	230.639	139.250	145.930	111.769	132.695	78.212	27.708	45.416	9.234	2.319	1.212	0.268	0.157	0.065
1982	140.599	230.639	139.250	114.670	74.648	75.958	38.409	11.876	17.474	3.612	0.938	0.550	0.118	0.069
1983	139.345	140.599	230.639	108.791	74.421	40.631	34.713	15.030	4.109	6.159	1.322	0.391	0.222	0.048
1984	303.152	139.346	140.599	180.729	71.660	41.577	19.272	14.238	5.494	1.528	2.374	0.576	0.166	0.094
1985	251.883	303.151	139.345	110.497	120.789	41.071	20.454	8.279	5.493	2.154	0.619	1.079	0.255	0.073
1986	176.012	251.883	303.152	108.974	72.067	66.318	19.003	8.130	2.917	1.971	0.802	0.262	0.443	0.105
1987	96.786	176.012	251.884	234.746	67.674	36.303	27.133	6.464	2.389	0.876	0.619	0.295	0.093	0.157
1988	131.121	96.786	176.012	194.398	143.394	33.115	14.250	8.758	1.786	0.676	0.260	0.217	0.099	0.031
1989	113.564	131.121	96.786	135.689	118.089	69.484	12.818	4.519	2.371	0.495	0.197	0.090	0.072	0.033
1990	170.010	113.564	131.121	75.410	86.881	92.665	30.696	4.805	1.487	0.796	0.173	0.079	0.035	0.028
1991	126.349	170.010	113.564	102.087	48.112	45.891	40.570	11.377	1.560	0.493	0.275	0.069	0.030	0.013
1992	81.465	126.349	170.010	87.568	62.084	23.360	17.814	12.912	3.093	0.434	0.144	0.095	0.023	0.010
1993	145.063	81.465	126.349	130.205	51.490	28.411	8.333	5.094	3.098	0.762	0.113	0.045	0.028	0.007
1994	159.988	145.063	81.465	96.895	77.068	23.838	10.304	2.433	1.252	0.782	0.203	0.036	0.014	0.009

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1995	94.018	159.987	145.062	63.805	63.669	42.872	11.238	4.194	0.881	0.462	0.299	0.088	0.015	0.006
1996	158.086	94.019	159.988	114.594	45.594	38.565	22.454	5.154	1.771	0.347	0.174	0.111	0.033	0.006
1997	76.603	158.085	94.019	126.606	82.435	28.028	20.646	10.595	2.248	0.723	0.136	0.067	0.043	0.013
1998	162.111	76.603	158.086	74.347	90.821	50.361	14.867	9.626	4.558	0.905	0.278	0.051	0.026	0.017
1999	150.099	162.110	76.603	124.097	51.869	52.167	24.380	6.157	3.617	1.579	0.297	0.090	0.017	0.008
2000	156.510	150.099	162.111	59.691	84.180	27.996	23.029	8.958	2.018	1.078	0.442	0.081	0.025	0.005
2001	174.114	156.510	150.099	126.223	40.372	45.142	12.240	8.356	2.894	0.592	0.296	0.119	0.022	0.007
2002	88.497	174.115	156.510	117.331	86.659	22.379	20.731	4.734	2.904	0.920	0.177	0.087	0.036	0.007
2003	149.780	88.497	174.115	123.337	83.072	51.427	11.371	9.141	1.911	1.089	0.329	0.062	0.031	0.013
2004	130.720	149.780	88.497	137.321	87.592	49.634	26.393	5.079	3.745	0.729	0.396	0.117	0.023	0.011
2005	97.891	130.720	149.780	69.633	96.660	51.314	24.740	11.352	1.993	1.361	0.252	0.134	0.041	0.008
2006	127.510	97.891	130.720	118.046	49.321	57.414	26.107	10.927	4.592	0.749	0.487	0.089	0.048	0.015
2007	115.199	127.510	97.891	103.237	84.271	29.809	29.972	11.923	4.592	1.800	0.281	0.179	0.033	0.018
2008	125.757	115.200	127.510	77.527	74.487	52.146	16.115	14.323	5.276	1.906	0.716	0.110	0.071	0.013
2009	166.957	125.757	115.199	100.781	56.758	55.618	31.177	9.004	7.263	2.678	0.935	0.358	0.049	0.032
2010	177.841	166.957	125.757	90.813	73.174	37.647	32.485	16.933	4.407	3.558	1.265	0.450	0.153	0.021
2011	128.170	177.841	166.957	99.699	67.131	50.088	23.128	18.761	8.950	2.331	1.825	0.660	0.212	0.072
2012	169.553	128.170	177.841	132.645	74.201	46.501	31.363	13.670	10.208	4.874	1.234	0.980	0.322	0.103
2013	143.996	169.553	128.170	141.221	98.564	51.254	28.986	18.436	7.387	5.521	2.560	0.658	0.474	0.156
2014	96.821	143.996	169.554	101.529	104.126	67.164	31.260	16.594	9.637	3.865	2.799	1.319	0.305	0.220
2015	151.035	96.821	143.996	134.765	75.664	72.296	42.213	18.561	9.081	5.279	2.058	1.512	0.648	0.150
2016	153.302	151.035	96.821	114.579	100.790	52.863	45.895	25.371	10.313	5.050	2.856	1.129	0.758	0.325
2017	115.027	153.302	151.034	76.987	85.500	70.138	33.346	27.371	13.960	5.680	2.704	1.552	0.559	0.375
2018	143.158	115.027	153.302	120.085	57.434	59.473	44.213	19.871	15.046	7.681	3.038	1.468	0.767	0.276
2019	130.767	143.158	115.027	121.588	88.888	39.407	36.674	25.651	10.563	8.006	3.964	1.593	0.695	0.363
2020	189.564	130.766	143.159	90.964	89.170	60.004	23.674	20.613	13.104	5.402	3.960	1.995	0.717	0.313
2021	163.431	189.565	130.766	112.735	65.826	58.801	34.720	12.713	9.945	6.329	2.513	1.879	0.836	0.300

Table 3.13: Icelandic cod in Division 5.a. Catch (kt), average fishing mortality of age groups 5 to 10, recruitment to the fisheries at age 3 (millions), reference fishing biomass (B4+, kt), spawning stock biomass (kt) at spawning time and harvest ratio. 'Harvest rate' is the calendar year yield divided by the reference biomass in the start of the year, 'Harvest rate2' is 1/3 of the yield in the calendar year and 2/3 of the yield in the next year divided by the reference biomass at the start of the year. Predictions are based on the estimated yield in the assessment year.

Year	Recruits	SSB	Yield	F5-10	Reference biomass	Harvest rate
1955	151.013	726.241	545.250	0.35	2090.320	0.24
1956	143.752	583.804	486.909	0.35	1818.140	0.26
1957	161.466	574.563	455.182	0.39	1639.740	0.30
1958	215.103	689.959	517.359	0.44	1650.370	0.29
1959	304.213	639.226	459.081	0.38	1580.310	0.30
1960	153.622	583.530	470.121	0.43	1657.860	0.25
1961	195.930	399.302	377.291	0.40	1430.560	0.27
1962	125.111	505.480	388.985	0.40	1464.330	0.27
1963	173.200	460.469	408.800	0.46	1298.680	0.33
1964	197.565	420.076	437.012	0.52	1210.650	0.33
1965	219.616	322.911	387.106	0.56	1052.680	0.35
1966	233.050	295.681	353.357	0.52	1063.260	0.32
1967	320.419	280.570	335.721	0.48	1139.610	0.32
1968	171.116	248.410	381.770	0.56	1242.860	0.32
1969	239.593	354.183	403.205	0.46	1335.750	0.34
1970	179.438	354.785	475.077	0.56	1332.670	0.34
1971	192.968	252.991	444.248	0.67	1083.340	0.38
1972	141.824	225.430	395.166	0.67	978.206	0.39
1973	277.781	244.838	369.205	0.71	829.801	0.44
1974	186.988	188.285	368.133	0.73	908.077	0.40
1975	259.329	174.257	364.754	0.72	889.039	0.40
1976	370.982	144.821	346.253	0.71	945.577	0.36
1977	143.962	197.742	340.086	0.58	1297.470	0.26
1978	225.107	211.015	329.602	0.47	1306.800	0.27
1979	239.218	306.679	366.462	0.44	1409.580	0.29
1980	140.994	368.922	432.237	0.49	1512.890	0.30
1981	145.930	268.023	465.032	0.62	1244.300	0.33
1982	139.250	177.331	380.068	0.71	980.697	0.33
1983	230.639	139.019	298.049	0.66	794.045	0.36
1984	140.599	148.271	282.022	0.62	908.082	0.34
1985	139.345	164.568	323.428	0.69	929.609	0.38
1986	303.152	191.453	364.797	0.84	855.173	0.45
1987	251.884	144.474	389.915	0.89	989.609	0.39
1988	176.012	159.873	377.554	0.91	985.283	0.37
1989	96.786	161.381	363.125	0.75	950.420	0.36
1990	131.121	197.404	335.316	0.76	815.683	0.39
1991	113.564	155.780	307.759	0.90	696.868	0.40

Year	Recruits	SSB	Yield	F5-10	Reference biomass	Harvest rate
1992	170.010	141.908	264.834	1.01	563.578	0.45
1993	126.349	114.550	250.704	0.99	599.228	0.34
1994	81.465	152.348	178.138	0.67	572.173	0.30
1995	145.062	174.084	168.592	0.58	567.699	0.31
1996	159.988	157.872	180.701	0.55	685.535	0.29
1997	94.019	191.678	203.112	0.57	792.512	0.29
1998	158.086	200.239	243.987	0.69	733.200	0.35
1999	76.603	175.092	260.147	0.81	724.660	0.34
2000	162.111	160.381	235.092	0.82	585.873	0.40
2001	150.099	157.143	236.707	0.75	649.756	0.34
2002	156.510	189.278	209.535	0.62	694.293	0.30
2003	174.115	185.748	207.241	0.61	725.876	0.30
2004	88.497	192.443	228.330	0.65	791.616	0.28
2005	149.780	220.740	213.863	0.62	717.393	0.28
2006	130.720	211.858	197.200	0.59	675.921	0.27
2007	97.891	195.743	171.641	0.54	651.464	0.24
2008	127.510	245.586	147.663	0.39	659.452	0.26
2009	115.199	225.779	183.315	0.42	726.787	0.24
2010	125.757	254.755	170.018	0.36	773.335	0.22
2011	166.957	311.443	172.197	0.34	819.615	0.23
2012	177.841	344.400	196.188	0.34	940.442	0.23
2013	128.170	364.574	223.593	0.37	1065.260	0.21
2014	169.554	333.010	222.013	0.33	1074.200	0.21
2015	143.996	439.073	230.168	0.32	1149.060	0.21
2016	96.821	382.258	251.238	0.33	1193.030	0.21
2017	151.034	506.895	243.922	0.33	1116.430	0.23
2018	153.302	493.086	267.222	0.35	1154.570	0.23
2019	115.027	436.468	263.015	0.39	1086.780	0.25
2020	143.159	384.961	270.303	0.43	982.186	0.26
2021	130.766	361.348	247.078	0.44	940.767	0.24
2022	189.565	338.572	NA	0.40	898.237	0.23
2023	163.431	349.326	NA	NA	976.021	NA

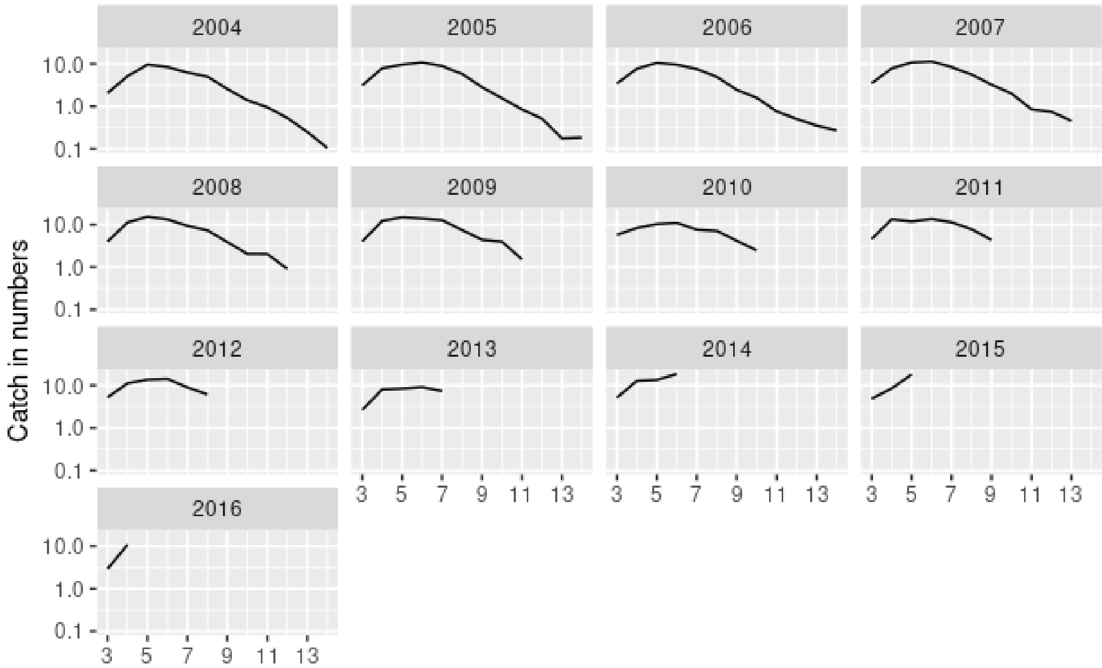


Figure 3.1: Icelandic cod division 5.a. Catch curve of recent year classes.

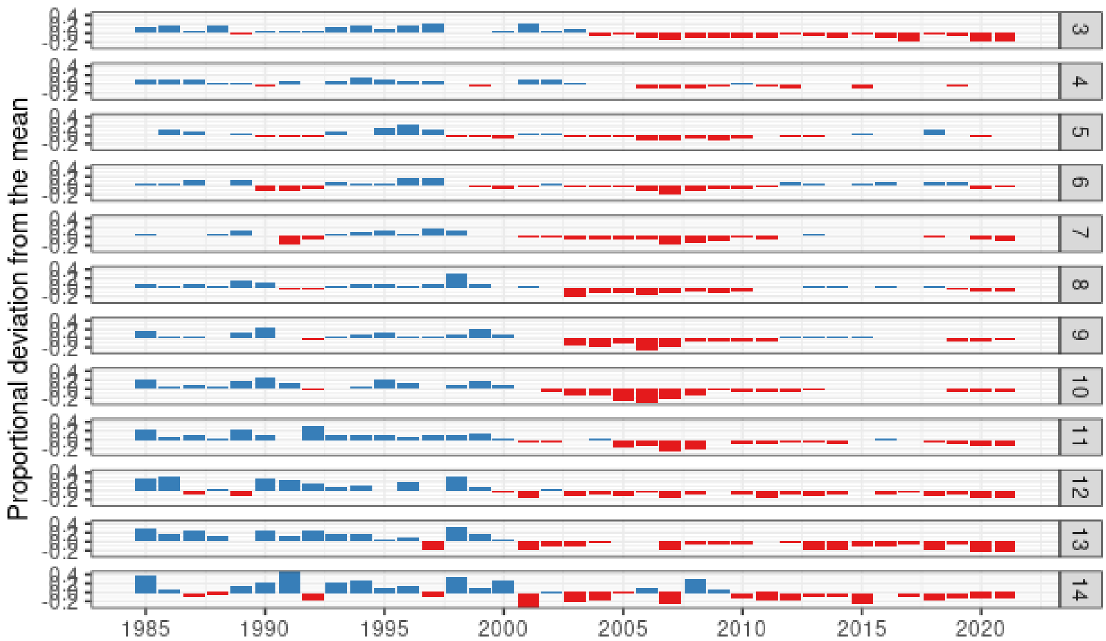


Figure 3.2: Icelandic cod division 5.a. Weight at age (numbers in panel indicate age classes) in the catches expressed as proportional deviations from the mean. Weight at age in the assessment year are estimates. Note that values that are equal to the mean are not visible in this type of a plot.

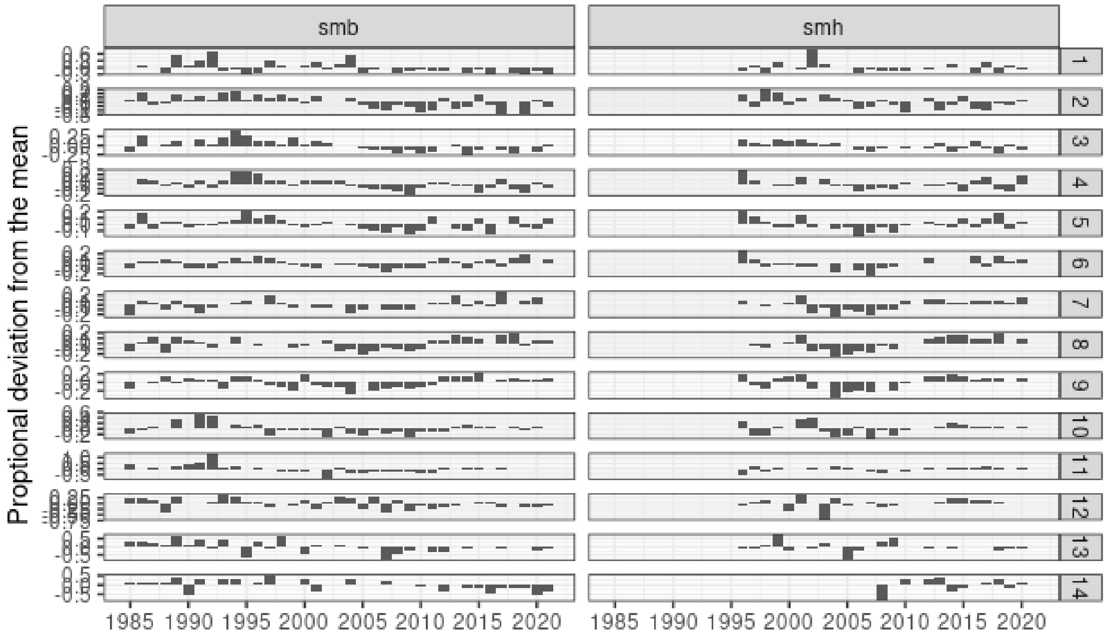


Figure 3.3: Icelandic cod division 5.a. Weight at age (numbers in panel indicate age classes) in the spring survey (SMB) and fall survey (SMH) expressed as proportional deviations from the mean. No fall survey was conducted in 2011. Note that values that are equal to the mean are not visible in this type of a plot.

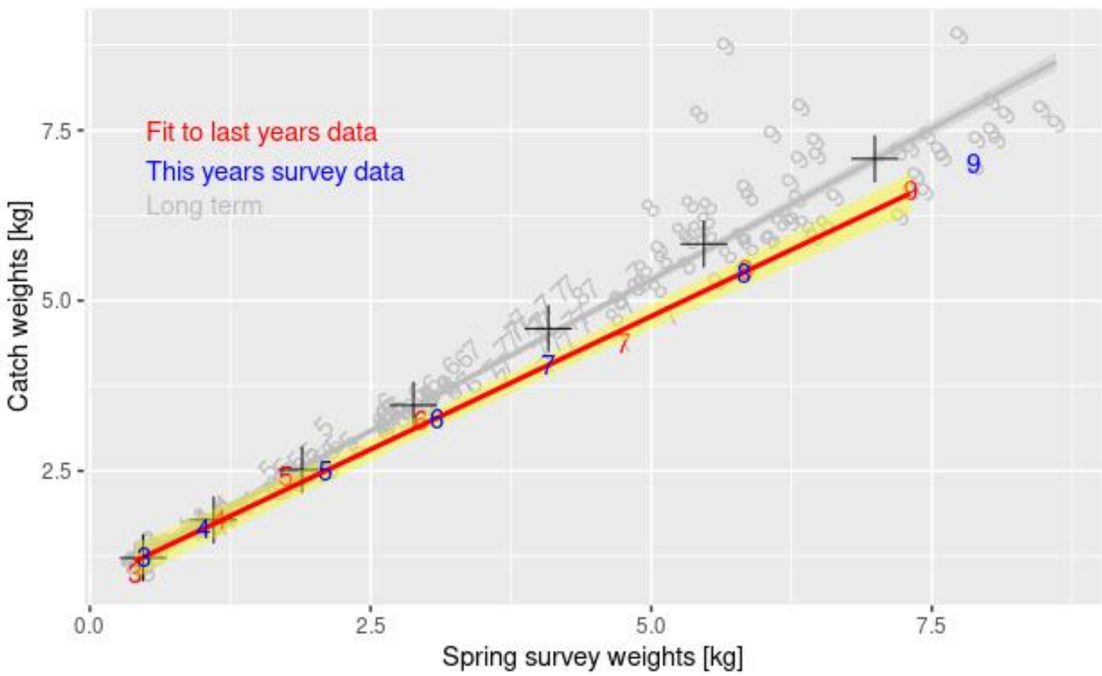


Figure 3.4: Icelandic cod division 5.a. Prediction of catch weights age 3 to 9 in the assessment year. The 'crossed' points are the mean from 1990 to the present.

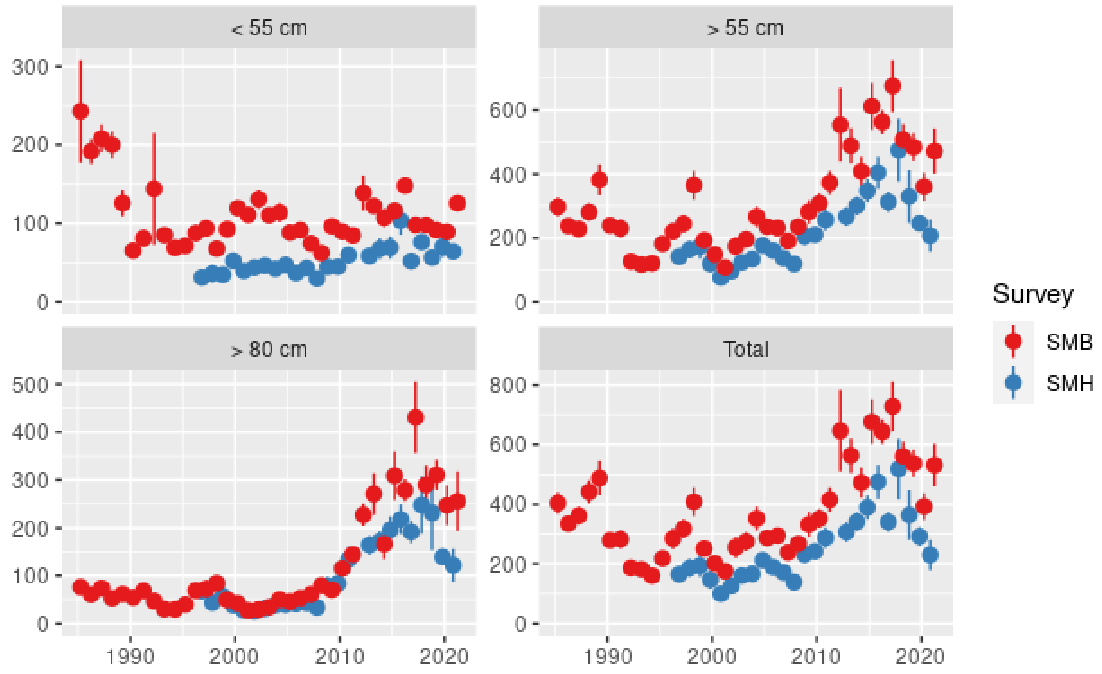


Figure 3.5: Icelandic cod division 5.a. Indices of cod in the spring (SMB, red) and fall (SMH, blue) groundfish surveys. Abundance index of fish less than 55 cm, (< 55 cm, top left) and biomass indices of 55 cm and larger (>55 cm, top right), biomass index 80 cm and larger (bottom left) and total biomass (Total, bottom right). The vertical bar show 1 standard error of the estimate.

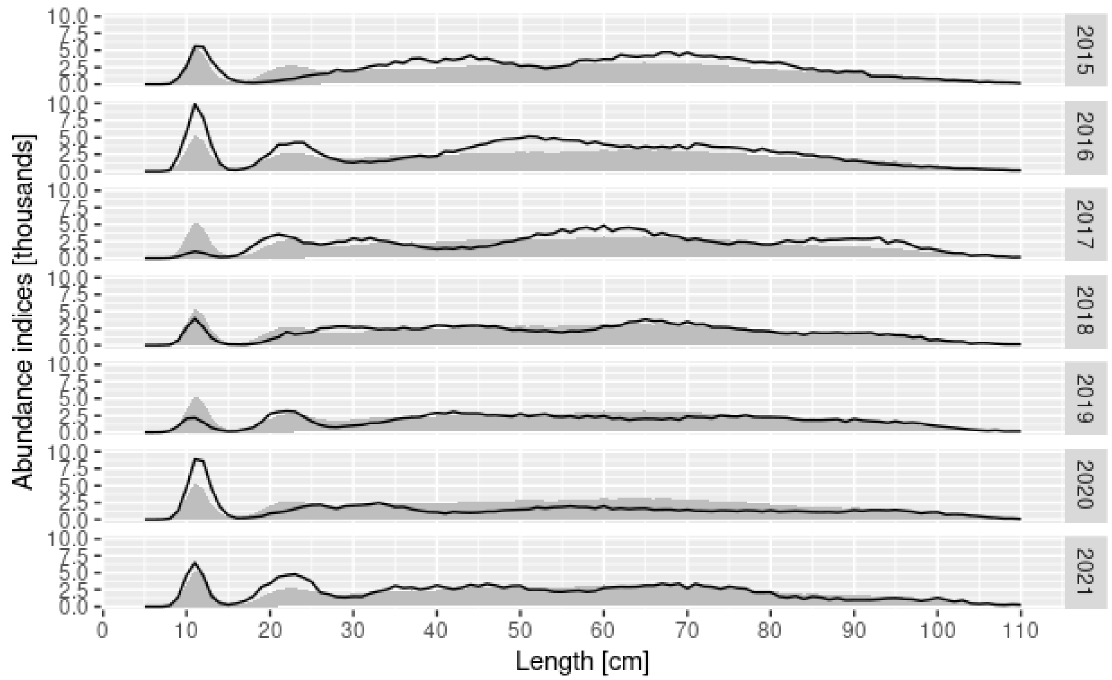


Figure 3.6: Icelandic cod division 5.a. Abundance indices of cod in the spring (SMB, red) by length in 2015 to 2021. The grey line is the average indices over the 6 years while the black line is yearly measurement.

Figure 3.7: Icelandic cod division 5.a. Age based abundance indices of cod in the groundfish survey in spring (SMB) and fall (SMH). The indices are standardized within each age group and within each survey. Indices for age 11 to 14 are not used in the SPALY assessment but used in an alternative assessment.

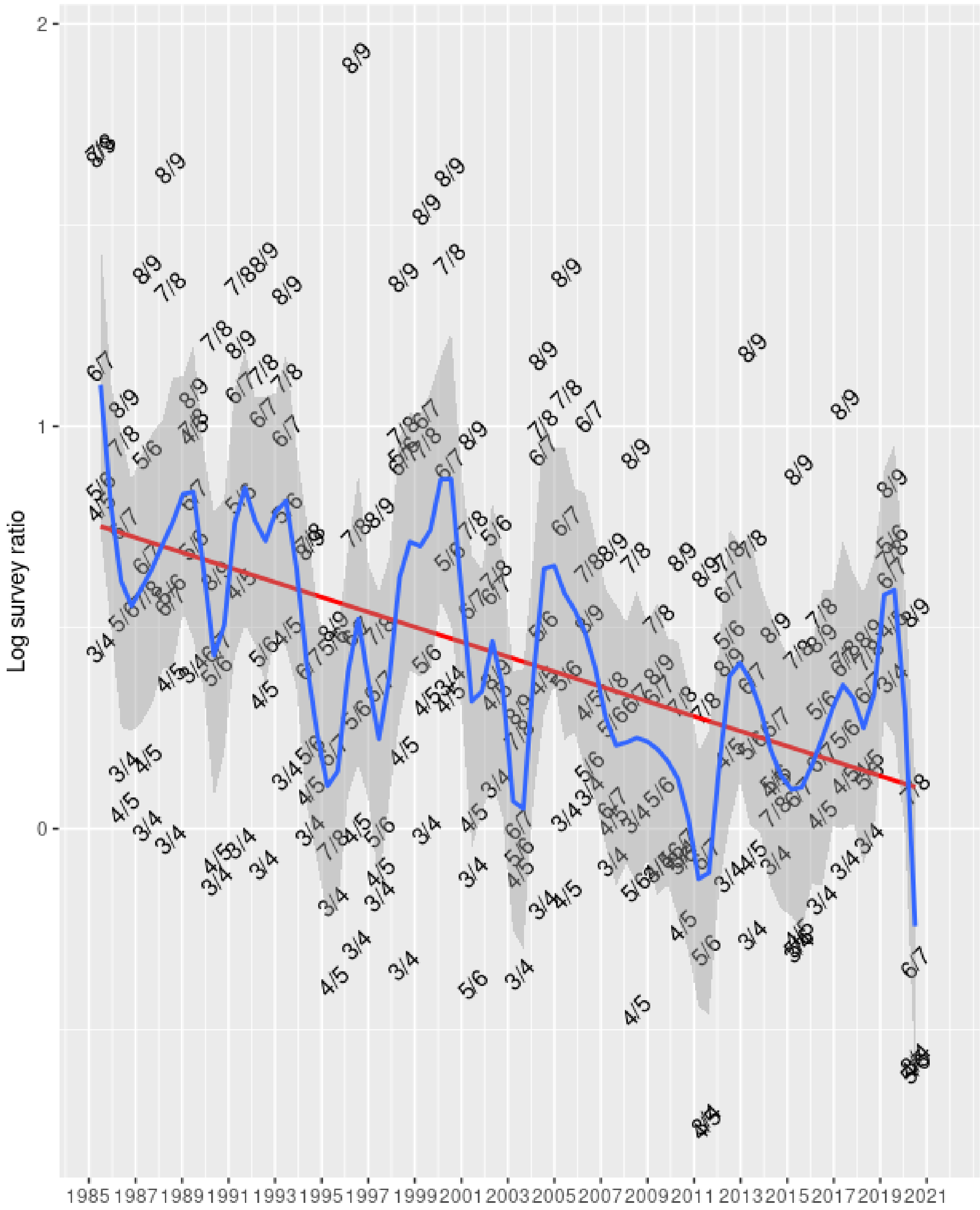


Figure 3.8: Icelandic cod division 5.a. Log ratio of the spring survey indices by age classes 3 to 9.

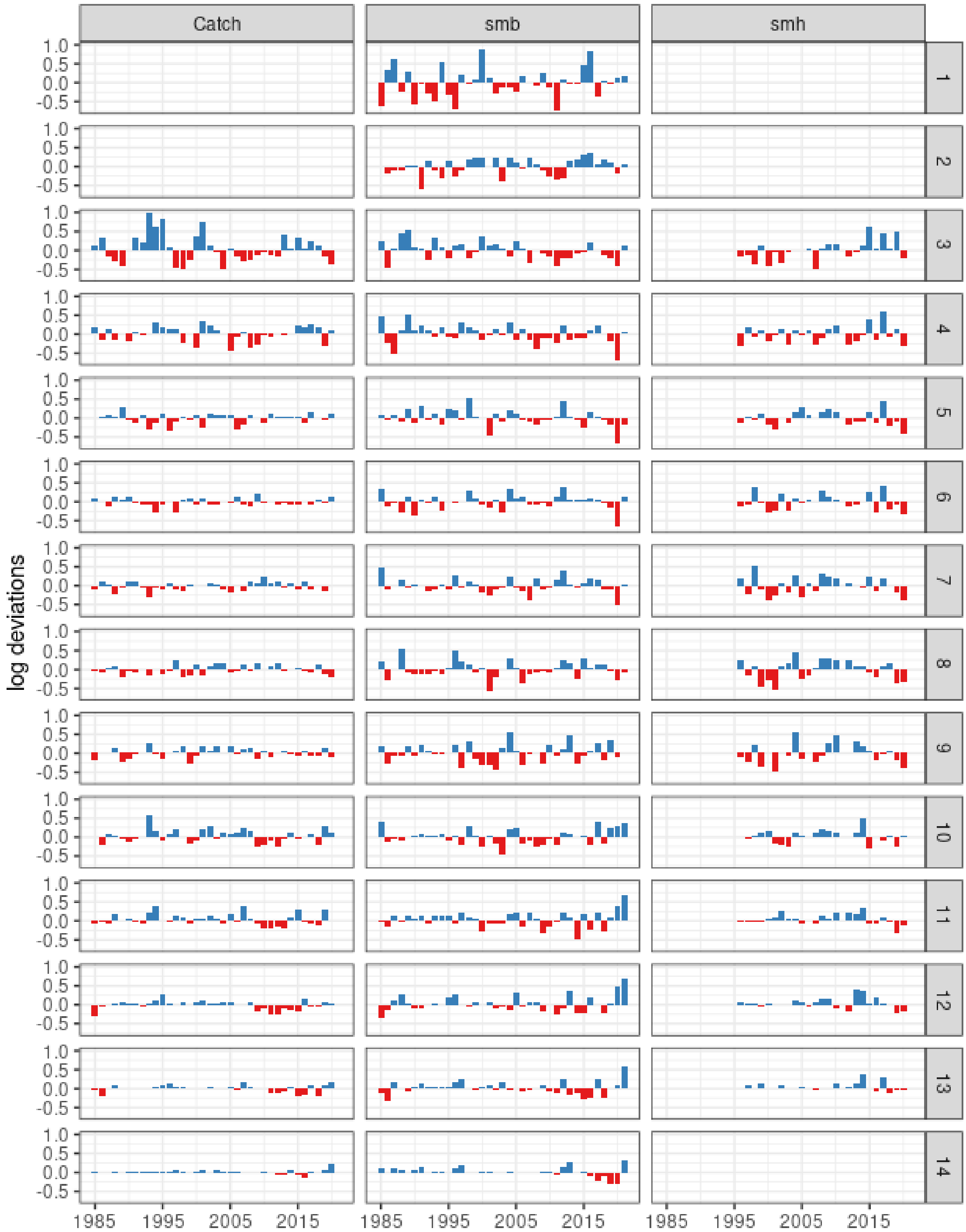


Figure 3.9: Catch residuals (left), spring survey residuals (SMB, middle) and fall survey residuals (SMH, right) by year and age. Note that values that are equal to zero are not visible in this type of a plot and that no survey was carried out in the fall 2011.

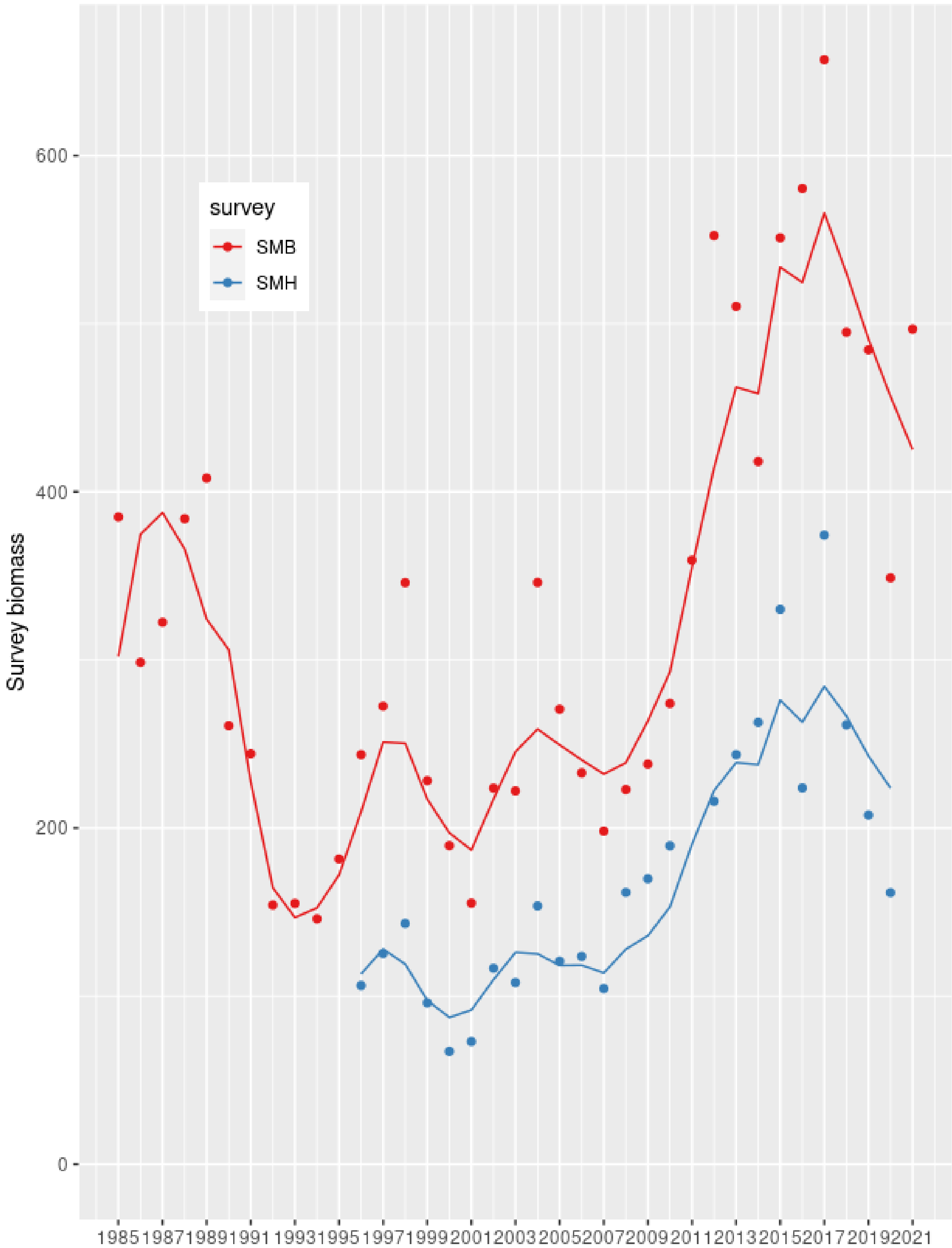


Figure 3.10: Summary plot of observed vs predicted survey biomass.

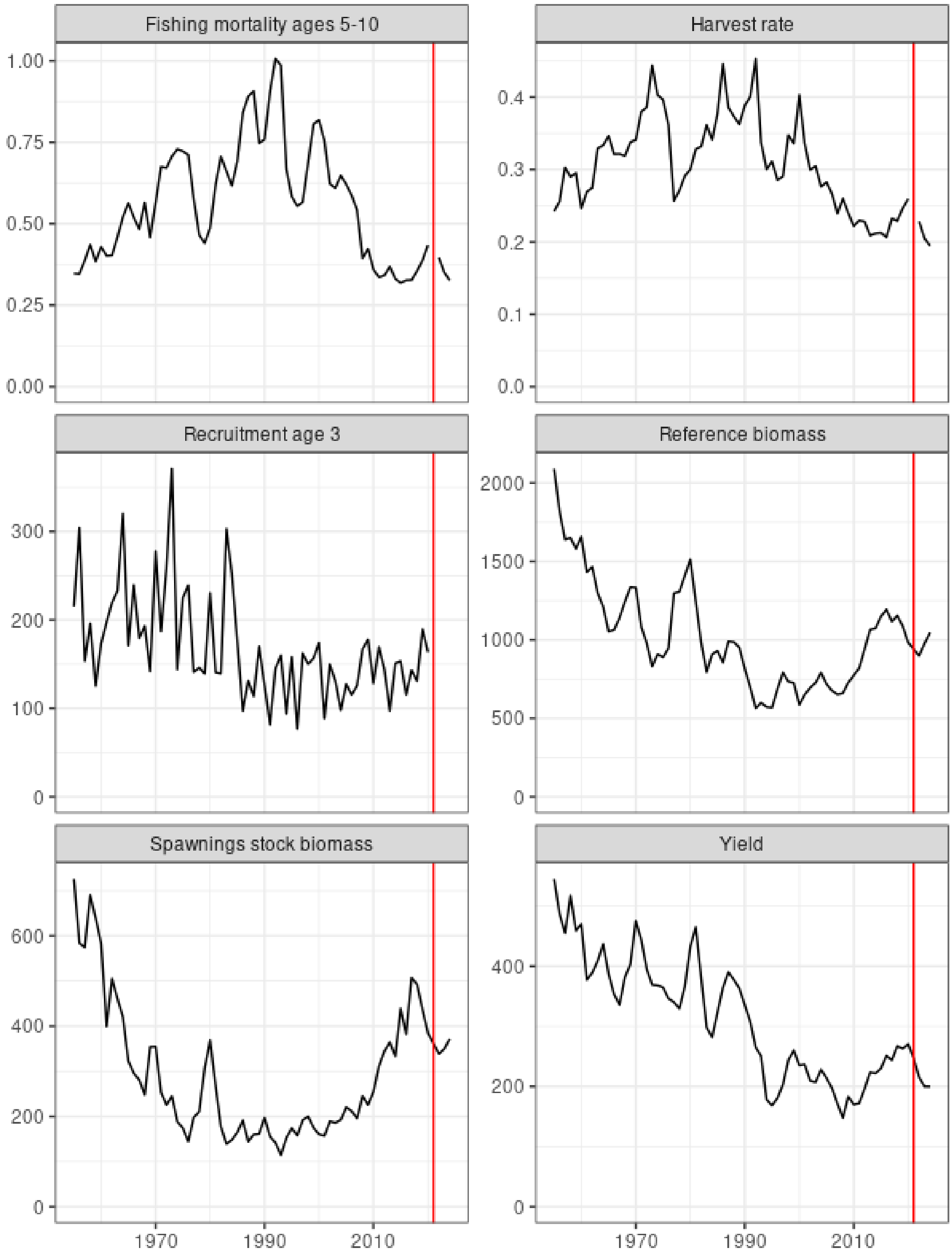


Figure 3.11: Icelandic cod in division 5.a. Assessment summary. The x-axis for the recruitment refer to the year class.

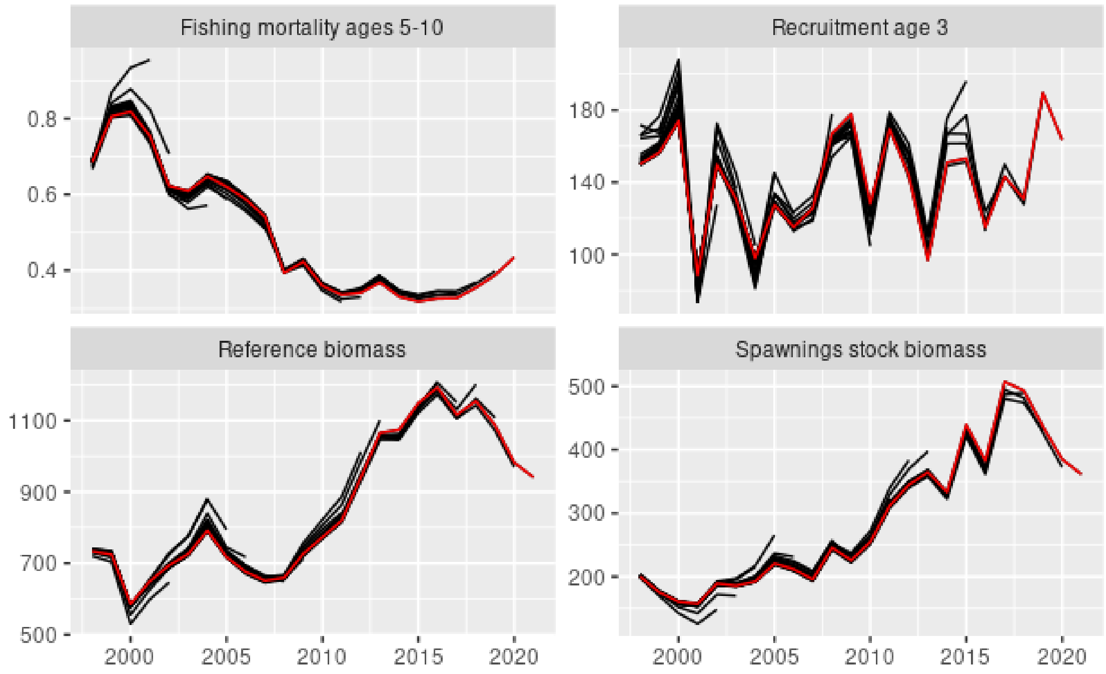


Figure 3.12: Icelandic cod in division 5.a. Analytical retrospective pattern of key metrics in the last eight years and the current estimates.

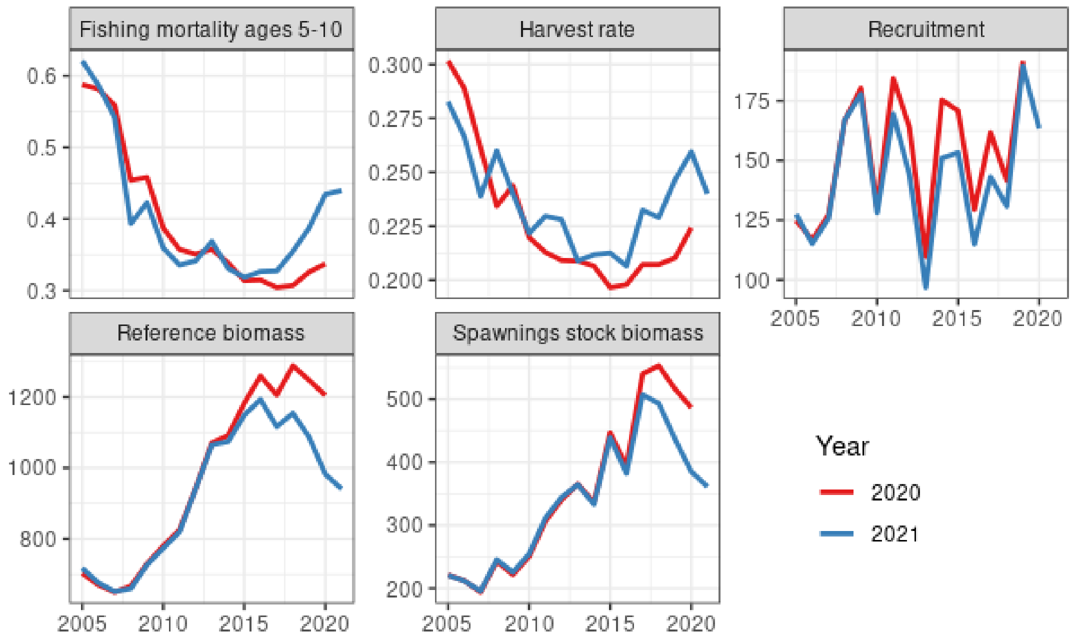


Figure 3.13: Icelandic cod in division 5.a. Comparison with last year's assessment

10 Haddock in 5.a

Icelandic haddock (*Melanogrammus aeglefinus*) is fairly 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 (less than 10 tonnes 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 fairly 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.

10.1 Fishery

The fishery for haddock in 5.a has not changed substantially in recent years, but the total number of boats that account for 95% of fishery have been declining steadily (Figure 10.1.1). Around 250 longliners annually report catches of haddock, around 60 trawlers and 40 demersal seine boats. Most of haddock in 5.a 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 was around 60% in 2019. At the same time the proportion caught by longlines has increased from around 15% in 1995–2000 to 40 % in 2011–2020. Catches in demersal seine have varied less and have been at around 15% of Icelandic catches of haddock in 5.a. 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 10.1.2). Most of the haddock caught in 5.a by Icelandic vessels is caught at depths less than 200 m (Figure 10.1.3). The main fishing grounds for haddock in 5.a, as observed from logbooks, are in the south, southwestern and western part of the Icelandic shelf (Figure 10.1.4) and Figure 10.1.5). The main trend in the spatial distribution of haddock catches in 5.a according to logbook entries is the increased proportion of catches caught in the north and northeast.

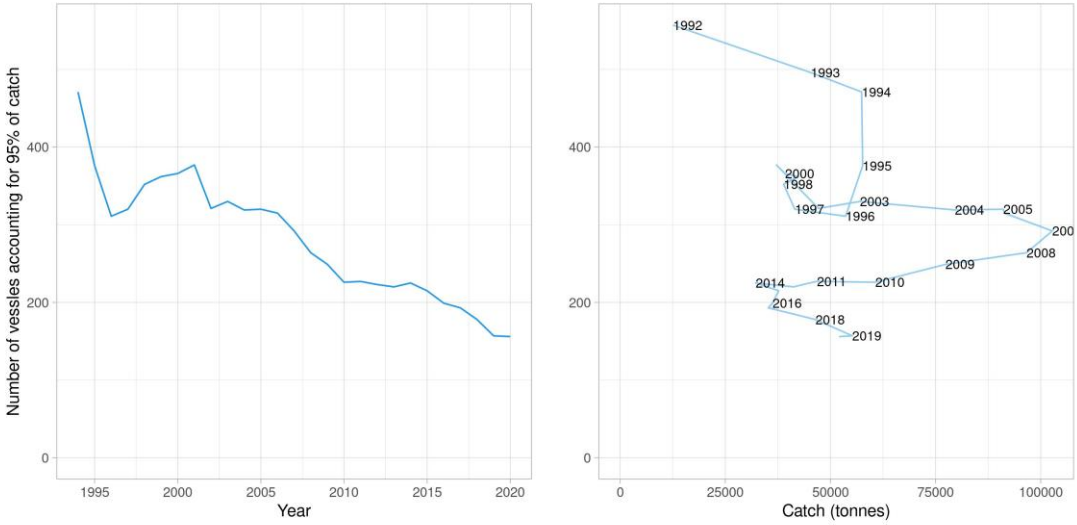


Figure 10.1.1: Haddock in 5.a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

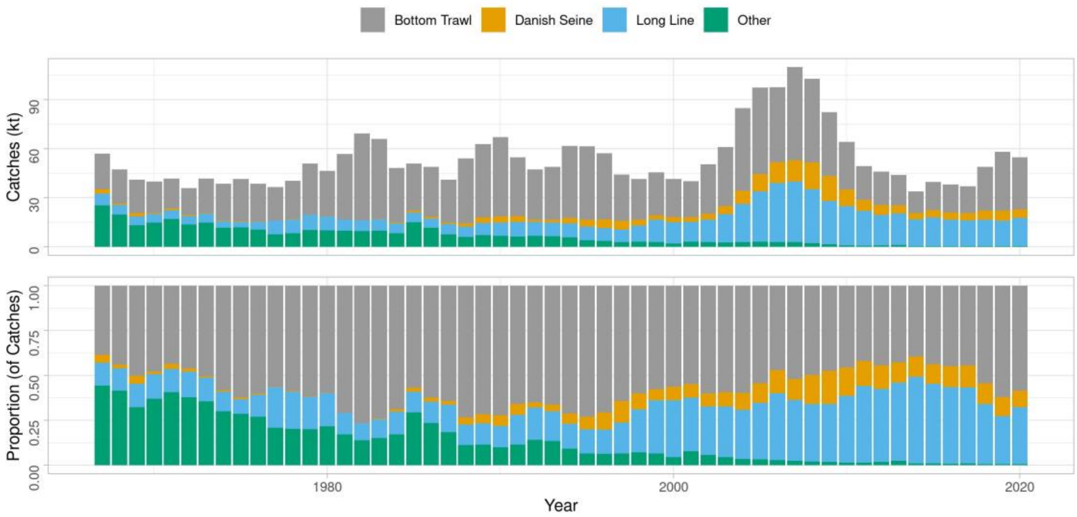


Figure 10.1.2: Haddock in 5.a. Landings in tonnes and percent of total by gear and year.

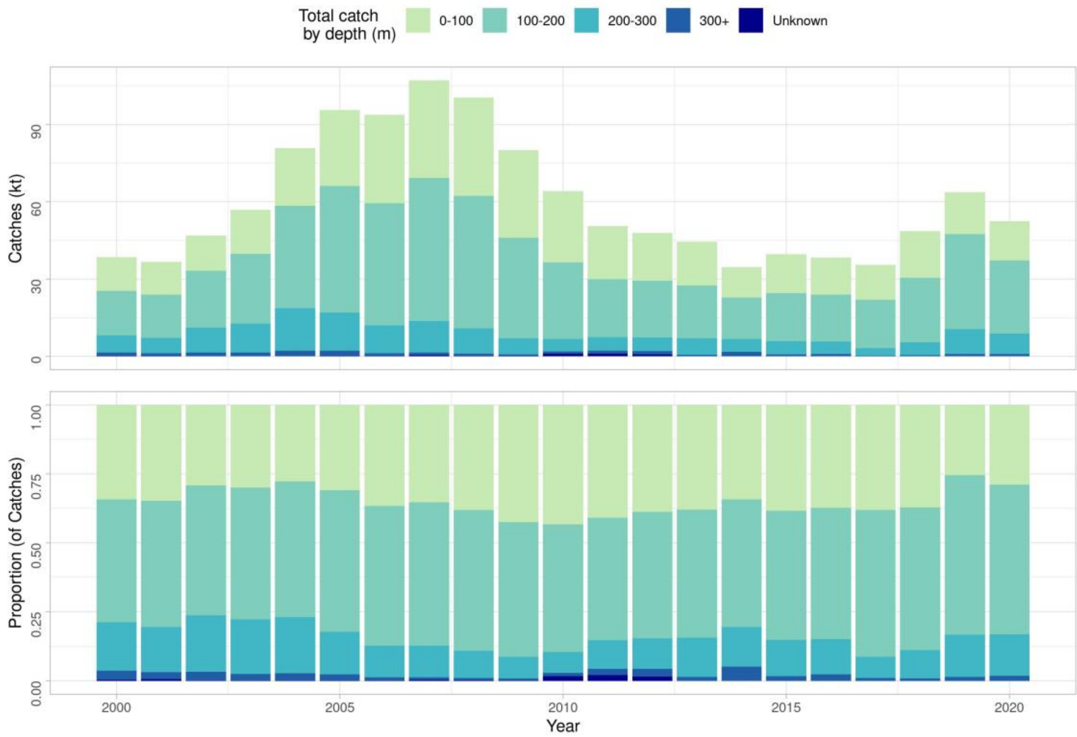


Figure 10.1.3: Haddock in 5.a. Depth distribution of haddock catches from bottom trawls, longlines, trawls and demersal seine from Icelandic logbooks.

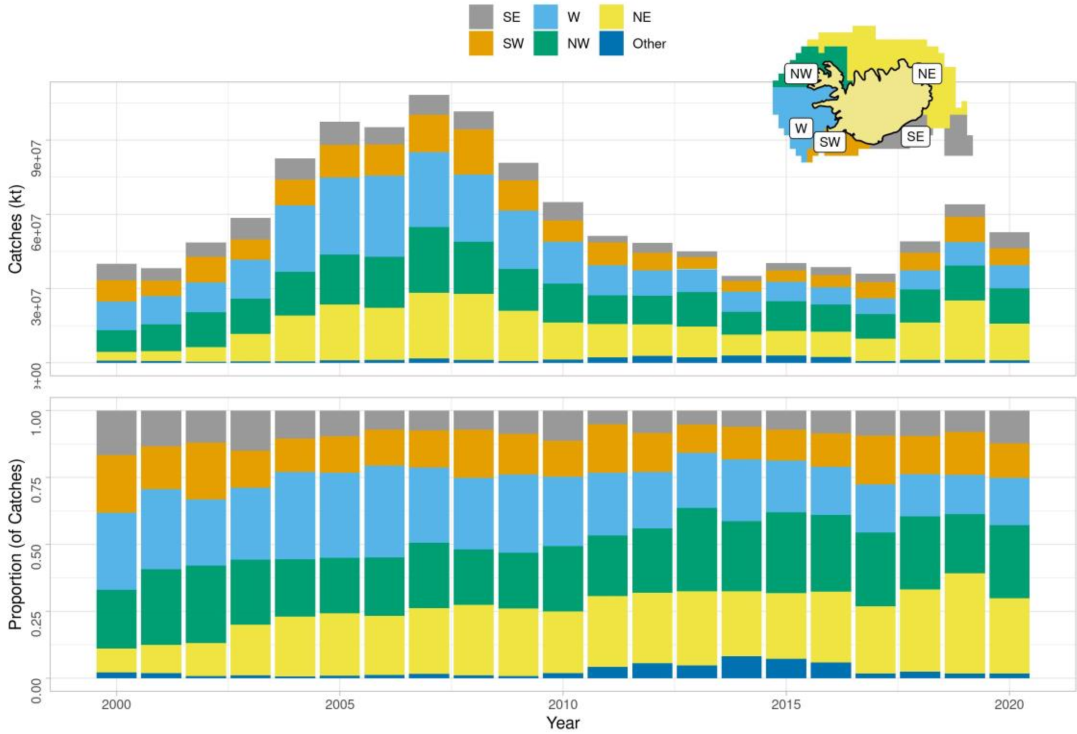


Figure 10.1.4: Haddock in 5.a. Changes in spatial distribution of haddock catches as recorded in Icelandic logbooks.

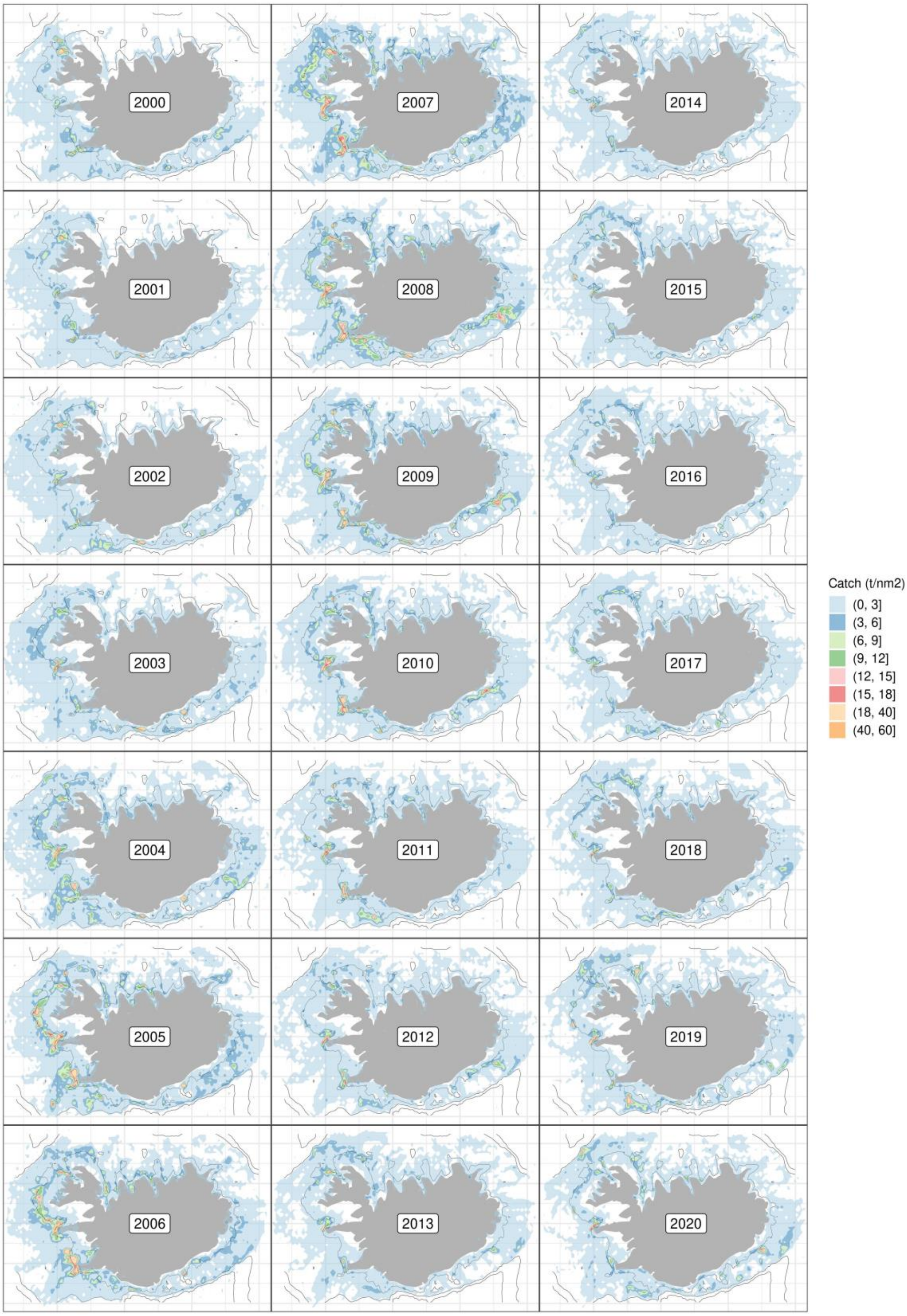


Figure 10.1.5: Haddock in 5.a. Spatial distribution of catches by all gears.

10.1.1 Landing trends

Landings of Icelandic haddock in 2020 are estimated to have been 5.478074^{4} thousand tonnes, see Figure 10.1.6. The landings in Division 5.a. 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 1.248329^{6} tonnes, while Norwegian vessels land considerably less haddock.

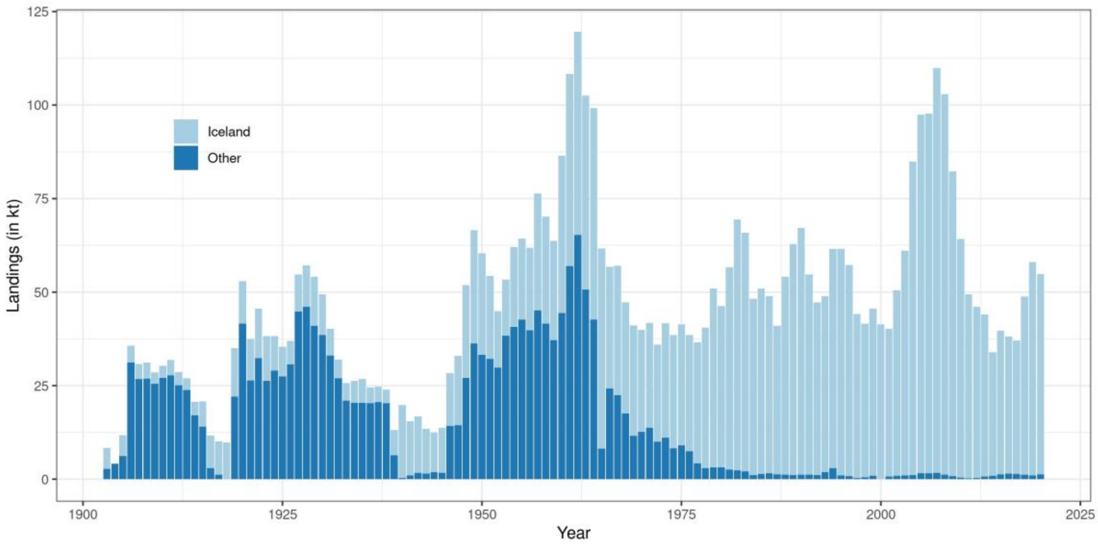


Figure 10.1.6: Haddock in 5.a. Recorded landings since 1905.

10.2 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 10.1.7and Figure 10.1.8. 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.

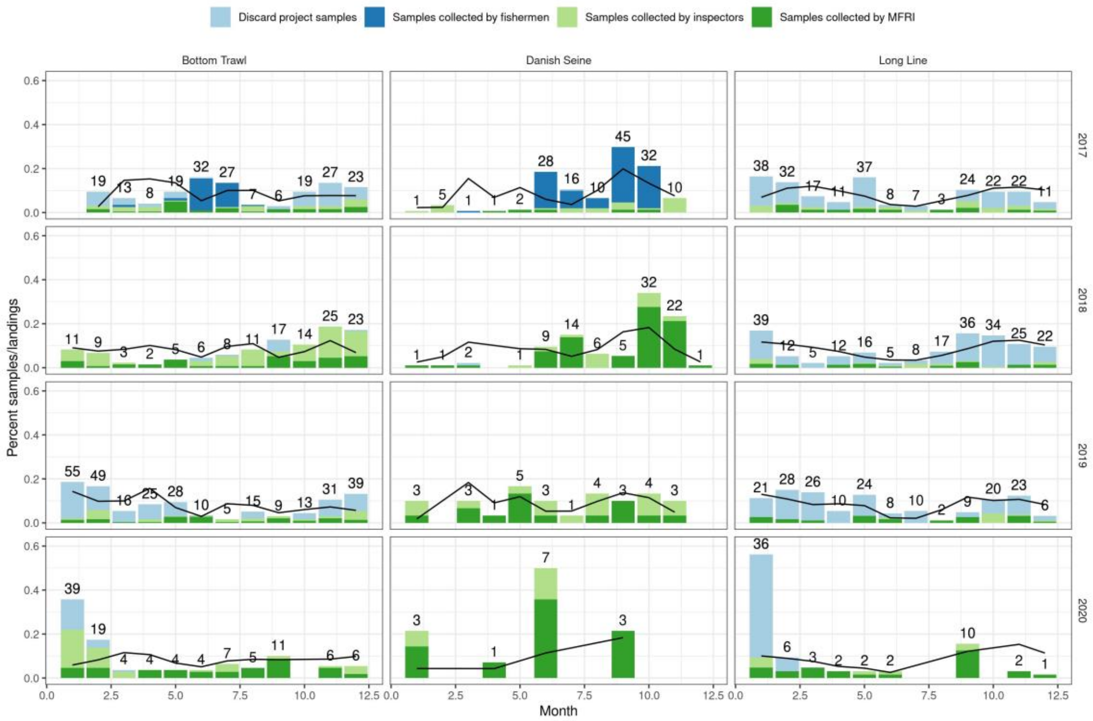


Figure 10.2.1: Haddock in 5.a. Ratio of samples by month (blue bars) compared with landings by month (solid black line) split by year and main gear types. Numbers of above the bars indicate number of samples by year, month and gear.

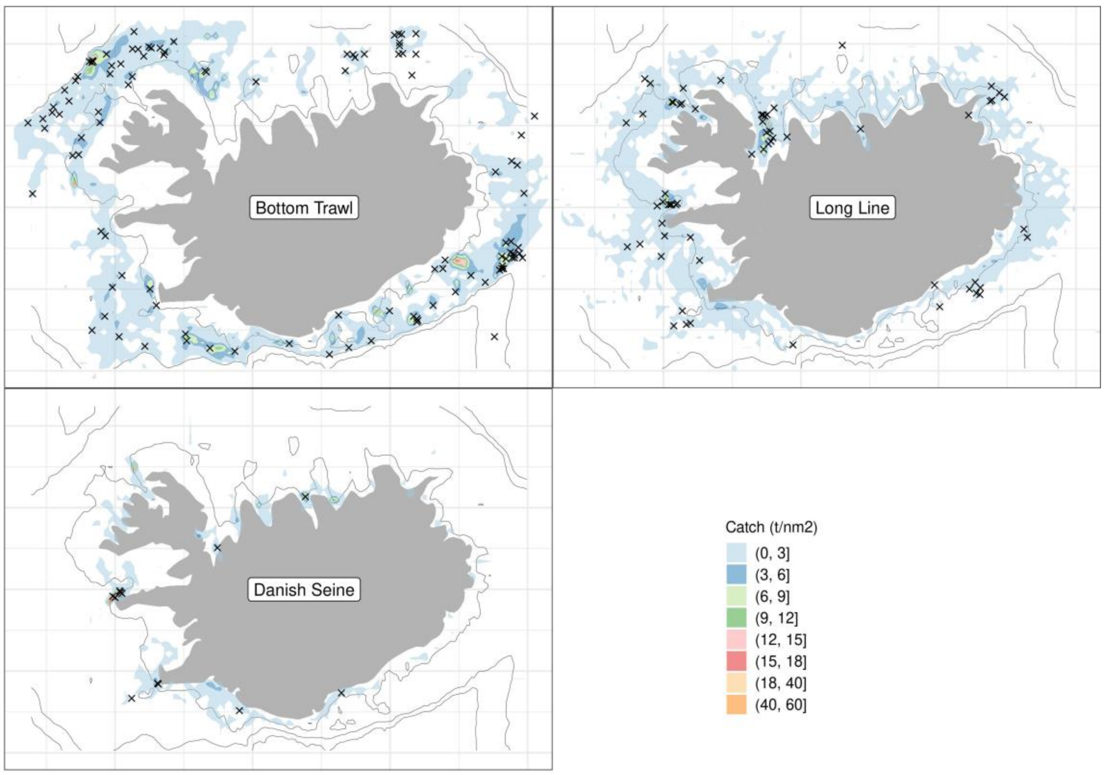


Figure 10.2.2: Haddock in 5.a. Fishing grounds in 2019 as reported in logbooks (tiles) and positions of samples taken from landings (asterisks) by main gear types.

10.2.1 Landings and discards

All landings in 5.a before 1982 are derived from the STATLANT database, and also all foreign landings in 5.a 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 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/.

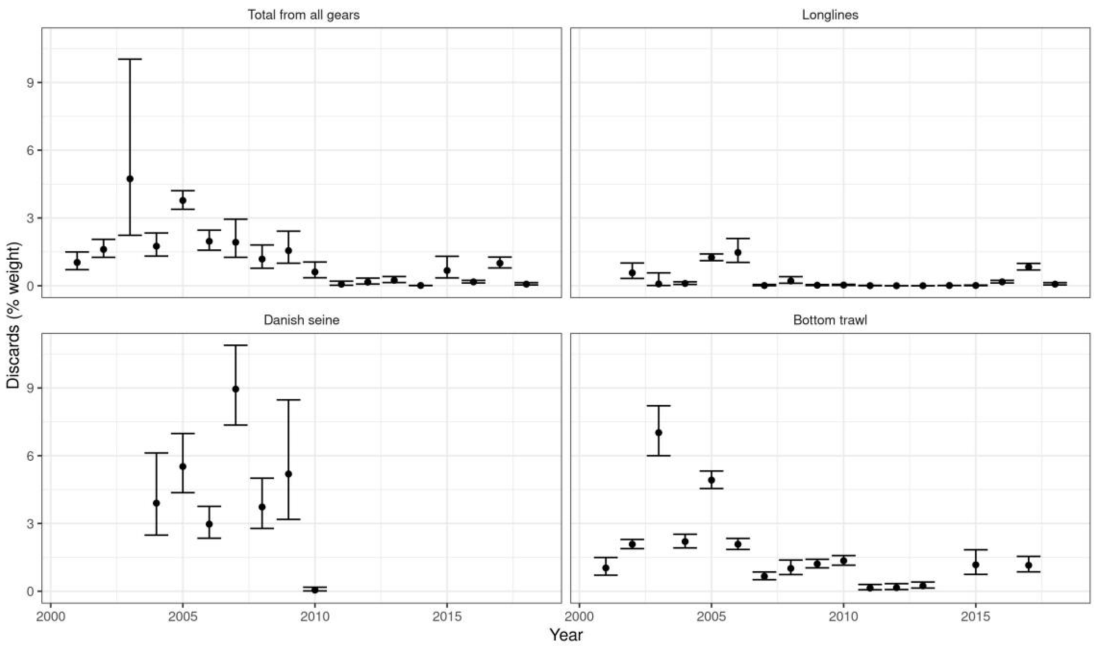


Figure 10.2.3: Haddock in 5.a. Estimates of annual discards by gear. Vertical lines indicate the 95 % confidence interval while dots the point estimates. No estimates are available for 2019 and 2020 at this time.

10.2.2 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 10.1.9. The sizes caught by the main gear types (bottom trawl and longlines) appear to be fairly 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.

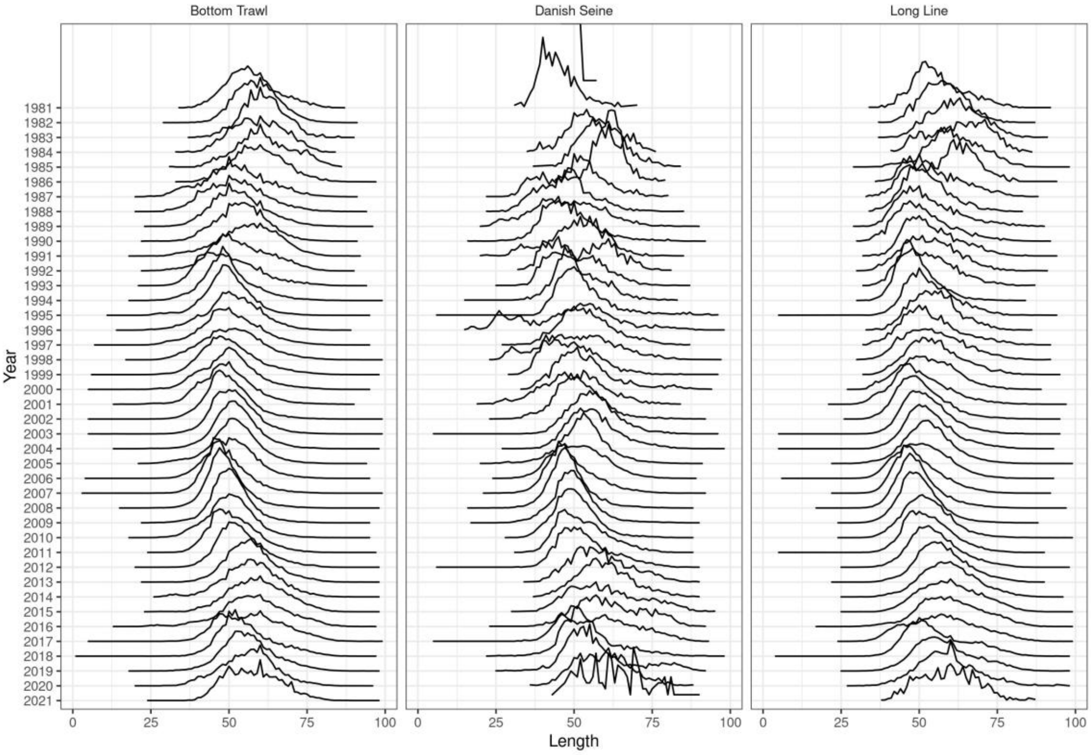


Figure 10.2.4: Haddock in 5.a. Commercial length distributions by gear and year

10.2.3 Age compositions

Catch in numbers-at-age is shown in Figure 10.1.10. The catches in 2020 are mainly composed of the 2014-year class largest component (approx. 35 %) with remainder spread across a number of relatively small 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 Figure 10.1.11.

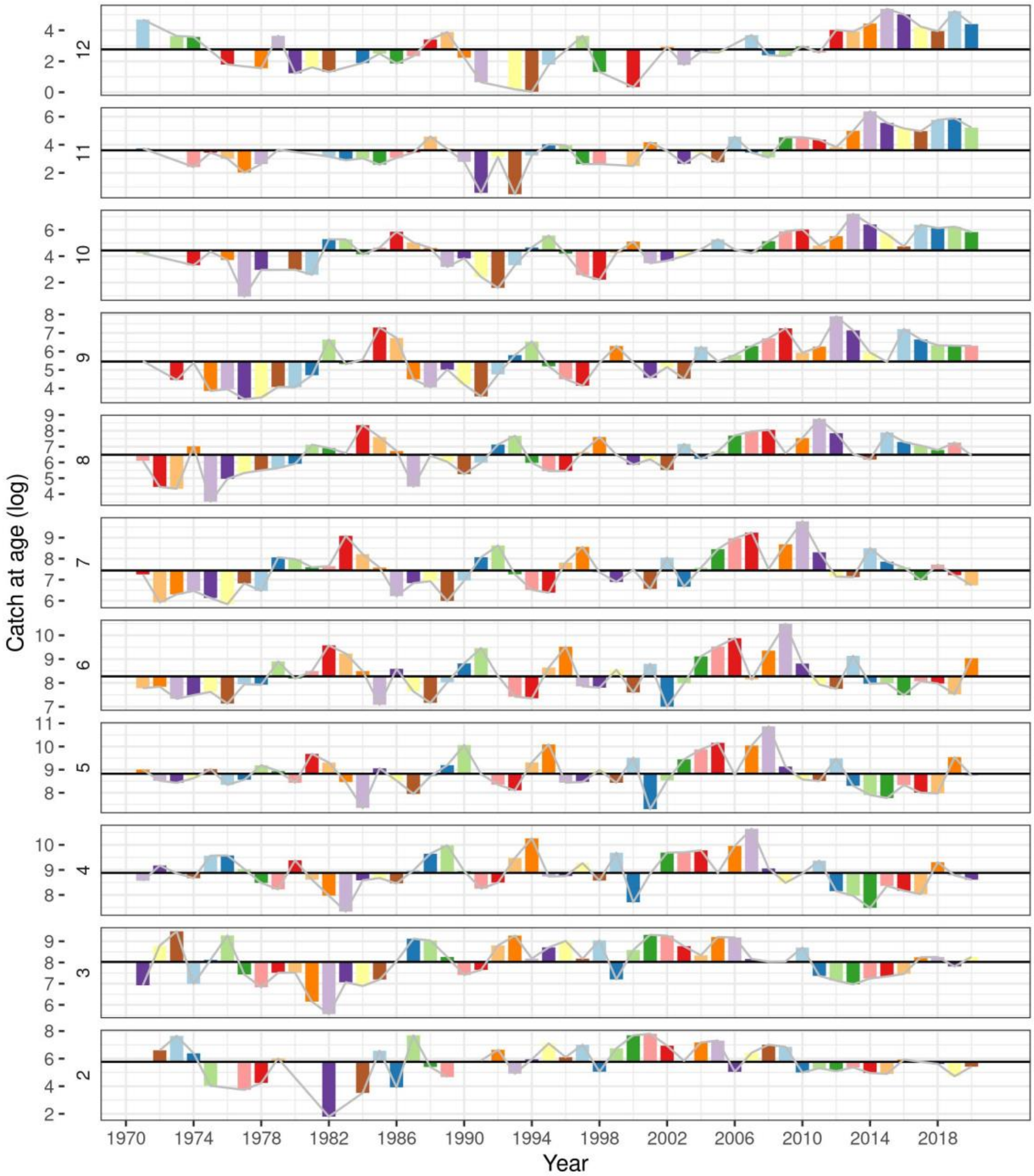


Figure 10.2.7: Haddock in 5.a. Catch at age from the commercial fishery in Iceland waters. Bar size is indicative of the catch in numbers and bars are coloured by cohort.

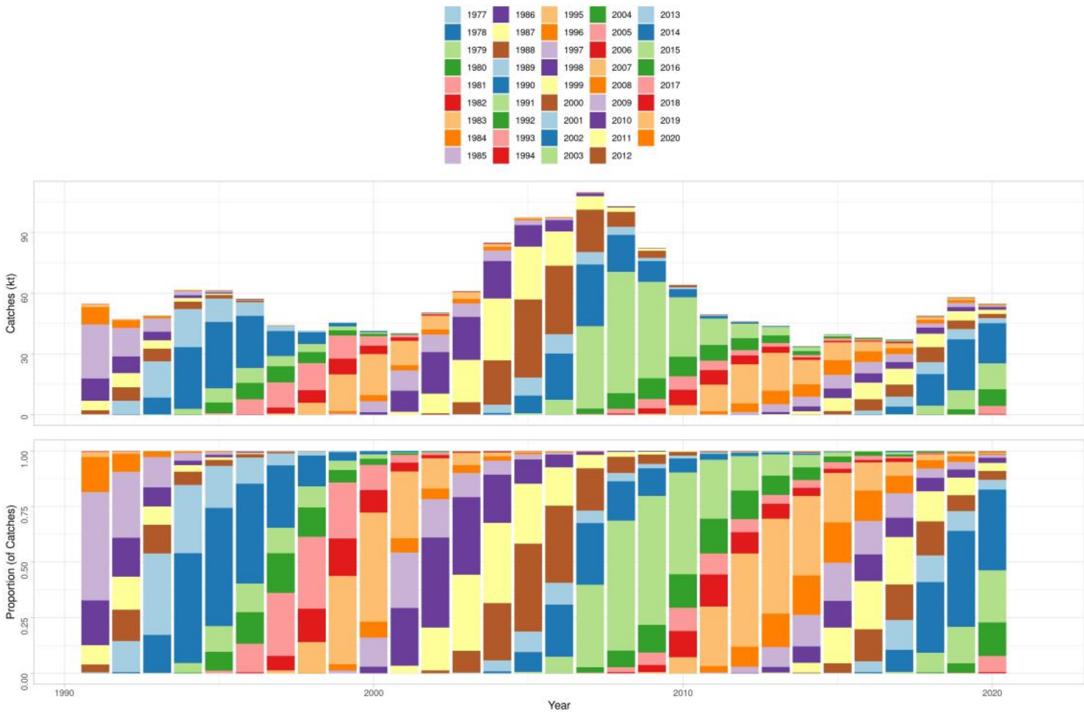


Figure 10.2.6: Haddock in 5.a. Catch at age from the commercial fishery in Iceland waters. Biomass caught by year and age, bars are coloured by cohort.

10.2.4 Weight at age

Mean weight at age in the stock and catch is shown in Figure 10.1.12. 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.

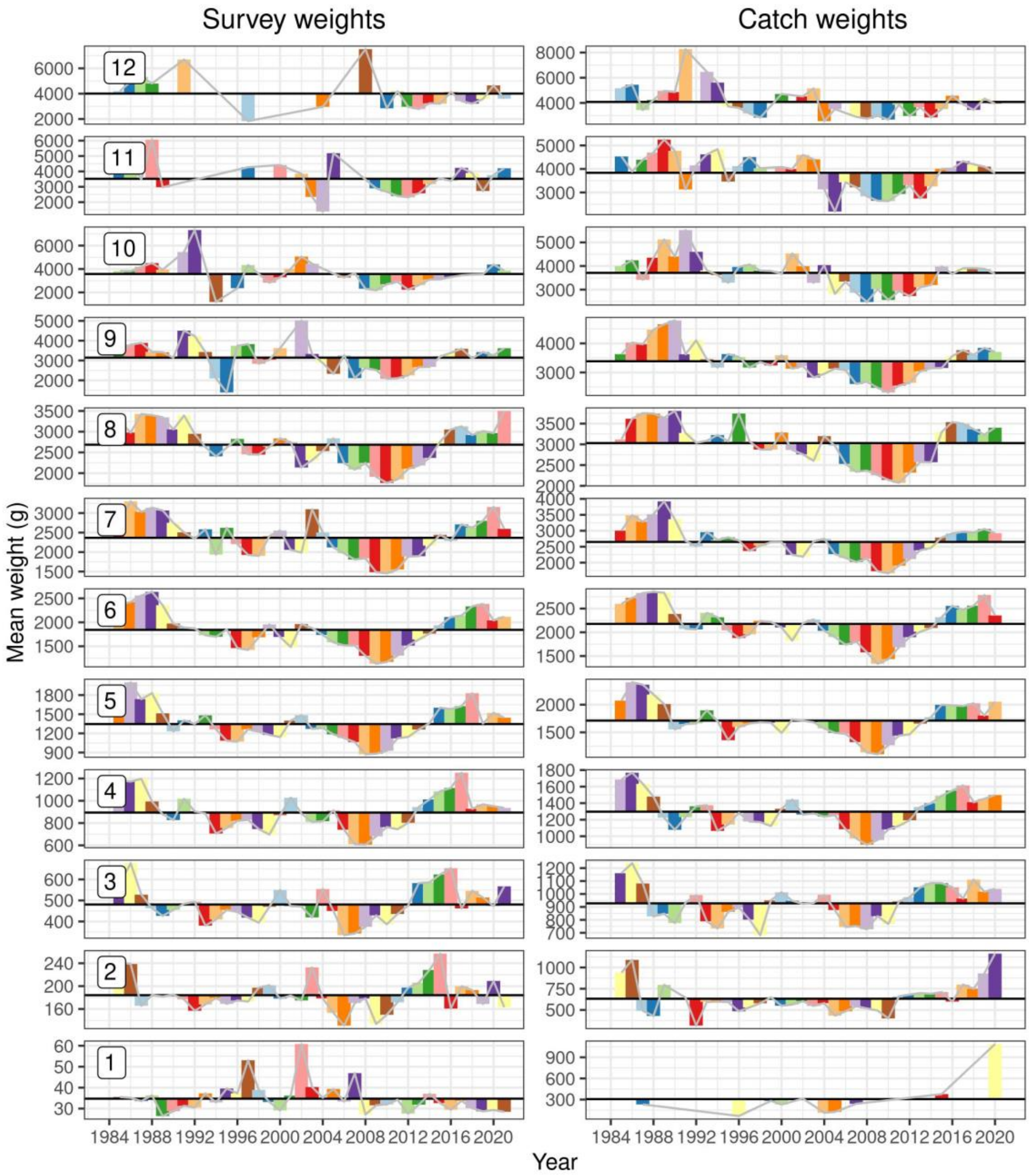


Figure 10.2.8: Haddock in 5.a. Catch weights from the commercial fishery and stock weights from the March survey in Icelandic waters. Bars are coloured by cohort.

10.2.5 Maturity at age

Maturity-at-age data are shown Figure 10.1.13. 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 10.1.14.

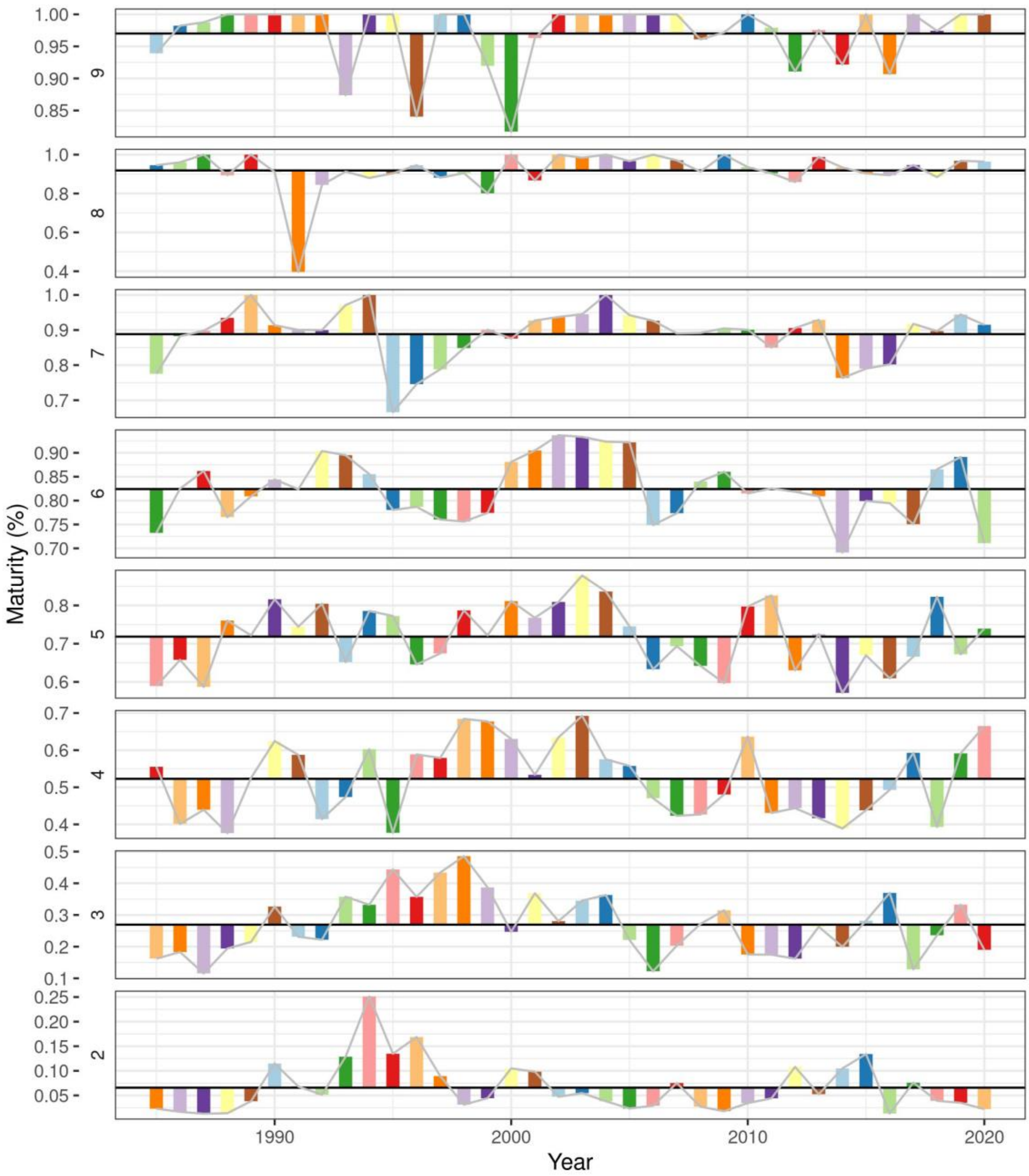


Figure 10.2.9: Haddock in Division 5.a. Maturity-at-age in the survey. The red bars indicates predictions. The values are used to calculate the spawning stock.

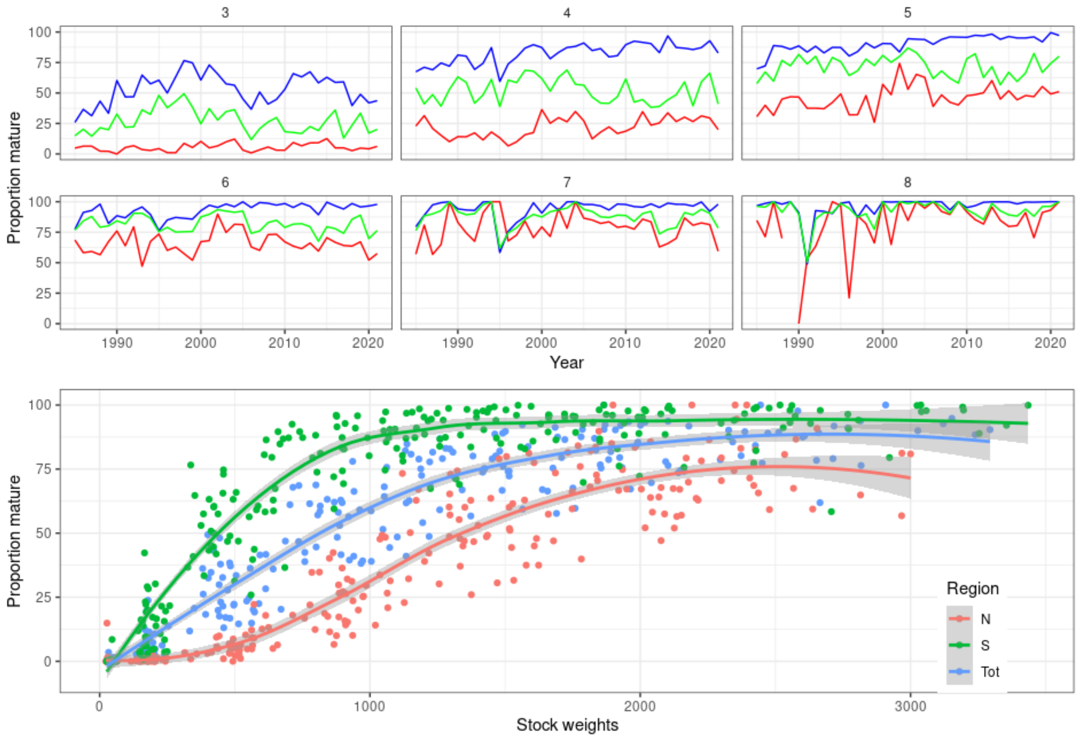


Figure 10.1.14: Haddock in 5.a. Geographical differences in proportion mature by year and age (top), and stock weights (below).

10.2.6 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.

10.2.7 Catch, effort and research vessel data

10.2.7.1 Catch per unit of effort from commercial fisheries

Catch per unit of effort data (Figure 10.1.15) gives different picture of the development of the stock than the surveys and assessment, much less increase after 2000 and much less decrease in recent years. The current assessment coupled with the relatively high CPUE, in recent years, confirms fishers' view that is now easier to catch haddock. The discrepancy observed between CPUE and stock size has not been explained, but a plausible explanation might be related to a couple reasons, and relate to the development of the stock, its spatial distribution and the evolution of the fisheries and management. As is evident, both from the survey data and commercial catch data, the spatial distribution of the stock started to shift northwards in the early 2000s. This shift in distribution is believed be the result of a surge in recruitment that occurred around that time. These shifts caused issues in the fisheries (as described in the management section below) and bycatch of juvenile haddock (<45 cm) which was exacerbated with slower growth of the stock due to higher densities. The opposite has happened in recent years, faster growth and poor recruitment lead to the fisheries not limited by small haddock. 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.

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.

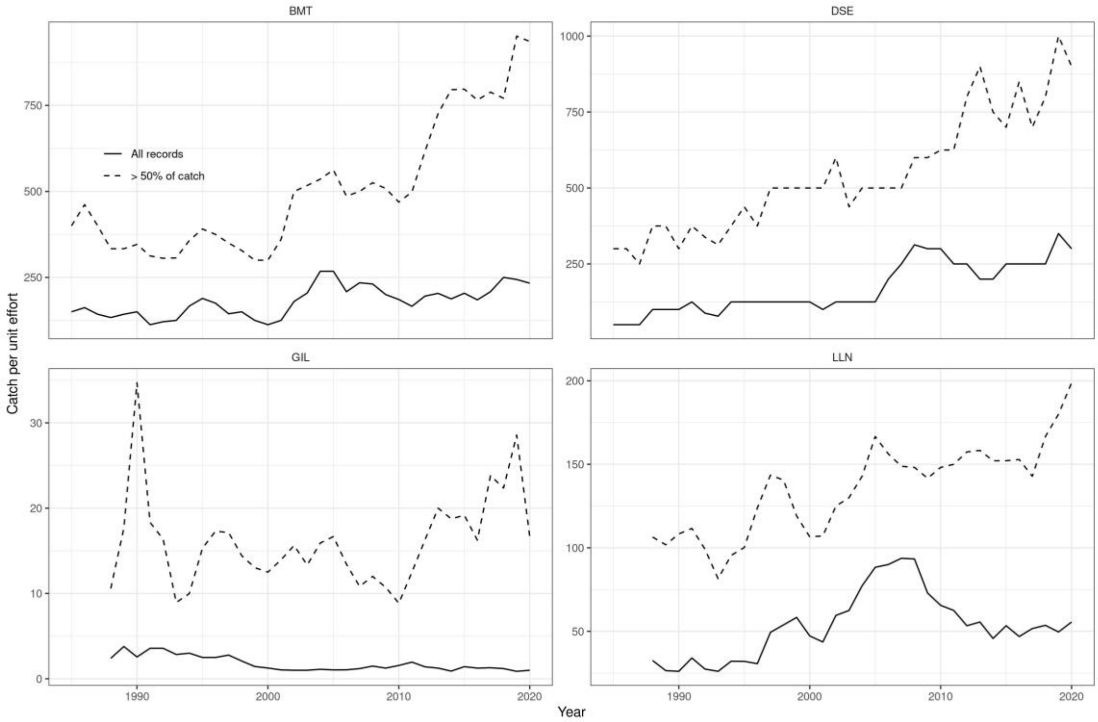


Figure 10.2.11: Catch per unit of effort in the most important gear types. The dashed lines are based on locations where more than 50% of the catch is haddock and solid lines on all records where haddock is caught. A change occurred in the longline fleet starting September 1999. Earlier only vessels larger than 10 BRT were required to return logbooks but later all vessels were required to return logbooks.

10.2.7.2 Icelandic survey data

Information on abundance and biological parameters from haddock in 5.a 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 with the exception of 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 fairly 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 10.1.16 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 10.1.17 and Figure 10.1.18. 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 10.1.19 and Figure 10.1.20 (abundance) and changes in spatial distribution in Figure 10.1.21.

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 10.1.22. Similar to the biomass of 60cm$^+$ 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 5.a. After a period of low recruitment, the biomass for other age groups is near the geometric mean in both surveys.

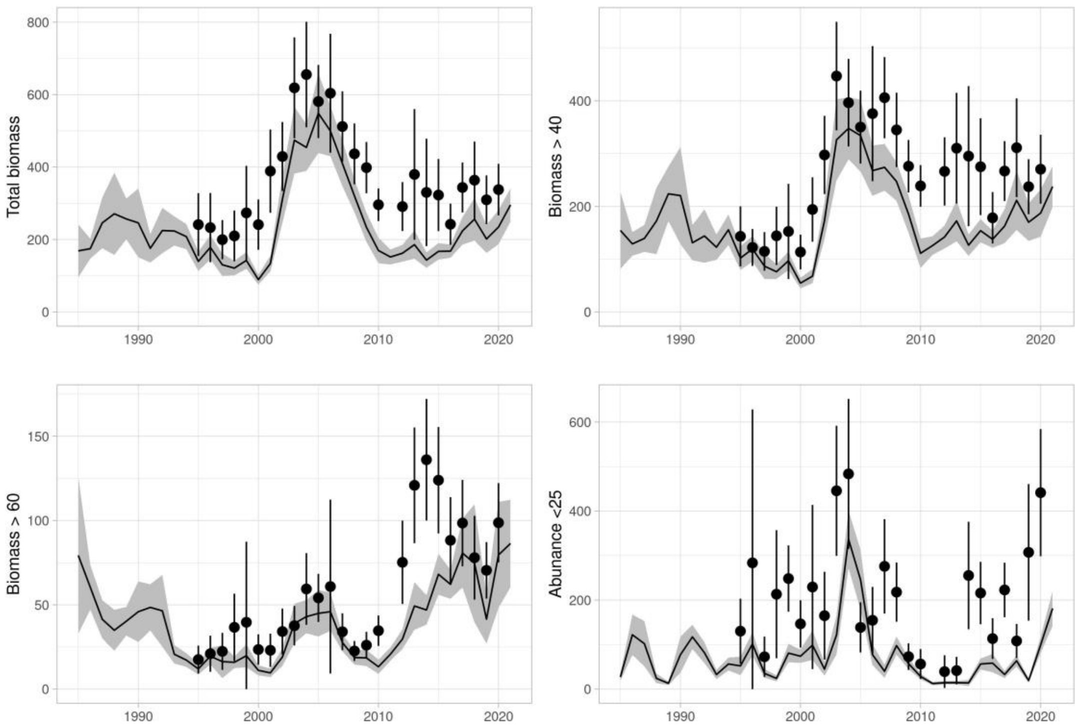


Figure 10.2.12: Haddock in 5.a. Indices in the Spring Survey (March) 1985 and onwards (line shaded area) and the autumn survey (point ranges).

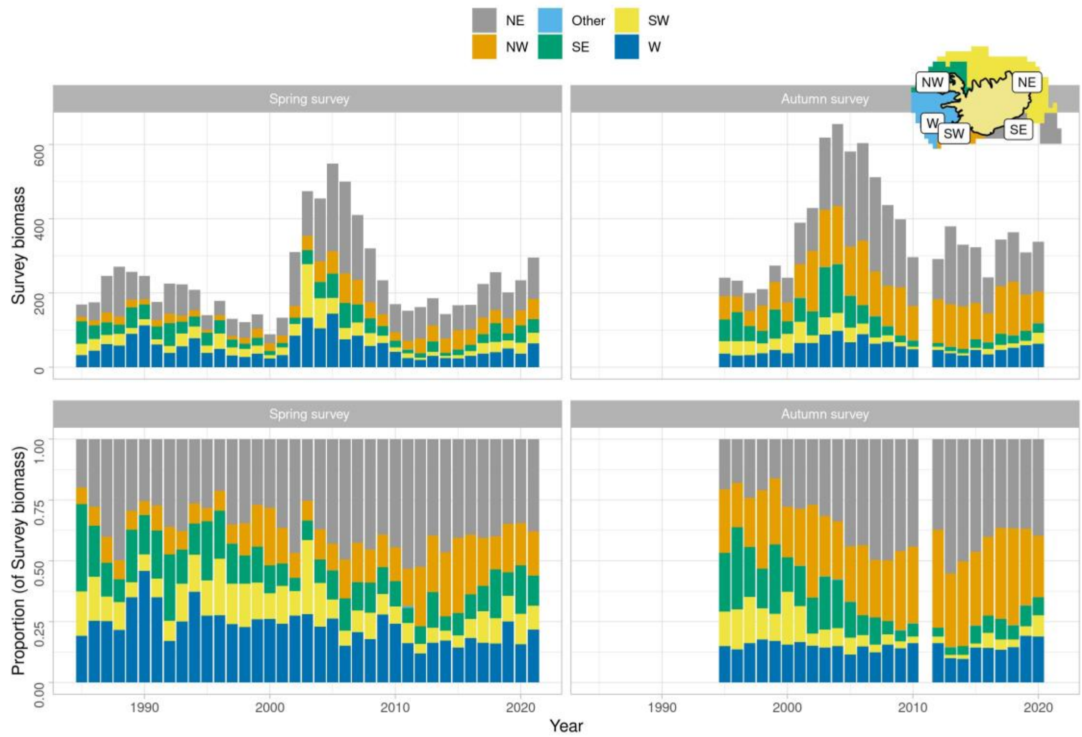


Figure 10.2.13: Haddock in 5.a. Changes in geographical distribution of the survey biomass.

Figure 10.2.17: Haddock in 5.a. Location of haddock in the March (SMB) and the Autumn (SMH) survey, bubble sizes are relative to catch sizes.

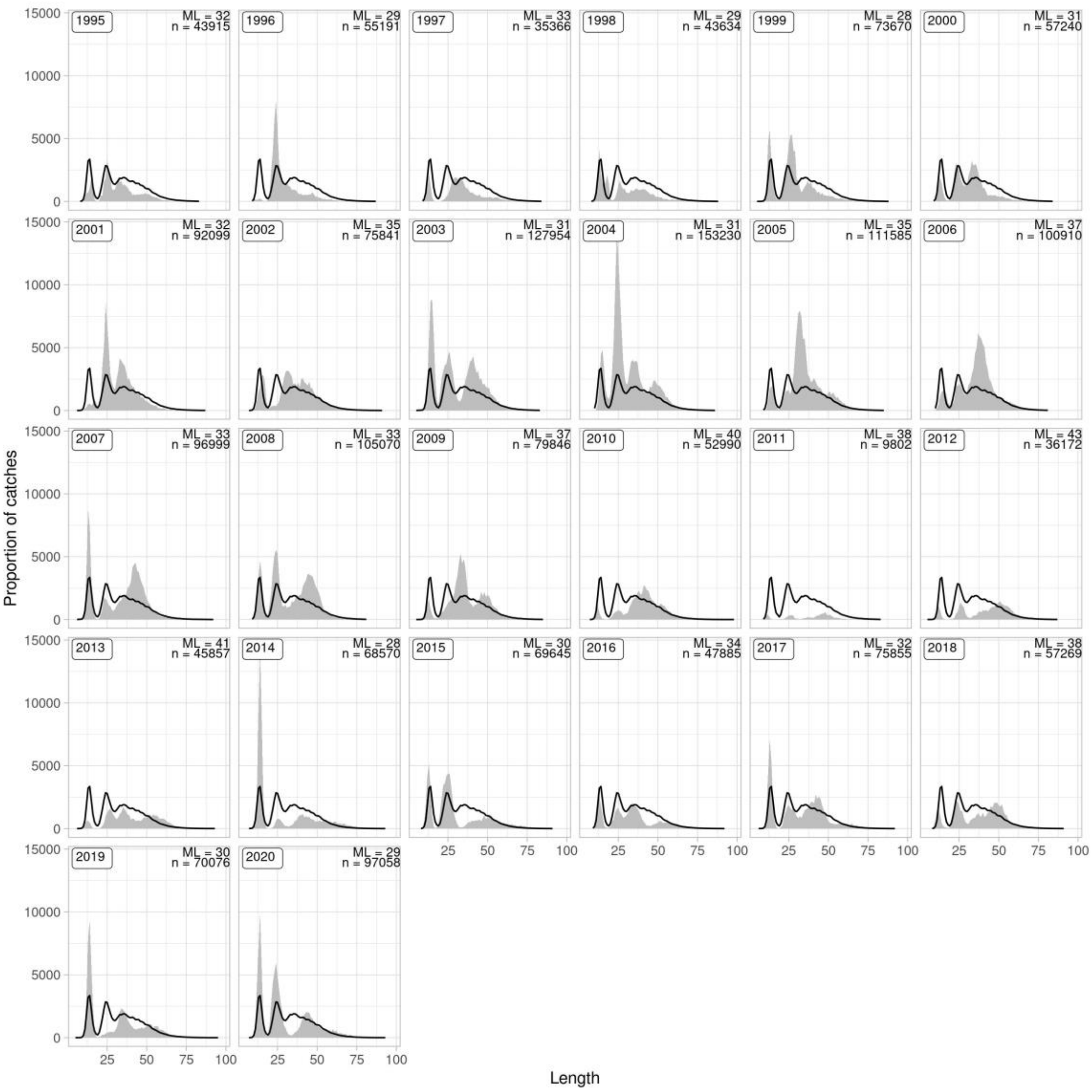


Figure 10.2.15: Haddock in 5.a. Length disaggregated abundance indices from the March survey 1985 and onwards.

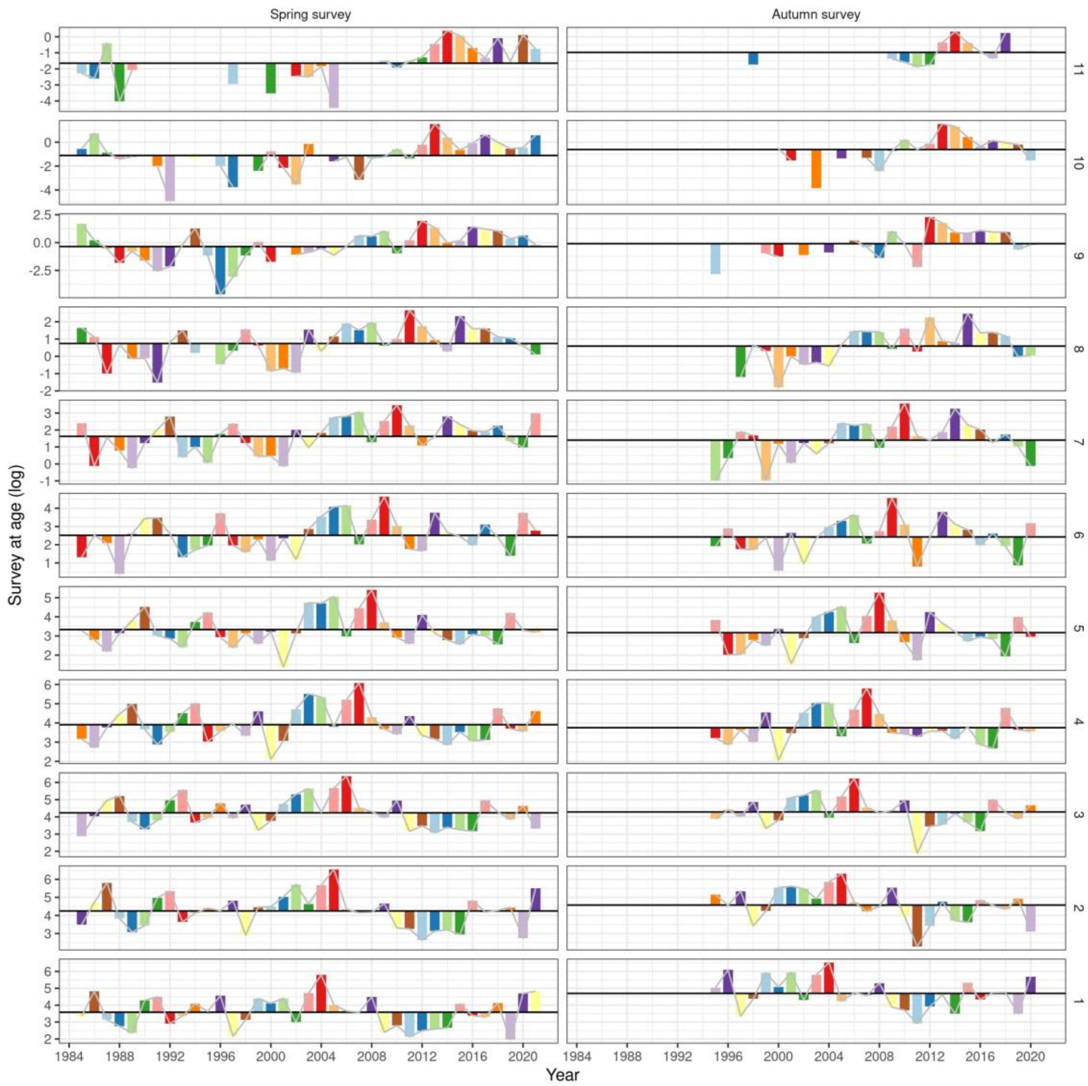


Figure 10.2.18: Haddock in 5.a. Age disaggregated indices in the Spring Survey (left) and the autumn survey (rights). Bars indicated the deviation from the log mean index, fill colours indicate cohorts.

10.3 Data analyses

10.3.1 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 5.a 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 Bjornsson, Hjorleifsson, 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:

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

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 10.1.12. 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 Bjornsson, Hjorleifsson, and Elvarsson 2019), shown in Figure 10.1.23.

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.

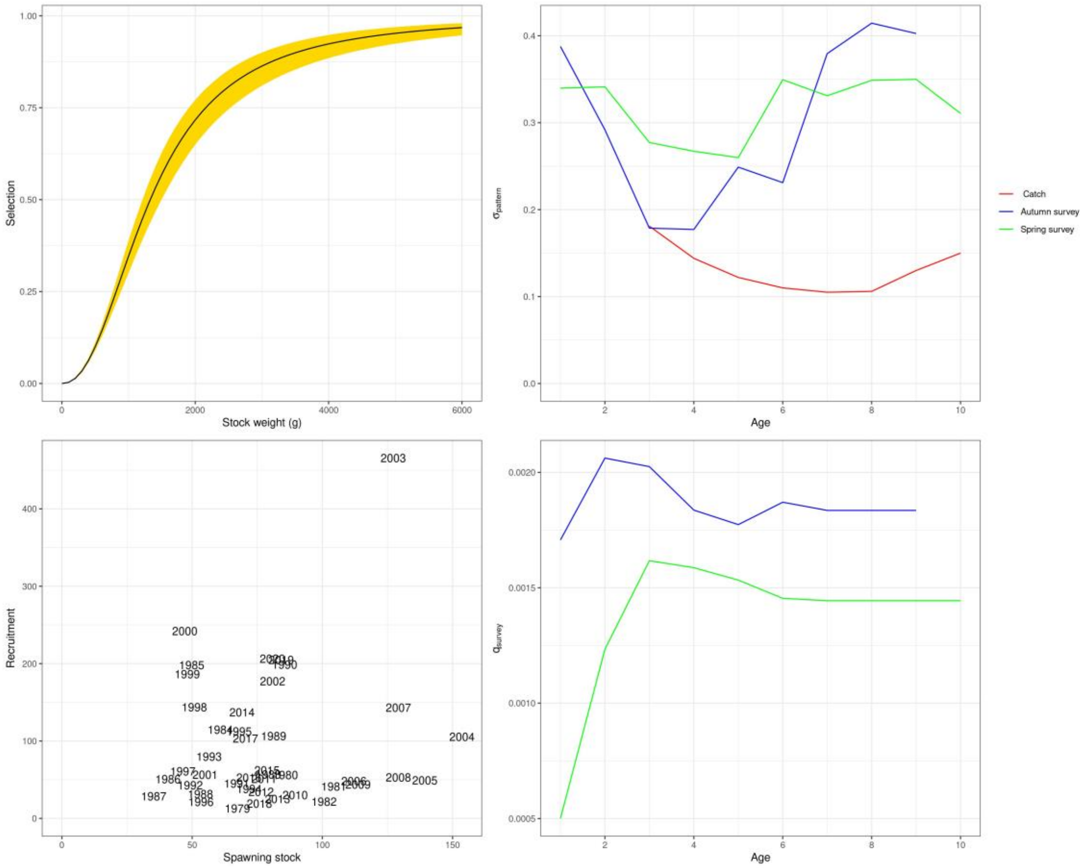


Figure 10.2.19: Haddock in 5.a. Estimated selection by weight, CV pattern, stock recruitment relationship and survey catchability.

10.3.2 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).

10.3.3 Diagnostics

The fit to data is illustrated in Figure 10.1.24 where no concerning residual patterns are observed. When looking at the combined fit (Figure 10.1.25) 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-2000s 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 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 10.1.23 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.

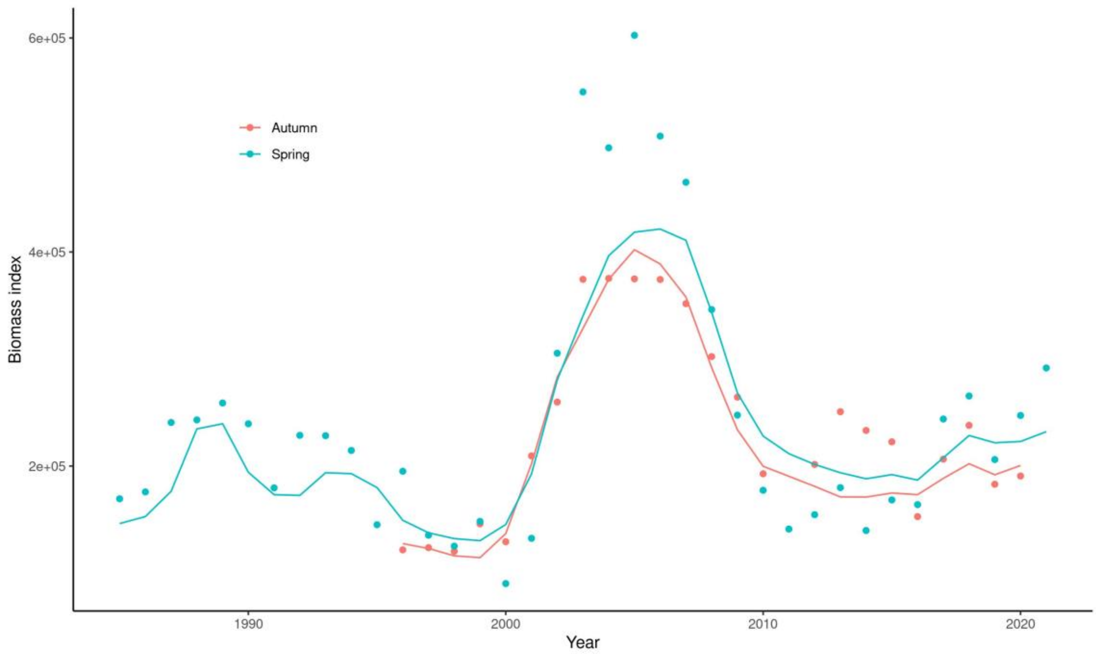


Figure 10.2.21: Haddock in Division 5.a. Aggregated model fit to the total biomass indices.

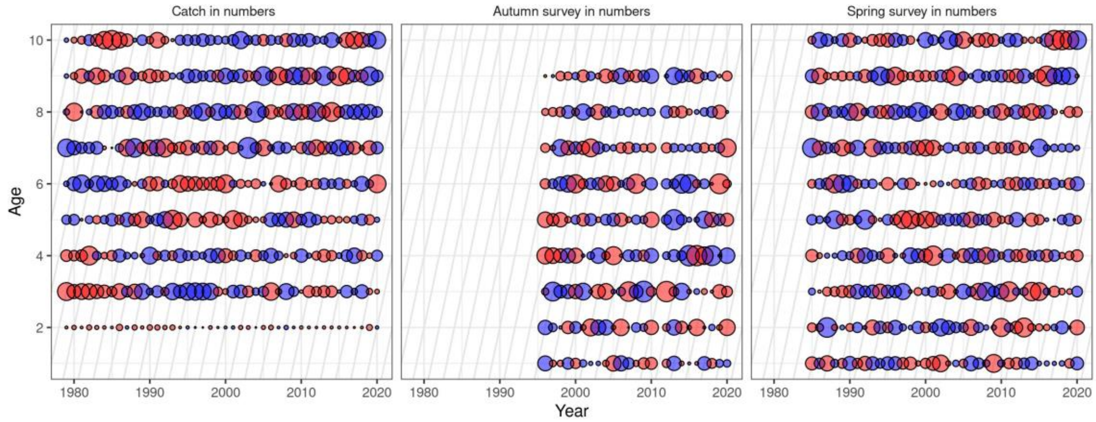


Figure 10.2.22: Haddock in Division 5.a. Residuals from the model fit to survey and catch data based on the both the surveys. Red circles indicate negative residuals (observed < modelled), while blue positive. Residuals are proportional to the area of the circles.

10.3.4 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 10.1.26). 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 10.1.27) indicates a slight upwards revision in the most recent years. The assessment can however be considered fairly stable and the estimated 5-year Mohn's ρ are within acceptable range or 0.035 for estimated recruitment, –0.065 for SSB and 0.064 for harvest rate.

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 10.1.28) but that has not always been the case.

Estimated selection is illustrated in Figure 10.1.29, 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 10.1.30.

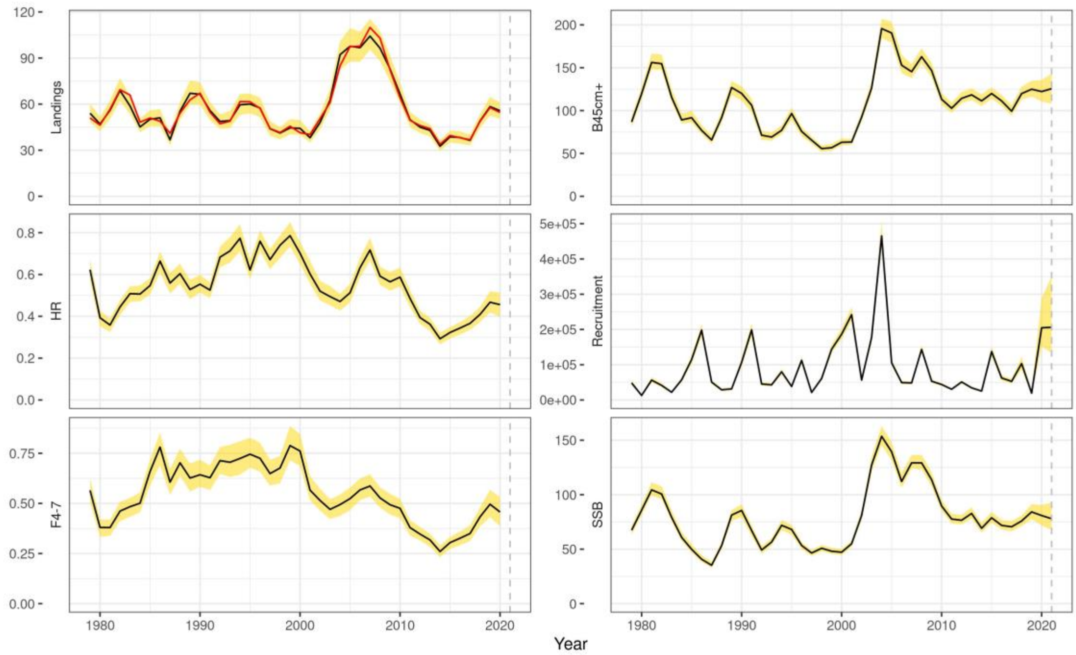


Figure 10.2.23: Haddock in Division 5.a. Summary from assessment. Dashed vertical line indicates the assessment year and yellow shaded region the uncertainty as estimated by the model.

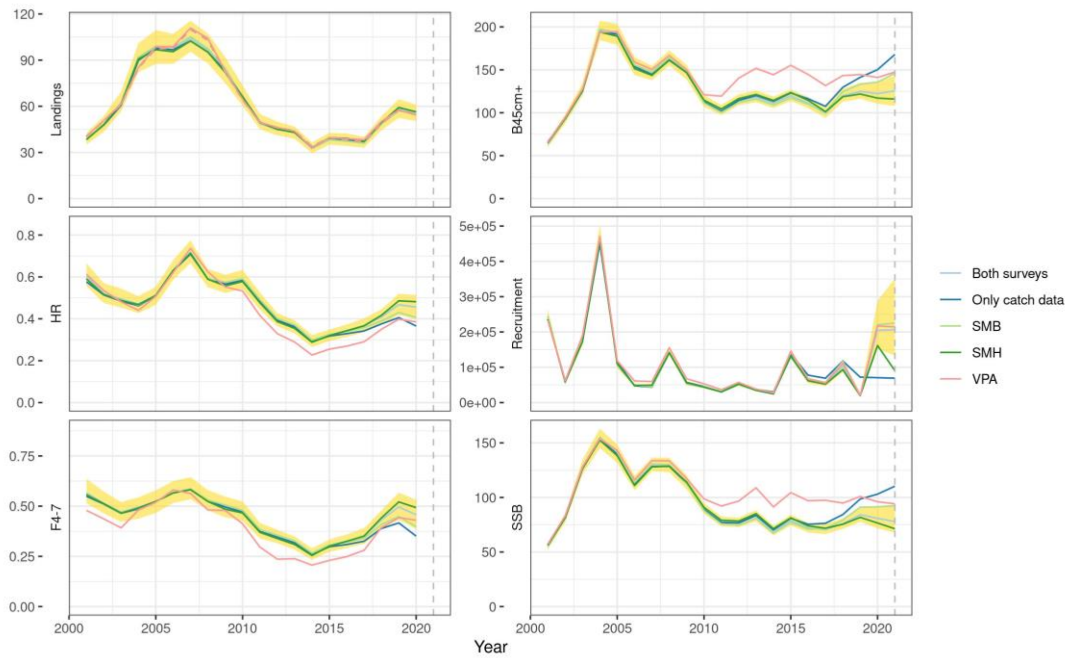


Figure 10.2.28: Haddock in 5.a. Comparison of assessment results where either the spring survey or the autumn survey is omitted from the estimation.

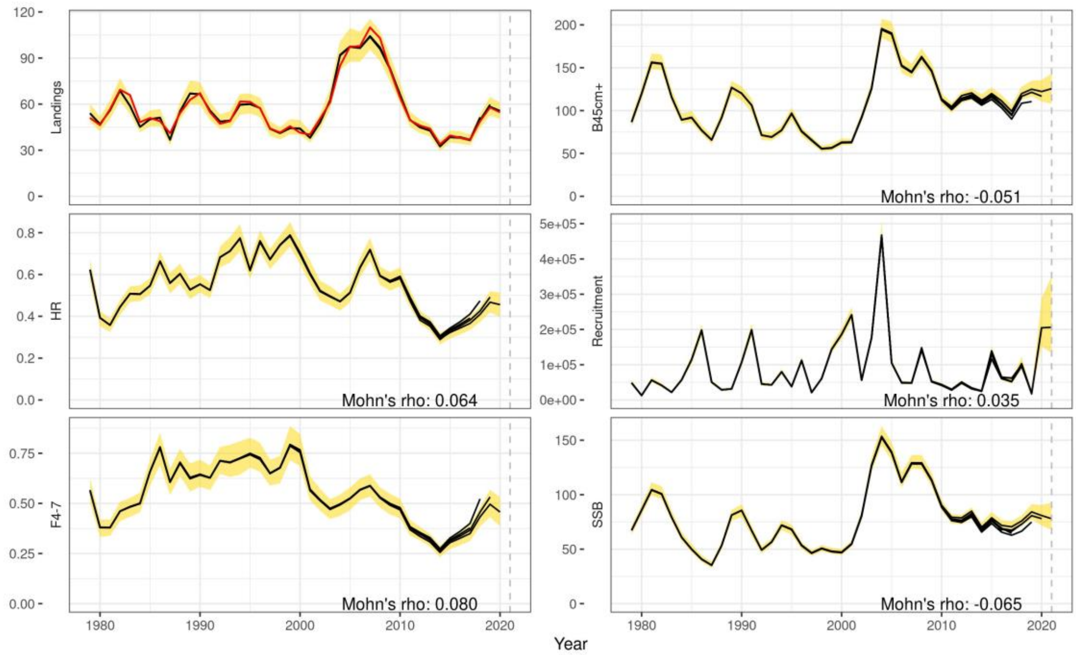


Figure 10.2.29: Haddock in Division 5.a. Analytical retrospective analysis of the assessment of haddock with a 5-year peel.

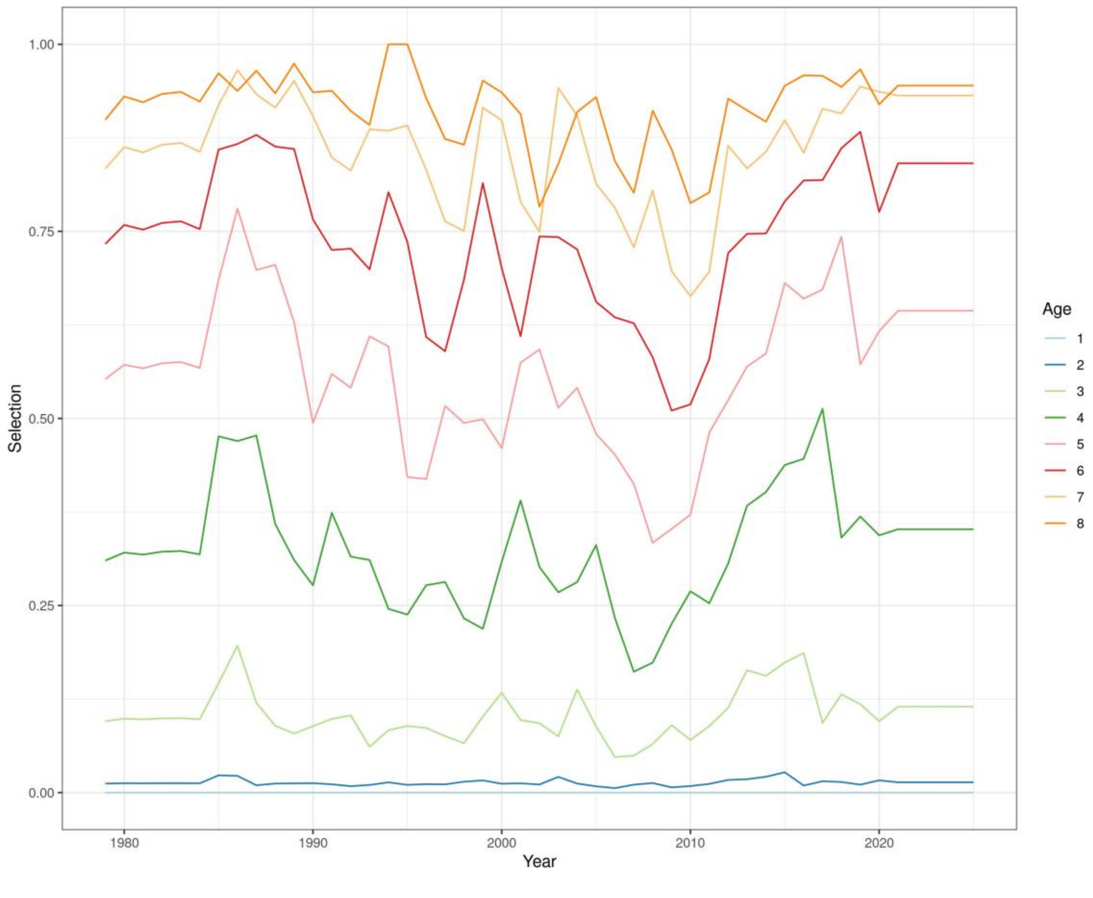


Figure 10.2.30: Haddock in 5.a. Estimated selection at age.

10.3.5 Short term projections

Following the management plan the advice for the coming fishing year (2021/2022) is based in the biomass of 45 cm$^+$ at the beginning the next calendar year (2022). 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 2022 is predicted by the equation:

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

where according to the stock annex the factor δ_y for the assessment year (Figure 10.1.30) 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 2021. 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 2021/2022 has some effect of the biomass at the beginning of 2022, which the TAC is based on. This procedure is described in the detail in the stock annex.

10.3.6 Updated management reference points

This year, in line with recent ICES guidelines, the definition of F_{pa} was set to $F_{p.05}$ as estimated by WKICEMSE 2019.

10.4 Management considerations

All the signs from commercial catch data and surveys indicate that haddock in 5.a 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 expected to remain at the current levels next year but it is, however projected to increase in coming years due to strong incoming recruitment from the 2019 and 2020 year classes.

Due to this good state of the stock, and CPUE are at its highest value, the landings are expected to substantially exceed the TAC advice for the 2020/2021. To prevent a possible quota choke, the Government of Iceland increased the TAC by 8000 tonnes while stating that the TAC for 2021/2022 will be reduced by 8000 tonnes. The advice for 2021/2020 is therefore based on catch constraint based on the remainder TAC advice.

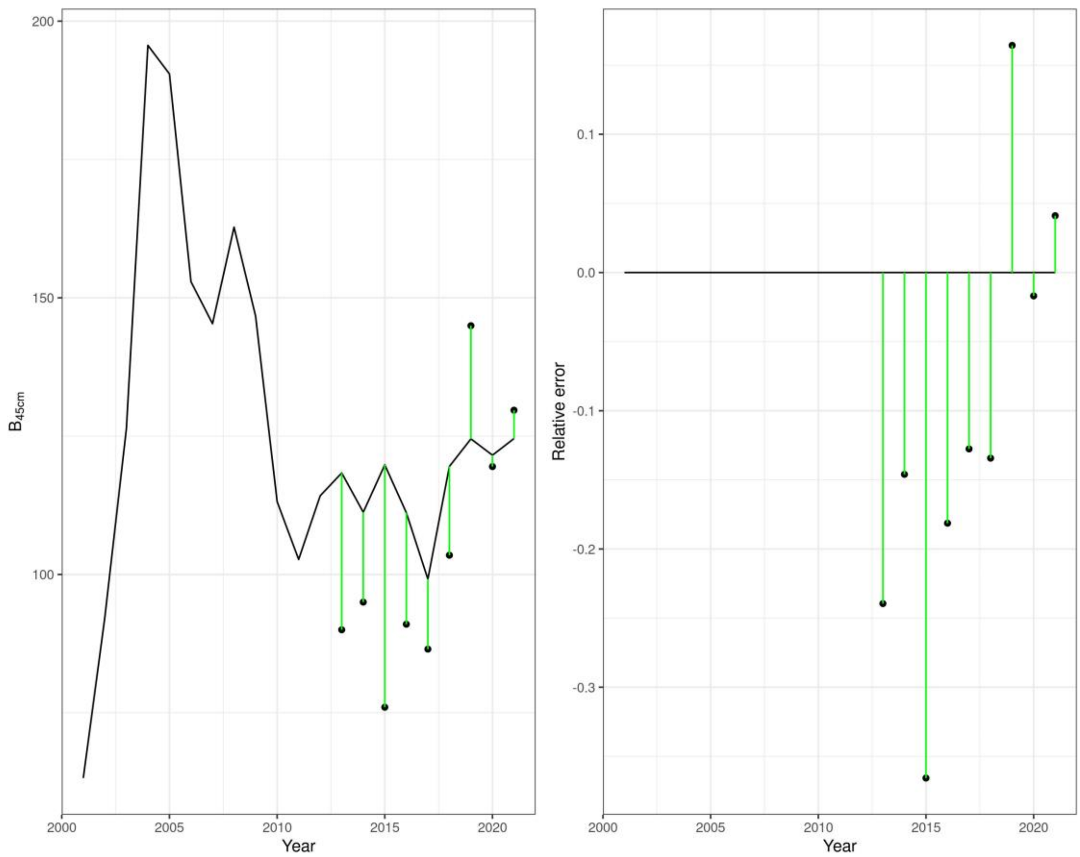


Figure 10.2.31: Haddock in 5.a. Comparison of the short-term prediction of reference biomass to the realised value a year later.

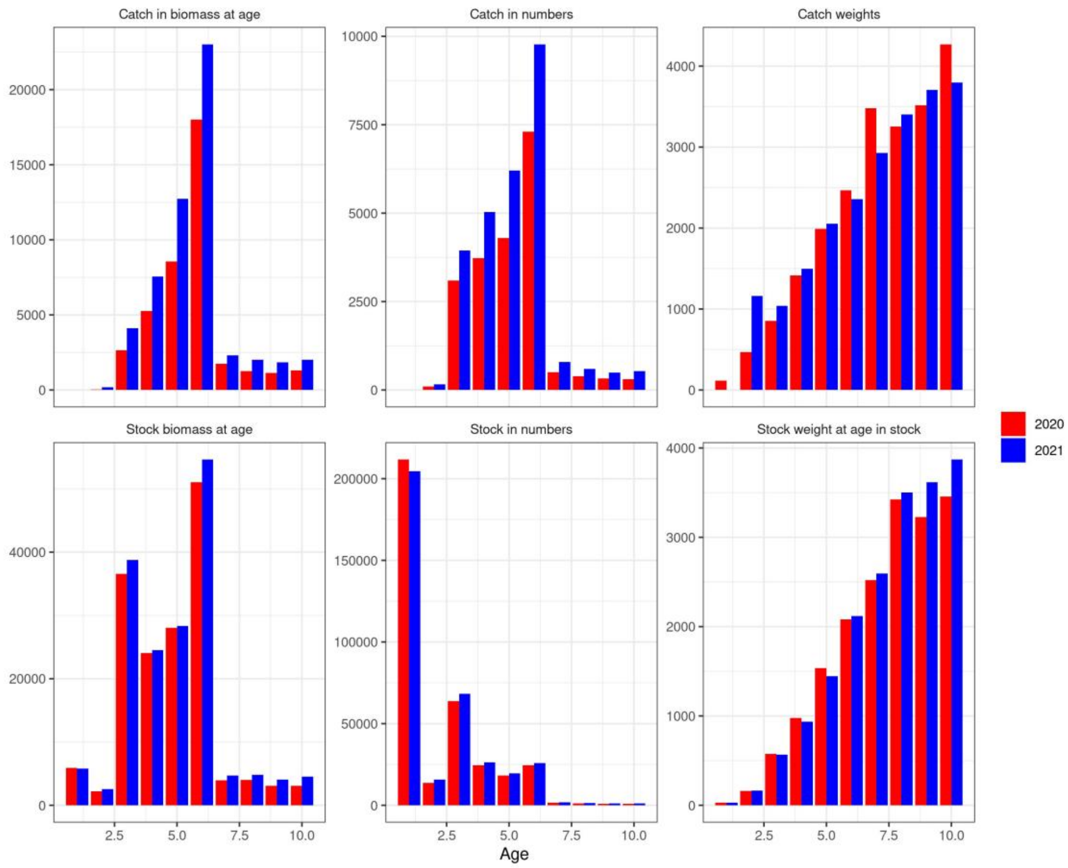


Figure 10.2.32: Haddock in 5.a. Comparison of some of the results of 2019 assessment based on different tuning data and 2017 assessment tuned with both the surveys.

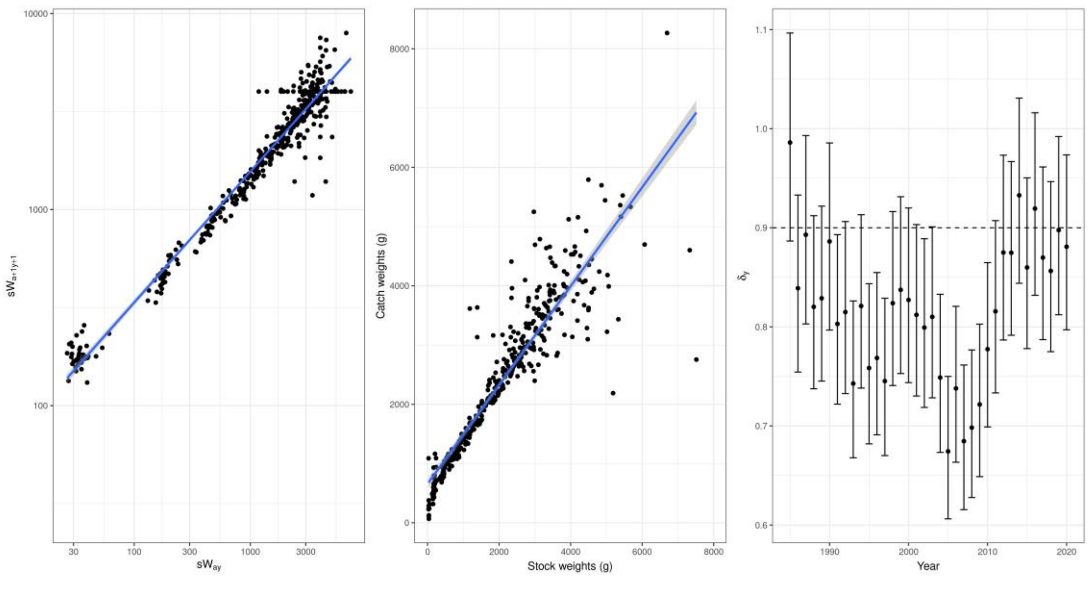


Figure 10.2.27: Haddock in 5.a. Input data to prediction model, where the exponent of the yearfactor (growth multiplier) is estimated to derive the reference biomass in the advisory year, as described in the text.

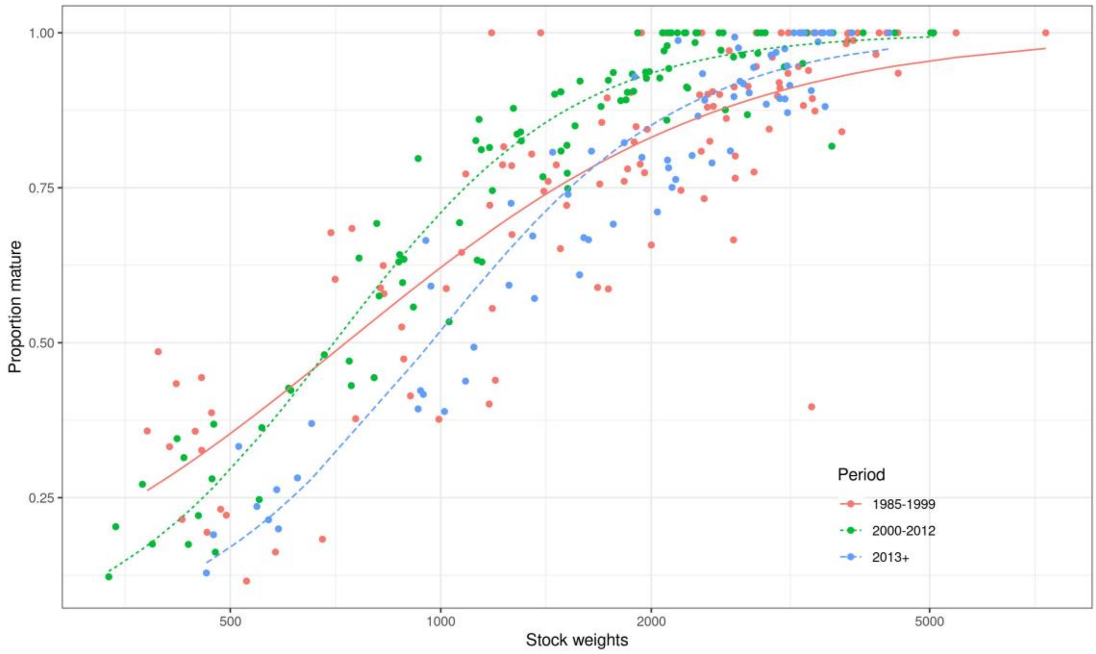


Figure 10.2.33: Haddock in 5.a. Maturity at weight as used in the projections.

10.5 Management

The Icelandic Ministry of Industries and Innovation (MII) 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 5.a has been managed by TAC since the 1987. Landings have roughly followed the advice given by MRI and the set TAC in all fishing years (Table 10.1.1 and Figure 10.1.31). Since the 2001/2002 the catches have exceeded more that 5% the set TAC in five 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 5.a. 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 tonnes of demersal fish species in Icelandic waters which includes maximum 1200 tonnes of cod and 40 tonnes of Atlantic halibut.

The effect of these species transformations and quota transfers is illustrated in Figure 10.1.32. 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 10.1.5, 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.

Figure 10.1.31 illustrates the difference between national TAC and landed catch in 5.a. The difference can be attributed to species transformation (in both directions), while for the 1999/2000 fishing year the government of Iceland increased TAC mid-season.

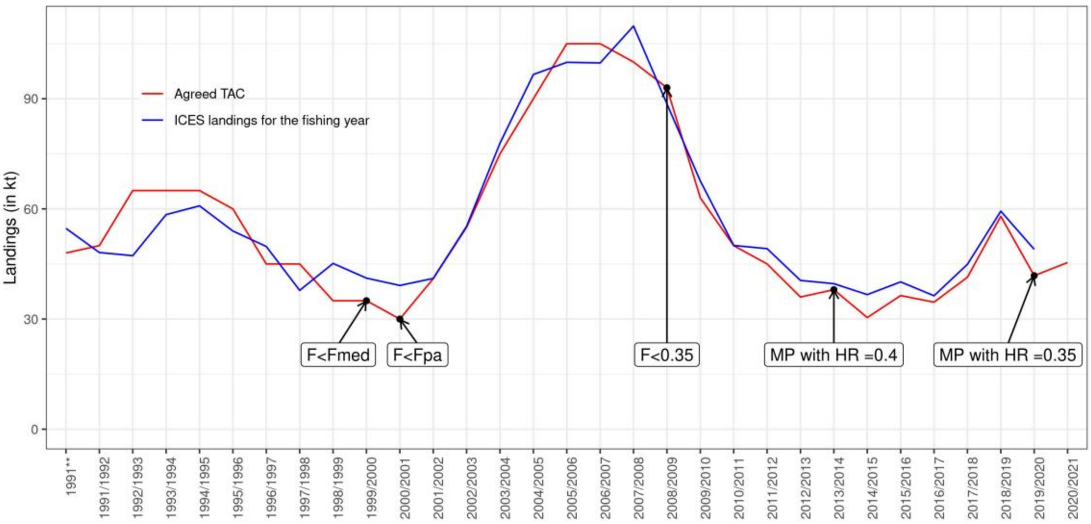


Figure 10.2.34: Haddock in 5.a. Comparison of the realised catches and the set TAC for the fishing operations in Icelandic waters. Note that in the 1999/2000 fishing year the government of Iceland increased TAC mid-season.

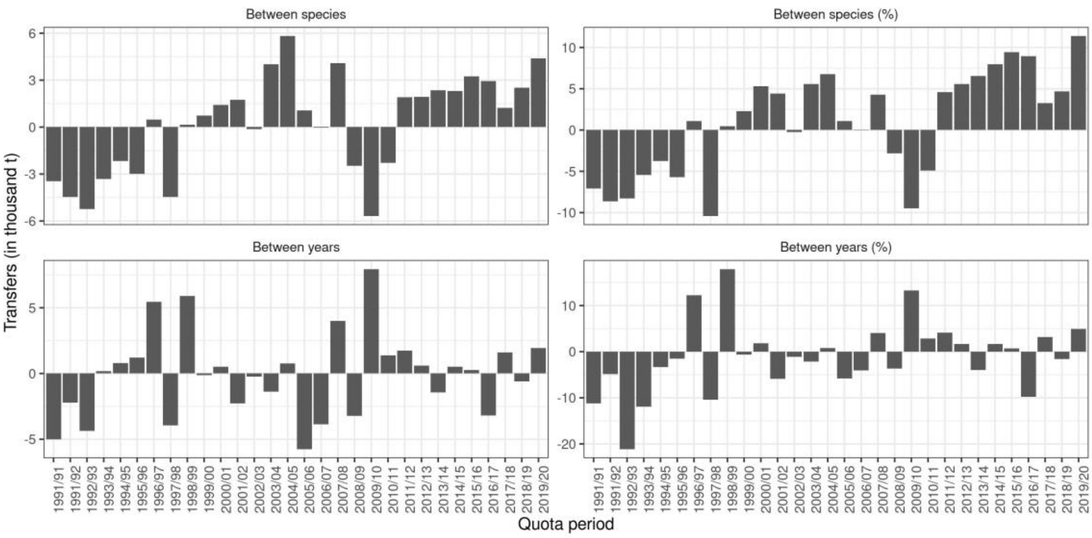


Figure 10.2.35: Haddock in 5.a. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

10.6 References

Bjornsson, Hoskur, Einar Hjorleifsson, and Bjarki or Elvarsson. 2019. "Muppet: Program for Simulating Harvest Control Rules." Reykjavik: Marine; Freshwater Research Institute. http://www.github.com/hoski/Muppet-HCR.

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Table 1.1: Haddock in Division 5.a. Landings by nation.

Year	Belgium	Faroe Islands	Germany	Greenland	Iceland	Norway	Russia	UK
1979	1010	2161			52152	11		
1980	1144	2029			47916	23		
1981	673	1839			61033	15		
1982	377	1982			66998	28		
1983	268	1783			63815	3		
1984	359	707			47167	3		
1985	391	987			49573	0		2
1986	257	1289			47335			
1987	238	1043			39751	1		
1988	352	797			52999	0		
1989	483	606			61715			
1990	595	603			65897			
1991	485	733			53491			
1992	361	757			46067			
1993	458	754			46231			
1994	271	915	1046	2	58677	13	492	173
1995		968	0		60424		2	57
1996		764			56317	4	17	0
1997		340			43717			
1998		513			40882			
1999		885			44523	18		0
2000		5			41229	4		1
2001		690			39101	56		
2002		847			49602	8		
2003		968			59991	1		51
2004		1125			83801	1		
2005		1515			95878	3		44
2006		1588			96130	4		
2007		1686		2	108181	11		
2008		1197			101680	11		
2009		824			81439	5		
2010		360			63869	8		
2011		214			49232	3		
2012		325			45711	13		
2013		654			43370	23		
2014		1626			33048	22		
2015		2337			38393	26		
2016		2858			36648	14		
2017		2515			35695	22		

Year	Belgium	Faroe Islands	Germany	Greenland	Iceland	Norway	Russia	UK
2018		2209			47677	30		
2019		1774			57075	1		

Table 1.2: Haddock in 5.a. Number of Icelandic boats and catches by fleet segment participating in the haddock fishery in 5.a.

Year	Bottom trawl	Danish seine	Longlines	Bottom trawl	Danish seine	Longlines	Other	Total catch
1993	223	79	130	31192	1308	3832	4068	40400
1994	186	90	163	42057	2861	3833	4743	53494
1995	159	97	140	43851	3766	3965	3543	55125
1996	145	107	146	41049	4887	4767	2410	53113
1997	139	93	157	28545	4706	4848	1770	39869
1998	133	77	200	24820	3162	6451	1595	36028
1999	130	68	222	26314	2213	9130	1041	38698
2000	118	63	223	23000	2533	7576	866	33975
2001	109	63	222	21858	2473	7031	921	32283
2002	101	63	238	29820	3026	9157	1295	43298
2003	101	77	259	36005	4002	12421	1142	53570
2004	104	74	290	50940	7167	16880	1274	76261
2005	103	72	307	52927	9821	23567	1561	87876
2006	91	77	308	46716	11904	28512	760	87892
2007	94	66	283	57009	11875	29814	1204	99902
2008	83	65	266	50572	15554	26064	551	92741
2009	79	65	228	38476	14418	20160	300	73354
2010	68	56	206	28551	9582	17528	872	56533
2011	64	52	203	20443	6337	15365	250	42395
2012	68	48	195	19988	5583	13227	459	39257
2013	69	47	198	18454	4440	13501	201	36596
2014	62	44	207	13043	3304	11489	202	28038
2015	62	41	199	16926	3851	12680	243	33700
2016	62	40	182	16735	3961	11754	87	32537
2017	63	41	164	16081	3982	11536	169	31768
2018	64	39	157	26316	4960	12639	175	44090
2019	61	41	142	35583	5829	12337	267	54016

Table 1.3: Haddock in 5.a. Number of available length measurements and samples from Icelandic commercial catches.

Year	Bottom Trawl	Danish Seine	Gillnets	Long Line	Other
2000	62409/326	3114/21	1353/11	12854/77	356/2
2001	69392/346	3900/24	3023/18	26610/151	3864/19
2002	83052/453	7644/47	2063/17	29578/196	1392/12
2003	70828/419	7066/47	2965/26	30259/203	1713/20
2004	82474/503	10201/74	1705/16	35405/252	785/12
2005	94529/514	14880/102	2426/25	53472/375	1778/18
2006	74451/416	29743/172	3395/35	75069/480	685/5
2007	101635/599	34293/196	3721/30	87705/499	1572/11
2008	82671/524	29062/177	3542/30	88912/570	378/4
2009	55862/347	34904/202	831/7	63816/406	658/6
2010	59118/330	19504/116	827/10	56533/343	229/4
2011	53239/278	8304/53	1350/9	43198/237	325/2
2012	41074/223	10084/59	1508/10	60838/302	3/1
2013	34131/198	2498/23	176/1	43132/237	560/4
2014	13529/79	3128/22	289/6	37035/217	
2015	25969/154	2742/18	125/1	41593/221	
2016	21303/129	2425/17	333/3	37490/202	849/6
2017	23123/144	6305/39	375/2	42360/232	1367/7
2018	21780/134	5611/94	414/29	35621/231	558/3
2019	50698/295	3254/30	431/4	25692/187	567/3

Table 1.4: Haddock in 5.a. Number of available age measurements and samples from Icelandic commercial catches.

year	Bottom Trawl	Danish Seine	Gillnets	Long Line	Other
2000	62409/326	3114/21	1353/11	12854/77	356/2
2001	69392/346	3900/24	3023/18	26610/151	3864/19
2002	83052/453	7644/47	2063/17	29578/196	1392/12
2003	70828/419	7066/47	2965/26	30259/203	1713/20
2004	82474/503	10201/74	1705/16	35405/252	785/12
2005	94529/514	14880/102	2426/25	53472/375	1778/18
2006	74451/416	29743/172	3395/35	75069/480	685/5
2007	101635/599	34293/196	3721/30	87705/499	1572/11
2008	82671/524	29062/177	3542/30	88912/570	378/4
2009	55862/347	34904/202	831/7	63816/406	658/6
2010	59118/330	19504/116	827/10	56533/343	229/4
2011	53239/278	8304/53	1350/9	43198/237	325/2
2012	41074/223	10084/59	1508/10	60838/302	3/1
2013	34131/198	2498/23	176/1	43132/237	560/4
2014	13529/79	3128/22	289/6	37035/217	
2015	25969/154	2742/18	125/1	41593/221	
2016	21303/129	2425/17	333/3	37490/202	849/6
2017	23123/144	6305/39	375/2	42360/232	1367/7
2018	21780/134	5611/94	414/29	35621/231	558/3
2019	50698/295	3254/30	431/4	25692/187	567/3

Table 1.5: Haddock in 5.a. Catch at age from the commercial fishery in Icelandic waters

Year	2	3	4	5	6	7	8	9	10
1979	0.149000	1.90800	3.76200	6.0570	9.02200	1.74300	0.43800	0.056000	0.11200
1980	0.595000	1.38500	11.48100	4.2980	3.79800	3.73200	0.54400	0.091000	0.03700
1981	0.010000	0.51400	4.91100	16.9000	5.99900	2.82500	1.80300	0.168000	0.05700
1982	0.107000	0.24500	3.14900	10.8510	14.04900	2.06800	1.00000	0.725000	0.20100
1983	0.034000	1.01000	1.58900	4.5960	9.85000	8.83900	0.76600	0.207000	0.28000
1984	0.241000	1.06900	4.94600	1.3410	4.77200	3.74200	4.07600	0.238000	0.08000
1985	1.320000	1.72800	4.56200	6.7960	0.85500	1.68200	1.91400	1.903000	0.29600
1986	1.012000	4.22300	4.06800	4.6860	5.13900	0.49400	0.79600	0.897000	0.40000
1987	1.939000	8.30800	6.96500	2.7280	2.04200	1.09400	0.13200	0.165000	0.33900
1988	0.237000	9.83100	15.16400	5.8240	1.30400	1.08400	0.60900	0.066000	0.21300
1989	0.188000	2.47400	22.56000	9.5710	3.19600	0.51300	0.55600	0.144000	0.14100
1990	1.857000	2.41500	8.62800	23.6110	6.33100	0.81600	0.15000	0.067000	0.07400
1991	8.617000	2.14500	5.39700	7.3420	14.10300	2.64800	0.33800	0.040000	0.02700
1992	5.405000	10.69300	5.72100	4.6100	3.69100	5.20900	0.99900	0.120000	0.01600
1993	0.769000	12.33300	12.81500	2.9680	1.72200	1.42500	2.23900	0.343000	0.03800
1994	3.198000	3.34300	28.25800	10.6820	1.46900	0.72600	0.35800	0.647000	0.10800
1995	4.015000	7.32300	5.74400	23.9270	5.76900	0.61500	0.29000	0.187000	0.33100
1996	3.090000	10.55200	7.63900	4.4680	12.89600	2.34600	0.20800	0.079000	0.12500
1997	1.364000	3.93900	10.91500	4.8950	2.61000	5.03500	0.71900	0.064000	0.06900
1998	0.279000	8.25700	5.66700	7.8560	2.41800	1.42200	1.89700	0.261000	0.04500
1999	1.434000	1.55000	17.24300	4.5160	4.83700	0.91500	0.62000	0.481000	0.06400
2000	2.659000	6.31700	2.35200	13.6150	1.94500	1.70600	0.32400	0.222000	0.19200
2001	2.515000	11.09800	6.95400	1.4460	6.26200	0.67500	0.47800	0.105000	0.09400
2002	1.082000	10.43400	15.99800	5.0990	1.13100	3.14900	0.26200	0.169000	0.10000
2003	0.401000	6.35200	16.26500	12.5480	2.96800	0.74800	1.23600	0.091000	0.07000
2004	1.597000	4.06300	17.65200	19.3580	8.87100	1.94000	0.47100	0.489000	0.15500
2005	2.405000	9.45000	6.92900	25.4210	13.77800	4.58400	0.80900	0.251000	0.23700
2006	0.241000	10.03800	21.24600	6.6460	18.84000	7.60000	2.18000	0.323000	0.20200
2007	0.782000	3.88400	42.22400	22.2390	3.35400	9.95200	2.74000	0.519000	0.18100
2008	2.316000	4.50800	9.70600	53.0220	11.01400	1.71700	3.03300	0.815000	0.19200
2009	1.066000	3.18500	4.88600	8.8920	35.01100	5.73300	0.72600	1.381000	0.50900
2010	0.121000	6.03200	7.06100	4.8060	6.76600	17.50300	1.87400	0.354000	0.52800
2011	0.253000	1.58400	11.79700	5.0800	2.85300	3.98300	6.22000	0.494000	0.18300
2012	0.196000	1.32200	3.42100	13.1070	2.22300	1.23100	2.48000	2.662000	0.37000
2013	0.250000	1.04200	2.86500	4.0080	9.22200	1.20600	0.66800	1.248000	1.59900
2014	0.238000	1.47800	1.75100	2.7250	2.73700	4.74200	0.44700	0.387000	1.40300
2015	0.232000	1.53200	4.15500	2.3170	2.91600	2.62300	2.71500	0.226000	0.82300
2016	0.481000	1.77300	3.43700	4.1300	1.72700	1.95300	1.42000	1.293000	0.45500
2017	0.573000	3.68000	3.07900	3.0130	3.13500	1.09700	1.18200	0.751000	0.94000

Year	2	3	4	5	6	7	8	9	10
2018	0.353000	3.57000	10.35600	2.9080	3.06300	2.41900	0.96400	0.622000	1.06600
2019	0.386757	2.42112	6.43663	13.9091	1.87026	1.36609	1.46909	0.552468	1.10759

Table 1.6: Haddock in 5.a. Catch weights from the commercial fishery in Icelandic waters.

Year	2	3	4	5	6	7	8	9	10
1979	620.000	960.00	1410.00	2030.00	2910.00	3800.00	4560.00	4720.00	5956.00
1980	837.000	831.00	1306.00	2207.00	2738.00	3188.00	3843.00	4506.00	4982.84
1981	584.000	693.00	1081.00	1656.00	2283.00	3214.00	3409.00	4046.00	5261.02
1982	289.000	959.00	1455.00	1674.00	2351.00	3031.00	3481.00	3874.00	4122.51
1983	320.000	1006.00	1496.00	1921.00	2371.00	2873.00	3678.00	4265.00	4501.74
1984	691.000	1007.00	1544.00	2120.00	2514.00	3027.00	2940.00	3906.00	4033.31
1985	652.000	1125.00	1811.00	2260.00	2924.00	3547.00	3733.00	4039.00	4658.72
1986	336.000	1227.00	1780.00	2431.00	2771.00	3689.00	3820.00	4258.00	4455.68
1987	452.000	1064.00	1692.00	2408.00	3000.00	3565.00	4215.00	4502.00	4024.82
1988	362.000	780.00	1474.00	2217.00	2931.00	3529.00	3781.00	4467.00	4418.39
1989	323.000	857.00	1185.00	1996.00	2893.00	4066.00	3866.00	4734.00	4989.60
1990	269.000	700.00	1054.00	1562.00	2364.00	3414.00	4134.00	4946.00	4451.01
1991	288.000	699.00	979.00	1412.00	1887.00	2674.00	3135.00	4341.00	4956.93
1992	313.000	806.00	1167.00	1524.00	1950.00	2357.00	3075.00	4053.00	4703.25
1993	303.000	705.00	1333.00	1875.00	2386.00	2996.00	3059.00	3363.00	4408.79
1994	337.000	668.00	1019.00	1717.00	2391.00	2717.00	3280.00	3156.00	3277.94
1995	351.000	746.00	1096.00	1318.00	2044.00	2893.00	3049.00	3675.00	3136.79
1996	311.000	787.00	1187.00	1560.00	1849.00	2670.00	3510.00	3567.00	3731.34
1997	379.000	764.00	1163.00	1649.00	1943.00	2342.00	3020.00	3337.00	3235.90
1998	445.000	724.00	1147.00	1683.00	2250.00	2475.00	2834.00	3333.00	3596.42
1999	555.000	908.00	1101.00	1658.00	2216.00	2659.00	2928.00	3209.00	3512.52
2000	495.000	978.00	1333.00	1481.00	2119.00	2696.00	3307.00	3597.00	3756.94
2001	541.000	945.00	1456.00	1731.00	1832.00	2243.00	3020.00	3328.00	4235.94
2002	564.000	928.00	1253.00	1737.00	2219.00	2230.00	2911.00	3365.00	4387.08
2003	498.000	922.00	1283.00	1704.00	2274.00	2744.00	2635.00	2819.00	3741.91
2004	559.000	1006.00	1258.00	1579.00	2044.00	2809.00	3123.00	2945.00	3759.31
2005	339.000	886.00	1265.00	1506.00	1916.00	2323.00	3028.00	3211.00	2890.52
2006	402.000	749.00	1093.00	1495.00	1758.00	2163.00	2555.00	3054.00	3589.48
2007	510.000	748.00	988.00	1346.00	1840.00	2062.00	2350.00	2525.00	3142.71
2008	383.000	636.00	857.00	1125.00	1575.00	2149.00	2417.00	2802.00	2600.47
2009	452.000	841.00	960.00	1131.00	1352.00	1757.00	2364.00	2497.00	3073.67
2010	447.000	756.00	1092.00	1294.00	1448.00	1685.00	2188.00	2366.00	2645.85
2011	588.000	905.00	1122.00	1455.00	1688.00	1914.00	2094.00	2455.00	2985.68
2012	668.000	978.00	1222.00	1492.00	1903.00	2164.00	2366.00	2704.00	2939.96
2013	678.000	1084.00	1358.00	1675.00	2036.00	2400.00	2554.00	3097.00	3097.31

Year	2	3	4	5	6	7	8	9	10
2014	536.000	1080.00	1433.00	1793.00	2121.00	2504.00	2624.00	3178.00	3349.39
2015	573.000	1084.00	1486.00	2011.00	2332.00	2823.00	3306.00	3258.00	3768.15
2016	513.000	1071.00	1590.00	2035.00	2607.00	2952.00	3616.00	3734.00	4096.66
2017	643.000	997.00	1587.00	2032.00	2546.00	3016.00	3518.00	3839.00	3915.67
2018	627.000	1070.00	1383.00	2007.00	2536.00	2919.00	3377.00	3671.00	4026.36
2019	541.285	1005.15	1457.86	1820.85	2702.88	3091.86	3352.01	3694.17	4015.07

Table 1.7: Haddock in 5.a. Stock weights from the March survey in Icelandic waters.

Year	1	2	3	4	5	6	7	8	9	10
1979	37	185	481	910	1409	1968	2496	3077	3300	5956.00
1980	37	185	481	910	1409	1968	2496	3077	3300	4982.84
1981	37	185	481	910	1409	1968	2496	3077	3300	5261.02
1982	37	185	481	910	1409	1968	2496	3077	3300	4122.51
1983	37	185	481	910	1409	1968	2496	3077	3300	4501.74
1984	37	185	481	910	1409	1968	2496	3077	3300	4033.31
1985	35	241	562	1195	1690	2418	2814	3245	3369	3901.80
1986	34	240	671	1134	1963	2425	3236	2964	3767	3824.29
1987	31	163	514	1219	1758	2605	3024	3524	3896	3773.70
1988	37	176	456	973	1851	2711	3118	3485	3277	4986.42
1989	27	181	438	888	1514	2372	2905	3509	3255	3748.60
1990	29	183	454	842	1232	1985	2714	3067	3337	4042.05
1991	31	176	496	1004	1417	1890	2510	3833	3719	4545.56
1992	29	157	497	893	1381	1866	2325	3009	3732	4753.75
1993	40	167	381	878	1488	1786	2581	2576	3277	4000.00
1994	33	179	402	704	1267	1721	1866	2628	2050	1844.64
1995	37	163	444	759	1062	1855	2664	5319	1313	4000.00
1996	40	174	447	816	1053	1452	2149	2365	4830	3133.12
1997	51	173	422	815	1223	1422	1883	2373	3771	2877.68
1998	41	201	400	737	1221	1677	1991	2338	3091	4000.00
1999	34	205	481	715	1191	1932	2387	2724	2933	2581.52
2000	29	179	553	897	1152	1694	2601	2910	3162	3370.46
2001	36	188	484	1048	1425	1501	2179	2803	4000	3958.89
2002	63	172	473	892	1467	1957	2017	1962	3756	4357.30
2003	40	231	412	800	1259	1869	3153	2314	3303	3945.97
2004	34	177	557	807	1280	1685	2444	2920	2927	3333.11
2005	41	153	448	921	1188	1564	2103	2792	2548	3633.75
2006	33	135	333	736	1134	1510	1927	2227	3270	3528.55
2007	48	170	350	615	1053	1493	1781	2067	2157	3801.33
2008	27	178	383	593	868	1295	1831	2204	2286	2924.73
2009	29	139	442	687	883	1137	1491	1905	2548	2937.31

Year	1	2	3	4	5	6	7	8	9	10
2010	32	150	392	777	936	1181	1462	1784	2037	2719.15
2011	35	175	443	759	1131	1307	1585	1867	2044	2956.30
2012	28	202	482	801	1145	1480	1908	2072	2352	2520.06
2013	33	202	589	967	1313	1709	2001	2264	2746	2658.79
2014	36	223	573	1005	1373	1751	2141	2299	2653	3134.85
2015	32	254	614	1073	1638	1924	2451	2772	3186	3388.15
2016	29	162	642	1101	1565	2094	2296	3067	3441	3486.42
2017	34	197	459	1258	1657	2162	2768	3200	3558	3675.10
2018	30	195	544	924	1836	2342	2660	2968	3204	3585.57
2019	29	166	505	962	1341	2472	2814	3035	3477	3532.69

Table 1.8: Haddock in 5.a. Sexual maturity-at-age in the stock (from the March survey). The numbers for age 10 only apply to the spawning stock.

Year	1	2	3	4	5	6	7	8	9	10
1979	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1980	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1981	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1982	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1983	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1984	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1985	0.000	0.016	0.149	0.541	0.577	0.767	0.764	0.962	0.933	0.983527
1986	0.000	0.022	0.203	0.410	0.672	0.842	0.884	0.956	0.986	0.991175
1987	0.000	0.020	0.146	0.487	0.597	0.879	0.900	1.000	0.988	0.967909
1988	0.000	0.013	0.215	0.392	0.767	0.791	0.927	0.913	1.000	0.970986
1989	0.000	0.040	0.199	0.530	0.723	0.802	1.000	1.000	1.000	1.000000
1990	0.000	0.115	0.327	0.632	0.816	0.843	0.918	0.897	1.000	1.000000
1991	0.000	0.066	0.219	0.587	0.738	0.818	0.893	0.505	1.000	1.000000
1992	0.000	0.050	0.223	0.416	0.801	0.905	0.902	0.859	1.000	1.000000
1993	0.005	0.123	0.362	0.484	0.667	0.905	0.977	0.910	0.868	1.000000
1994	0.035	0.238	0.325	0.611	0.791	0.865	1.000	0.908	1.000	1.000000
1995	0.000	0.130	0.481	0.389	0.757	0.754	0.619	0.986	1.000	1.000000
1996	0.000	0.197	0.379	0.606	0.643	0.790	0.745	0.946	0.897	1.000000
1997	0.016	0.092	0.432	0.585	0.682	0.751	0.787	0.874	1.000	1.000000
1998	0.000	0.030	0.494	0.686	0.778	0.754	0.855	0.901	1.000	1.000000
1999	0.000	0.048	0.384	0.679	0.725	0.756	0.896	0.773	0.920	1.000000
2000	0.000	0.103	0.247	0.619	0.808	0.875	0.875	1.000	0.781	0.959667
2001	0.002	0.097	0.372	0.515	0.752	0.897	0.918	0.915	1.000	1.000000
2002	0.000	0.045	0.278	0.629	0.800	0.935	0.933	1.000	1.000	1.000000
2003	0.005	0.062	0.347	0.688	0.869	0.923	0.948	0.984	1.000	1.000000
2004	0.000	0.038	0.363	0.571	0.831	0.913	1.000	1.000	1.000	1.000000

Year	1	2	3	4	5	6	7	8	9	10
2005	0.000	0.024	0.231	0.564	0.751	0.923	0.937	0.968	1.000	1.000000
2006	0.000	0.028	0.118	0.467	0.618	0.741	0.920	1.000	1.000	1.000000
2007	0.000	0.078	0.207	0.417	0.681	0.760	0.876	0.960	1.000	1.000000
2008	0.000	0.027	0.262	0.415	0.621	0.829	0.870	0.904	0.974	1.000000
2009	0.000	0.017	0.299	0.469	0.581	0.848	0.890	1.000	0.967	1.000000
2010	0.010	0.030	0.183	0.615	0.780	0.789	0.887	0.935	1.000	0.966447
2011	0.000	0.046	0.176	0.425	0.822	0.816	0.838	0.898	0.976	1.000000
2012	0.000	0.107	0.168	0.446	0.627	0.820	0.903	0.853	0.911	0.973381
2013	0.000	0.047	0.225	0.382	0.716	0.795	0.921	0.986	0.974	0.988984
2014	0.000	0.108	0.192	0.390	0.567	0.676	0.736	0.925	0.906	0.951132
2015	0.000	0.138	0.283	0.444	0.670	0.795	0.773	0.892	1.000	0.961426
2016	0.000	0.008	0.360	0.485	0.594	0.779	0.787	0.882	0.902	0.971048
2017	0.000	0.073	0.131	0.591	0.664	0.741	0.911	0.939	1.000	0.970437
2018	0.000	0.035	0.235	0.395	0.824	0.856	0.892	0.881	0.974	1.000000
2019	0.009	0.036	0.335	0.591	0.669	0.890	0.938	0.960	1.000	0.964376

Table 1.9: Haddock in Division 5.a. Age disaggregated survey indices from the groundfish survey in March

Year	1	2	3	4	5	6	7	8	9	10
1985	29.91	32.25	17.67	23.26	26.30	3.73	11.01	4.87	5.68	0.63
1986	122.05	109.77	61.10	13.39	16.84	13.57	1.00	3.17	1.27	2.43
1987	21.50	324.64	148.07	44.69	7.77	7.53	4.77	0.40	0.62	1.28
1988	15.71	39.99	184.56	90.07	23.12	1.37	2.23	1.81	0.17	0.26
1989	10.45	23.09	40.59	145.63	45.09	12.92	0.79	0.81	0.42	0.41
1990	72.10	31.55	26.67	38.57	92.00	30.73	3.43	0.88	0.23	0.00
1991	88.43	147.01	42.92	17.86	20.17	32.71	7.64	0.31	0.10	0.09
1992	17.21	211.29	139.98	35.42	16.63	13.63	16.15	2.25	0.18	0.05
1993	30.58	38.93	252.31	88.40	11.35	3.89	1.68	4.51	0.89	0.00
1994	58.68	61.57	40.90	147.33	40.55	5.47	2.82	1.37	3.67	0.22
1995	37.07	84.74	47.12	19.82	69.91	7.71	1.31	0.12	0.34	0.00
1996	96.53	67.19	121.31	36.89	19.78	41.00	5.84	0.60	0.13	0.13
1997	8.41	122.61	51.08	53.11	10.80	7.28	10.85	1.34	0.07	0.09
1998	23.17	18.73	110.23	28.45	23.27	4.89	3.48	4.52	0.34	0.00
1999	80.92	86.14	25.79	98.86	12.99	9.88	1.43	1.78	1.04	0.09
2000	60.41	88.73	43.92	8.33	24.82	3.12	1.58	0.40	0.15	0.56
2001	81.03	153.29	116.21	21.70	4.03	10.45	0.89	0.55	0.00	0.10
2002	20.68	304.47	198.83	110.43	22.88	3.45	7.39	0.30	0.34	0.21
2003	112.29	97.95	283.72	247.05	115.11	18.26	2.60	4.57	0.49	0.91
2004	325.12	291.10	70.86	208.82	110.08	34.24	6.82	1.26	0.83	0.16
2005	57.55	693.57	288.64	44.58	157.39	57.69	15.78	3.36	0.32	0.28
2006	39.87	78.50	575.82	181.71	19.34	63.24	16.54	6.80	0.70	0.29

Year	1	2	3	4	5	6	7	8	9	10
2007	34.23	65.13	89.00	437.40	85.58	7.84	21.32	4.67	2.13	0.07
2008	88.07	67.69	71.12	75.02	220.74	29.75	3.51	7.42	1.63	0.27
2009	10.87	112.24	53.00	40.53	41.31	104.80	12.76	2.19	3.04	0.65
2010	15.25	27.69	137.03	29.60	18.10	20.48	31.38	2.90	0.46	0.80
2011	8.76	27.46	24.33	76.71	13.95	5.88	9.40	14.89	1.28	0.54
2012	12.33	14.76	31.18	27.15	58.16	5.22	2.92	5.28	6.85	1.05
2013	13.93	23.05	19.56	22.61	22.25	41.48	4.76	2.49	3.82	5.16
2014	14.15	24.53	30.15	17.69	16.40	14.76	16.39	1.33	1.04	3.14
2015	62.08	19.53	26.50	34.10	12.62	11.11	9.57	9.85	1.16	1.70
2016	29.85	162.26	23.51	22.09	22.24	7.17	7.27	5.05	4.25	1.39
2017	26.66	66.57	140.89	23.02	20.29	22.05	6.47	5.05	3.53	2.21
2018	64.07	70.39	73.53	118.35	13.70	11.54	10.06	3.41	3.29	2.11
2019	7.14	85.21	47.89	40.85	67.31	4.13	3.80	3.08	1.61	0.86
2020	111.97	13.95	97.24	35.18	27.72	42.48	2.86	1.87	2.17	1.79

Table 1.10: Haddock in 5.a. Age disaggregated survey indices from the groundfish survey in October.

Year	1	2	3	4	5	6	7	8	9	10
1985	29.91	32.25	17.67	23.26	26.30	3.73	11.01	4.87	5.68	0.63
1986	122.05	109.77	61.10	13.39	16.84	13.57	1.00	3.17	1.27	2.43
1987	21.50	324.64	148.07	44.69	7.77	7.53	4.77	0.40	0.62	1.28
1988	15.71	39.99	184.56	90.07	23.12	1.37	2.23	1.81	0.17	0.26
1989	10.45	23.09	40.59	145.63	45.09	12.92	0.79	0.81	0.42	0.41
1990	72.10	31.55	26.67	38.57	92.00	30.73	3.43	0.88	0.23	0.00
1991	88.43	147.01	42.92	17.86	20.17	32.71	7.64	0.31	0.10	0.09
1992	17.21	211.29	139.98	35.42	16.63	13.63	16.15	2.25	0.18	0.05
1993	30.58	38.93	252.31	88.40	11.35	3.89	1.68	4.51	0.89	0.00
1994	58.68	61.57	40.90	147.33	40.55	5.47	2.82	1.37	3.67	0.22
1995	37.07	84.74	47.12	19.82	69.91	7.71	1.31	0.12	0.34	0.00
1996	96.53	67.19	121.31	36.89	19.78	41.00	5.84	0.60	0.13	0.13
1997	8.41	122.61	51.08	53.11	10.80	7.28	10.85	1.34	0.07	0.09
1998	23.17	18.73	110.23	28.45	23.27	4.89	3.48	4.52	0.34	0.00
1999	80.92	86.14	25.79	98.86	12.99	9.88	1.43	1.78	1.04	0.09
2000	60.41	88.73	43.92	8.33	24.82	3.12	1.58	0.40	0.15	0.56
2001	81.03	153.29	116.21	21.70	4.03	10.45	0.89	0.55	0.00	0.10
2002	20.68	304.47	198.83	110.43	22.88	3.45	7.39	0.30	0.34	0.21
2003	112.29	97.95	283.72	247.05	115.11	18.26	2.60	4.57	0.49	0.91
2004	325.12	291.10	70.86	208.82	110.08	34.24	6.82	1.26	0.83	0.16
2005	57.55	693.57	288.64	44.58	157.39	57.69	15.78	3.36	0.32	0.28
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Year	1	2	3	4	5	6	7	8	9	10
2008	88.07	67.69	71.12	75.02	220.74	29.75	3.51	7.42	1.63	0.27
2009	10.87	112.24	53.00	40.53	41.31	104.80	12.76	2.19	3.04	0.65
2010	15.25	27.69	137.03	29.60	18.10	20.48	31.38	2.90	0.46	0.80
2011	8.76	27.46	24.33	76.71	13.95	5.88	9.40	14.89	1.28	0.54
2012	12.33	14.76	31.18	27.15	58.16	5.22	2.92	5.28	6.85	1.05
2013	13.93	23.05	19.56	22.61	22.25	41.48	4.76	2.49	3.82	5.16
2014	14.15	24.53	30.15	17.69	16.40	14.76	16.39	1.33	1.04	3.14
2015	62.08	19.53	26.50	34.10	12.62	11.11	9.57	9.85	1.16	1.70
2016	29.85	162.26	23.51	22.09	22.24	7.17	7.27	5.05	4.25	1.39
2017	26.66	66.57	140.89	23.02	20.29	22.05	6.47	5.05	3.53	2.21
2018	64.07	70.39	73.53	118.35	13.70	11.54	10.06	3.41	3.29	2.11
2019	7.14	85.21	47.89	40.85	67.31	4.13	3.80	3.08	1.61	0.86
2020	111.97	13.95	97.24	35.18	27.72	42.48	2.86	1.87	2.17	1.79

Table 1.11: Haddock in 5.a. ICES advice and official landings. All weights are in tonnes. * Calendar year. ** January to August

Year	ICES advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings for the fishing year	ICES landings for the calendar year
1987*	National advice	< 50000	60000		40760
1988*	National advice	< 60000	65000		54204
1989*	National advice	< 60000	65000		62885
1990*	National advice	< 60000	65000		67198
1991**	National advice	< 38000	48000		54692
1991/1992	National advice	< 50000	50000	48123	47121
1992/1993	National advice	< 60000	65000	47255	48123
1993/1994	National advice	< 65000	65000	58443	59502
1994/1995	National advice	< 65000	65000	60829	60884
1995/1996	National advice	< 55000	60000	53972	56890
1996/1997	National advice	< 40000	45000	49764	43764
1997/1998	National advice	< 40000	45000	37811	41192
1998/1999	National advice	< 35000	35000	45146	45411
1999/2000	F reduced below F_{med}	< 35000	35000	41150	42105
2000/2001	F reduced below provisional F_{pa}	< 31000	30000	39143	39654
2001/2002	F reduced below provisional F_{pa}	< 30000	41000	41069	50498
2002/2003	F reduced below provisional F_{pa}	< 55000	55000	55269	60883
2003/2004	F reduced below provisional F_{pa}	< 75000	75000	77916	84828
2004/2005	F reduced below provisional F_{pa}	< 97000	90000	96617	97225

Year	ICES advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings for the fishing year	ICES landings for the calendar year
2005/2006	F reduced below provisional F_{pa}	< 110000	105000	99926	97614
2006/2007	F reduced below provisional F_{pa}	< 112000	105000	99763	109966
2007/2008	F reduced below provisional F_{pa}	< 120000	100000	109810	102872
2008/2009	F reduced below 0.35	< 83000	93000	88617	82045
2009/2010	F reduced below 0.35	< 57000	63000	67579	64169
2010/2011	F reduced below 0.35	< 51000	50000	50042	49433
2011/2012	F reduced below 0.35	< 42000	45000	49179	46208
2012/2013	F reduced below 0.35	< 32000	36000	40512	44097
2013/2014	TAC 0.4 × B45+cm,2014	< 38000	38000	39628	33900
2014/2015	TAC 0.4 × B45+cm,2015	< 30400	30400	36656	39646
2015/2016	TAC 0.4 × B45+cm,2016	< 36400	36400	40117	38109
2016/2017	TAC 0.4 × B45+cm,2017	< 34600	34600	36340	37062
2017/2018	TAC 0.4 × B45+cm,2018	< 41390	41390	44905	49993
2018/2019	TAC 0.4 × B45+cm,2019	< 57982	57982	59382	58850
2019/2020	TAC 0.35 x B45+cm,2020	< 41823	41823		

10 Haddock in 5.a

Icelandic haddock (*Melanogrammus aeglefinus*) is fairly 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 (less than 10 tonnes 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 fairly 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.

10.1 Fishery

The fishery for haddock in 5.a has not changed substantially in recent years, but the total number of boats that account for 95% of fishery have been declining steadily (Figure 10.1.1). Around 250 longliners annually report catches of haddock, around 60 trawlers and 40 demersal seine boats. Most of haddock in 5.a 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 was around 60% in 2019. At the same time the proportion caught by longlines has increased from around 15% in 1995–2000 to 40 % in 2011–2020. Catches in demersal seine have varied less and have been at around 15% of Icelandic catches of haddock in 5.a. 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 10.1.2). Most of the haddock caught in 5.a by Icelandic vessels is caught at depths less than 200 m (Figure 10.1.3). The main fishing grounds for haddock in 5.a, as observed from logbooks, are in the south, southwestern and western part of the Icelandic shelf (Figure 10.1.4) and Figure 10.1.5). The main trend in the spatial distribution of haddock catches in 5.a according to logbook entries is the increased proportion of catches caught in the north and northeast.

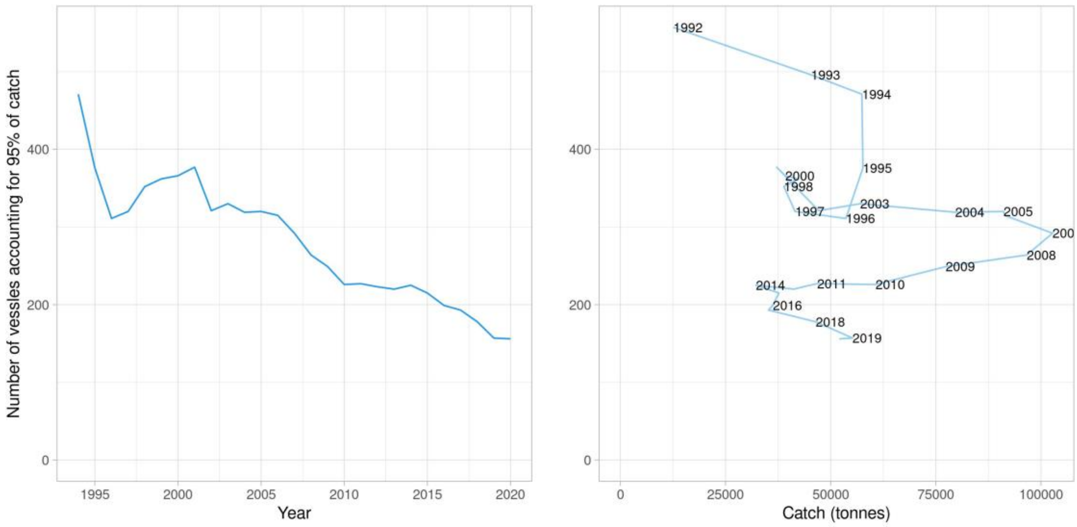

Figure 10.1.1: Haddock in 5.a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

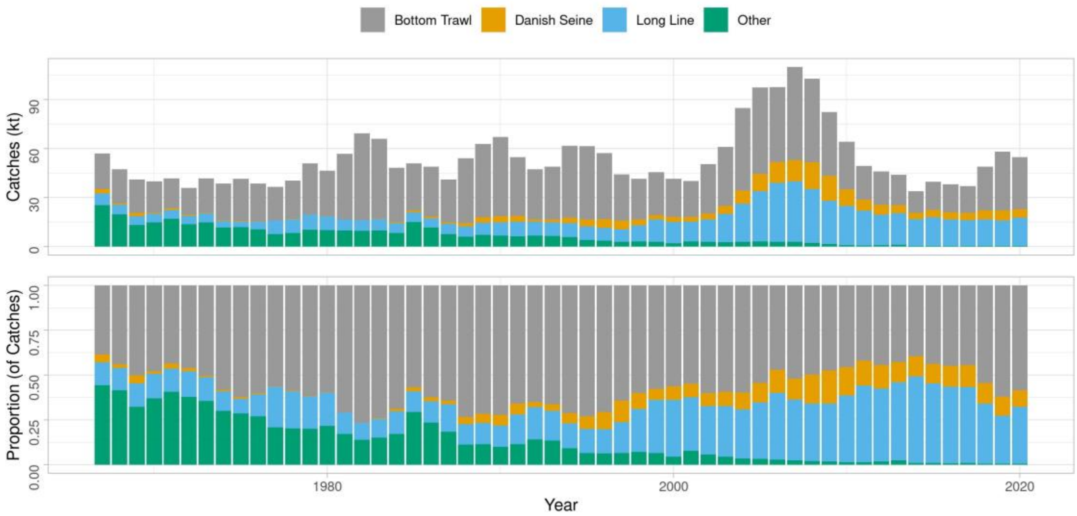

Figure 10.1.2: Haddock in 5.a. Landings in tonnes and percent of total by gear and year.

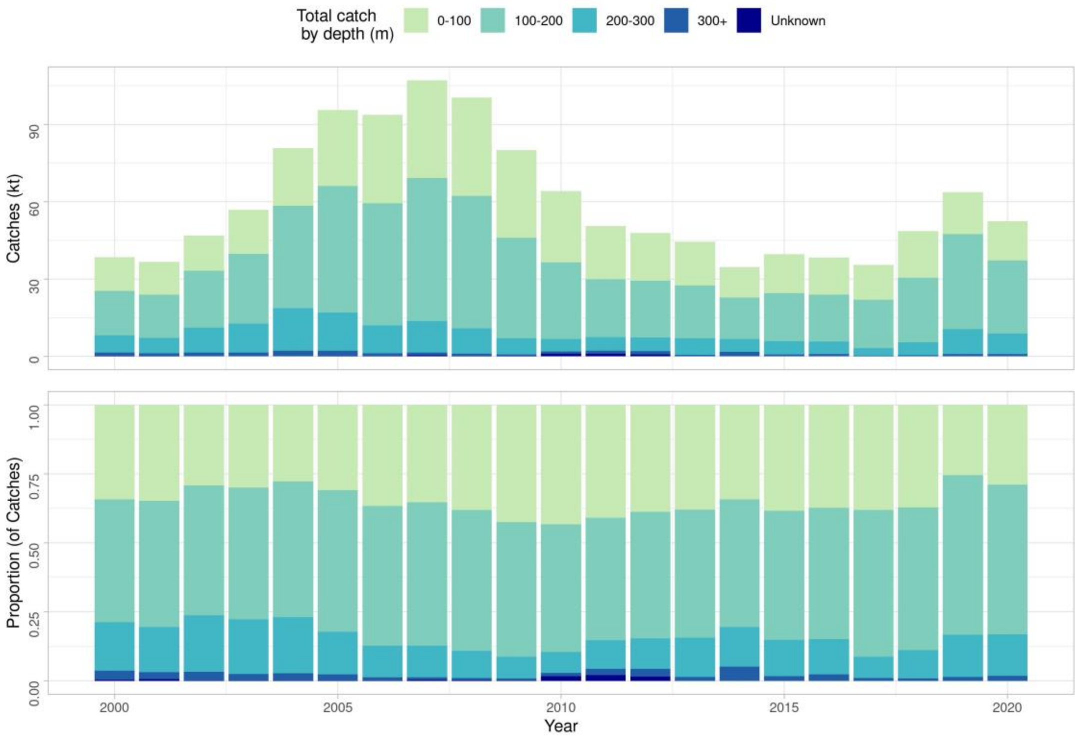

Figure 10.1.3: Haddock in 5.a. Depth distribution of haddock catches from bottom trawls, longlines, trawls and demersal seine from Icelandic logbooks.

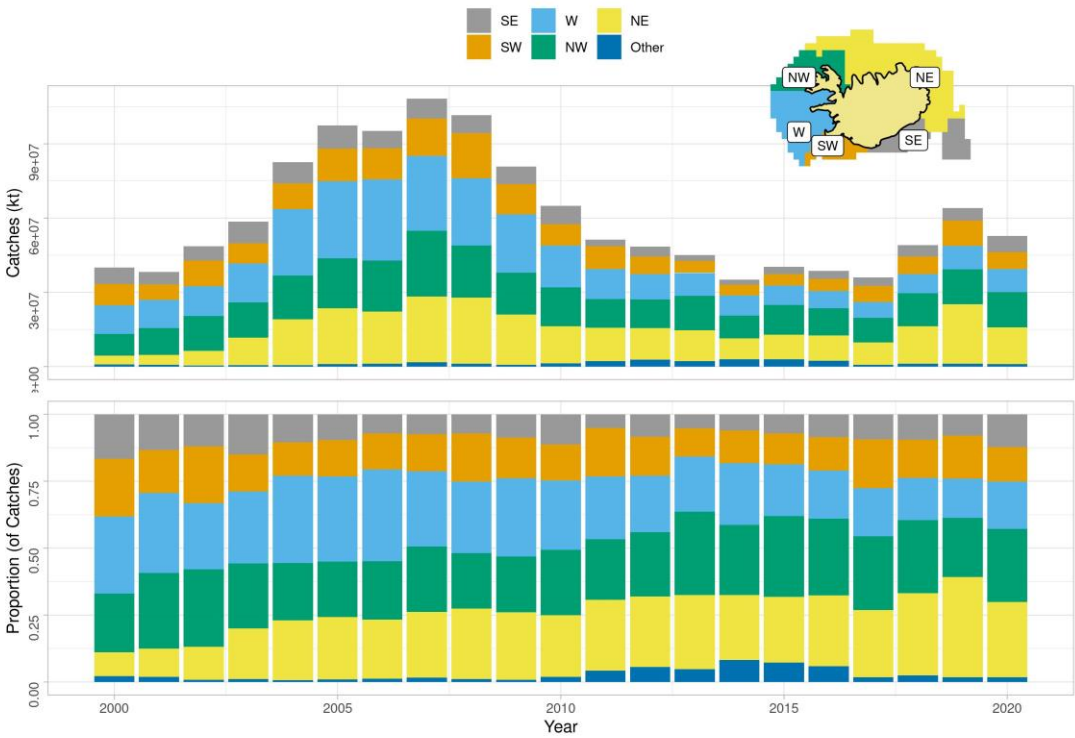

Figure 10.1.4: Haddock in 5.a. Changes in spatial distribution of haddock catches as recorded in Icelandic logbooks.

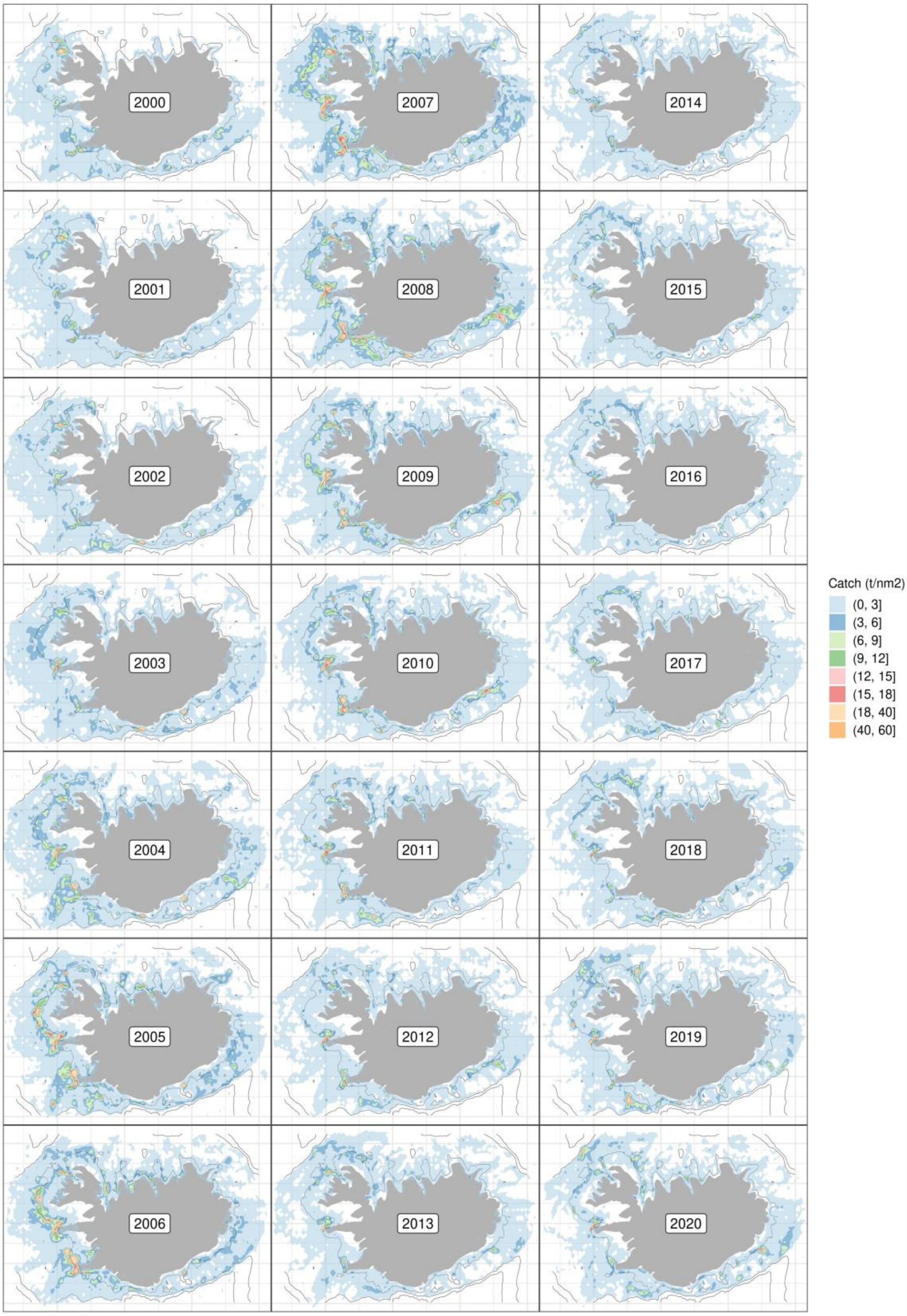

Figure 10.1.5: Haddock in 5.a. Spatial distribution of catches by all gears.

10.1.1 Landing trends

Landings of Icelandic haddock in 2020 are estimated to have been 5.478074^{4} thousand tonnes, see Figure 10.1.6. The landings in Division 5.a. 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 1.248329^{6} tonnes, while Norwegian vessels land considerably less haddock.

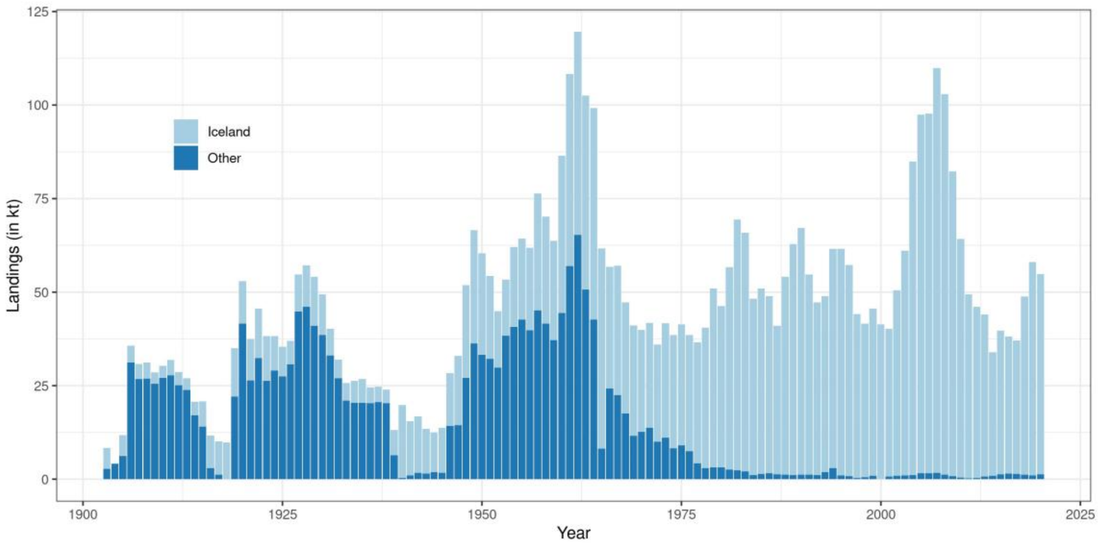

Figure 10.1.6: Haddock in 5.a. Recorded landings since 1905.

10.2 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 10.1.7and Figure 10.1.8. 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.

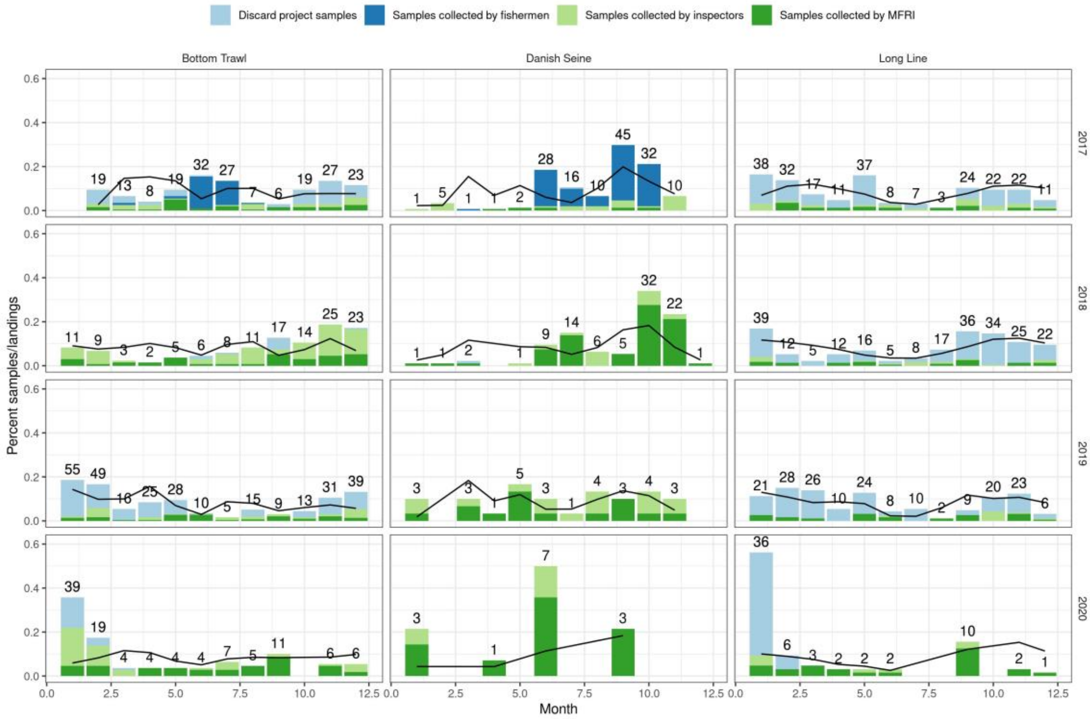

Figure 10.2.1: Haddock in 5.a. Ratio of samples by month (blue bars) compared with landings by month (solid black line) split by year and main gear types. Numbers of above the bars indicate number of samples by year, month and gear.

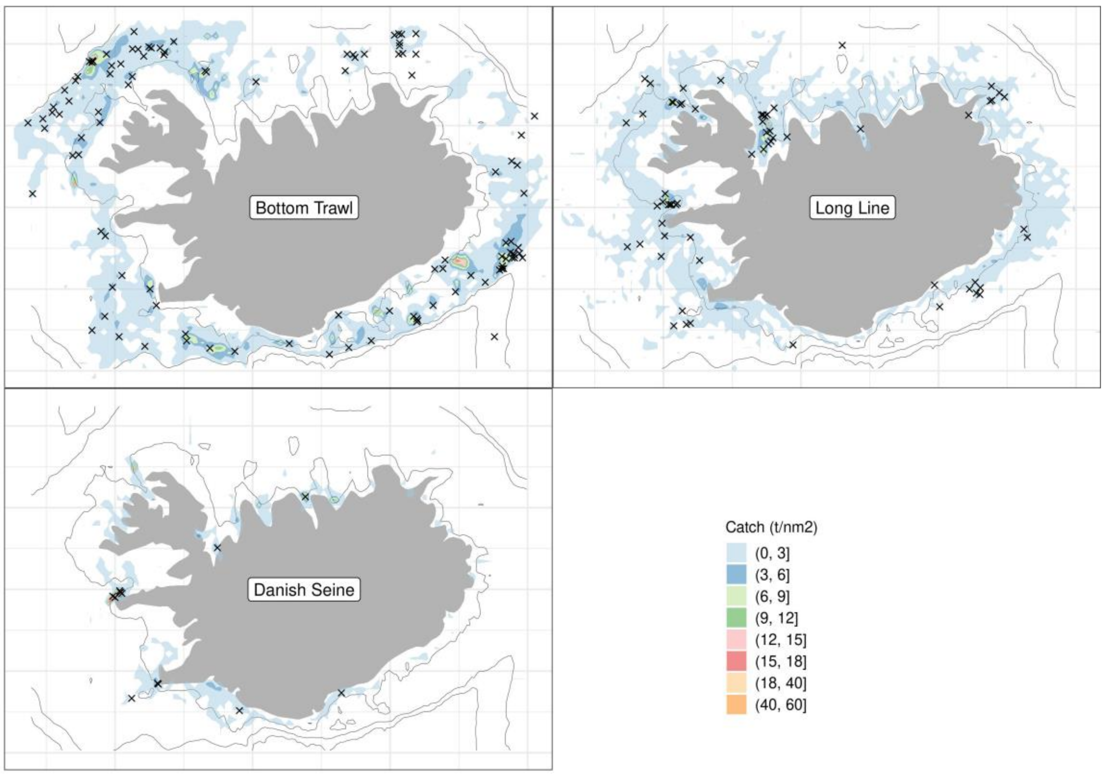

Figure 10.2.2: Haddock in 5.a. Fishing grounds in 2019 as reported in logbooks (tiles) and positions of samples taken from landings (asterisks) by main gear types.

10.2.1 Landings and discards

All landings in 5.a before 1982 are derived from the STATLANT database, and also all foreign landings in 5.a 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 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/.

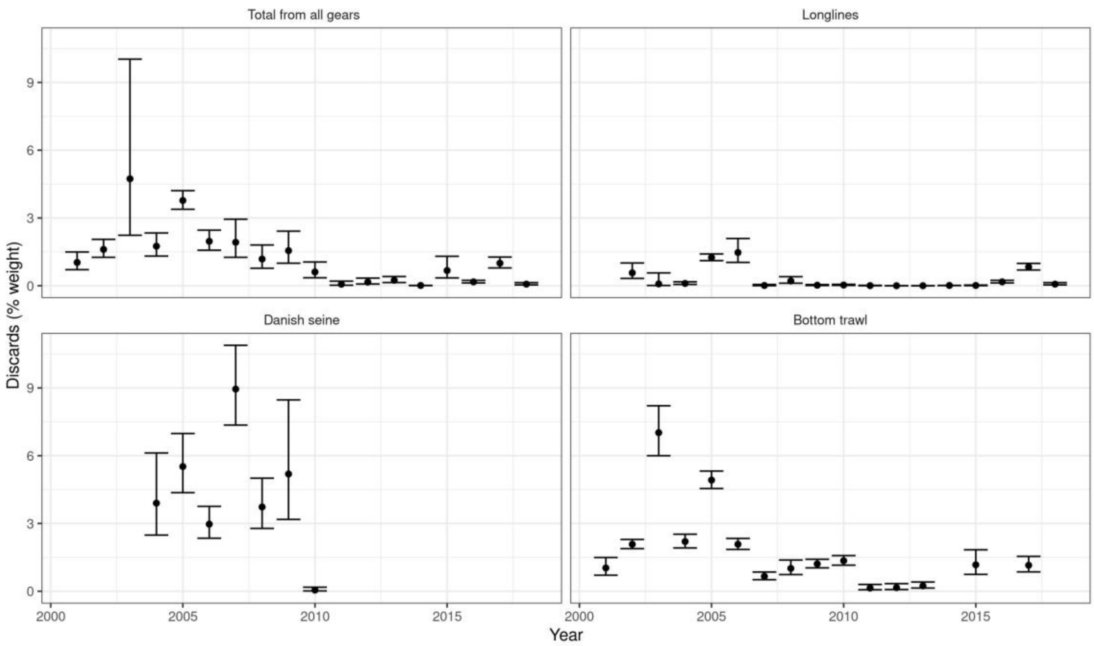

Figure 10.2.3: Haddock in 5.a. Estimates of annual discards by gear. Vertical lines indicate the 95 % confidence interval while dots the point estimates. No estimates are available for 2019 and 2020 at this time.

10.2.2 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 10.1.9. The sizes caught by the main gear types (bottom trawl and longlines) appear to be fairly 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.

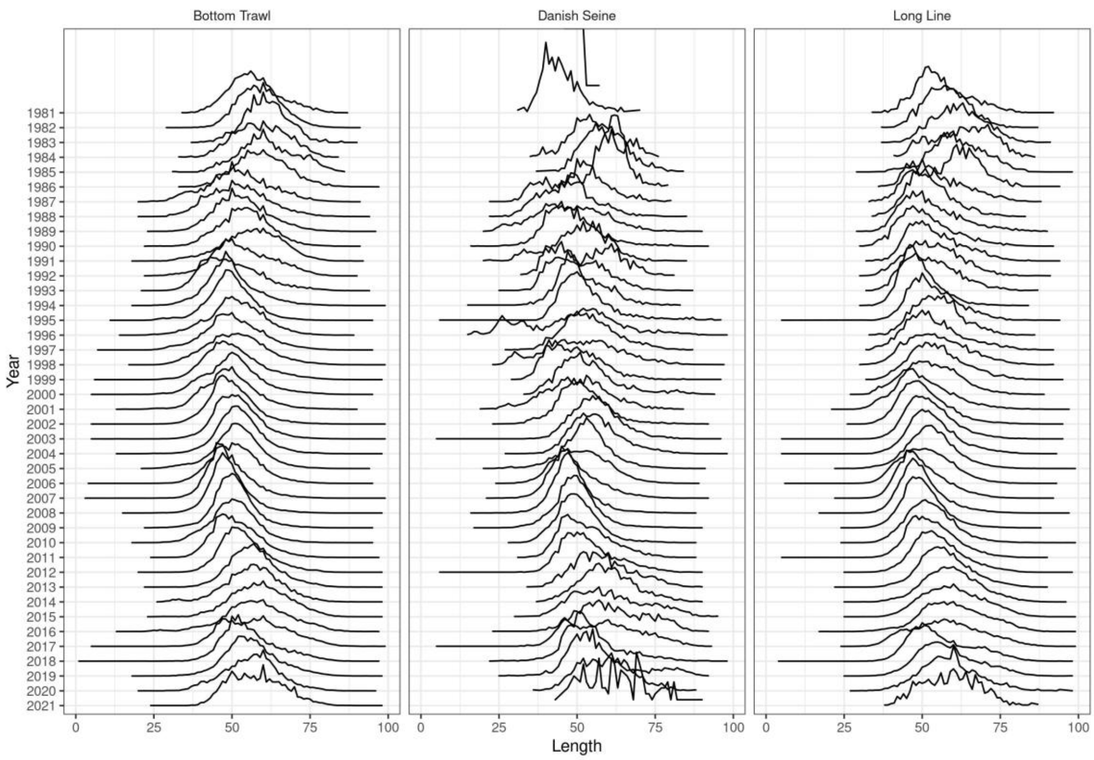

Figure 10.2.4: Haddock in 5.a. Commercial length distributions by gear and year

10.2.3 Age compositions

Catch in numbers-at-age is shown in Figure 10.1.10. The catches in 2020 are mainly composed of the 2014-year class largest component (approx. 35 %) with remainder spread across a number of relatively small 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 Figure 10.1.11.

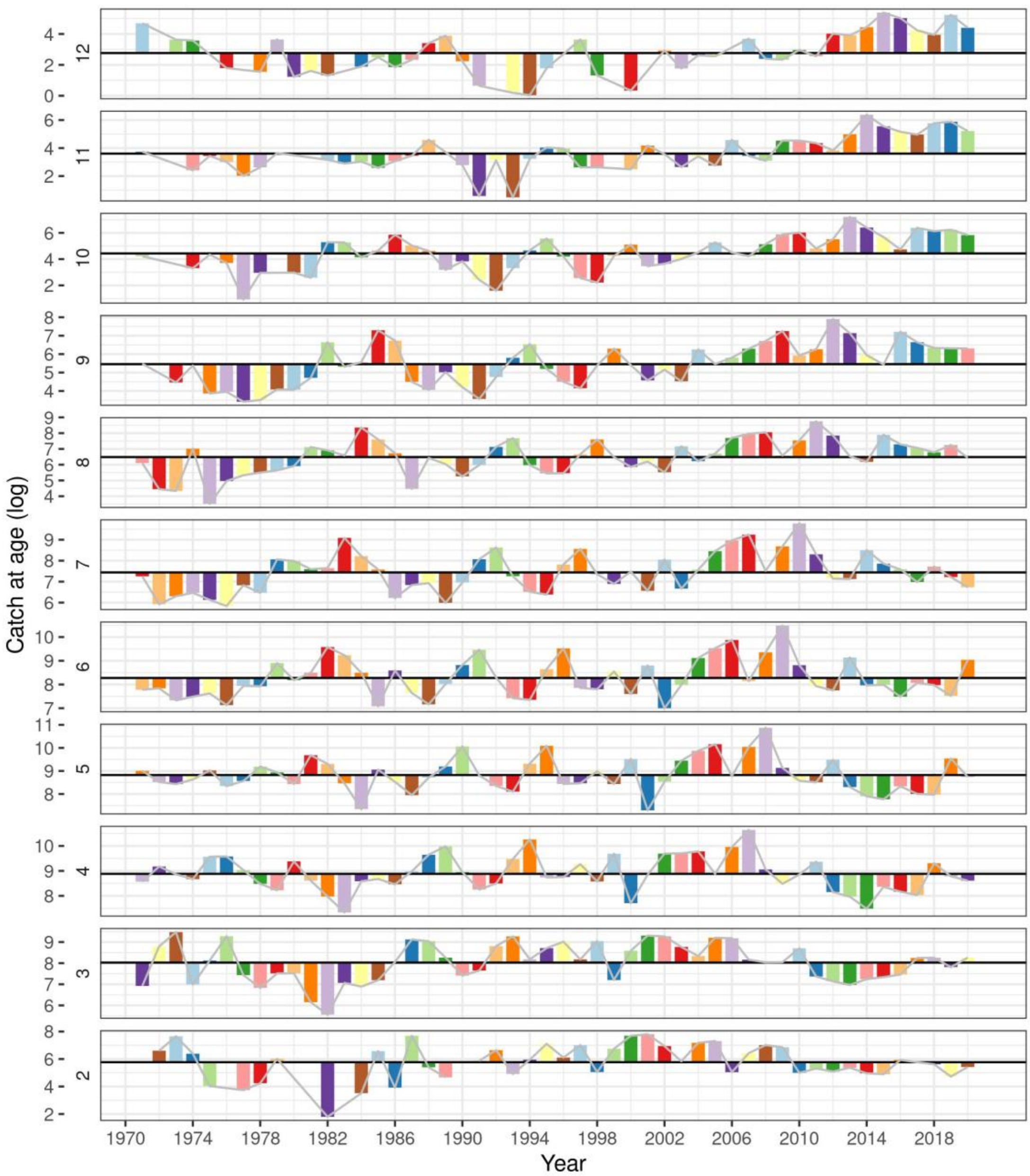

Figure 10.2.7: Haddock in 5.a. Catch at age from the commercial fishery in Iceland waters. Bar size is indicative of the catch in numbers and bars are coloured by cohort.

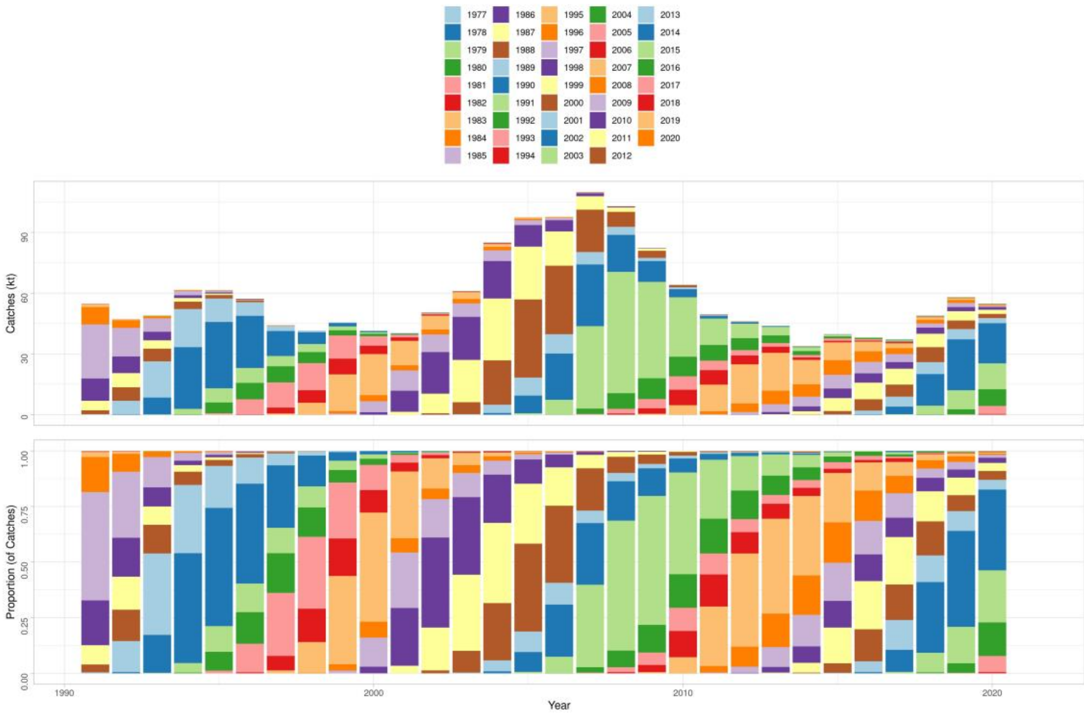

Figure 10.2.6: Haddock in 5.a. Catch at age from the commercial fishery in Iceland waters. Biomass caught by year and age, bars are coloured by cohort.

10.2.4 Weight at age

Mean weight at age in the stock and catch is shown in Figure 10.1.12. 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.

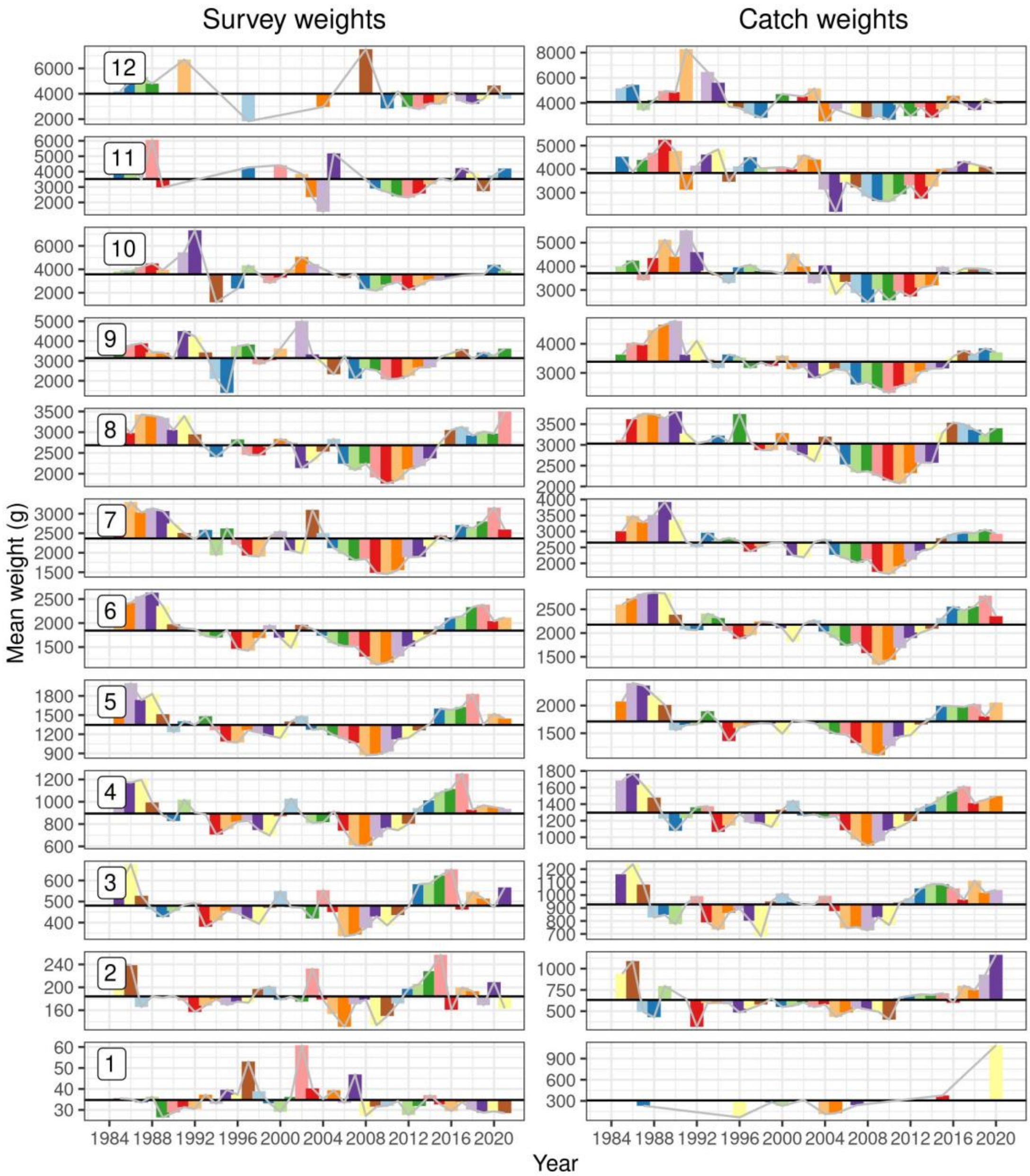

Figure 10.2.8: Haddock in 5.a. Catch weights from the commercial fishery and stock weights from the March survey in Icelandic waters. Bars are coloured by cohort.

10.2.5 Maturity at age

Maturity-at-age data are shown Figure 10.1.13. 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 10.1.14.

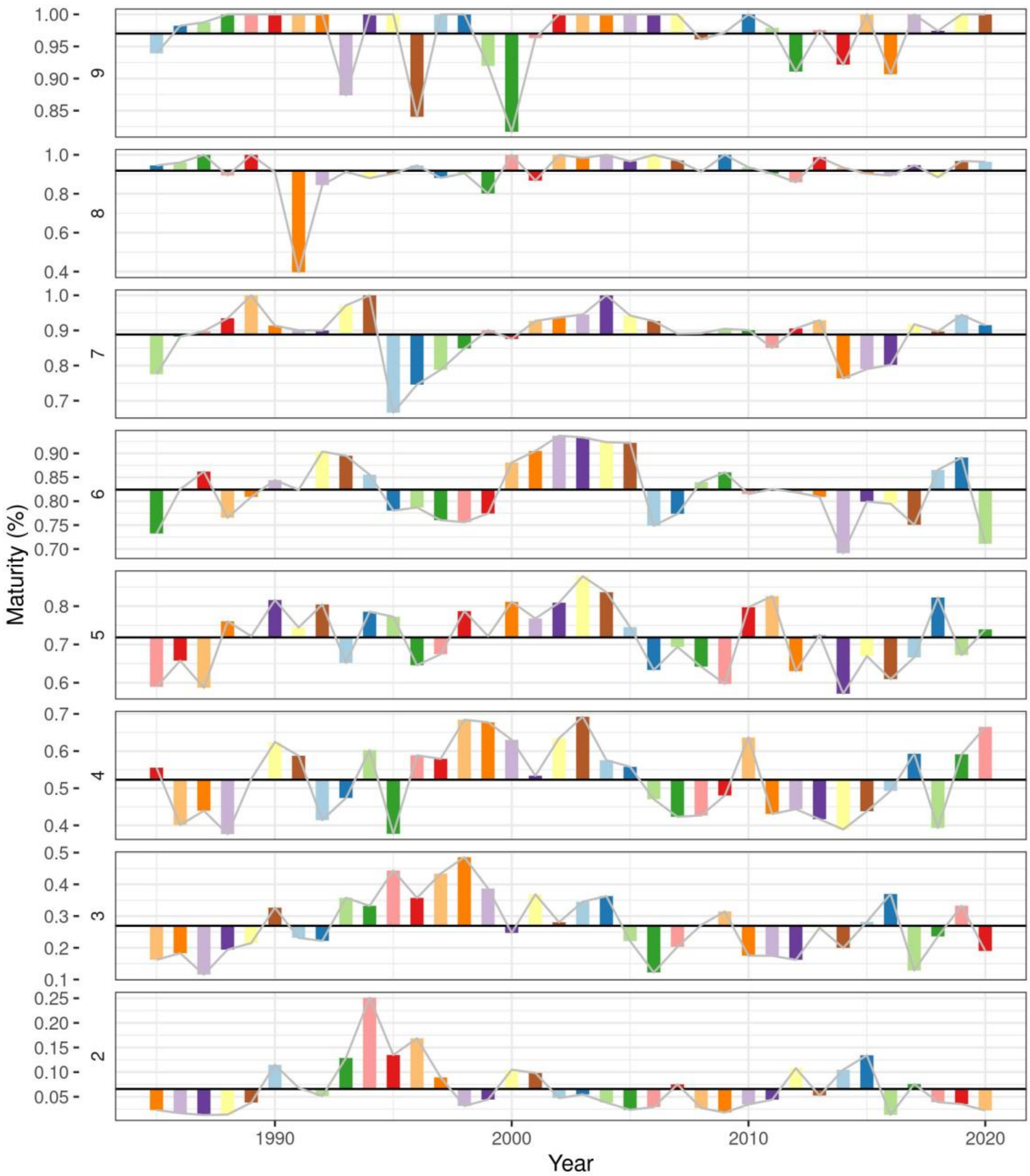

Figure 10.2.9: Haddock in Division 5.a. Maturity-at-age in the survey. The red bars indicates predictions. The values are used to calculate the spawning stock.

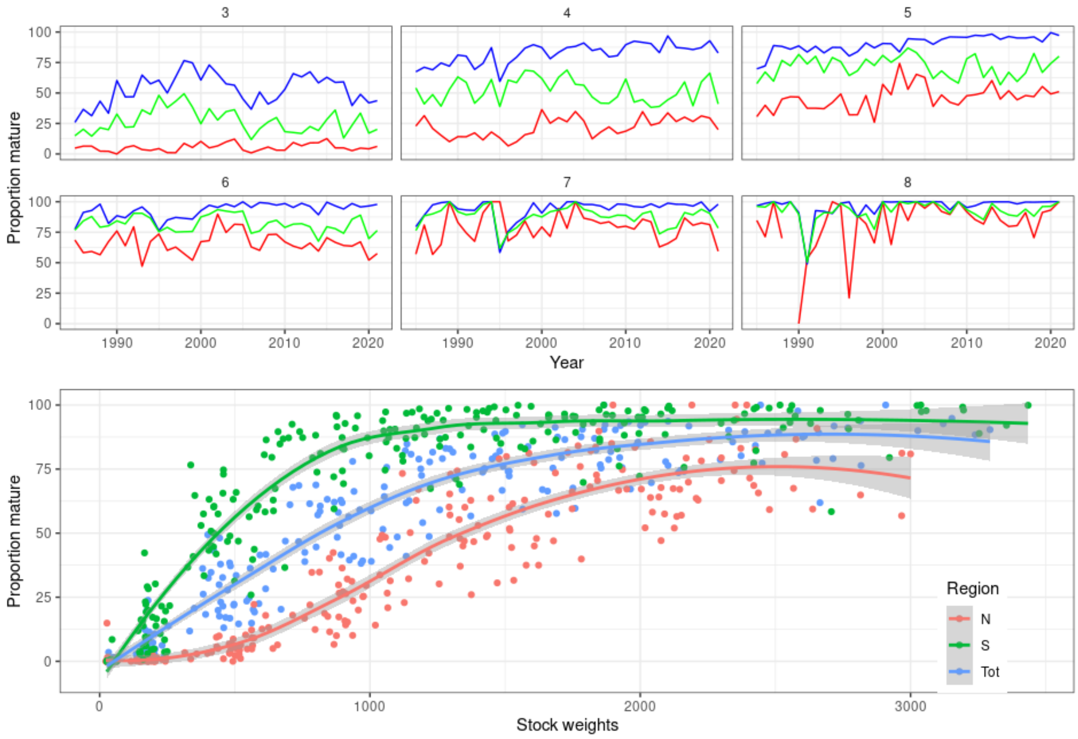

Figure 10.1.14: Haddock in 5.a. Geographical differences in proportion mature by year and age (top), and stock weights (below).

10.2.6 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.

10.2.7 Catch, effort and research vessel data

10.2.7.1 Catch per unit of effort from commercial fisheries

Catch per unit of effort data (Figure 10.1.15) gives different picture of the development of the stock than the surveys and assessment, much less increase after 2000 and much less decrease in recent years. The current assessment coupled with the relatively high CPUE, in recent years, confirms fishers' view that is now easier to catch haddock. The discrepancy observed between CPUE and stock size has not been explained, but a plausible explanation might be related to a couple reasons, and relate to the development of the stock, its spatial distribution and the evolution of the fisheries and management. As is evident, both from the survey data and commercial catch data, the spatial distribution of the stock started to shift northwards in the early 2000s. This shift in distribution is believed be the result of a surge in recruitment that occurred around that time. These shifts caused issues in the fisheries (as described in the management section below) and bycatch of juvenile haddock (<45 cm) which was exacerbated with slower growth of the stock due to higher densities. The opposite has happened in recent years, faster growth and poor recruitment lead to the fisheries not limited by small haddock. 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.

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.

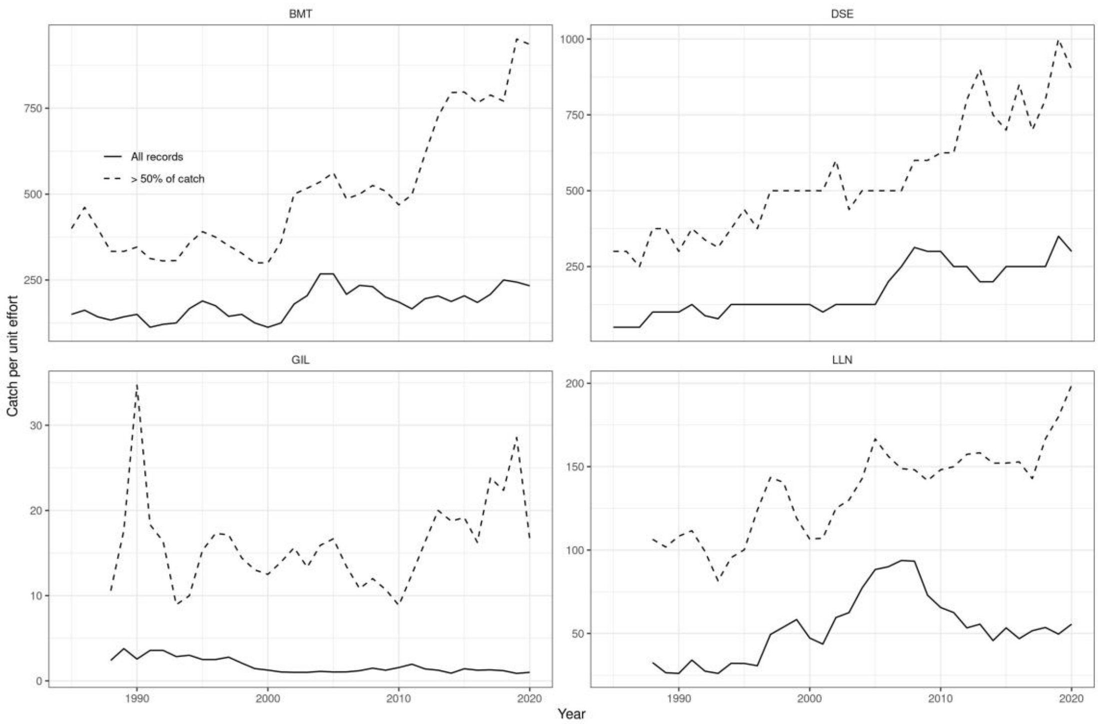

Figure 10.2.11: Catch per unit of effort in the most important gear types. The dashed lines are based on locations where more than 50% of the catch is haddock and solid lines on all records where haddock is caught. A change occurred in the longline fleet starting September 1999. Earlier only vessels larger than 10 BRT were required to return logbooks but later all vessels were required to return logbooks.

10.2.7.2 Icelandic survey data

Information on abundance and biological parameters from haddock in 5.a 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 with the exception of 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 fairly 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 10.1.16 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 10.1.17 and Figure 10.1.18. 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 10.1.19 and Figure 10.1.20 (abundance) and changes in spatial distribution in Figure 10.1.21.

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 10.1.22. Similar to the biomass of 60cm^{+} 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 5.a. After a period of low recruitment, the biomass for other age groups is near the geometric mean in both surveys.

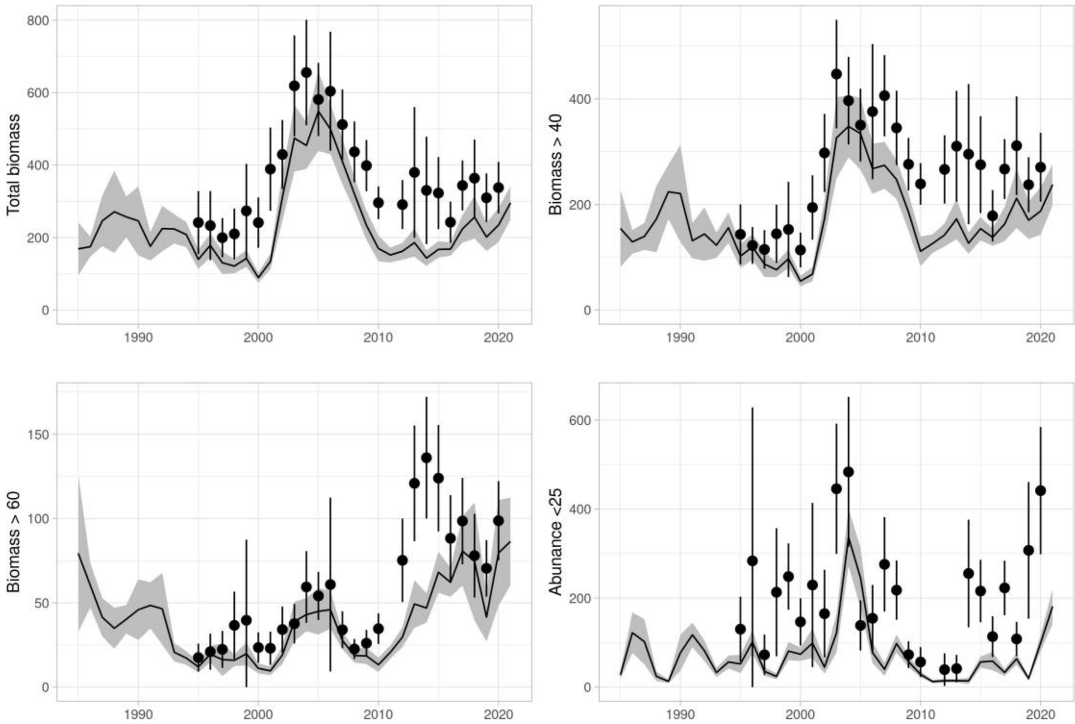

Figure 10.2.12: Haddock in 5.a. Indices in the Spring Survey (March) 1985 and onwards (line shaded area) and the autumn survey (point ranges).

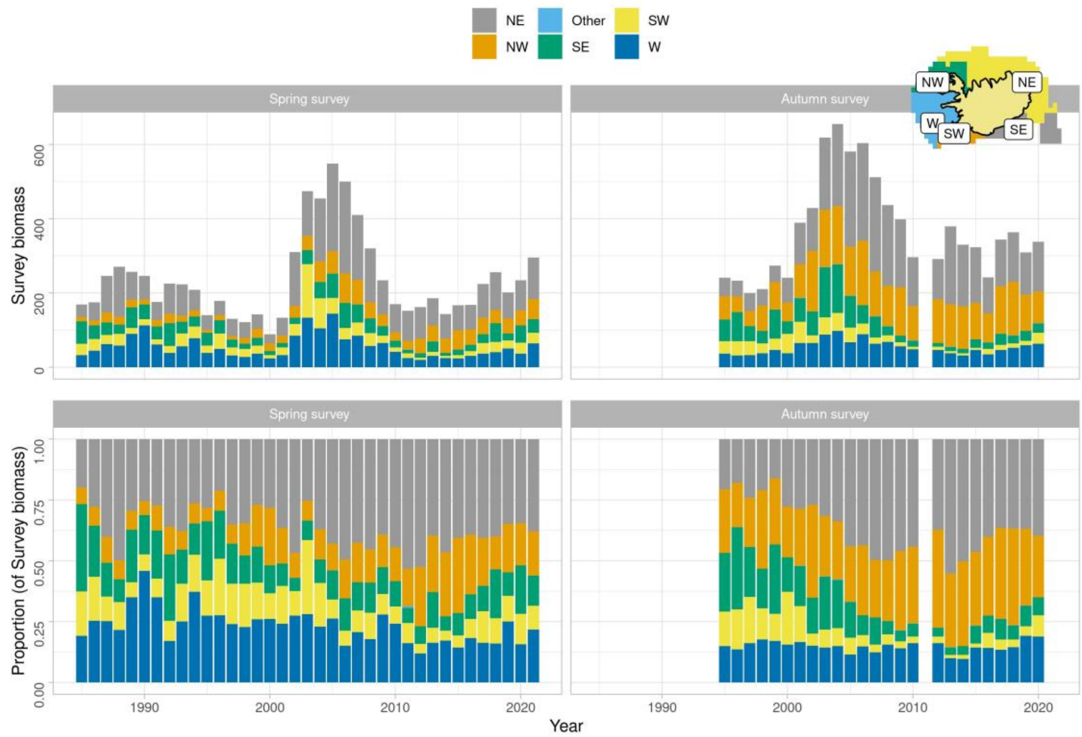

Figure 10.2.13: Haddock in 5.a. Changes in geographical distribution of the survey biomass.

Figure 10.2.17: Haddock in 5.a. Location of haddock in the March (SMB) and the Autumn (SMH) survey, bubble sizes are relative to catch sizes.

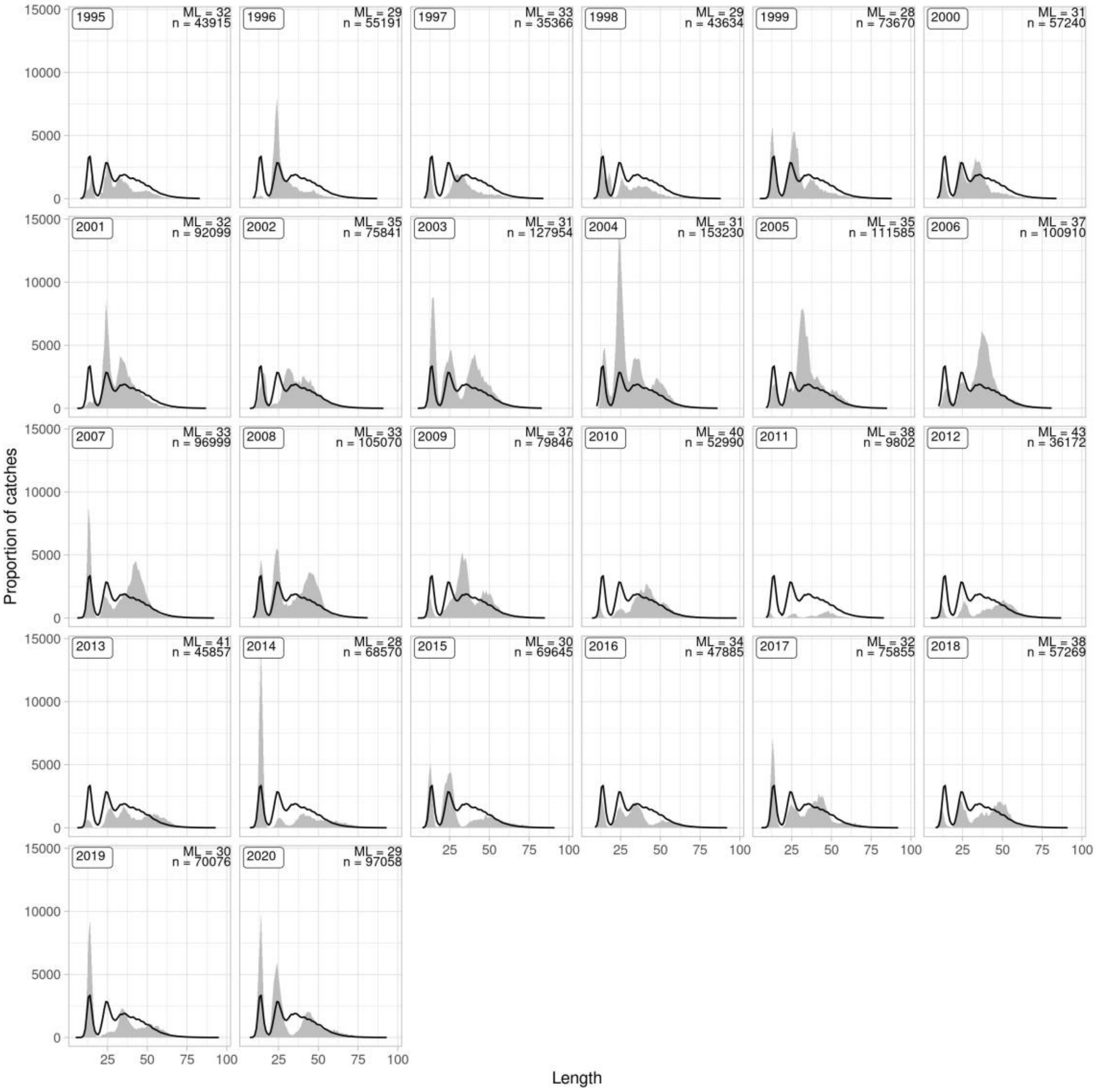

Figure 10.2.15: Haddock in 5.a. Length disaggregated abundance indices from the March survey 1985 and onwards.

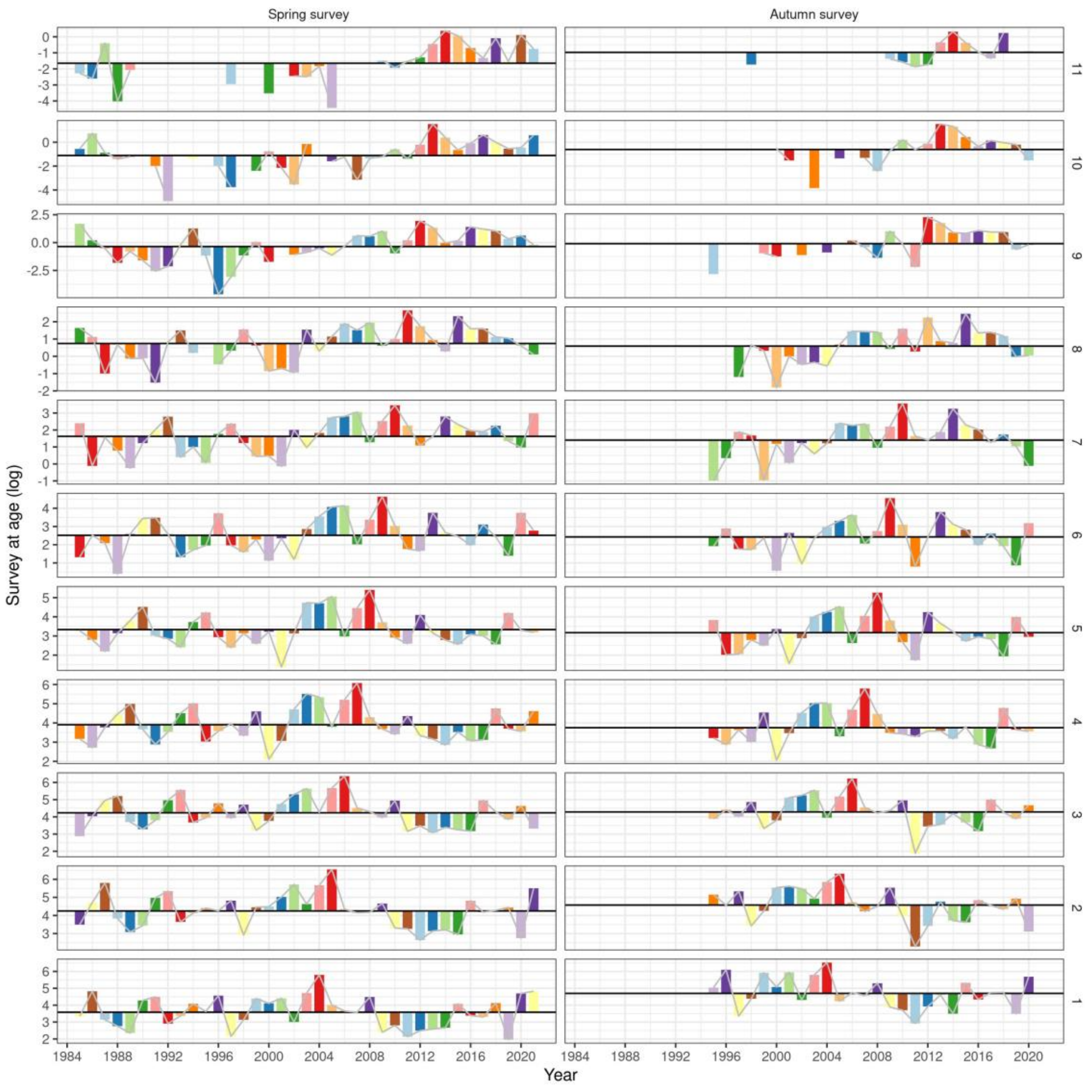

Figure 10.2.18: Haddock in 5.a. Age disaggregated indices in the Spring Survey (left) and the autumn survey (rights). Bars indicated the deviation from the log mean index, fill colours indicate cohorts.

10.3 Data analyses

10.3.1 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 5.a 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 Bjornsson, Hjorleifsson, 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:

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

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 10.1.12. 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 Bjornsson, Hjorleifsson, and Elvarsson 2019), shown in Figure 10.1.23.

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.

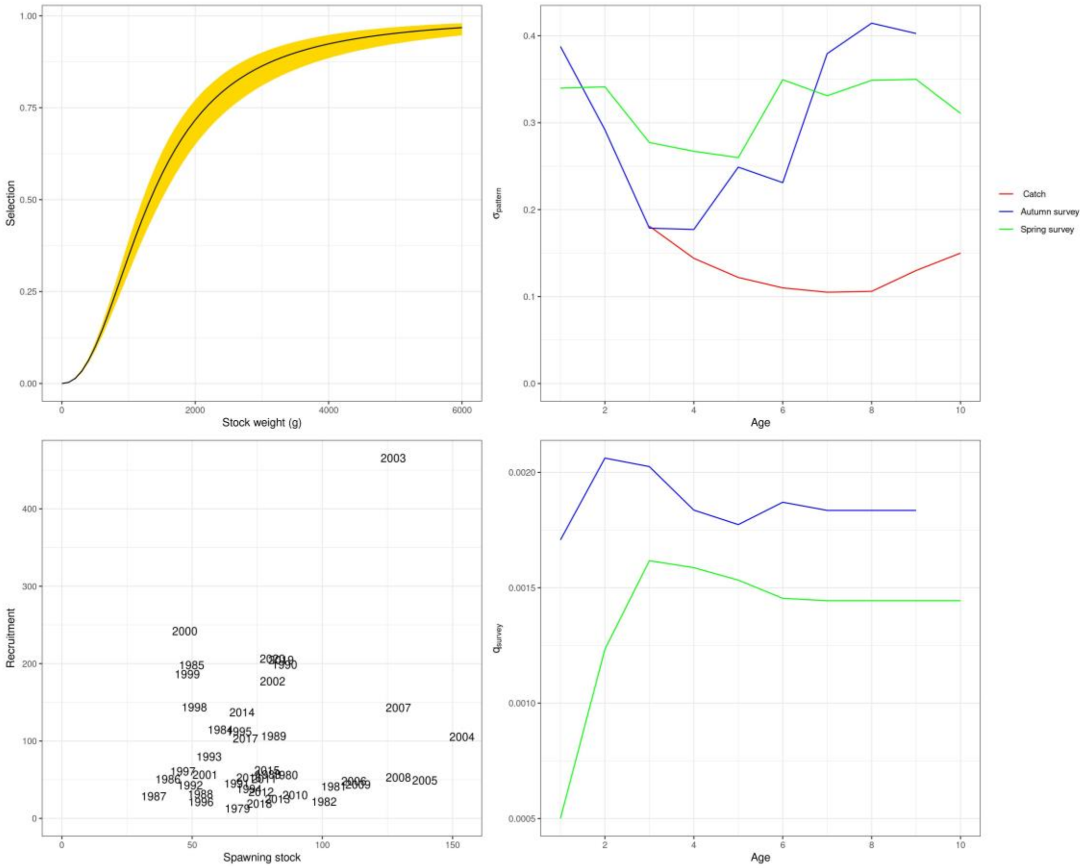

Figure 10.2.19: Haddock in 5.a. Estimated selection by weight, CV pattern, stock recruitment relationship and survey catchability.

10.3.2 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).

10.3.3 Diagnostics

The fit to data is illustrated in Figure 10.1.24 where no concerning residual patterns are observed. When looking at the combined fit (Figure 10.1.25) 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-2000s 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 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 10.1.23 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.

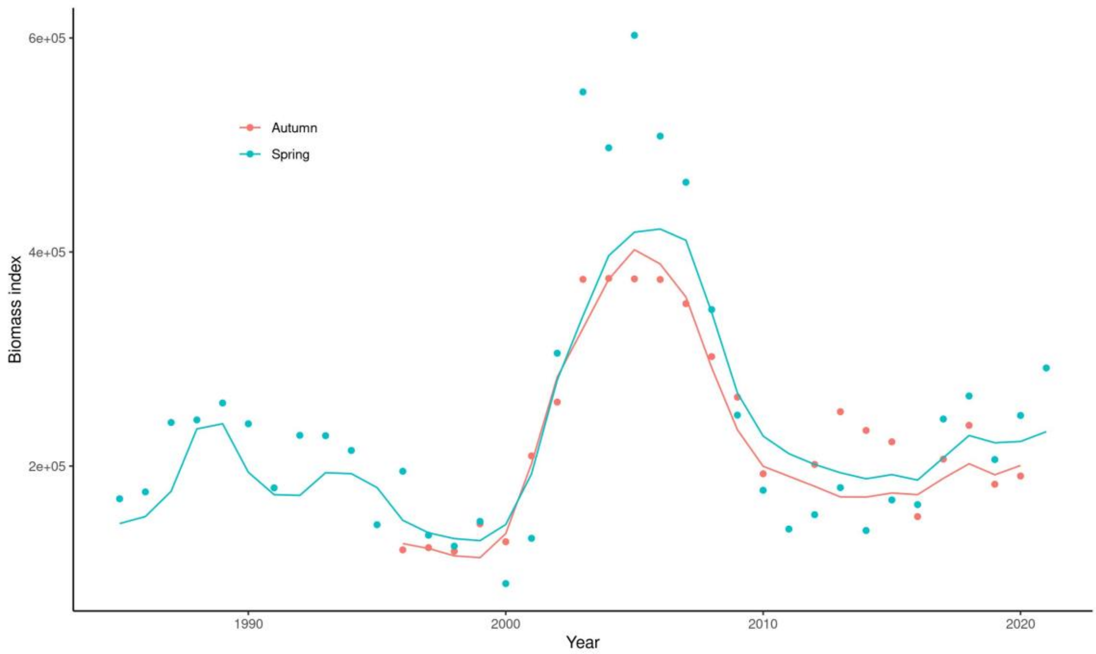

Figure 10.2.21: Haddock in Division 5.a. Aggregated model fit to the total biomass indices.

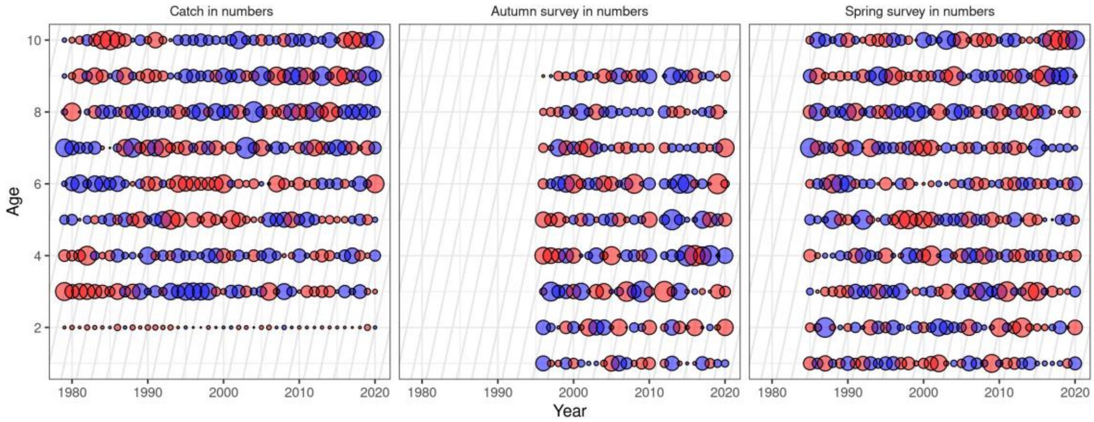

Figure 10.2.22: Haddock in Division 5.a. Residuals from the model fit to survey and catch data based on the both the surveys. Red circles indicate negative residuals (observed < modelled), while blue positive. Residuals are proportional to the area of the circles.

10.3.4 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 10.1.26). 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 10.1.27) indicates a slight upwards revision in the most recent years. The assessment can however be considered fairly stable and the estimated 5-year Mohn's ρ are within acceptable range or 0.035 for estimated recruitment, –0.065 for SSB and 0.064 for harvest rate.

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 10.1.28) but that has not always been the case.

Estimated selection is illustrated in Figure 10.1.29, 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 10.1.30.

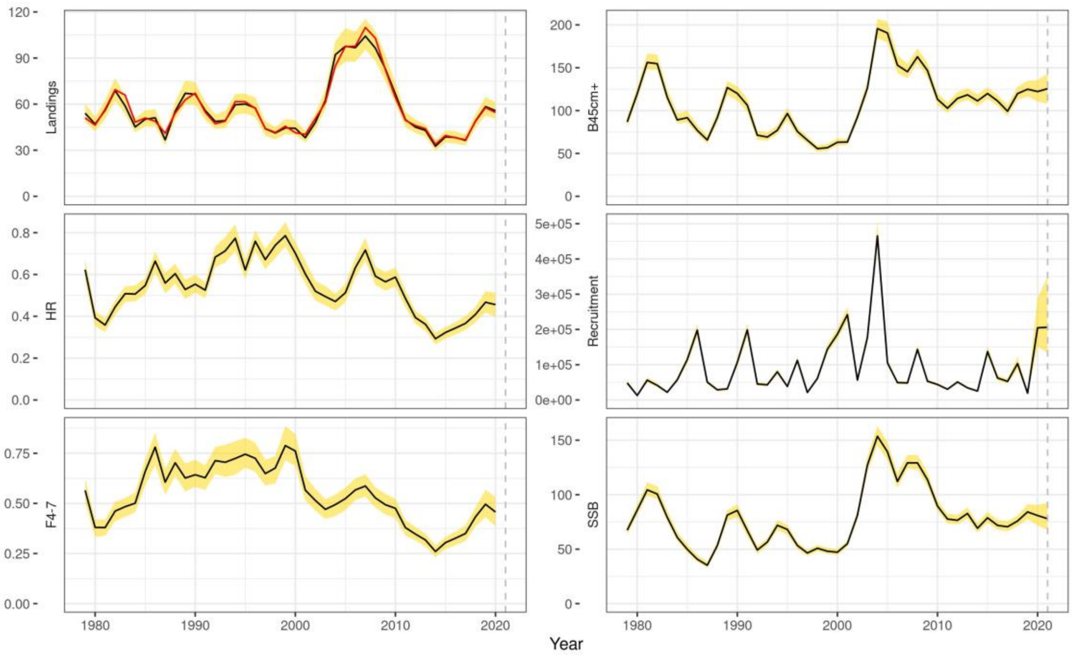

Figure 10.2.23: Haddock in Division 5.a. Summary from assessment. Dashed vertical line indicates the assessment year and yellow shaded region the uncertainty as estimated by the model.

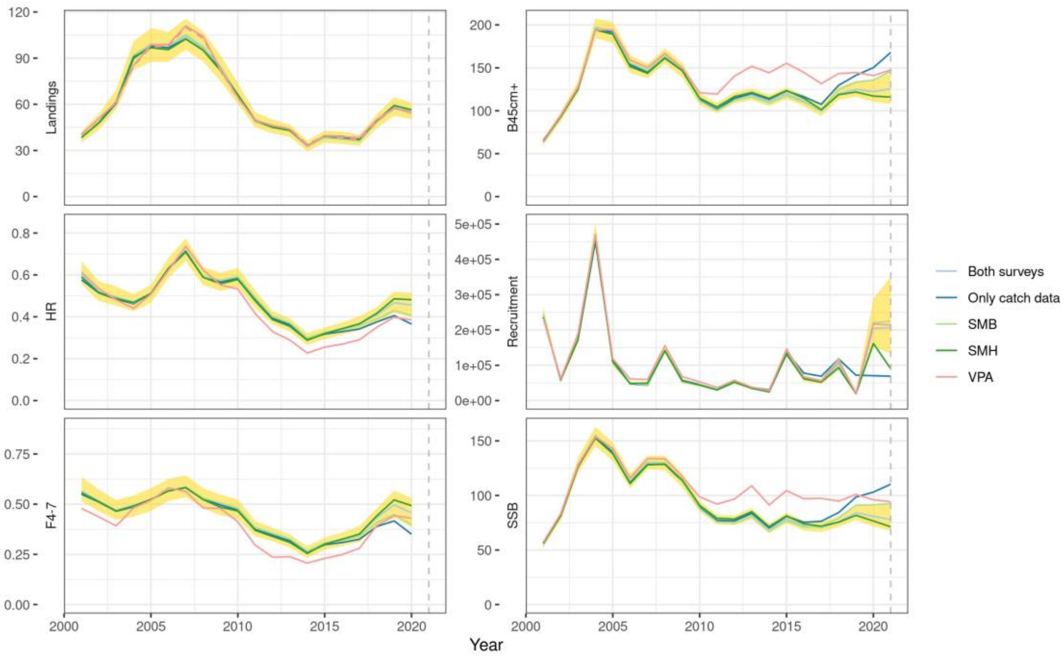

Figure 10.2.28: Haddock in 5.a. Comparison of assessment results where either the spring survey or the autumn survey is omitted from the estimation.

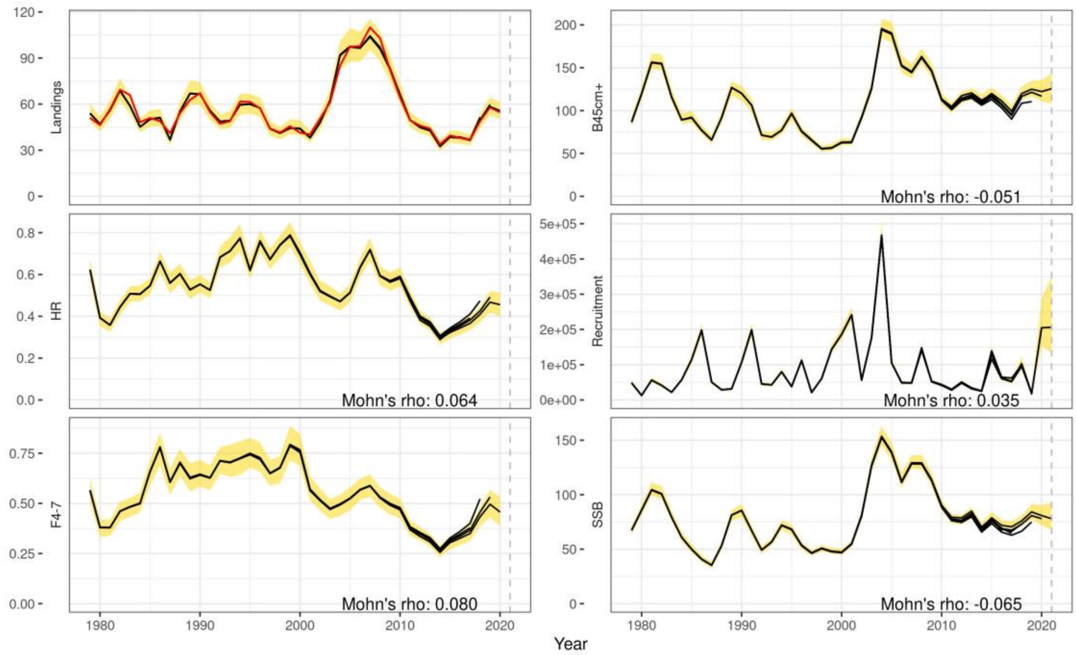

Figure 10.2.29: Haddock in Division 5.a. Analytical retrospective analysis of the assessment of haddock with a 5-year peel.

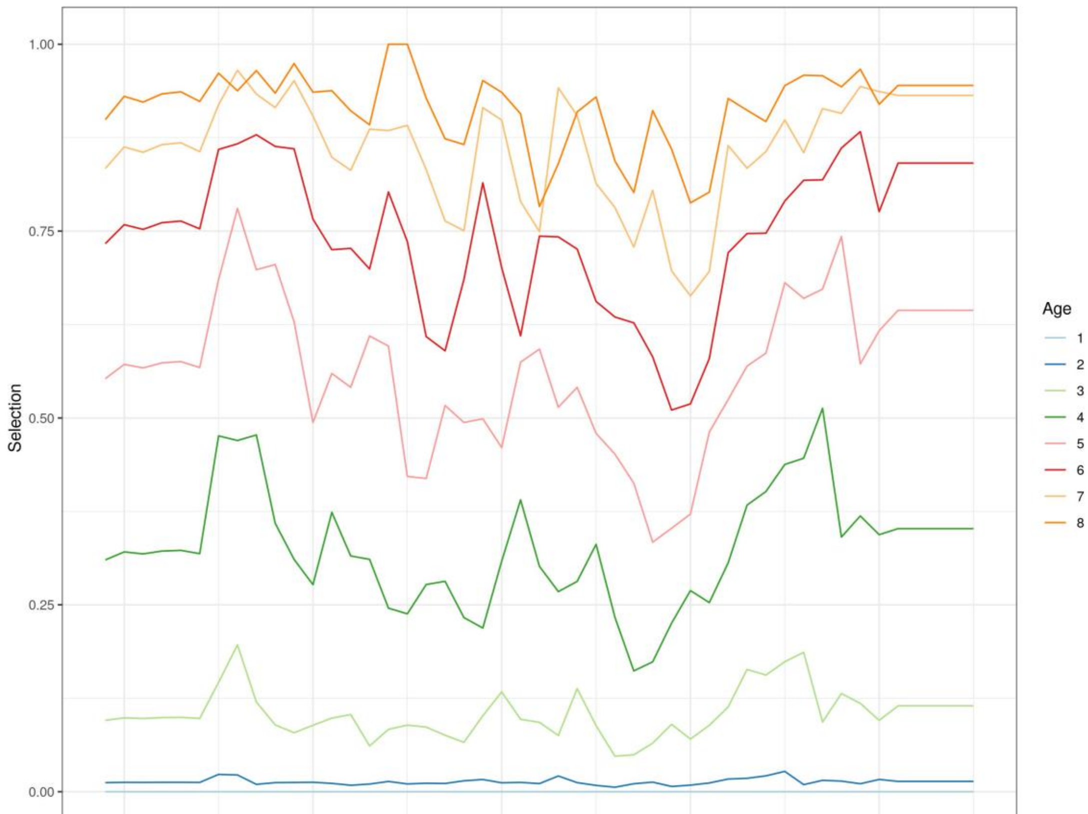

Figure 10.2.30: Haddock in 5.a. Estimated selection at age.

10.3.5 Short term projections

Following the management plan the advice for the coming fishing year (2021/2022) is based in the biomass of 45 cm^{+} at the beginning the next calendar year (2022). 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 2022 is predicted by the equation:

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

where according to the stock annex the factor δ_y for the assessment year (Figure 10.1.30) 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 2021. 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 2021/2022 has some effect of the biomass at the beginning of 2022, which the TAC is based on. This procedure is described in the detail in the stock annex.

10.3.6 Updated management reference points

This year, in line with recent ICES guidelines, the definition of F_{pa} was set to $F_{p.05}$ as estimated by WKICEMSE 2019.

10.4 Management considerations

All the signs from commercial catch data and surveys indicate that haddock in 5.a 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 expected to remain at the current levels next year but it is, however projected to increase in coming years due to strong incoming recruitment from the 2019 and 2020 year classes.

Due to this good state of the stock, and CPUE are at its highest value, the landings are expected to substantially exceed the TAC advice for the 2020/2021. To prevent a possible quota choke, the Government of Iceland increased the TAC by 8000 tonnes while stating that the TAC for 2021/2022 will be reduced by 8000 tonnes. The advice for 2021/2020 is therefore based on catch constraint based on the remainder TAC advice.

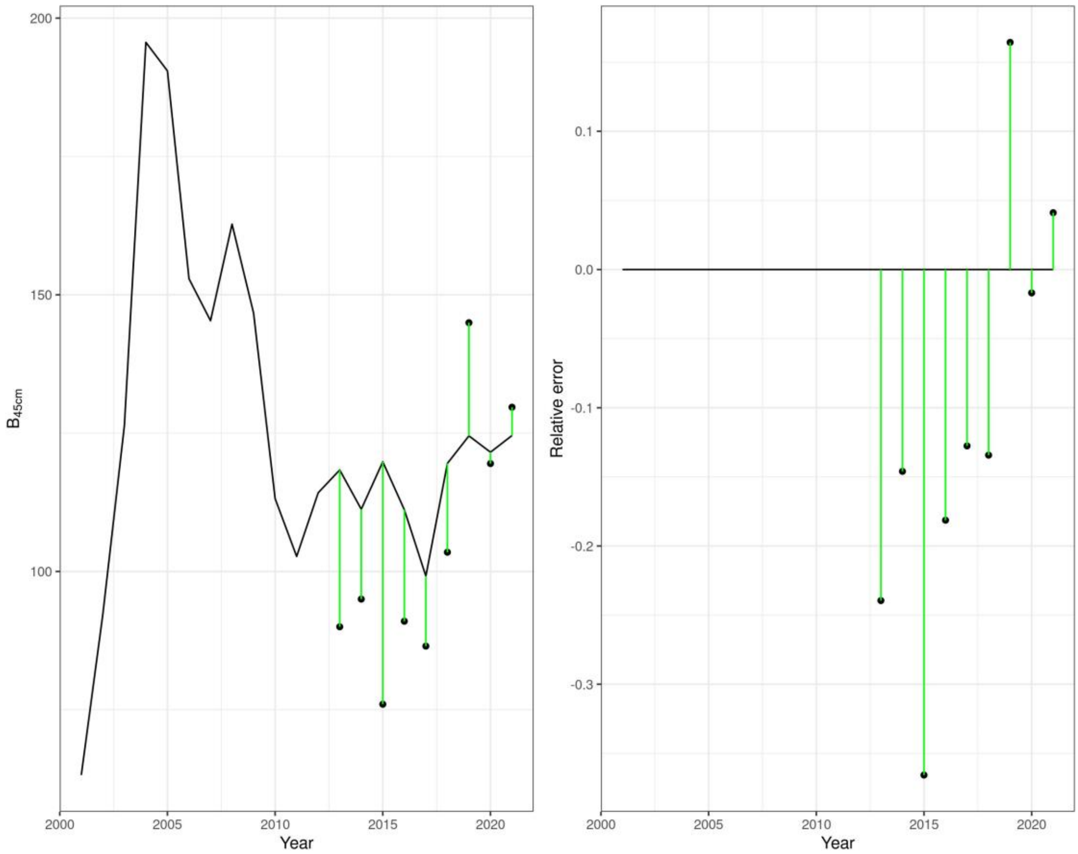

Figure 10.2.31: Haddock in 5.a. Comparison of the short-term prediction of reference biomass to the realised value a year later.

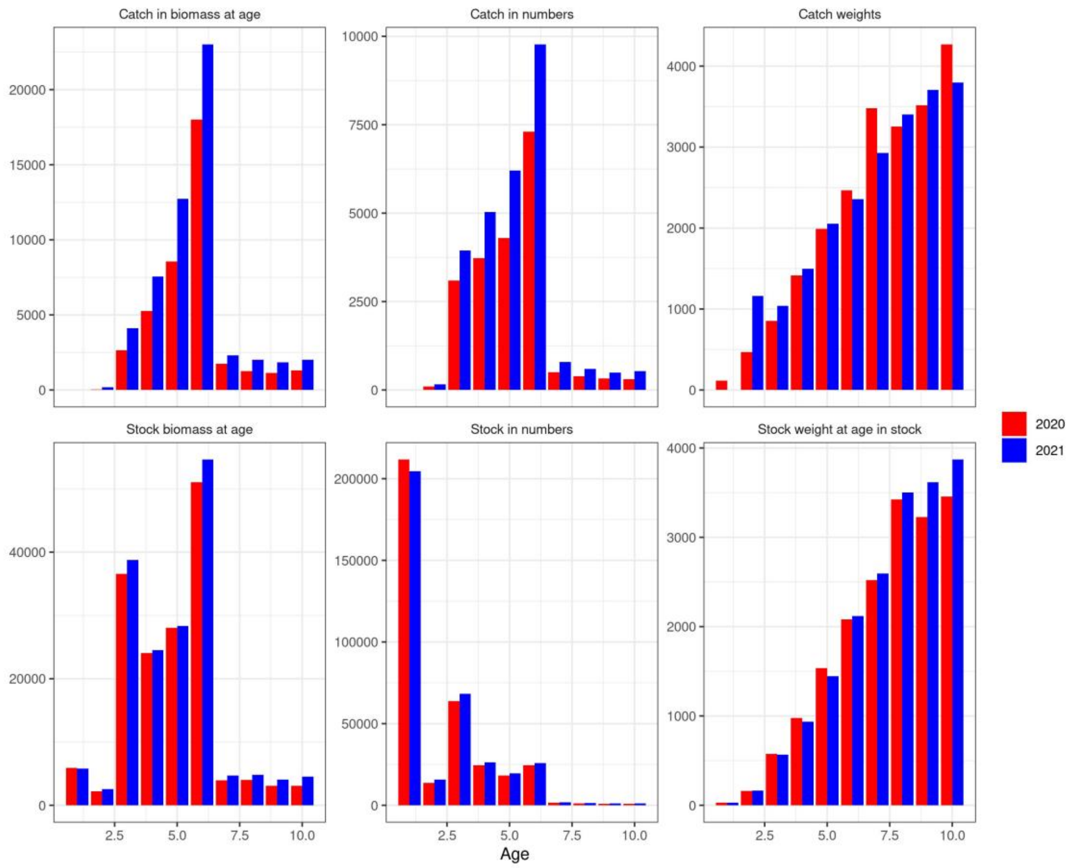

Figure 10.2.32: Haddock in 5.a. Comparison of some of the results of 2019 assessment based on different tuning data and 2017 assessment tuned with both the surveys.

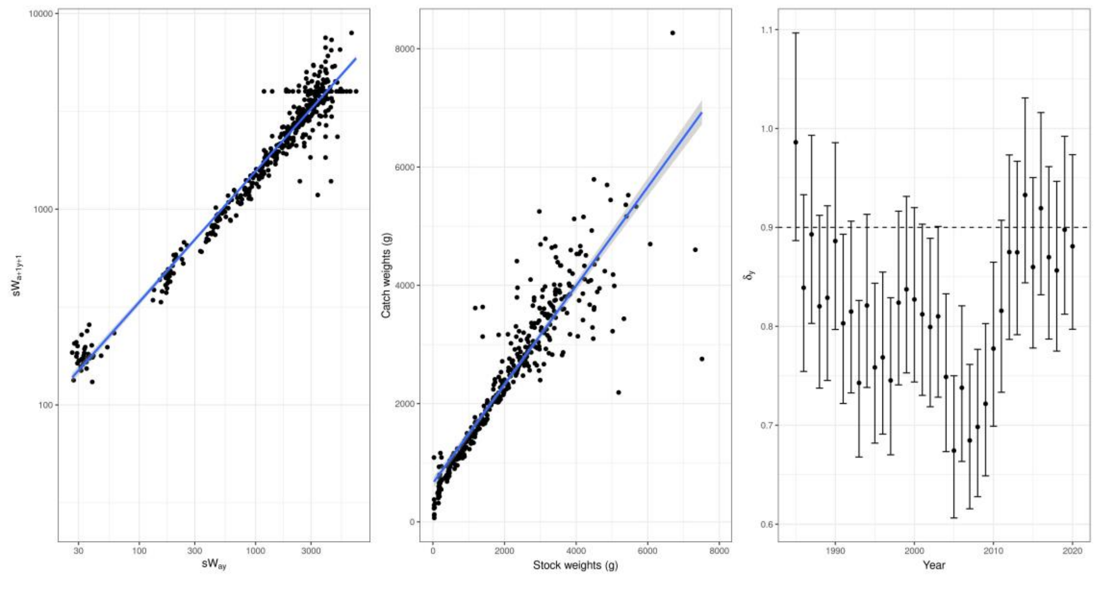

Figure 10.2.27: Haddock in 5.a. Input data to prediction model, where the exponent of the yearfactor (growth multiplier) is estimated to derive the reference biomass in the advisory year, as described in the text.

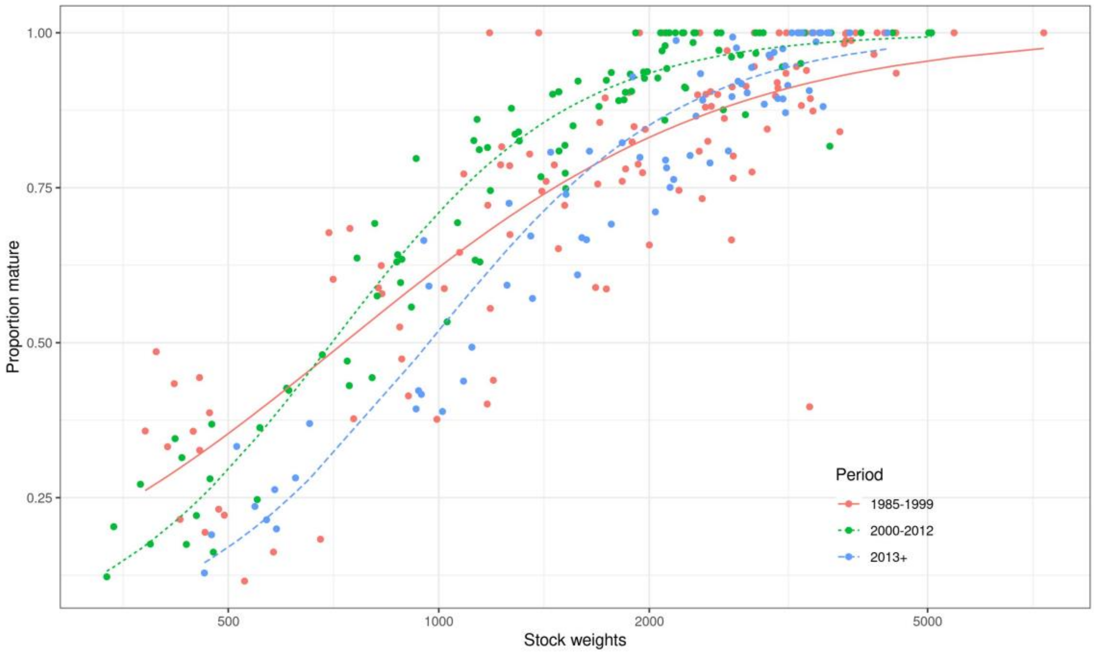

Figure 10.2.33: Haddock in 5.a. Maturity at weight as used in the projections.

10.5 Management

The Icelandic Ministry of Industries and Innovation (MII) 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 5.a has been managed by TAC since the 1987. Landings have roughly followed the advice given by MRI and the set TAC in all fishing years (Table 10.1.1 and Figure 10.1.31). Since the 2001/2002 the catches have exceeded more that 5% the set TAC in five 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 5.a. 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 tonnes of demersal fish species in Icelandic waters which includes maximum 1200 tonnes of cod and 40 tonnes of Atlantic halibut.

The effect of these species transformations and quota transfers is illustrated in Figure 10.1.32. 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 10.1.5, 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.

Figure 10.1.31 illustrates the difference between national TAC and landed catch in 5.a. The difference can be attributed to species transformation (in both directions), while for the 1999/2000 fishing year the government of Iceland increased TAC mid-season.

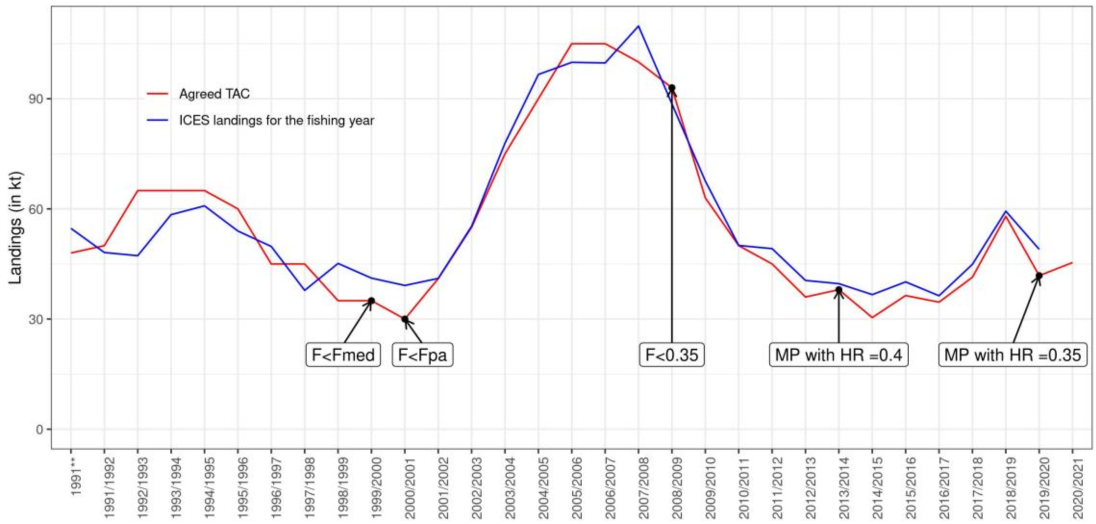

Figure 10.2.34: Haddock in 5.a. Comparison of the realised catches and the set TAC for the fishing operations in Icelandic waters. Note that in the 1999/2000 fishing year the government of Iceland increased TAC mid-season.

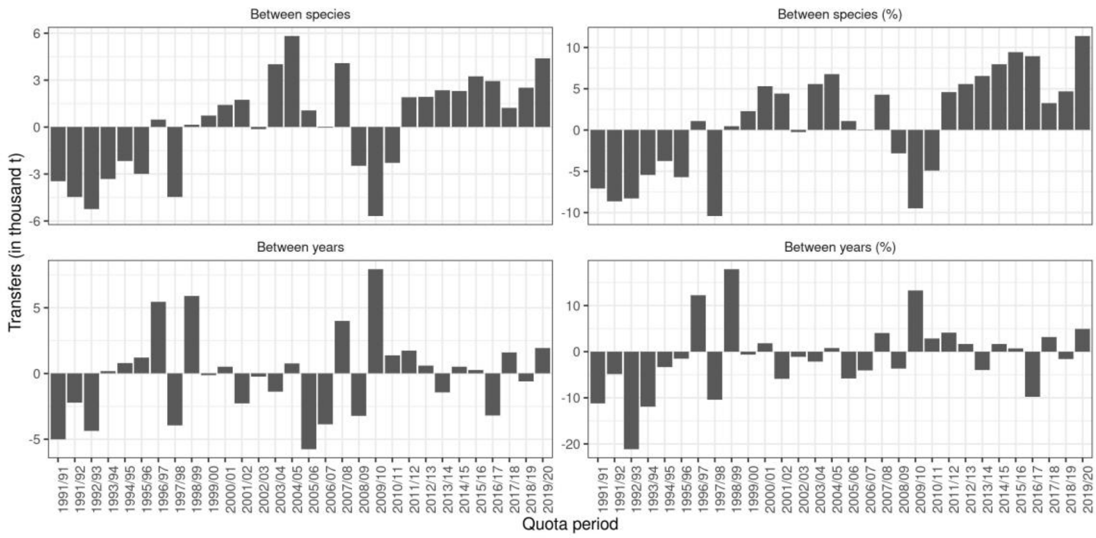

Figure 10.2.35: Haddock in 5.a. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

10.6 References

Bjornsson, Hoskur, Einar Hjorleifsson, and Bjarki or Elvarsson. 2019. "Muppet: Program for Simulating Harvest Control Rules." Reykjavik: Marine; Freshwater Research Institute. http://www.github.com/hoski/Muppet-HCR.

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Table 1.1: Haddock in Division 5.a. Landings by nation.

Year	Belgium	Faroe Islands	Germany	Greenland	Iceland	Norway	Russia	UK
1979	1010	2161			52152	11		
1980	1144	2029			47916	23		
1981	673	1839			61033	15		
1982	377	1982			66998	28		
1983	268	1783			63815	3		
1984	359	707			47167	3		
1985	391	987			49573	0		2
1986	257	1289			47335			
1987	238	1043			39751	1		
1988	352	797			52999	0		
1989	483	606			61715			
1990	595	603			65897			
1991	485	733			53491			
1992	361	757			46067			
1993	458	754			46231			
1994	271	915	1046	2	58677	13	492	173
1995		968	0		60424		2	57
1996		764			56317	4	17	0
1997		340			43717			
1998		513			40882			
1999		885			44523	18		0
2000		5			41229	4		1
2001		690			39101	56		
2002		847			49602	8		
2003		968			59991	1		51
2004		1125			83801	1		
2005		1515			95878	3		44
2006		1588			96130	4		
2007		1686		2	108181	11		
2008		1197			101680	11		
2009		824			81439	5		
2010		360			63869	8		
2011		214			49232	3		
2012		325			45711	13		
2013		654			43370	23		
2014		1626			33048	22		
2015		2337			38393	26		
2016		2858			36648	14		
2017		2515			35695	22		

Year	Belgium	Faroe Islands	Germany	Greenland	Iceland	Norway	Russia	UK
2018		2209			47677	30		
2019		1774			57075	1		

Table 1.2: Haddock in 5.a. Number of Icelandic boats and catches by fleet segment participating in the haddock fishery in 5.a.

Year	Bottom trawl	Danish seine	Longlines	Bottom trawl	Danish seine	Longlines	Other	Total catch
1993	223	79	130	31192	1308	3832	4068	40400
1994	186	90	163	42057	2861	3833	4743	53494
1995	159	97	140	43851	3766	3965	3543	55125
1996	145	107	146	41049	4887	4767	2410	53113
1997	139	93	157	28545	4706	4848	1770	39869
1998	133	77	200	24820	3162	6451	1595	36028
1999	130	68	222	26314	2213	9130	1041	38698
2000	118	63	223	23000	2533	7576	866	33975
2001	109	63	222	21858	2473	7031	921	32283
2002	101	63	238	29820	3026	9157	1295	43298
2003	101	77	259	36005	4002	12421	1142	53570
2004	104	74	290	50940	7167	16880	1274	76261
2005	103	72	307	52927	9821	23567	1561	87876
2006	91	77	308	46716	11904	28512	760	87892
2007	94	66	283	57009	11875	29814	1204	99902
2008	83	65	266	50572	15554	26064	551	92741
2009	79	65	228	38476	14418	20160	300	73354
2010	68	56	206	28551	9582	17528	872	56533
2011	64	52	203	20443	6337	15365	250	42395
2012	68	48	195	19988	5583	13227	459	39257
2013	69	47	198	18454	4440	13501	201	36596
2014	62	44	207	13043	3304	11489	202	28038
2015	62	41	199	16926	3851	12680	243	33700
2016	62	40	182	16735	3961	11754	87	32537
2017	63	41	164	16081	3982	11536	169	31768
2018	64	39	157	26316	4960	12639	175	44090
2019	61	41	142	35583	5829	12337	267	54016

Table 1.3: Haddock in 5.a. Number of available length measurements and samples from Icelandic commercial catches.

Year	Bottom Trawl	Danish Seine	Gillnets	Long Line	Other
2000	62409/326	3114/21	1353/11	12854/77	356/2
2001	69392/346	3900/24	3023/18	26610/151	3864/19
2002	83052/453	7644/47	2063/17	29578/196	1392/12
2003	70828/419	7066/47	2965/26	30259/203	1713/20
2004	82474/503	10201/74	1705/16	35405/252	785/12
2005	94529/514	14880/102	2426/25	53472/375	1778/18
2006	74451/416	29743/172	3395/35	75069/480	685/5
2007	101635/599	34293/196	3721/30	87705/499	1572/11
2008	82671/524	29062/177	3542/30	88912/570	378/4
2009	55862/347	34904/202	831/7	63816/406	658/6
2010	59118/330	19504/116	827/10	56533/343	229/4
2011	53239/278	8304/53	1350/9	43198/237	325/2
2012	41074/223	10084/59	1508/10	60838/302	3/1
2013	34131/198	2498/23	176/1	43132/237	560/4
2014	13529/79	3128/22	289/6	37035/217	
2015	25969/154	2742/18	125/1	41593/221	
2016	21303/129	2425/17	333/3	37490/202	849/6
2017	23123/144	6305/39	375/2	42360/232	1367/7
2018	21780/134	5611/94	414/29	35621/231	558/3
2019	50698/295	3254/30	431/4	25692/187	567/3

Table 1.4: Haddock in 5.a. Number of available age measurements and samples from Icelandic commercial catches.

year	Bottom Trawl	Danish Seine	Gillnets	Long Line	Other
2000	62409/326	3114/21	1353/11	12854/77	356/2
2001	69392/346	3900/24	3023/18	26610/151	3864/19
2002	83052/453	7644/47	2063/17	29578/196	1392/12
2003	70828/419	7066/47	2965/26	30259/203	1713/20
2004	82474/503	10201/74	1705/16	35405/252	785/12
2005	94529/514	14880/102	2426/25	53472/375	1778/18
2006	74451/416	29743/172	3395/35	75069/480	685/5
2007	101635/599	34293/196	3721/30	87705/499	1572/11
2008	82671/524	29062/177	3542/30	88912/570	378/4
2009	55862/347	34904/202	831/7	63816/406	658/6
2010	59118/330	19504/116	827/10	56533/343	229/4
2011	53239/278	8304/53	1350/9	43198/237	325/2
2012	41074/223	10084/59	1508/10	60838/302	3/1
2013	34131/198	2498/23	176/1	43132/237	560/4
2014	13529/79	3128/22	289/6	37035/217	
2015	25969/154	2742/18	125/1	41593/221	
2016	21303/129	2425/17	333/3	37490/202	849/6
2017	23123/144	6305/39	375/2	42360/232	1367/7
2018	21780/134	5611/94	414/29	35621/231	558/3
2019	50698/295	3254/30	431/4	25692/187	567/3

Table 1.5: Haddock in 5.a. Catch at age from the commercial fishery in Icelandic waters

Year	2	3	4	5	6	7	8	9	10
1979	0.149000	1.90800	3.76200	6.0570	9.02200	1.74300	0.43800	0.056000	0.11200
1980	0.595000	1.38500	11.48100	4.2980	3.79800	3.73200	0.54400	0.091000	0.03700
1981	0.010000	0.51400	4.91100	16.9000	5.99900	2.82500	1.80300	0.168000	0.05700
1982	0.107000	0.24500	3.14900	10.8510	14.04900	2.06800	1.00000	0.725000	0.20100
1983	0.034000	1.01000	1.58900	4.5960	9.85000	8.83900	0.76600	0.207000	0.28000
1984	0.241000	1.06900	4.94600	1.3410	4.77200	3.74200	4.07600	0.238000	0.08000
1985	1.320000	1.72800	4.56200	6.7960	0.85500	1.68200	1.91400	1.903000	0.29600
1986	1.012000	4.22300	4.06800	4.6860	5.13900	0.49400	0.79600	0.897000	0.40000
1987	1.939000	8.30800	6.96500	2.7280	2.04200	1.09400	0.13200	0.165000	0.33900
1988	0.237000	9.83100	15.16400	5.8240	1.30400	1.08400	0.60900	0.066000	0.21300
1989	0.188000	2.47400	22.56000	9.5710	3.19600	0.51300	0.55600	0.144000	0.14100
1990	1.857000	2.41500	8.62800	23.6110	6.33100	0.81600	0.15000	0.067000	0.07400
1991	8.617000	2.14500	5.39700	7.3420	14.10300	2.64800	0.33800	0.040000	0.02700
1992	5.405000	10.69300	5.72100	4.6100	3.69100	5.20900	0.99900	0.120000	0.01600
1993	0.769000	12.33300	12.81500	2.9680	1.72200	1.42500	2.23900	0.343000	0.03800
1994	3.198000	3.34300	28.25800	10.6820	1.46900	0.72600	0.35800	0.647000	0.10800
1995	4.015000	7.32300	5.74400	23.9270	5.76900	0.61500	0.29000	0.187000	0.33100
1996	3.090000	10.55200	7.63900	4.4680	12.89600	2.34600	0.20800	0.079000	0.12500
1997	1.364000	3.93900	10.91500	4.8950	2.61000	5.03500	0.71900	0.064000	0.06900
1998	0.279000	8.25700	5.66700	7.8560	2.41800	1.42200	1.89700	0.261000	0.04500
1999	1.434000	1.55000	17.24300	4.5160	4.83700	0.91500	0.62000	0.481000	0.06400
2000	2.659000	6.31700	2.35200	13.6150	1.94500	1.70600	0.32400	0.222000	0.19200
2001	2.515000	11.09800	6.95400	1.4460	6.26200	0.67500	0.47800	0.105000	0.09400
2002	1.082000	10.43400	15.99800	5.0990	1.13100	3.14900	0.26200	0.169000	0.10000
2003	0.401000	6.35200	16.26500	12.5480	2.96800	0.74800	1.23600	0.091000	0.07000
2004	1.597000	4.06300	17.65200	19.3580	8.87100	1.94000	0.47100	0.489000	0.15500
2005	2.405000	9.45000	6.92900	25.4210	13.77800	4.58400	0.80900	0.251000	0.23700
2006	0.241000	10.03800	21.24600	6.6460	18.84000	7.60000	2.18000	0.323000	0.20200
2007	0.782000	3.88400	42.22400	22.2390	3.35400	9.95200	2.74000	0.519000	0.18100
2008	2.316000	4.50800	9.70600	53.0220	11.01400	1.71700	3.03300	0.815000	0.19200
2009	1.066000	3.18500	4.88600	8.8920	35.01100	5.73300	0.72600	1.381000	0.50900
2010	0.121000	6.03200	7.06100	4.8060	6.76600	17.50300	1.87400	0.354000	0.52800
2011	0.253000	1.58400	11.79700	5.0800	2.85300	3.98300	6.22000	0.494000	0.18300
2012	0.196000	1.32200	3.42100	13.1070	2.22300	1.23100	2.48000	2.662000	0.37000
2013	0.250000	1.04200	2.86500	4.0080	9.22200	1.20600	0.66800	1.248000	1.59900
2014	0.238000	1.47800	1.75100	2.7250	2.73700	4.74200	0.44700	0.387000	1.40300
2015	0.232000	1.53200	4.15500	2.3170	2.91600	2.62300	2.71500	0.226000	0.82300
2016	0.481000	1.77300	3.43700	4.1300	1.72700	1.95300	1.42000	1.293000	0.45500
2017	0.573000	3.68000	3.07900	3.0130	3.13500	1.09700	1.18200	0.751000	0.94000

Year	2	3	4	5	6	7	8	9	10
2018	0.353000	3.57000	10.35600	2.9080	3.06300	2.41900	0.96400	0.622000	1.06600
2019	0.386757	2.42112	6.43663	13.9091	1.87026	1.36609	1.46909	0.552468	1.10759

Table 1.6: Haddock in 5.a. Catch weights from the commercial fishery in Icelandic waters.

Year	2	3	4	5	6	7	8	9	10
1979	620.000	960.00	1410.00	2030.00	2910.00	3800.00	4560.00	4720.00	5956.00
1980	837.000	831.00	1306.00	2207.00	2738.00	3188.00	3843.00	4506.00	4982.84
1981	584.000	693.00	1081.00	1656.00	2283.00	3214.00	3409.00	4046.00	5261.02
1982	289.000	959.00	1455.00	1674.00	2351.00	3031.00	3481.00	3874.00	4122.51
1983	320.000	1006.00	1496.00	1921.00	2371.00	2873.00	3678.00	4265.00	4501.74
1984	691.000	1007.00	1544.00	2120.00	2514.00	3027.00	2940.00	3906.00	4033.31
1985	652.000	1125.00	1811.00	2260.00	2924.00	3547.00	3733.00	4039.00	4658.72
1986	336.000	1227.00	1780.00	2431.00	2771.00	3689.00	3820.00	4258.00	4455.68
1987	452.000	1064.00	1692.00	2408.00	3000.00	3565.00	4215.00	4502.00	4024.82
1988	362.000	780.00	1474.00	2217.00	2931.00	3529.00	3781.00	4467.00	4418.39
1989	323.000	857.00	1185.00	1996.00	2893.00	4066.00	3866.00	4734.00	4989.60
1990	269.000	700.00	1054.00	1562.00	2364.00	3414.00	4134.00	4946.00	4451.01
1991	288.000	699.00	979.00	1412.00	1887.00	2674.00	3135.00	4341.00	4956.93
1992	313.000	806.00	1167.00	1524.00	1950.00	2357.00	3075.00	4053.00	4703.25
1993	303.000	705.00	1333.00	1875.00	2386.00	2996.00	3059.00	3363.00	4408.79
1994	337.000	668.00	1019.00	1717.00	2391.00	2717.00	3280.00	3156.00	3277.94
1995	351.000	746.00	1096.00	1318.00	2044.00	2893.00	3049.00	3675.00	3136.79
1996	311.000	787.00	1187.00	1560.00	1849.00	2670.00	3510.00	3567.00	3731.34
1997	379.000	764.00	1163.00	1649.00	1943.00	2342.00	3020.00	3337.00	3235.90
1998	445.000	724.00	1147.00	1683.00	2250.00	2475.00	2834.00	3333.00	3596.42
1999	555.000	908.00	1101.00	1658.00	2216.00	2659.00	2928.00	3209.00	3512.52
2000	495.000	978.00	1333.00	1481.00	2119.00	2696.00	3307.00	3597.00	3756.94
2001	541.000	945.00	1456.00	1731.00	1832.00	2243.00	3020.00	3328.00	4235.94
2002	564.000	928.00	1253.00	1737.00	2219.00	2230.00	2911.00	3365.00	4387.08
2003	498.000	922.00	1283.00	1704.00	2274.00	2744.00	2635.00	2819.00	3741.91
2004	559.000	1006.00	1258.00	1579.00	2044.00	2809.00	3123.00	2945.00	3759.31
2005	339.000	886.00	1265.00	1506.00	1916.00	2323.00	3028.00	3211.00	2890.52
2006	402.000	749.00	1093.00	1495.00	1758.00	2163.00	2555.00	3054.00	3589.48
2007	510.000	748.00	988.00	1346.00	1840.00	2062.00	2350.00	2525.00	3142.71
2008	383.000	636.00	857.00	1125.00	1575.00	2149.00	2417.00	2802.00	2600.47
2009	452.000	841.00	960.00	1131.00	1352.00	1757.00	2364.00	2497.00	3073.67
2010	447.000	756.00	1092.00	1294.00	1448.00	1685.00	2188.00	2366.00	2645.85
2011	588.000	905.00	1122.00	1455.00	1688.00	1914.00	2094.00	2455.00	2985.68
2012	668.000	978.00	1222.00	1492.00	1903.00	2164.00	2366.00	2704.00	2939.96
2013	678.000	1084.00	1358.00	1675.00	2036.00	2400.00	2554.00	3097.00	3097.31

Year	2	3	4	5	6	7	8	9	10
2014	536.000	1080.00	1433.00	1793.00	2121.00	2504.00	2624.00	3178.00	3349.39
2015	573.000	1084.00	1486.00	2011.00	2332.00	2823.00	3306.00	3258.00	3768.15
2016	513.000	1071.00	1590.00	2035.00	2607.00	2952.00	3616.00	3734.00	4096.66
2017	643.000	997.00	1587.00	2032.00	2546.00	3016.00	3518.00	3839.00	3915.67
2018	627.000	1070.00	1383.00	2007.00	2536.00	2919.00	3377.00	3671.00	4026.36
2019	541.285	1005.15	1457.86	1820.85	2702.88	3091.86	3352.01	3694.17	4015.07

Table 1.7: Haddock in 5.a. Stock weights from the March survey in Icelandic waters.

Year	1	2	3	4	5	6	7	8	9	10
1979	37	185	481	910	1409	1968	2496	3077	3300	5956.00
1980	37	185	481	910	1409	1968	2496	3077	3300	4982.84
1981	37	185	481	910	1409	1968	2496	3077	3300	5261.02
1982	37	185	481	910	1409	1968	2496	3077	3300	4122.51
1983	37	185	481	910	1409	1968	2496	3077	3300	4501.74
1984	37	185	481	910	1409	1968	2496	3077	3300	4033.31
1985	35	241	562	1195	1690	2418	2814	3245	3369	3901.80
1986	34	240	671	1134	1963	2425	3236	2964	3767	3824.29
1987	31	163	514	1219	1758	2605	3024	3524	3896	3773.70
1988	37	176	456	973	1851	2711	3118	3485	3277	4986.42
1989	27	181	438	888	1514	2372	2905	3509	3255	3748.60
1990	29	183	454	842	1232	1985	2714	3067	3337	4042.05
1991	31	176	496	1004	1417	1890	2510	3833	3719	4545.56
1992	29	157	497	893	1381	1866	2325	3009	3732	4753.75
1993	40	167	381	878	1488	1786	2581	2576	3277	4000.00
1994	33	179	402	704	1267	1721	1866	2628	2050	1844.64
1995	37	163	444	759	1062	1855	2664	5319	1313	4000.00
1996	40	174	447	816	1053	1452	2149	2365	4830	3133.12
1997	51	173	422	815	1223	1422	1883	2373	3771	2877.68
1998	41	201	400	737	1221	1677	1991	2338	3091	4000.00
1999	34	205	481	715	1191	1932	2387	2724	2933	2581.52
2000	29	179	553	897	1152	1694	2601	2910	3162	3370.46
2001	36	188	484	1048	1425	1501	2179	2803	4000	3958.89
2002	63	172	473	892	1467	1957	2017	1962	3756	4357.30
2003	40	231	412	800	1259	1869	3153	2314	3303	3945.97
2004	34	177	557	807	1280	1685	2444	2920	2927	3333.11
2005	41	153	448	921	1188	1564	2103	2792	2548	3633.75
2006	33	135	333	736	1134	1510	1927	2227	3270	3528.55
2007	48	170	350	615	1053	1493	1781	2067	2157	3801.33
2008	27	178	383	593	868	1295	1831	2204	2286	2924.73
2009	29	139	442	687	883	1137	1491	1905	2548	2937.31

Year	1	2	3	4	5	6	7	8	9	10
2010	32	150	392	777	936	1181	1462	1784	2037	2719.15
2011	35	175	443	759	1131	1307	1585	1867	2044	2956.30
2012	28	202	482	801	1145	1480	1908	2072	2352	2520.06
2013	33	202	589	967	1313	1709	2001	2264	2746	2658.79
2014	36	223	573	1005	1373	1751	2141	2299	2653	3134.85
2015	32	254	614	1073	1638	1924	2451	2772	3186	3388.15
2016	29	162	642	1101	1565	2094	2296	3067	3441	3486.42
2017	34	197	459	1258	1657	2162	2768	3200	3558	3675.10
2018	30	195	544	924	1836	2342	2660	2968	3204	3585.57
2019	29	166	505	962	1341	2472	2814	3035	3477	3532.69

Table 1.8: Haddock in 5.a. Sexual maturity-at-age in the stock (from the March survey). The numbers for age 10 only apply to the spawning stock.

Year	1	2	3	4	5	6	7	8	9	10
1979	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1980	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1981	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1982	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1983	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1984	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000000
1985	0.000	0.016	0.149	0.541	0.577	0.767	0.764	0.962	0.933	0.983527
1986	0.000	0.022	0.203	0.410	0.672	0.842	0.884	0.956	0.986	0.991175
1987	0.000	0.020	0.146	0.487	0.597	0.879	0.900	1.000	0.988	0.967909
1988	0.000	0.013	0.215	0.392	0.767	0.791	0.927	0.913	1.000	0.970986
1989	0.000	0.040	0.199	0.530	0.723	0.802	1.000	1.000	1.000	1.000000
1990	0.000	0.115	0.327	0.632	0.816	0.843	0.918	0.897	1.000	1.000000
1991	0.000	0.066	0.219	0.587	0.738	0.818	0.893	0.505	1.000	1.000000
1992	0.000	0.050	0.223	0.416	0.801	0.905	0.902	0.859	1.000	1.000000
1993	0.005	0.123	0.362	0.484	0.667	0.905	0.977	0.910	0.868	1.000000
1994	0.035	0.238	0.325	0.611	0.791	0.865	1.000	0.908	1.000	1.000000
1995	0.000	0.130	0.481	0.389	0.757	0.754	0.619	0.986	1.000	1.000000
1996	0.000	0.197	0.379	0.606	0.643	0.790	0.745	0.946	0.897	1.000000
1997	0.016	0.092	0.432	0.585	0.682	0.751	0.787	0.874	1.000	1.000000
1998	0.000	0.030	0.494	0.686	0.778	0.754	0.855	0.901	1.000	1.000000
1999	0.000	0.048	0.384	0.679	0.725	0.756	0.896	0.773	0.920	1.000000
2000	0.000	0.103	0.247	0.619	0.808	0.875	0.875	1.000	0.781	0.959667
2001	0.002	0.097	0.372	0.515	0.752	0.897	0.918	0.915	1.000	1.000000
2002	0.000	0.045	0.278	0.629	0.800	0.935	0.933	1.000	1.000	1.000000
2003	0.005	0.062	0.347	0.688	0.869	0.923	0.948	0.984	1.000	1.000000
2004	0.000	0.038	0.363	0.571	0.831	0.913	1.000	1.000	1.000	1.000000

Year	1	2	3	4	5	6	7	8	9	10
2005	0.000	0.024	0.231	0.564	0.751	0.923	0.937	0.968	1.000	1.000000
2006	0.000	0.028	0.118	0.467	0.618	0.741	0.920	1.000	1.000	1.000000
2007	0.000	0.078	0.207	0.417	0.681	0.760	0.876	0.960	1.000	1.000000
2008	0.000	0.027	0.262	0.415	0.621	0.829	0.870	0.904	0.974	1.000000
2009	0.000	0.017	0.299	0.469	0.581	0.848	0.890	1.000	0.967	1.000000
2010	0.010	0.030	0.183	0.615	0.780	0.789	0.887	0.935	1.000	0.966447
2011	0.000	0.046	0.176	0.425	0.822	0.816	0.838	0.898	0.976	1.000000
2012	0.000	0.107	0.168	0.446	0.627	0.820	0.903	0.853	0.911	0.973381
2013	0.000	0.047	0.225	0.382	0.716	0.795	0.921	0.986	0.974	0.988984
2014	0.000	0.108	0.192	0.390	0.567	0.676	0.736	0.925	0.906	0.951132
2015	0.000	0.138	0.283	0.444	0.670	0.795	0.773	0.892	1.000	0.961426
2016	0.000	0.008	0.360	0.485	0.594	0.779	0.787	0.882	0.902	0.971048
2017	0.000	0.073	0.131	0.591	0.664	0.741	0.911	0.939	1.000	0.970437
2018	0.000	0.035	0.235	0.395	0.824	0.856	0.892	0.881	0.974	1.000000
2019	0.009	0.036	0.335	0.591	0.669	0.890	0.938	0.960	1.000	0.964376

Table 1.9: Haddock in Division 5.a. Age disaggregated survey indices from the groundfish survey in March

Year	1	2	3	4	5	6	7	8	9	10
1985	29.91	32.25	17.67	23.26	26.30	3.73	11.01	4.87	5.68	0.63
1986	122.05	109.77	61.10	13.39	16.84	13.57	1.00	3.17	1.27	2.43
1987	21.50	324.64	148.07	44.69	7.77	7.53	4.77	0.40	0.62	1.28
1988	15.71	39.99	184.56	90.07	23.12	1.37	2.23	1.81	0.17	0.26
1989	10.45	23.09	40.59	145.63	45.09	12.92	0.79	0.81	0.42	0.41
1990	72.10	31.55	26.67	38.57	92.00	30.73	3.43	0.88	0.23	0.00
1991	88.43	147.01	42.92	17.86	20.17	32.71	7.64	0.31	0.10	0.09
1992	17.21	211.29	139.98	35.42	16.63	13.63	16.15	2.25	0.18	0.05
1993	30.58	38.93	252.31	88.40	11.35	3.89	1.68	4.51	0.89	0.00
1994	58.68	61.57	40.90	147.33	40.55	5.47	2.82	1.37	3.67	0.22
1995	37.07	84.74	47.12	19.82	69.91	7.71	1.31	0.12	0.34	0.00
1996	96.53	67.19	121.31	36.89	19.78	41.00	5.84	0.60	0.13	0.13
1997	8.41	122.61	51.08	53.11	10.80	7.28	10.85	1.34	0.07	0.09
1998	23.17	18.73	110.23	28.45	23.27	4.89	3.48	4.52	0.34	0.00
1999	80.92	86.14	25.79	98.86	12.99	9.88	1.43	1.78	1.04	0.09
2000	60.41	88.73	43.92	8.33	24.82	3.12	1.58	0.40	0.15	0.56
2001	81.03	153.29	116.21	21.70	4.03	10.45	0.89	0.55	0.00	0.10
2002	20.68	304.47	198.83	110.43	22.88	3.45	7.39	0.30	0.34	0.21
2003	112.29	97.95	283.72	247.05	115.11	18.26	2.60	4.57	0.49	0.91
2004	325.12	291.10	70.86	208.82	110.08	34.24	6.82	1.26	0.83	0.16
2005	57.55	693.57	288.64	44.58	157.39	57.69	15.78	3.36	0.32	0.28
2006	39.87	78.50	575.82	181.71	19.34	63.24	16.54	6.80	0.70	0.29

Year	1	2	3	4	5	6	7	8	9	10
2007	34.23	65.13	89.00	437.40	85.58	7.84	21.32	4.67	2.13	0.07
2008	88.07	67.69	71.12	75.02	220.74	29.75	3.51	7.42	1.63	0.27
2009	10.87	112.24	53.00	40.53	41.31	104.80	12.76	2.19	3.04	0.65
2010	15.25	27.69	137.03	29.60	18.10	20.48	31.38	2.90	0.46	0.80
2011	8.76	27.46	24.33	76.71	13.95	5.88	9.40	14.89	1.28	0.54
2012	12.33	14.76	31.18	27.15	58.16	5.22	2.92	5.28	6.85	1.05
2013	13.93	23.05	19.56	22.61	22.25	41.48	4.76	2.49	3.82	5.16
2014	14.15	24.53	30.15	17.69	16.40	14.76	16.39	1.33	1.04	3.14
2015	62.08	19.53	26.50	34.10	12.62	11.11	9.57	9.85	1.16	1.70
2016	29.85	162.26	23.51	22.09	22.24	7.17	7.27	5.05	4.25	1.39
2017	26.66	66.57	140.89	23.02	20.29	22.05	6.47	5.05	3.53	2.21
2018	64.07	70.39	73.53	118.35	13.70	11.54	10.06	3.41	3.29	2.11
2019	7.14	85.21	47.89	40.85	67.31	4.13	3.80	3.08	1.61	0.86
2020	111.97	13.95	97.24	35.18	27.72	42.48	2.86	1.87	2.17	1.79

Table 1.10: Haddock in 5.a. Age disaggregated survey indices from the groundfish survey in October.

Year	1	2	3	4	5	6	7	8	9	10
1985	29.91	32.25	17.67	23.26	26.30	3.73	11.01	4.87	5.68	0.63
1986	122.05	109.77	61.10	13.39	16.84	13.57	1.00	3.17	1.27	2.43
1987	21.50	324.64	148.07	44.69	7.77	7.53	4.77	0.40	0.62	1.28
1988	15.71	39.99	184.56	90.07	23.12	1.37	2.23	1.81	0.17	0.26
1989	10.45	23.09	40.59	145.63	45.09	12.92	0.79	0.81	0.42	0.41
1990	72.10	31.55	26.67	38.57	92.00	30.73	3.43	0.88	0.23	0.00
1991	88.43	147.01	42.92	17.86	20.17	32.71	7.64	0.31	0.10	0.09
1992	17.21	211.29	139.98	35.42	16.63	13.63	16.15	2.25	0.18	0.05
1993	30.58	38.93	252.31	88.40	11.35	3.89	1.68	4.51	0.89	0.00
1994	58.68	61.57	40.90	147.33	40.55	5.47	2.82	1.37	3.67	0.22
1995	37.07	84.74	47.12	19.82	69.91	7.71	1.31	0.12	0.34	0.00
1996	96.53	67.19	121.31	36.89	19.78	41.00	5.84	0.60	0.13	0.13
1997	8.41	122.61	51.08	53.11	10.80	7.28	10.85	1.34	0.07	0.09
1998	23.17	18.73	110.23	28.45	23.27	4.89	3.48	4.52	0.34	0.00
1999	80.92	86.14	25.79	98.86	12.99	9.88	1.43	1.78	1.04	0.09
2000	60.41	88.73	43.92	8.33	24.82	3.12	1.58	0.40	0.15	0.56
2001	81.03	153.29	116.21	21.70	4.03	10.45	0.89	0.55	0.00	0.10
2002	20.68	304.47	198.83	110.43	22.88	3.45	7.39	0.30	0.34	0.21
2003	112.29	97.95	283.72	247.05	115.11	18.26	2.60	4.57	0.49	0.91
2004	325.12	291.10	70.86	208.82	110.08	34.24	6.82	1.26	0.83	0.16
2005	57.55	693.57	288.64	44.58	157.39	57.69	15.78	3.36	0.32	0.28
2006	39.87	78.50	575.82	181.71	19.34	63.24	16.54	6.80	0.70	0.29
2007	34.23	65.13	89.00	437.40	85.58	7.84	21.32	4.67	2.13	0.07

Year	1	2	3	4	5	6	7	8	9	10
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2009	10.87	112.24	53.00	40.53	41.31	104.80	12.76	2.19	3.04	0.65
2010	15.25	27.69	137.03	29.60	18.10	20.48	31.38	2.90	0.46	0.80
2011	8.76	27.46	24.33	76.71	13.95	5.88	9.40	14.89	1.28	0.54
2012	12.33	14.76	31.18	27.15	58.16	5.22	2.92	5.28	6.85	1.05
2013	13.93	23.05	19.56	22.61	22.25	41.48	4.76	2.49	3.82	5.16
2014	14.15	24.53	30.15	17.69	16.40	14.76	16.39	1.33	1.04	3.14
2015	62.08	19.53	26.50	34.10	12.62	11.11	9.57	9.85	1.16	1.70
2016	29.85	162.26	23.51	22.09	22.24	7.17	7.27	5.05	4.25	1.39
2017	26.66	66.57	140.89	23.02	20.29	22.05	6.47	5.05	3.53	2.21
2018	64.07	70.39	73.53	118.35	13.70	11.54	10.06	3.41	3.29	2.11
2019	7.14	85.21	47.89	40.85	67.31	4.13	3.80	3.08	1.61	0.86
2020	111.97	13.95	97.24	35.18	27.72	42.48	2.86	1.87	2.17	1.79

Table 1.11: Haddock in 5.a. ICES advice and official landings. All weights are in tonnes. * Calendar year. ** January to August

Year	ICES advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings for the fishing year	ICES landings for the calendar year
1987*	National advice	< 50000	60000		40760
1988*	National advice	< 60000	65000		54204
1989*	National advice	< 60000	65000		62885
1990*	National advice	< 60000	65000		67198
1991**	National advice	< 38000	48000		54692
1991/1992	National advice	< 50000	50000	48123	47121
1992/1993	National advice	< 60000	65000	47255	48123
1993/1994	National advice	< 65000	65000	58443	59502
1994/1995	National advice	< 65000	65000	60829	60884
1995/1996	National advice	< 55000	60000	53972	56890
1996/1997	National advice	< 40000	45000	49764	43764
1997/1998	National advice	< 40000	45000	37811	41192
1998/1999	National advice	< 35000	35000	45146	45411
1999/2000	F reduced below F_{med}	< 35000	35000	41150	42105
2000/2001	F reduced below provisional F_{pa}	< 31000	30000	39143	39654
2001/2002	F reduced below provisional F_{pa}	< 30000	41000	41069	50498
2002/2003	F reduced below provisional F_{pa}	< 55000	55000	55269	60883
2003/2004	F reduced below provisional F_{pa}	< 75000	75000	77916	84828
2004/2005	F reduced below provisional F_{pa}	< 97000	90000	96617	97225

Year	ICES advice	Predicted catch corresp. to advice	Agreed TAC	ICES landings for the fishing year	ICES landings for the calendar year
2005/2006	F reduced below provisional F_{pa}	< 110000	105000	99926	97614
2006/2007	F reduced below provisional F_{pa}	< 112000	105000	99763	109966
2007/2008	F reduced below provisional F_{pa}	< 120000	100000	109810	102872
2008/2009	F reduced below 0.35	< 83000	93000	88617	82045
2009/2010	F reduced below 0.35	< 57000	63000	67579	64169
2010/2011	F reduced below 0.35	< 51000	50000	50042	49433
2011/2012	F reduced below 0.35	< 42000	45000	49179	46208
2012/2013	F reduced below 0.35	< 32000	36000	40512	44097
2013/2014	TAC 0.4 × B45+cm,2014	< 38000	38000	39628	33900
2014/2015	TAC 0.4 × B45+cm,2015	< 30400	30400	36656	39646
2015/2016	TAC 0.4 × B45+cm,2016	< 36400	36400	40117	38109
2016/2017	TAC 0.4 × B45+cm,2017	< 34600	34600	36340	37062
2017/2018	TAC 0.4 × B45+cm,2018	< 41390	41390	44905	49993
2018/2019	TAC 0.4 × B45+cm,2019	< 57982	57982	59382	58850
2019/2020	TAC 0.35 x B45+cm,2020	< 41823	41823		

11 Icelandic summer spawning herring

11.1 Scientific data

11.1.1 Survey description

The scientific data used for assessment of the Icelandic summer-spawning (ISS) herring stock derives from annual acoustic surveys (IS-Her-Aco-4Q/1Q), which have been ongoing since 1973 (Table 11.1.1.1). Normally these surveys are conducted in the period of October–January, but also as late as end of March. The surveyed area each year is decided based on available information on the distribution of the stock in the previous and the current year, which include information from the fishery. Thus, the survey area varies spatially as the survey is focused on the adult and incoming year classes but is considered to cover the whole stock each year.

The acoustic abundance index for the adult stock in the winter 2020/2021 derives from two dedicated acoustic surveys on RV Bjarni Sæmundsson: (1) A survey aiming at herring juveniles in the east and southeast of Iceland in November; (2) A survey in the end of March aiming at the fishable stock at the main overwintering area of the stock west of Iceland.

In addition to getting an acoustic estimate on the adult part and on juveniles at age 1, the objective was also to get an estimate of the prevalence of *Ichthyophonus* infection in the stock. The instrument and methods in the surveys were the same as in previous years. The biological sampling in the survey is detailed in Table 11.1.1.2.

11.1.2 The survey results

The fishable part of the Icelandic summer-spawning herring stock was observed mainly in two areas, west of Iceland in Kolluáll in the end of March, and east and southeast of Iceland (Figure 11.1.2.1). The total acoustic estimate, according to these two surveys, came to 3.8 billion in numbers and the total biomass index was 623 kt (Table 11.1.1.1). The fishable part of the stock (≥ 27 cm) accounted for 50% in number and 75% of the biomass, or 465 kt. When considering age, the 2017-year class was the most numerous and accounted for 25% of the total biomass (177 kt), with the 2018 year class next in line with 17% (106 kt).

The annual survey aiming for the abundance of herring juveniles east and southeast of Iceland took place in November 2020. Areas covered (Figure 11.1.2.1) were different from previous years, with the distribution more to the south. The juvenile survey is specially aimed for assessing the number-at-age 1. This is different from number-at-age 2, because number-at-age 1 has been shown to give a signal of year class strength later at age 3 (Gudmundsdottir *et al.,* 2007). The herring juvenile survey has been conducted in a comparable way since 1980, with gaps in the time series.

A widespread ichthyophoniasis epizootic infection has been occurring in ISS-herring since 2008. This is caused by the parasite *Ichthyophonus* sp. Results of comprehensive analyses for the period 2008–2014 imply that significant infection mortality took place in the first three years after the outbreak started (2009–2011) but not the years after (2012–2016; Óskarsson *et al.*, 2018b). The level of the mortality was estimated with series of runs of the NFT-adapt assessment model, which gave the best fit to the data when applying infection mortality equivalent to 30% of the infected herring (heart inspection and survey abundance estimates provided $M_{infected}$) died annually in the first three years of the outbreak ($M_{year,\ age} = M_{fixed} + M_{infected,\ year,\ age} \times 0.3$; Table 11.3.2.1). The prevalence of the *Ichthyophonus* infection in the stock in 2020/21 was estimated in a same way as has been done since the initiation of the infection in the autumn 2008 (Óskarsson and Pálsson, 2018). The prevalence of infection shows a declining trend for all age classes for the past decade. The infection rate for the large 2017-year class seems to be low, or 5.4% in the west and 15% in the southeast (Figure 11.1.3.1.) There are still new infections taking place as seen with the younger ages, so infection mortality is assumed to take place in 2021, like in previous years. Thus, in the stock prognosis (Section 11.6), the abundance estimates from the final year of the assessment (1 January 2021) is lowered by this additional M as done in assessments for the past years. The level of M should then follow the results by Óskarsson *et al.* (2018b), where age specific $M_{infected}$ (estimated from the catch samples; Figure 11.1.3.1) is multiplied by 0.3 and the fixed M (0.1) added to it. These M for 2020 (Table 11.3.2.1) should be used in the prognosis in 2021 and in the analytical assessment from 2021 and onwards, until better more reliable estimates become available.

11.2 Information from the commercial fishery

The total landings of ISS herring in 2020/2021 season was 36 100 t with no discards reported (Table 11.2.1 and in Figure 11.2.1). This includes also bycatches of ISSH in the mackerel and Norwegian spring-spawning herring (NSSH) fisheries in June–November 2020, where the part caught in June–August belongs to the official fishing season September 2019/August 2020. Including the summer catches in the subsequent fishing season, as done here, is a traditional handling of the catch data when assessing this stock. The quality of the herring landing data regarding discards and misreporting are consider adequate as implied in the Her-Vasu stock annex.

The recommended TAC for 2020/2021 fishing season (September–August; ICES, 2018) and TAC (Regulation No. 672, 2 July 2020) was 35.5 kt (Table 11.2.1). Officially, according to the Directorate of Fisheries (http://www.fiskistofa.is/veidar/aflaupplysingar/heildaraflamarksstada/), 36.1 kt had been caught in April 2021, slightly above the TAC.

The direct fishery in offshore areas west of Iceland in November-February contributed 44% (15.8 kt) of the total catches (Figure 11.2.2). The remaining 56% (20.3 kt) of the catch was taken as bycatch in the fishery for mackerel in the southwest in June-July (3.4 kt), and in the fishery for mackerel and NSS-herring in the east in June-July (4.4 kt) and September-November (12.5 kt) (Figure 11.2.2).

11.2.1 Fleets and fishing grounds

The herring fishing season has taken minor changes in the last three decades as detailed in the stock annex. All seasonal restricted landings, catches and recommended TACs since 1985 are given in thousands of tonnes (kt) in Table 11.2.1.

All the catch in 2020/2021 was taken in pelagic trawls (Figure 11.2.1), which reflects that both the targeting and bycatch fisheries takes mainly place in offshore areas. During all fishing seasons from 2007/2008 to 2012/2013, most of the catches (~90%) were taken in inshore areas west off Iceland in Breiðafjörður, while prior to that they were mainly taken off the south-, southeast-, and the east coast. In 2013/2014 there was an indication for changes in this pattern, with less proportion in Breiðafjörður, and then in 2014/2015 almost all the overwintering west of Iceland took place offshore, which continued this winter. These changes in the stock distribution explain the dominance of pelagic trawl in the fishery, which is preferred by the fleet over purse seine in offshore areas.

To protect juvenile herring (27 cm and smaller) in the fishery, area closures are enforced based on a regulation of the herring fishery set by the Icelandic Ministry of Fisheries (no. 376, 8 October

1992). No closure was enforced in this herring fishery in 2020/21. Normally, the age of first recruitment to the fishery is age-3, which is fish at length around 26–29 cm.

11.2.2 Catch in numbers, weight at age and maturity

Catch at age in 2020/2021:

The procedure for the catch at age estimations, as described in the Stock Annex, was followed for the 2020/21 fishing season. It involves calculations from catch data collected at the harbours by the research personnel (0%) or at sea by fishermen (100%). This year, the calculations were accomplished by dividing the total catch into four cells confined by season and area. In the same way, weight-at-length relationships derived from the length and weight measurements of the catch samples were used. On basis of difference in length-at-age between the summer months and the winter, four length-age keys were applied. The catches of the Icelandic summer spawners in number-at-age for this fishing season as well as back to 1975 are given in Table 11.2.2.1. The geographical location of the sampling in 2020/2021 is shown on Figure 11.2.2.

Weight at age:

As stated in the stock annex, the mean weight-at-age of the stock is derived from the catch samples (Table 11.2.2.2).

Proportion mature:

The fixed maturity ogives were used in this year's assessment, as described in detail in the stock annex, where proportion mature-at-age 3 is set 20% and 85% for fish at age 4, while all older fish is considered mature.

11.3 Analytical assessment

11.3.1 Analysis of input data

Examination of catch curves for the year classes from 1987 to 2016 (Figure 11.3.1.1) indicates, in general, that the total mortality signal (Z) in the fully recruited age groups is around 0.4. It is under the assumption that the effort has been the same the whole time. In recent years the effort has changed a lot because of the infection and spatial distribution of the stock, and the mass mortality in 2012/2013, which makes any strong deductions from the catch curves for those recent less meaningful.

Catch curves were also plotted using the age disaggregated survey indices for each year class from 1987–2016 (Figure 11.3.1.2). Even if the total mortalities look at bit noisy for some year classes, they seem to be fairly close to 0.4. There is an indication that the fish is fully assessable to the survey at age 3–5.

Increased mortality in the stock because of the *Ichthyophonus* outbreak cannot be detected clearly from the catch curves of the surveys. However, considering that F was reduced drastically in the beginning of the outbreak, similar Z means an increased M during that period, representing infection mortality.

11.3.2 Exploration of different assessment models

Input data:

In order to explore the data this year, two models were run, NFT-ADAPT (VPA/ADAPT version 3.3.0 NOAA Fisheries Toolbox) that has been used as the basis for the assessments since 2005 and a separable model (Muppet) also used in the MSE in 2017 for the stock (ICES 2017b; Björnsson 2018) as well as analytical assessment of Icelandic saithe. Applying NFT-ADAPT was evaluated at benchmark assessment in January 2011 (ICES, 2011a) and it found to be appropriate as the principal assessment tool for the stock. The catch data used were from 1987/88–2020/21 (Table 11.2.2.1) and survey data from 1987/88–2020/21 (Table 11.1.1.1). Other input data consisted of: (i) mean weight at age (Table 11.2.2.2); (ii) maturity ogive (Table 11.2.2.3); (iii) natural mortality, M, that was set to 0.1 for all age groups in all years, except for 2009–2011 and 2017–2020 where additional age dependent mortality was applied because of the *Ichthyophonus* infection (see Section 11.1.3; Table 11.3.2.1; Óskarsson *et al.*, 2018b); (iv) proportion of M before spawning was set to 0.5; and (v) proportion of F before spawning was set to 0. Thus, in comparison to last year's assessment, all the input data are the same with an additional year of data.

Results:

The estimated parameters in NFT Adapt are the stock in numbers at age. The parameters are output by the Levenburg-Marquardt Non-Linear Least Squares minimization algorithm (see VPA/ADAPT Version 3.3.0, Reference Manual). The estimated parameters were stock numbers for ages 4 to 12 in the beginning of year 2021, while the stock numbers at age 3 was derived from survey estimates in 2020 (i.e. projection from age-1 survey index to age-3 according to Gudmundsdóttir *et al.,* 2007 and recommended by ICES (2011a)) instead of geometric mean as default in the model. Like in last years' assessments, the *input partial recruitment* was set to 1 for ages 4 and older and the *classic* method was used to calculate the value of fully-recruited fishing mortality in the terminal year.

The catchability at age in the survey, as estimated by the NFT Adapt, and the CV is shown in Figure 11.3.2.1. The age groups 3–10 were used for tuning (Table 11.1.1.1 as decided at the benchmark in ICES (2011a). In comparison to last year, the catchability of the survey is relatively the same with similar uncertainty.

The output and model settings of the NFT-Adapt run (the adopted final assessment model) are shown in Table 11.3.2.2. Stock numbers and fishing mortalities derived from the run are shown in Table 11.3.2.3 and Table 11.3.2.4, respectively, and summarized in Table 11.3.2.5 and Figure 11.3.2.2.

Residuals of the model fit are shown in Figure 11.3.2.3 and Table 11.3.2.6, and shows both cohort and year affects. The main pattern is the same as presented in recent assessments. Positive residuals, where the model estimates are smaller than seen in the survey, can be seen for 1994- and 1999-year classes for almost all age groups and negative residuals for the 2001 and 2003 year classes. Year blocks of positive residuals are apparent for the years ~2000 to 2006 (i.e. referring to 1 January). During these years, the stock was overwintering in offshore areas off the east and west coast, compare to mainly easterly distribution before and overwintering in inshore areas there after (from ~2006–2012). These positive blocks could therefore reflect changes in catchability of the survey for these years. After 2008 the residuals are generally behaving well.

Retrospective analyses indicate a consistency over the most recent six years, i.e. adding new data to the model does not change the present perception of the stock size much (Figure 11.3.2.4). The small upward revision for the last years is likely caused by the increased M in 2017 and 2018 (due to infection mortality), and for compensating for it, the model increased the stock size back in time. This is a pattern seen before (ICES, 2017c). The retros for the fishing mortality and recruits behave, in a same way, well for the last four years.

Like demonstrated and analysed earlier (ICES, 2014), the main difference between observed and predicted survey values from the NFT-Adapt model was for the period 1999–2004, where the observed values were well above the predicted (Figure 11.3.2.5), otherwise they fitted relatively well. Like seen in the residual plot (Figure 11.3.2.3), the observed value for the 2009 survey was lower than predicted and the vice versa for the 2012 survey (referring to the beginning of the year; Figure 11.3.2.5). The low survey value in 2009 is likely underestimate due to distribution of the stock that year in the fjord west of Iceland (Breiðafjörður; Óskarsson *et al.*, 2010), while the positive block during 2000–2004 was previously found to be mainly caused by the large 1999-year class (ICES, 2014) and possibly changes in the catchability of the survey as suggested above. However, an exploratory run in NFT-Adapt done in the 2011 assessment (ICES, 2011b) where these years were excluded in the tuning, did not change the point estimate of the stock size in the latest year (1 January 2011), implying that the terminal point estimates in the final run was not driven by this residual block.

Comparisons of different models:

The two models explored, NFT-Adapt and the separable model (Muppet), gave very similar results, and especially for the latest years of the assessments (Figure 11.3.2.2). This indicates that the results are driven by the input data and not by the model used.

11.3.3 Final assessment and TAC advice on basis of Management Plan

In this update assessment, where the 2020/21 catch and survey data have been added to the input data, additional natural mortality was applied for 2020 because of the *Ichthyophonus* infection in the stock. The same approach was used as for 2009–2011 and 2017-2020 where the applied mortality corresponds to that 30% of infected herring died.

The results from the analytical assessment model, NFT-Adapt, indicate that the stock size has increased because of an upward revision in the stock size, due to a large 2017 year-class entering the fishery at age 4 this autumn. Spawning stock biomass for 2021 is estimated 377.1 kt and the reference biomass of age 4+ (B_{Ref}) is 481.6 kt in the beginning of the year 2021. As the SSB will be above MGT $B_{trigger}$ = 200 kt, the advised TAC according to the Iceland Management Plan is $HR_{MGT} \times B_{Ref} = 0.15 \times 481\,594 = 72\,239$ tonnes.

11.4 Reference points and the Management plan

Precautionary approach reference points:

The working group points out that managing this stock at an exploitation rate at or above $F_{0.1} = F_{MSY} = 0.22$ has been successful in the past for almost 30 years, despite biased assessments. At the 2016 NWWG meeting, the PA reference points for the stock were verified and revised (ICES, 2016). On basis of the stock-recruitment relationship deriving from time-series ranging from 1947–2015, keeping B_{lim} = 200 kt was considered reasonable as the Study Group on Precautionary Reference Points for Advice on Fishery Management concluded also in February 2003. Other PA reference points were derived from B_{lim} and these data in accordance to the ICES Advice Technical Guidelines and became these: B_{pa} = 273 kt ($B_{pa} = B_{lim} \times e^{1.645\sigma}$, where $\sigma = 0.19$); F_{lim} = 0.61 (F that leads to SSB = B_{lim}, given mean recruitment); F_{pa}= 0.43 ($F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$, where $\sigma = 0.18$).

MSY based reference points:

At a NWWG meeting in 2011 an exploratory work, using the HCS program Version 10.3 (Skagen, 2012), was used to evaluate possible points based on the MSY framework that could be a basis for a management plan and Harvest Control Rule later (ICES, 2011b). Number of different runs was made with varying settings. The results implied that the MSY framework was confirmative with the currently used precautionary reference points. It means that the currently used $F_{0.1}$ = 0.22 could be a valid candidate for F_{MSY}. During a Management Strategy Evaluation (MSE) for the stock in April 2017 (ICES, 2017b), F_{MSY} = 0.22 was not considered to be significantly different from results of simulation giving 0.24. Thus, it was concluded adequate to keep F_{MSY} = 0.22.

Management plan

A Management Strategy Evaluation (MSE) for the stock took place in 2017 (ICES, 2017b). Five different HCRs were tested and all of them, except for the advisory rule applied at that time (F_{MGT} = 0.22), were considered precautionary and in accordance with the ICES MSY approach. One of these HCR was later adopted by Icelandic Government as a Management plan for the stock. This HCR is based on reference biomass of age 4+ in the beginning of the assessment years ($B_{ref,\ Y}$), a spawning stock biomass trigger (MGT $B_{trigger}$) is defined as 200 kt, and the harvest rate (HR_{MGT}) is set as 15% of the reference biomass age4+ in the beginning of the assessment year. In the assessment year (Y) the TAC in the next fishing year (1 September of year Y to 31 August of year Y+1) is calculated as follows:

When SSB_Y is equal or above MGT $B_{trigger}$:

$TAC_{Y/y+1} = HR_{MGT} * B_{Ref,y}$

When SSB_Y is below MGT $B_{trigger}$:

$TAC_{Y/y+1} = HR_{MGT} * (SSB_y / MGT\ B_{trigger}) * B_{ref,y}$

In the MSE simulation, the ongoing *Ichthyophonus* epidemic was considered to continue and was accounted for. Consequently, this HCR is independent of estimated level of *Ichthyophonus* mortality and requires no further action during such epidemics.

The distribution of the realized harvest rate when the HCR is followed showed that the 90% expected range are within a harvest rate of 0.099–0.22 with no bias and 0.122–0.247 if bias is applied. The recent realized harvest rates are within the above range.

11.5 State of the stock

The stock was at high levels around 2002 but showed a steady decline to 2017 despite a low fishing mortality. The reduction is a consequence of mortality induced by the *Ichthyophonus* outbreak in the stock in 2009–2011 and 2016–2018 in addition to small year classes entering the stock since around 2005, particularly the 2011–2014-year classes. Survey indices from autumn 2020 and spring 2021 indicate that the 2017-year class is well above average and will enter the fishable stock in autumn 2021, causing an upward revision of the stock size.

11.6 Short term forecast

11.6.1 The input data

The final adopted model, NFT-Adapt, which gave the number-at-age on 1 January, 2021, was used for the prognosis. All input values for the prognosis are given in Table 11.6.1.1. Because of the expected *Ichthyophonus* mortality in the stock in the spring 2021 (see Section 11.1.3), the NFT-Adapt model output were reduced according to the infection ratios times 0.3 (Table 11.3.2.1), or the same approach as used in the assessments in 2009–2011 and 2018–2020 (ICES, 2011b; 2018a; Óskarsson *et al.*, 2018b).

The weights were estimated from the last year catch weights (see Stock Annex) and as in the recent years, the weights are expected to continue to be high, except for the youngest age groups, which is though still well within observed range (Figure 11.6.1.1). The weight for age 3 was set equal to the value used in 2020 (ICES; 2020) because the weight deriving from the formula provided in the Stock Annex gave much lower and unrealistic value.

In summary, the basis for the stock projection is as follows: SSB(2021) = 377 kt; Biomass age 4+ (1 January 2021) = 481.6 kt; Catch (2020/21) = 36.1 kt; $WF_{5\text{–}10}$(2020) = 0.228; HCR (2020) = 0.15.

11.6.2 Prognosis results

SSB in the beginning of the fishing season 2021/22 (approximately the same time as spawning in July 2021) is estimated to be 377 kt, which is above MGT $B_{trigger}$ of 200 kt. Consequently, advised TAC on basis of the Management rule is 0.15 × Biomass 4+ (481 594 kt) = 72 239 kt. This results in $F_{W5\text{–}10}$ = 0.217 in 2021/22 and SSB = 421 132 kt in 2022 (Table 11.6.2.1). The results of different options are given in Table 11.6.2.1.

11.7 Medium term predictions

Because of the increased uncertainty of the assessment in relation to the development of the *Ichthyophonus* outbreak in the coming months and years, the uncertainty in size of the recruiting year classes, and the new management rule, no medium-term prediction is provided.

11.8 Uncertainties in assessment and forecast

11.8.1 Uncertainty in assessment

There are number of factors that could lead to uncertainty in the assessment. Two of them are addressed here. Additional natural mortality caused by the *Ichthyophonus* infection was set for the first three years of the outbreak (2009–2011) and in 2017-2020 ($M_{infected,\ age,\ year}$ multiplied by 0.3 (see Section 11.1.3). This quantification of the infection mortality based on Óskarsson *et al.* (2018b), was considered to improve the assessment and reduce its uncertainty. For the most recent years, where new infection reappeared (2017–2020), more accurate estimation of the infection mortality will be possible in the years to come but until then, this approach will add uncertainty to the assessment. Worth noticing, increasing M has been shown to increase the historical perception of the stocks size but has minor impacts on the assessment of the final year and the resulting advice.

The signals from the last catches and the surveys give somewhat contradicting results about the size of the 2013–2015-year classes (Figure 11.2.2.1), even if all of them appears to be small, particularly the 2014-year class. The size of these year classes is therefore not very well determined yet, which adds uncertainty to the assessment. Considering that the direct winter fishery west of Iceland is not targeting these year classes, which are mainly found southeast and east of Iceland, their size is more likely to be underestimated in the analytical assessment.

11.8.2 Uncertainty in forecast

It is important to notice that the advice for 2019/2020 fishing season deriving from the Management plan is independent of the forecast and its uncertainty as it is only based on the reference biomass in the beginning of the assessment year. The uncertainty in the assessment mentioned above related to the apparent new infection in the stock in 2017–2019 and size of the recruiting year classes, apply also for the forecast.

Moreover, the number-at-age 3 in the beginning of the year 2019 used in the prognosis (360 millions) was predicted from a survey estimate of number at age 1 in 2017 in accordance with the approach described in the Stock Annex. This index derives from an incomplete survey but is used here as it is in accordance with the Stock Annex, the survey covered the single most important nursery grounds of the stock (Eyjafjörður), it was considered to be more appropriate than applying geometric mean, and this decision has no impact on the fishing advice. Thus, the resulting stock size in 2020 is likely to be too pessimistic.

11.8.3 Assessment quality

For a period, there was concerns regarding the assessment because of retrospective patterns of the results. No assessment was provided in the 2005 due to data and model problems and in the two next consecutive years, ACFM rejected the assessment due to the retrospective pattern. In the assessments in 2007–2009 there was observed an improvement in the pattern from NFT-Adapt, while in 2010–2011, a retrospective pattern appeared again which was both related to the high M because of the *Ichthyophonus* infection but also due to new and more optimistic information about incoming year classes to the fishable stock (particularly the 2008-year class) and fishing pattern in recent year. The retrospective pattern in the last five and this year's assessment are less than seen for many years for SSB and F (Figure 11.3.2.4). Simultaneously the residuals from the survey are behaving better than before (Figure 11.3.2.3). This together could be interpreted as indications for improvements in the assessment quality in recent years in comparison to the years before. The small retros in the SSB for this year's assessment is considered to be related to the additional infection mortality set for 2017–2018, where the model increase the stock size back in time to compensate for the increase M.

As stated in the 2017 NWWG report (ICES, 2017c), the revision of the infection mortality applied in the analytical assessment for the years 2009–2011 in accordance to the estimated mortality levels (Section 11.1.3), is also considered as an improvement of the assessment. Thus, the downward revision of the stock size over the period ~2003–2011 compared to the last year's assessment (Figure 11.3.2.2) is considered to provide more robust figure of development in the historical stock's size.

11.9 Comparison with previous assessment and forecast

This year's assessment was conducted in the same way as in last year, apart from the correction on the survey indices from 2017 (see Section 11.2.3). Additional natural mortality was applied to 2017–2018 because of the infection (see Section 11.1.3), which caused an upward revision of the stock size for the most recent years (Figure 11.3.2.4). When the estimates for 1 January 2018 are compared with last year's assessment, the results of the final NFT run in 2019 gives a more optimistic view on the size of the small 2013- and 2014-year classes (Figure 11.3.2.6). Apart from that there is not a big difference. Note that the estimate of the 2015-year class in 2018 was based on a survey estimation while in the assessment model in 2019.

11.10 Management consideration

Inspections indicate still a high prevalence of heart lesions related to *Ichthyophonus hoferi* in the herring stock. More importantly, new infection has been taken place in the stock last three winters but possibly with a decreased intensity in 2018/2019. Significant new infection was otherwise last observed in 2010 (Óskarsson *et al.*, 2018b). Correspondingly, induced mortality due to the infection was unavoidably applied for 2017–2019, and this second outbreak might continue in the coming year. Considering the presently low stock size, the ongoing second outbreak, and continuing poor year classes entering the fishable stock, the stock size will most likely remain at low level in the next two years and be between B_{lim} and MSY $B_{trigger}$. The survey results implying large 2017-year class might change this situation from 2021 onwards when it starts to enter the fishable stock.

11.11 Ecosystem considerations

The reason for the outbreak of *Ichthyophonus* infection in the herring stock that was first observed in the autumn 2008 is not known but is probably the effect of interaction between environmental factors and distribution of the stock (Óskarsson *et al.* 2009). It includes that outbreak of *Ichthyophonus* spores in the environment, which infect the herring via oral intake (Jones and Dawe, 2002), could be linked to the observed increased temperature off the southwest coast. Further researches on the causes and origins of such an outbreak are ongoing at MFRI. It involves scanning for *Ichthyophonus* DNA in zooplankton species that the herring feeds on with PCR (Polymerase chain reaction) technique. Results from that work (MS thesis) can be expected in the summer 2019, while preliminary results indicate that the source of the infection is widespread and is in various zooplankton groups and species. With respect to the impacts of the outbreak on the herring stock, recent analyses show that significant additional mortality took place over the first three years only (Óskarsson *et al.*, 2018b), despite a high prevalence of infection for now nine years. As pointed out above, a new infection since the summer 2016 is however, expected to cause significant mortality again. For how long time this outbreak will last is unknown as this is basically an unprecedented outbreak. The signs of the infection that is found in the stock will most likely remain for some years, even if no new infection will occur, and then decrease and disappear over some years as new year classes replace the older ones. The observed new infection will however delay this process.

All general ecosystem consideration with respect to the stock can be found in the Ecosystem Overview for the Icelandic Ecoregion (ICES, 2017a).

11.12 Regulations and their effects

The fishery of the Icelandic summer-spawning herring is limited to the period 1 September to 1 May each season, according to regulations set by the Icelandic Fishery Ministry (**no. 770, 8 September 2006**). Several other regulations are enforced by the Ministry that effect the herring fishery. They involve protections of juvenile herring (27 cm and smaller) in the fishery where area closures are enforced if the proportion of juveniles exceeds 25% in number (no. 376, 8 October 1992). No such closures took place in 2020/2021. Another regulation deals with the quantity of bycatch allowed. Then there is a regulation that prohibits use of pelagic trawls within the 12 nautical miles fishing zone (**no. 770, 8 September 2006**), which is enforced to limit bycatch of juveniles of other fish species.

11.13 Changes in fishing technology and fishing patterns

There are no recent changes in fishing technology which may lead to different catch compositions. The fishing pattern in the seasons 2014/2015 to 2020/2021 was different from the previous nine seasons. Instead of fishing near only in a small inshore area off the west coast in purse seine, the directed fishery took place in offshore areas west and east of Iceland by pelagic trawls. These changes are not considered to affect the selectivity of the fishery because the fishery is still targeting dense schools of overwintering herring in large fishing gears, getting huge catches in each haul and is by none means size selective.

Bycatch of Icelandic summer-spawning herring in summer fishery for NE-Atlantic mackerel and Norwegian spring-spawning herring has been taken place since around mid-2000s. Until that time, no summer fishery on this stock had taken place for decades. Part of this bycatch is on the stock components (e.g. juveniles and herring east of Iceland) that are not fished in the direct fishery on the overwintering grounds in the west. However, these bycatches are well sampled and contributes normally to less than 10% of the total annual catch, but were as high as 37% in the season 2017/2018. It can be explained by the low TAC, so the fleet did not have much quota left for direct autumn fishery. Still, the impacts of these changes on the assessment are considered to be insignificant.

The fishing pattern varies annually as noted in Section 11.2 and it is related to variation in winter distribution of the different age classes of the stock. This variation can have consequences for the catch composition but it is impossible to provide a forecast about this variation.

11.14 Species interaction effects and ecosystem drivers

The WG have not dealt with this issue in a thoroughly and dedicated manner. However, some work has been done in this field in recent years in one way or another.

Regarding relevant researches on species interaction, the main work relates to the increasing amount of North East Atlantic mackerel (NEAM) feeding in Icelandic waters after 2006 (Astthorsson *et al*., 2012; Nøttestad *et al*., 2016). Surveys in the summers since 2010 indicate a high overlap in spatial and temporal distribution of NEAM and Icelandic summer-spawning herring (Óskarsson *et al*., 2016). Moreover, the diet composition of NEAM in Icelandic waters showed a clear overlap with those of the two herring stocks, i.e. Icelandic summer-spawning herring and Norwegian spring-spawning herring (Óskarsson *et al*., 2016). Even if copepoda was important diet group for all the three stocks its relative contribution to the total diet was apparently higher for NEAM than the two herring stocks. Considering former studies of herring diet, this finding was unexpected, and particularly how little the copepoda contributed to the herring diet. This difference in the stomach content of NEAM and the two herring stocks indicated that there could be some difference in feeding ecology between them in Icelandic waters, where NEAM preferred copepoda, or feed in the water column where they dominate over other prey groups, while the opposite would be for the herring and the prey Euphausiacea. Recent studies in the Nordic Seas have shown similar results (Langøy *et al*., 2012; Debes *et al*., 2012). The indication for difference in feeding ecology of the species is further supported by the fact that the body condition of the two herring stocks showed no clear decreasing trend since the invasion of NEAM started into Icelandic waters. On the contrary the mean weights-at-age (and at-length) of the summer spawners have been high after 2010 (Óskarsson, 2019b) and for example record high in the autumn 2014 (Figure 11.6.1.1). It should though be noted that comparison of the diet composition of herring in recent years to earlier studies, mainly on NSS herring, indicate that the herring might have shifted their feeding preference towards Euphausiacea instead of Copepoda. That is possibly a consequence of increased competition for food with NEAM, where the herring is overwhelmed and shifts towards other preys.

The WG is not aware of documentations of strong signals from ecosystem or environmental variables that impact the herring stock and could possibly be a basis for implementing ecosystem drivers in the analytical basis for its advice. For example, recruitment in the stock has been positively, but weakly, linked to NAO winter index (North Atlantic Oscillation) and sea temperature (Óskarsson and Taggart, 2010), while indices representing zooplankton abundance in the spring have not been found to impact the recruitment (Óskarsson and Taggart, 2010) or body condition and growth rate of the adult part of the stock (Óskarsson, 2008). Considering these relations derived from the historical data, relatively warm waters around Icelandic (MRI 2016), and high positive NAO in recent years (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml), it was concluded in last year's report (ICES, 2018) that we could expect a good recruitment in the stock. It seems to be coming about with an encouraging first measurement of the 2017-year class.

11.15 Comments on the PA reference points

The WG dealt with the reference points in 2016 and revised them in accordance to the ICES Technical Guidelines (ICES, 2016).

11.16 Comments on the assessment

The assessment shows that the stock size was declining 2000–2018 due to a combination of *Ichthyophonus* mortality and series of below average and poor year classes entering the stock. The 2017-year class entering the reference biomass and SSB in 2021 is estimated large and will cause an upward revision from last year's assessment.

There is compelling evidence for new infection by *Ichthyophonus* in the stock in the winter 2021/22, even if less intensive than in the years before. This called for applying additional infection mortality. This current outbreak adds uncertainty to the assessment and advice.

11.17 References

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11.18 Tables

Table 11.1.1.1. Icelandic summer-spawning herring. Acoustic estimates (in millions) in the winters 1973/74–2020/21 (age refers to the autumns). No surveys (and gaps in the time-series) were in 1976/77, 1982/83, 1986/87, 1994/95.

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1973/74	154.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	154
1974/75	5.000	137.000	19.000	21.000	2.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	186
1975/76	136.000	20.000	133.000	17.000	10.000	3.000	3.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	322
1977/78	212.000	424.000	46.000	19.000	139.000	18.000	18.000	10.000	0.000	0.000	0.000	0.000	0.000	0.000	886
1978/79	158.000	334.000	215.000	49.000	20.000	111.000	30.000	30.000	20.000	0.000	0.000	0.000	0.000	0.000	967
1979/80	19.000	177.000	360.000	253.000	51.000	41.000	93.000	10.000	0.000	0.000	0.000	0.000	0.000	0.000	1004
1980/81	361.000	462.000	85.000	170.000	182.000	33.000	29.000	58.000	10.000	0.000	0.000	0.000	0.000	0.000	1390
1981/82	17.000	75.000	159.000	42.000	123.000	162.000	24.000	8.000	46.000	10.000	0.000	0.000	0.000	0.000	666
1983/84	171.000	310.000	724.000	80.000	39.000	15.000	27.000	26.000	10.000	5.000	12.000	0.000	0.000	0.000	1419
1984/85	28.000	67.000	56.000	360.000	65.000	32.000	16.000	17.000	18.000	9.000	7.000	4.000	5.000	5.000	689
1985/86	652.000	208.000	110.000	86.000	425.000	67.000	41.000	17.000	27.000	26.000	16.000	6.000	6.000	1.000	1688
1987/88	115.544	401.246	858.012	308.065	57.103	32.532	70.426	36.713	23.586	18.401	24.278	10.127	3.926	4.858	1965
1988/89	635.675	201.284	232.808	381.417	188.456	46.448	25.798	32.819	17.439	10.373	9.081	5.419	3.128	5.007	1795
1989/90	138.780	655.361	179.364	278.836	592.982	179.665	22.182	21.768	13.080	9.941	1.989	0.000	0.000	0.000	2094
1990/91	403.661	132.235	258.591	94.373	191.054	514.403	79.353	37.618	9.394	12.636	0.000	0.000	0.000	0.000	1733
1991/92	598.157	1049.990	354.521	319.866	89.825	138.333	256.921	21.290	9.866	0.000	9.327	0.000	0.000	1.494	2850
1992/93	267.862	830.608	729.556	158.778	130.781	54.156	96.330	96.649	24.542	1.130	1.130	3.390	0.000	0.000	2395
1993/94	302.075	505.279	882.868	496.297	66.963	58.295	106.172	48.874	36.201	0.000	4.224	18.080	0.000	0.000	2525
1995/96	216.991	133.810	761.581	277.893	385.027	176.906	98.150	48.503	16.226	29.390	47.945	4.476	0.000	0.000	2197
1996/97	33.363	270.706	133.667	468.678	269.888	325.664	217.421	92.979	55.494	39.048	30.028	53.216	18.838	12.612	2022
1997/98	291.884	601.783	81.055	57.366	287.046	155.998	203.382	105.730	35.469	27.373	14.234	36.500	14.235	11.570	1924
1998/99	100.426	255.937	1081.504	103.344	51.786	135.246	70.514	101.626	53.935	17.414	13.636	2.642	4.209	8.775	2001
1999/00	516.153	839.491	239.064	605.858	88.214	43.353	165.716	89.916	121.345	77.600	21.542	3.740	11.149	0.000	2823
2000/01	190.281	966.960	1316.413	191.001	482.418	34.377	15.727	37.940	14.320	15.413	14.668	1.705	3.259	0.000	3284
2001/02	1047.643	287.004	217.441	260.497	161.049	345.852	62.451	57.105	38.405	46.044	38.114	21.062	3.663	0.000	2586

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
2002/03	1731.809	1919.368	553.149	205.656	262.362	153.037	276.199	99.206	47.621	55.126	18.798	24.419	24.112	1.377	5372
2003/04	1115.255	1434.976	2058.222	330.800	109.146	100.785	38.693	45.582	7.039	6.362	7.509	10.894	0.000	2.289	5268
2004/05	2417.128	713.730	1022.326	1046.657	171.326	62.429	44.313	10.947	23.942	12.669	0.000	1.948	11.088	0.000	5539
2005/06	469.532	443.877	344.983	818.738	1220.902	281.448	122.183	129.588	73.339	65.287	10.115	9.205	3.548	12.417	4005
2006/07	109.959	608.205	1059.597	410.145	424.525	693.423	95.997	123.748	48.773	0.955	0.000	0.000	0.000	0.480	3576
2007/08	90.231	456.773	289.260	541.585	309.443	402.889	702.708	221.626	244.772	13.997	22.113	68.105	10.136	2.800	3376
2008/09	149.466	196.127	416.862	288.156	457.659	266.975	225.747	168.960	29.922	26.281	17.790	9.881	0.974	3.195	2258
2009/10	151.066	315.941	490.653	554.818	271.445	327.275	149.143	83.875	156.920	36.666	13.649	8.507	1.458	5.590	2567
2010/11	106.178	280.582	228.857	304.885	296.254	138.686	301.285	60.997	141.323	97.412	37.006	0.000	4.019	0.000	1997
2011/12	704.863	977.323	434.876	313.742	272.140	239.320	154.581	175.088	84.582	92.435	89.376	17.638	6.808	4,989	3676
2012/13	178.500	781.083	631.421	166.627	126.961	142.044	110.084	97.000	74.340	69.473	43.376	38.450	7.458	0.773	2468
2013/14	15.919	314.865	218.715	344.981	151.631	132.767	120.756	118.377	89.555	74.602	48.695	44.637	31.096	11.598	1718
2014/15	152.422	90,269	330.084	260.919	259.079	187.905	111.955	91.629	37.855	76.680	30.366	10.619	22.799	10.108	1667
2015/16	381.900	164.221	174.507	312.350	225.836	215.207	93.743	62.753	75.339	41.961	15.696	26.756	20.159	5.401	1816
2016/17	97.036	220.642	137.217	151.937	262.488	136.801	241.382	61.220	55.869	62.805	11.435	20.135	13.733	0.313	1473
2017/18	32.749	22.947	95.097	171.664	201.944	319.933	209.174	255.348	75.813	34.505	83.460	54.903	25.370	28.115	1611
2018/19	306.295	137.402	67.933	201.362	101.946	110.810	167.397	163.804	73.346	30.040	29.950	38.499	9.138	7.271	1445
2019/20	1525	229.841	158.605	103.631	211.106	98.785	53.723	59.527	42.221	37.186	21.341	15.089	10.393	0.986	2568
2020/21	1399.761	1114.743	424.292	138.193	81.983	127.703	66.488	102.847	82.755	63.522	56.970	22.767	11.122	21.563	3802

Table 11.1.1.2. Icelandic summers-spawning herring. Number of fish aged (number of scales) and number of samples taken in the annual acoustic surveys in the seasons 1987/88–2020/21 (age refers to the former year, i.e. autumns). In 2000 seven samples were used from the fishery.

	Number of scales															N of samples		
Year/age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Total	West	East
1987/88	11	59	246	156	37	28	58	33	22	16	23	10	5	8	712	8	1	7
1988/89	229	78	181	424	178	69	50	77	42	29	23	13	7	12	1412	18	5	10
1989/90	38	245	96	132	225	35	2	2	3	3	2	0	0	0	783	8		8
1990/91	418	229	303	90	131	257	28	6	3	8	0	0	0	0	1473	15		15
1991/92	414	439	127	127	33	48	84	5	3	0	2	0	0	1	1283	15		15
1992/93	122	513	289	68	73	28	38	34	6	2	2	6	0	0	1181	12		12
1993/94	63	285	343	129	13	15	7	14	11	0	1	3	0	0	884	9		9
1994/95*																		
1995/96	183	90	471	162	209	107	38	18	8	14	18	2	0	0	1320	14	9	5
1996/97	24	150	88	351	141	137	87	32	15	10	7	14	4	2	1062	11	4	7
1997/98	101	249	50	36	159	95	122	62	21	13	8	15	8	5	944	14	7	7
1998/99	130	216	777	72	31	65	59	86	37	22	17	5	6	11	1534	17	10	7
1999/00	116	227	72	144	17	13	26	26	27	10	8	2	1	0	689	7	3	4
2000/01	116	249	332	87	166	10	7	21	8	14	11	3	1	0	1025	14	10	4
2001/02	61	56	130	114	62	136	25	24	17	21	17	10	3	0	676	9	4	5
2002/03	520	705	258	104	130	74	128	46	26	25	13	15	10	1	2055	22	12	10
2003/04	126	301	415	88	35	32	15	17	3	4	4	6	1	1	1048	13	8	5
2004/05	304	159	284	326	70	29	17	5	8	4	0	3	3	0	1212	13	4	9
2005/06	217	312	190	420	501	110	40	38	26	18	5	5	5	7	1894	22	14	8
2006/07	19	77	134	64	71	88	22	4	2	2	0	0	0	1	484	6	4	2
2007/08	58	288	180	264	85	80	104	19	15	2	2	6	1	3	1107	17	13	4
2008/09	274	208	213	136	204	123	125	97	18	13	9	7	4	17	1448	29	19	10
2009/10	104	100	105	116	60	74	34	19	36	8	3	4	2	2	667	17	10	7
2010/11	35	74	102	157	139	61	119	22	52	36	13	0	1	0	811	11	8	3
2011/12	229	330	134	115	100	106	74	87	45	48	51	10	3	3	1335	15	9	6
2012/13‡	42	266	554	273	220	252	198	165	126	114	69	61	12	2	2370	60	55‡	5
2013/14	26	472	275	414	199	200	199	208	163	138	90	85	60	23	2552	45	37‡	8
2014/15	83	50	96	71	72	53	32	26	11	22	8	3	6	4	534	10	8	2
2015/16	229	112	131	208	148	123	47	32	32	22	13	7	12	4	1120	14	7	7§
2016/17	66	164	122	137	202	117	169	43	50	44	14	15	9	4	1162	14	12	2
2017/18	35	58	82	77	75	101	65	77	29	11	27	18	8	9	672	10	5	5
2018/19	28	39	31	98	50	53	77	75	36	15	15	21	5	4	547	7	5	2
2019/20	265	143	94	48	101	60	43	54	45	43	27	26	20	6	975	10	5	5
2020/21	248	215	116	68	59	104	52	79	55	44	35	13	6	8	1102	13	5	8

*** No survey ‡ Samples in the western part were mainly from the commercial catch as there was impossible to secure a usable research survey samples from Kolgrafafjörður where most of the herring was observed. § Three samples were taken in the east and south in this survey (B1-2016), while four were taken in the west and used also in the age-length key.**

Table 11.2.1. Icelandic summer spawners. Landings, catches, recommended TACs, and set National TACs in thousand tonnes.

Year	Landings	Catches	Recom. TACs	Nat. TACs	Year	Landings	Catches	Recom. TACs	Nat. TACs
1972	0.31	0.31			2007/2008	158.9	158.9	130	150
1973	0.254	0.254			2008/2009	151.8	151.8	130	150
1974	1.275	1.275			2009/2010	46.3	46.3	40	47
1975	13.28	13.28			2010/2011	43.5	43.5	40	40
1976	17.168	17.168			2011/2012‡	49.4	49.4	40	45
1977	28.925	28.925			2012/2013‡	72.0	72.0	67	68.5
1978	37.333	37.333			2013/2014‡	72.0	72.0	87	87
1979	45.072	45.072			2014/2015‡§	95.0	95.0	83	83
1980	53.268	53.268			2015/2016‡	69.7	69.7	71	71
1981	39.544	39.544			2016/2017‡	60.4	60.4	63	63
1982	56.528	56.528			2017/2018‡	35.0	35.0	39	39
1983	58.867	58.867			2018/2019‡	40.7	40.7	35.1	35.1
1984	50.304	50.304			2019/2020	30.0	30.0	34.6	34.6
1985	49.368	49.368	50	50	2020/2021	36.1	36.1	35.5	35.5
1986	65.5	65.5	65	65	2021/2022			72.2	72.2
1987	75	75	70	73					
1988	92.8	92.8	90	90					
1989	97.3	101	90	90					
1990/1991	101.6	105.1	80	110					
1991/1992	98.5	109.5	80	110					
1992/1993	106.7	108.5	90	110					
1993/1994	101.5	102.7	90	100					
1994/1995	132	134	120	120					
1995/1996	125	125.9	110	110					
1996/1997	95.9	95.9	100	100					
1997/1998	64.7	64.7	100	100					
1998/1999**	87	87	90	70					
1999/2000	92.9	92.9	100	100					
2000/2001	100.3	100.3	110	110					
2001/2002	95.7	95.7	125	125					
2002/2003*	96.1	96.1	105	105					
2003/2004*	130.7	130.7	110	110					
2004/2005	114.2	114.2	110	110					
2005/2006	103	103	110	110					
2006/2007	135	135	130	130					

***Summer fishery in 2002 and 2003 included**

**** TAC was decided 70 thousand tonnes but because of transfers from the previous quota year the national TAC became 90 thousand tonnes.**

‡ Landings and catches include bycatch of Icelandic summer-spawning herring in the mackerel and NSS herring fishery during the preceding summer (i.e. from the fishing season before in June–August).

§ The landings and catches in 2014/2015 consist of transfer of 7 kt from the year before and 5 kt from the year to come, which explains the discrepancy to the TACs.

Table 11.2.2.1. Icelandic summer-spawning herring. Catch in numbers (millions) and total catch in weight (thousand tonnes) (1981 refers to season 1981/1982 etc).

Year\ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Catch
1975	1.518	2.049	31.975	6.493	7.905	0.863	0.442	0.345	0.114	0.004	0.001	0.001	0.001	0.001	13.280
1976	0.614	9.848	3.908	34.144	7.009	5.481	1.045	0.438	0.296	0.134	0.092	0.001	0.001	0.001	17.168
1977	0.705	18.853	24.152	10.404	46.357	6.735	5.421	1.395	0.524	0.362	0.027	0.128	0.001	0.001	28.925
1978	2.634	22.551	50.995	13.846	8.738	39.492	7.253	6.354	1.616	0.926	0.4	0.017	0.025	0.051	37.333
1979	0.929	15.098	47.561	69.735	16.451	8.003	26.04	3.05	1.869	0.494	0.439	0.032	0.054	0.006	45.072
1980	3.147	14.347	20.761	60.727	65.328	11.541	9.285	19.442	1.796	1.464	0.698	0.001	0.11	0.079	53.268
1981	2.283	4.629	16.771	12.126	36.871	41.917	7.299	4.863	13.416	1.032	0.884	0.760	0.101	0.062	39.544
1982	0.454	19.187	28.109	38.280	16.623	38.308	43.770	6.813	6.633	10.457	2.354	0.594	0.075	0.211	56.528
1983	1.475	22.499	151.718	30.285	21.599	8.667	14.065	13.713	3.728	2.381	3.436	0.554	0.100	0.003	58.867
1984	0.421	18.015	32.244	141.354	17.043	7.113	3.916	4.113	4.517	1.828	0.202	0.255	0.260	0.003	50.304
1985	0.112	12.872	24.659	21.656	85.210	11.903	5.740	2.336	4.363	4.053	2.773	0.975	0.480	0.581	49.368
1986	0.100	8.172	33.938	23.452	20.681	77.629	18.252	10.986	8.594	9.675	7.183	3.682	2.918	1.788	65.500
1987	0.029	3.144	44.590	60.285	20.622	19.751	46.240	15.232	13.963	10.179	13.216	6.224	4.723	2.280	75.439
1988	0.879	4.757	41.331	99.366	69.331	22.955	20.131	32.201	12.349	10.250	7.378	7.284	4.807	1.957	92.828
1989	3.974	22.628	26.649	77.824	188.654	43.114	8.116	5.897	7.292	4.780	3.449	1.410	0.844	0.348	101.000
1990	12.567	14.884	56.995	35.593	79.757	157.225	30.248	8.187	4.372	3.379	1.786	0.715	0.446	0.565	105.097
1991	37.085	88.683	49.081	86.292	34.793	55.228	110.132	10.079	4.155	2.735	2.003	0.519	0.339	0.416	109.489
1992	16.144	94.86	122.626	38.381	58.605	27.921	38.42	53.114	11.592	1.727	1.757	0.153	0.376	0.001	108.504
1993	2.467	51.153	177.78	92.68	20.791	28.56	13.313	19.617	15.266	4.254	0.797	0.254	0.001	0.001	102.741
1994	5.738	134.616	113.29	142.876	87.207	24.913	20.303	16.301	15.695	14.68	2.936	1.435	0.244	0.195	134.003
1995	4.555	20.991	137.232	86.864	109.14	76.78	21.361	15.225	8.541	9.617	7.034	2.291	0.621	0.235	125.851
1996	0.717	15.969	40.311	86.187	68.927	84.66	39.664	14.746	8.419	5.836	3.152	5.18	1.996	0.574	95.882
1997	2.008	39.24	30.141	26.307	36.738	33.705	31.022	22.277	8.531	3.383	1.141	10.296	0.947	2.524	64.682
1998	23.655	45.39	175.529	22.691	8.613	40.898	25.944	32.046	14.647	2.122	2.754	2.15	1.07	1.011	86.998
1999	5.306	56.315	54.779	140.913	16.093	13.506	31.467	19.845	22.031	12.609	2.673	2.746	1.416	2.514	92.896
2000	17.286	57.282	136.278	49.289	76.614	11.546	8.294	16.367	9.874	11.332	6.744	2.975	1.539	1.104	100.332
2001	27.486	42.304	86.422	93.597	30.336	54.491	10.375	8.762	12.244	9.907	8.259	6.088	1.491	1.259	95.675
2002	11.698	80.863	70.801	45.607	54.202	21.211	42.199	9.888	4.707	6.52	9.108	9.355	3.994	5.697	96.128
2003	24.477	211.495	286.017	58.120	27.979	25.592	14.203	10.944	2.230	3.424	4.225	2.562	1.575	1.370	130.741
2004	23.144	63.355	139.543	182.45	40.489	13.727	9.342	5.769	7.021	3.136	1.861	3.871	0.994	1.855	114.237
2005	6.088	26.091	42.116	117.91	133.437	27.565	12.074	9.203	5.172	5.116	1.045	1.706	2.11	0.757	103.043
2006	52.567	118.526	217.672	54.800	48.312	57.241	13.603	5.994	4.299	0.898	1.626	1.213	0.849	0.933	135.303
2007	10.817	94.250	83.631	163.294	61.207	87.541	92.126	23.238	11.728	7.319	2.593	4.961	2.302	1.420	158.917
2008	10.427	38.830	90.932	79.745	107.644	59.656	62.194	54.345	18.130	8.240	5.157	2.680	2.630	1.178	151.780
2009	5.431	21.856	35.221	31.914	18.826	22.725	10.425	9.213	9.549	2.238	1.033	0.768	0.406	0.298	46.332
2010	1.476	8.843	22.674	29.492	24.293	14.419	17.407	10.045	7.576	8.896	1.764	1.105	0.672	0.555	43.533
2011	0.521	9.357	24.621	20.046	22.869	23.706	13.749	16.967	10.039	7.623	7.745	1.441	0.618	0.785	49.446
2012*	0.403	17.827	89.432	51.257	43.079	51.224	41.846	34.653	27.215	24.946	15.473	13.575	2.595	0.253	125.369
2013	6.888	46.848	24.833	35.070	17.250	18.550	19.032	21.821	15.952	15.804	10.081	9.775	6.722	2.486	72.058
2014	0.000	3.537	53.241	50.609	70.044	34.393	22.084	22.138	13.298	17.761	7.974	4.461	2.862	1.746	94.975
2015	0.089	6.024	29.89	53.573	43.501	43.015	15.533	10.76	8.664	8.161	6.981	2.726	2.467	1.587	69.729
2016	0.072	10.740	25.575	29.908	41.952	25.823	24.925	9.516	7.734	6.088	4.284	7.154	3.108	0.827	60.403
2017	1.262	5.236	31.855	18.113	10.239	15.506	10.223	8.830	5.676	3.399	1.616	2.220	1.533	1.596	35.034
2018	0.000	8.911	19.642	34.284	16.847	12.376	17.161	6.978	7.379	3.482	1.713	1.153	2.159	0.489	40.683
2019	0.461	4.601	15.845	12.970	16.084	12.244	6.944	9.531	6.167	4.732	2.983	2.808	2.200	1.866	30.038
2020	0.384	23.603	15.956	22.572	16.333	19.385	11.071	7.098	6.241	3.035	3.359	1.809	1.567	1.129	36.100

*** Includes both the landings (73.4 kt) and the herring that died in the mass mortality (52.0 kt) in the winter 2012/13 in Kolgrafafjörður.**

Table 11.2.2.2. Icelandic summer-spawning herring. The mean weight (g) at age from the commercial catch (1981 refers to season 1981/1982 etc.).

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	110	179	241	291	319	339	365	364	407	389	430	416	416	416
1976	103	189	243	281	305	335	351	355	395	363	396	396	396	396
1977	84	157	217	261	285	313	326	347	364	362	358	355	400	420
1978	73	128	196	247	295	314	339	359	360	376	380	425	425	425
1979	75	145	182	231	285	316	334	350	367	368	371	350	350	450
1980	69	115	202	232	269	317	352	360	380	383	393	390	390	390
1981	61	141	190	246	269	298	330	356	368	405	382	400	400	400
1982	65	141	186	217	274	293	323	354	385	389	400	394	390	420
1983	59	132	180	218	260	309	329	356	370	407	437	459	430	472
1984	49	131	189	217	245	277	315	322	351	334	362	446	417	392
1985	53	146	219	266	285	315	335	365	388	400	453	469	433	447
1986	60	140	200	252	282	298	320	334	373	380	394	408	405	439
1987	60	168	200	240	278	304	325	339	356	378	400	404	424	430
1988	75	157	221	239	271	298	319	334	354	352	371	390	408	437
1989	63	130	206	246	261	290	331	338	352	369	389	380	434	409
1990	80	127	197	245	272	285	305	324	336	362	370	382	375	378
1991	74	135	188	232	267	289	304	323	340	352	369	402	406	388
1992	68	148	190	235	273	312	329	339	355	382	405	377	398	398
1993	66	145	211	246	292	324	350	362	376	386	419	389	389	389
1994	66	134	201	247	272	303	333	366	378	389	390	412	418	383
1995	68	130	183	240	277	298	325	358	378	397	409	431	430	467
1996	75	139	168	212	258	289	308	325	353	353	377	404	395	410
1997	63	131	191	233	269	300	324	341	355	362	367	393	398	411
1998	52	134	185	238	264	288	324	340	348	375	406	391	426	456
1999	74	137	204	233	268	294	311	339	353	362	378	385	411	422
2000	62	159	217	268	289	325	342	363	378	393	407	425	436	430
2001	74	139	214	244	286	296	324	347	354	385	403	421	421	433
2002	85	161	211	258	280	319	332	354	405	396	416	433	463	460
2003	72	156	189	229	260	283	309	336	336	369	394	378	412	423
2004	84	149	213	248	280	315	331	349	355	379	388	412	419	425
2005	106	170	224	262	275	298	324	335	335	356	372	394	405	413
2006	107	189	234	263	290	304	339	349	369	416	402	413	413	467
2007	93	158	221	245	261	277	287	311	339	334	346	356	384	390
2008	105	174	232	275	292	307	315	327	345	366	377	372	403	434
2009	113	190	237	274	304	318	326	335	342	360	372	394	409	421
2010	87	204	243	271	297	315	329	335	341	351	367	366	405	416
2011	97	187	245	283	309	328	343	352	356	364	375	386	378	432
2012	65	206	244	282	301	320	333	344	350	359	364	367	373	391
2013	95	182	238	271	300	322	337	349	360	365	362	375	377	394
2014		202	259	288	306	328	346	354	362	366	367	380	383	403
2015	107	203	249	275	299	313	329	347	352	358	361	368	380	378
2016	129	202	242	281	303	322	336	355	359	368	369	379	386	402
2017	95	192	252	281	303	324	341	350	367	376	384	389	395	402
2018		191	252	293	317	333	347	350	366	375	389	388	392	383
2019	103	175	244	282	305	308	328	340	349	357	360	366	374	374
2020	81	140	229	267	288	311	329	345	351	367	372	370	382	398

Table 11.2.2.3. Icelandic summer-spawning herring. Proportion mature at age (1981 refers to season 1981/1982 etc.).

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	0	0.27	0.97	1	1	1	1	1	1	1	1	1	1	1
1976	0	0.13	0.9	1	1	1	1	1	1	1	1	1	1	1
1977	0	0.02	0.87	1	1	1	1	1	1	1	1	1	1	1
1978	0	0.04	0.78	1	1	1	1	1	1	1	1	1	1	1
1979	0	0.07	0.65	0.98	1	1	1	1	1	1	1	1	1	1
1980	0	0.05	0.92	1	1	1	1	1	1	1	1	1	1	1
1981	0	0.03	0.65	0.99	1	1	1	1	1	1	1	1	1	1
1982	0.02	0.05	0.85	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0.64	1	1	1	1	1	1	1	1	1	1	1
1984	0	0.01	0.82	1	1	1	1	1	1	1	1	1	1	1
1985	0	0	0.9	1	1	1	1	1	1	1	1	1	1	1
1986–2020	0	0.2	0.85	1	1	1	1	1	1	1	1	1	1	1

Table 11.3.2.1. Icelandic summer-spawning herring. Natural mortality at age for the different years (refers to the autumn) where the deviation from the fixed M = 0.1 is due to the *Ichthyophonus* infection (1981 refers to season 1981/1982 etc.). The estimate of, for example, M for age 4 in 2020 represents estimated infection rate of age 3 in 2019.

Year\age	3	4	5	6	7	8	9	10	11	12	13	14	15	13+
1987–2008	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2009*	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
2010*	0.29	0.29	0.28	0.26	0.25	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23
2011*	0.13	0.26	0.26	0.25	0.23	0.24	0.25	0.24	0.20	0.21	0.21	0.21	0.21	0.21
2012-2016	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
2017	0.111	0.118	0.124	0.173	0.175	0.175	0.207	0.187	0.256	0.279	0.210	0.180	0.191	0.183
2018	0.116	0.112	0.172	0.162	0.175	0.228	0.226	0.247	0.275	0.338	0.307	0.184	0.186	0.250
2019**	0.111	0.135	0.144	0.168	0.216	0.169	0.171	0.183	0.245	0.189	0.243	0.182	0.140	0.189
2020***	0.119	0.146	0.122	0.155	0.191	0.164	0.193	0.159	0.230	0.100	0.146	0.151	0.100	0.275

*** Based on prevalence of infection estimates and acoustic measurements ($M_{infected}$ multiplied by 0.3 and added to 0.1; Óskarsson *et al.* 2018b).**

**** Based on prevalence of infection estimates in the winter 2019/20 and 2020/21 (multiplied by 0.3 and added to 0.1; Óskarsson and Pálsson, 2017; 2018).**

***** Based on prevalence of infection estimates in the winter 2020/21 (multiplied by 0.3 and added to 0.1) and should be applied in the prognosis in the 2021 assessment.**

Table 11.3.2.2. Model settings and results of model parameters from the final NFT-Adapt run in 2021 for Icelandic summer spawning herring.

VPA Version 3.3.0

Model ID: RUN1 2021

Input File: C:\HAFRONET_GOGN\NWWG OG UTTEKTIR\NWWG2021\VPA\RUN1_2021_R_00.DAT

Date of Run: 26-APR-2021 Time of Run: 13:27

Levenburg-Marquardt Algorithm Completed 7 Iterations

Residual Sum of Squares = 59.4232

Number of Residuals = 264

Number of Parameters = 9

Degrees of Freedom = 255

Mean Squared Residual = 0.233032

Standard Deviation = 0.482734

Number of Years = 34

Number of Ages = 11

First Year = 1987

Youngest Age = 3

Oldest True Age = 12

Number of Survey Indices Available = 10

Number of Survey Indices Used in Estimate = 8

VPA Classic Method - Auto Estimated Q's

Stock Numbers Predicted in Terminal Year Plus One (2021)

Age	Stock Predicted	Std. Error	CV
4	1130123.745	0.554399E+06	0.490565E+00
5	257398.668	0.918374E+05	0.356791E+00
6	88145.395	0.293167E+05	0.332595E+00
7	29378.669	0.103832E+05	0.353427E+00
8	64413.772	0.196232E+05	0.304643E+00
9	39228.065	0.111259E+05	0.283621E+00
10	34522.515	0.900332E+04	0.260795E+00
11	43267.578	0.109880E+05	0.253954E+00
12	31864.455	0.865457E+04	0.271606E+00

Catchability Values for Each Survey Used in Estimate

INDEX	Catchability	Std. Error	CV
1	0.986382E+00	0.940359E-01	0.953342E-01
2	0.127444E+01	0.106471E+00	0.835434E-01
3	0.138258E+01	0.797671E-01	0.576942E-01
4	0.150767E+01	0.959402E-01	0.636346E-01

5	0.159940E+01	0.113761E+00	0.711275E-01
6	0.178267E+01	0.144659E+00	0.811474E-01
7	0.189357E+01	0.201581E+00	0.106456E+00
8	0.177107E+01	0.187207E+00	0.105703E+00

-- Non-Linear Least Squares Fit --

Maximum Marquadt Iterations = 100

Scaled Gradient Tolerance = 6.055454E-05

Scaled Step Tolerance = 1.000000E-18

Relative Function Tolerance = 1.000000E-18

Absolute Function Tolerance = 4.930381E-32

Reported Machine Precision = 2.220446E-16

VPA Method Options

- Catchability Values Estimated as an Analytic Function of N
- Catch Equation Used in Cohort Solution
- Plus Group Forward Calculation Method Used
- Arithmetic Average Used in F-Oldest Calculation
- F-Oldest Calculation in Years Prior to Terminal Year

  Uses Fishing Mortality in Ages 8 to 11
- Calculation of Population of Age 3 In Year 2021

  = Geometric Mean of First Age Populations

  Year Range Applied = 1991 to 2014
- Survey Weight Factors Were Used

Stock Estimates

Age 4

Age 5

Age 6

Age 7

Age 8

Age 9

Age 10

Age 11

Age 12

Full F in Terminal Year = 0.2098

F in Oldest True Age in Terminal Year = 0.1512

Full F Calculated Using Classic Method

F in Oldest True Age in Terminal Year has been

Calculated in Same Manner as in All Other Years

Age	Input Partial Recruitment	Calc Partial Recruitment	Fishing Mortality	Used In Full F	Comments
3	0.500	0.048	0.0196	NO	Stock Estimate in T+1
4	0.800	0.139	0.0568	NO	Stock Estimate in T+1
5	1.000	0.521	0.2123	YES	Stock Estimate in T+1
6	1.000	1.000	0.4073	YES	Stock Estimate in T+1
7	1.000	0.600	0.2444	YES	Stock Estimate in T+1
8	1.000	0.568	0.2313	YES	Stock Estimate in T+1
9	1.000	0.418	0.1702	YES	Stock Estimate in T+1
10	1.000	0.301	0.1225	YES	Stock Estimate in T+1
11	1.000	0.199	0.0809	YES	Stock Estimate in T+1
12	1.000	0.371	0.1512		F-Oldest

Table 11.3.2.3. Icelandic summer spawners stock estimates (from NFT-Adapt in 2021) in numbers (millions) by age (years) at 1 January during 1987–2021.

Year\Age	3	4	5	6	7	8	9	10	11	12	13+	Total
1987	529.83	988.96	300.67	84.6	69.14	107.46	42.63	38.03	26.41	34.26	34.29	2256.28
1988	270.99	476.42	852.47	214.85	56.99	43.83	53.49	24.15	21.19	14.26	36.99	2065.62
1989	447.32	240.68	391.81	676.97	128.7	29.84	20.62	18.03	10.18	9.48	26.1	1999.74
1990	300.82	383.25	192.47	280.67	433.68	75.61	19.3	13.07	9.41	4.69	26.46	1739.43
1991	840.53	258.05	292.66	140.37	178.35	243.51	39.78	9.72	7.68	5.31	24.86	2040.81
1992	1033.07	676.3	186.91	183.01	94.01	109.04	116.17	26.44	4.86	4.36	24.19	2458.36
1993	635.4	844.64	495.55	132.7	110.06	58.6	62.27	54.88	12.95	2.76	23.67	2433.49
1994	691.69	526.33	595.58	360.43	100.33	72.5	40.39	37.75	35.19	7.69	22.92	2490.81
1995	202.69	498.11	368.75	403.38	243.41	67.16	46.36	21.12	19.31	17.95	23.14	1911.36
1996	181.37	163.46	320.6	251.26	261.5	147.48	40.52	27.52	11.03	8.38	27.53	1440.65
1997	772.48	148.94	109.67	208.36	162	156.4	95.84	22.7	16.92	4.46	22.16	1719.93
1998	320.43	661.68	106.16	74.28	153.66	114.6	112.07	65.59	12.46	12.1	10.03	1643.06
1999	552.47	246.83	432.26	74.53	59.03	100.26	79.08	71.03	45.45	9.26	13.4	1683.61
2000	391.18	446.4	171.37	257.61	52.17	40.6	60.9	52.74	43.39	29.17	11.67	1557.18
2001	468.43	299.56	274.75	108.34	160.47	36.25	28.87	39.58	38.35	28.51	25.24	1508.35
2002	1455.46	383.66	189.13	159.94	69.27	93.58	22.97	17.81	24.21	25.3	32.44	2473.75
2003	1074.87	1240.11	279.95	127.87	93.37	42.57	44.76	11.42	11.66	15.72	25.65	2967.95
2004	663.28	771.87	850.77	198.16	89.15	60.22	25.07	30.12	8.22	7.3	28.2	2732.36
2005	991.08	539.98	565.97	596.69	140.88	67.64	45.62	17.21	20.59	4.47	23.99	3014.11
2006	736.81	871.97	448.57	400.23	413.31	101.32	49.74	32.54	10.67	13.78	20.42	3099.35
2007	658.32	554.17	582.54	353.84	316.26	319.63	78.76	39.31	25.36	8.8	26.55	2963.54
2008	526.78	506.71	423.38	375.43	259.83	201.22	200.64	49.06	24.43	15.98	21.3	2604.75
2009	444.7	439.76	372.18	307.4	237.65	178.51	123.12	130.02	27.22	14.3	22.7	2297.55
2010	468.5	338.4	322.49	271.05	230.6	170.99	134.37	90.87	96.12	19.91	27.54	2170.83
2011	532.88	342.25	233.22	218.93	187.97	166.92	118.63	96.72	64.93	68.33	34.04	2064.82
2012	394.18	459.16	242.63	162.99	150.43	128.05	119.41	77.77	67.37	46.19	73.87	1922.04
2013	478.67	339.72	330.59	170.9	106.63	87.59	76.21	75.2	44.59	37.33	78.39	1825.83
2014	240.45	388.62	283.8	265.82	138.25	78.88	61.19	48.27	52.91	25.37	77.15	1660.71
2015	223.09	214.21	301.08	208.75	174.1	92.48	50.43	34.4	31.07	31.05	76.59	1437.25
2016	288.88	196.13	165.44	221.58	147.61	116.73	68.93	35.42	22.91	20.38	84.33	1368.34
2017	122.79	251.18	153.18	121.31	160.67	109.05	81.98	53.33	24.72	14.96	80.15	1173.31
2018	191.51	104.94	193.25	118.33	92.67	120.71	82.2	58.72	39.09	16.16	71.16	1088.74
2019	346.73	162.14	75.3	131.39	85.15	66.49	80.87	59.37	39.38	26.67	62.17	1135.65
2020	1286.45	305.95	126.88	53.17	96.33	57.67	49.79	59.44	43.83	26.66	64.56	2170.73
2021	572	1130.12	257.4	88.15	29.38	64.41	39.23	34.52	43.27	31.86	65.33	2328.37

Table 11.3.2.4. Estimated fishing mortality at age of Icelandic summer-spawning herring (from NFT-Adapt in 2021) by age (years) during 1987–2020 (referring to the autumn of the fishing season) and weighed average F by numbers for age 5–10.

Year\Age	3	4	5	6	7	8	9	10	11	12	13+	WF5-10
1987	0.006	0.049	0.236	0.295	0.356	0.598	0.468	0.485	0.516	0.517	0.517	0.347
1988	0.019	0.096	0.131	0.412	0.547	0.654	0.988	0.764	0.704	0.777	0.506	0.266
1989	0.055	0.124	0.234	0.345	0.432	0.336	0.356	0.550	0.674	0.479	0.111	0.322
1990	0.053	0.170	0.216	0.353	0.477	0.542	0.586	0.431	0.472	0.508	0.071	0.400
1991	0.117	0.223	0.370	0.301	0.392	0.640	0.309	0.593	0.466	0.502	0.055	0.436
1992	0.101	0.211	0.243	0.409	0.373	0.460	0.650	0.613	0.465	0.547	0.023	0.415
1993	0.088	0.249	0.218	0.180	0.317	0.272	0.400	0.345	0.421	0.360	0.011	0.248
1994	0.228	0.256	0.290	0.293	0.302	0.347	0.549	0.571	0.573	0.510	0.090	0.312
1995	0.115	0.341	0.284	0.333	0.401	0.405	0.422	0.550	0.735	0.528	0.154	0.343
1996	0.097	0.299	0.331	0.339	0.414	0.331	0.479	0.386	0.804	0.500	0.350	0.361
1997	0.055	0.239	0.290	0.205	0.246	0.233	0.279	0.500	0.235	0.312	1.042	0.250
1998	0.161	0.326	0.254	0.130	0.327	0.271	0.356	0.267	0.197	0.273	0.582	0.280
1999	0.113	0.265	0.418	0.257	0.274	0.399	0.305	0.393	0.344	0.360	0.735	0.377
2000	0.167	0.385	0.359	0.373	0.264	0.241	0.331	0.219	0.320	0.278	0.700	0.335
2001	0.100	0.360	0.441	0.347	0.439	0.357	0.383	0.392	0.316	0.362	0.457	0.415
2002	0.060	0.215	0.291	0.438	0.387	0.638	0.598	0.324	0.332	0.473	0.947	0.418
2003	0.231	0.277	0.246	0.261	0.339	0.430	0.296	0.229	0.368	0.331	0.255	0.280
2004	0.106	0.210	0.255	0.241	0.176	0.178	0.276	0.280	0.510	0.311	0.287	0.244
2005	0.028	0.086	0.247	0.267	0.230	0.207	0.238	0.378	0.302	0.281	0.223	0.253
2006	0.185	0.303	0.137	0.136	0.157	0.152	0.135	0.149	0.093	0.132	0.167	0.144
2007	0.162	0.169	0.339	0.209	0.352	0.366	0.373	0.376	0.362	0.369	0.419	0.322
2008	0.081	0.209	0.220	0.357	0.275	0.391	0.334	0.489	0.436	0.412	0.384	0.310
2009	0.056	0.093	0.100	0.071	0.112	0.067	0.087	0.085	0.096	0.084	0.075	0.088
2010	0.022	0.080	0.110	0.107	0.073	0.122	0.088	0.098	0.109	0.104	0.100	0.101
2011	0.019	0.085	0.102	0.125	0.152	0.097	0.175	0.124	0.139	0.134	0.097	0.126
2012*	0.049	0.229	0.250	0.324	0.441	0.419	0.362	0.456	0.490	0.432	0.265	0.354
2013	0.108	0.080	0.118	0.112	0.202	0.259	0.357	0.252	0.464	0.333	0.293	0.175
2014	0.016	0.155	0.207	0.323	0.302	0.347	0.476	0.341	0.433	0.399	0.132	0.296
2015	0.029	0.158	0.207	0.247	0.300	0.194	0.253	0.307	0.322	0.269	0.098	0.240
2016	0.040	0.147	0.210	0.221	0.203	0.254	0.157	0.260	0.326	0.249	0.149	0.216
2017	0.046	0.144	0.134	0.096	0.111	0.108	0.127	0.124	0.169	0.132	0.076	0.116
2018	0.051	0.220	0.214	0.167	0.157	0.173	0.099	0.152	0.107	0.133	0.062	0.171
2019	0.014	0.110	0.204	0.142	0.174	0.120	0.137	0.120	0.145	0.131	0.129	0.151
2020	0.020	0.057	0.212	0.407	0.244	0.231	0.170	0.123	0.081	0.151	0.081	0.228

*** Derived from both the landings ($WF_{5–10}$ ~0.209) and the herring that died in the mass mortality (0.148) in the winter 2012/13 in Kolgrafafjörður (Óskarsson *et al.*, 2018a). WF5–10 without the mass mortality was 0.214.**

Table 11.3.2.5. Summary table from NFT-Adapt run in 2021 for Icelandic summer spawning herring.

Year	Recruits age 3 (millions)	Biomass age 3+ (kt)	Biomass age 4+ (kt)	SSB (kt)	Landings age 3+ (kt)	Yield/SSB	$WF_{age\ 5\text{-}10}$	HR 4+
1987	530	504	415	384	75	0.20	0.35	0.182
1988	271	495	452	423	93	0.22	0.27	0.205
1989	447	459	401	386	101	0.26	0.32	0.251
1990	301	410	371	350	104	0.30	0.40	0.281
1991	841	424	310	310	107	0.34	0.44	0.344
1992	1033	502	349	343	107	0.31	0.42	0.307
1993	635	546	454	424	103	0.24	0.25	0.226
1994	692	553	461	441	134	0.30	0.31	0.290
1995	203	462	435	406	125	0.31	0.34	0.288
1996	181	347	322	307	96	0.31	0.36	0.297
1997	772	368	267	269	65	0.24	0.25	0.243
1998	320	366	323	298	86	0.29	0.28	0.266
1999	552	373	297	290	93	0.32	0.38	0.312
2000	391	386	324	306	100	0.33	0.34	0.308
2001	468	347	282	272	94	0.34	0.41	0.332
2002	1455	512	278	297	96	0.32	0.42	0.346
2003	1075	579	411	389	129	0.33	0.28	0.313
2004	663	615	516	486	112	0.23	0.24	0.218
2005	991	705	537	526	102	0.19	0.25	0.191
2006	737	785	646	612	130	0.21	0.14	0.201
2007	658	699	595	569	158	0.28	0.32	0.265
2008	527	684	593	564	151	0.27	0.31	0.254
2009	445	628	543	489	46	0.09	0.09	0.084
2010	469	602	507	451	43	0.10	0.10	0.086
2011	533	575	476	429	49	0.12	0.13	0.104
2012	394	538	457	434	72	0.16	0.21	0.158
2013	479	486	399	384	71	0.19	0.18	0.179
2014	240	482	434	408	95	0.23	0.30	0.219
2015	223	409	364	347	70	0.20	0.24	0.192
2016	289	392	333	321	60	0.19	0.22	0.181
2017	123	350	326	296	35	0.12	0.12	0.107
2018	192	329	292	268	41	0.15	0.17	0.139
2019	347	305	244	229	30	0.13	0.15	0.123
2020	1286	437	257	260	36	0.14	0.23	0.140
2021	572	578	482	377				

*** The mass mortality of 52 thousand tonnes in Kolgrafafjörður in the winter 2012/13 is not included in the landings, yield/SSB, or WF, even if included as landings in the analytical assessment.**

Table 11.3.2.6. The residuals from survey observations and NFT-Adapt 2021 results for Icelandic summer spawning herring (no surveys in 1987 and 1995) on 1 January.

Year\Age	4	5	6	7	8	9	10	11
1987								
1988	-0.158	-0.236	0.036	-0.409	-0.768	-0.303	-0.220	-0.464
1989	-0.165	-0.763	-0.898	-0.029	-0.027	-0.354	-0.039	-0.034
1990	0.550	-0.313	-0.331	-0.098	0.396	-0.439	-0.128	-0.242
1991	-0.655	-0.366	-0.721	-0.342	0.278	0.112	0.715	-0.371
1992	0.454	0.398	0.234	-0.456	-0.232	0.216	-0.855	0.136
1993	-0.003	0.144	-0.145	-0.238	-0.548	-0.142	-0.073	0.067
1994	-0.027	0.151	-0.004	-0.815	-0.688	0.388	-0.380	-0.543
1995								
1996	-0.186	0.623	-0.223	-0.024	-0.288	0.307	-0.072	-0.185
1997	0.611	-0.045	0.487	0.100	0.264	0.241	0.771	0.616
1998	-0.081	-0.512	-0.582	0.214	-0.161	0.018	-0.161	0.474
1999	0.050	0.675	0.003	-0.541	-0.170	-0.693	-0.280	-0.400
2000	0.645	0.090	0.531	0.115	-0.404	0.423	-0.105	0.457
2001	1.186	1.324	0.243	0.690	-0.523	-1.185	-0.681	-1.557
2002	-0.277	-0.103	0.164	0.433	0.838	0.422	0.526	-0.110
2003	0.451	0.439	0.151	0.623	0.810	1.242	1.523	0.836
2004	0.634	0.641	0.188	-0.208	0.045	-0.144	-0.224	-0.727
2005	0.293	0.349	0.238	-0.215	-0.550	-0.607	-1.091	-0.421
2006	-0.661	-0.505	0.392	0.673	0.552	0.321	0.743	1.356
2007	0.107	0.356	-0.176	-0.116	0.305	-0.380	0.508	0.082
2008	-0.090	-0.623	0.042	-0.236	0.225	0.675	0.869	1.733
2009	-0.794	-0.129	-0.389	0.245	-0.067	0.028	-0.376	-0.477
2010	-0.055	0.177	0.392	-0.248	0.180	-0.474	-0.719	-0.081
2011	-0.185	-0.261	0.007	0.044	-0.655	0.354	-1.099	0.206
2012	0.769	0.341	0.331	0.182	0.156	-0.320	0.173	-0.344
2013	0.846	0.405	-0.349	-0.236	0.014	-0.210	-0.384	-0.061
2014	-0.197	-0.503	-0.063	-0.318	0.051	0.102	0.259	-0.045
2015	-0.850	-0.151	-0.101	-0.013	0.239	0.219	0.341	-0.374
2016	-0.164	-0.189	0.019	0.015	0.142	-0.271	-0.067	0.619
2017	-0.116	-0.353	-0.099	0.080	-0.243	0.502	-0.501	0.244
2018	-1.507	-0.952	0.048	0.368	0.505	0.356	0.831	0.091
2019	-0.152	-0.345	0.103	-0.230	0.041	0.149	0.376	0.050
2020	-0.272	-0.019	0.343	0.374	0.069	-0.502	-0.637	-0.609
2021	0.000	0.257	0.126	0.616	0.215	-0.050	0.453	0.077
Max. Residuals	1.186	1.324	0.531	0.690	0.838	1.242	1.523	1.733

Table 11.6.1.1. The input data used for prognosis of the Icelandic summer-spawning herring in the 2021 assessment: the predicted weights, the selection pattern, M, proportion of M before spawning, and the number-at-age derived from NFT-Adapt run.

Age (year class)	Mean weights (kg)	M	Maturity ogive	Selection pattern	Mortality prop. before spawning		Number at age
					F	M	1 January 2021
3 (2018)	0.153	0.11	0.200	0.207	0.000	0.500	572.0
4 (2017)	0.199	0.12	0.850	0.784	0.000	0.500	1130.1
5 (2016)	0.268	0.15	1.000	1.000	0.000	0.500	257.4
6 (2015)	0.297	0.12	1.000	1.000	0.000	0.500	88.1
7 (2014)	0.314	0.15	1.000	1.000	0.000	0.500	29.4
8 (2013)	0.332	0.19	1.000	1.000	0.000	0.500	64.4
9 (2012)	0.346	0.16	1.000	1.000	0.000	0.500	39.2
10 (2011)	0.358	0.19	1.000	1.000	0.000	0.500	34.5
11 (2010)	0.363	0.16	1.000	1.000	0.000	0.500	43.3
12 (2009)	0.375	0.23	1.000	1.000	0.000	0.500	31.9
13+ (2008+)	0.379	0.28	1.000	1.000	0.000	0.500	65.3

Table 11.6.2.1. Icelandic summer-spawning herring. Catch options table for the 2021/2022 season according to the Management plan where the basis is: SSB (1 July 2021) 377 kt (accounted for $M_{infection}$ in 2020); Biomass age 4+ (1 January 2021) is 481.6 kt; Catch (2020/21) 36.1 kt; HR (2020) 0.15, and $WF_{5\text{–}10}$(2020) 0.228. Other options are also shown, including MSY approach, where SSB_{2021} < MSY $B_{trigger}$ = 273 kt, hence resulting F = 0.217.

Rationale	Catches (2021/2022)	Basis	F (2021/2022)	Biomass of age 4+ (2022)	SSB 2022	%SSB change *	% TAC change **
Management plan	**72.2**	**HR = 0.15**	**0.217**	**441**	**421**	**12**	**100**
MSY approach	73.0	F_{MSY}=0.22	0.220	440	420	11	2
Zero catch	0	F = 0	0	515	492	30	-100
F_{pa}	45.4	F_{pa} = 0.43	0.430	379	363	-4	29
F_{lim}	106.9	F_{lim} = 0.61	0.612	334	321	-15	204

***SSB 2022 relative to SSB 2021**

****TAC 2021/22 relative to landings 2020/21**

11.19 Figures

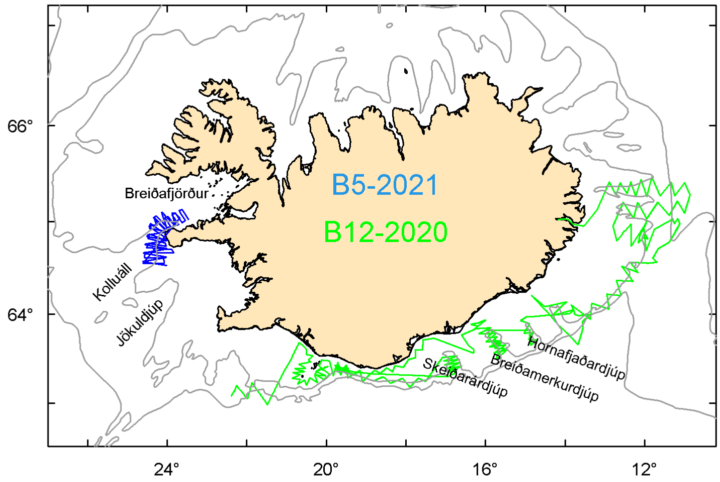


Figure 11.1.2.1. The survey tracks of two acoustic surveys on Icelandic summer-spawning herring in the south and south-east (B12-2020; juveniles; green) and in the west (B5-2021; adult; blue) in 2020/21 and locations of the areas that are referred to in the text.

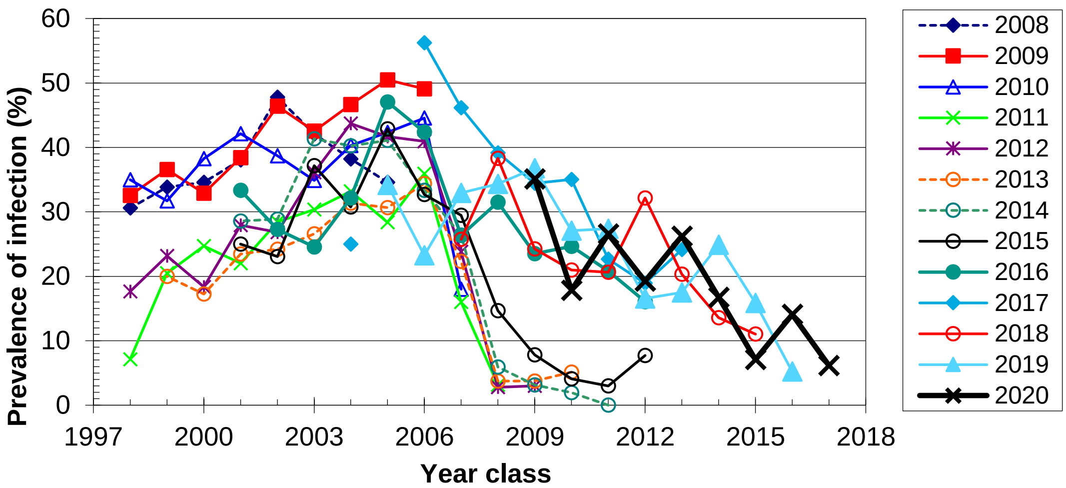


Figure 11.1.3.1. The prevalence of the *Ichthyophonus* infection for each age of Icelandic summer-spawning herring as estimated from catch samples southwest of Iceland in the autumn (Oct.–Dec.) and samples southeast of Iceland from the acoustic survey (Nov).

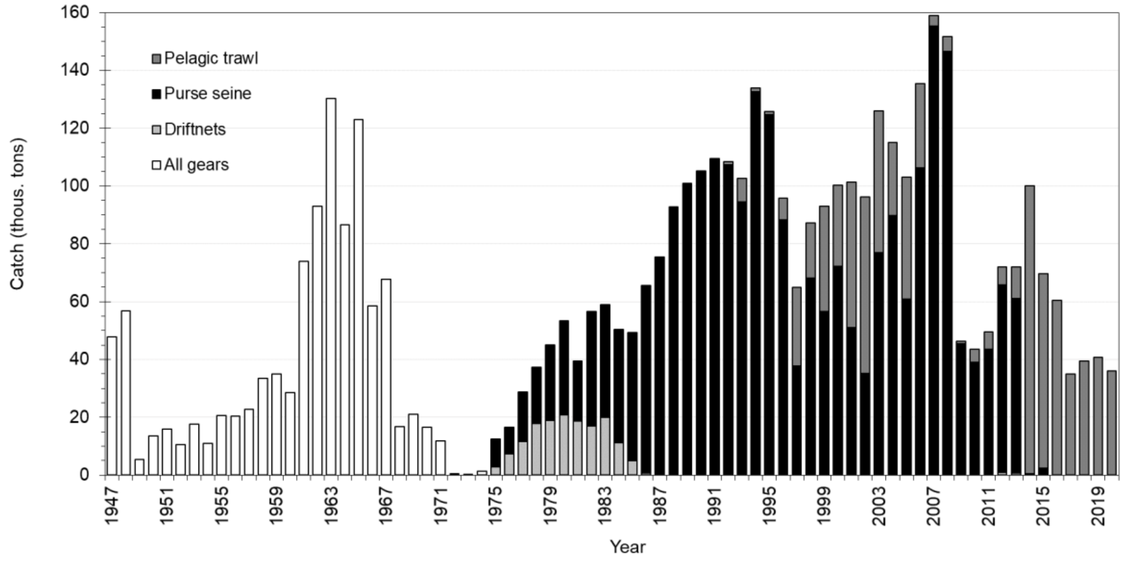


Figure 11.2.1. Icelandic summer spawning herring. Seasonal total landings (in thousand tonnes) during 1947–2020, referring to the autumns, by different fishing gears from 1975 onwards).

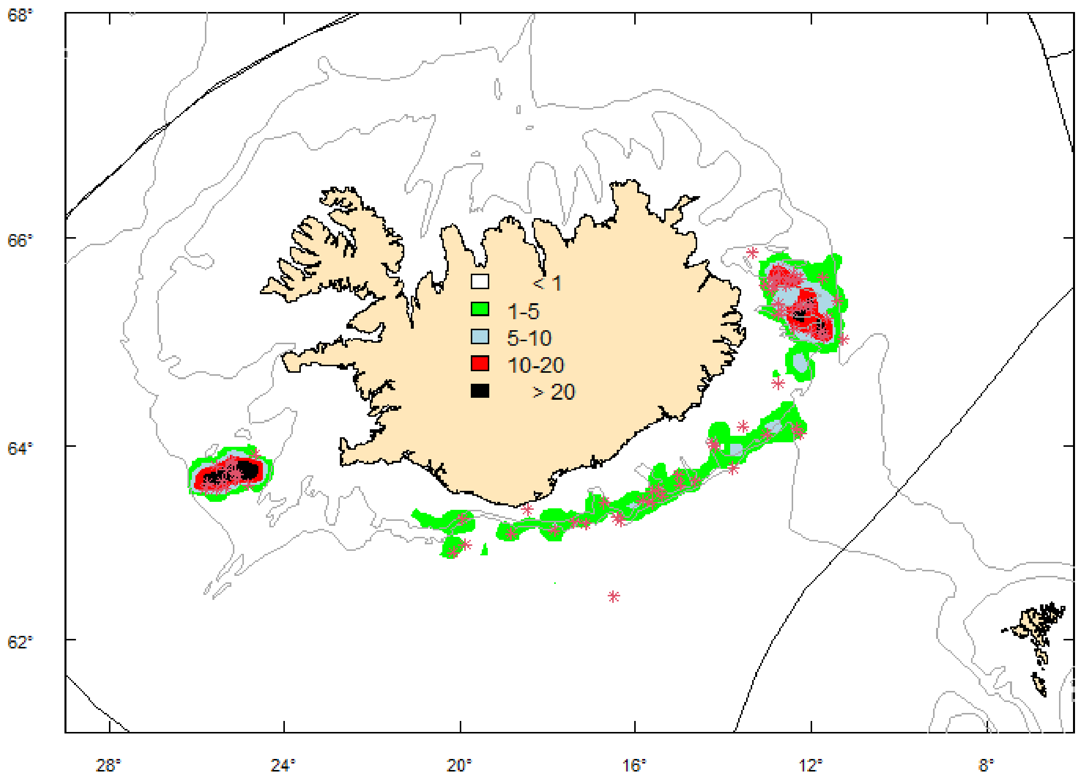


Figure 11.2.2. The distribution of the fishery (in tonnes) of Icelandic summer spawning herring during the fishing season 2020/21, including the bycatch in the mackerel fishery in July–September 2020. The stars indicate the location of catch samples.

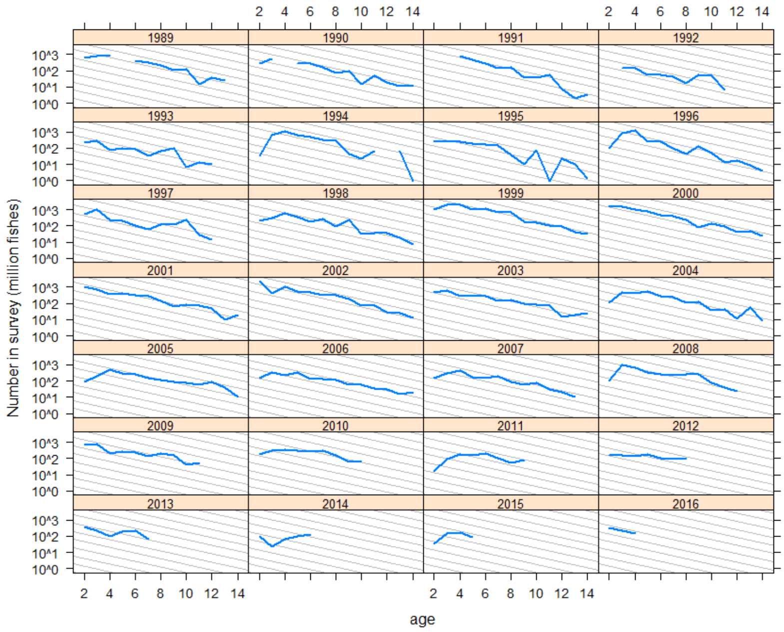


Figure 11.3.1.1. Icelandic summer-spawning herring. Catch curves (log_2 of catches) by year classes 1987–2016. Grey lines correspond to Z = 0.4. Note that the mass mortality in Kolgrafafjörður is added to the catches in 2012.

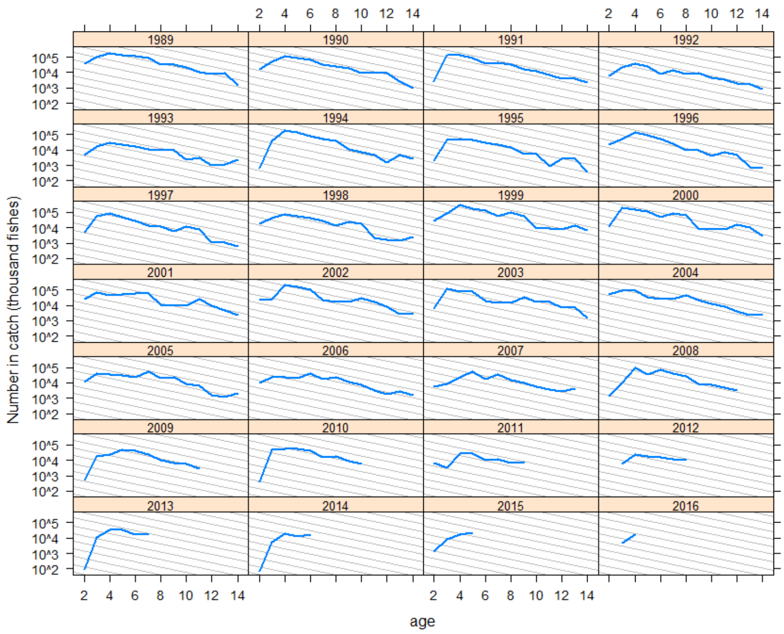


Figure 11.3.1.2. Icelandic summer spawning herring. Catch curves (log_2 of indices) from survey data by year classes 1987–2016. Grey lines correspond to Z = 0.4.

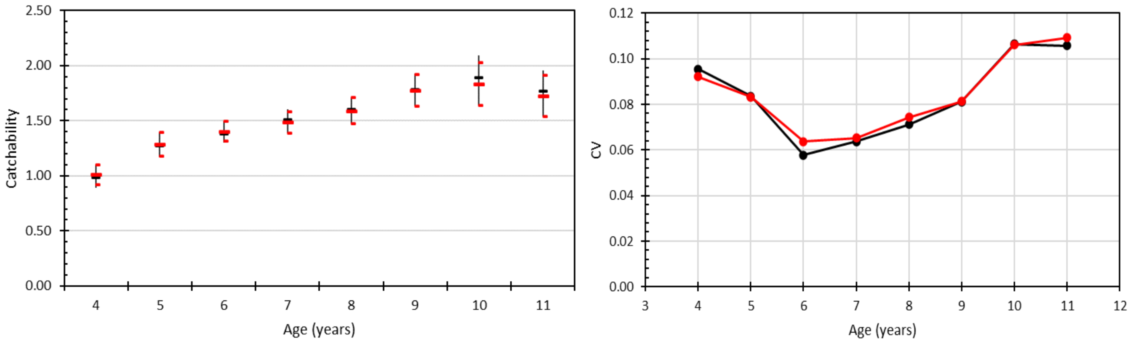


Figure 11.3.2.1. Icelandic summer-spawning herring. The catchability (± 2 SE; left graph) and its CV (right graph) for the acoustic surveys used in the final Adapt run in 2021 (1987–2020) compared to the assessment in 2020 (red lines).

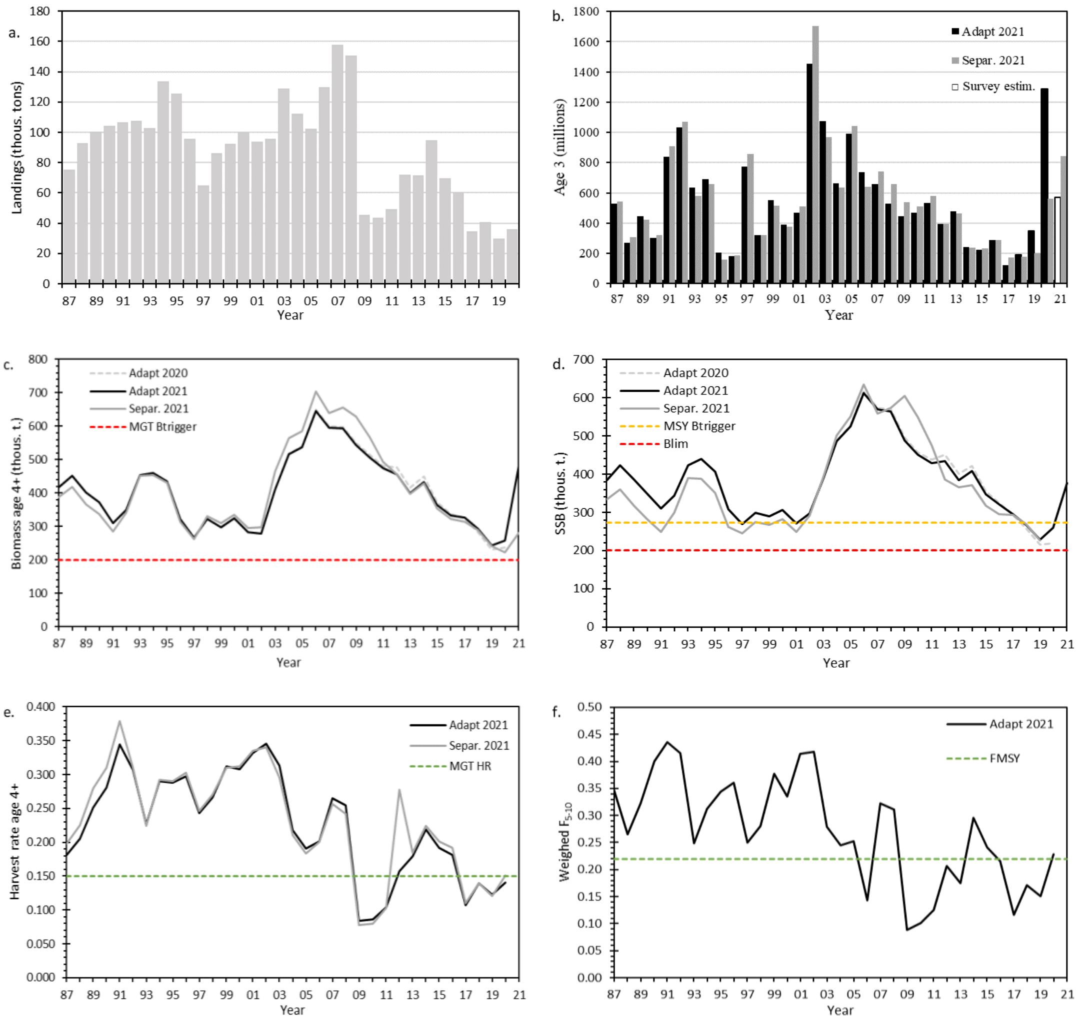


Figure 11.3.2.2. Icelandic summer-spawning herring. Comparisons of the final NFT-Adapt run in 2021, NFT-Adapt run in 2020 and a run from a separable model (Muppet) in 2021 concerning (a) landings, (b) number at age-3 (recruitment), (c) biomass of age 4+ (reference biomass) and (d) SSB. Harvest rate (e) of the reference biomass (HR_{MGT} shown) and (f) N-weighed F for age 5–10. Some reference points are also shown. Note that the mass mortality in Kolgrafafjörður in the winter 2012/13 is included in harvest rate (e) for Muppet but not in Adapt run 2021.

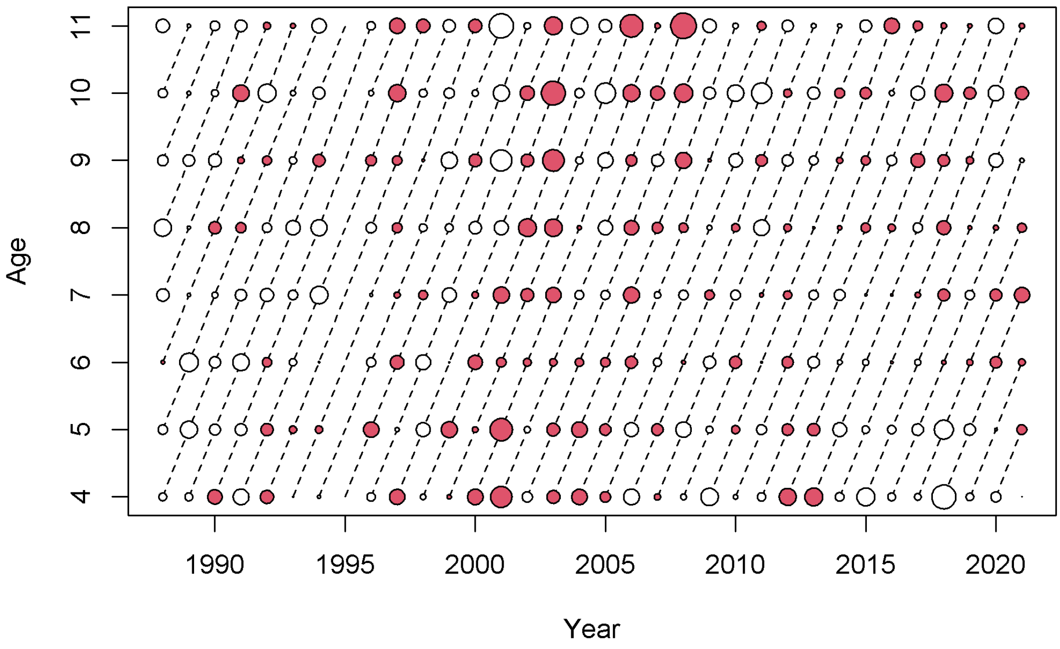


Figure 11.3.2.3. Icelandic summer spawning herring. Residuals of NFT-Adapt run in 2021 from survey observations (moved to 1 January). Filled bubbles are positive (i.e. survey estimates higher than the assessment) and open negative. Max bubble = 1.73.

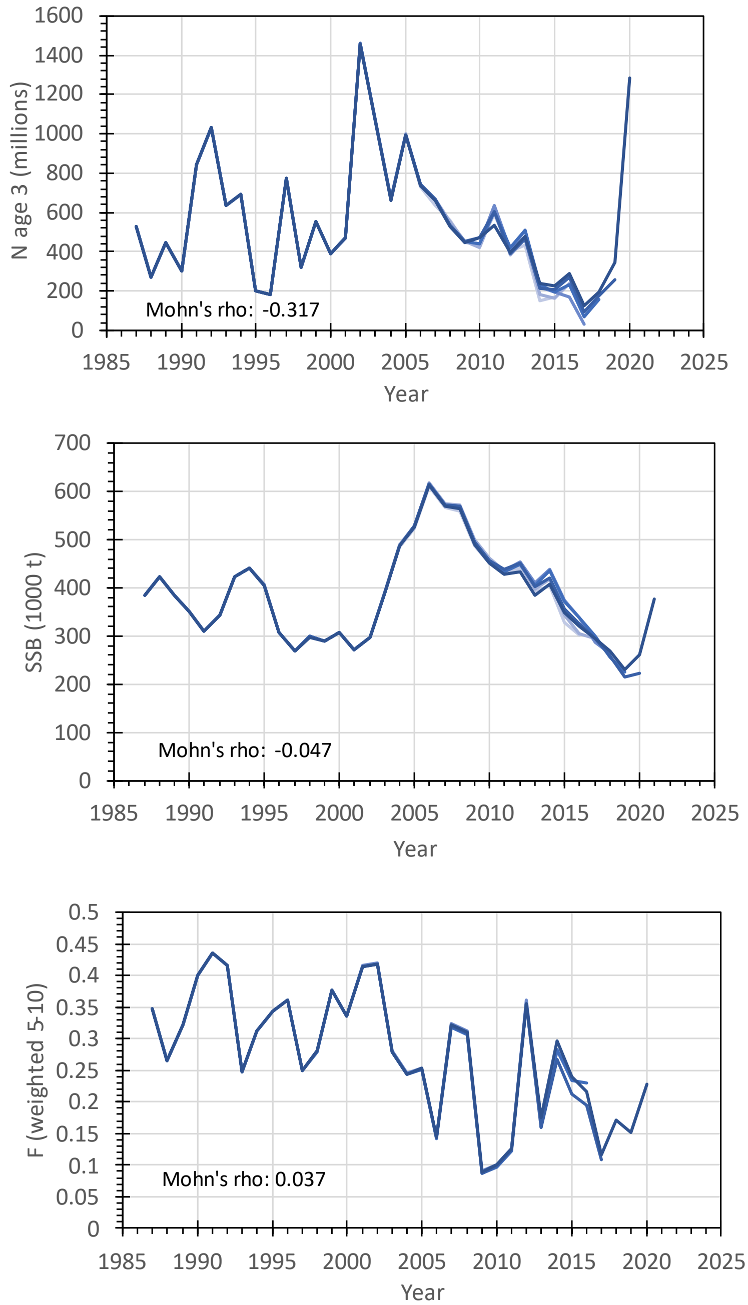
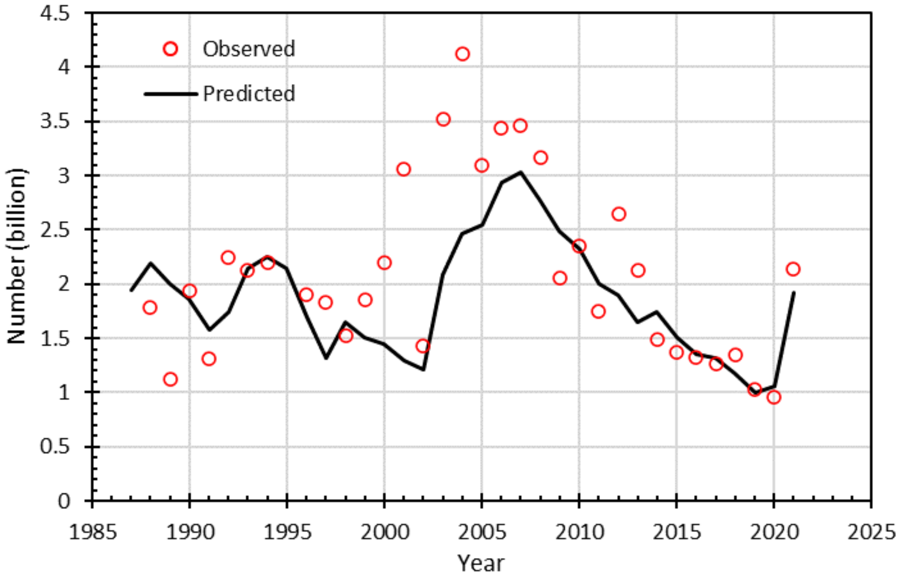


Figure 11.3.2.4. Icelandic summer spawning herring. Six years (2014–2021) retrospective pattern from NFT-Adapt in 2021 in recruitment as number at age 3 (the top panel), spawning stock biomass (middle panel) and N weighted F_{5-10} (lowest panel).



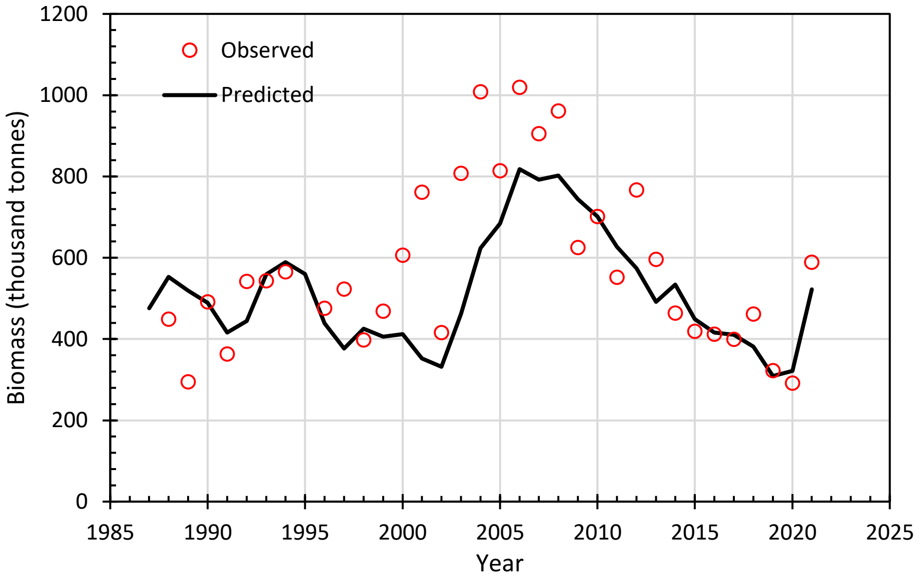


Figure 11.3.2.5. Icelandic summer-spawning herring. Observed versus predicted survey values from NFT-Adapt run in 2021 for ages 4–11 with respect to numbers (upper) and biomass (lower). Note that there was no survey in 1995.

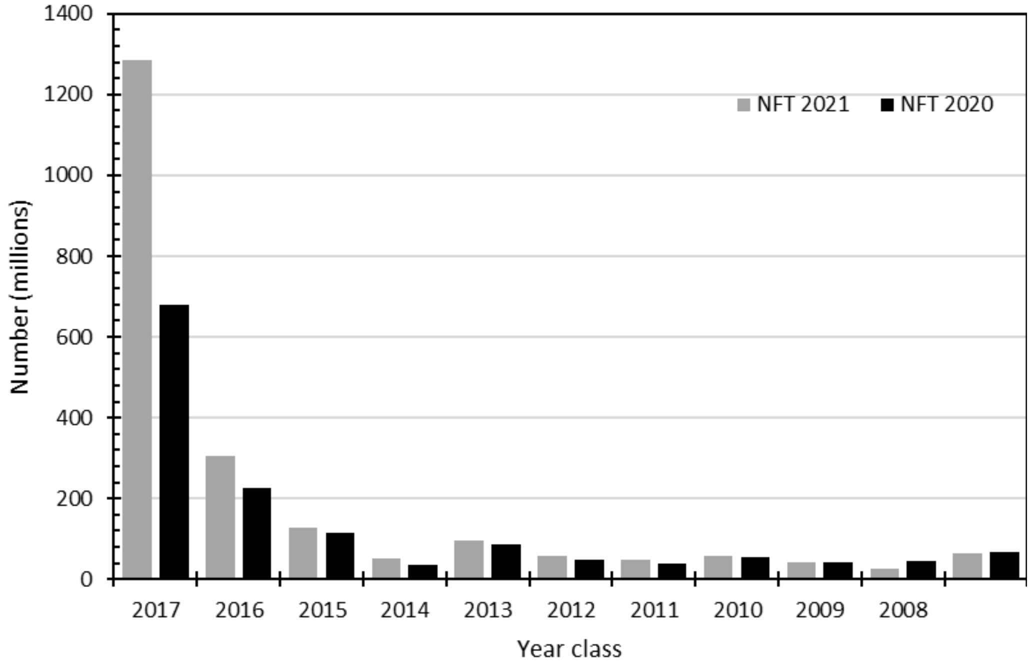


Figure 11.3.2.6. Icelandic summer-spawning herring. Comparison of number-at-age on 1 January from the final NFT model runs in 2020 and 2021 assessments.

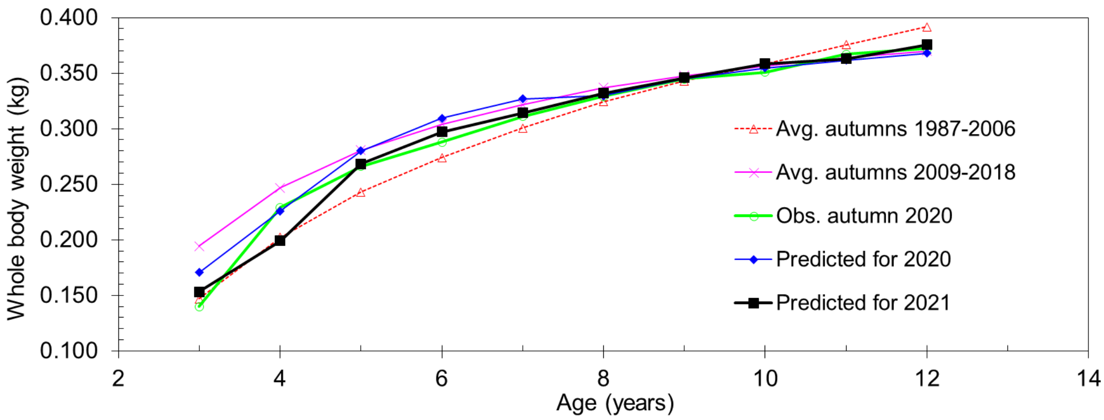


Figure 11.6.1.1. Icelandic summer spawning herring. The mean weight-at-age for age groups 3 to 12 (+ group) in 1987–2006, 2009–2018, in the catches in the autumn 2019, predicted weights for autumn 2020 in the 2020 assessment (ICES, 2020) and finally predicted weights for the autumn 2021 from the weights in 2020, which was used in the stock prognosis.

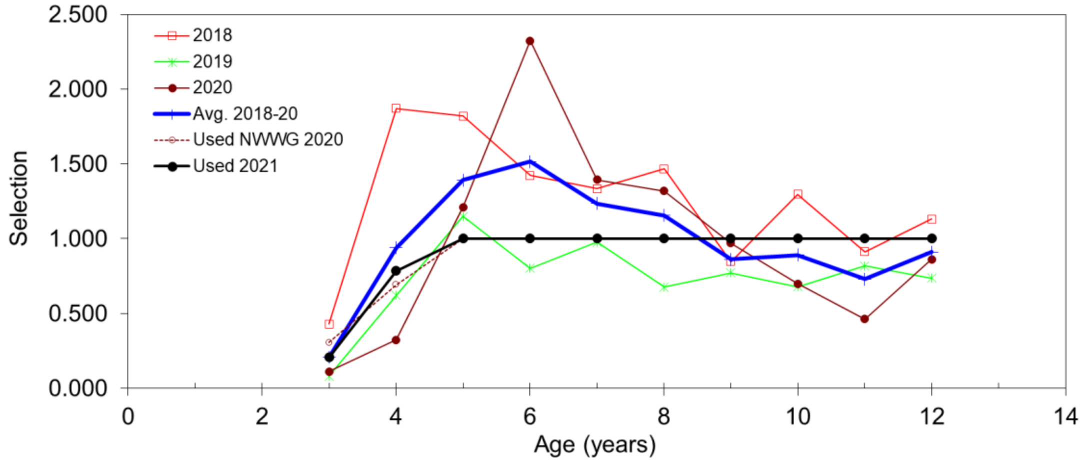


Figure 11.6.1.2. Icelandic summer spawning herring. Estimate of selection pattern ($F_{age}/F_{weighed\ mean\ 5–10}$) in the fishery in the stock prognosis for age groups 3 to 12 (+ group) on basis of the Fs in 2018 to 2020, the average over these three years (used for the prognosis according to the Stock Annex), the selection used in 2020 (ICES, 2020), and the selection used in the prognosis 2021.

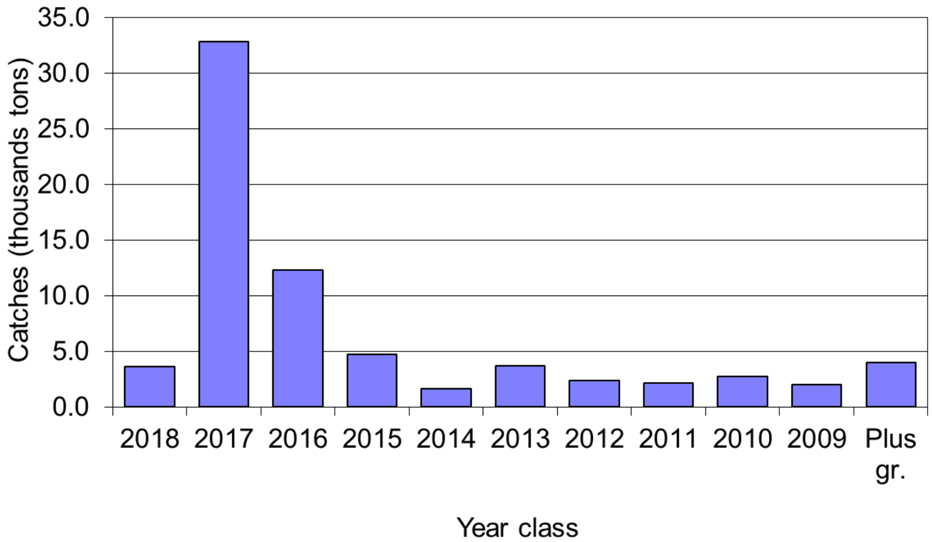


Figure 11.6.2.1. Icelandic summer spawning herring. The predicted biomass contribution of the different year classes to the catches in the fishing season 2021/2022 (total catch of 72 239 tonnes).

12 Capelin in the Iceland-East Greenland-Jan Mayen Area

12.1 Stock description and management units

See stock annex.

12.2 Fishery independent abundance surveys

The capelin stock in Iceland-East Greenland-Jan Mayen area has been assessed by acoustics annually since 1978. The surveys have been conducted in autumn (September–December) and in winter (January–February). An overview is given in the stock annex.

12.2.1 Autumn survey during September and October 2020

The survey was conducted with the aim of assessing both the immature and the maturing part of the stock. Since 2010, the autumn surveys have started in September, a month earlier than in previous years because of difficulties in covering the stock due to drift ice and weather during later months. The survey was conducted on the research vessels Arni Fridriksson (14 September–5 October) and Eros (7–26 September).

The survey area was on and along the shelf edge off East Greenland from about 63°30′N towards about 73°20′ N, also covering the Denmark Strait and the slope off west, north and east Iceland. The Iceland Sea, Kolbeinsey ridge and Greenland basin were also surveyed but with less transect density (Bardarson *et al*., 2020). Survey tracks are shown on Figure 12.2.1.

Eros departed from Helguvik harbour on 7 September and sailed westwards over Irminger Sea to start surveying from the southwest end of the survey area. Eros followed preset transects covering the Greenlandic shelf areas until Tasilaq region. There, the plan was to survey Angmakssalik fjord towards Kungmiut but was aborted due to weather and ice conditions. Hence, Eros continued covering the East-Greenland shelf areas to northeast. The morning of 16 September, Eros sailed to Helguvik harbour for personnel change on 17 September. Eros was back on the research area on 18 September and surveyed, in collaboration with Arni, the preset transects in Denmark Strait until finishing his last transect early on 25 September and arriving to Helguvik harbour on 26 September. Eros was held up for more than 2 days due to bad weather and also delayed by changing the order of transects in 3 cases to have better conditions to do hydrography and zooplankton transects.

Arni departed from Hafnarfjordur harbour on 14 September and sailed north of Iceland towards the shelf edge northeast off Langanes. From there Arni followed transects westwards covering the shelf edges north of Iceland towards Denmark Strait. Arni mainly covered the northeastern Denmark Strait in coordination with Eros which covered the remaining southeast Denmark Strait. Drift ice was distributed along the Greenlandic coast and extending into the northeast Denmark Strait. The ice hindered the coverage of Arni having to shorten transects of up to 30 nmi towards the Greenlandic coast. Then, Arni followed preset transects perpendicular to the East Greenlandic shelf edge until reaching the area east of Scoresby. There, a trial was made to launch acoustic probe (Simrad WBT-Tube) intended for estimation of acoustic properties of capelin, but the associated optical cable winch broke down and the operation was cancelled. Also, the retrieval of an oceanographic mooring in the proximity of Scoresby for the Greenland Institute of

Natural Resources (GINR) had to be aborted due to drift ice. In the region north of Scoresby drift ice obstructed the coverage severely and winds slowed the progress. Hence, Arni changed from the preset transects towards zik-zak stragedy northeastwards along the ice edge. East of Kong Oscar Fjord, the vessel had to leave the shelf area due to heavy northern winds and seek calmer seas further east where the vessel managed to survey further northwards to 73°20'N and then return to the shelf areas off Kong Oscar Fjord as weather was getting calmer. From there Arni crossed the West Jan-Mayen Ridge and followed the Kolbeinsey Ridge southwards. In the end Arni scouted along the shelf edges east of Iceland and arrived to Hafnarfjordur harbour the 5 October.

Maturing capelin was mainly observed along the East Greenlandic continental shelf and shelf edges in Denmark Strait and the Scoresby Sund areas, but was absent in explorable areas north of Kong Oscar fjord. In Denmark Strait maturing capelin was mixed with immature capelin, but mainly maturing capelin was found further north. No capelin was found by West Jan Mayen ridge or Kolbeinsey ridge. In general, there were no signs of any important quantities of capelin east of Kolbeinsey ridge. Juveniles (0-group) of various species, including 3 capelin (although not quantified) were observed along the continental shelf north of Iceland. Immature capelin was found along the Greenlandic shelf, dominating in southwestern part of the survey area and western Denmark Strait. High abundances of immature capelin were found in the proximities of Angmagssalik fjord and Kangerdlugssuaq fjord. The distribution of capelin was westerly as in recent years. Figure 12.2.2 shows the distribution and relative density of the capelin during the survey.

The total number of capelin amounted to 162 billion whereof the 1-group was about 140.6 billion. The total estimate of 2 group capelin was about 20 billion. The total biomass estimate was 1078 000 tonnes of which about 406 000 tonnes were 2 years and older. About 0.6 % in numbers of the 1-group was estimated to be maturing to spawn, about 67.5 % of the 2-year-old and 99.1 % of the 3-year-old capelin appeared to be maturing. This gives about 344 000 tonnes of maturing 1–4 year old capelin. Tables 1–6 give the age disaggregate biomass, numbers and weights of the capelin stock components. High estimate of numbers immature is under further scrutiny with multi-frequency acoustic methods.

Tables 12.2.2 and 12.2.3 show the historic time series of abundance and mean weights by age and maturity in autumn. On the basis of the estimate of the maturing part of the stock the Marine and Freshwater Research Institute recommended no fishery (intermediate TAC of 0 tonnes) for the fishing season 2020/2021 (Anon, 2020). This recommendation was in accordance with existing HCR and management plan between Iceland, Norway and Greenland.

12.2.2 Surveys in winter 2020/2021

Winter surveys were conducted in December–February resulting in 4 separate coverages of stock components. The main objective of the winter surveys was to assess the maturing part of the stock with coverages designed for acoustic stock assessment. This was a coordinated collaboration of several research and fishing vessels where each coverage was based on combined acoustic and trawl data from 2–5 vessels assisted by up to 3 scouting vessels. Scientists from MFRI were on board each vessel performing acoustic stock estimates and all assessments were based on acoustic data from calibrated echosounders.

12.2.2.1 Winter surveys 1. Coverage in 6–11 December 2020

The acoustic measurements were conducted by the fishing vessels Asgrimur Halldorsson, Jona Edvalds, Kap and Iivid with 3 scientists from the Marine and Freshwater Research Institute onboard each vessel.

The survey area was on and along the shelf edge from Vikurall northwest of Iceland to Vopnafjardargrunn east of Iceland (Figure 12.2.3). Three vessels, Asgrimur Halldorsson, Jona Edvalds and Kap, started their transects in the proximity of Kolbeinsey-ridge while Iivid started at the western part of the survey area progressing from west to east towards the coverage of Kap. In the beginning, the echosounders of Asgrimur Halldorsson and Jona Edvalds were calibrated in Eskifjordur, while Iivid was calibrated in Hvalfjordur, but Kap had previously been calibrated in March. The vessels managed to cover the planned survey area except for considerably hindered coverage in Denmark Strait due to sea ice.

Immature capelin dominated in the western most part of the survey region while mature capelin was found further east in the Denmark Strait (in the proximity of the sea ice edge). Mixtures of immature and mature capelin were found between Denmark Strait and Kolbeinsey-ridge. Further to the east, in the proximity of Kolbeinsey-ridge, mature capelin dominated. Total SSB was estimated 487 000 tonnes but due to restricted coverage because of sea ice in the Denmark Strait, this could be an underestimate.

12.2.2.2 Winter surveys 2. Coverage in 4–9 January 2021

The acoustic measurements were conducted by the research vessels Arni Friðriksson and Bjarni Sæmundsson and the fishing vessels Aðalsteinn Jónsson, Asgrimur Halldorsson and Polar Amaroq with 3 scientists from the Marine and Freshwater Research Institute onboard each vessel.

The survey area was on and along the shelf edge from Vikurall northwest of Iceland to Heradsdjup east of Iceland (Figure 12.2.4). Arni Fridriksson and Bjarni Sæmundsson started north of the Vestfirdir peninsula in the proximity of Kögurgrunn bank, Arni covering westwards and Bjarni to the east. Three vessels, Adalsteinn Jonsson, Polar Amaroq and Asgrimur Halldorsson started their transects northeast of Iceland in the proximity of Rifsbanki bank where Adalsteinn and Polar Amaroq progressed from east to west towards the coverage of Bjarni while Asgrimur progressed eastwards. During sailing to and from the research areas all vessels searched for capelin on shallower shelf areas. Before the survey, the echosounders of Adalsteinn Jonsson and Polar Amaroq were calibrated in Eskifjordur and Nordfjordur respectively, but other vessels had been previously calibrated. The vessels managed to cover the planned survey area except coverage in Denmark Strait was considerably hindered due to sea ice.

Mature capelin dominated in main parts of the survey area although immature capelin was observed in occasional samples. Total SSB was estimated 144 000 tonnes but due to restricted coverage because of sea ice in the Denmark Strait and much lower observed abundance than in same areas in December 2020, it is likely that a good part of the population was undiscovered during this coverage.

12.2.2.3 Winter surveys 3. Coverage in 17–20 January 2021

The acoustic measurements were conducted by the fishing vessels Asgrimur Halldorsson and Polar Amaroq with 3 scientists from the Marine and Freshwater Research Institute onboard each vessel. Further, the fishing vessel Bjarni Olafsson searched for capelin with some assistance from the fishing vessel Venus.

Due to very short weather window the survey area was limited to a small region along and outside the shelf edge east of Iceland extending from about 66°N southwards to about 64°15N (Figure 12.2.5). The initiative of this survey was based on confirmed observations of abundant capelin in the area and hence the need to measure the capelin before it migrates further south into areas less favourable for acoustic measurements. Both Asgrimur Halldorsson and Polar Amaroq were measuring along east-west transects progressing from south to north while Bjarni Olafsson mainly searched on eastern edge of the survey region. Also, the fishing vessel Venus searched the shelf just west of the measured transects while passing by.

Mature capelin dominated in the region with the greatest abundance measured south of 65°N mainly 10–25 nmi east off the shelf edge. Total SSB was estimated 401 000 tonnes where of 325 000 tonnes were observed south of 65°N. The main part of the estimated abundance is likely to have been outside the first January survey coverage.

12.2.2.4 Winter surveys 4. Coverage in 26–30 January 2021

The acoustic measurements were conducted by the research vessels Arni Friðriksson and Bjarni Sæmundsson and the fishing vessels Aðalsteinn Jónsson, Asgrimur Halldorsson and Borkur with 2-3 scientist from the Marine and Freshwater Research Institute onboard each vessel. Further, the fishing vessels Bjarni Olafsson, Hakon and Jona Edvalds searched for capelin.

The vessels Arni Fridriksson, Asgrimur Halldorsson, Adalsteinn Jonsson and Borkur started measurements in the southeast end of the survey area assisted by the scouting of Bjarni Olafsson on the shelf side while Jona Edvalds scouted deep areas east of the main survey transects. The aim was to start measuring capelin north of 65°N in the east and progressing northwards along eastfjords and then westward. When the vessels were arriving towards 65°N they observed high abundance of capelin on shelf areas just south of 65°N, hence they extended the coverage further to the south on the shelf. At the beginning of the survey there were no conditions for acoustic measurements in the Denmark Strait and other northwestern areas due to weather but consistent winds from east and northeast in Denmark Strait had caused a favourable retreat of the sea ice in that region. Hence, based on forecasted calm weather window in Denmark Strait Arni Fridriksson headed towards Denmark Strait on the evening of 26 January and the day after Bjarni Saemundsson and Hakon left harbour to also measure and search the northwestern regions. Early on the 28 January the three vessels arrived to their first transects by the shelf edge north of Straumnes and Arni Fridriksson progressed along the shelf edges westwards, Bjarni Saemundsson eastwards along the shelf edges while Hakon searched the shallower shelf areas off northwest Iceland. On the morning of 30 January, the following four vessels met about 40 nmi west of Kolbeinsey, Bjarni Saemundsson approaching from the west, Adalsteinn Jonsson, Borkur and Asgrimur Halldorsson approaching from the east and hence closing the coverage gap between them. Although, Bjarni Saemundsson continued to finish unfinished transects in the north that had to be abandoned earlier due to weather and icy conditions. Further, Arni Fridriksson continued progressing westwards along unfinished transects. The whole survey was finished the 30 January. The echosounder on Borkur was calibrated after the survey, other vessels had previously calibrated echosounders.

Immature capelin dominated in Denmark Strait while mixtures of immature and mature capelin were found between Denmark Strait and Rifsbanki north of Melrakkasletta peninsula. Further to the east mature capelin dominated. Total SSB was estimated 415 000 tonnes where of 325 000 tonnes were north of 65°N.

12.3 The fishery (fleet composition, behaviour and catch)

Initial catch quota for the 2020/2021 fishing season was 270 000 tonnes, but no summer or autumn fishery took place in 2020.

The intermediate TAC advice based on the autumn survey recommended no fisheries (TAC = 0 tonnes) and this advice was updated to a final quota of 127 300 t in winter 2021. In total, 129 433 t were caught in the 2020/2021 fishing season.

The total catches in numbers by age during the summer/autumn since 1985 are given in Table 12.3.2 and for the winter since 1986 in Table 12.3.3.

Initial and final TAC as well as landings for the fishing seasons since 1992/93 are given in Table 12.3.4 and total catch by season is shown in Figure 12.3.1.

12.4 Biological data

12.4.1 Growth

Seasonal growth pattern, with considerably increased growth rate during summer and autumn has been observed in this capelin stock in a study of the period 1979–1992. Where immature fish had slower growth during winter, the maturing fish had faster summer growth that continued throughout the winter until spawning in March/April, followed by almost 100% spawning mortality (Vilhjalmsson, 1994). Further examination of the growth of immature capelin at age 1 in autumn to mature at age 2 in autumn the year after in the period 1979–2013 showed on average almost 4-fold weight increase during one year (Gudmundsdottir and Sigurdsson, 2014). This considerable weight increase and seasonal pattern in growth the year before spawning should be taken into account when deciding the timing of the capelin fisheries.

Immature capelin has considerably low fat content, usually less than 3–4%. The fat content rises from approximately 5% in the summer to 20% in late autumn. In the fall and winter the fat content slowly declines, until the spawning migration begins in early January where the fat content drops drastically from about 15% to 5% in mid-April (Engilbertsson *et al.*, 2012).

12.5 Methods

The objective of the HCR for the stock is to leave at least 150 000 tonnes (= B_{lim}) for spawning (escapement strategy). The initial (preliminary), intermediate and final TACs are based on acoustic surveys.

a) The initial TAC advice for the subsequent fishing season is issued by ICES around 1 December. It is based on the autumn survey abundance estimate of immature 1- and 2-year-old capelin. Before 2017, this advice was issued later (May/June).

b) The intermediate TAC advice is issued by MFRI in autumn based on the biomass estimate of maturing capelin.

c) The final TAC advice is issued by MFRI in January/February based on the biomass estimate of maturing capelin.

The initial (preliminary) quota follows a simple forecast that is based on a linear relation between historic observations of the abundance of 1- and 2-year-old juveniles from the acoustic autumn surveys and the corresponding final TACs nearly 1½ year later. This rule was applied by ICES NWWG (subgroup online video conferencing meeting in November 2018) to advice the initial quota for the fishing season 2019/20. Figure 12.8.1 shows the relation and the associated precautionary initial quota.

The intermediate and final TACs are set so that there is at least 95% probability that there will be at least 150 000 tonnes (= B_{lim}) of mature capelin left for spawning at the spawning time (15 March). This was done for the first time in 2015/2016 by the Icelandic Marine Research Institute and was not evaluated by ICES.

These methods were endorsed by the benchmark working group WKICE in 2015. See WKICE (ICES, 2015) and the Stock Annex for the capelin in the Iceland-East Greenland-Jan Mayen area.

Previously, (since early 1980s) the stock has been managed according to an escapement strategy, leaving 400 000 tonnes to spawning (uncertainty of the estimates were not considered). To predict the TAC for the next fishing season a model was developed in the early 1990s

(Gudmundsdottir and Vilhjalmsson, 2002). These models were not endorsed by the benchmark working group WKSHORT 2009.

12.6 Reference points

During WKICE, a B_{lim} of 150 000 tonnes was defined (ICES, 2015). No other reference points are defined for this stock.

12.7 State of the stock

The spawning stock biomass (SSB) was estimated to 649 000 tonnes in January 2020. The predation model (ICES, 2015), accounting for catches (in this case 127 300 t) and predation between survey and spawning by cod, saithe and haddock, estimated that 344 000 tonnes were left for spawning in spring 2020 (Table 12.7.1). Given the uncertainty estimates, there was 95% probability that at least 150 000 tonnes was left for spawning. This was above B_{lim} within the sustainable HCR.

The acoustic estimate of immature capelin at age 1 and 2 from the autumn survey in September 2020 was 146.3 billion. The estimate is above long-term average (Figure 12.7.1) and the initial advice according to the HCR is 400 000 tonnes in the fishing season 2021/22 (Figure 12.7.2).

12.8 Uncertainties in assessment and forecast

The uncertainty of the assessment and forecast depends largely on the quality of the acoustic surveys in terms of coverage, conditions for acoustic measurements and the aggregation (high patchiness leads to high variance) of the capelin.

The uncertainty is estimated by bootstrapping (see stock annex). The CV for the immature abundance was estimated to 0.23 in the 2020 autumn survey. The CV for the mature biomass was estimated to 0.18 in the 2020 autumn survey but in the winter survey (January) used for the assessment in 2021 it was 0.22.

Spatial coverage in the autumn survey 2020 was hindered by sea ice in northeast Denmark Strait and also the eastern areas of the survey region (assumed to be on periphery of capelin distribution) had less dense coverage. Hence, it is likely that the mature component of the stock was underestimated in the autumn survey (affecting intermediate TAC advice 2020/2021) although the immature component is believed to have been successfully covered (affecting initial advice 2021/2022). The final estimate was based on combination of partial coverages within two surveys based on assumptions about southern direction of capelin spawning migration east of Iceland. Unexpected migration behaviour might lead to bias in the estimate. The final estimate did not involve repeated surveying with and against the migration direction. Although some components of the stock are likely to have been measured with the survey migration and others against it, there could be some bias due to migration direction.

12.9 Comparison with previous assessment and forecast

For the fishing season 2020/2021 170 000 t initial quota was advised and intermediate TAC was set to 0 tonnes while final advice was 127 300 t. This is the initiative of capelin fisheries after a two fishing seasons with no fisheries. High juvenile index in autumn 2020 predicts large fishable stock in 2021/2022.

12.10 Management plans and evaluations

See Section 12.5.

12.11 Management considerations

The fishing season for capelin has since 1975 started in the period from late June to July/August when surveys on the juvenile part of the stock the year before have resulted in the setting of an initial (preliminary) catch quota. During summer, the availability of plankton is at its highest and the fishable stock of capelin is feeding very actively over large areas between Iceland, Greenland and Jan Mayen, increasing rapidly in length, weight and fat content. By late September/beginning of October this period of rapid growth is over. The growth is fastest the first two years, but the weight increase is highest in the year before spawning (Vilhjálmsson, 1994).

Given the large weight increase in the summer before spawning (Section 12.4) it is likely that there will be more biomass of maturing fish in autumn than in summer, even though the level of natural mortality is not well known during this time period. This should be considered for optimal timing of fishery in relation to yield and ecological impact. This is also supported by information for the Barents Sea capelin where it has been shown that fishing during autumn would maximize the yield, but from the ecosystem point of view a winter fishery were preferable (Gjøsæter *et.al.*, 2002). As the biology and role in the ecosystem of these two capelin stocks are similar, this is considered to be valid for the capelin in the Iceland-East Greenland-Jan Mayen area as well - until it is studied for this specific stock.

During the autumn surveys, juvenile and adult capelin is often found together. This should be considered during summer fishing because the survival rate of juvenile capelin that escapes through the trawl net is unknown.

12.12 Ecosystem considerations

Capelin is an important forage fish and its dynamics are expected to have implications on the productivity of their predators (see further in Section 7.3).

The importance of capelin in East Greenlandic waters is not well documented but effort has been increased considerably during autumn surveys towards evaluation of capelin role in the ecosystem e.g. by research on feeding of capelin, estimates of prey availability, predators distributions and environmental monitoring.

In Icelandic waters, capelin is the main single item in the diet of Icelandic cod, a key prey to several species of marine mammals and seabirds and also important as food for several other commercial fish species (see e.g. Vilhjálmsson, 2002).

12.13 Regulations and their effects

Over the years, the fishery has been closed during April–late June and the season has started in July/August or later, depending on the state of the stock.

Areas with high abundances of juvenile age 1 and 2 capelin (on the shelf region off NW-, N- and NE-Iceland) have usually been closed to the summer and autumn fishery.

It is permissible to transfer catches from the purse seine of one vessel to another vessel, in order to avoid slippage. However, if the catches are beyond the carrying capacity of the vessel and no other vessel is nearby, slippage is allowed. In recent years, reporting of such slippage has not been frequent. Industrial trawlers do not have the permission to slip capelin in order to harmonize catches to the processing.

In Icelandic waters, fishing with pelagic trawl is only allowed in limited area off the NE-coast (fishing in January) to protect juvenile capelin and to reduce the risk of affecting the spawning migration route (shuttering of migrating capelin schools by pelagic trawling has been hypothesized).

Taking precautionary measures to protect juvenile capelin, the coastal states (Iceland, Greenland and Norway) have agreed that from 2021 fishing shall not start until 15 October.

12.14 Changes in fishing technology and fishing patterns

The catches in 2020/21 (129 433, preliminary numbers) were taken by purse-seining (95%) and pelagic trawl (5%),, but historically a variable amount of the catches have been taken with pelagic trawl through the fishing seasons. Discards have been considered negligible.

12.15 Changes in the environment

Icelandic and East Greenlandic waters are characterized by highly variable hydrographical conditions, with temperatures and salinities depending on the strength of Atlantic inflow through the Denmark Strait and the variable flow of polar water from the north. A rise in ambient sea temperatures for the migrating and spawning capelin was especially abrupt around 2003, coinciding with a decrease in recruitment, and a change in nursery areas that may partly be a be a consequence of a change in spawning distribution (Jansen *et al.*, 2021). Including consequences on the progress of spawning migration (Singh *et al.*, 2020). The acoustic surveys in autumn 2010, 2012–2019 confirmed this change in distribution of immatures and maturing capelin. Fisheries data suggests that the major part of the spawning still takes place on the usual grounds by the South and Southwest coasts of Iceland and possibly to increased extent by the North coast of Iceland.

A more detailed environmental description is in Section 7.3.

12.16 Recommendations

In coming years when experience of the new HCR will be gained it is recommended that assumptions and practical operation of the HCR will be evaluated. E.g. by refining the model for the initial TAC, reviewing the predation/prey relationships and how SSB estimates from autumn and winter surveys should be weighted when final TAC is calculated. NWWG therefore recommends that the assessment of this capelin stock goes through a benchmark workshop in near future. Further, it is recommended that the option to run this benchmark jointly with a benchmark workshop for the Barents Sea capelin stock will be examined.

Studies of optimal harvesting of capelin should be conducted. These estimates should take account of ecological impact, growth, mortality and gear selection in relation to the timing of the fishery.

Profound changes in the distribution, migration and productivity of this capelin stock, likely caused by environmental changes, urge the need for further biological studies i.e. regarding life history (including changes in spawning grounds, larval drift and migration at times not observed by autumn and winter surveys) and the role of capelin (predation/prey relationships) as a key species in the ecosystem.

The assessment and advice on the final TAC for capelin based on the autumn and winter surveys are issued directly to the Coastal States by the Icelandic Marine and Freshwater Research Institute. This process is not internationally peer reviewed prior to the release of the advice. Among the reasons for using this process is the need for fast advice once the survey result is available. The ICES ACOM procedure is more time consuming. NWWG has recommended that a fast track workflow based on online meetings is established if possible. The coastal states evaluated this recommendation in 2017 and concluded that a current regime for setting intermediate and final TAC should be maintained. When planning acoustic surveys for capelin stock assessment, allocation of effort in terms of ship time, number of ships and manpower, should be sufficient for a likely full coverage in the first attempt given the demanding weather and ice conditions during autumn and winter surveys.

12.17 References

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12.18 Tables

Table 12.2.1 Icelandic Capelin. Estimated stock size of the capelin total stock component in numbers (millions) by age (years) and length (cm), and biomass (thous. tonnes) from the acoustic survey in 7. September – 5. October 2020.

Length (cm)	Numbers at Age (10^9)				Numbers (10^9)	Biomass (10^3t)	Mean weight (g)
	1	2	3	4			
8	886.95	0	0	0	886.95	1493.03	1.68
8.5	1034.77	0	0	0	1034.77	1930.59	1.87
9	6356.45	0	0	0	6356.45	15206.7	2.39
9.5	13156.37	0	0	0	13156.37	36230.28	2.75
10	21434.54	295.65	0	0	21730.19	71691.88	3.3
10.5	17314.33	0	0	0	17314.33	67021.41	3.87
11	24724.43	295.65	0	0	25020.08	112589.9	4.5
11.5	17962.26	739.12	0	0	18701.38	97141.82	5.19
12	19849.42	739.12	0	0	20588.54	133841.1	6.5
12.5	9662.76	295.65	0	0	9958.41	75495.34	7.58
13	6527.54	924.7	0	0	7452.24	62638.8	8.41
13.5	1347.27	94.39	0	0	1441.66	14001.55	9.71
14	192.41	1728.46	0	0	1920.87	22526.2	11.73
14.5	147.82	1151.18	6.83	0	1305.84	18542.11	14.2
15	18.88	2954.37	25.71	0	2998.95	47257.75	15.76
15.5	0	1117.86	77.12	0	1194.98	21539.33	18.02
16	0	2209.64	47.8	0	2257.44	45079.92	19.97
16.5	0	1882.26	305.28	0	2187.54	50554.52	23.11
17	0	2445.45	267.53	0	2712.98	68105.01	25.1
17.5	0	1606.34	327.38	0	1933.71	54642.13	28.26
18	0	947.98	320.55	0	1268.53	38789.82	30.58
18.5	0	485.63	53.02	0	538.66	18340.3	34.05
19	0	47.8	20.49	0	68.29	2660.24	38.96
19.5	0	13.66	6.83	0	20.49	860.57	42.01
20	0	6.83	0	0	6.83	301.15	44.1

Table 12.2.1 Icelandic Capelin. Summary of the capelin stock components from the acoustic survey in 7. September – 5. October 2020. Age (years) aggregated spawning stock component summary. T = Total, S = Stock, N = Numbers (billions), W = Weight(grams), L = Length(Cm), p = %

	Age				Total	Mean
	1	2	3	4		
TSN	140.62	19.98	1.46	0	162.06	
TSB	672.05	367.87	38.56	0	1078.48	
MeanW	4.78	18.41	26.44	0		6.65
MeanL	10.95	15.34	17.16	0		11.55
TSNp	86.77	12.33	0.9	0	100	
SSN	0.82	13.49	1.44	0	15.76	
SSB	8.23	297.33	38.51	0	344.08	
MeanW	10.02	22.03	26.66	0		21.83
MeanL	13.21	16.23	17.15	0		16.15
SSNp	5.21	85.62	9.17	0	100	
ISN	139.79	6.47	0.01	0	146.28	
ISB	663.7	70.06	0.43	0	734.19	
MeanW	4.75	10.83	31.29	0		5.02
MeanL	10.94	13.5	18	0		11.05
ISNp	95.57	4.42	0.01	0	100	

Table 12.2.2. Icelandic Capelin. Abundance of age-classes in numbers (10^9) measured in acoustic surveys in autumn.

Year	Mon	Day	Age1 Imm.	Age1 Mat.	Age2 Imm.	Age2 Mat.	Age3 Imm.	Age3 Mat.	Age4 Mat.	Age5 Mat.
1978	10	16				60.0		13.9	0.4	
1979	10	14	10.0			49.7		9.1	0.4	
1980	10	11	23.5			19.5		4.8		
1981	11	26	21.0		1.1	11.9		0.6		
1982	10	2	68.0		1.7	15.0		1.6		
1983	10	3	44.1		8.2	58.6		5.6	0.1	
1984	11	1	73.8		4.6	31.9		10.3	0.3	
1985	10	8	33.8		12.6	43.7		14.4	0.4	0.1
1986	10	4	58.6		1.4	19.9		29.8	0.3	
1987	11	18	21.3		2.5	52.0		13.5		
1988	10	6	43.9		6.7	53.0		17.0	0.4	
1989	10	26	29.2		1.8	2.9		0.6		
1990	11	8	24.9		1.3	16.4		2.7	0.1	
1991	11	15	60.0		5.3	44.7		4.2		
1992	10	13	104.6		2.3	54.5		4.3	0.1	
1993	11	18	100.4		9.8	55.1		4.9		
1994	11	25	119.0		6.9	29.2		4.4		
1995	11	30	165.0		30.1	84.6		7.0		
1996	11	27	111.9		16.4	70.0		15.9		
1997	11	1	66.8		30.8	52.5		8.5		
1998	11	13	121.0		5.9	20.5		3.3		
1999	11	15	89.8		4.4	18.1		0.9		
2000	11	10	103.7		10.9	11.6	0.1	0.6		
2001	11	12	101.8		2.4	22.1	0.0	0.7		
2002	11	12	1.0		0.5					
2003	11	6	4.9		3.1	1.7	0.1	0.2		
2004	11	22	7.9		0.1	7.3		0.8	0.0	
2005	11									
2006	11	6	44.7		0.3	5.2		0.4		
2007	11	7	5.7		0.1	1.3		0.0		
2008	11	17	7.5	5.1	0.4	12.1		1.8		
2009	11	24	13.0	2.4		5.0		0.7		
2010	10	1	91.6	9.6	6.3	25.8	0.1	0.8	0.02	
2011	11	29	9.0	0.6	3.6	19.9	0.05	2.1		
2012	10	3	18.5	0.9	2.0	21.2	0.07	11.4	0.1	
2013	9	17	60.1	0.6	6.9	25.0	1.3	6.9	0.1	
2014	9	16	57.0	1.0	3.3	26.5	0.2	7.6	0.1	
2015	9	16	5.0	0.4	1.2	21.2		6.7		

Year	Mon	Day	Age1	Age1	Age2	Age2	Age3	Age3	Age4	Age5
			Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Mat.	Mat.
2016	9	10	8.7	0.5	0.7	4.5	0.0	0.9	0.01	
2017	9	7	24.6	1.3	1.5	35.5	0.0	5.1	0.05	
2018	9	6	10.3	1.5	0.4	8.8	0.0	1.0		
2019	9	12	81.5	1.8	1.1	6.1		0.6	0.0	
2020	9	7	139.8	0.8	6.5	13.5	0.0	1.44		

1987 - The number at age 1 was from survey earlier in autumn.
2005 - Scouting vessels searched for capelin. r/s ÁF measured. No samples taken for age determination. Estimated to be < 50 000 t.
2011 - Only limited coverage of the traditional capelin distribution area. 2001–2009 and 2016 – Not full coverage of stock.

Table 12.2.3. Icelandic Capelin. Mean weight (g) of age-classes measured in acoustic surveys in autumn. (imm = immature, mat = mature). See footnotes in Table 12.2.2.

Year	Mon	Age1	Age1	Age2	Age2	Age3	Age3	Age4	Age5
		Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Mat.	Mat.
1978	10				19.8		25.4	26.3	
1979	10	6.2			15.7		23.0	20.8	
1980	10	7.3			19.4		26.7		
1981	11	3.6		12.3	19.4		22.5		
1982	10	3.8		8.5	16.5		24.1		
1983	10	5.1		9.5	16.8		22.5	23.0	
1984	11	2.9		8.3	15.8		25.7	23.2	
1985	10	3.8		8.5	15.5		23.8	29.5	31.0
1986	10	4.0		6.1	18.1		24.1	28.8	
1987	11	2.8		8.7	17.9		25.8		
1988	10	3.0		8.0	15.4		23.4	20.9	
1989	10	3.5		8.0	12.9		24.0		
1990	11	3.9		8.4	18.0		25.5	36.0	
1991	11	4.7		7.9	16.3		25.4		
1992	10	3.7		8.6	16.5		22.6	22.0	
1993	11	3.6		8.9	16.2		23.3		
1994	11	3.3		7.9	15.9		23.6		
1995	11	3.7		7.0	14.0		20.8		
1996	11	3.1		7.4	15.8		20.6		
1997	11	3.3		8.5	14.3		20.1		
1998	11	3.5		9.9	13.7		18.8		
1999	11	3.6		8.0	15.4		19.5		
2000	11	3.9		8.5	13.4	13.0	20.8		
2001	11	3.8		8.8	16.3	15.7	23.9		
2002	11								
2003	11	7.2		14.9	17.0	22.6	23.7		
2004	11	7.4		7.6	16.0		18.0	14.5	

Year	Mon	Age1 Imm.	Age1 Mat.	Age2 Imm.	Age2 Mat.	Age3 Imm.	Age3 Mat.	Age4 Mat.	Age5 Mat.
2005									
2006	11	3.7		7.9	15.0		16.7		
2007	11	5.5		8.6	14.9		15.8		
2008	11	6.2	11.0	6.9	18.6		22.4		
2009	11	5.1	9.8		20.0		23.8		
2010	10	5.8	12.9	12.2	19.0	12.9	24.0	21.2	
2011	11	6.8	11.4	11.1	18.7	15.8	24.4		
2012	10	6.5	16.0	15.3	22.0	22.4	28.0	26.6	
2013	9	5.8	12.6	10.9	18.0	11.2	20.9	23.6	
2014	9	4.2	9.9	12.7	18.3	16.6	21.2	25.0	
2015	9	8.5	12.3	13.4	18.4	21.5	23.1		
2016	9	9.0	15.1	13.1	25.5	11.5	31.7	39.2	
2017	9	8.0	12.6	15.0	22.2	22.3	27.2	33.2	
2018	9	8.8	12.9	16.5	21.7	21.2	27.1		
2019	9	7.3	13.4	14.5	24.0	15.7	27.1	28.4	
2020	9	4.8	10.0	10.8	22.0	31.3	26.7		

Table 12.2.4. Icelandic Capelin. Estimated stock size of Iceland-Greenland-Jan Mayen capelin total stock in numbers (millions) by age (years) and length (cm), and biomass (thous. tonnes) from the acoustic surveys in 17. – 30. January 2021.

Length (cm)	Numbers at Age (10^9)				Numbers (10^9)	Biomass (10^3t)	Mean weight (g)
	1	2	3	4			
9	0	28.43	0	0	28.43	69.65	2.45
9.5	0	85.29	0	0	85.29	226.01	2.65
10	0	184.78	0	0	184.78	590.88	3.2
10.5	0	787.6	0	0	787.6	2970.02	3.77
11	0	1039.31	0	0	1039.31	4529.8	4.36
11.5	0	1692.83	0	0	1692.83	8783.71	5.19
12	0	1799.37	0	0	1799.37	10798.35	6
12.5	0	2005.44	9.76	0	2015.2	14144.46	7.02
13	0	1748.12	23.97	0	1772.09	14481.92	8.17
13.5	0	984.87	53.24	2.52	1040.63	9660.07	9.28
14	0	813.08	138.19	0	951.27	10215.56	10.74
14.5	0	443.06	224.41	0	667.47	8350.4	12.51
15	0	169.52	765.45	0	934.97	13489.03	14.43
15.5	0	81.33	993.38	9.76	1084.46	17909.93	16.52
16	0	14.21	1809.52	35.77	1859.5	34906.54	18.77
16.5	0	4.58	2423.49	148.16	2576.23	55266.04	21.45
17	0	14.21	3228.05	148	3394.85	81416.96	23.98
17.5	0	0	3400.49	282.74	3683.22	98668.71	26.79
18	0	0	4149.24	518.67	4667.91	138373.6	29.64
18.5	0	0	3056.47	616.99	3673.46	120496.4	32.8
19	0	0	1887.82	92.98	1980.8	70261.6	35.47
19.5	0	0	590.08	139.87	729.95	28580.83	39.15
20	0	0	38.71	0	38.71	1703.16	44

Table 12.2.4 Icelandic Capelin. Summary of the capelin stock components from the acoustic surveys in 17. – 30. January 2021. Age (years) aggregated spawning stock component summary. T = Total, S = Stock, N = Numbers(billions), W = Weight(grams), L = Length(Cm), p = %

	Age				Total	Mean
	1	2	3	4		
TSN	0	11.9	22.79	2	36.69	
TSB	0	84.24	602	59.55	745.89	
MeanW	0	7.08	26.41	29.84		20.33
MeanL	0	12.35	17.37	18		15.78
TSNp	0	32.42	62.12	5.44	100	
SSN	0	0.77	21.43	1.97	24.17	
SSB	0	9.49	580.66	59.03	649.3	
MeanW	0	12.3	27.09	30.02		26.86
MeanL	0	14.16	17.49	18.03		17.43
SSNp	0	3.19	88.65	8.13	100	
ISN	0	11.12	1.36	0.03	12.51	
ISB	0	74.66	21.42	0.52	96.59	
MeanW	0	6.71	15.74	17.66		7.72
MeanL	0	12.22	15.48	16		12.59
ISNp	0	88.89	10.88	0.23	100	

Table 12.3.1 Capelin. The international catch since 1964 (thousand tonnes).

Year	Winter season					Summer and autumn season						Total
	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Norway	Faroes	Greenland	EU	Season total	
1964	8.6	-	-		8.6	-	-	-		-	-	8.6
1965	49.7	-	-		49.7	-	-	-		-	-	49.7
1966	124.5	-	-		124.5	-	-	-		-	-	124.5
1967	97.2	-	-		97.2	-	-	-		-	-	97.2
1968	78.1	-	-		78.1	-	-	-		-	-	78.1
1969	170.6	-	-		170.6	-	-	-		-	-	170.6
1970	190.8	-	-		190.8	-	-	-		-	-	190.8
1971	182.9	-	-		182.9	-	-	-		-	-	182.9
1972	276.5	-	-		276.5	-	-	-		-	-	276.5
1973	440.9	-	-		440.9	-	-	-		-	-	440.9
1974	461.9	-	-		461.9	-	-	-		-	-	461.9
1975	457.1	-	-		457.1	3.1	-	-		-	3.1	460.2
1976	338.7	-	-		338.7	114.4	-	-		-	114.4	453.1
1977	549.2	-	24.3		573.5	259.7	-	-		-	259.7	833.2
1978	468.4	-	36.2		504.6	497.5	154.1	3.4		-	655	1,159.60
1979	521.7	-	18.2		539.9	442	124	22		-	588	1,127.90
1980	392.1	-	-		392.1	367.4	118.7	24.2		17.3	527.6	919.7
1981	156	-	-		156	484.6	91.4	16.2		20.8	613	769
1982	13.2	-	-		13.2	-	-	-		-	-	13.2
1983	-	-	-		-	133.4	-	-		-	133.4	133.4
1984	439.6	-	-		439.6	425.2	104.6	10.2		8.5	548.5	988.1
1985	348.5	-	-		348.5	644.8	193	65.9		16	919.7	1,268.20
1986	341.8	50	-		391.8	552.5	149.7	65.4		5.3	772.9	1,164.70

Year	Winter season					Summer and autumn season						Total
	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Norway	Faroes	Greenland	EU	Season total	
1987	500.6	59.9	-		560.5	311.3	82.1	65.2		-	458.6	1,019.10
1988	600.6	56.6	-		657.2	311.4	11.5	48.5		-	371.4	1,028.60
1989	609.1	56	-		665.1	53.9	52.7	14.4		-	121	786,1
1990	612	62.5	12.3		686.8	83.7	21.9	5.6		-	111.2	798
1991	202.4	-	-		202.4	56	-	-		-	56	258.4
1992	573.5	47.6	-		621.1	213.4	65.3	18.9	0.5	-	298.1	919.2
1993	489.1	-	-	0.5	489.6	450	127.5	23.9	10.2	-	611.6	1,101.20
1994	550.3	15	-	1.8	567.1	210.7	99	12.3	2.1	-	324.1	891.2
1995	539.4	-	-	0.4	539.8	175.5	28	-	2.2	-	205.7	745.5
1996	707.9	-	10	5.7	723.6	474.3	206	17.6	15	60.9	773.8	1,497.40
1997	774.9	-	16.1	6.1	797.1	536	153.6	20.5	6.5	47.1	763.6	1,561.50
1998	457	-	14.7	9.6	481.3	290.8	72.9	26.9	8	41.9	440.5	921.8
1999	607.8	14.8	13.8	22.5	658.9	83	11.4	6	2	-	102.4	761.3
2000	761.4	14.9	32	22	830.3	126.5	80.1	30	7.5	21	265.1	1,095.40
2001	767.2	-	10	29	806.2	150	106	12	9	17	294	1,061.20
2002	901	-	28	26	955	180	118.7	-	13	28	339.7	1,294.70
2003	585	-	40	23	648	96.5	78	3.5	2.5	18	198.5	846.5
2004	478.8	15.8	30.8	17.5	542.9	46	34	-	12		92	634.9
2005	594.1	69	19	10	692	9	-	-	-	-	9	701.1
2006	193	8	30	7	238	-	-	-	-		-	238
2007	307	38	19	12.8	376.8	-	-	-	-	-	-	376.8
2008	149	37.6	10.1	6.7	203.4	-	-	-	-	-	-	203.4
2009	15.1	-	-	-	15.1	-	-	-	-	-	-	15.1
2010	110.6	28.3	7.7	4.7	150.7	5.4	-	-	-	-	5.4	156.1
2011	321.8	30.8	19.5	13.1	385.2	8.4	58.5		5.2	-	72.1	457.3

Year	Winter season					Summer and autumn season						Total
	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Norway	Faroes	Greenland	EU	Season total	
2012	576.2	46.2	29.7	22.3	674.4	9	-		1	-	10	684.4
2013	454	40	30	17	541	-	-		-	-	-	541
2014	111.4	6.2	8	16.1	141.7	-	30.5		5.3	9.7	45.5	187.2
2015	353.6	50.6	29.9	37.9	471.9	-	-		2.5	-	2.5	474.4
2016	101.1	58.2	8.5	3.3	171.1	-	-		-	-	-	171.1
2017	196.8	60.4	15	27.4	299.8	-	-		-	-	-	299.8
2018	186.3	74.5	14.3	11.4	286.5	-	-		-	-	-	286.5
2019	-	-	-	-	-	-	-		-	-	-	-
2020	-	-	-	-	-	-	-		-	-	-	-
2021*	67	49.4	6.4	6.6	129.4							

*** Preliminary, provided by working group members.**

Table 12.3.2 Icelandic capelin. The total international catch of capelin in the Iceland-East Greenland-Jan Mayen area by age group in numbers (billions) and the total catch by numbers and weight (thousand tonnes) in the autumn season (August–December) since 1985.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Total number	Total weight
1985	0.8	25.6	15.4	0.2		42.0	919.7
1986	+	10.0	23.3	0.5		33.8	772.9
1987	+	27.7	6.7	+		34.4	458.6
1988	0.3	13.6	5.4	+		19.3	371.4
1989	1.7	6.0	1.5	+		9.2	121.0
1990	0.8	5.9	1.0	+		7.7	111.2
1991	0.3	2.7	0.4	+		3.4	56.0
1992	1.7	14.0	2.1	+		17.8	298.1
1993	0.2	24.9	5.4	0.2		30.7	611.6
1994	0.6	15.0	2.8	+		18.4	324.1
1995	1.5	9.7	1.1	+		12.3	205.7
1996	0.2	25.2	12.7	0.2		38.4	773.7
1997	1.8	33.4	10.2	0.4		45.8	763.6
1998	0.9	25.1	2.9	+		28.9	440.5
1999	0.3	4.7	0.7	+		5.7	102.4
2000	0.2	12.9	3.3	0.1		16.5	265.1
2001	+	17.6	1.2	+		18.8	294.0
2002	+	18.3	2.5	+		20.8	339.7
2003	0.3	11.8	1	+		14.3	199.5
2004	+	5.3	0.5	-		5.8	92.0
2005	-	0.4	+	-		0.4	9.0
2006	-	-	-	-		-	-
2007	-	-	-	-		-	-
2008	-	-	-	-		-	-
2009	-	-	-	-		-	-
2010	0.01	0.23	0.02	-		0.25	5.4
2011	-	2.45	1.61	-	0.08	4.13	72.1
2012	-	0.2	0.2	-	-	0.4	10.4
2013	-	-	-	-	-	-	-
2014	0.01	2.22	0.6	0.02	-	2.8	45.5
2015	0.03	0.08	0.03			1.4	2.5
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-
2021	-	-	-	-	-	-	-

Table 12.3.3 Icelandic capelin. The total international catch of capelin in the Iceland-East Greenland-Jan Mayen area by age group in numbers (billions) and the total catch by numbers and weight (thousand tonnes) in the winter season (January–March) since 1986.

Year	age 1	age 2	age 3	age 4	age 5	Total number	Total weight
1986		0.1	9.8	6.9	0.2	17.0	391.8
1987		+	6.9	15.5	-	22.4	560.5
1988		+	23.4	7.2	0.3	30.9	657.2
1989		0.1	22.9	7.8	+	30.8	665.1
1990		1.4	24.8	9.6	0.1	35.9	686.8
1991		0.5	7.4	1.5	+	9.4	202.4
1992		2.7	29.4	2.8	+	34.9	621.1
1993		0.2	20.1	2.5	+	22.8	489.6
1994		0.6	22.7	3.9	+	27.2	567.1
1995		1.3	17.6	5.9	+	24.8	539.8
1996		0.6	27.4	7.7	+	35.7	723.6
1997		0.9	29.1	11	+	41.0	797.6
1998		0.3	20.4	5.4	+	26.1	481.3
1999		0.5	31.2	7.5	+	39.2	658.9
2000		0.3	36.3	5.4	+	42.0	830.3
2001		0.4	27.9	6.7	+	35.0	787.2
2002		0.1	33.1	4.2	+	37.4	955.0
2003		0.1	32.2	1.9	+	34.4	648.0
2004		0.6	24.6	3	+	28.3	542.9
2005		0.1	31.5	3.1	-	34.7	692.0
2006		0.1	10.4	0.3	-	10.8	230.0
2007		0.3	19.5	0.5	-	20.3	376.8
2008		0.5	10.6	0.4	-	11.5	202.4
2009		0.1	0.6	0.1	-	0.7	15.1
2010		0.7	5.3	0.9	0.01	6.9	150.7
2011		0.1	16.2	0.6	-	17.0	385.2
2012	0.02	0.6	25.0	6.1	0.02	31.8	674.4
2013	-	0.3	12.1	9.7	0.2	22.3	541.0
2014	-	0.1	4.8	1.3	+	6.1	141.8
2015	-	0.3	17.5	4.7	0.1	22.7	471.9
2016		0.4	5.5	2.0	0.02	8.0	171.1
2017		0.4	5.4	4.1	0.1	10.0	299.8
2018		0.6	10.4	0.9	0.01	11.91	286.5
2019	-	-	-	-	-	0	0
2020	-	-	-	-	-	-	-
2021	-	0.0	4.8	0.3	-	5.2	129.4

Table 12.3.4. Initial quota and final TAC and landings by seasons.

Fishing season	Initial advice	Final TAC	Landings
1992/931	500	900	788
1993/94[1]	900	1250	1179
1994/95	950	850	842
1995/96[1]	800	1390	930
1996/97[1]	1100	1600	1571
1997/98	850	1265	1245
1998/99	950	1200	1100
1999/00	866	1000	934
2000/01	650	1090	1065
2001/02	700	1300	1249
2002/03	690	1000	988
2003/04[2]	555	900	741
2004/05[3]	335	985	783
2005/06	No fishery	235	238
2006/07	No fishery	385	377
2007/08	207	207	202
2008/09[4]	No fishery		15
2009/10	No fishery	150	151
2010/11	No fishery	390	391
2011/12	366	765	747
2012/13	No fishery	570	551
2013/14[1]	No fishery	160	142
2014/15	225[5]	580	517
2015/16	No fishery[5]	173	174
2016/17	No fishery[5]	299	300
2017/18	No fishery[5]	285	287
2018/19	No fishery[5]	0	0
2019/20	No fishery[5]	0	0
2020/21[6]	170[5]	127	129

1) **The final TAC was set on basis of autumn surveys in the season.**
2) **Indices from April 2003 were projected back to October 2002.**
3) **The initial quota was set on a basis of an acoustic survey in June/July 2004**
4) **No fishery was allowed, 15 000 t was assigned to scouting vessels.**
5) **Initial advice based on low probability of exceeding final TAC.**
6) **Preliminary landings.**

Table 12.7.1 Icelandic capelin in the Iceland-East Greenland-Jan Mayen area since the fishing season 1978/79. (A fishing season e.g. 1978/79 starts in summer 1978 and ends in March 1979). Recruitment of 1-year-old fish (unit 10^9) as measured in autumn survey. Spawning stock biomass ('000 t) is given at the time of spawning at the end of the fishing season. Landings ('000 t) are sum of total landings in the season.

Season (Summer/winter)	Recruitment	Landings	Spawning stock biomass
1978/79	-	1195	600
1979/80	22	980	300
1980/81	23.5	684	170
1981/82	21	626	140
1982/83	68	0	260
1983/84	44.1	573	440
1984/85	73.8	896	460
1985/86	33.8	1312	460
1986/87	58.6	1334	420
1987/88	2.6	1116	400
1988/89	43.9	1036	440
1989/90	29.2	807	115
1990/91	27.2	313	330
1991/92	60	677	475
1992/93	104.6	788	499
1993/94	100.4	1178	460
1994/95	119	864	420
1995/96	165	930	830
1996/97	111.9	1570	430
1997/98	66.8	1246	492
1998/99	121	1100	500
1999/00	89.8	932	650
2000/01	103.7	1071	450
2001/02	101.8	1249	475
2002/03	-	988	410
2003/04	4.9	742	535
2004/05	7.9	784	602
2005/06	-	247	400
2006/07	44.7	377	410
2007/08	5.7	203	406
2008/09	12.6	150	328
2009/10	15.4	151	410
2010/11	101.2	391	411
2011/12	9.6	747	418
2012/13	19.4	551	417
2013/14	60.7	142	424
2014/15	58	518	460
2015/16	5.4	174	304*

Season (Summer/winter)	Recruitment	Landings	Spawning stock biomass
2016/17	9.4	300	361*
2017/18	25.9	287	352*
2018/19	10.3	0	127*
2019/20	81.5	0	157*
2020/21	146.3	129	344*

*** Based on predation model in current HCR.**

12.19 Figures

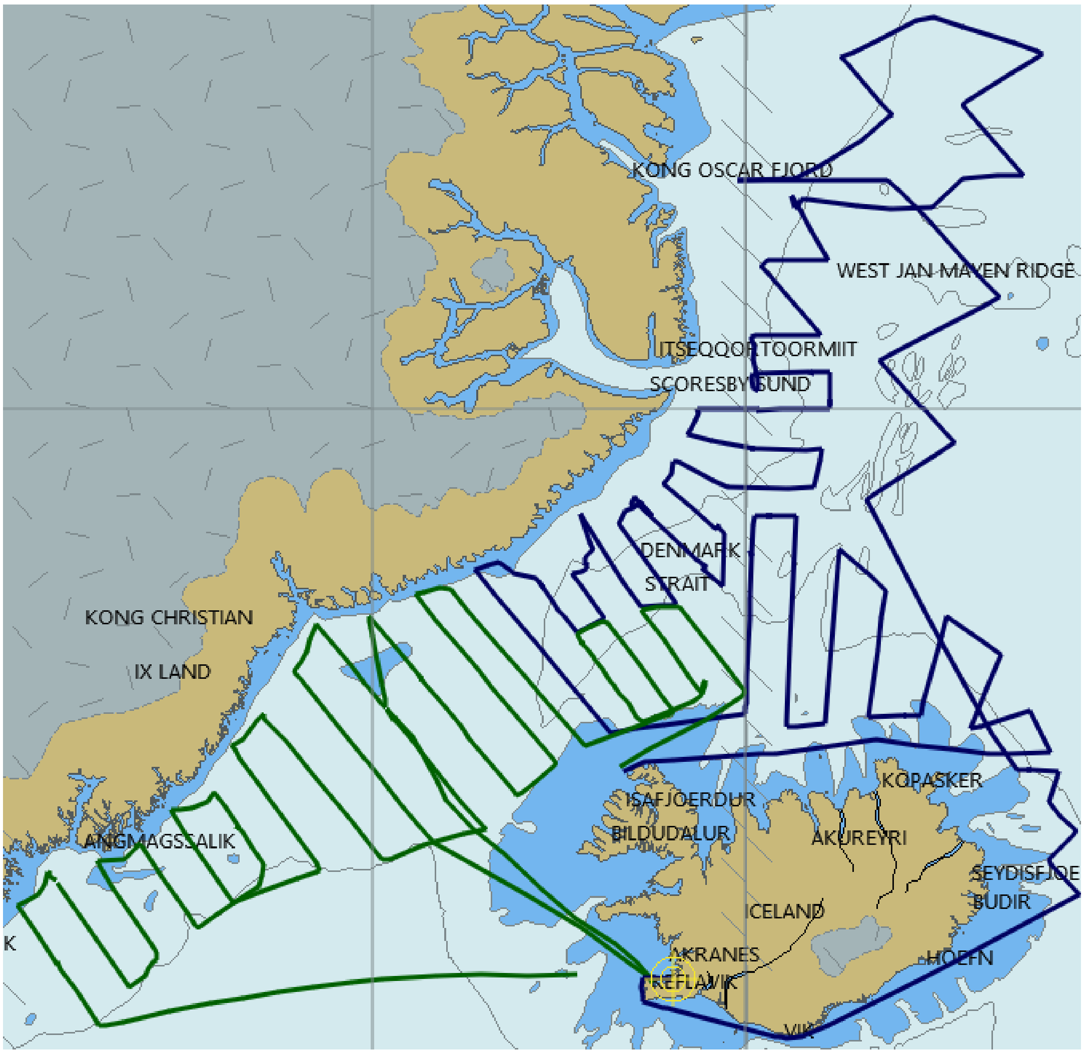

Figure 12.2.1. Icelandic capelin. Cruise tracks during an acoustic survey by r/v Arni Fridriksson (blue) and Eros (GREEN) during 7 September – 5 October 2020.

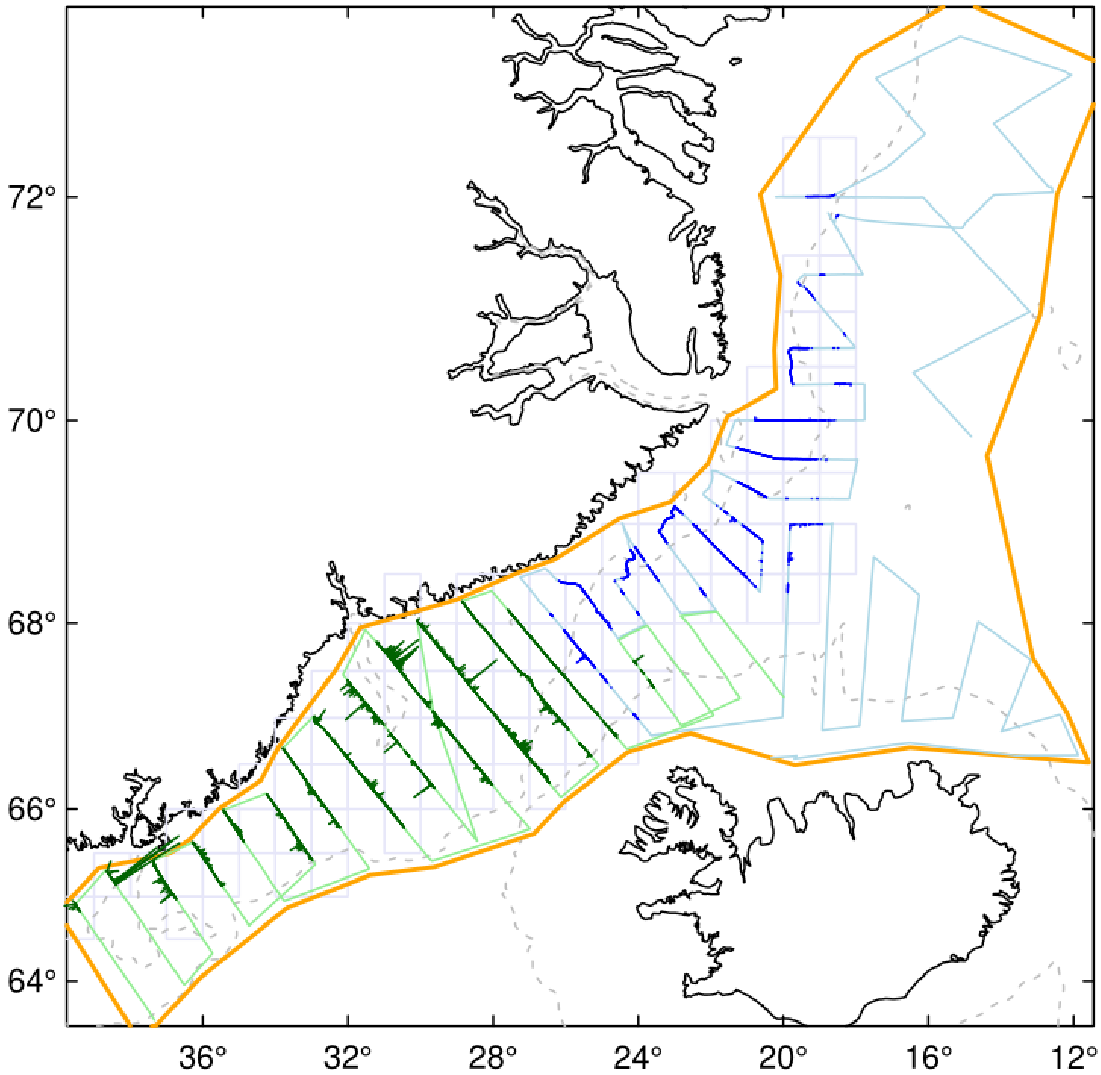

Figure 12.2.2. Icelandic capelin. Relative density and distribution of capelin shown as peri bars during an acoustic survey by r/v Arni Fridriks- son Eros during 7 September – 5 October 2020.

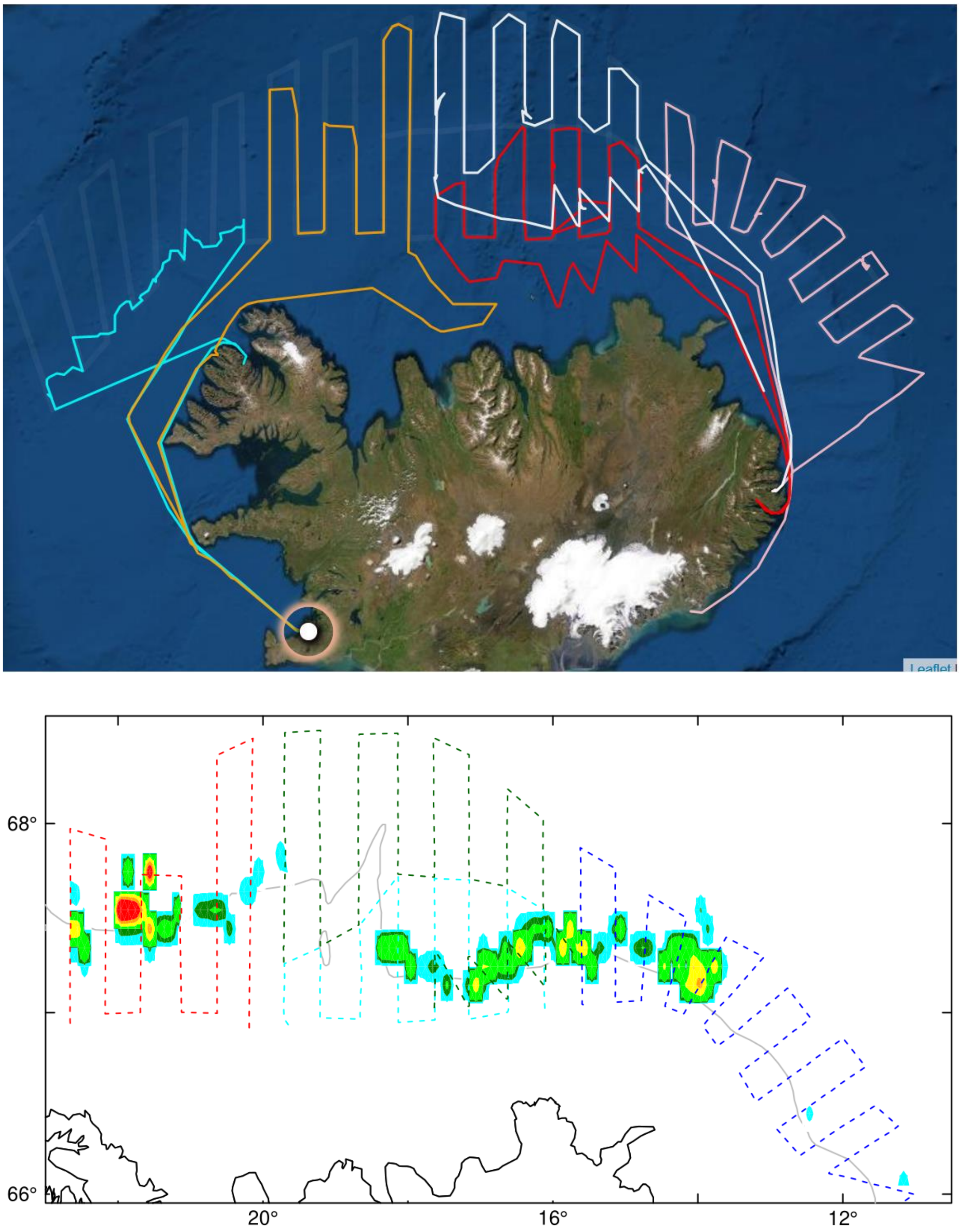

Figure 12.2.3. Icelandic capelin. Survey tracks (A) of the participating vessels during 4–9 January 2021 and distribution (B) of capelin.

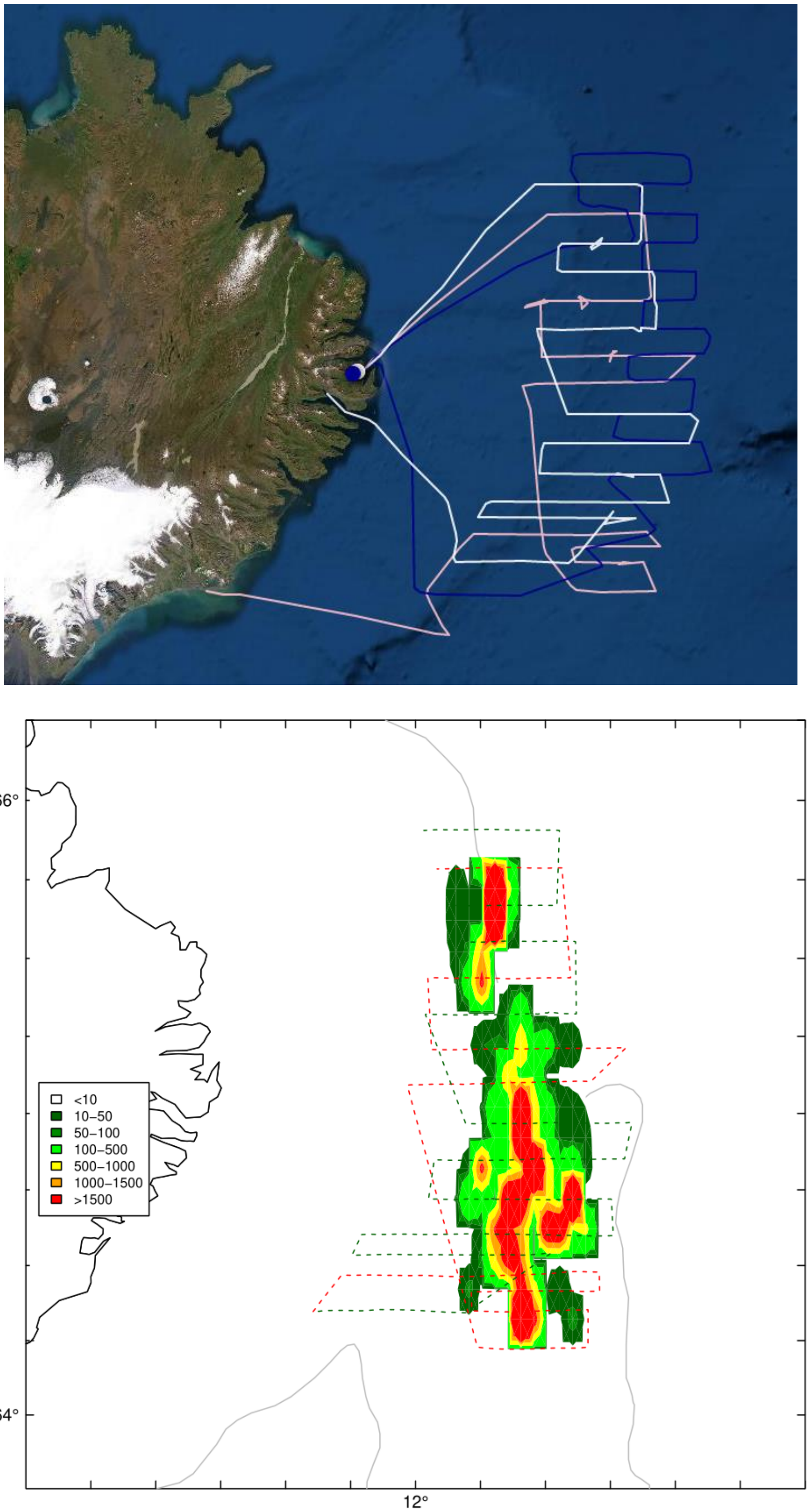

Figure 12.2.4. Icelandic capelin. Survey tracks (A) of participating vessels during 17–20 February 2021 and distribution (B) of capelin.

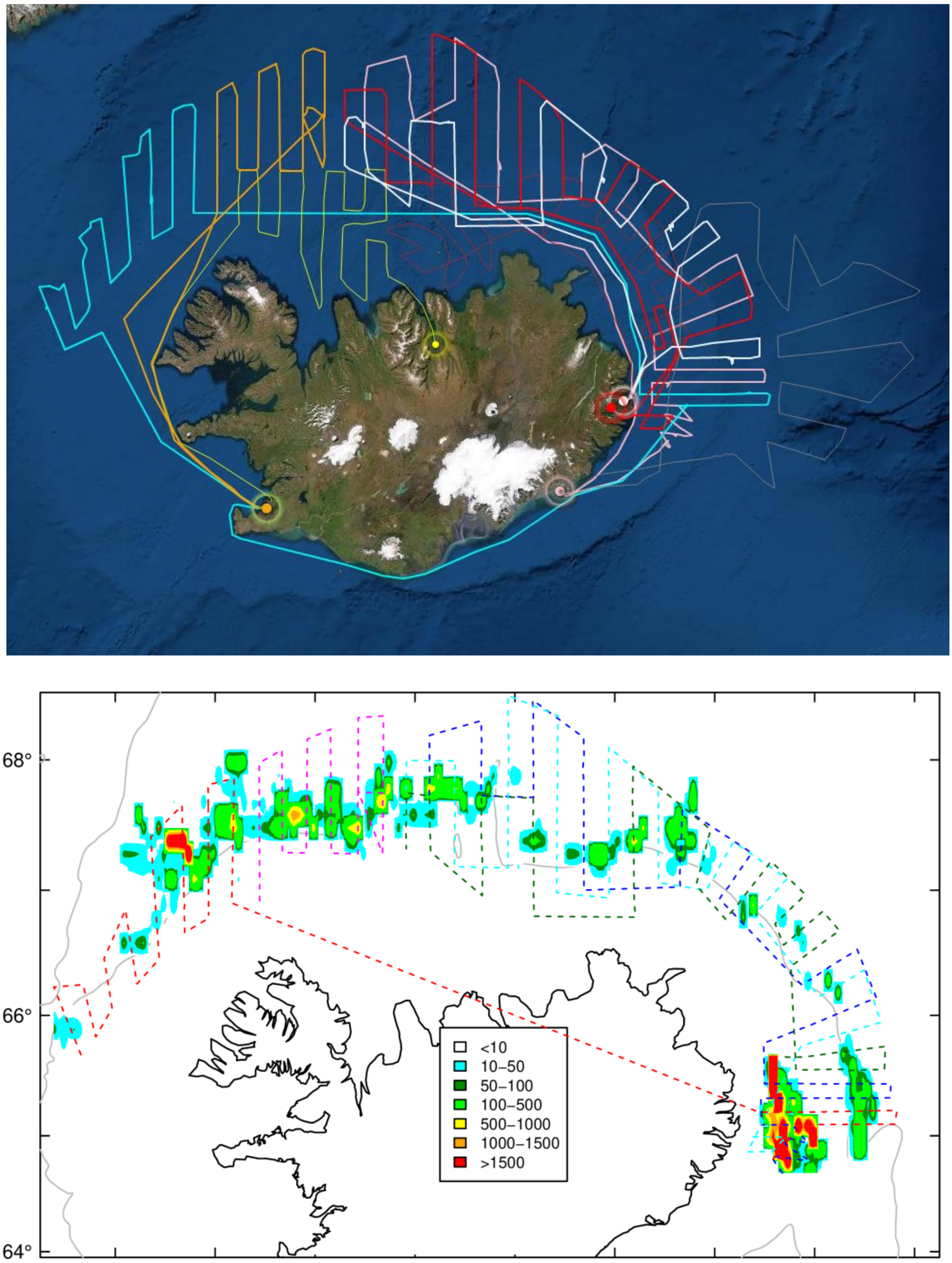

Figure 12.2.5. Icelandic capelin. Survey tracks (A) of participating vessels during 26–30 January 2021 and distribution (B) of capelin.

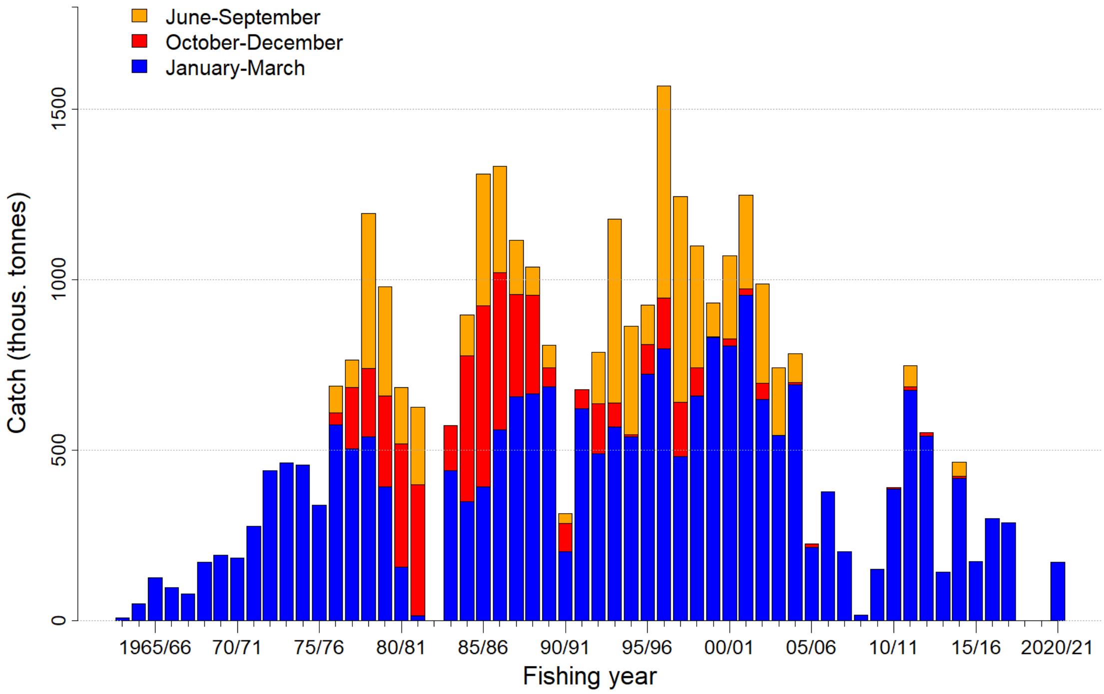

Figure 12.3.1. Icelandic capelin. The total catch (in thousand tonnes) of the Icelandic capelin since 1963/64 by season.

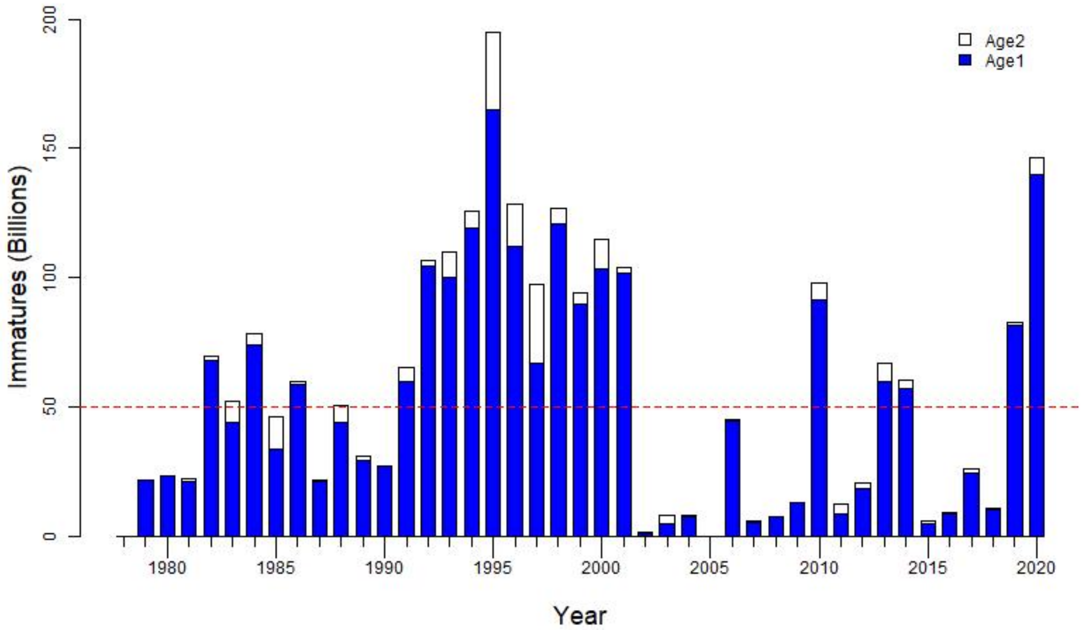

Figure 12.7.1. Icelandic capelin. Indices of immature 1 and immature 2 years old capelin from acoustic surveys in autumn since 1979.

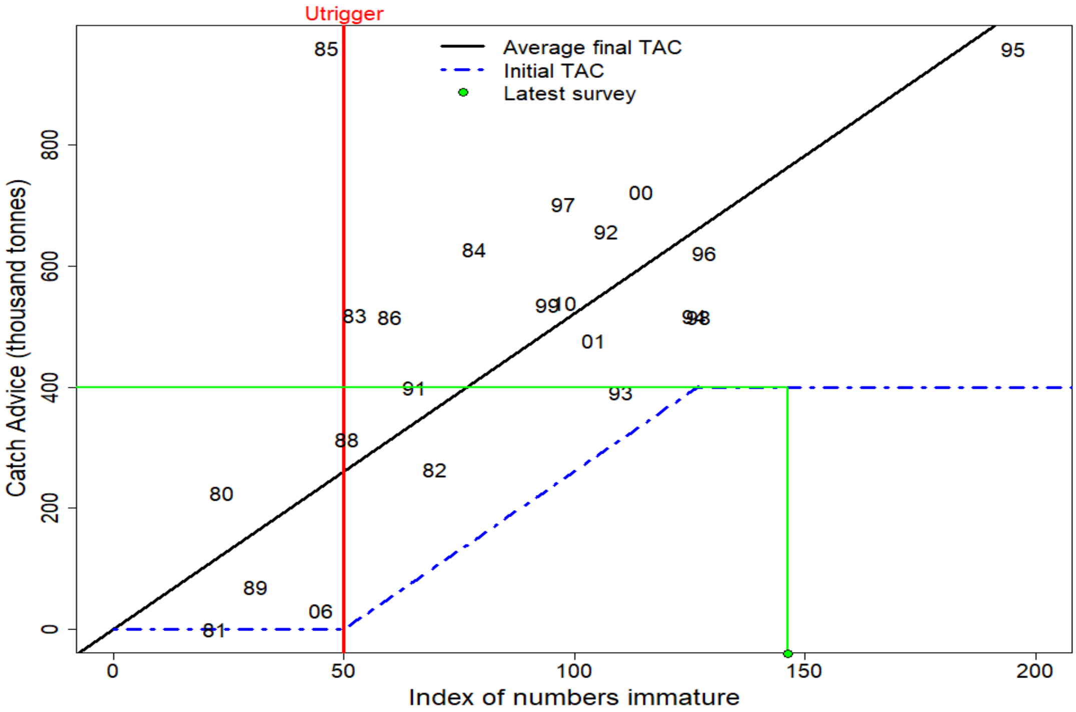

Figure 12.7.2 Icelandic Capelin. Catch advice according to the proposed stochastic HCR, based on the measured number of immature capelin about 15 months earlier. The figure shows the estimated final TAC (black unbroken line) and the initial (preliminary) TAC (blue dashed line). The latter is set using a Utrigger (red vertical line) of 50 billion immature fish, with a cap on the initial (preliminary) TAC of 400 kt. The green lines show the index value from the autumn survey 2020, with the corresponding initial TAC for 2021/2022 shown on the y-axis. (The figure adapted from stock-annex, WKICE 2015).

13 Overview on ecosystem, fisheries and their management in Greenland waters

13.1 Ecosystem considerations

The marine ecosystem around Greenland is located from arctic to Subarctic regions. The water masses in East Greenland are composed of the polar *East Greenland Current* and the warm and saline *Irminger Current* of Atlantic origin. As the currents round Cape Farewell at Southernmost Greenland the saline, warm Irminger water subducts the colder polar water and forms the relatively warm *West Greenland Current*. This flows along the West Greenland coast mixing extensively as it flows north. This current is of importance in the transport of larval and juvenile fish along the coast for important species such as cod and Greenland halibut. Additionally, cod from Icelandic waters spawning south and west of Iceland occasionally enters Greenland waters via the Irminger current and is distributed along both the Greenland East and West coast (Figure 1).

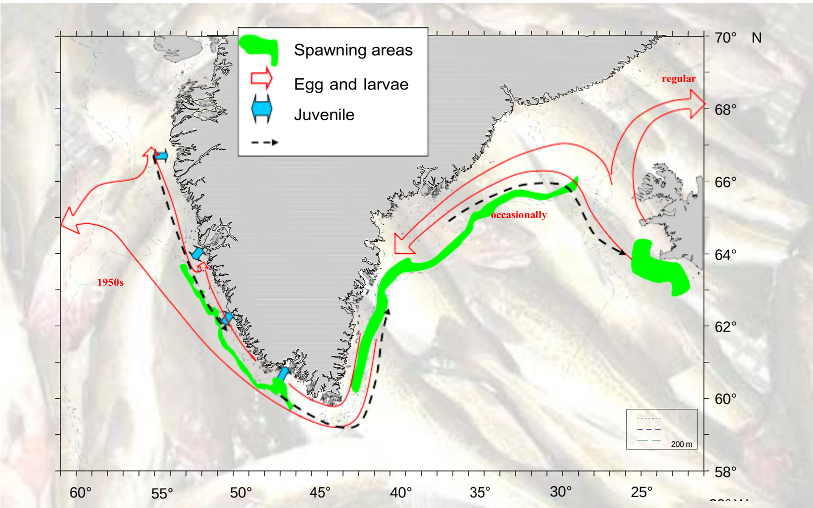

Figure 1. Spawning areas, egg and larval transport of Atlantic cod (*Gadus morhus*) in Greenlandic and Icelandic waters.

Depending of the relative strength of the two East Greenland currents, the Polar Current and the Irminger Current, the marine environment experience extensive variability with respect to the hydrographical properties of the West Greenland Current. The general effects of such changes have been increased production during warm periods as compared to cold periods, and resulted in extensive distribution and productivity changes of many commercial stocks. Historically, cod is the most prominent example of such a change (Hovgård and Wieland, 2008).

In recent years, temperature have increased significantly in Greenland waters. In West Greenland the sea temperature have increased particularly compared to the years in 1970s–mid1990s and historical highs was registered in 2005 for the time-series 1880–2012 (Figure 2).

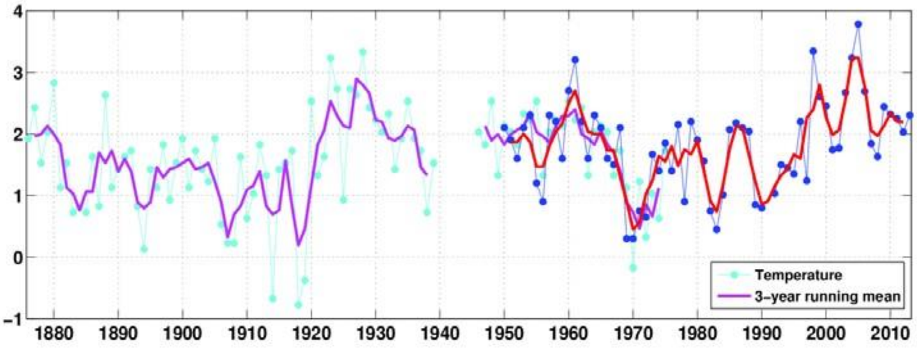

Figure 2. Mean temperature on top of Fylla Bank (located outside Nuuk Fjord, 0–40 m depth) in the middle of June for the period 1950–2013. The curves are 3 year running mean values. The magenta/purple line is extended back to 1876 using Smed-data for area A1. From Ribergaard (2014).

Temperature in the centre of the Irminger Sea, in the depth interval 200–400 m, shows no such clear long-term trend (ICES, 2013c). However, Rudels *et al.* (2012) finds that between 1998–2010, the salinity and temperature of the deep water in the Greenland Sea increased. Furthermore, increasing temperatures in the Atlantic Water entering the Arctic in the Fram Strait has increased throughout the period 1996–2012, though with the highest observation in 2006 (ICES, 2013c). Such environmental changes might well propagate to different trophic levels. Accordingly, shrimp biomass fluctuations in Greenland waters as a result of environmental changes could affect fish predators such as cod (Hvingel and Kingsley, 2006) and the other way around.

The primary production period in Greenland is timely displaced along the coast due to increasing sea ice cover and a shorter summer period moving north (Blicher *et al.*, 2007), but the main primary production takes place in May–June (Figure 3). The large latitudinal gradient spanned by Greenland, the ecosystem structure shifts moving north. For instance, the secondary producer assembly (e.g. mainly copepods) shifts from being dominated by smaller Atlantic species (*Calanus finmarchicus* and *Calanus glacialis*) to being increasingly dominated by the (sub)arctic species *Calanus hyperboreus.*

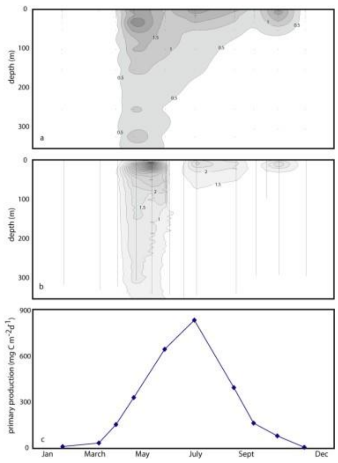

Figure 3. Annual variation in algal biomass and productivity at the inlet of Nuuk Fjord. a: chlorophyll (µg l^{-1}), b: fluorescence, c: primary production (mg C m^{-2} d^{-1}). Dots represent sampling points. From Mikkelsen *et al.* (2008).

Recently, the distribution of commercial species such as cod and shrimp has shifted considerably in the north. Such shifts have previously been associated with temperature, and may very well be linked to the observed increase in temperature. Additionally, changes in growth of fish may also increase as a result of temperature changes as seen for both Greenland halibut (Sünksen *et al.*, 2010) and cod (Hovgård and Wieland, 2008).

In recent years, more southerly distributed species not normally seen in Greenland waters such as pearlside (*Maurolicus muelleri*), whiting (*Merlangius merlangus*), blackbelly rosefish (*Helicolenus dactylopterus*), angler (*Lophius piscatorius*) and snake pipefish (*Entelurus aequoreus*) have been observed in surveys in offshore West and East Greenland and inshore West Greenland and their presence is possibly linked to increases in temperature (Møller *et al.*, 2010).

In 2011, a mackerel (*Scomber scombrus)* fishery was initiated in East Greenland waters. Previous to this, no catches had ever been reported for this area and in 2013 mackerel was for the first time documented along the West Greenland coast. The reason(s) for the increased abundance of mackerel in Greenlandic waters has not been clarified, however factors such as changes in the regime for their usual food resources, a density-dependent effect and increased temperatures have been proposed (ICES, 2013a). The effects of increased pelagic fish abundance and their distributional shifts on demersal fish are unknown.

13.1.1 Atmospheric conditions

Cod and possibly other species recruitment in Greenland waters is significantly influenced by environmental factors such as sea surface temperatures in the important Dohrn Bank region during spawning and hence by air temperatures together with the meridional wind in the region between Iceland and Greenland (Stein and Borovkov, 2004). The effect of the meridional wind component in the region off South Greenland on the first winter of the offspring appears to play a vital role for the cod recruitment process. For instance, during 2003, when the strong 2003 YC was born, negative anomalies were more than -2.0 m/sec, and that particular YC was large in East Greenland waters. In general, it seems that during anomalous east wind conditions during summer months, anomalous numbers of 0-group cod are also found in Greenland waters.

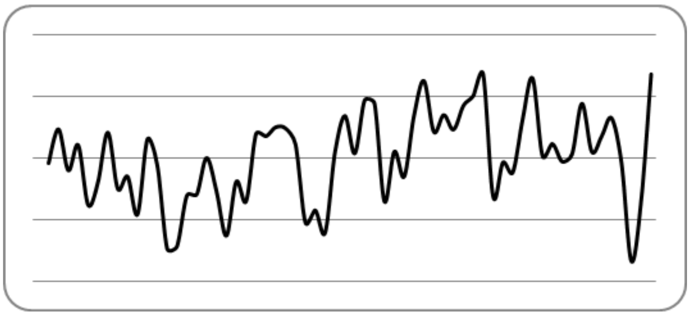

Figure 4. NAO Index (Dec–Feb) 1950–2012.

The NAO index

The NAO index, as given for 1950–2012 (Figure 4), shows negative values for winter (December–February) 2008/2009, 2009/2010 and 2010/2011. The 2009/2010 index is the strongest negative index (-1.64), encountered since 1950.

During the second half of the last century the 1960s were generally “low-index” years while the 1990s were “high-index” years. A major exception to this pattern occurred between the winter preceding 1995 and 1996, when the index flipped from being one of its most positive (1.36) values to a negative value (-0.62). The direct influence of NAO on Nuuk winter mean air temperatures is as follows: A “low-index” year corresponds to warmer-than-normal years. Colder-than-normal temperature conditions at Nuuk are linked to “high-index” years and hence indicate a negative correlation of Nuuk winter air temperatures with the NAO. Correlation between both time series is significant (r = -0.73, p << 0.001; Stein, 2004). This is seen for instance in 2009, 2010 and 2011 where air temperature anomalies at Nuuk (1.0K, 4.8K and 2.9K) where associated with low NAO values (Figure 5). The 2010 air temperature anomaly (4.0K) was the highest recorded, and was associated with the largest negative NAO anomaly (see Figure 6).

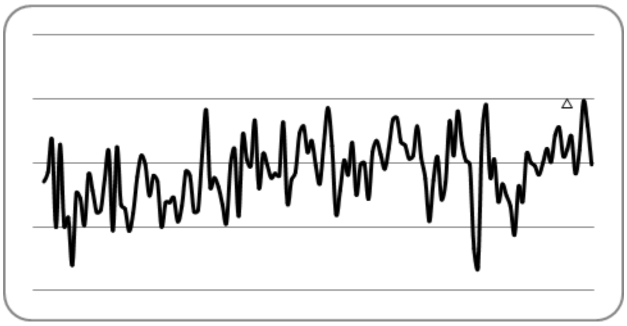

Figure 5. Time-series of annual mean winter (DEC–FEB) air temperature anomalies (K) at Nuuk (1876–2012, rel. 1961–1990)

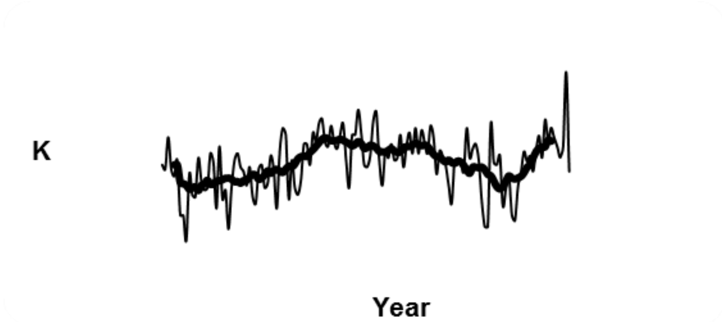

Figure 6. Time-series of annual mean air temperature anomalies (K) at Nuuk (1876–2011, rel. 1961–1990), and 13 year running mean.

Zonal wind components

A negative anomaly of zonal wind components for the Northwest Atlantic is associated with atmospheric conditions in the Iceland-Greenland region enclosing strong easterly winds (Figure 7, top left panel). These winds favour surface water transports from Iceland to East Greenland and was particularly strong in 2009, while it was completely different during the same months in 2010 (Figure 7). During May–August in 2011, the cells of negative anomalies were seen to the east of Newfoundland (anomalies < 3.0 m/sec), and to the east of Iceland.

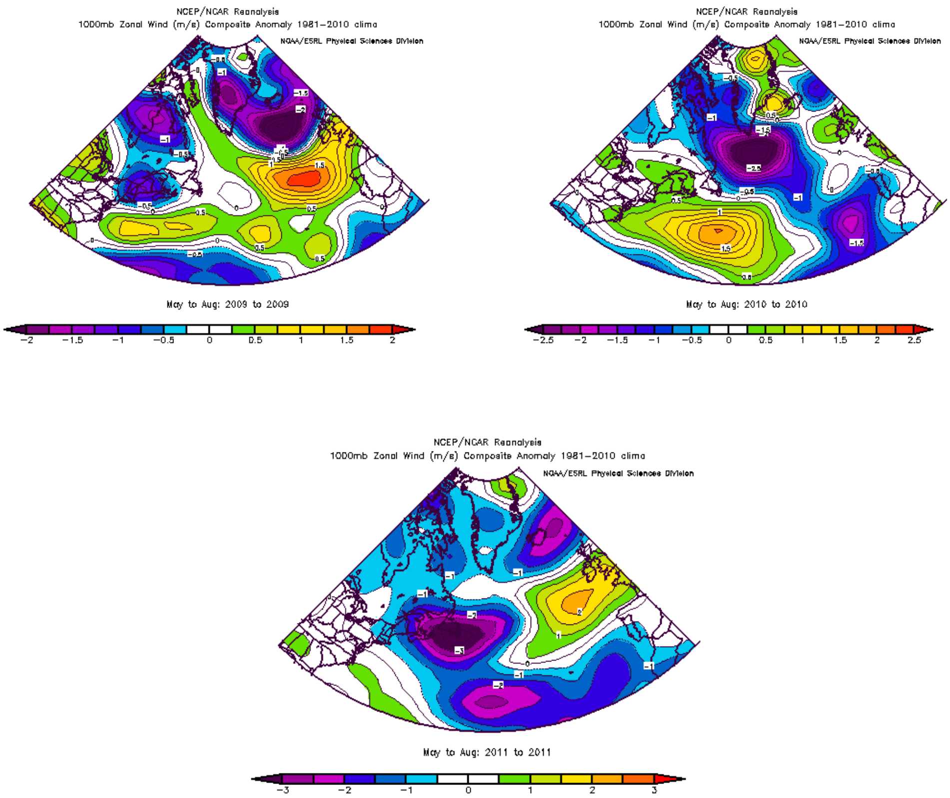

Figure 7. Zonal wind components for the North Atlantic (May–Aug), anomalies from 1981–2010.Top left: 2009; top right: 2010; bottom: 2011.

Meridional wind components

As discussed in Stein and Borovkov (2004), the meridional wind component (Dec–Jan) from the Southwest Greenland region correlated positively with the trend in Greenland cod recruitment time-series (first winter of age-0 cod). During winter 2009/2010, positive meridional wind anomalies were observed Southwest Greenland (Figure 8, top left panel). During winter 2010/2011, the center of positive meridional wind anomalies had moved to the Davis Strait region (Figure 5, top right panel), and during winter 2011/2012, positive meridional wind anomalies had moved to the Northeast off Newfoundland (bottom panel in Figure 8).

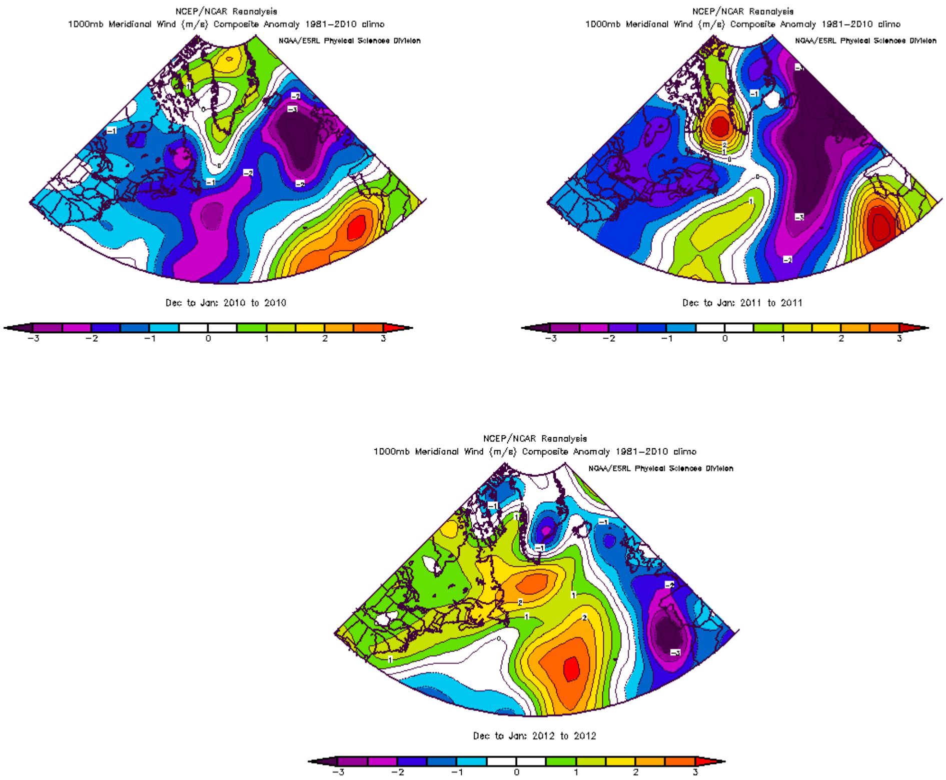

Figure 8. Meridional wind component (Dec–Jan), anomalies from 1981–2010. top left: 2009/2010; top right: 2010/2011; bottom: 2011/2012;

13.1.2 Description of the fisheries

Fisheries targeting marine resources off Greenland can be divided into inshore and offshore fleets. The majority of the Greenland fleet has been built up through the 60s and is today comprised of approx. 450 larger vessels and a big fleet of small boats. It is estimated that around 1700 small boats are dissipating in some sort of artisanal fishery mainly for private use or in the poundnet fishery.

Active fishing fleet reported to Greenland statistic by GRT in 1996 – no later number is available:

All fleet (N)	< 5GRT	6–10GRT	11–20GRT	21–80GRT	> 80GRT
441	31%	34%	2%	9%	6%

There is a large difference between the fleet in the northern and southern part of Greenland. In south, were the cod fishery has historically been important the average vessel age is 22 years, in north only 9 years as it is mostly comprised of smaller boats targeting Greenland halibut using longlines.

13.1.3 Inshore fleets

The fleet is constituted by a variety of different platforms from dog sledges used for ice fishing, to small multipurpose boats engaged in whaling or deploying passive gears such as gillnets, poundnets, traps, dredges and longlines.

In the northern areas from Disko Bay at 72ºN and north to Upernavik at 74º30N, dog sledge are the platforms in winter and small open vessels the units in summer, both fishing with longlines to target Greenland halibut in the ice fjords. The main bycatch from this fishery is redfish, Greenland shark, roughhead grenadier and in recent years, cod in Disko Bay.

The coastal shrimp fisheries are distributed along most of the West coast from 61–72ºN. The main bycatch with the inshore shrimp trawlers is juvenile redfish, cod and Greenland halibut. An inshore shrimp fishery is conducted mainly in Disko Bay. Sorting grid is mandatory for the shrimp fishery; however, several small inshore shrimp trawlers have dispensation for using sorting grid.

Cod is targeted all year, but with a peak in effort in June–July as cod in this period is accessible in shallow waters facilitating the use of the main gear types, pound and gillnets. Bycatches are limited and are mainly Greenland cod (*Gadus ogac*) and wolffish.

In the recent years there has been an increasing exploitation rate for lumpfish. The fishing season is short, with the majority of the catch being caught in May–June. Lumpfish is caught along most of the West coast and is caught using gillnets. In small areas there is a substantial by catch of birds, especially common eiders (*Somateria mollissima*)

The scallop fishery is conducted with dredges at the West coast from 64–72 ºN, with the main landings at 66ºN. Bycatch in this fishery is considered insignificant.

Snow crabs are caught in traps in areas 62–70ºN. Problems with bycatch are at present unknown, but are believed to be insignificant.

Salmon are caught in August–October with drifting nets and gillnets. The fishery is a mix of salmon of European and North American origin.

The coastal fleets fishing for Atlantic cod, snow crab, scallops and shrimp are regulated by licenses, TAC and closed areas. Fishery for salmon and lumpfish are unregulated.

13.1.4 Offshore fleets

Apart from the Greenland fleet, the marine resources in Greenland waters are exploited by several nations, mainly EU, Iceland and Norway using bottom and pelagic trawls as well as long-lines.

The demersal offshore fishery is comprised of vessels primarily fishing Greenland halibut, shrimp, redfish and cod. Greenland halibut and redfish have been targeted since 1985 using demersal otter board trawls with a minimum mesh size of 140 mm. A cod fishery has previously been conducted since 1920s in West Greenland offshore waters but was absent from 1992–2000s. In 2010, the cod fishery was closed off West Greenland and catches has been insignificant since. The Greenland offshore shrimp fleet consist of 15 freezer trawlers. They exclusively target shrimp stocks off West and East Greenland with landings slightly below 100 000 tonnes. The shrimp fleet is close to or above 80 BT and 75% of the fleet process the shrimp on board. Shrimp trawls are used with a minimum mesh size of 44 mm and a mandatory sorting grid (22 mm) to avoid bycatch of juvenile fish. The three most economically important fish species in Greenland: Greenland halibut, redfish and cod are found in relatively small proportions in the bycatch. However, when juvenile fish are caught, even small biomasses can correspond to relatively large numbers.

Longliners are operating on both the East and West coast with Greenland halibut and cod as targeted species. Bycatches include roundnose grenadier, roughhead grenadier, tusk, Atlantic halibut and Greenland shark (Gordon *et al.*, 2003).

The pelagic fishery in Greenland waters is conducted in East Greenland and currently targeted species are mackerel and pelagic redfish. A relatively small fishery after herring is carried out in the border area between Greenland, Iceland and Jan Mayen. A capelin fishery has previously been done but as the Greenland share of the TAC is taken in other waters. Generally, the pelagic fishery in Greenland is very clean, with small amounts of bycatch seen.

The demersal and pelagic offshore fishing, together with longlines are managed by TAC, minimum landing sizes, gear specifications and irregularly closed areas.

13.2 Overview of resources

In the last century, the main target species of the various fisheries in Greenland waters have changed. A large international fleet in the 1950s and 1960s landed large catches of cod reaching historic high in 1962 with about 450 000 tonnes. The offshore stock collapsed in the late 1960s–early 1970s due to heavy exploitation and possibly due to environmental conditions. Since then the stock has been low, with occasional larger YC being transported from Iceland (i.e. 1984 and 2003). Since 2010, the cod biomass has been concentrated in the spawning grounds off East Greenland. Following the cod collapse, the offshore shrimp fishery started in 1969 and has been increasing up to 2003 reaching a catch level close to 150 000 tonnes. The stock decreased thereafter and is now at the low 1990 level with an advised TAC for 2015 of 60 000 tonnes. The advised TAC for 2016 increased to 90 000 tonnes.

13.2.1 Shrimp

The shrimp (*Pandalus borealis)* stock in Greenland waters has been declining since 2003. The stock in East Greenland is at a low level based on available information. The 2003 West Greenland shrimp biomass was at the highest in the time-series, but it has since decreased.

13.2.2 Snow crab

The biomass of snow crab (*Chionoecetes opilio*) in West Greenland waters has decreased substantially since 2001. Snow crab has been exploited inshore since the mid-1990s and offshore since 1999. Total landings have since 2010 been reported at around 2000 tonnes a decrease from a high level in 2001 at 15 000 tonnes. After several years of decreasing CPUE it now appears to have stabilized at low levels in the majority of areas.

13.2.3 Scallops

The status of scallops in Greenland is unknown. From the mid-1980s to the start 1990s landings were between 4–600 tonnes yearly, increased to around 2000 tonnes in late 1990s. Catches decreased again and is below 600 tonnes in 2014. The fishery is based on license and is exclusively at the west coast between 20–60 m. The growth rate is considered very low reaching the minimum landing size on 65 mm in 10 years.

13.2.4 Squids

The status of squids in Greenland waters are unknown.

13.2.5 Cod

Since 2015, assessment and advice for cod in Greenland water take into account that three different stocks, based on spawning areas and genetics, are the basis for the cod fishery and the following management is therefore recommended for different three areas: a) inshore in Western Greenland (NAFO Subdivision 1A–1F), b) offshore Western Greenland (NAFO Subdivision

1A–1E) and offshore Eastern and South Greenland (ICES Subarea 14.b and NAFO Subdivision 1F). Current landings for inshore cod are 35 000 tonnes, and have steadily increased since 2009 where landings were 7000 tonnes. Landing from offshore Western Greenland was minor (less than 500 tonnes since 2006) until 2015 where catches increased to 4600 tonnes. From offshore Eastern Greenland area 2015 landing was 15 800 tonnes, an increase from the 2011–2013 level at 5000 tonnes.

Catches are high compared to the last three decades; however, they are only a fraction of the landings caught in the 1950s and 1960s. Recruitment has been negligible since the 1984- and 1985-year classes, though it has improved in the last decade, especially inshore, where the 2009 YC is the best seen in the time-series since 1982. In 2007 and 2009, dense concentrations of unusually large cod were documented to be actively spawning off East Greenland, and management actions have been taken to protect these spawning aggregations. The inshore fishery has been regulated since 2009 and the offshore fishery is managed with license and minimum size (40 cm). As a response to the favourable environmental conditions (large shrimp stock, high temperatures) there is a possibility that the offshore cod will rebuild to historical levels if managed with this objective. A management plan with the objective of achieving this goal has been implemented for the fishing seasons 2014–2016. Several YC are present in the inshore fishery, and with the stable recruitment in recent years and widespread fishery there are several indications that the stock is experiencing favourable conditions and that recruitment is not impaired despite an increased fishing effort in later years. However, in 2015 signs of increasing fishing pressure is seen as the biomass index in the inshore survey is stable and recruitment is low.

13.2.6 Redfish

Redfish (*Sebastes mentella* and *Sebastes norvegicus*) are primarily caught of East Greenland. Catches have been small since 1994, but recently large year classes have given rise to a significant fishery with catches in 2010–16 being around 8000 tonnes. This includes both redfish species. The majority (e.g. ~70%) has earlier been identified as *S. mentella*. However, recent East Greenland survey estimates indicate a decline in *S. mentella* while *S. norvegicus* is increasing, and based on samples from the fishery the proportion of *S. norvegicus* exceeded *S. mentella* in 2016 for the first time.

13.2.7 Greenland halibut

Greenland halibut in the Greenland area consist of at least two stocks and several components; the status of the inshore component is not known, but it has sustained catches of 15–20 000 tonnes annually, taken primarily in the northern area (north of 68°N). The offshore stock component in West Greenland (NAFO SA 0+1) is a part of a shared stock between Greenland and Canada. The stock has remained stable in the last decade, sustaining a fishery of about 30 000 tonnes annually (15 000 tonnes in Greenland water). The East Greenland stock is a part of a stock complex extending from Greenland to the Barents Sea. The stock size is currently estimated as being at a historical low. In 2015, catches were around 9400 tonnes.

13.2.8 Lumpfish

The status of the lumpfish is unknown. The landing of lumpfish has increased dramatically in the last decades with catches being close to 13 000 tonnes in 2013. Catches are highest in the southern-mid section of the Greenland west coast. There are no indications of the impact on the stock. A management plan was implemented in 2014 regulating the fishery with TAC and number of fishing days.

13.2.9 Capelin

On the Greenland East coast an offshore pelagic fleet have been conducting a fishery on capelin (2500 tonnes (summer/autumn) landed in 2015 by Greenland, EU, Norway and Iceland). The capelin has shifted distribution more west and north in recent years, and are believed to spend a substantial amount of time in Greenland waters. The west Greenland capelin stock is not fished and its size is unknown.

13.2.10 Mackerel

A mackerel fishery in Greenland waters initiated in 2011 with catches of 162 tonnes and increased to more than 32 000 tonnes in 2015. Mackerel is known to feed on various species, including fish larvae, and it competes with others pelagic species, such as herring, for resources (Langøy *et al.,* 2012). Thus, it might/can have a key role on the ecosystem of many commercial important species in Greenland.

13.2.11 Herring

A fishery for Norwegian spring-spawning herring in Greenland water has increased in recent years and in 2014 catches increased to 9000 tonnes. The herring has shifted distribution more west in recent years.

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14 Cod (*Gadus morhua*) in NAFO Subdivisions 1A–1E (Offshore West Greenland)

14.1 Stock definition

The cod found in Greenland is derived from four separate "stocks" that each is labelled by their spawning areas: I) offshore West Greenland waters; II) West Greenland fiords; III) offshore East Greenland and Icelandic waters and IV) inshore Icelandic waters (Therkildsen *et al*., 2013), (Figure 14.1).

From 2012, the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. From 2015 the offshore West Greenland (NAFO subdivisions 1A–

E) and East Greenland (NAFO subdivision 1F and ICES Subarea 14) components was assessed separately. The Stock Annex provides more details on the stock identities including the references to the primary literature.

14.2 Fishery

14.2.1 The emergence and collapse of the Greenland offshore cod fisheries

The Greenland commercial cod fishery in West Greenland started in the 1920s. The fishery gradually developed culminating with catch levels at 400 000 tonnes annually in the 1960s. Due to overfishing and deteriorating environmental conditions, the stock size declined and the fishery completely collapsed in the early 1990s (Table 14.2.1, Figure 14.2.1). More details on the historical development in the fisheries are provided in the Stock Annex.

In the period 2015-2018 a TAC of 5 000 tonnes was introduced as an experimental fishery. In 2019 the start TAC was 0 tons, but during the year 2,000 tons were allocated from the inshore TAC. Since 2015 it has been allowed to fish offshore on the inshore quota. The offshore catches on the inshore quota have been between 400-600 t annually in the period 2015-2019.

14.2.2 The fishery in 2020

In 2020 TAC was 0 tons, however 103 tons were fished offshore on the inshore quota.

Main fishing ground was Tovqussaq Bank (NAFO division 1C, between 66°15–66°30N, Table 14.2.2.1, figures 14.2.2.1 and 14.2.2.2).

The fishery was conducted from July to October with 82 % caught in August-September. One small trawler (<25 m) participated in the fishery (table 14.2.2.2).

No biological sampling (i.e. length measurement and otoliths) were taken from the fishery in 2020. Catch at age and Weight at age in the period 2007-2019 can be seen in table 14.2.3.1.

A detailed description of the fishery is available in Retzel 2021a.

14.3 Surveys

At present, two offshore trawl surveys (Greenland and German) provide the core information relevant for stock assessment purposes.

The German survey targets cod and has since 1982 covered the main cod grounds off West Greenland up to 67°N at depths down to 400 m, thus including periods of both high and low cod abundance. The German survey has not been conducted in the area in the period 2015-2019. However in 2019 the southern part of the survey area (NAFO 1E) was covered.

The Greenland survey targets shrimp and cod off West Greenland up to 72°N and from 0 to 600 m from 1992, hereby extending into northern areas where large cod concentrations are not expected. Although most of the effort has previously been allocated towards shrimp, but since 2005 the addition of additional fish stations implies a fair coverage of the West Greenland cod habitat in this survey.

For details of survey design, see stock annex.

In 2018, 2019 and 2020 the annual trawl survey was conducted with a chartered vessel. All the standard gear from the research vessel Paamiut (such as cosmos trawl, doors, all equipment such as bridles ect., Marport sensors on doors and headlines) were used, in attempt to make the chartered surveys as identical as possible with the previous years' survey (Burmeister and Riget, 2018; Burmeister and Riget, 2019; Burmeister and Riget, 2020).

In 2020 trawling was conducted primarily at night-time in the shallow strata (51-100 + 101-150), whereas previously trawling was restricted to between 08.00 UTC and 20.00 UTC. In total 37 of the hauls was conducted during night-time and 3 during daytime. Preliminary analyses of commercial logbooks showed that standardized CPUE was 9-10% higher during daytime than during the nightline, however, the difference was not significant ($p = 0.32$). The introduction of night hauls in 2020 is evaluated to have a minor effect on the estimated abundance and biomass estimates. The gain by trawling around the clock instead of only daytime, by increased strata coverage is evaluated to be larger than the possible day and night influence, which may be able to correct for in the future.

14.3.1 Results of the Greenland Shrimp and Fish Survey

The numbers valid hauls were 208 in 2020 (Table 14.3.1.1, figures 14.3.1.1 and 14.3.1.2).

The 2020 survey abundance of Atlantic cod in West Greenland was estimated at 24 million individuals and the survey biomass at 15,000 tons (tables 14.3.1.2 and 14.3.1.3). Survey abundance and biomass are on the same low level as the period 2016-2018.

Overall the 3 year olds (2017 YC) dominated the survey in 2020 (Table 14.3.1.4, Figure 14.3.1.3). However the 2015 YC is more abundant in the southern part of the survey (NAFO 1E), whereas younger yearclasses, at size ranges < 40 cm, are more abundant in the northern part of the survey area (NAFO 1A to 1D, table 14.3.1.5, figure 14.3.1.4).

The distribution pattern is similar with previous years with younger cod in the northern part of the survey area, and at older ages moving further to the south. Length distribution is similar to 2018 with few cod larger than 40 cm (figure 14.3.1.5).

The main part of cod found offshore in West Greenland have since the beginning of the survey been younger than 5 years. However, since 2017 increasing numbers of older cod (especially the 2009 and 2010 YC) have been registered in the survey (table 14.3.1.4).

Genetics. In the 2019 survey samples for genetic analysis were taken from each NAFO division. In total 527 samples were analysed for genetic assignment. Samples with assignment probability > 70% (499) were used in the data analysis. In the northern area of the survey (NAFO 1A and 1B) the West-Greenland offshore component dominated (60%) followed by the EastGreenland-Iceland offshore component (30%, figure 14.3.1.6). The composition changed with latitude with the EastGreenland-Iceland offshore component dominating in the southern area (80 %, NAFO 1E and 1F), followed by the WestGreenland offshore component (10%). The dominating YC in 2019 survey catches was the 2015 YC and the genetic composition showed that the overall majority belonged to the EastGreenland-Iceland offshore component (75%, figure 14.3.1.7). In general the EastGreenland-Iceland offshore component is found in varying amounts in all yearclasses.

The survey biomass in 2019 was weighted with the genetic split in each NAFO area. This resulted in 75% of the total biomass index was assigned to the EastGreenland-Iceland component, followed by the WestGreenland offshore component with 20% (figure 14.3.1.8).

The genetic composition between yearclasses between NAFO divisions reveals a pattern of West Greenland offshore component dominating the yearclasses in the north (NAFO 1A and 1B, figure 14.3.1.9) and EastGreenland-Iceland offshore component dominating in the south (NAFO 1D, 1E and 1F).

The overall patterns identified from the Greenland surveys are that a) Old and large cod (>6 yrs) are found off East Greenland primarily north of 63°N, b) Cod at ages 4-6 yrs are found primarily in Southwest Greenland and c) Young cod (<3 yrs) are primarily found in the northern part of West Greenland. This pattern suggest that West Greenland is a nursing area for the East Greenland cod stock, and that the West Greenland cod stock is at a very low level. The increasing trend in the biomass in the southern part of the survey (NAFO 1E) in 2014 and 2015 with record high numbers of especially the 2009 YC has reversed in the period 2016 – 2018. In 2019 a massive increase in numbers and biomass was registered in the southern part of the survey (NAFO 1D and 1E), however interpretation of these findings must be precautious as they are caused by two very large hauls located in each NAFO division. The dominating yearclass in 2019 is the 2015 YC, and this YC is also dominating the same region in 2020 but not in the same high numbers. The genetic composition within the survey in 2019 revealed a north-south gradient with the WestGreenland offshore stock dominating in the northern areas corresponding to NAFO divisions 1A and 1B, whereas the EastGreenland-Iceland offshore stock is dominating in the southern region corresponding to NAFO divisions 1D and 1E.

A detailed description of the survey is available in Retzel (2021b).

14.3.2 Results of the German groundfish survey

Due to technical problems and weather issues, the German survey did not manage to cover the West Greenland area in 2016, 2017 and 2018. In 2019, the survey managed to cover the southern part (NAFO 1E, strata 3).

The numbers valid hauls were 37 in 2020 (Table 14.3.2.1, figures 14.3.2.1).

The German survey in 2020 confirmed the findings of the Greenland survey, i.e. low abundance and biomass indices (table 14.3.2.2 and 14.3.2.3), a 2017 YC dominating the area especially in the northern part (NAFO 1C and 1D) and the presence of older year-classes (Table 14.3.2.4 and 14.3.2.6).

A detailed description of the survey is available in Werner & Fock (2021).

14.4 Information on spawning

Before 2017, no spawning of significance has been documented on the banks in West Greenland (Retzel, 2015).

In 2017 and 2018, fishing was allowed outside a box covering Dana Bank in April and May with requirements of increased collection of biological sampling in order to investigate the maturity stage of the fish caught. In addition, samples of whole cod was sent to GINR for investigation of maturity. In general, the majority of the cod sent to GINR from the commercial fishery in NAFO division 1C and 1D were spawning (Retzel, 2018).

In 2019 (just prior to the NWWG meeting), a pilot cruise with GINR small research vessel Sanna was undertaken on Tovqussaq Bank in NAFO 1C with the objection to locate and investigate spawning on the bank in combination with tagging of spawning cod. The survey found actively spawning cod with several year-classes being part of the spawning stock (Retzel, 2020).

14.5 Tagging experiments

A total of 25 377 cod have been tagged in different regions of Greenland in the period of 2003–2020 (Table 14.5.1). Cod on two banks in West Greenland have been tagged; 2 667 on Tovqussaq bank in NAFO division 1C and 6 649 on Dana Bank in NAFO division 1D+1E.

40% of recaptured fish tagged recently on the West Greenland banks are recaptured in the same area as tagged, 20 % are recaptured inshore and 40% are recaptured in East Greenland/Iceland (table 14.5.2). The majority of recaptures are tagged on the southern Dana Bank (NAFO 1E) while very few recaptures are tagged on Tovqussaq Bank which is located further to the north in NAFO 1C. None of the recaptured cod tagged on Tovqussaq Bank (NAFO 1C) have been recaptured in East Greenland or Iceland.

Limited fishing in several areas and years influences the signal from the recaptures, and more analysis needs to be performed taking the fishing effort into account in order to investigate magnitude of the eastward migration rate.

14.6 State of the stock

The West Greenland offshore stock component has been severely depleted since the 1970s and collapsed in the 1990s. The surveys showed only an increase in biomass until 2015 and has since 2016 been low. Abundance however has fluctuated since 2005, indicating that small fish enter the survey but are not caught at older ages. This is caused by an eastward migration out of the area, and the area is presently considered to act mainly as a nursing area for the East Greenland and Icelandic stock components.

Until 2015, the 2009 and 2010 YCs have been caught in considerable numbers in the survey. Since then few cod older than 3 yrs and larger than 40 cm have been caught especially in 2018. The fishery between 3000–5000 tonnes in 2015–2017 primarily fished the 2009 and 2010 YC’s. The reason for the reduction of the 2009 and the 2010 YC in 2016 is considered to be caused by a combined effect of migration out of the area and fishery. However, abundance indices in the Greenland survey of these year-classes are highest observed in the survey in 2017–2019 compared to same ages in previous years.

The stock is considered to be at a very low level compared to historic.

As described in Section 1.3, MSY proxies should be evaluated to determine stock status. ICES suggested four methods for this purpose, and all methods were tested on the stock (Hedeholm, 2017; ICES, 2017). All the length-based indicators rely heavily on length distributions from the commercial fishery. For this stock, the fishery has been very limited since the early 1990 collapse. Hence, commercial data are limited and not really suited for such analysis; especially with the general assumptions of no migration underlying most of the approaches.

With these shortcomings, the results from all analysis support the general notion from surveys: this stock is at a low level and no fishing should take place until a spawning component is established that is composed of a number of year classes. Spawning investigations in 2017-2019 indicate that a spawning stock composed of several year classes is recovering.

14.7 Implemented management measures for 2021

No fishery is allowed in 2021 in NAFO subdivision 1A–1E. It is however allowed to fish parts of the inshore West Greenland quota in the offshore West Greenland areas.

14.8 Management plan

There is no management plan for the offshore fishery in NAFO Subdivision 1A–1E.

14.9 Management considerations

The fishery in West Greenland should be considered a mixed stock fishery, containing fish from both Greenland and Iceland stocks. There is currently no standardized procedure to determine the proportional contribution of each stock to the landings.

The traditional spawning grounds in West Greenland are well described and if any fishing is allowed such areas should be protected. This will both protect any present spawning stock and minimize the proportion of the West Greenland stock in the catches.

From 2015, it is allowed to fish parts of the inshore West Greenland quota in the offshore West Greenland areas. These catches are additional to the offshore TAC, and have been between 400-600 tonnes annually.

14.10 Basis for advice

Basis for advice is the precautionary approach where biomass is extremely low and ICES advised zero catch for 2022 and 2023.

14.11 Benchmark 2022

The stock is proposed to go through a benchmark in 2022.

Survey indices are variable and recent decline in offshore indices coincides with historic high catches inshore. Genetic analysis of inshore commercial and survey catches reveals a mix of different stocks. Genetics from inshore areas on the west coast reveal that the offshore stock may contribute a large part to the catches in these areas. Further analysis of the genetic composition in combination with tagging studies is needed to gain further insight into migration pattern across areas and year classes.

Survey trends are basis for advice. Zero advice have been given for several decades. Data on spawning indicate stock is reproducing and spawning stock is established. Genetic data suggest large migration and mixing with the inshore cod stock (cod.21.1, Christensen, 2019; Buch *et al*. 2021).

The main aim of the benchmark is to move away from using the current simplified geographical borders to separate the three cod stocks in Greenland waters. This will be done by developing a modelling approach that can use genetic data based on samples covering the distribution of the three stocks (Buch *et al*. 2021). The model will utilize the spatial resolution of the genetics data to estimate the split between the stocks along a spatial gradient. The catch and survey data will then be split into separate stocks and used as input into an analytical assessment models for each stock. This would account for differences in stock dynamics between stocks and may improve the understanding of migration patterns.

The benchmark also aims to improve the estimation of the survey indices available for the stocks. There are currently two offshore surveys in Greenland waters. One Greenlandic survey, covering the West and East coast up to and including the Dohrn bank area. One German survey covers a similar area on the east coast and some of the west coast. A spatial model will be developed to allow combination of the survey data and allow incorporation of spatial patterns. The new model will also be able to better account for occasionally large catches.

14.12 References

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14.13 Tables

Table 14.2.1. Offshore catches (t) divided into NAFO divisions in West Greenland. 1924–1991: Horsted 2000, 2004–present: Greenland Fisheries License Control.

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
1924							200	
1925							1871	
1926							4452	
1927							4427	
1928							5871	
1929							22304	
1930							94722	
1931							120858	
1932							87273	
1933							54351	
1934							88422	
1935							65796	
1936							125972	
1937							90296	
1938							90042	
1939							62807	
1940							43122	
1941							35000	
1942							40814	
1943							47400	
1944							51627	
1945							45800	
1946							44395	
1947							63458	
1948							109058	
1949							156015	

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
1950							179398	
1951							222340	
1952	0	261	2996	18188	707	37905	257488	117126*
1953	4546	46546	10611	38915	932	25242	98225	180220*
1954	2811	97306	18192	91555	727	15350	60179	266682*
1955	773	50106	32829	87327	3753	4655	68488	241499*
1956	15	56011	38428	128255	8721	4922	66265	296315*
1957	0	58575	32594	62106	29093	16317	47357	225836*
1958	168	55626	41074	73067	21624	26765	75795	258062*
1959	986	74304	10954	30254	12560	11009	67598	191343*
1960	35	58648	18493	35939	16396	9885	76431	200522*
1961	503	78018	43351	70881	16031	14618	90224	293104*
1962	1017	122388	75380	57972	25336	17289	125896	400719*
1963	66	70236	73142	76579	46370	16440	122653	381917*
1964	96	49049	49102	82936	33287	13844	99438	307878*
1965	385	80931	66817	71036	15594	15002	92630	321829*
1966	12	99495	43557	62594	19579	18769	95124	313044*
1967	361	58612	78270	122518	34096	12187	95911	385949*
1968	881	12333	89636	94820	61591	16362	97390	350870*
1969	490	7652	31140	65115	41648	11507	35611	179055*
1970	278	3719	13244	23496	23215	15519	18420	78775*
1971	39	1621	28839	21188	9088	20515	26384	80501*
1972	0	3033	42736	18699	7022	4396	20083	90410*
1973	0	2341	17735	18587	10581	2908	1168	50347*
1974	36	1430	12452	14747	8701	1374	656	37999*
1975	0	49	18258	12494	6880	3124	549	38188*
1976	0	442	5418	10704	8446	2873	229	25215*
1977	127	301	4472	7943	8506	2175	35477[1]	53546*
1978	0	0	11856	2638	3715	549	34563[1]	51760*

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
1979	0	16	6561	4042	1115	537	51139[1]	60635*
1980	0	1800	2200	2117	1687	384	7241[1]	14705*
1981	0	0	4289	4701	4508	255	0	13498
1982	0	133	6143	10977	11222	692	1174	29621*
1983	0	0	717	6223	16518	4628	293	23703*
1984	0	0	0	4921	5453	3083	0	10374
1985	0	0	0	145	1961	1927	2402	3360*
1986	0	0	0	2	72	24	1203	982*
1987	0	0	5	815	67	43	3041	3787*
1988	0	0	919	17463	10913	6466	8101	35931*
1989	0	0	0	11071	48092	14248	2	59165
1990	0	0	2	563	21513	10580	7503	27151*
1991	0	0	0	0	104	1942	0	104
1992	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0
2004	0	0	0	5	3	1	0	8
2005	0	0	1	0	0	71	0	1
2006	0	0	0	0	0	414	0	0
2007	0	0	0	31	435	2011[2]	0	466

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	NAFO 1A–1E
2008	0	0	0	23	526	11370[2]	0	549
2009	0	0	0	0	6	3323[2]	0	6
2010	0	0	0	0	2	281	0	2
2011	0	0	0	0	8	542	0	8
2012	0	0	1	95	236	1470	0	332
2013	0	0	0	209	270	1405	0	479
2014	0	0	30	68	18	1833	0	116
2015	0	0	341	954	3564	3984	0	4860
2016	0	0	67	1911	1762	2335	0	3740
2017	0	1	1442	730	852	2560	0	3025
2018	0	0	1988	678	1521	1820	0	4187
2019	0	0	656	57	186	916	0	899
2020	0	0	102	0	1	675	0	103

1 Estimates for assessment include estimates of unreported catches. The total estimated value for West Greenland (inshore + offshore) was 73 000 t in 1977 and 1978, 1979: 99 000 t, 1980: 54 000 t. The value given in the table are these values minus the inshore catches minus known offshore NAFO Division catches.

2 Include catches taken with small vessels and landed to a factory in South Greenland (Qaqortoq), 2007: 597 t, 2008: 2262 t, 2009: 136 t.

*** Unknown NAFO Division catches added accordingly to the proportion of known catch in NAFO divisions 1A–1E to known total catch in all NAFO divisions.**

Table 14.2.2.1: Cod catches (t) divided into month and NAFO areas, caught by the offshore fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1C							9	41	43	8	1		**102**	99%
1D														
1E				1									**1**	1%
Total				**1**			**9**	**41**	**43**	**8**	**1**		**103**	
%				1%			9%	40%	42%	8%	1%			

Table 14.2.2.2: Cod catches (t) by gear, area and month in West Greenland.

Gear	NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Trawl	1C							9	41	43	8	1		**102**
	1D													
	1E				1									**1**
	Total				**1**			**9**	**41**	**43**	**8**	**1**		**103**

Table 14.2.3.1. Cod in Greenland. Catch at age ('000) and Weight at age (kg) for offshore fleets in West Greenland (NAFO 1A–1E). No samples from commercial fishery in 2008-2011 and 2020.

CATCH AT AGE								
Year/age	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2007	6	167	66	42	6	1		
2008								
2009								
2010								
2011								
2012	8	33	107	38	18	2	0.01	0.003
2013		15	44	113	29	15	4	1
2014	1	18	45	7	9	2	0.02	
2015	6	67	502	1061	240	158	45	16
2016	1	12	198	923	490	69	20	5
2017	2	20	132	340	532	272	55	23
2018		37	130	521	600	434	173	51
2019		29	56	54	74	80	32	15
2020								
WEIGHT AT AGE								
2007	0.647	0.906	1.949	3.440	5.817	6.053		
2008								
2009								
2010								
2011								
2012	0.560	0.935	1.395	2.139	3.232	4.194	8.325	12.500
2013		1.120	1.462	1.947	2.978	3.754	6.398	7.342
2014	0.488	0.693	1.199	1.738	3.040	4.817	5.318	
2015	0.474	0.734	1.316	1.982	3.186	5.043	7.167	10.329
2016	0.345	0.810	1.237	1.931	2.560	4.299	5.573	7.947
2017	0.404	0.776	1.230	1.580	2.138	2.830	4.340	7.091
2018		0.813	1.114	1.562	1.988	2.807	3.259	4.445
2019	0.390	1.008	1.500	1.997	2.646	3.126	4.006	6.895
2020								

Table 14.3.1.1. Number of hauls in the Greenland Shrimp and Fish survey in West Greenland by year and NAFO sub-divisions.

WEST GREENLAND							
Year/NAFO	**0A**	**1A**	**1B**	**1C**	**1D**	**1E**	**Total**
1992		92	44	18	18	11	183
1993		69	49	21	15	12	166
1994		76	58	23	8	9	174
1995		83	61	29	13	14	200
1996		71	57	29	12	9	178
1997		84	56	32	12	12	196
1998		77	80	27	19	14	217
1999		84	81	33	16	14	228
2000		56	62	37	23	14	192
2001		60	75	36	24	15	210
2002		50	80	32	18	20	200
2003		51	63	30	18	15	177
2004		54	55	24	22	20	175
NEW SURVEY GEAR INTRODUCED							
2005	6	65	56	26	19	23	195
2006	5	86	60	26	20	21	218
2007	8	73	58	26	27	31	223
2008	6	69	61	28	23	25	212
2009	8	74	75	28	22	24	231
2010	10	95	76	30	23	25	259
2011	0	73	64	24	18	12	191
2012	0	73	64	21	18	18	194
2013	4	73	52	20	13	21	183
2014	0	78	57	19	17	23	194
2015	0	70	49	24	22	21	186
2016	0	59	38	26	14	19	156
2017	3	99	52	25	18	25	222
2018	0	78	42	26	23	20	189
2019	0	86	36	20	18	14	174
2020	0	84	51	29	21	23	208

Table 14.3.1.2 Cod abundance indices ('000) from the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.

WEST GREENLAND								
Year	**0A**	**1A**	**1B**	**1C**	**1D**	**1E**	**Total**	**CV**
1992		4	53	243	345	0	645	
1993		2	16	54	135	286	493	
1994		10	41	87	0	6	144	
1995		0	51	380	44	62	537	
1996		0	0	46	68	87	201	
1997		0	7	31	0	0	38	
1998		0	4	0	26	26	56	
1999		32	136	16	23	6	213	
2000		585	437	71	58	9	1160	
2001		26	305	110	448	305	1194	
2002		13	203	78	3294	114	3702	
2003		492	1395	351	727	214	3179	
2004		197	152	379	2630	1538	4896	
NEW SURVEY GEAR INTRODUCED								
2005	143	198	871	1845	4796	6683	14537	25
2006	453	371	4454	2564	15703	3359	26905	45
2007	737	1318	3302	7353	3624	3296	19628	31
2008	1209	897	4185	4068	9008	11553	30913	27
2009	881	889	4195	3272	2788	1252	13277	12
2010	338	720	2837	2712	8295	2745	17647	23
2011		8756	47092	2179	26510	1013	85549	14
2012		7661	10228	3017	1270	27081	49258	54
2013	4613	8951	12864	5673	7887	29924	69911	43
2014		6911	5670	78854	2456	16254	110145	67
2015		6542	11213	27248	31703	26980	103685	33
2016		4892	3243	6961	1564	3437	20096	26
2017	451	2562	4302	15723	4877	6305	34220	35
2018		2725	14808	8019	6449	5889	37890	16
2019		3818	9126	19836	170252	112712	315744	61
2020		1203	10456	3684	1987	6834	24164	24

Table 14.3.1.3. Cod biomass indices (tonnes) from the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions.

WEST GREENLAND								
	0A	1A	1B	1C	1D	1E	Total	CV
1992		23	54	75	118	0	270	
1993		2	5	25	39	124	195	
1994		3	9	38	0	1	51	
1995		5	6	120	23	3	157	
1996		0	0	15	23	27	65	
1997		0	2	53	0	0	55	
1998		1	1	0	47	50	99	
1999		29	28	1	17	1	76	
2000		226	130	21	9	2	388	
2001		140	155	56	178	98	627	
2002		67	128	41	1489	42	1767	
2003		444	323	264	453	118	1602	
2004		542	53	176	680	685	2136	
NEW SURVEY GEAR INTRODUCED								
2005	38	69	364	458	1084	1141	3155	26
2006	114	62	677	537	5131	525	7046	64
2007	247	387	872	1562	628	659	4355	31
2008	413	377	2046	929	1633	3227	8625	28
2009	208	230	1251	711	439	253	3092	14
2010	180	263	999	543	2426	908	5319	22
2011		1569	9654	408	5316	191	17140	14
2012		1932	2938	1125	464	14103	20562	69
2013	2395	2692	3960	1732	4551	19017	34345	53
2014		2639	2305	56061	2511	21381	84897	64
2015		3463	4456	19705	33169	40525	101318	36
2016		2256	1174	5817	1347	2697	13290	32
2017	697	1273	1254	14111	3032	4721	25088	49
2018		1084	2108	2369	2796	2289	10646	20
2019		1350	1778	7123	170822	84352	265425	69
2020		490	2824	1043	774	9842	14973	58

Table 14.3.1.4: Abundance indices ('000) by year-class/age from the Greenland Shrimp and Fish survey in West Greenland (NAFO 1A–1E).

WEST GREENLAND											
Year/age	0	1	2	3	4	5	6	7	8	9	10+
2005	134	815	10247	1604	1514	186	35	2	0	0	0
2006	249	6543	3577	12677	3395	401	47	16	0	0	0
2007	152	270	13792	3439	1934	37	4	0	0	0	0
2008	31	3472	2692	18780	4904	868	121	44	0	0	0
2009	0	124	9442	1666	1717	326	3	0	0	0	0
2010	209	2703	2094	10566	1252	775	42	7	0	0	0
2011	19	4940	71837	4453	3735	391	175	0	0	0	0
2012	0	204	11264	31593	3648	2427	116	7	0	0	0
2013	0	2904	8912	15168	36226	5665	848	142	22	25	0
2014	0	471	4792	8088	56469	35839	2597	1718	125	35	11
2015	0	2210	3932	15038	21509	34766	21117	1196	348	70	12
2016	0	1155	5103	2746	5680	3487	1442	418	56	0	0
2017	0	1214	6926	7128	3917	7452	5384	1905	288	6	0
2018	26	9205	9008	13155	4312	639	601	264	564	123	28
2019	290	136	14793	45862	107027	89246	22279	20476	12341	1971	1322
2020	31	3008	1670	10563	3150	3127	1328	562	533	115	76

Table 14.3.1.5 Abundance indices ('000) by age and NAFO divisions from the Greenland Shrimp and Fish survey in West Greenland. NAFO division 1E furthest to the south.

WEST GREENLAND											
Year class	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	<2010
Age	0	1	2	3	4	5	6	7	8	9	10+
Div. 0A											
Div. 1A	31	101	22	342	601	95	0	0	0	10	0
Div. 1B	0	2557	883	5652	1009	233	110	0	13	0	0
Div. 1C	0	83	282	2966	335	0	19	0	0	0	0
Div. 1D	0	79	44	1106	571	164	12	12	0	0	0
Div. 1E	0	188	440	498	634	2636	1188	550	521	105	76

Table 14.3.1.6 Mean weight of cod from the Greenland Shrimp and Fish survey in West Greenland (NAFO 1A–1E).

WEST GREENLAND											
Year/age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2005	0.002	0.031	0.146	0.298	0.596	1.208	1.800	3.338			
2006	0.004	0.025	0.120	0.338	0.477	0.680	2.581	2.714			
2007	0.002	0.026	0.138	0.320	0.601	1.446	4.375				
2008	0.006	0.025	0.098	0.239	0.497	0.939	1.774	2.742			
2009		0.024	0.104	0.329	0.620	1.353	2.103				
2010	0.003	0.017	0.136	0.291	0.683	1.191	1.952	3.066			
2011	0.001	0.038	0.164	0.377	0.626	1.151	2.081				
2012		0.019	0.137	0.419	0.763	1.200	1.371	3.396			
2013		0.038	0.112	0.337	0.611	0.781	1.722	2.905	3.560	6.460	
2014		0.014	0.133	0.300	0.675	0.977	1.708	2.704	4.108	5.710	9.245
2015		0.011	0.102	0.349	0.623	1.062	1.594	2.478	4.276	5.308	9.065
2016		0.028	0.094	0.314	0.711	1.145	1.742	2.542	3.844		
2017		0.015	0.097	0.262	0.622	1.009	1.404	1.843	3.254	5.345	
2018	0.003	0.012	0.078	0.272	0.551	0.867	1.409	1.923	2.536	3.419	3.529
2019	0.000	0.015	0.096	0.305	0.575	0.911	1.227	1.745	2.057	2.357	5.020
2020	0.004	0.020	0.101	0.284	0.530	1.192	1.796	3.148	3.427	4.492	4.666

Table 14.3.2.1 ***German survey*****. Numbers of valid hauls by stratum in West Greenland (NAFO 1C–E): No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.**

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum
	Str 1.1	Str. 1.2	Str. 2.1	Str. 2.2	Str. 3.1	Str. 3.2	
1981	1	1	13	2	3	1	21
1982	20	11	16	7	9	6	69
1983	26	11	25	11	17	5	95
1984	25	13	26	8	19	6	97
1985	10	8	26	10	17	5	76
1986	27	9	21	9	16	7	89
1987	25	19	21	4	18	4	91
1988	34	21	28	5	18	5	111
1989	25	14	30	9	8	3	89
1990	19	7	23	8	16	3	76
1991	19	11	23	7	13	6	79
1992	6	6	6	5	6	6	35
1993	9	7	9	6	10	8	49
1994	16	13	13	8	10	6	66
1995	.	.	3	.	10	7	20
1996	5	5	8	5	12	5	40
1997	5	6	5	5	6	5	32
1998	9	5	10	7	11	6	48
1999	8	7	14	8	13	6	56
2000	13	6	15	6	14	5	59
2001	.	.	15	7	15	5	42
2002	.	.	7	2	5	6	20
2003	.	.	7	6	7	7	27
2004	8	8	11	9	9	5	50
2005	.	.	9	7	8	6	30
2006	6	5	7	5	7	7	37
2007	5	5	7	5	6	5	33
2008	5	.	7	7	7	9	35
2009	2	.	5	5	6	6	24
2010	5	5	10	5	7	9	41
2011	.	.	5	5	5	5	20
2012	5	5	10	8	9	7	44
2013	6	6	8	6	10	7	43
2014	5	5	10	8	10	7	45
2015	7	7	7	4	5	5	35
2016	.	.	.	.	3	2	.
2017	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum
	Str 1.1	Str. 1.2	Str. 2.1	Str. 2.2	Str. 3.1	Str. 3.2	
2019	.	.	.	.	9	7	
2020	9	6	12	4	2	4	37

Table 14.3.2.2 *German survey*. Cod abundance indices ('000) from the German survey in West Greenland (NAFO 1C– 1E) by year and stratum: No survey in 2016, 2017 and 2018. 2019: only strata 3 covered. * Calculated by Greenland.

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
1982	2364	408	27594	920	7401	1801	40488	18605
1983	177	196	7079	2230	8678	1230	19590	7266
1984	189	90	2524	98	2666	364	5931	3629
1985	8094	1107	7237	2348	4984	840	24610	10809
1986	4716	630	22985	108	16570	609	55618	29631
1987	3517	482	115172	3790	72349	186	365496	331763
1988	6027	1106	186523	43090	21037	51	297834	216925
1989	1362	483	16280	325	129005	678	148133	65933
1990	619	299	2279	235	3827	61	7320	5462
1991	142	116	88	92	474	387	1299	412
1992	274	334	72	127	57	38	902	314
1993	327	243	105	109	53	21	858	195
1994	95	53	16	17	34	11	226	79
1995	.	.	27	.	72	34	133	60
1996	82	70	42	20	65	0	279	80
1997	0	24	17	0	57	3	101	45
1998	793	0	23	28	7	0	851	573
1999	103	33	33	11	197	7	384	171
2000	205	250	50	174	288	9	976	383
2001	.	.	584	36	3020	9	3649	3481
2002	.	.	238	21	342	23	624	257
2003	.	.	625	99	1625	73	2422	945
2004	503	213	1522	123	2709	638	5708	1592
2005	.	.	1586	264	5666	419	7935	3115
2006	495	485	87439	858	4481	1323	95081	99523
2007	1430	3261	3417	687	9861	71	18727	8645
2008	2666	.	916	911	23527	616	28636	26712
2009	72	.	1370	850	1068	378	3738	879
2010	2644	464	4451	631	5148	274	13612	6231
2011	.	.	716	375	1242	337	2670	782
2012	99609	1253	6007	442	8455	1251	117017	68441
2013	4457	1585	20122	221	7138	252	33775	22438

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
2014	9952	2008	28102	413	1261	86	41822	38616
2015	13315	906	73434	471	2432	102	90660	73453
2016	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.
2019*					13032	59		
2020	1744	355	1455	212	476	48	4290	1997

Table 14.3.2.3 *German survey,* Cod biomass indices (tonnes) from the German survey in West Greenland (NAFO 1C–1E) by year and stratum: No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
1982	1113	163	37404	1280	9970	4483	54413	26014
1983	144	87	9052	3381	12953	5015	30632	10295
1984	406	104	3998	137	3643	551	8839	5507
1985	1046	112	6543	1181	4700	506	14088	18209
1986	4858	254	11787	36	12381	651	29967	13885
1987	148896	156	93292	2446	54178	107	299075	299459
1988	47085	579	190073	39548	19663	54	297002	227428
1989	384	124	15061	211	113614	710	130104	55334
1990	130	66	1948	123	3652	56	5975	4986
1991	45	38	36	28	549	374	1070	529
1992	65	104	15	33	10	7	234	97
1993	77	45	27	27	30	6	212	53
1994	13	17	3	12	11	5	61	17
1995	.	.	14	.	13	7	34	12
1996	13	35	12	11	28	0	99	29
1997	0	21	11	0	50	3	85	43
1998	38	0	1	7	1	0	47	25
1999	16	11	6	3	63	5	104	57
2000	54	71	11	83	73	5	297	117
2001	.	.	163	17	1024	5	1209	1212
2002	.	.	89	16	136	7	248	108
2003	.	.	98	44	736	32	910	461
2004	172	83	274	45	547	186	1307	342
2005	.	.	605	124	1796	146	2671	1057
2006	102	138	45616	250	2046	614	48766	52298
2007	319	885	1579	244	7804	43	10874	7524
2008	872	.	193	206	11479	175	12925	13686
2009	19	.	309	293	372	153	1146	255
2010	1012	244	2234	312	2703	173	6678	3057
2011	.	.	189	128	1040	194	1551	602
2012	52497	588	4185	240	8203	848	66561	35693
2013	2703	1670	17316	142	11251	544	33626	18801

Year	NAFO 1C		NAFO 1D		NAFO 1E		Sum	SD
	str1_1	str1_2	str2_1	str2_2	str3_1	str3_2		
2014	10597	2154	35741	422	3561	397	52872	47451
2015	17221	1105	109073	522	5999	216	134136	108717
2016	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.
2019	.	.	.	.	20577	130		
2020	2817	314	1655	145	2588	51	7570	3802

Table 14.3.2.4 *German survey*, West Greenland (NAFO 1C–E). Age disaggregated abundance indices ('1000): No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.

Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
1982		77	505	14266	5195	14798	4144	908	178	344	35	34	40484
1983*)													
1984	80	3	13	709	604	3495	289	628	32	61	13	0	5927
1985	202	16823	623	330	2271	1100	2982	112	164	2	3	0	24612
1986		3600	45772	1686	321	2386	652	1098	22	74	3	1	55615
1987		147	22578	318948	13977	2930	4603	649	1506		131	13	365482
1988		124	1357	44364	247618	2660	311	521	318	529	12	15	297829
1989	0	163	1293	3821	79642	62126	1008		47	7	24	0	148131
1990	11	17	595	1242	368	4089	990	6	0	0		1	7319
1991		86	94	193	350	36	461	57	2			0	1279
1992		88	672	100	17	25		0				0	902
1993		8	499	318	12	21						0	858
1994		98	18	90	14	3		2				0	225
1995			111	6	16							0	133
1996		76	6	193	5		0					0	280
1997		6	13	7	76							0	102
1998	0	845		3	3	0						0	851
1999	8	165	166	36	3		3					0	381
2000		60	524	328	62							0	974
2001		266	2753	527	65	20						0	3631
2002	0	6	309	290	17							0	622
2003		1368	205	511	284	36	9					0	2413
2004	132	3078	2008	307	108	55	15	0				0	5703
2005	91	156	6893	653	40	16	14	0	0			0	7863
2006	157	1949	6961	83106	2708	45	51	67	0			0	95044
2007	139	229	9402	1655	6989	227	35	38	12			0	18726
2008	8	1224	2317	20080	3747	1235	20	3	2	0	0	0	28636
2009	36	326	2513	363	406	37	40	14				0	3735

Year	0	1	2	3	4	5	6	7	8	9	10	11+	TOTAL
2010	208	1531	1726	9201	577	259	51	48	3	3		5	13612
2011		195	1572	385	368	68	33	26	24	0	0	0	2671
2012	142	1191	37872	66947	7682	2847	227	76	8	18		0	117010
2013		152	1562	12824	15859	1783	1135	234	86	23	18	4	33680
2014			880	4629	17021	17863	1080	277	32	0	4	0	41786
2015	159	189	1353	10921	16208	43991	16909	708	87	117	8	12	90660
2016	.	.	.	.	.	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.	.	.	.	.	.
2019	17	0	0	1191	8374	1843	381	365	328	348	217	27	13091
2020	54	317	157	1376	963	532	130	49	131	243	188	148	4290

***) calculated proportionally using age compositions reported by the ICES Working Group on Cod Stocks off East Greenland (ICES, 1984).**

Table 14.3.2.5 *German survey*, West Greenland (NAFO 1C–E). Mean weight at age. No survey in 2016, 2017 and 2018. 2019: only strata 3 covered.

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989		34	144	278	874	1636	1456				6535	
1990		20	135	288	474	877	2076					3935
1991		52	157	371	586	873	1173	1711	1260			
1992		61	220	332	797	974						
1993		35	119	356	457	832						
1994		50	157	418	573	1090		2240				
1995			172	410	511							
1996		51	90	480	690							
1997		65	288	360	1032							

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1998		49		610	1320							
1999		67	354	658	950		2985					
2000		36	228	431	821							
2001		62	297	651	1229	1063						
2002		55	231	548	821							
2003		114	412	669	1169	1572	2415					
2004		78	314	534	1105	1508	3007					
2005		67	292	830	1254	3066	5383					
2006	21	49	226	543	1166	2314	4099	8710				
2007	21	121	227	540	937	3051	6899	5600	8010			
2008		52	143	449	738	1581	5246	0	5192			
2009		50	183	431	694	1453	3252	4796				
2010	59	102	294	540	944	1608	2010	6019	3729	8870		11360
2011		234	228	542	1041	1201	3356	4562	6962			
2012	93	135	355	665	1145	2147	3827	5337	7299	9150		
2013		71	269	706	1145	1907	3333	5707	8445	8907	18270	18200
2014			271	574	1099	1698	4118	4929	6418			28180
2015		57	216	697	1242	2003	2597	3211	6428	3145		
2016	.	.	.	.	.	.	.	.	.	.	.	.
2017	.	.	.	.	.	.	.	.	.	.	.	.
2018	.	.	.	.	.	.	.	.	.	.	.	.
2019	.	.	.	.	.	.	.	.	.	.	.	.

Table 14.3.2.6 ***German survey*****, The abundance indices ('000) by year class/age, 2019. West Greenland. Calculated by Greenland.**

Year class	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	<2010
Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
Strat 1 (NAFO 1C)	49	78	128	787	500	215	51	20	51	131	
Strat 2 (NAFO 1D)	4	214	22	570	445	243	55	11	31	43	
Strat 3 (NAFO 1E)	0	25	6	18	19	74	24	16	49	128	165

Table 14.5.1. Number of tagged cod in the period of 2003 to 2019 in different regions. Bank (West) = NAFO Division 1D+1E. East Greenland = NAFO Division 1F + ICES Division 14.b.

Year	TAGGED			
	Fjord	Bank (West) NAFO 1C Tovqussaq	Bank (West) NAFO 1D+1E Dana	East Greenland
2003	599		1061	
2004	658			
2005	565			
2006	41			
2007	1137			1047
2008	231			1296
2009	633			526
2010	88			
2011	28			403
2012	86		1563	2359
2013	186		2321	
2014				1203
2015		57		1220
2016		299	998	1912
2017	350	1871	706	
2018		115		
2019	1040	325		
2020				458

Table 14.5.2: Number of recaptured cod in the period of 2003 to 2019 in different regions. Fjord (West) = NAFO divisions 1B–1F. Bank (West) = NAFO Division 1D+1E. East Greenland = NAFO division 1F + ICES Division 14.

	RECAPTURES			
	Fjord (West)	Bank (West) NAFO 1C Tovqussaq	Bank (West) NAFO 1D+1E Dana	East Greenland
Fjord (West)	547	3	29	8
Bank (West) NAFO 1C, Tovqussaq		1		4
Bank (West) NAFO 1D+1E, Dana		2	69	
East Greenland			35	118
Iceland	3		45	192

14.14 Figures

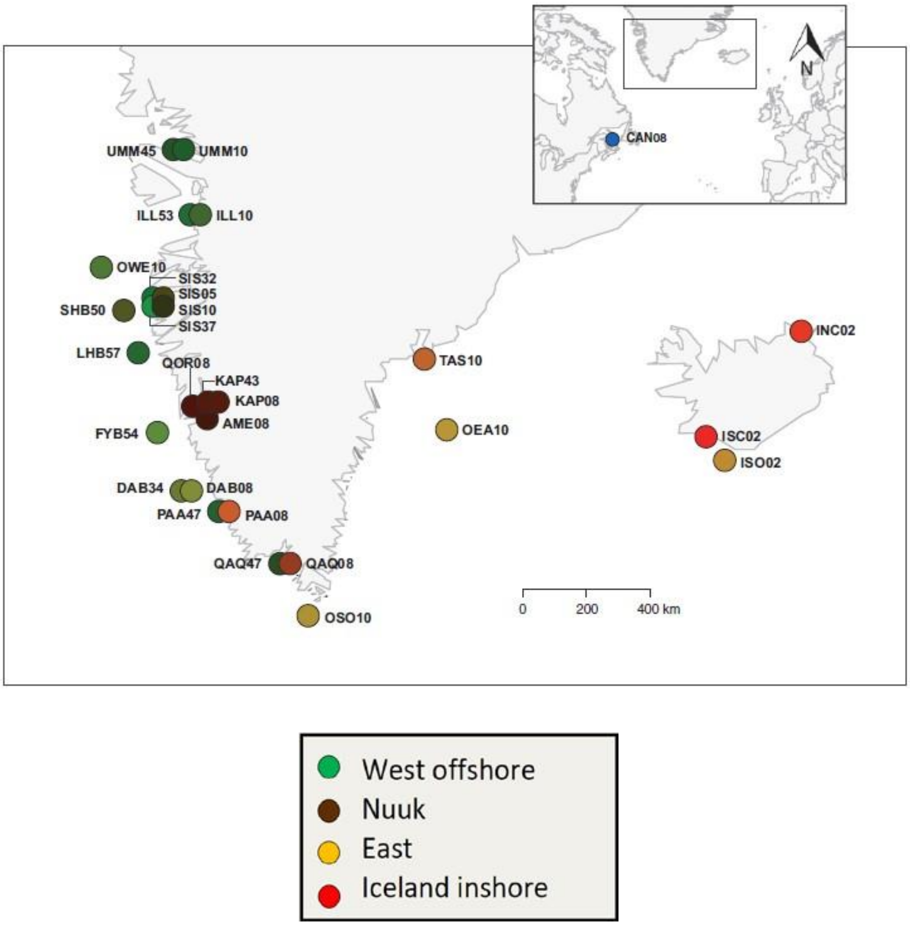

Figure. 14.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red, respectively. After Therkildsen *et al.* (2013).

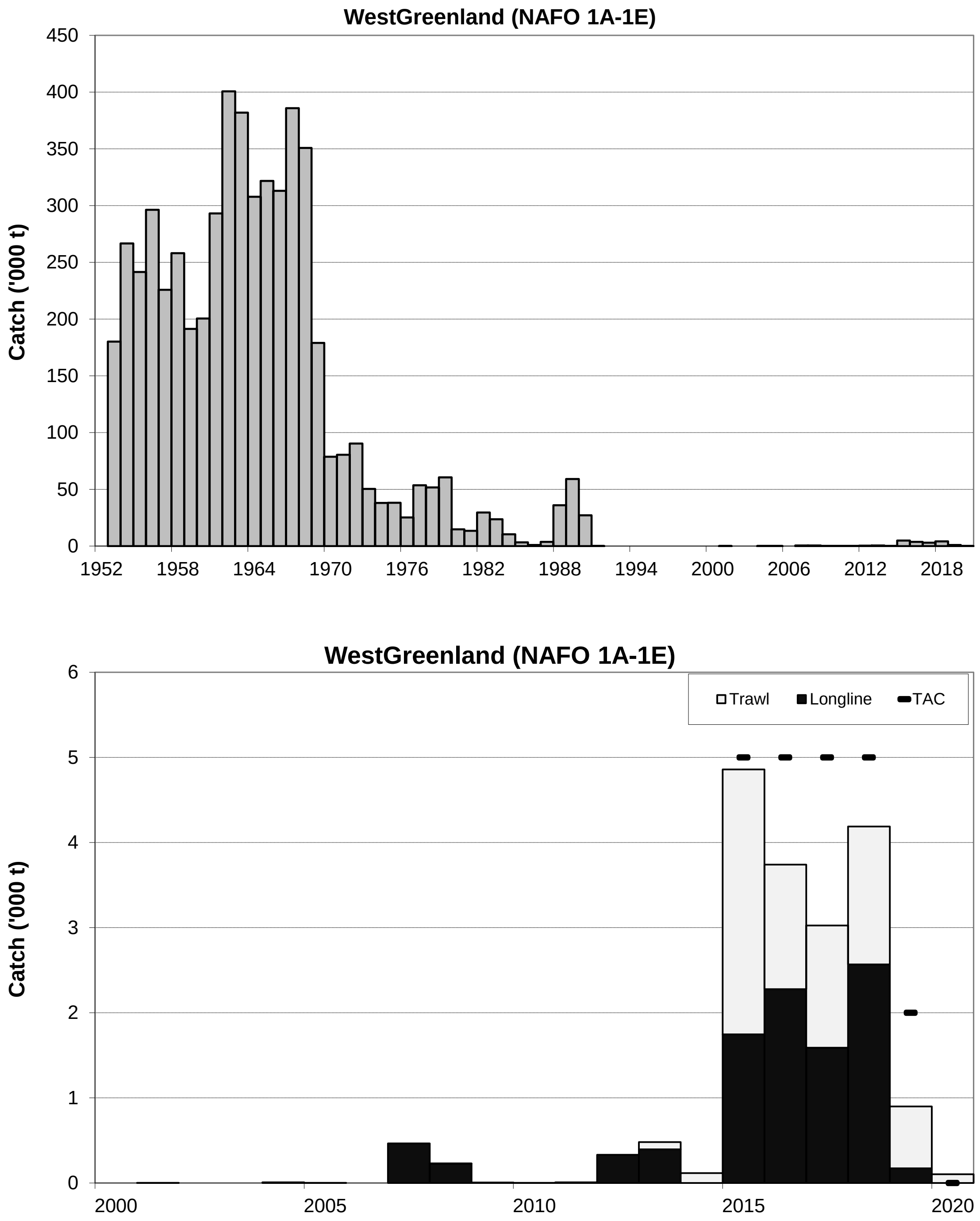

Figure 14.2.1. Annual catch of cod in offshore West Greenland (NAFO subdivisions 1A–1E) used by the Working Group. Top: from 1952, bottom from 2000.

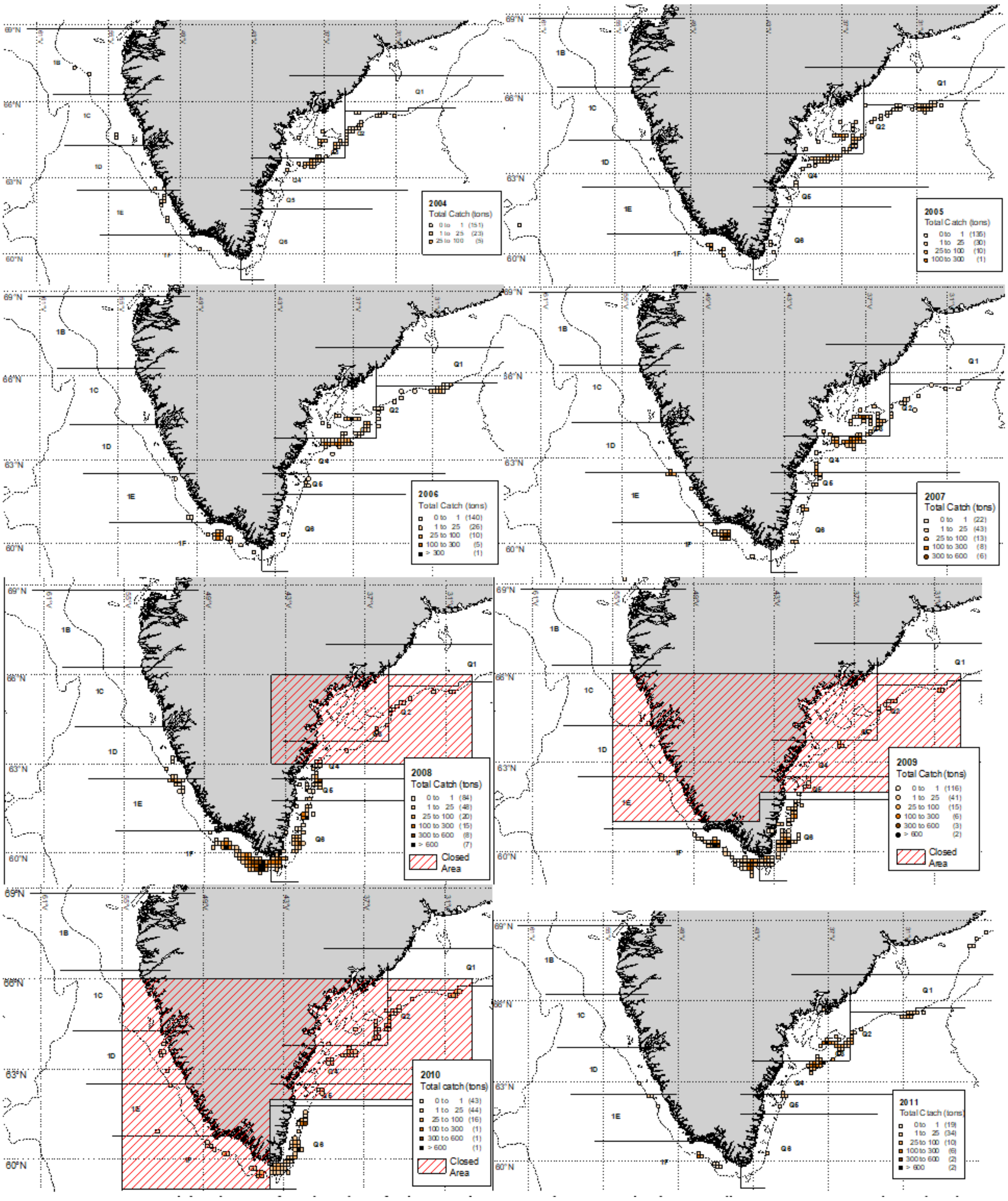

Figure 14.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

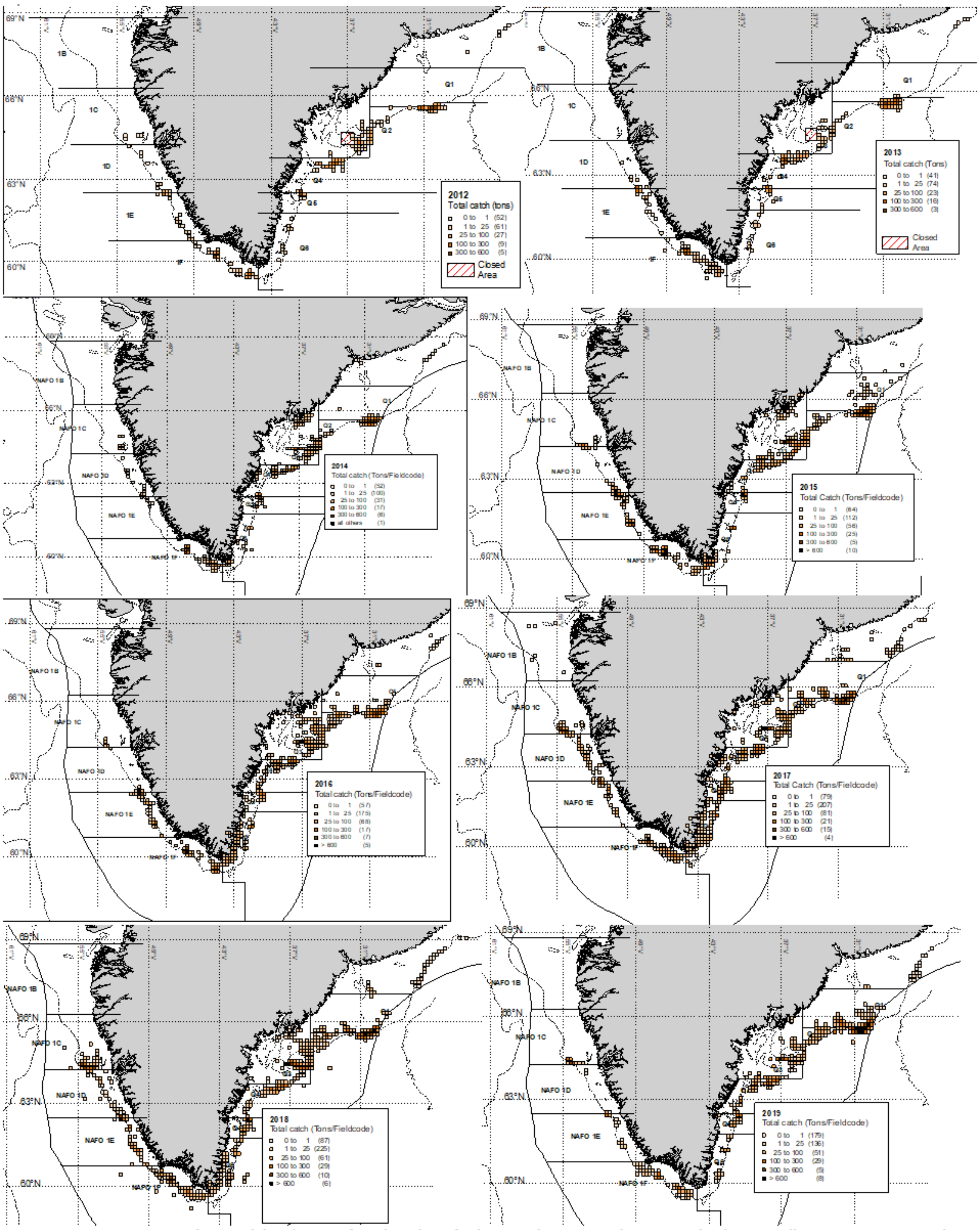

Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

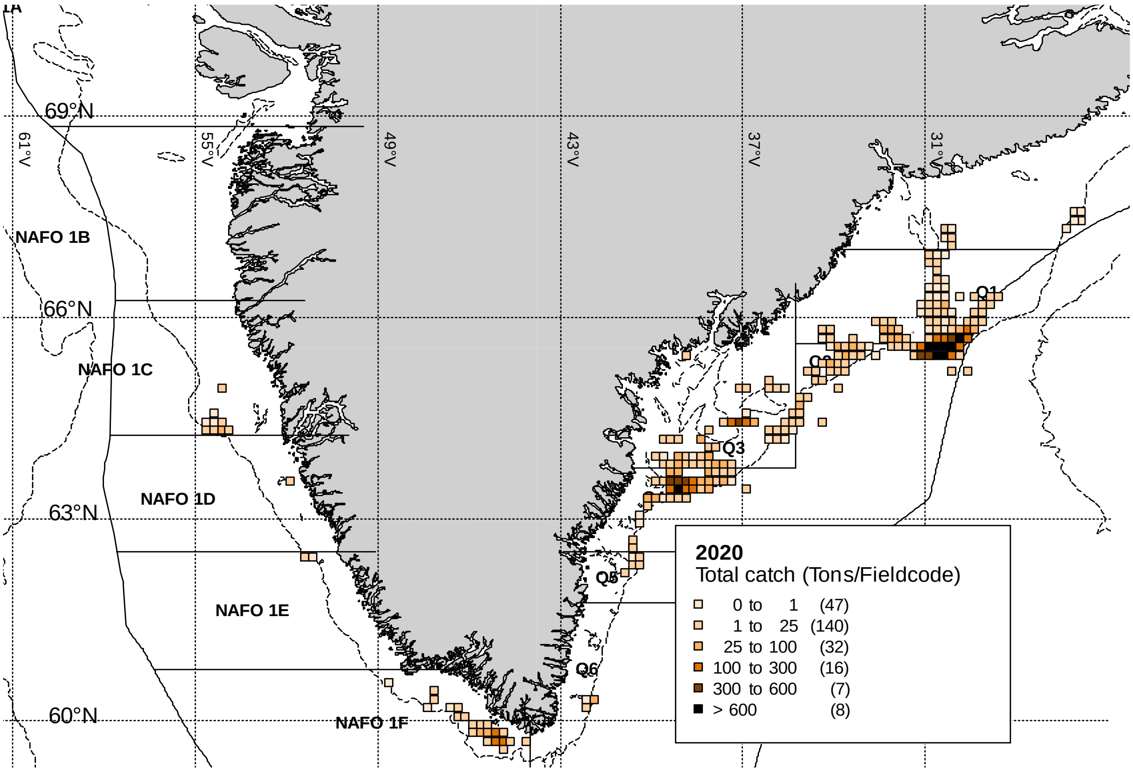

Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

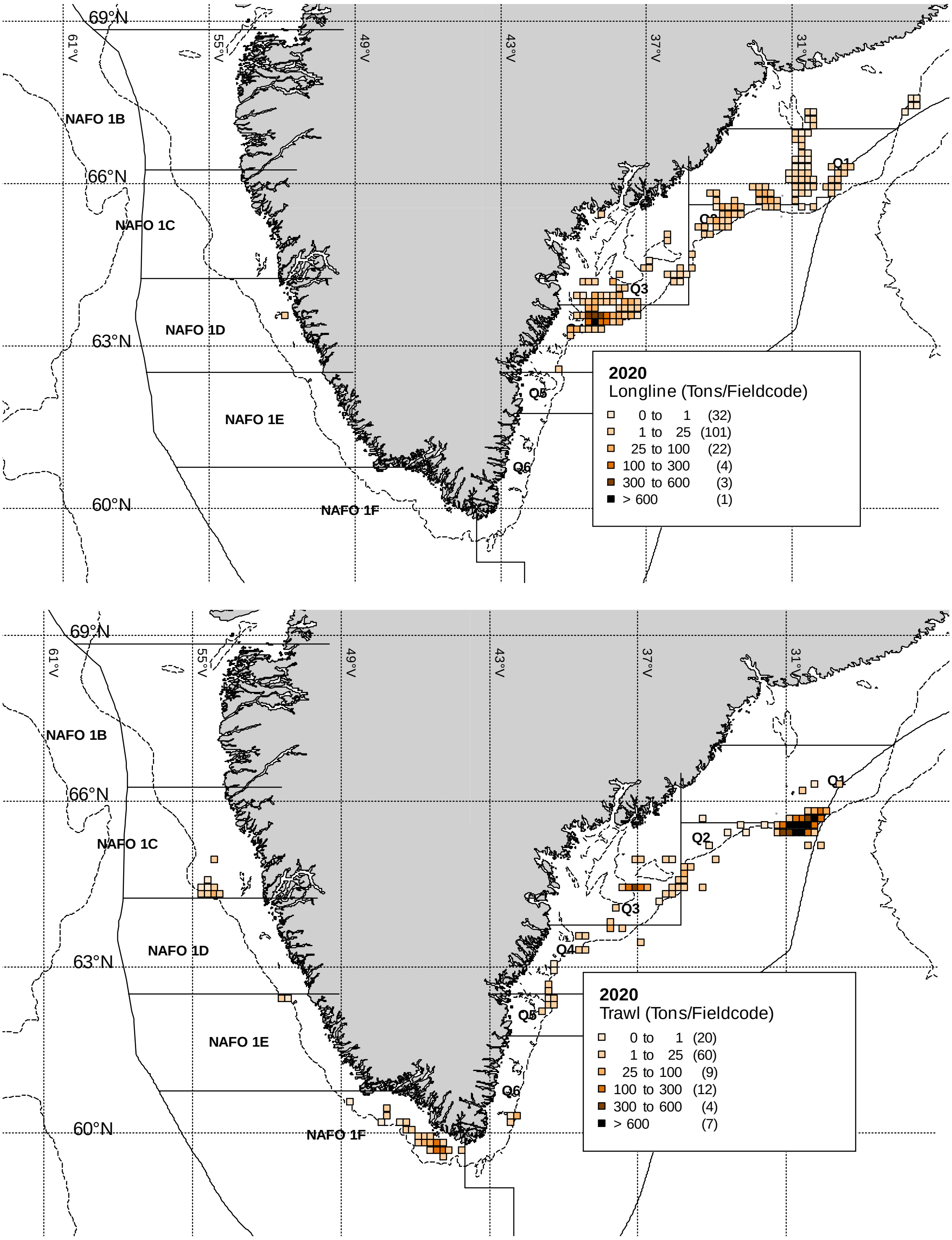

Figure 14.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

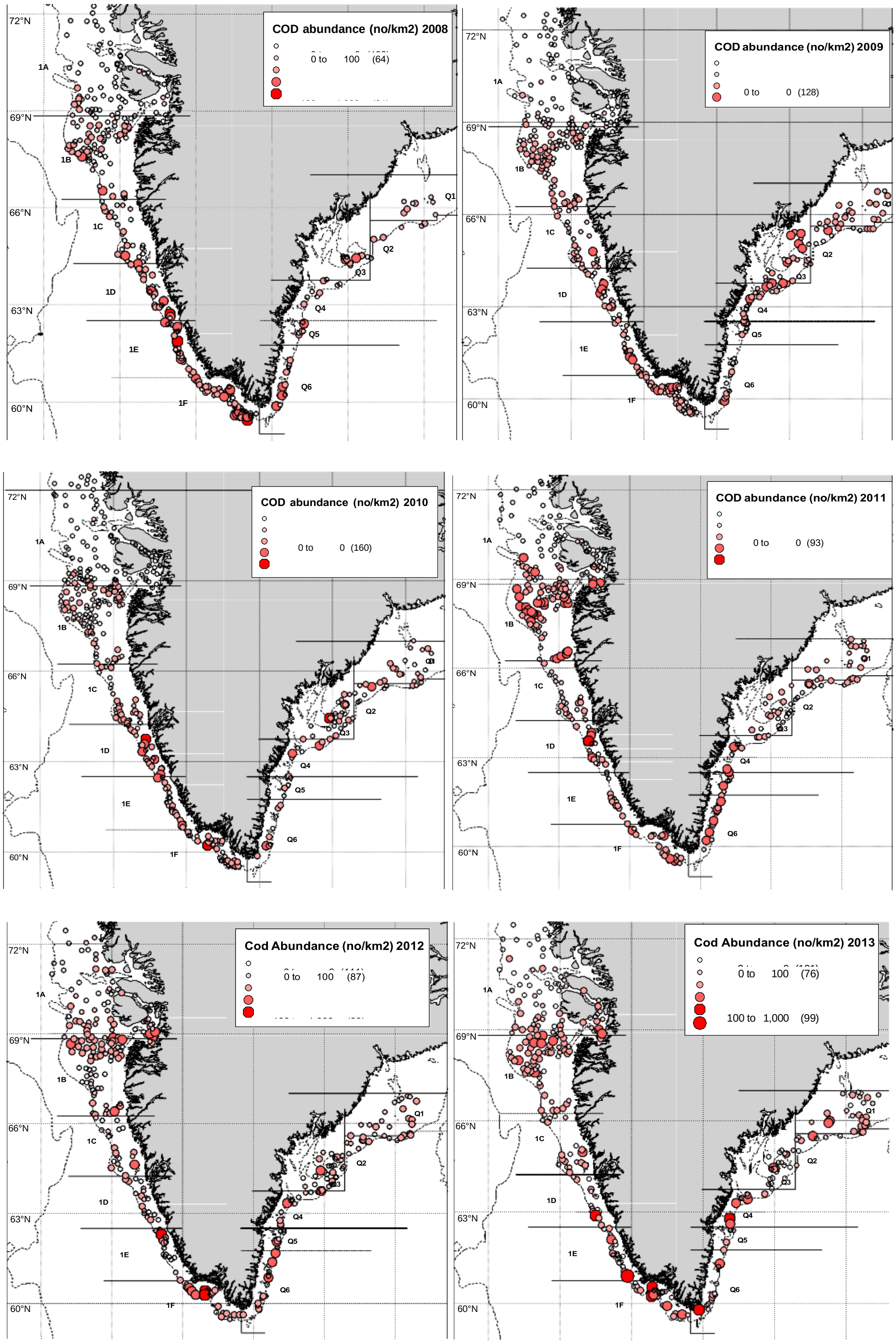

Figure 14.3.1.1. Greenland shrimp and fish survey. Abundance per km².

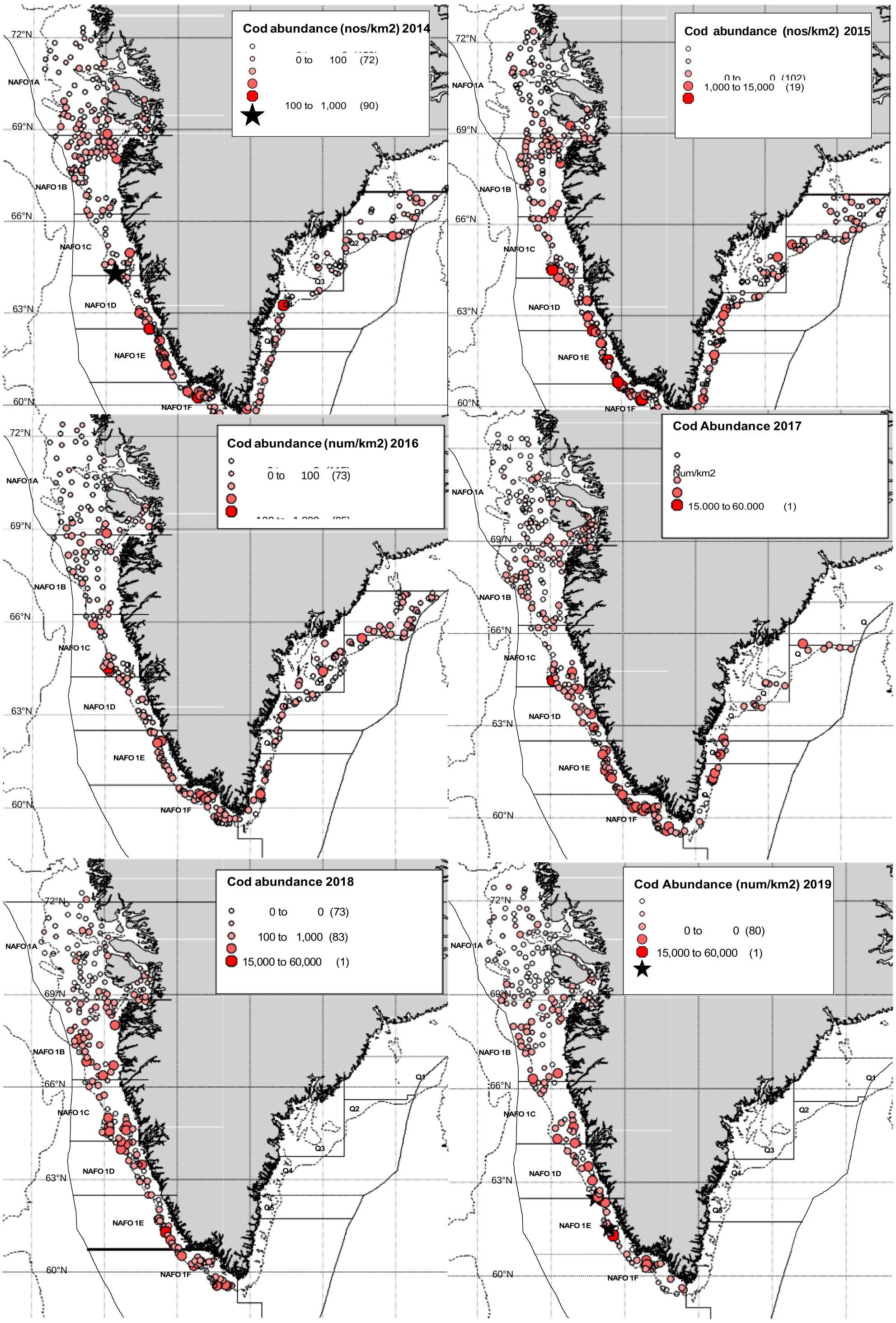

Figure14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per km².

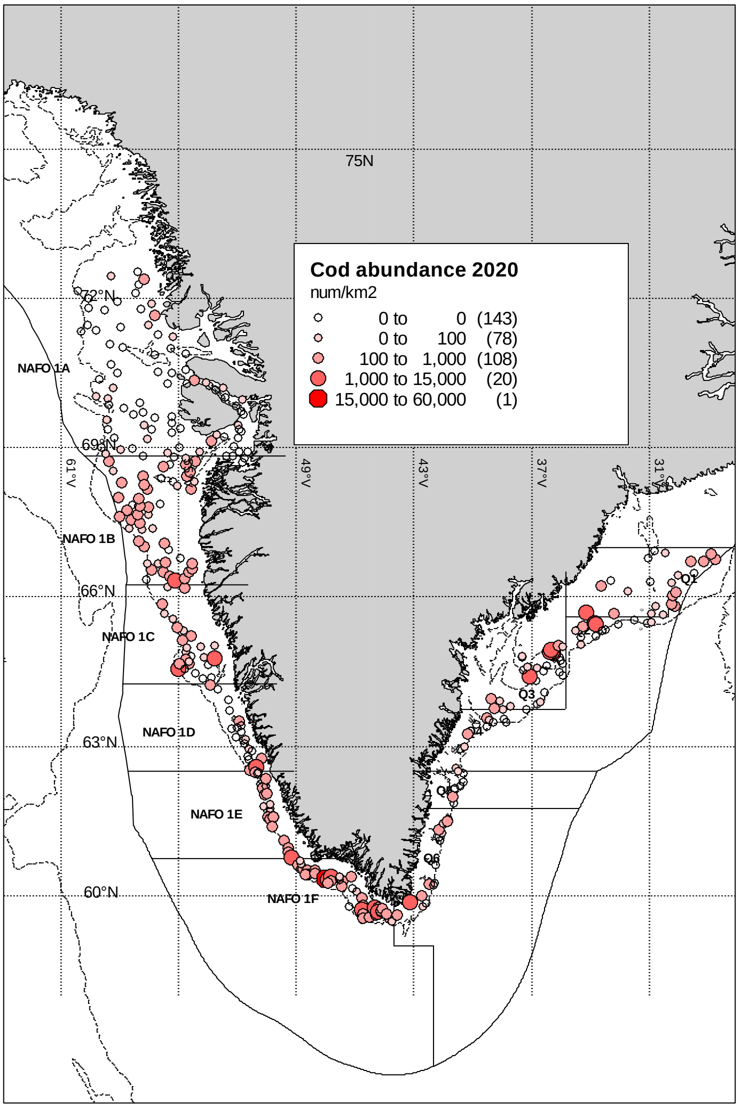

Figure 14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per km².

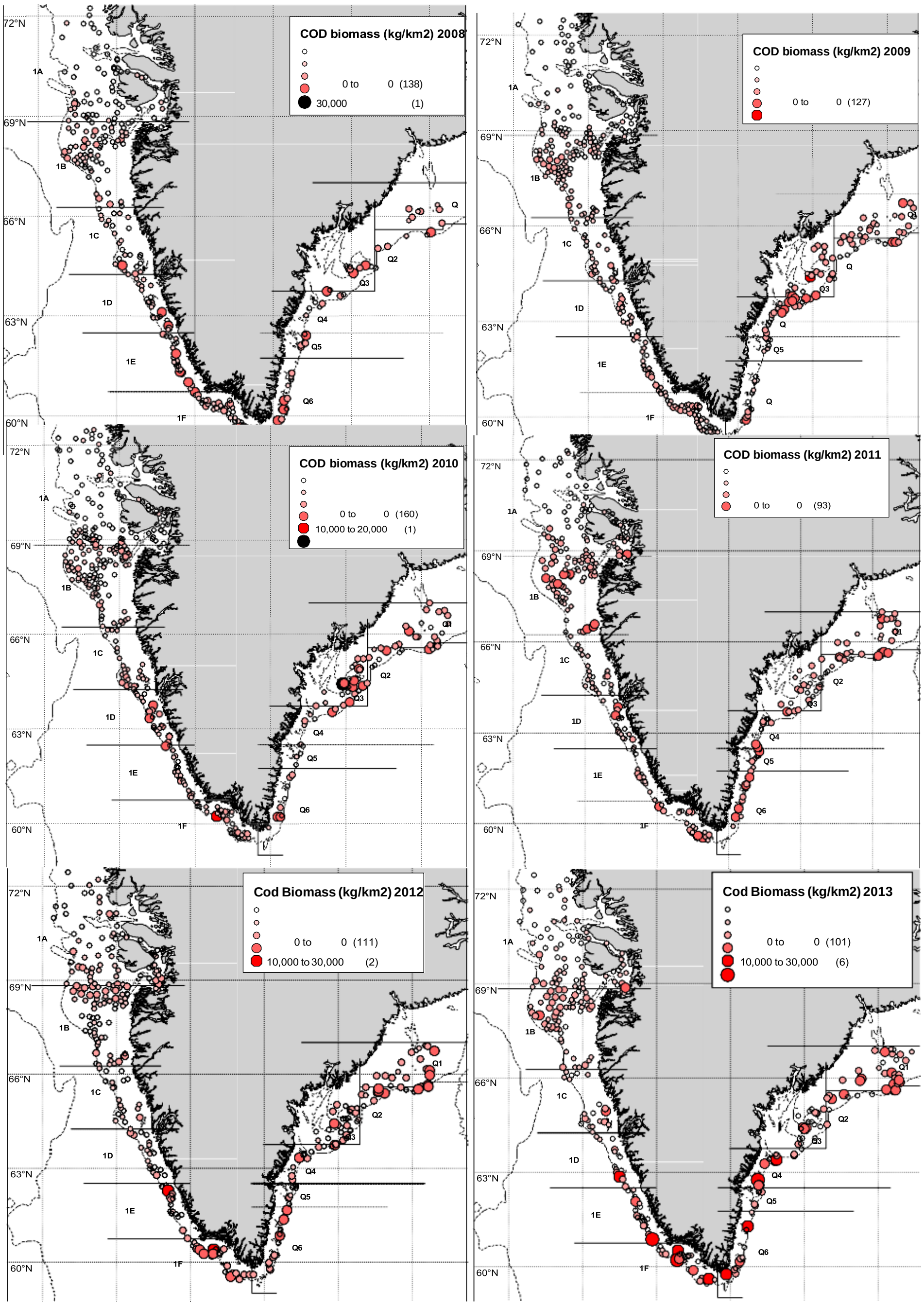

Figure 14.3.1.2. Greenland shrimp and fish survey. Catch weight kg per km².

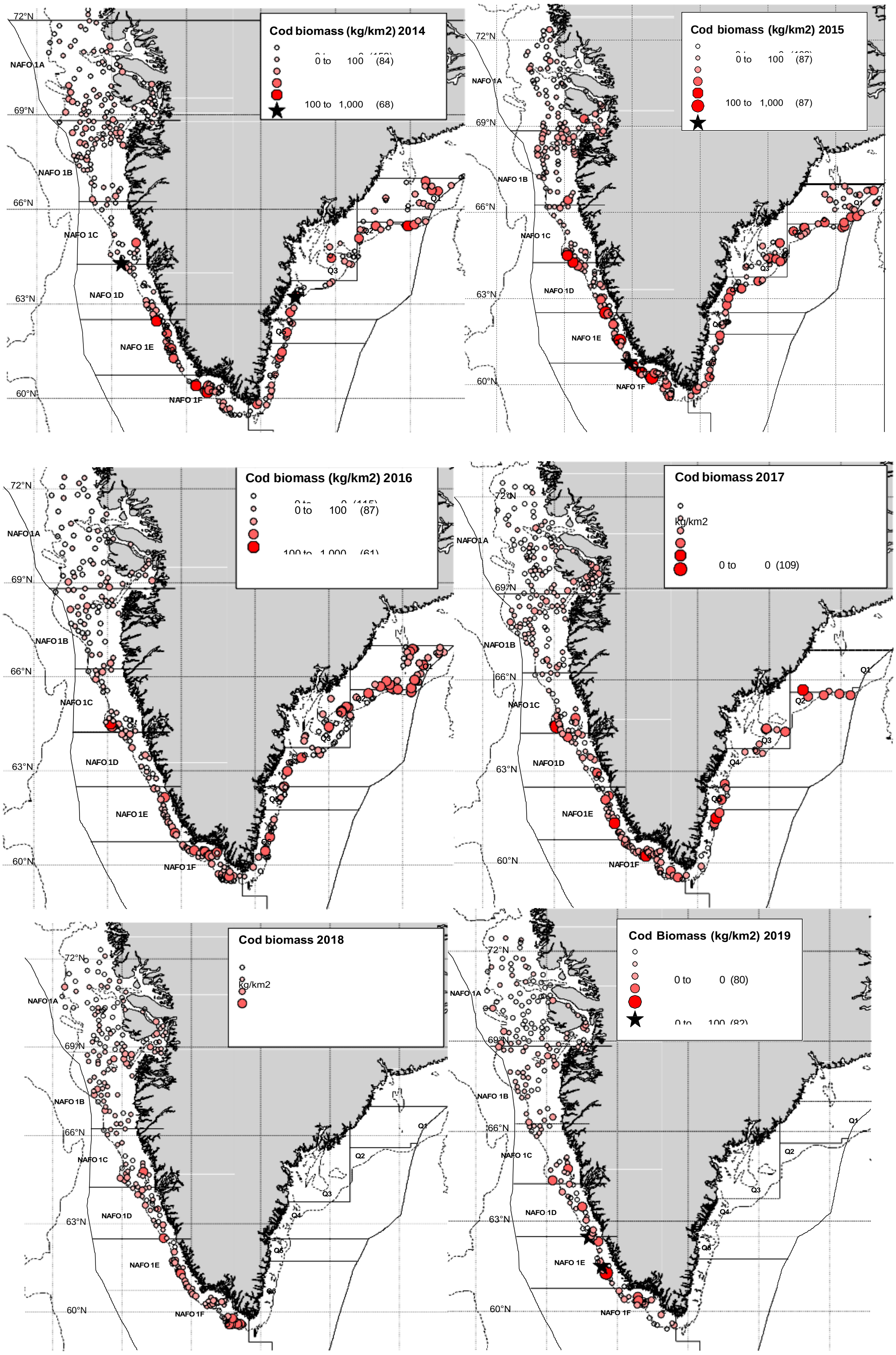

Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per km².

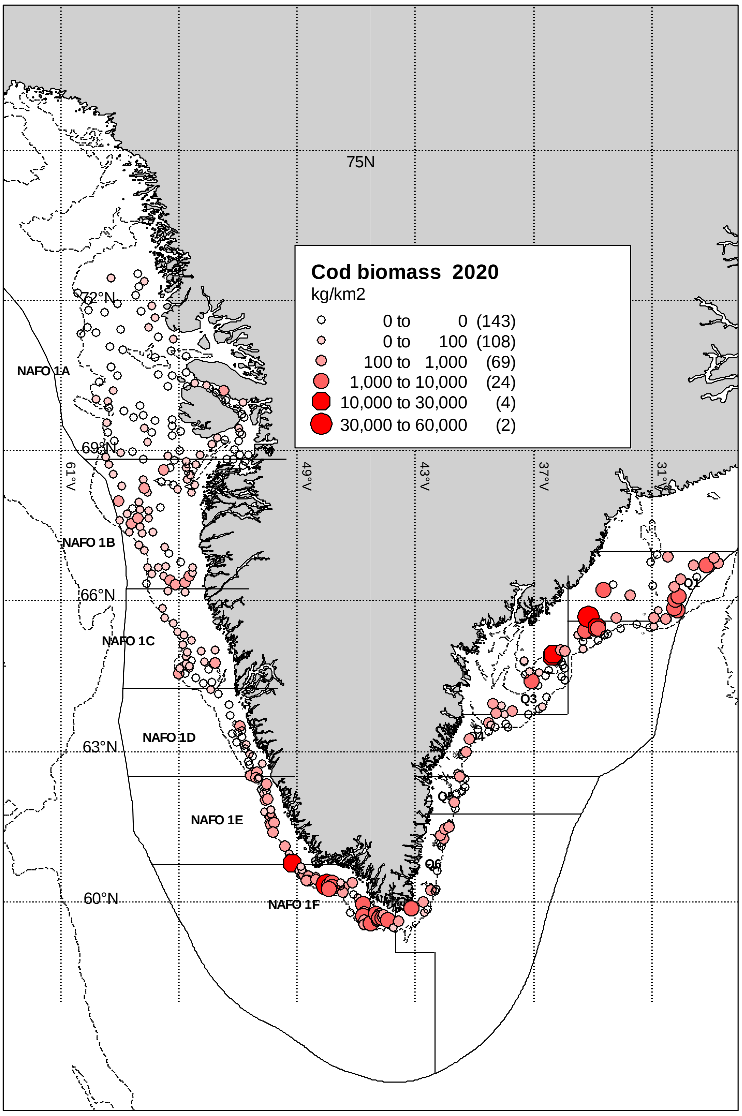

Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per km².

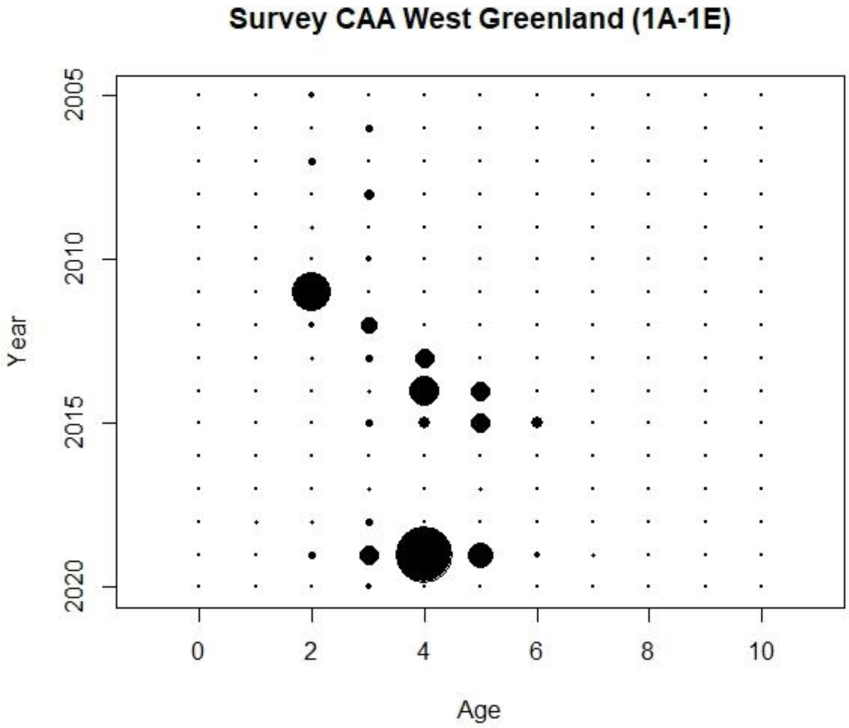

Figure 14.3.1.3: Abundance index by age in NAFO 1A–1E combined. Size of circles represents index size of index.

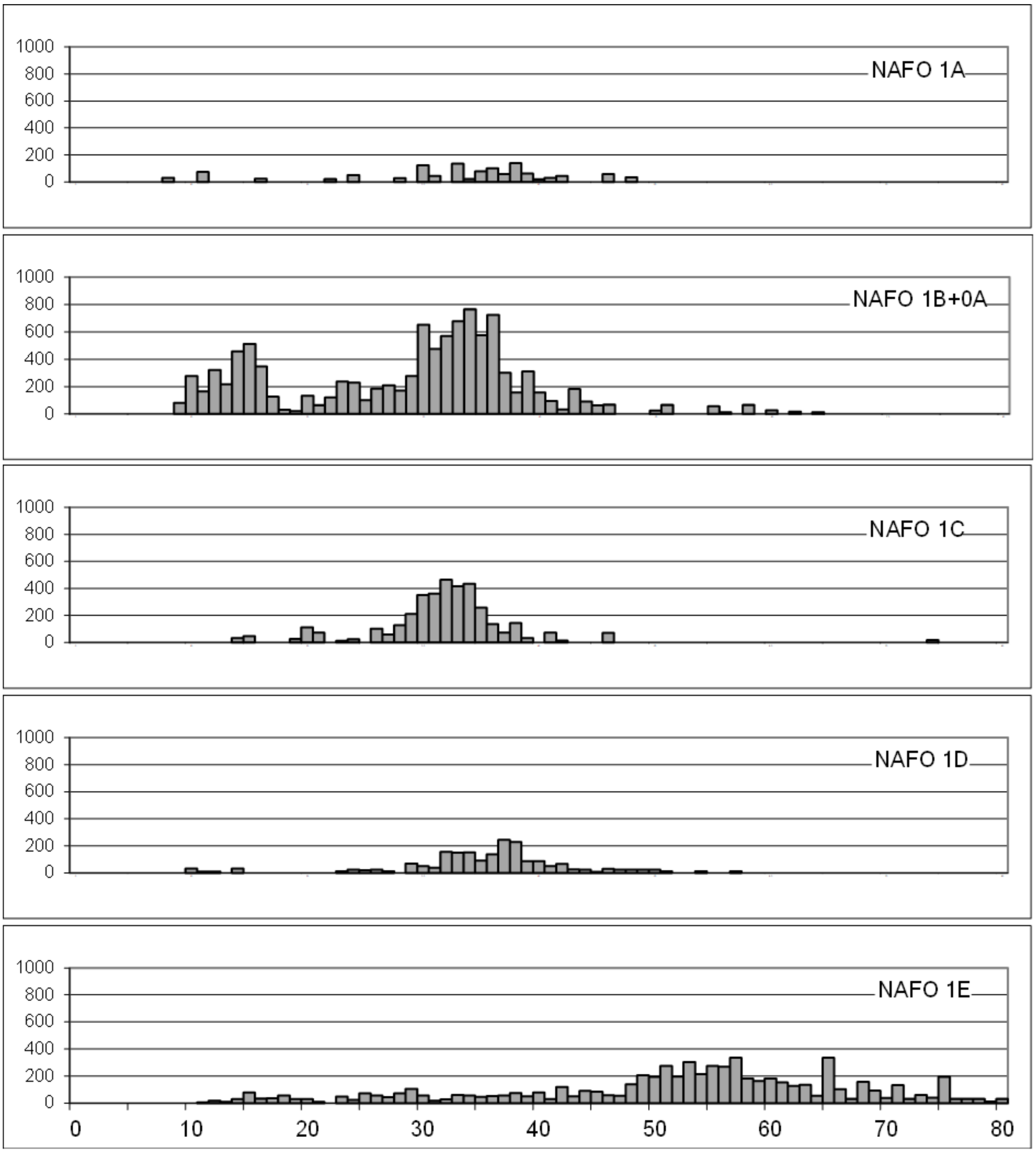

Figure 14.3.1.4: West Greenland Shrimp and fish survey. Abundance index by length (cm) and area. Areas from north (top) to south (bottom) are: NAFO division 1A; 1B+0A; 1C, 1D, 1E.

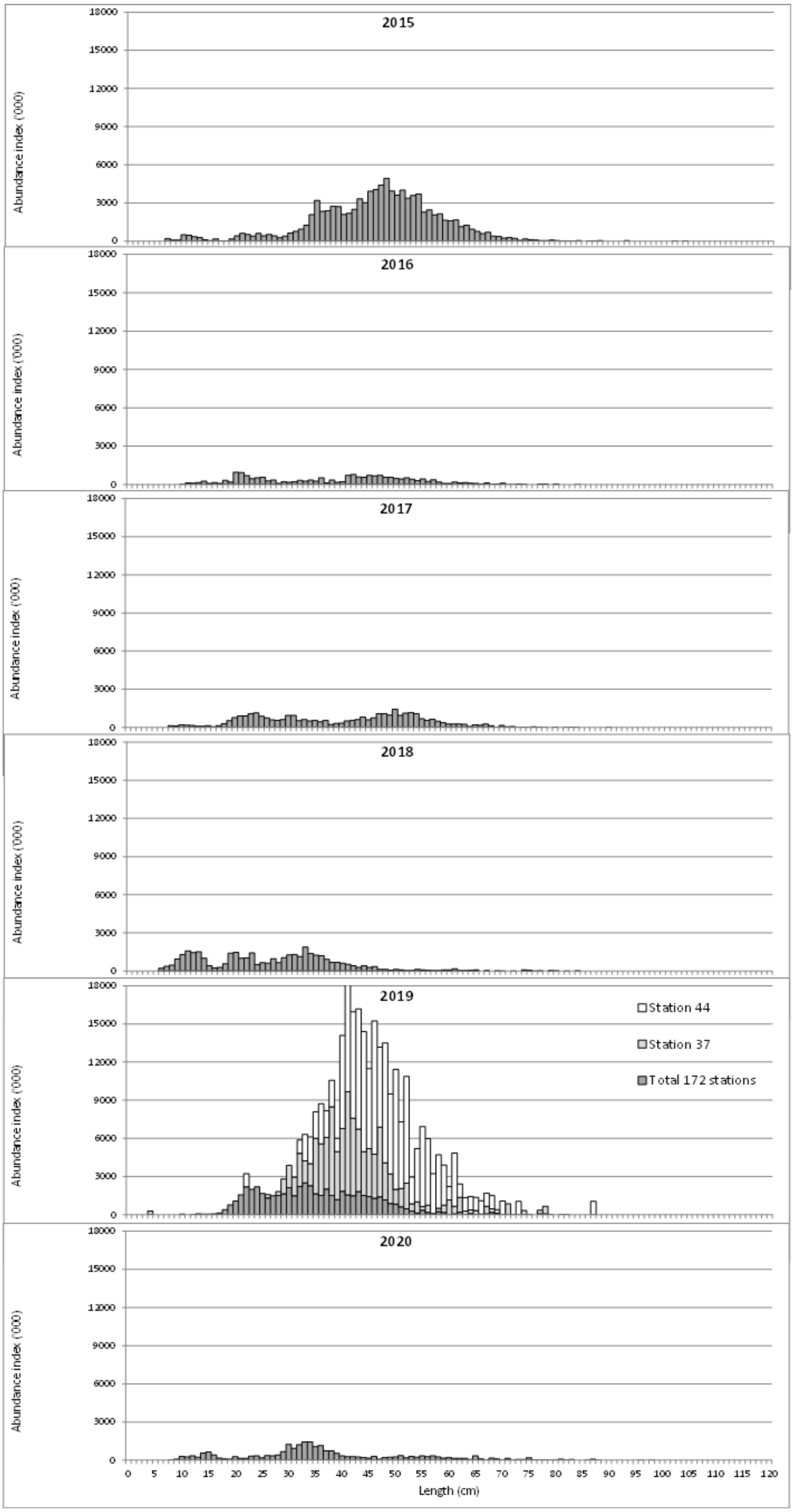

Figure 14.3.1.5: Total abundance indices by length in West Greenland shrimp and fish survey (NAFO 1A–1E).

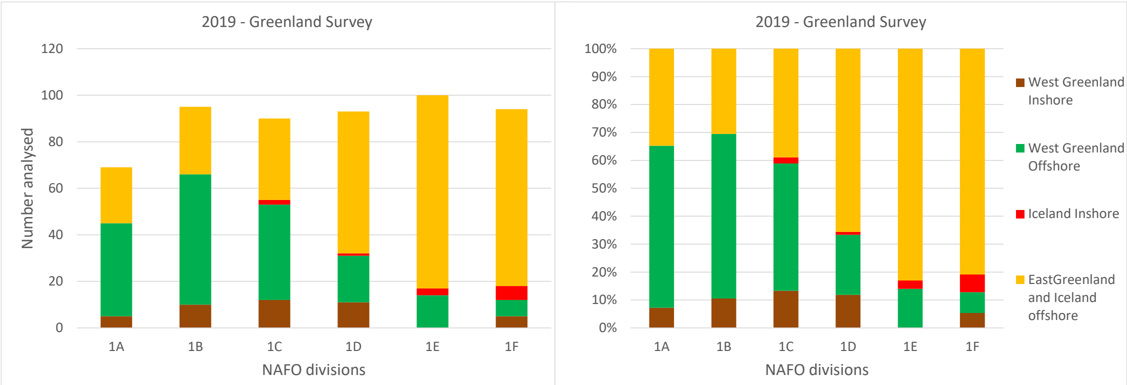

Figure 14.3.1.6: Genetic split in the 2019 trawl survey by NAFO divisions in numbers analyzed and %.

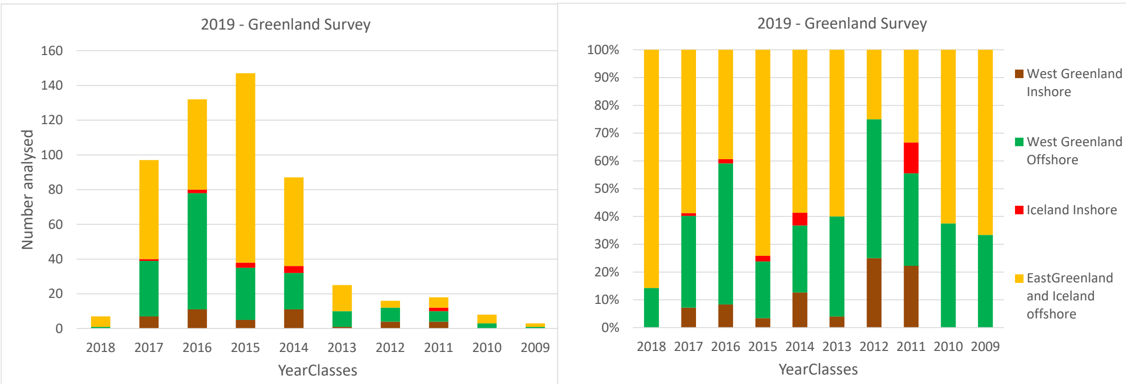

Figure 14.3.1.7: Genetic split in 2019 trawl survey by year-class in numbers analyzed and %.

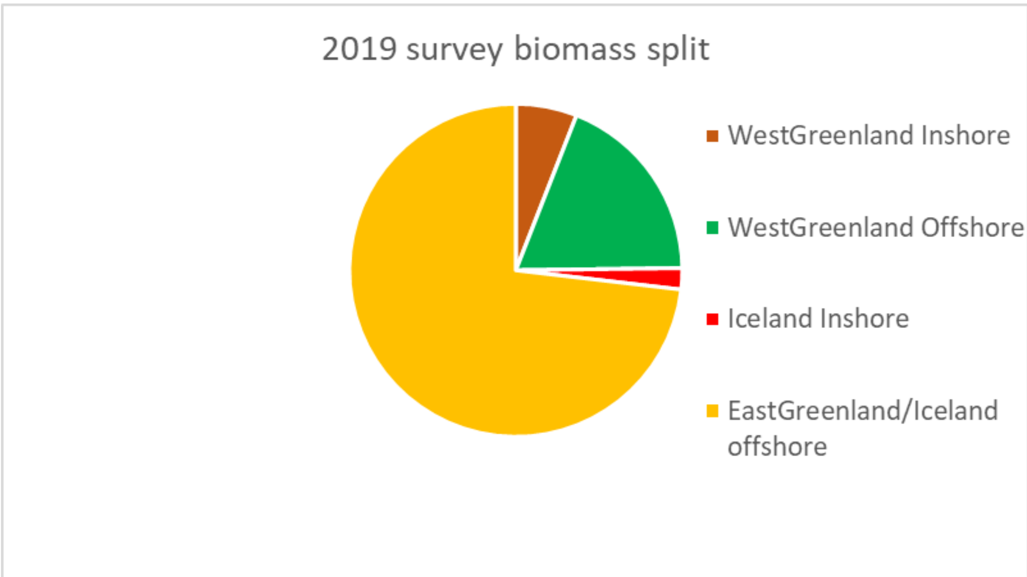

Figure 14.3.1.8: Genetic split weighted with biomass from each NAFO area in the 2019 survey biomass indices.

Figure 14.3.1.9: Genetic split in 2019 trawl survey by year class within NAFO divisions in numbers analyzed and %.

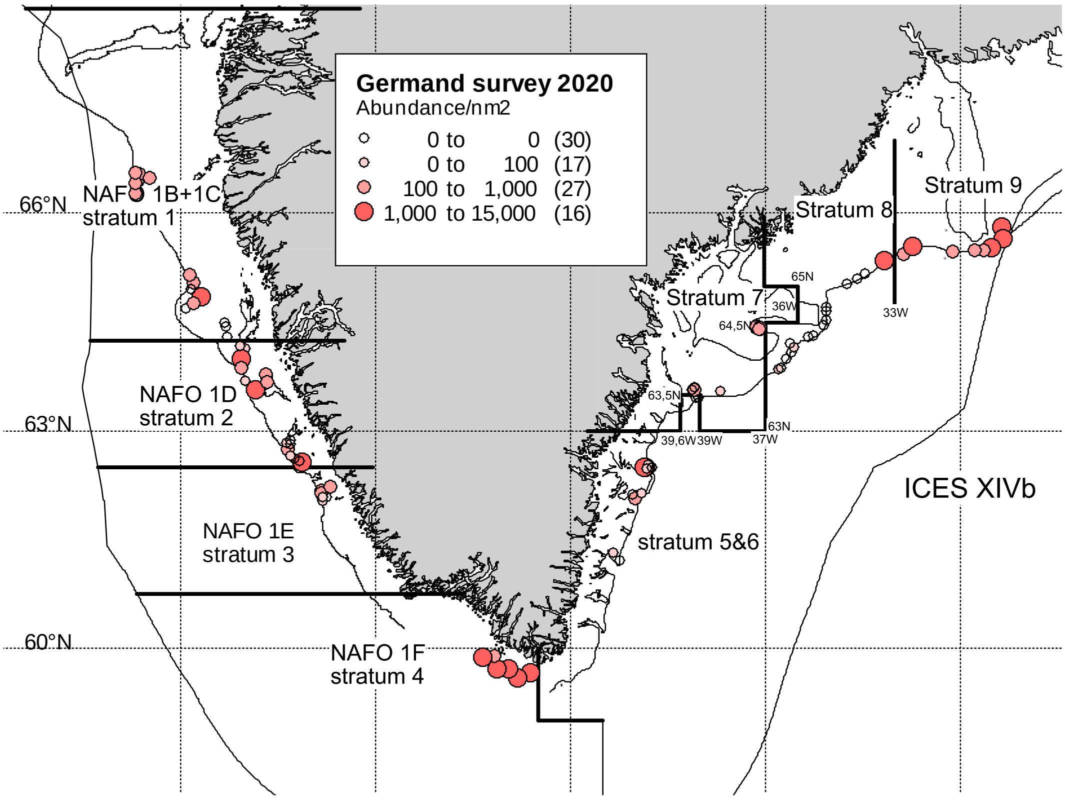

Figure 14.3.2.1. German ground fish survey. Abundance per nm².

15 Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West Greenland cod)

15.1 Stock description and management units

Cod in Greenland originate from four distinct stocks that are labelled by their spawning areas: I) offshore West Greenland; II) West Greenland fjords (inshore); III) East Greenland and offshore Icelandic and IV) inshore Icelandic waters (Therkildsen *et al*., 2013).

The inshore component (West Greenland, NAFO Subarea 1) has since 2012 been assessed separately from the offshore stocks. The Stock Annex provides more details on the stock identities including the references to the primary literature.

15.2 Scientific data

Historical trends in landings and fisheries

Details on the historical development of the fishery is described in the stock annex. The fishery developed in the yearly part of the 20th century, and by 1960 it peaked at 35 000 t (Figure 15.2.1). The fishery then declined but additional peaks in landings resulted from single large year classes during the 1970s and 1980s. Between 1990 and 2000, landings were below 5000 t, but has since increased gradually to a historic high of 35.000 tons in 2016. Catches have since then declined.

The present fishery

The TAC in 2020 was originally 30 000 tons. The 2020 catches were 17 926 t, which is a decrease of 9% compared to 2019 (Table 15.2.1). Pound net remains the dominant gear, accounting for 69% of the catches followed by the longlines (17%), hooks (8%) and gill nets (6%) (Table 15.2.2, Figure 15.2.1,). Approximately 72% of the total catch is fished from May-August with a peak (25%) in June (Table 15.2.3). More details on the inshore fishery are given in Retzel 2021a.

North Greenland (NAFO division 1A, subarea 1AX (Disco Bay))

Catches in North Greenland have gradually increased from 500 t in 2012 to an historic high of nearly 6000 t comprising close to 20% of the catches in 2017 (Table 15.2.1, Figure 15.2.2). Since 2017 catches decreased with app. 75% in 2020 to 931 t. and they accounted for 5% of the total catch in 2020 (Table 15.2.3). Cod are caught as a combination of bycatch in the gillnet and longline fishery for Greenland Halibut and a pound net directed fishery (Table 15.2.2).

Midgreenland (NAFO divisions 1B and 1C)

6806 tons were fished in Midgreenland in 2020 which is a decrease of 70% from the historic high of 22 000 t in 2016 and 2017 (Table 15.2.1, Figure 15.2.2). In both areas the dominating gear are pound nets which caught 30% of the total catch in 2020 (Table 15.2.2). The fishery is concentrated around the towns of Kangatsiaq, Sisimiut and Maniitsoq (figure 15.2.3 and 15.2.4).

Midgreenland (NAFO divisions 1D)

The fishery in NAFO division 1D south of 1C has in contrast with the northern areas increased to historic height in 2019 with 8700 tons. This is the highest caught since 1990. In 2020 catches decreased by 15 % to 7412 t (Table 15.2.3). The catches in NAFO 1D comprised 41% of the total catch in 2020.

South Greenland (NAFO divisions 1E and 1F)

The catches in South Greenland have over the last decade gradually declined to 421 tons in 2018 corresponding to 2 % of the total inshore catch (Table 15.2.1, Figure 15.2.2). In 2019 and 2020 however a drastic increase from 390 t in 2018 to 1823 t in 2019 and 2104 t in 2020 occurred in NAFO 1F resulting in 12% of the total inshore catch was caught in this region (table 15.2.3). The inshore cod stock is believed to be distributed from Midgreenland and northwards as there are no significant spawning taking place in South Greenland (Retzel and Hedeholm, 2012). Hence, the fishery in this area depends on offshore fish migrating inshore. Survey results from the offshore area found increasing numbers of cod in South Greenland especially of the 2015-Yearclass which is the main YearClass in the inshore fishery in this area (Retzel 2021b, Werner & Fock 2021).

East Greenland (ICES Subdivision 14.b)

Over the past five years, a small inshore fishery using hooks has developed in East Greenland, but less than 250 t are caught annually (Table 15.2.1, Figure 15.2.3). No length measurements are available from this fishery but individuals in this area do not belong to the West Greenland inshore cod stock. These fish are therefore not included in the overall calculations of catch and weight at age, but since the area is by definition part of the inshore area the catches are compiled here.

Catch-at-age

Several YC (YC 2013-2016) were caught in the inshore fishery in 2020, with the 2014 and 2015 YC (age 5-6) dominating the catches (Table 15.2.4, Figure 15.2.5, Figure 15.2.6).

Weight-at-age

Geographical conditions, i.e., the existence of many small landing sites separated along more than 1000 km of coastline prevents a well-balanced sampling of the Greenland coastal fleets catches. Cod are also landed without head, which hinder otolith sampling. This means that age information from the commercial fishery is limited. The mean weight-at-age in the landings are therefore primarily based on survey sampling and set equal to stock mean weight-at-age in the assessment. A more comprehensive description of the fishery and sampling procedures are provided in the stock annex.

Maturity-at-age

Maturity information from the early period of the assessment is only available for November 1987 (n = 484 cod). Although of limited size, the sample is from the bottom of the fjord where there is minimal mixing with the offshore stock (Storr-Poulsen *et al.*, 2004) and represents the best estimate of maturity during this period. Recent maturity (2007–2015) information is available from the spawning season (n = 3326 cod). The maturity ogive for the two periods was estimated by a general linear model (GLM) with binomial errors. The ogives for the two periods are different: L50 was 5.07 years in 1987 (SE = 0.18), and 4.32 years (SE = 0.04) from 2007 to 2015. It was decided to use the years with very low catches (600–800 t) as transition years between the two maturity ogives. The maturity ogive for the period 1976–2006 was set to that of the 1987 ogive. For the remaining period (2007–present) the maturity ogive was set constant based on maturity information from 2007–2015. The reason for not applying different maturity ogives for each year is due to high variation in number of samples between years that results in noisy data. Even though the maturity ogive for the period 1976–2006 is based on relatively few fish caught outside spawning season it was decided to use it as this maturity ogive is supported by earlier maturity ogives from the 1930s with a similar L50 (Hansen, 1949).

Results of the West Greenland gillnet survey

The numbers of valid net settings in 2020 was 53 in NAFO 1B and 50 in NAFO 1D (Table 15.2.5). Area and site specific catch rates can be seen in Figure 15.2.7.

In Sisimiut (NAFO 1B) the index of age 2 (45 cod/100hr) and 3 (99 cod/100 hr) abundance have decreased compared to 2019 (Table 15.2.6) and are below the time series mean (figure 15.2.8). The overall abundance index including all ages have also decreased (233 cod/100 hr) and is at the time series mean (230 cod/100hr).

In NAFO 1D the abundance index of age 2 (7 cod/100hr) decreased whereas the index of age 3 (60 cod/100 hr) increased compared to 2019 (Table 15.2.6). The combined index for age 2 and 3 is around the time series mean (figure 15.2.8). The overall abundance index including all ages have decreased (165 cod/100 hr) but is above the time series mean (113 cod/100 hr).

Combining 1B and 1D in a joint index across all ages results in a decrease compared to 2019, but is around the time series mean (Figure 15.2.8). The index remains intermediate compared to 2010–2013 and is similar to the values in 2014 and 2018, but 2010–2013 was a period of historic high recruitment. Normally, catch rates are highest in 1B, but in the period 2014-2018, the two areas have had similar recruitment (Table 15.2.6, Figure 15.2.8). In 2020 recruitment was higher in 1B.

In 2017 and 2019 the survey was extended to include Kangaatsiaq (NAFO 1B) and since 2017 to include Maniitsoq (NAFO 1C). A similar number of stations as in the traditional areas were successfully fished (Table 15.2.5). In Maniitsoq, the index combining all ages was similar to 1B and 1D in 2017. The index decreased in 2018 and further in 2019 and increased slightly in 2020 (Table 15.2.6). Similar to 1D, the number of 2 year olds decreased, whereas number of 3 year olds increased. In Kangatsiaq, the index combining all ages was much lower than in Sisimiut, Maniitsoq and Nuuk in both 2017 and 2019.

Disko Bay survey

For 2020 40 gillnets where set targeting Greenland Halibut at fixed stations corresponding to previous years in the Disko Bay. Catches in the Disko Bay gill net survey were low from 2005–2012 (Table 15.2.7). From 2013–2016, catches of cod increased substantially, mainly driven by the 2009 and 2010 YCs. Catches declined in 2017, 2018 and 2020 but were in 2019 slightly below the high catch rates in the period 2013-2016.

Disko Bay is also covered as part of the annual bottom trawl survey in West Greenland. The trawl survey catches smaller cod, and a similar increase as seen in the gill net survey was documented two years earlier, driven by the 2009 YC and subsequently by the relatively large 2010 and 2011 YCs (Table 15.2.8). In the period 2011-2016, catches have remained substantial in both the gill net and the trawl survey, but since 2016 numbers indicate a decline in abundance, which is consistent with smaller year classes as observed in the 1B and 1D recruitment surveys. Jointly, the inshore surveys suggests that the increase in recruitment starting with the 2009 YC resulted in not only local biomass increases, but also an expansion of the stock into the northern part of the inshore area. Recent recruitment declines can therefore also be expected to have the largest effect in the northern part of the area.

More details on inshore survey results can be found in Retzel (2021c).

Genetics

In 2019 samples for genetic analysis were taken from the inshore fishery in 5 areas from NAFO 1B (Kangaatsiaq) in the north to NAFO 1F in the South. A shift in genetic composition in the inshore fishery is seen from north to south (figure 15.2.9). In the north (Kangaatsiaq) the West-Greenland offshore stock is dominating with 40% in the catches followed by the WestGreenland inshore stock (35%) and the EastGreenland-Iceland offshore stock (25%). In contrast the West-Greenland Inshore stock is dominating in MidGreenland, especially in Sisimiut where 70% belongs to the WestGreenland inshore stock. In Maniitsoq and Nuuk 50% belong to this stock. In SouthGreenland (NAFO 1F) the dominating stock is the EastGreenland-Iceland offshore stock with 60%, followed by the WestGreenland inshore stock with 30%. Ages were only obtained from the collections from the fishery in the Nuuk (NAFO 1D) area and South Greenland (NAFO 1F). The composition between YearClasses seems stable in the Nuuk area (figure 15.2.10), whereas the 2015 and 2014 YC in SouthGreenland predominantly belongs to the EastGreenland-Iceland offshore stock and the 2013 YC belongs to the WestGreenland inshore stock.

In 2019 genetic samples were taken from every inshore survey. The results of the genetic investigation in 2019 showed that the majority (50%) of the cod in the surveys in the northern area (Disco Bay and Kangaatsiaq, figure 15.2.11) belong to the WestGreenland offshore stock component. The WestGreenland inshore and EastGreenland-Iceland stock component constituted 25% each. In contrast further south the WestGreenland inshore stock component dominates, especially in the Sisimiut area where 70% belong to this stock. In Maniitsoq and Nuuk 55% belong to this stock. The WestGreenland offshore stock component is the second largest in the survey with 25% in Sisimiut and 30% in Maniitsoq and Nuuk. Investigations of the split in yearclasses revealed that in the Sisimiut area older yearclasses belong almost exclusively to the WestGreenland inshore stock component (figure 15.2.12). This pattern seems only to be evident in Sisimiut.

15.3 Tagging experiments

A total of 5642 cod have been tagged inshore in West Greenland from 2003–2019, primarily in NAFO 1B, 1D and 1F (table 15.3.1).

Inshore recaptures are found almost exclusively in the same fjord as tagged (Table 15.3.2). No tags from the inshore area have been recaptured offshore except three that were recaptured in Iceland. These three cod were tagged in the South Greenland (1F) inshore area. Three cod tagged offshore in NAFO 1C was recaptured inshore in NAFO 1E, 29 cod tagged offshore on Dana Bank have been recaptured in the inshore fjord system. Most of these were recaptured in the inshore area south of Dana Bank, but four were recaptured inshore north of Dana Bank. These results confirm the general perception: adult cod present deep in the fjords tends to remain in the same area and that the southern part of the inshore area is a mixing area of different stocks.

15.4 Methods

The stock was benchmarked in 2018 (ICES, 2018). It was decided to use the SAM model and perform an analytical assessment. Hence, the assessment was upgraded from a category 3 (Data Limited Stock) to a category 1 stock. This is considered a vast improvement, as all data are now utilized, and the assessment is presented with uncertainty estimates and multiple catch options.

15.5 Reference points

Reference points were defined at IBPGCod (ICES, 2018). The estimations were conducted in EQSIM according to ICES guidelines (see ICES (2018) for details). The reference points are shown in Table 15.5.1. However, F_{lim} and F_{pa} has not be defined. A benchmark for the stock is proposed to take place in 2022.

15.6 State of the stock

There have been several years of high recruitment between 2003 and 2012 and the spawning stock biomass was at a level not seen for 25 years in 2015, since then it has declined. The recruitment has been stable on a low level in the last five years. The recent decrease in stock size was expected as the failing recruitment begins to affect the number of adults. The catches have decreased since the time series highs in 2016 and 2017. Catches are comprised of ages 4–7 and low recruitment for a few consecutive years will quickly affect the fishable biomass, which is evident in the catches of 2020 that was around half compared to 2016. TACs have not been obtained the last four years and it is unlikely that the TAC of 21 000 t in 2021 will be caught.

Genetic studies have been carried out on catches from the surveys and the fishery along the coast line from Disko Bay in the north to South Greenland. Both in surveys and the fishery a gradient is evident with the West Greenland Offshore stock dominating in the north (NAFO 1A+ northern part of NAFO 1B), the Inshore stock dominating in mid (Southern part of NAFO 1B+NAFO 1C and 1D) and the East Greenland – Iceland offshore stock dominating in the South (NAFO 1F). The main part of the fishery is conducted in mid Greenland where the Inshore stock is dominating the catches, the proportion varies between 50%–70% (Christensen, 2019, Retzel, 2021a).

However, a considerable proportion (30%) of the inshore catches belongs to the West Greenland offshore stock. The stock is in a depleted condition and the current ICES advice is zero catch. A continued high fishing pressure in the inshore areas can prolong the recovery time of the offshore stock.

The remaining part (20%) of the inshore catches belongs to the East Greenland/Icelandic offshore stock. It is assumed that a large part of these cod migrates to East Greenland/Iceland to spawn. The spawning stock in East Greenland has in recent years declined. A continued high fishing pressure in the inshore areas can have a negative influence on the spawning stock in East Greenland.

15.7 Short term forecast

Input data

The SAM model provides predictions that carry the signals from the assessment into the short-term forecast. The forecast procedure starts from the last year's estimate of the state (log(N) and log(F)). One thousand replicates of the last state are simulated from the estimated joint distribution. Each of these replicates are then simulated forward according to the assumptions and parameter estimates found by the assessment model.

In the forward simulations, a 5-year average (up to the assessment year) is used for catch mean weight, stock mean weight, proportion mature, and natural mortality. Recruitment is re-sampled from the entire time series. In each forward simulation step the fishing mortality is scaled, such that the median of the distribution is matching the requirement in the scenario (e.g. hitting a specific mean F value, a specific catch or level of SSB).

Results

The results from the assessment are shown as estimated numbers-at-age and F-at-age in Tables 15.7.1 and 15.7.2. All other output can be found on stockassessment.org (run: cod-WestInsNWWG2021, Riget *et al*., 2021).

The forecasts from the different scenarios are presented in Table 15.7.3. Fishing at F_{MSY} in 2022 will result in catches of 4780 t and a spawning stock biomass increase with 18% in 2023. Recently the catches have been above the ICES advice, and an F status quo will result in catches of 10 141 t, but at the same time a decrease in the spawning stock biomass of 11% in 2023.

15.8 Long term forecast

No long-term forecast was performed for this stock.

15.9 Uncertainties in assessment and forecast

The major uncertainty of the assessment is related to mixing of cod stocks (West Greenland offshore and East Greenland/Icelandic offshore).

There is no incentive to discard fish or misreport catches under the current management system and any small cod released from the pound nets survive. The surveys show relatively good internal consistency and jointly data input to the assessment is of high quality and the time series are long which should provide a good basis for a robust assessment.

The model fits the data relatively well (Figure 15.9.2) but does consistently underestimate the spawning stock biomass (Figure 15.9.3). Although this is consistently a way-residual, the Mohn's rho measure of uncertainty is -0.22, which is not considered high (Hurtado-Ferro *et al.*, 2015) and the 95% confidence intervals include the most recent years retrospective runs. For the fishing mortality, there are also year-to-year changes in the perception (Figure 15.9.4). These are, however, both positive and negative, and the resulting Mohn's rho is only 0.03 with all retrospective runs being inside the model 95% confidence intervals.

The poorest model performance is in the fit between actual and estimated catches (Figure 15.9.2). Especially the poor fit to the catches in years with large catches is noteworthy, as catches are known with a high degree of certainty. The cause of this is emigration; immigration and mixing of stocks both in the survey and in the catches (see 'State of the stock'). The general picture of the stock dynamics is relatively well understood, but difficult to quantify, especially on an annual basis. It does present a challenge in the forecast. The TAC in the intermediate year is known at the time of the assessment meeting. This TAC is valid for the mixed fishery and does not reflect the expected catch of solely the inshore stock. Because of this, the TAC is not used in the forecast. Instead, we have assumed that F will be similar and applied an F-scaler of 1 in the intermediate year. This then assumes that the model output is a valid estimate of the inshore cod stock landings and not total catches. In the current period, with very high landings, the model has estimated the actual landings to be roughly double the model estimate.

Hence, the forecast should be considered as an estimate of the development of the inshore cod stock and not cod in the inshore area.

15.10 Comparison with previous assessment and forecast

The stock was benchmarked in 2018 (ICES, 2018) and the SAM model accepted. The spawning-stock biomass (SSB) of West Greenland inshore cod has decreased since 2015 after having been at a historical high level. Fishing mortality (F) has increased slightly in recent years and have been above F_{MSY} during the whole time-series. Recent recruitment has gradually decreased from a decade of high values and is currently close to historically low levels.

15.11 Management plans and evaluations

There is no management plan for this stock.

15.12 Management considerations

The TAC for this stock has consistently been set above the ICES advice. The quota is a common TAC for the entire inshore area and does not distinguish between stocks. Furthermore, it is allowed to fish offshore on the inshore quota. Historically, when the TAC was reached, the TAC was increased. Hence, the fishery in the West Greenland inshore area has always been an unlimited fishery.

Due to stock mixing, ICES is currently not able to accurately estimate the stock proportions in the catches. Therefore, the TAC can be set higher than the ICES advice, while still being in accordance with the advice. ICES cannot advice on such a TAC level.

15.13 Ecosystem considerations

The gear used for this fishery have little effect on the ecosystem, especially the main gear (pound-net).

15.14 Regulations and their effects

The fishery has never been limited by a TAC, as the TAC has always been set well above the fleet capacity or raised when reached. Therefore, it is unknown what the effect would be of limiting the fishery.

15.15 Changes in fishing technology and fishing patterns

With the northward expansion of the fishery over the past decade, there has been an increase in the importance of the gill nets, long liners and hooks. This has changed the selectivity of the fishery, as these gears have a higher selectivity for the older ages. This is also reflected in the assessment, where the F selectivity has gradually increased in recent years and the SAM model is explicitly able to handle time-varying selectively (Nielsen and Berg, 2014).

15.16 Changes in the environment

No data is collected to support any conclusions.

15.17 Benchmark 2022

Inshore catches have recently increased to historic highs. New genetic investigations of especially the inshore component reveals that the WestGreenland offshore component (cod.21.1.a-e) is mixing with the inshore component to a larger extent than previously thought (Christensen 2019, Buch et al. 2021, Retzel 2021a, Retzel 2021c).

The main aim of the benchmark is to move away from using the current simplified geographical borders to separate the three cod stocks in Greenland waters. This will be done by developing a modelling approach that can use genetic data based on samples covering the distribution of the three stocks (Buch et al. 2021). The model will utilize the spatial resolution of the genetics data to estimate the split between the stocks along a spatial gradient. The catch and survey data will then be split into separate stocks and used as input into an analytical assessment models for each stock. This would account for differences in stock dynamics between stocks and may improve the understanding of migration patterns.

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15.19 Tables

Table 15.2.1. Cod catches (t) divided into NAFO divisions, caught in the inshore fishery (1911–1993: Horsted 2000, 1994–2006: ICES 2007, Statistic Greenland, 2007-present: Greenland Fisheries License Control). ICES 14.b = inshore East Greenland.

	NAFO divisions								
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div.	Total West Greenland	ICES 14b
1911				19				19	
1912				5				5	
1913				66				66	
1914				60				60	
1915		47	6	45				98	
1916		66	24	103				193	
1917		67	28	59				154	
1918		106	26	140		169		441	
1919		39	37	140	148	137		501	
1920		117	32	187	23	95		454	
1921		116	92	97	7	196		508	
1922		82	178	144	40	158		602	
1923		120	116	147	0	307		690	
1924		131	223	221	1	267		843	
1925		122	371	318	45	168		1024	
1926		97	785	673	170	499		2224	
1927		282	974	982	305	1027		3570	
1928		426	888	1153	497	1199		4163	
1929		1479	1572	1335	642	2052		7080	
1930	137	2208	2326	1681	994	2312		9658	
1931	315	1905	2026	1520	835	2453		9054	
1932	358	1713	2130	1042	731	3258		9232	
1933	304	1799	1743	1148	948	2296		8238	
1934	451	2080	1473	652	921	3591		9168	

NAFO divisions									
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div.	Total West Greenland	ICES 14b
1935	524	1870	1277	769	670	2466		7576	
1936	329	2039	1199	705	717	2185		7174	
1937	135	1982	1433	854	496	2061		6961	
1938	258	1743	1406	703	347	1035		5492	
1939	416	2256	1732	896	431	1430		7161	
1940	482	2478	1600	1061	646	1759		8026	
1941	636	3229	1473	823	593	1868		8622	
1942	879	3831	2249	1332	1003	2733		12027	
1943	1507	5056	2016	1240	1134	2073		13026	
1944	1795	4322	2355	1547	1198	2168		13385	
1945	1585	4987	2844	1207	1474	2192		14289	
1946	1889	5210	2871	1438	1139	2715		15262	
1947	1573	5261	3323	2096	1658	4118		18029	
1948	1130	5660	3756	1657	1652	4820		18675	
1949	1403	4580	3666	2110	2151	3140		17050	
1950	1657	6358	4140	2357	2278	4383		21173	
1951	1277	5322	3324	2571	2101	3605		18200	
1952	646	4443	2906	2437	2216	4078		16726	
1953	1092	5030	3662	5513	3093	4261		22651	
1954	950	6164	3118	3275	1773	3418		18698	
1955	591	5523	3225	4061	2773	3614		19787	
1956	475	5373	3175	5127	3292	3586		21028	
1957	277	6146	3282	5257	4380	5251		24593	
1958	19	6178	3724	5456	3975	6450		25802	
1959	237	6404	5590	5009	3767	6570		27577	
1960	188	6741	6230	3614	3626	6610		27009	
1961	601	6569	6726	4178	6182	9709		33965	

NAFO divisions									
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div.	Total West Greenland	ICES 14b
1962	315	7809	6269	3824	5638	11525		35380	
1963	295	4877	3178	2804	3078	9037		23269	
1964	275	3311	2447	8766	2206	4981		21986	
1965	325	5209	4818	6046	2477	5447		24322	
1966	483	8738	5669	7022	2335	4799		29046	
1967	310	5658	6248	6747	2429	6132		27524	
1968	142	1669	2738	6123	2837	7207		20716	
1969	57	1767	4287	7540	2017	5568		21236	
1970	136	1469	2219	3661	2424	5654		15563	
1971	255	1807	2011	3802	1698	3933		13506	
1972	263	1855	3328	3973	1533	3696		14648	
1973	158	1362	1225	3682	1614	1581		9622	
1974	454	926	1449	2588	1628	1593		8638	
1975	216	1038	1930	1269	964	1140		6557	
1976	204	644	1224	904	1367	831		5174	
1977	216	580	2505	2946	3521	4231		13999	
1978	348	1587	3244	2614	4642	7244		19679	
1979	433	1768	2201	6378	9609	15201		35590	
1980	719	2303	2269	7781	10647	14852		38571	
1981	281	2810	3599	6119	7711	11505	7678	39703	
1982	206	2448	3176	7186	4536	3621	5491	26664	
1983	148	2803	3640	7430	5016	2500	7205	28742	
1984	175	3908	1889	5414	1149	1333	6090	19958	
1985	149	2936	957	1976	1178	1245		8441	
1986	76	1038	255	1209	1456	1268		5302	
1987	77	2366	423	6407	3602	1326	403	14604	
1988	333	6294	1342	2992	3346	4484		18791	

NAFO divisions									
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div.	Total West Greenland	ICES 14b
1989	634	8491	5671	8212	10845	4676		38529	
1990	476	9857	1482	9826	1917	5241		28799	
1991	876	8641	917	2782	1089	4007		18312	
1992	695	2710	563	1070	239	450		5727	
1993	333	327	168	970	19	109		1926	
1994	209	332	589	914	11	62		2117	
1995	53	521	710	332	4	81		1701	
1996	41	211	471	164	11	46		944	
1997	18	446	198	99	13	130	282	1186	
1998	9	118	79	78	0	38		322	
1999	68	142	55	336	8	4		613	
2000	154	266	0	332	0	12		764	
2001	117	1183	245	54	0	81		1680	
2002	263	1803	505	214	24	813		3622	
2003	1109	1522	334	274	3	479	1494	5215	
2004	535	1316	242	116	47	84	2608	4948	
2005	650	2351	1137	1162	278	382	83	6043	
2006	922	1682	577	943	630	1461	1173	7388	
2007	416	2547	1195	1842	659	4391		11050	42
2008	870	3066	1539	3172	225	1133		10005	6
2009	325	1288	1189	2009	1142	1581		7534	2
2010	559	2990	1607	1795	1458	859		9268	2
2011	567	2364	2850	2905	1274	1047		11007	0
2012	546	1376	2061	4375	1989	325		10672	0.02
2013	1506	2552	2784	4711	1450	198		13202	35
2014	3084	6142	3710	4629	684	82		18331	38
2015	4088	7912	6426	6613	117	115		25272	50

NAFO divisions									
Year	1A	1B	1C	1D	1E	1F	Unknown NAFO div.	Total West Greenland	ICES 14b
2016	5929	11466	11270	5279	87	173		34204	39
2017	5797	11110	10060	4066	56	131		31220	82
2018	2213	6422	6190	7043	31	390		22290	51
2019	1987	2925	4214	8673	131	1823		19753	143
2020	1382	2324	4482	7412	222	2104		17926	223

Table 15.2.2: Landings (%) divided into month and gear and NAFO divisions and gear.

Gear/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Poundnet	0.006%		0.1%	2%	13%	24%	19%	7%	2%	2%	1%	1%	**69%**
Gillnet	0.3%	0.4%	0.4%	0.5%	1%	0.2%	1%	0.3%	0.2%	1%	1%	1%	**6%**
Jig	0.1%	0.2%	0.2%	0.2%	0.4%	1%	2%	2%	1%	1%	0.5%	0.1%	**8%**
Longline	2%	2%	1%	2%	1%	1%	1%	1%	1%	2%	2%	2%	**17%**
Total	**2%**	**2%**	**2%**	**5%**	**15%**	**25%**	**22%**	**10%**	**4%**	**5%**	**4%**	**4%**	

Gear/NAFO	1AUM	1AUP	1AX	1B	1C	1D	1E	1F	Total	14b
Poundnet	1%		1%	10%	20%	29%	1%	7%	**69%**	
Gillnet	0.2%		2%	2%	0.3%	0.4%	0.01%	2%	**6%**	
Jig	0.1%		1%	1%	2%	3%	0.3%	1%	**8%**	6%
Longline	1%	0.001%	1%	0.2%	3%	10%	0.03%	2%	**17%**	94%
Total	**3%**		**5%**	**13%**	**25%**	**41%**	**1%**	**12%**		

Table 15.2.3 Catches (t) divided into month and NAFO Divisions, caught by the coastal fisheries.

NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
1AUM	8	17	18	25	23	17	14	208	85	22	7	7	451	3%
1AUP														
1AX	22	55	58	42	36	157	204	67	57	87	113	33	931	5%
1B	0.1	1	7	47	273	813	416	170	62	122	207	206	2324	13%
1C	67	33	24	76	783	1302	1152	355	94	231	202	163	4482	25%
1D	268	243	189	588	1117	1693	1372	685	333	426	245	253	7412	41%
1E	0.1	0.1	4	21	54	6	40	57	29	8	1	2	222	1%
1F	19	26	35	42	329	561	780	166	50	55	23	18	2104	12%
Total	384	375	335	841	2615	4549	3978	1708	710	951	798	682	17926	
%	2%	2%	2%	5%	15%	25%	22%	10%	4%	5%	4%	4%		
ICES 14b				1	1	1	22	37	63	79	19		223	

Table 15.2.4 Estimated commercial landings in numbers ('000) at age, and total tones by year. * no sampling.

Year	Age								Tonnes
	3	4	5	6	7	8	9	10+	Landed
1976	2508	924	556	287	38	31	11	7	5174
1977	467	5437	1100	883	179	7	142	46	13999
1978	97	1262	9904	132	68	7	3		19679
1979	323	2297	2380	8281	170	96	4	14	35590
1980	4343	4334	1646	806	6492	106	29	37	38571
1981	87	15793	5225	725	499	2906	61	17	39703
1982	3013	1587	6309	1545	798	152	610	154	26664
1983	229	16877	1381	4352	368	139	65	75	28742
1984	520	4451	9269	346	634	18	42	12	19958
1985	5	2400	1028	2229	196	363	14	78	8441
1986	286	178	896	460	721	16	102	38	5302
1987	5503	1334	228	710	340	1084	46	265	14604
1988	419	15588	150	51	39	90	161	12	18791
1989	15	5962	23956	271	46	2	93	176	38529
1990	212	2997	15403	6732	33	11	7	16	28799
1991	124	6022	4910	5695	330	0			18312
1992	8	2408	2344	452	139	46	13	5	5727
1993	28	661	575	206	34	41	10	7	1926
1994	22	1468	342	62	45	8	11	1	2117
1995	1	834	773	37	5	0	0		1701
1996	2	165	362	130	25	3	1	0	944
1997	1	397	311	179	31	0			1186
1998*									322
1999	87	465	105	1	0	0			613
2000	4	228	336	7	0	0			764
2001*									1680
2002	532	2243	657	29	9	1	0	0	3622

Year	Age								Tonnes
	3	4	5	6	7	8	9	10+	Landed
2003	152	581	1547	258	51	16	15	11	5215
2004	530	1669	1095	228	37	3			4948
2005	1392	2408	944	186	36	10	4	0	6043
2006	4256	3363	680	22	0	0	0		7388
2007	1944	7910	1010	116	38	13	8	4	11050
2008	1176	5012	2793	319	36	6	2		10005
2009	487	3540	2372	194	13	3	0	4	7534
2010	301	1091	2475	1524	141	32	21	27	9268
2011	129	2929	2567	1480	255	90	12	7	11007
2012	735	1725	2681	850	182	21	13	13	10672
2013	143	3806	2477	1083	361	115	67	9	13202
2014	40	1389	4024	2292	328	168	103	52	18331
2015	20	2006	5680	3008	1337	133	9	8	25272
2016	32	2146	9701	5732	1179	239	57	7	34203
2017	44	1384	6351	5241	3370	498	168	48	31220
2018	21	2214	4255	4180	2319	850	169	76	22290
2019	47	1941	6727	3679	1885	624	145	46	19753
2020	113	1686	4418	4437	987	534	136	63	17926

Table 15.2.5: Survey effort in the Greenland Inshore Gill-net survey (nos. of valid net settings)

Division (area)	1B (Kangtsiaq)	1B (Sisimiut)	1C	1D	1F	Total
1985		3		38	27	68
1986		26		22	23	71
1987		24		27	26	77
1988		21		24	24	69
1989		28		19	32	79
1990		18		21	18	57
1991		23		24	20	67
1992		27		29	23	79
1993		23		25	19	67
1994		20		29	17	66
1995		24		21	20	65
1996		26		25	-	51
1997		20		23	-	43
1998		24		26	22	72
1999		-		24	-	24
2000		-		27	20	47
2001		-		-	-	-
2002		21		20	-	41
2003		33		27	-	60
2004		27		31	-	58
2005		25		28	-	53
2006		45		51	-	96
2007		52		-	39	91
2008		-		58	60	118
2009		-		58	18	76
2010		66		52	-	118
2011		57		44	-	101
2012		54		52	-	106

Division (area)	1B (Kangtsiaq)	1B (Sisimiut)	1C	1D	1F	Total
2013		58		52	-	110
2014		60		41	-	101
2015		59		44	-	103
2016		58		40	-	98
2017	60	57	59	46	-	222
2018		58	61	52	-	171
2019	50	48	47	54	-	199
2020	-	53	50	50	-	153

Table 15.2.6: NAFO Div. 1B. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gill-net survey. Na = data not available.

Year	Age								All
	1	2	3	4	5	6	7	8+	
1985	26	23	0	6	0	0	0	0	54
1986	4	245	16	8	2	2	0	0	278
1987	0	122	233	25	1	0	0	0	381
1988	0	33	130	111	2	0	0	0	276
1989	1	110	83	57	32	1	0	0	283
1990	0	109	108	62	53	12	0	0	344
1991	0	3	131	53	11	3	0	0	202
1992	0	43	10	18	3	0	0	0	74
1993	0	22	22	2	1	0	0	0	47
1994	4	8	19	12	0	0	0	0	43
1995	2	115	19	7	1	0	0	0	143
1996	0	28	40	7	1	0	0	0	77
1997	0	14	8	3	1	0	0	0	26
1998	2	7	4	6	3	0	0	0	23
1999	na	na	na	na	na	na	na	na	na
2000	na	na	na	na	na	na	na	na	na
2001	na	na	na	na	na	na	na	na	na

Year	Age								All
	1	2	3	4	5	6	7	8+	
2002	31	207	72	21	9	1	0	0	340
2003	1	68	69	21	3	0	0	0	163
2004	32	28	29	9	5	0		0	102
2005	47	123	35	7	5	1	3	0	221
2006	32	148	60	24	1	1	0	0	170
2007	7	170	82	15	1	0	0	0	275
2008	na	na	na	na	na	na	na	na	na
2009	na	na	na	na	na	na	na	na	na
2010	138	155	120	58	12	1	0	0	484
2011	20	526	106	44	19	1	0	0	717
2012	7	184	304	30	8	3	0	0	536
2013	4	158	105	104	27	8	1	1	408
2014	7	46	45	25	19	4	0	1	146
2015	2	39	44	59	49	39	3	1	236
2016	6	31	98	42	36	23	7	2	245
2017	1	6	71	79	33	23	10	2	225
2018	1	27	25	26	15	6	2	1	103
2019	0	80	136	19	35	12	1	2	285
2020	17	45	99	51	15	5	0	1	233

Table 15.2.6, *continued* : NAFO Div. 1D. Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gill-net survey.

Year	Age								All
	1	2	3	4	5	6	7	8+	
1985	68	77	0	3	3	3	0	1	155
1986	0	96	15	0	0	0	0	0	114
1987	1	16	68	5	0	0	0	0	90
1988	0	20	48	30	1	0	0	0	99
1989	0	78	47	13	13	0	0	0	152
1990	0	14	35	4	4	3	0	0	60
1991	124	3	17	6	2	1	0	0	154
1992	0	61	22	10	7	1	0	0	100
1993	0	4	57	20	2	0	0	0	83
1994	0	0	6	5	1	0	0	0	12
1995	0	3	2	4	4	0	0	0	12
1996	0	1	1	1	2	0	0	0	4
1997	3	3	1	0.2	0.5	0.4	0.1	0	8
1998	0	10	17	1	0	0	0	0	28
1999	0	0	1	3	0	0	0	0	5
2000	0	2	2	1	1	0	0	0	6
2001	na	na	na	na	na	na	na	na	na
2002	0	7	4	3	0	0	0	0	14
2003	0	6	4	2	1	0	0	0	13
2004	3	43	6	3	1	1	0	0	57
2005	9	27	7	2	0	0	0	0	45
2006	2	114	37	13	4	0	0	0	170
2007	na	na	na	na	na	na	na	na	na
2008	4	4	47	63	7	0	0	0	124
2009	4	52	14	72	23	1	0	0	166
2010	1	33	107	18	27	3	0	0	189
2011	10	45	3	18	6	4	1	0	88

Year	Age								All
	1	2	3	4	5	6	7	8+	
2012	2	52	46	21	28	2	0	1	151
2013	0	91	61	77	25	8	3	2	267
2014	0	41	74	46	27	6	1	0	196
2015	2	42	79	68	30	7	2	0	229
2016	1	59	92	34	47	9	1	1	243
2017	0	8	81	57	51	18	1	1	217
2018	0	14	50	59	44	31	10	2	210
2019	0	29	41	60	60	20	7	0	217
2020	1	7	60	24	31	32	5	5	165

Table 15.2.6, *continued* : NAFO division 1F, 1B (Kangatsiaq) and 1C Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the West Greenland inshore gill-net survey. Na = Data not available.

Year	Age NAFO 1F								All
	1	2	3	4	5	6	7	8+	
1985	204	8	1	1	1	1	1	0	217
1986	17	112	5	0	2	0	0	0	136
1987	0	143	147	1	0	0	0	0	291
1988	0	1	83	6	0	0	0	0	89
1989	0	5	2	19	2	0	0	0	29
1990	0	0	3	2	13	1	0	0	18
1991	2	2	0	2	0	1	0	0	7
1992	0	3	1	0	1	0	1	0	6
1993	0	5	2	1	0	0	0	0	8
1994	0	0	1	1	0	0	0	0	3
1995	0	0	0	0	0	0	0	0	0
1996	na	na	na	na	Na	na	na	na	na
1997	na	na	na	na	Na	na	na	na	na
1998	0	4	12	0	0	0	0	0	17
1999	na	na	na	na	Na	na	na	na	na
2000	0	14	8	0	2	0	1	0	24
2001	na	na	na	na	Na	na	na	na	na
2002	na	na	na	na	Na	na	na	na	na
2003	na	na	na	na	Na	na	na	na	na
2004	na	na	na	na	Na	na	na	na	na
2005	na	na	na	na	Na	na	na	na	na

Year	Age NAFO 1F								All
	1	2	3	4	5	6	7	8+	
2006	na	na	na	na	Na	na	na	na	na
2007	6	90	9	21	1	0	0	0	108
2008	8	17	30	4	2	0	0	0	62
2009	3	39	14	15	0	0	0	0	71
2010–2020	na	na	na	na	na	na	na	na	na

Year	Age NAFO 1B (Kangatsiaq)								All
	1	2	3	4	5	6	7	8+	
2017	1	2	40	8	13	6	5	1	75
2018	na	na	na	na	na	na	na	na	Na
2019	0	26	14	6	5	1	0	0	52

Year	Age NAFO 1C								All
	1	2	3	4	5	6	7	8+	
2017	1	9	94	40	35	18	12	1	210
2018	0	13	19	47	19	11	10	3	122
2019	0	20	34	14	40	4	2	2	116
2020	1	6	56	33	30	18	2	1	147

Table 15.2.7: Cod abundance indices (numbers of cod caught per 100 hours net settings) by age in the Greenland Halibut gill net survey in Disco Bay. Na = Data not available.

Year/age	1	2	3	4	5	6	7	8	9	10+	Total
2005	0	0.07	0.35	0.51	0.51	0.04	0.04	0	0	0	1.52
2006	0	0.21	0.12	0.02	0	0.07	0.04	0	0	0	0.46
2007	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2008	0	0.01	0.01	0.63	3.38	1.80	0.46	0	0	0	6.29
2009	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
2010	0	0	0.01	0.98	2.71	1.81	0.13	0	0	0	5.64
2011	0	0.48	0.17	1.26	0.93	2.94	1.38	0.10	0	0	7.26
2012	0	0.01	2.09	2.75	1.65	1.09	0.24	0.16	0	0	7.99
2013	0	0	3.45	43.43	38.21	13.59	2.58	1.06	0.41	0	102.73
2014	0	0	0.37	23.92	46.16	20.56	0.78	0.08	0.26	0.23	92.36
2015	0	0	1.18	8.13	53.86	31.50	6.05	1.70	0	0.40	102.82
2016	0	0	0.6	11	29	59	17	1	0.4	0.1	119
2016 cod st.	0	0	0	5	9	12	4	0.1	0	0	30
2017	0	0	3	4	11	13	17	2	0	0	50
2018		0.2	1	3	3	7	6	8	1	0.3	28
2019			3	3	10	10	31	20	6	0.3	83
2020			0.5	2.6	0.5	2.5	2.1	2.7	2.6	0.7	14.2

Table 15.2.8: Cod abundance indices ('000) by age and total in Disco Bay (NAFO 1AX) in the Greenland Shrimp and Fish bottom trawl survey.

Year/age	0	1	2	3	4	5	6	7	8	9	10+	All
2005	0	52	0	0	90	0	0	0	0	0	0	142
2006	0	0	117	1	1	0	0	0	0	0	0	119
2007	0	20	142	98	0	0	0	0	0	0	0	261
2008	0	38	21	25	24	0	0	0	0	0	0	108
2009	0	0	14	1	16	11	0	0	0	0	0	41
2010	0	0	7	0	9	0	0	0	0	0	0	16
2011	0	400	2907	324	47	26	5	0	0	0	0	3710
2012	0	0	1967	661	31	0	0	0	0	0	0	2659
2013	0	137	1420	1656	479	111	14	0	0	0	0	3817
2014	0	14	159	119	79	25	8	0	13	0	10	428
2015	0	93	411	1271	502	429	197	27	4	0	0	2935
2016	0	24	177	76	38	95	56	40	0	0	0	506
2017	0	19	42	386	84	50	21	64	15	0	0	681
2018	24	29	204	99	121	26	30	44	31	0	0	607
2019	0	0	103	341	139	71	0	22	18	1	0	693
2020	0	0	20	80	110	0	16	0	0	10	0	236

Table 15.3.1. Number of tagged cod in the period of 2003 to 2019 in different regions. Bank (West) = NAFO Division 1D+1E. East Greenland = NAFO Division 1F + ICES Division 14.b.

Year	Fjord	Bank (West) NAFO 1C Tovqussaq	TAGGED Bank (West) NAFO 1D + 1E Dana	East Greenland
2003	599			
2004	658			
2005	565			
2006	41			
2007	1137		1061	1047
2008	231			1296
2009	633			526
2010	88			
2011	28			403
2012	86		1563	2359
2013	186		2321	
2014				1203
2015	57			1220
2016		299	998	1912
2017	350	1871	706	
2018		115		
2019	1040	325		
2020				458

Table 15.3.2: Number of recaptured cod in the period of 2003 to 2019 in different regions. Fjord (West) = NAFO divisions 1B–1F. Bank (West) = NAFO Division 1D+1E. East Greenland = NAFO division 1F + ICES Division 14.

	Recaptures			
	Fjord (West)	Bank (West) NAFO 1C Tovqussaq	Bank (West) NAFO 1D + 1E Dana	East Greenland
Fjord (West)	547	3	29	8
Bank (West) NAFO 1C, Tovqussaq		1		4
Bank (West) NAFO 1D+1E, Dana		2	69	
East Greenland			35	118
Iceland	3		45	192

Table 15.5.1: Reference points

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	5983 t	Assumed at B_{pa}	ICES (2018a)
	F_{MSY}	0.27	Stochastic simulations with segmented regression and a Beverton–Holt stock–recruitment curve from 1973 to 2018.	ICES (2018a)
Precautionary approach	B_{lim}	4346 t	Breakpoint in segmented regression	ICES (2018a)
	B_{pa}	5983 t	$B_{lim} \times e^{1.645\sigma}$, $\sigma = 0.194$	ICES (2018a)
	F_{lim}	-	Not defined	
	F_{pa}	-	Not defined	
Management plan	SSB_{mgt}	-	-	
	F_{mgt}	-	-	

Table 15.7.1: Estimated number at age in the stock

Year / Age	1	2	3	4	5	6	7	8	9	10
1976	14624	12644	62173	3692	1944	422	65	277	63	29
1977	21448	11416	10352	47991	2256	966	149	19	179	55
1978	39060	17093	8911	7874	31382	1012	359	39	10	116
1979	17196	38166	13622	7466	4781	15660	495	143	20	63
1980	35916	11597	37291	10778	4449	2056	7172	218	68	45
1981	15819	35695	7821	30757	5578	1968	859	2421	108	50
1982	8177	12696	35476	5686	15441	1848	842	269	843	73
1983	3073	6965	10189	30739	2579	5878	511	253	106	247
1984	8103	1974	5934	8173	14908	871	1879	112	110	108
1985	34624	6247	1268	4358	3463	5719	286	619	49	97
1986	24423	35476	4816	962	1627	1350	2138	88	289	58
1987	12688	20773	36350	3308	435	496	472	873	44	130
1988	16891	9930	18940	30750	1117	158	90	171	393	43
1989	8490	15613	8065	16439	14731	398	47	22	83	134
1990	4479	7889	12934	7016	8724	4183	87	15	11	53
1991	12947	2967	6767	9823	3226	2082	436	29	7	19

Year / Age	1	2	3	4	5	6	7	8	9	10
1992	4630	9732	2410	4827	3363	515	242	85	13	8
1993	2212	3656	6704	1944	1357	323	67	68	24	7
1994	2746	1608	2995	4511	697	100	50	19	26	8
1995	1837	2212	1185	2375	1579	91	20	13	8	13
1996	2487	1288	1495	970	1044	242	30	7	5	9
1997	3273	2043	860	1108	471	240	90	11	3	7
1998	3046	2429	1678	685	480	73	112	38	6	5
1999	4438	2308	1781	1330	291	33	39	51	20	5
2000	6318	3644	1749	1248	616	38	20	18	29	12
2001	7752	5269	3308	1679	623	104	23	10	11	21
2002	9750	6327	4394	2932	996	130	55	11	6	16
2003	10049	6950	4598	3104	1380	252	60	28	8	11
2004	23537	8610	5022	3340	1369	299	98	23	17	7
2005	36788	19148	7087	3436	1273	259	107	40	13	10
2006	26635	29758	15717	5344	1149	201	89	43	23	10
2007	14870	22533	22779	10835	1696	206	82	33	25	15
2008	21829	10882	18614	16616	3907	315	73	35	16	20
2009	21261	18784	9118	14076	7043	699	97	31	21	18
2010	38708	16044	15523	7300	6852	1580	232	50	20	21
2011	34175	34528	11395	11523	4286	1824	419	101	26	17
2012	24212	27262	28954	9760	6750	1411	490	163	44	18
2013	18524	22138	21277	22102	7017	2678	427	199	84	22
2014	19049	15806	18430	16978	13339	3406	898	145	81	38
2015	14871	16639	13855	17561	13358	6401	1433	330	43	31
2016	9627	14425	15259	13393	14367	7353	2444	535	124	24
2017	9962	7670	14197	13749	11181	7742	3123	834	208	57
2018	11666	9303	7646	13575	10203	6019	3073	1008	271	92
2019	9600	11724	9359	7755	11100	5349	2379	951	288	113
2020	11829	7474	11259	8258	5933	5565	1900	748	264	129

Table 15.7.2: Estimated fishing mortality-at-age in the stock

Year Age	1	2	3	4	5	6	7	8	9	10
1976			0.037	0.280	0.529	0.813	1.030	0.324	0.417	0.417
1977			0.035	0.273	0.566	0.750	1.036	0.390	0.510	0.510
1978			0.032	0.303	0.567	0.603	0.790	0.446	0.493	0.493
1979			0.034	0.361	0.632	0.630	0.749	0.541	0.494	0.494
1980			0.039	0.435	0.681	0.676	0.880	0.608	0.618	0.618
1981			0.035	0.496	0.816	0.742	0.960	0.751	0.708	0.708
1982			0.038	0.540	0.795	0.956	1.047	0.717	0.972	0.972
1983			0.035	0.586	0.831	0.941	1.178	0.651	0.872	0.872
1984			0.034	0.649	0.798	0.895	0.967	0.587	0.692	0.692
1985			0.027	0.690	0.789	0.856	0.930	0.577	0.751	0.751
1986			0.030	0.636	0.892	0.951	0.813	0.545	0.854	0.854
1987			0.028	0.693	0.863	1.333	0.888	0.597	1.109	1.109
1988			0.019	0.629	0.898	1.141	1.048	0.558	1.024	1.024
1989			0.012	0.600	1.119	1.347	0.983	0.518	1.159	1.159
1990			0.011	0.667	1.313	1.797	0.970	0.601	1.012	1.012
1991			0.010	0.825	1.658	1.963	1.145	0.647	0.966	0.966
1992			0.007	0.906	2.095	1.813	1.086	0.760	0.953	0.953
1993			0.006	0.802	2.320	1.628	1.070	0.747	0.920	0.920
1994			0.005	0.757	1.859	1.351	1.058	0.704	0.690	0.690
1995			0.004	0.637	1.665	0.951	0.870	0.672	0.614	0.614
1996			0.004	0.554	1.408	0.763	0.796	0.586	0.548	0.548
1997			0.005	0.579	1.685	0.588	0.684	0.506	0.540	0.540
1998			0.008	0.572	2.266	0.440	0.618	0.437	0.534	0.534
1999			0.012	0.537	1.833	0.334	0.576	0.380	0.528	0.528
2000			0.014	0.499	1.572	0.365	0.548	0.337	0.529	0.529
2001			0.024	0.497	1.373	0.440	0.533	0.303	0.549	0.549
2002			0.040	0.577	1.212	0.529	0.542	0.276	0.605	0.605
2003			0.052	0.629	1.365	0.697	0.678	0.314	0.730	0.730
2004			0.072	0.765	1.469	0.778	0.686	0.312	0.662	0.662

Year Age	1	2	3	4	5	6	7	8	9	10
2005			0.088	0.881	1.568	0.791	0.691	0.335	0.597	0.597
2006			0.091	0.864	1.520	0.711	0.714	0.356	0.555	0.555
2007			0.073	0.774	1.519	0.828	0.665	0.376	0.499	0.499
2008			0.055	0.584	1.467	0.945	0.625	0.348	0.475	0.475
2009			0.040	0.440	1.242	0.958	0.560	0.360	0.527	0.527
2010			0.026	0.336	1.064	1.124	0.642	0.467	0.700	0.700
2011			0.018	0.289	0.892	1.124	0.715	0.560	0.726	0.726
2012			0.013	0.235	0.726	0.998	0.739	0.554	0.803	0.803
2013			0.009	0.201	0.593	0.866	0.829	0.703	0.883	0.883
2014			0.006	0.166	0.549	0.784	0.812	0.879	1.050	1.050
2015			0.004	0.154	0.508	0.758	0.841	0.813	0.867	0.867
2016			0.004	0.153	0.509	0.744	0.882	0.815	0.811	0.811
2017			0.004	0.153	0.504	0.755	0.949	0.923	0.896	0.896
2018			0.004	0.165	0.514	0.779	0.975	1.033	0.949	0.949
2019			0.005	0.179	0.540	0.825	0.974	1.074	0.924	0.924
2020			0.006	0.187	0.576	0.863	0.963	1.092	0.904	0.904

Table 15.7.3: Cod in NAFO Subarea 1, inshore. Catch scenarios for 2022 assuming $F_{2020} = F_{2021}$. All weights are in tonnes.

Rationale	Catch (2022)	F (2022)	SSB (2023)	% SSB change *	% advice change **	% TAC change ***
ICES advice basis						
MSY approach: F_{MSY}	4780	0.268	23880	+18%	-10%	-75%
Other scenarios						
F = 0	0	0	29570	+46%	-100%	-100%
$F = F_{2020}$ (*status quo*)	10141	0.736	17907	-11%	+92%	-52%
$SSB_{2022} = B_{lim}$	24387	11.7	4261	-79%	+410%	+16%
$SSB_{2022} = B_{pa}$= MSY $B_{trigger}$	22191	5.6	6024	-70%	+364%	+6%

*** SSB2023 relative to SSB2022.**
**** Advice value for 2022 relative to the advice value for 2021, from this updated assessment.**
***** Advice value for 2022 relative to the TAC in 2021, from this updated assessment.**

15.20 Figures

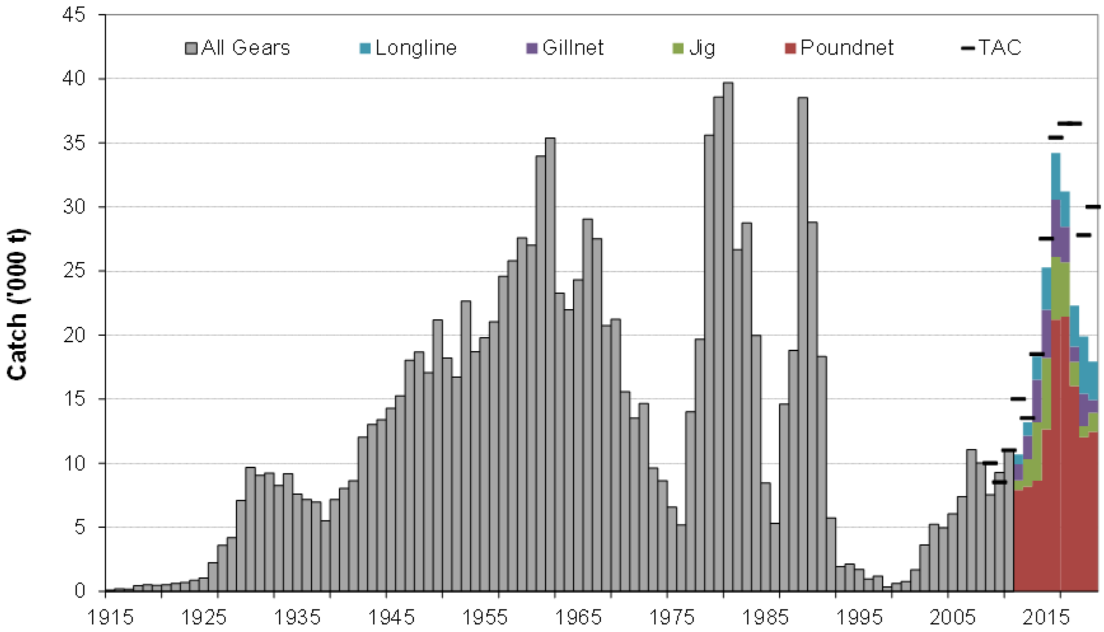


Figure 15.2.1 Inshore landings from West Greenland (Horsted, 1994; 2000). From 2012 divided into gears.

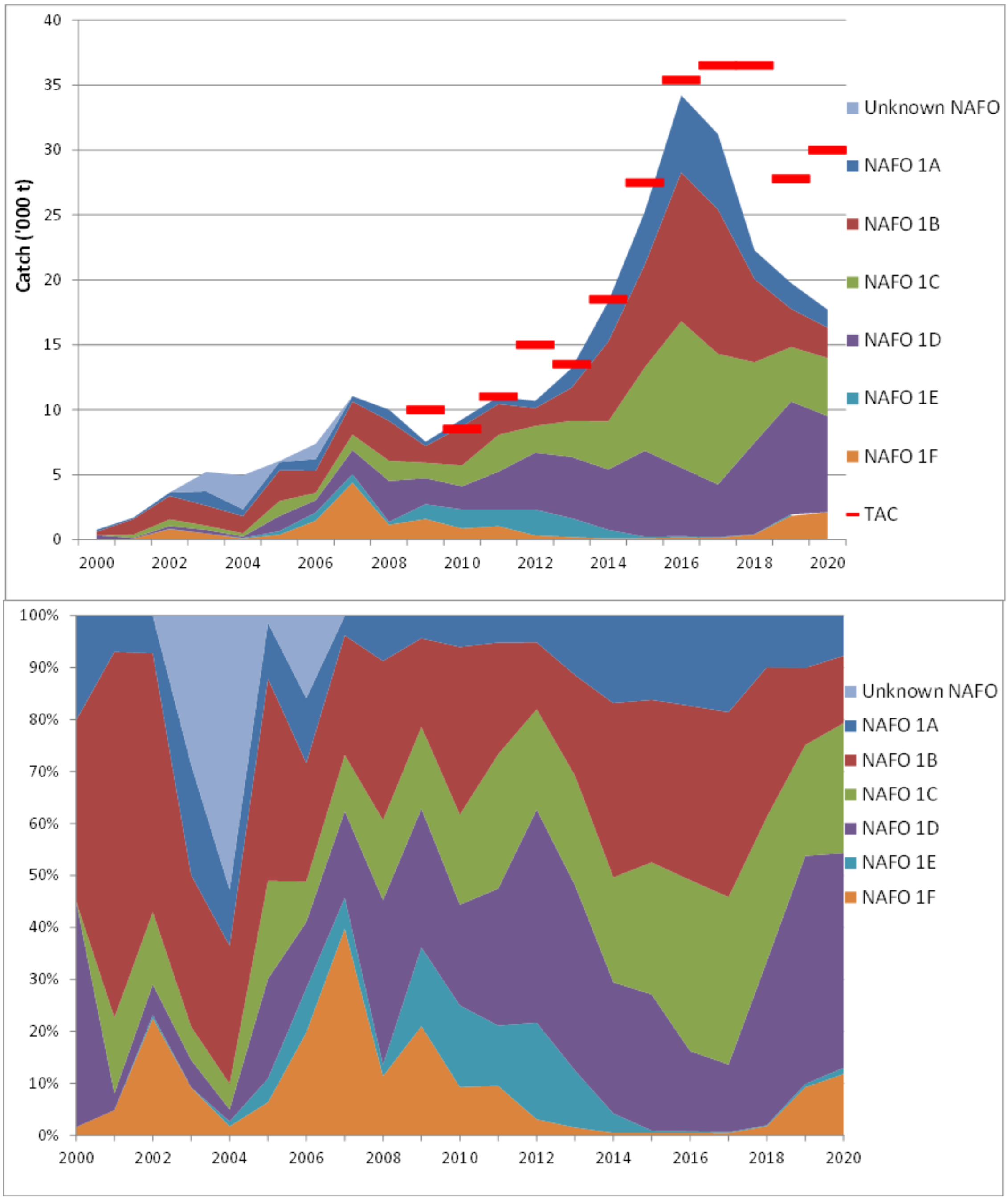


Figure 15.2.2. Total (top) and percentage (bottom) cod catches and TAC in the inshore fishery by NAFO divisions from 2000.

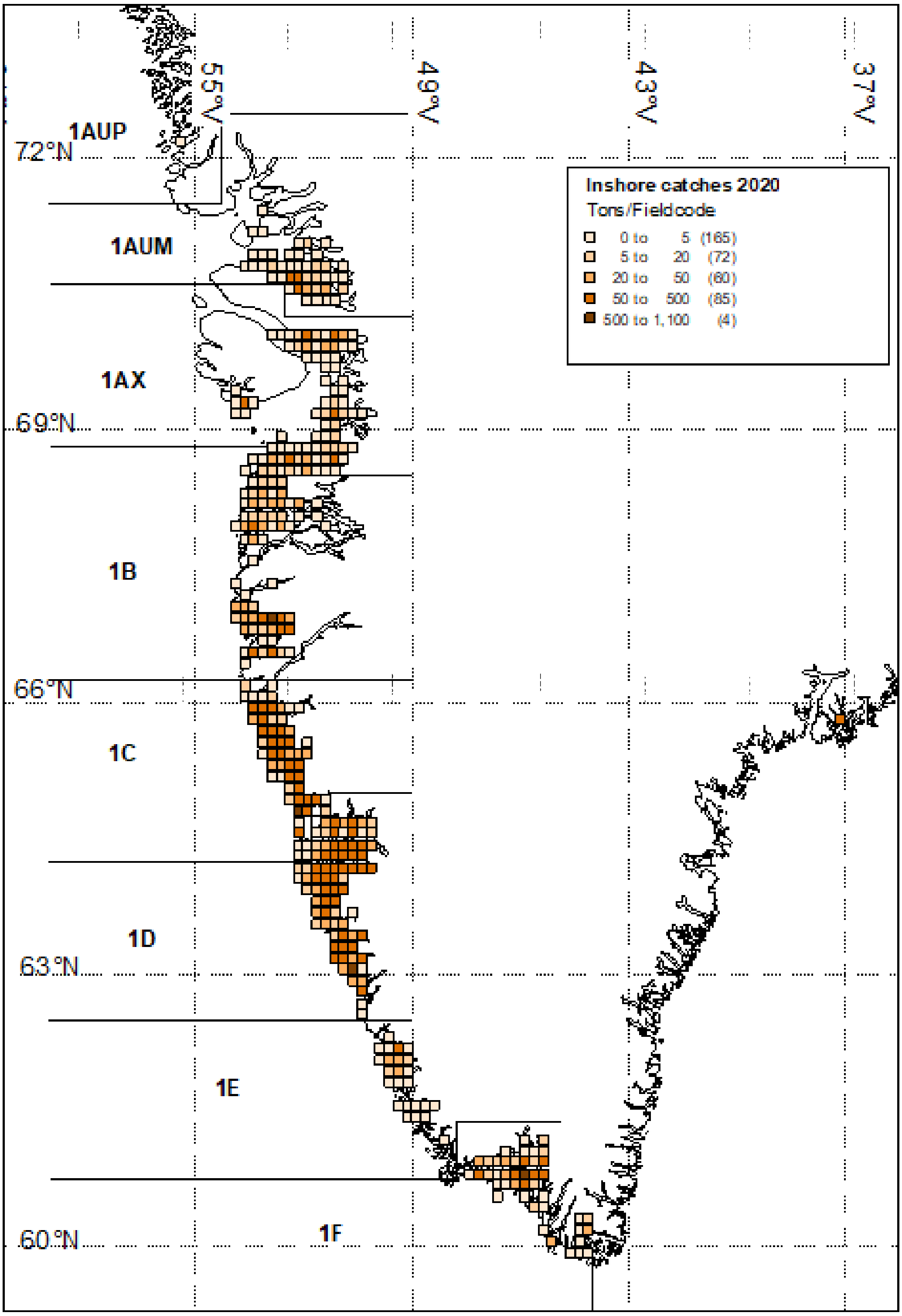


Figure 15.2.3. Distribution of commercial fishery along the coastline of West Greenland in total tonnes by field code.

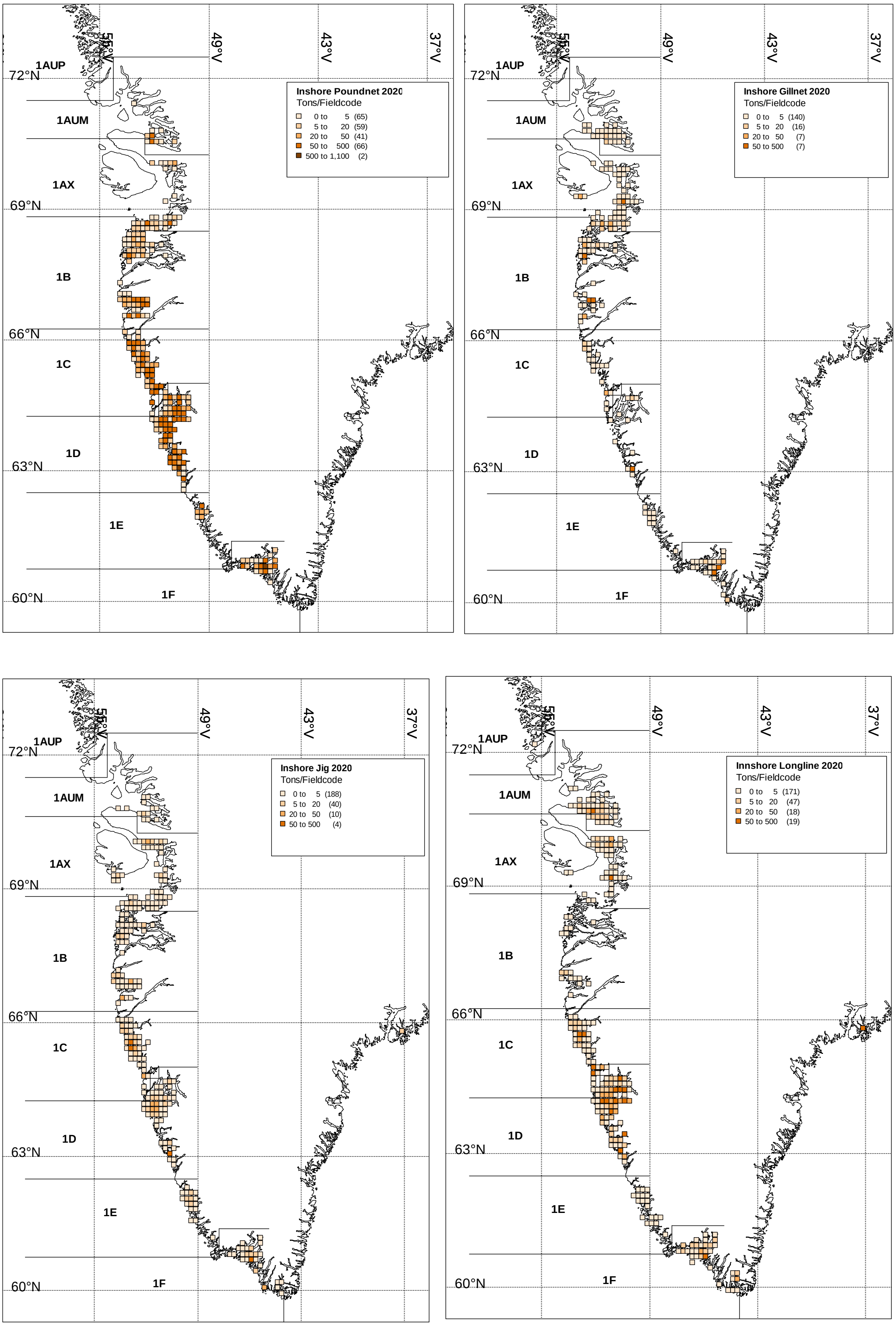


Figure 15.2.4 Distribution of the inshore commercial fishery by gear (tonnes/fieldcode).

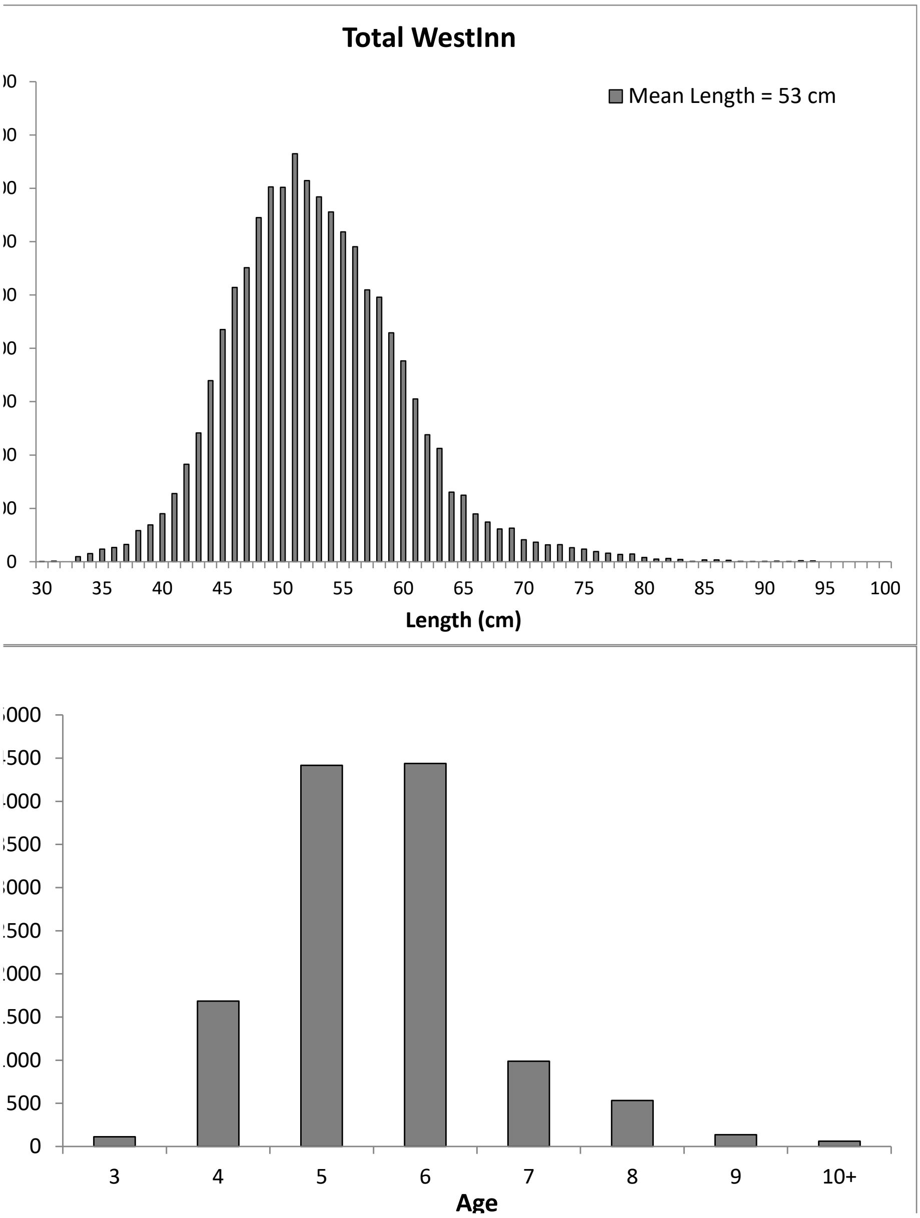


Figure 15.2.5. Total length and age distributions of inshore cod catches.

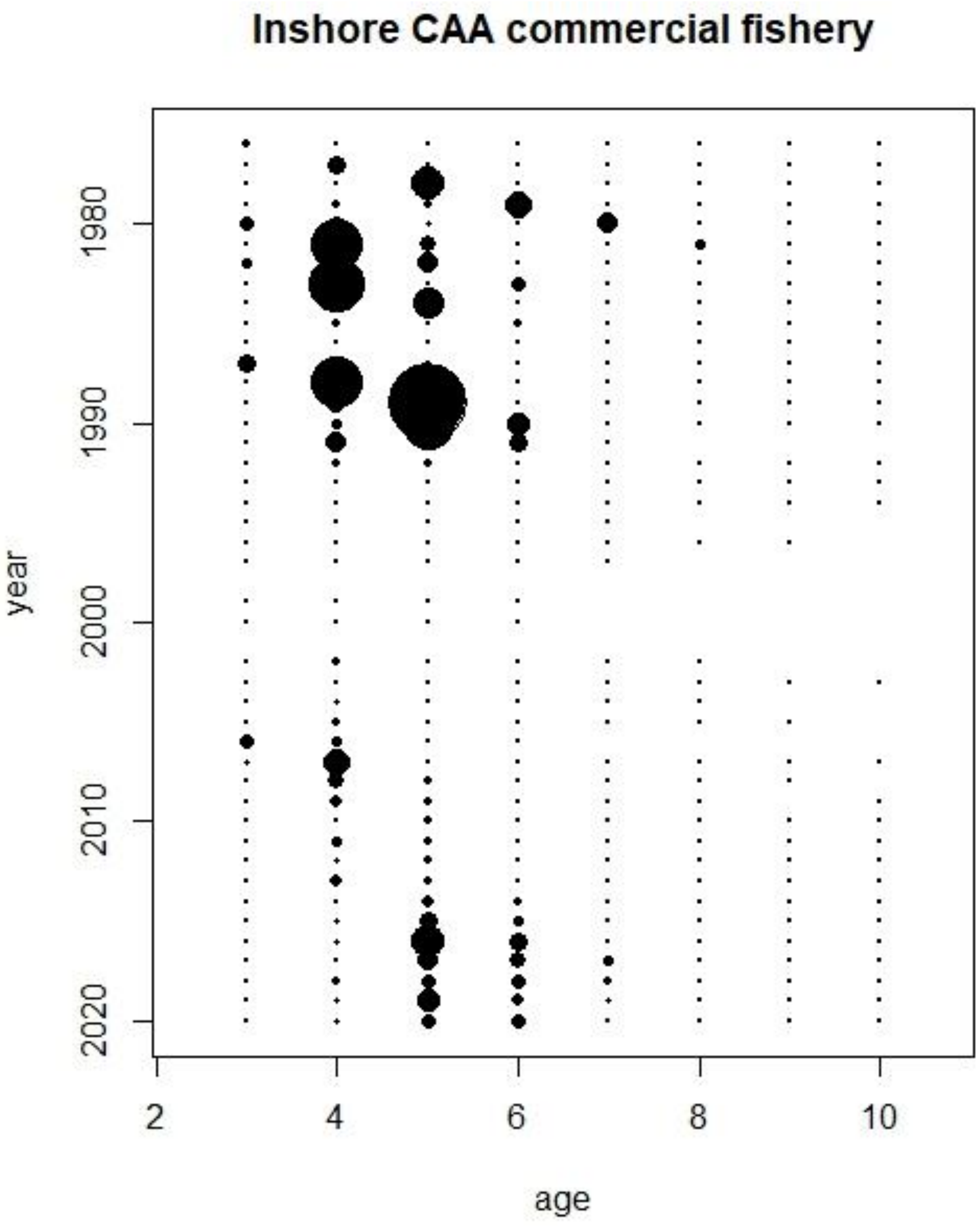


Figure 15.2.6. Catch at age in the commercial fishery in the West Greenland inshore area. Size of circles represents size of catch numbers.

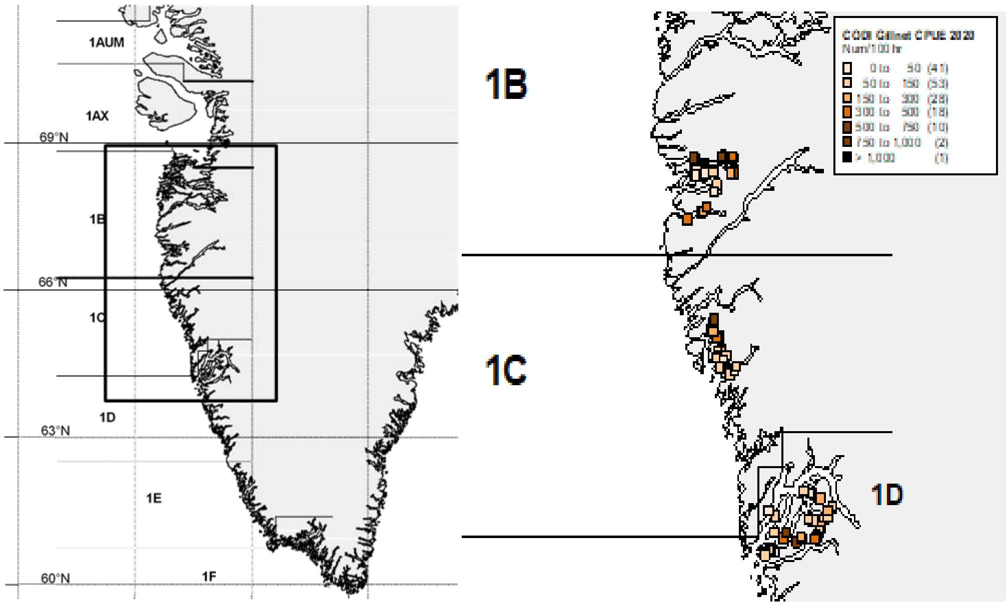


Figure 15.2.7. The inshore gill net survey area on the Greenland West coast. Survey catch rates are indicated on both as #caught/100h.

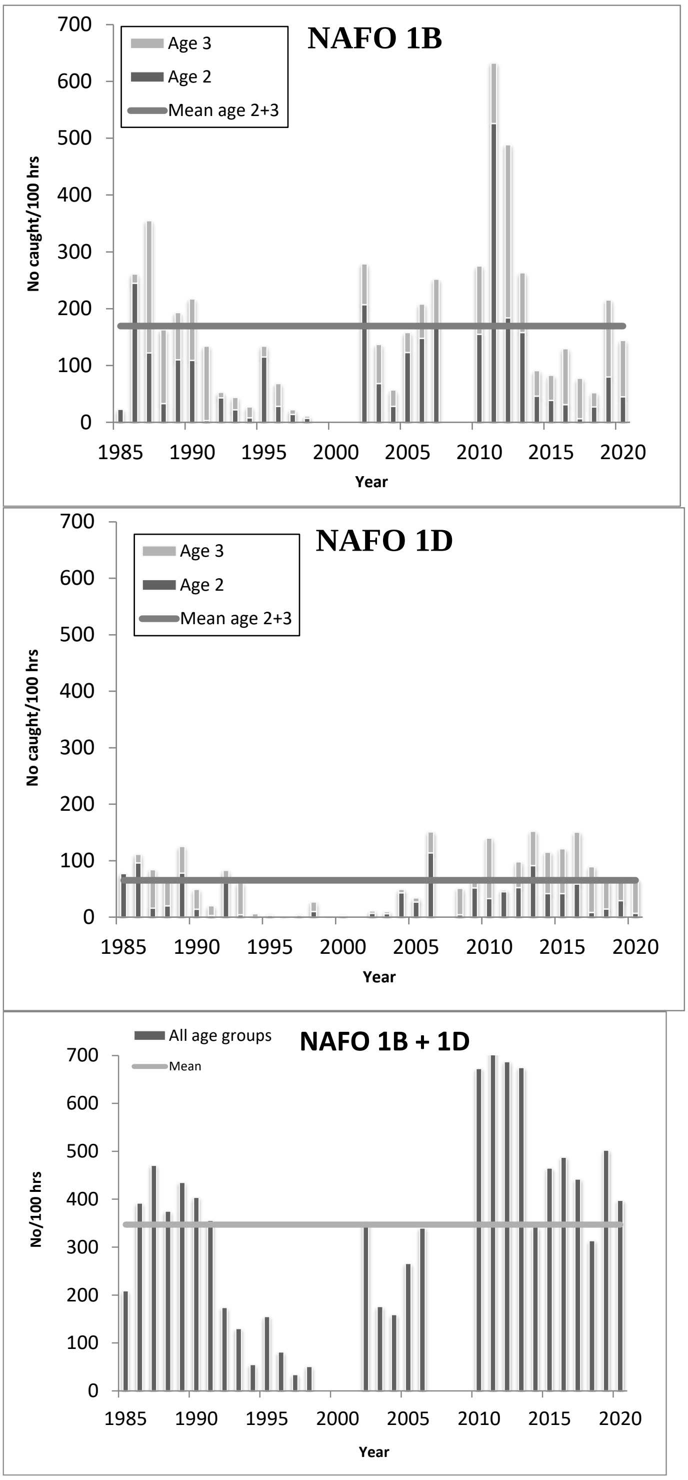


Figure 15.2.8: Recruitment indices (numbers caught/100 hr.) for ages 2 and 3 in 1B (top), 1D (middle) and all age groups (ages 1-8) 1B and 1D combined (lower) in West Greenland. Simultaneous surveys were not carried out 1999–2001 and 2007–2009.

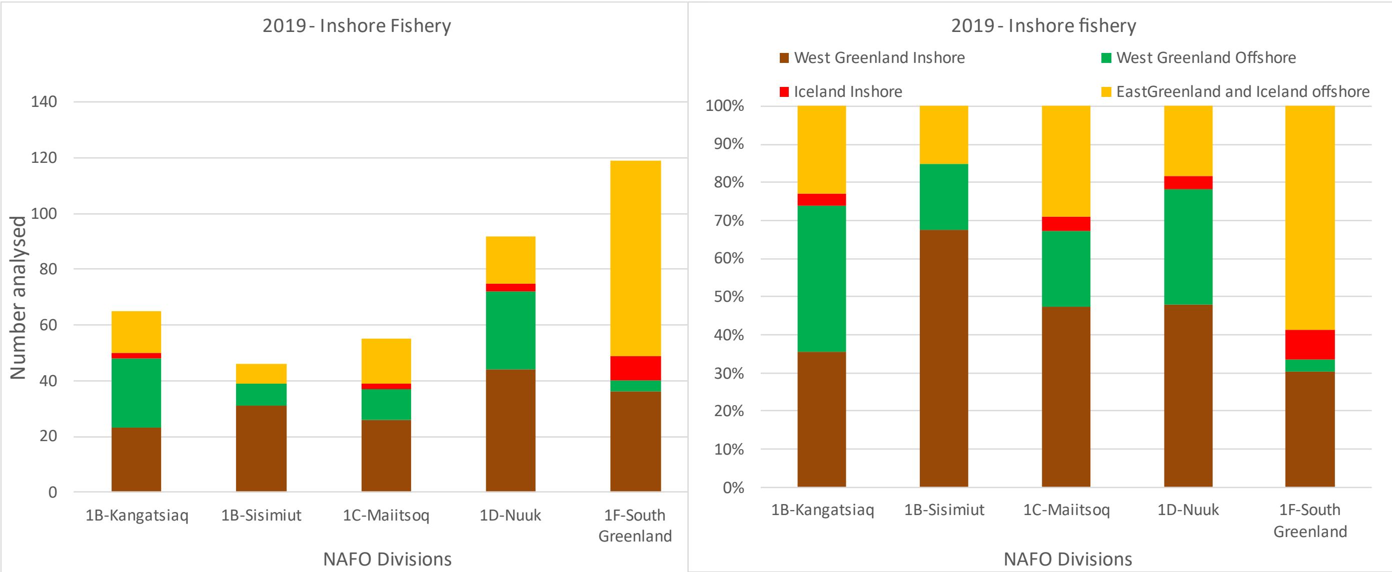


Figure 15.2.9: Genetic composition in the inshore fishery in 2019 by NAFO divisions. Left: Samples analysed, right: In percentage.

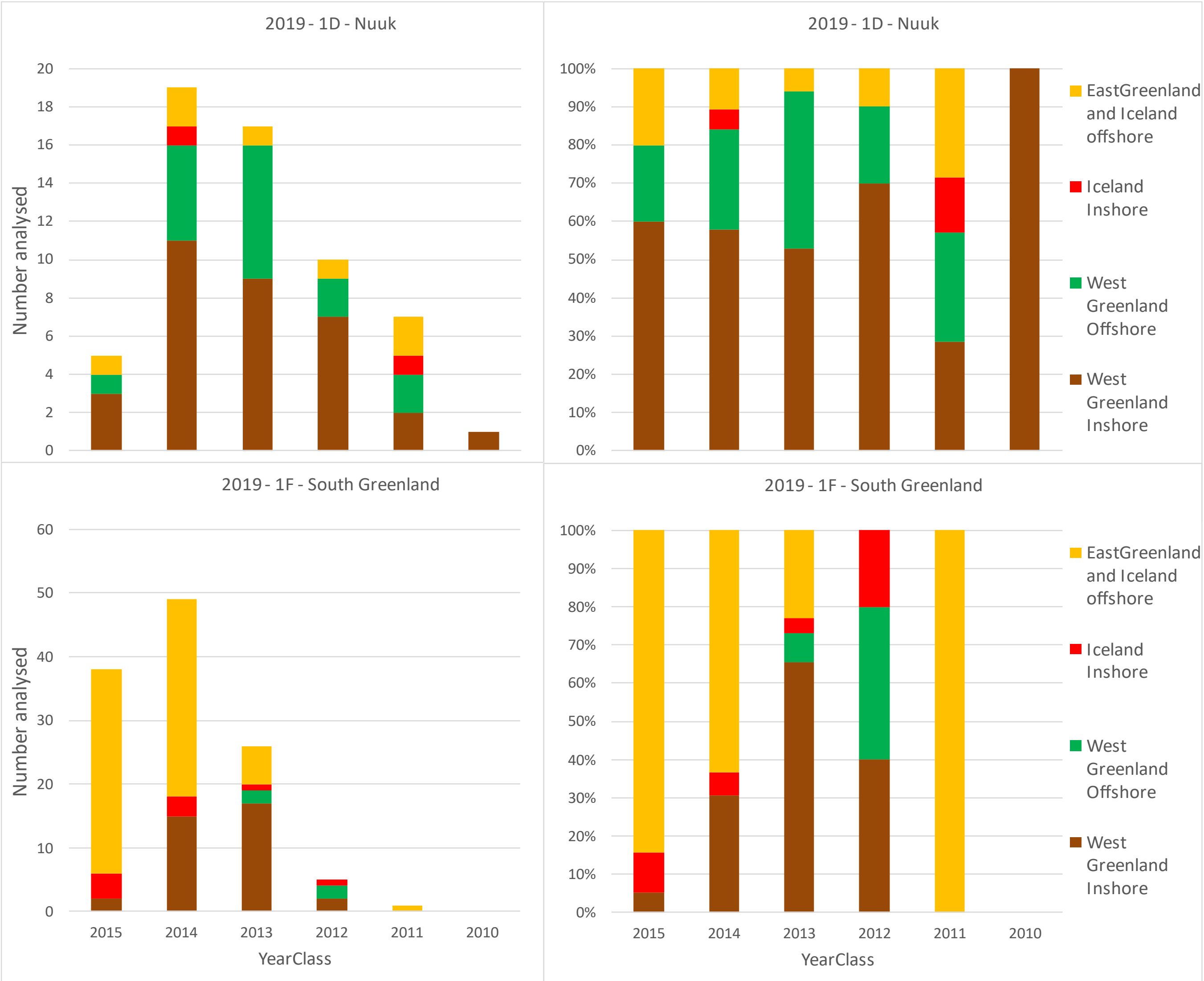


Figure 15.2.10: Genetic composition in the inshore fishery in 2019 by Yearclasses within NAFO division 1D and 1F. Left: Samples analysed, Right: in percentage.

Figure 15.2.11: Genetic composition in the inshore surveys by fjord systems. Left: Samples analysed, right: In percentage.

Figure 15.2.12: Genetic composition in the inshore surveys by yearclass and fjord systems. Left: Samples analysed, right: In percentage.

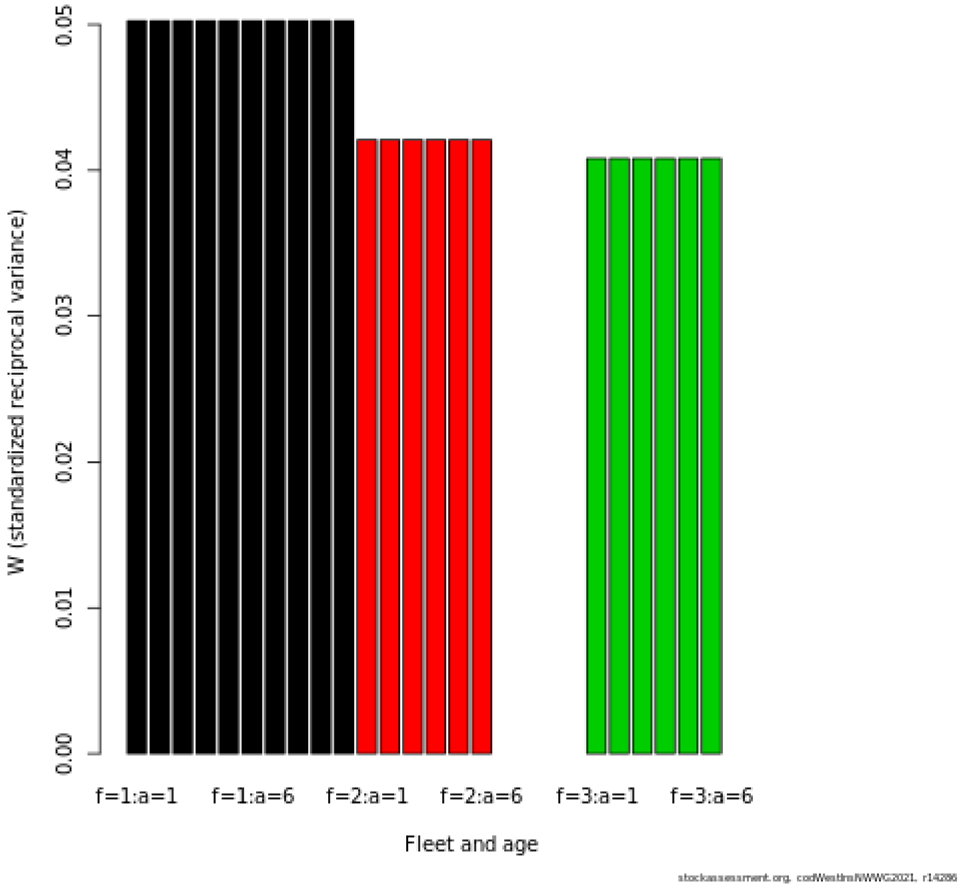


Figure 15.6.1: Standardized reciprocal variance from left to right: catches, 1B survey and 1D survey.

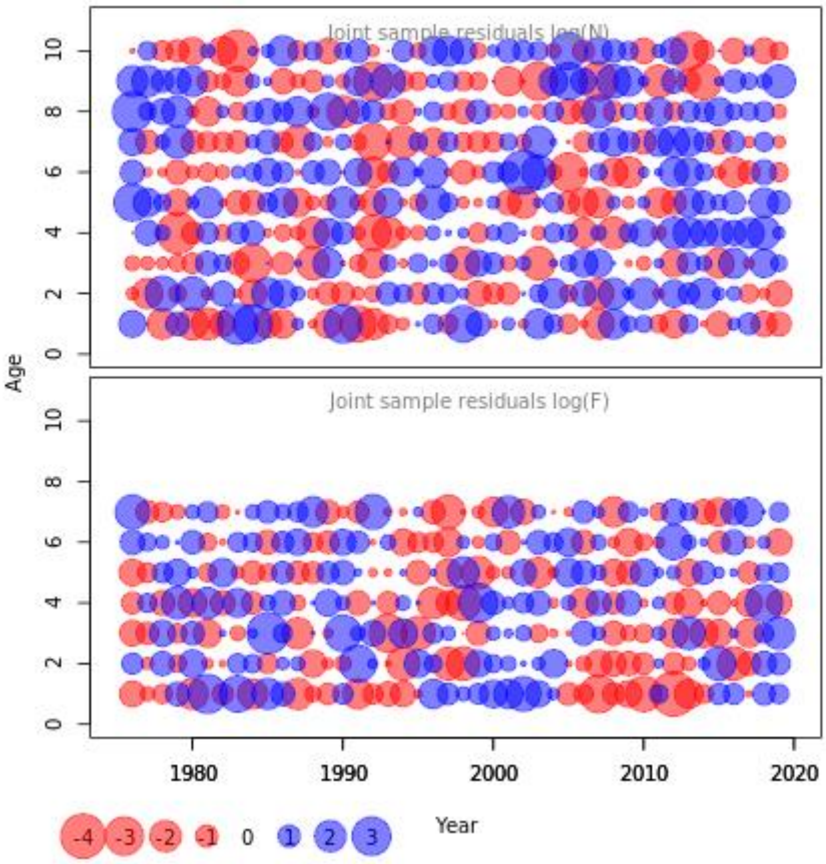


Figure 15.9.1: Normalized residuals derived from the SAM base run. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

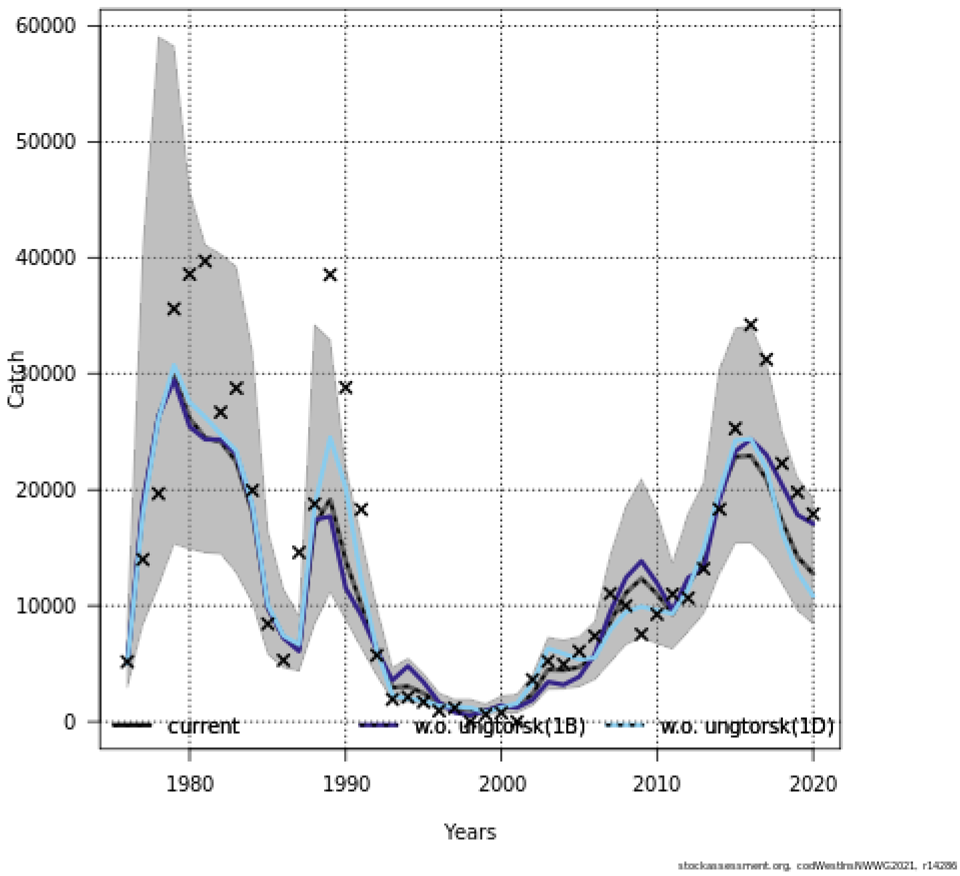


Figure 15.9.2: Estimated (line) and observed catch (x). Estimated catch is shown with 95% confidence intervals.

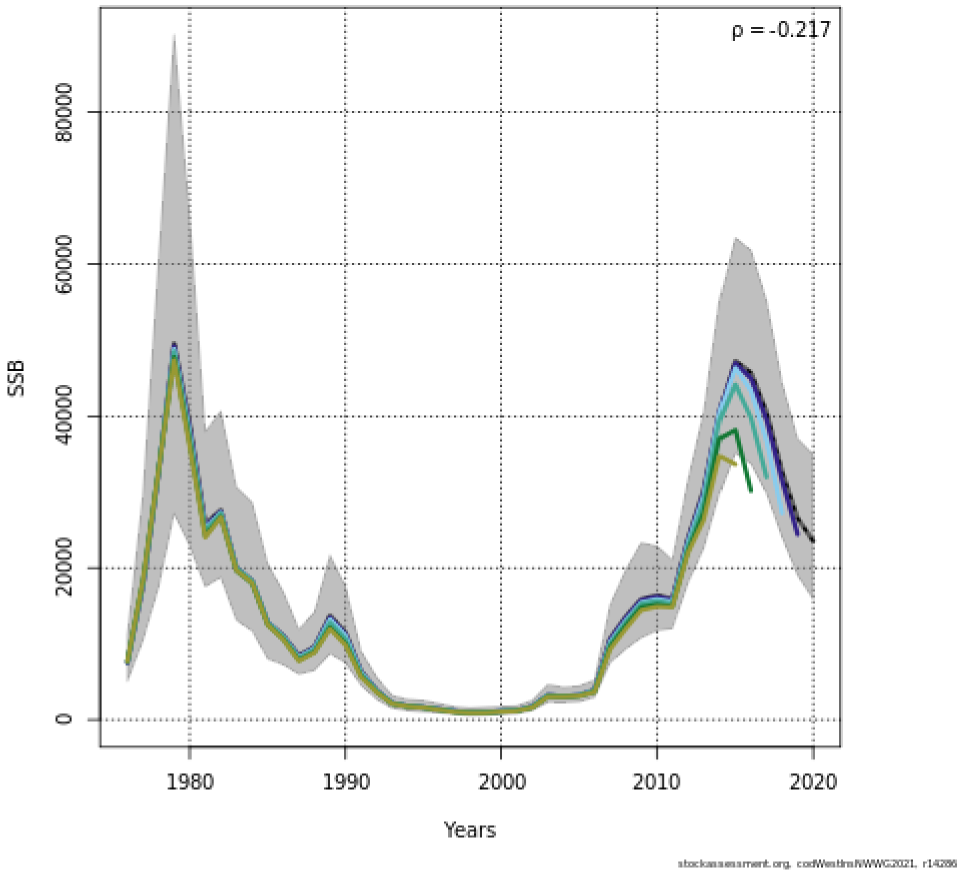


Figure 15.9.3: Analytical retrospective plots of spawning stock biomass. Mohn's rho is given in the upper right corner.

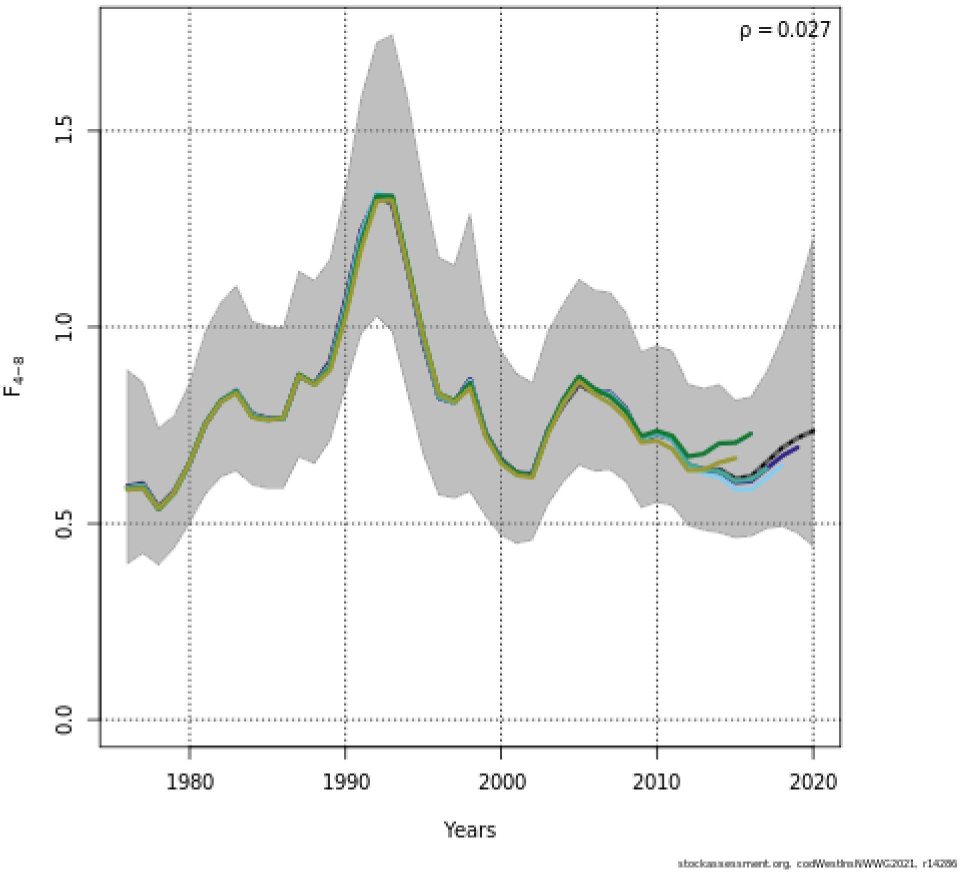


Figure 15.9.4: Analytical retrospective plots of $F_{4\text{-}8s}$. Mohn's rho is given in the upper right corner.

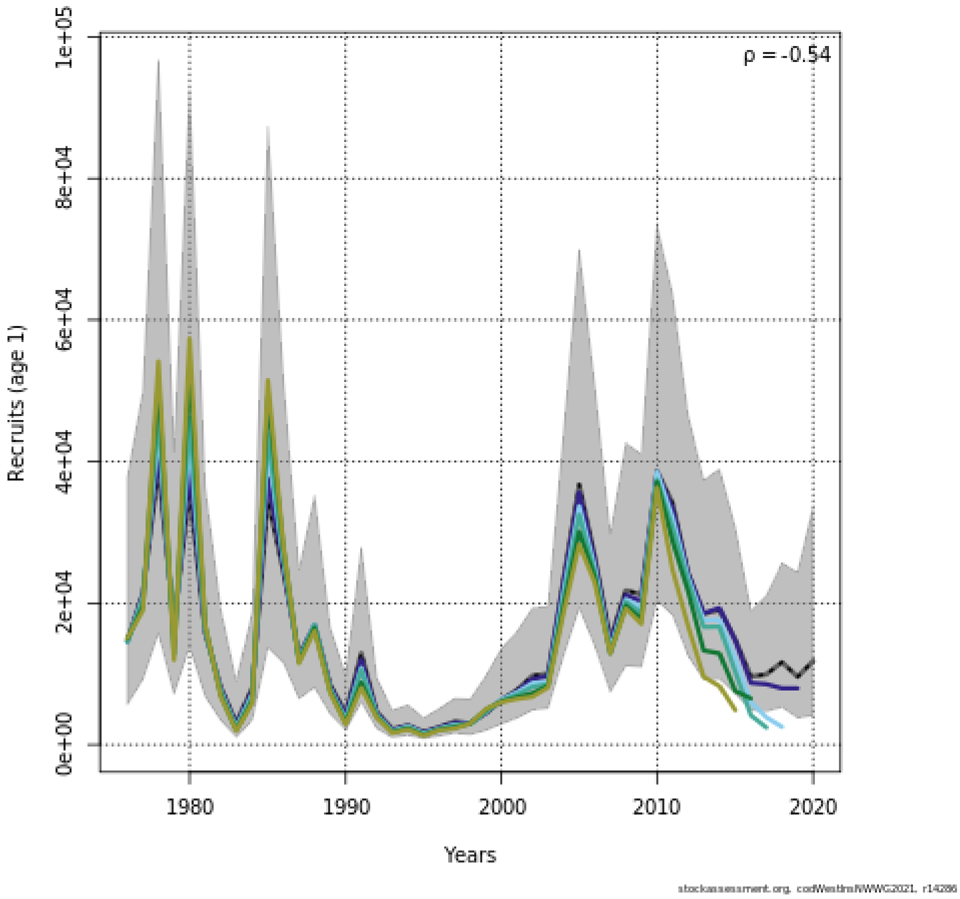
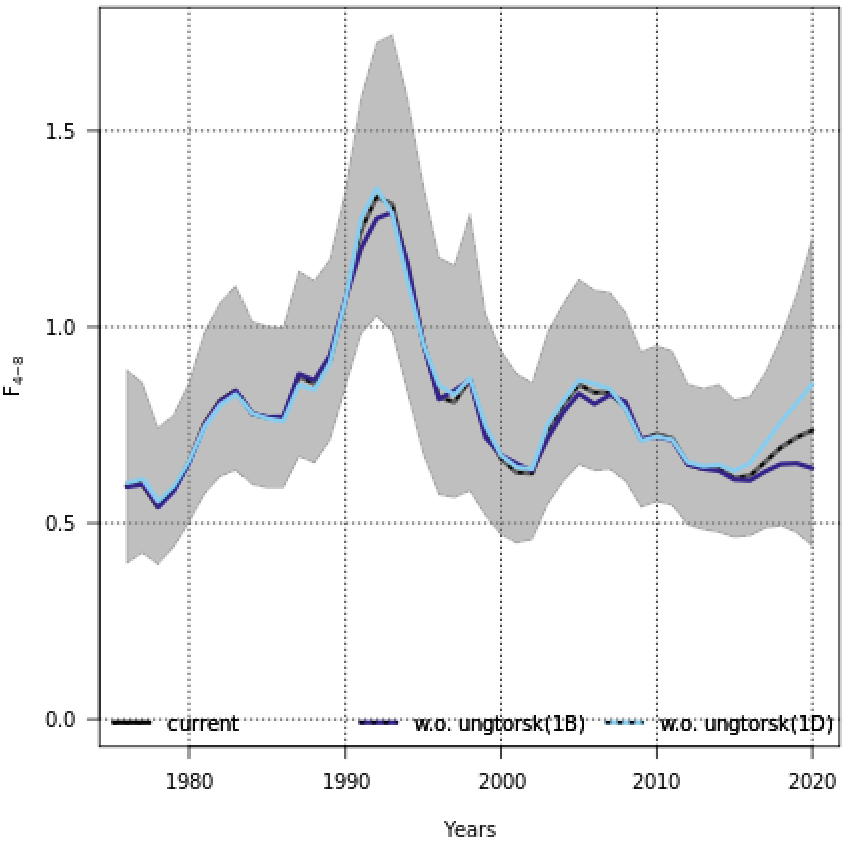


Figure 15.9.5: Analytical retrospective plots of Recruiet. Mohn's rho is given in the upper right corner.



stockassessment.org, codWestIrmNWWG2021, r14286

Figure 15.9.6: Leave out plot of F_{4-8}.

16 Cod (*Gadus morhua*) in ICES Subarea 14 and NAFO Division 1.F (East Greenland, South Greenland)

Please note, that an Interbenchmark process for cod in ICES Subarea 14 and NAFO Division 1F (East Greenland, Southwest Greenland) took place in August 2021 which changed the assessment originally presented to NWWG in April 2021 and updated the biological reference points for the stock (IBPGCOD2; ICES, 2021). Therefore, Sections 16.5–16.10 in the current report are outdated. For more information on the alterations and outcome of the assessment, see Section 16.17 and the IBPGCOD2 report (ICES, 2021).

16.1 Stock definition

The cod found in Greenland is derived from four separate "stocks" that each is labelled by their spawning areas: I) offshore West Greenland waters; II) West Greenland inshore fiords; III) East Greenland and offshore Icelandic waters and IV) inshore Icelandic waters (Therkildsen *et al*., 2013), (Figure 16.1).

From 2012 the inshore component (West Greenland, NAFO Subarea 1) was assessed separately from all offshore components. From 2016 the offshore West Greenland (NAFO subdivisions 1A–E) and East Greenland (NAFO Subdivision 1F and ICES Subarea 14) components was assessed separately. The Stock Annex provides more details on the stock identities including the references to primary works.

16.2 Scientific data

Historical trends in landings and fisheries

The Greenland commercial cod fishery in East Greenland started in 1954 but started earlier in Southwest Greenland (NAFO Subdivision 1F, Table 16.2.1, Figure 16.2.1). The fishery gradually developed culminating with catch levels above 40 000 tonnes annually in the 1960s. Due to overfishing, deteriorating environmental conditions and emigration to Iceland the stock size declined and the fishery completely collapsed in the early 1990s. More details on the historical development in the fisheries are provided in the stock annex.

The present fishery

TAC for 2020 was set at 18 824 t. The TAC was divided between the following countries and management areas (se section 16.12 for definition of management areas):

Management Area	TAC (tonnes)	Country
403 (Q1Q2)	9226	Greenland
404 (Q3Q4)	2524	Greenland
403+404	4800	EU (1950 t), Faeroes Island (1500 t) and Norway (1350 t)
415 (Q5Q61F)	2274	Greenland

In 2020 a total of 15 933 tons with 675 tons caught in SouthWest Greenland (NAFO 1F) and 15 258 tons caught in East Greenland (Tables 16.2.1 and 16.2.2).

Trawlers fished 72% of the total catch (Table 16.2.3, Figure 16.2.1) almost exclusively (84%) south of Dohrn Bank in a small area between 65–66°N ; 29–31°W on the edge of the continental shelf close to the EEZ to Iceland (figure 16.2.2 and 16.2.3). The longlining fishery fished exclusively in management areas 403+404 (East Greenland north of 63°N). 80% of the longline catches were taken on in management area 403 mainly on the Heimlandsridge (between63-64°N).

A detailed description of the fishery in 2020 is found in Retzel 2021a.

Catch-at-age

The 2010 and older YC's dominated the total catches (Table 16.2.4, Figure 16.2.4 and 16.2.5). Younger fish of YC 2015 (age 5) is dominating the catch in SouthWest Greenland (NAFO 1F) whereas the oldest of ages 10+ is dominating the catch on Dohrn Bank (Q1Q2, table 16.2.5). The general pattern is that large fish (> 9 year old, mean length 85 cm) dominate the catch furthest to the north on Dorhn Bank and smaller fish (ages 5 years, mean length 65 cm) dominated the catch in South Greenland (Figure 16.2.5).

Weight-at-age

Annual weight-at-age are obtained from sampling on board fishing vessels since 2005, see stock annex for further details.

Maturity-at-age

Maturity at age is fixed for 1973-2017 and is based on samples from an experimental fishery in the spawning areas in 2007 (see stock annex for further details). Since 2018 a separate ogive was estimated based on cod sampled from an experimental fishery in the same spawning area as in 2007 (GINR, 2018). The two maturity ogives were similar.

Surveys

Two offshore bottom trawl surveys (Greenlandic and German) are conducted in the offshore region of Greenland. The German survey targets mainly cod and has since 1982 covered the main cod grounds off both East and West Greenland at depths down to 400 m. The Greenland survey in West Greenland targets shrimp and cod down to 600 m. The Greenland survey is believed to provide a better coverage of the cod distribution in especially East Greenland as the survey has twice as many stations covering both shelf edge and top, whereas the stations in the German survey are usually concentrated at the shelf edge. For details of survey design see stock annex.

Greenland Shrimp and Fish survey

No survey was carried out in 2018 and 2019 as the Greenland research vessel (Paamiut) was scrapped. However West Greenland, including NAFO 1F (South West Greenland), was surveyed by a hired vessel with same gear rigging. In 2020 the survey was conducted with a chartered fishing vessel *Helga Maria.* All fishing gear were removed from *Paamiut* and installed at the chartered vessel. Fishing practice and handling of catch were exactly as used on the research ship *Paamiut* to make it as comparable as possible with previous year's survey.

In 2020 trawling was conducted both during daytime and night-time, whereas previously trawling was restricted to between 08.00 UTC and 20.00 UTC. In total 77 hauls were conducted during daytime and 65 during the night. In all area strata the number of day and night hauls were about equal. In general, no differences between day and night hauls densities were found ($p = 0.53$). In accordance, preliminary analyses of commercial logbooks showed that standardized CPUE was 5-6% higher during daytime than during the nightline, however, the difference was not significant ($p = 0.06$). The introduction of night hauls in 2020 is evaluated to have a minor effect on the estimated abundance and biomass estimates. The gain by trawling around the clock instead of only daytime, by increased strata coverage is evaluated to be larger than the possible day and night influence, which may be able to correct for in the future.

A total number of 142 valid hauls were made in 2020 (table 16.2.6, figure 16.2.6 and 16.2.7). For Atlantic cod the abundance index was estimated at 57.7 million individuals and the survey biomass at 117,000 tons, close to the average for the survey period (tables 16.2.7 and 16.2.8). The CV of the abundance and biomass estimates were 23% and 18%, respectively and below the average of the timeseries. The dominating cohort is the 2015 and to some extent 2014 YC (table 16.2.9).

A detailed description of the survey is available in Retzel 2021b.

German groundfish survey

No survey was carried out in 2018 due to mechanical problems.

In 2020, 53 valid trawl stations were sampled during the autumn in the German Greenland offshore groundfish survey (table 16.2.11). The abundance and biomass indices amounted to 15 mill. Individuals and 12 million tons respectively, and was highest in NAFO 1F (strata 4, table 16.2.12 and 16.2.13, figure 16.2.8). The 2015 yearclass (age 5) dominated the survey, followed by the 2014 yearclass (age 6, table 16.2.14). The 2015 yearclass dominated the survey in all areas (table 16.2.15). A detailed description of the survey in 2020 is found in Werner & Fock 2021.

Weight-at-age

During exploration of the survey data for the analytical assessment, it became clear that a substantial discrepancy between the German and the Greenland age-readings of cod otoliths exists. That became obvious, because mean weight-at-age data from both surveys differed systemically between German mean-weights-at-age, which were always considerably higher than the Greenlandic ones. An otolith exchange in order to compare age readings between both Institutes was conducted in the spring 2018 and showed that age readings of the same set of otoliths showed a one-year systemic difference between both institutes. Age readings were on average one year older for the same fish as read by the Greenlandic institute compared to the German institute (Hedeholm et al. 2018).

To investigate the issue a workshop on age reading of cod in Greenland was arranged with participants from the Greenland Institute of Natural Resources and the Thünen Institute of Sea Fisheries in Germany (Retzel, 2019). The Icelandic Marine and Freshwater Research Institute hosted the workshop that was held January 8-9, 2019, Reykjavik, Iceland. The cause for the discrepancy was identified as the German Institute not reading the last wintering on the edge of the otolith. Afterwards CAA were calculated for the German survey based on Greenland age-length keys in order to identify in which period age readings went wrong by the German Institute (Retzel, 2019). It was recommended that the German Institute reread their survey otolith from 2011 and onwards. By the time of the 2019 NWWG meeting the otoliths from the German surveys in 2016 and 2017 had been reread but there were still considerable differences in weight-at-age (Fock & Werner, 2019). By the time of the 2021 NWWG no further years in the German survey had been reread and the difference in weight-at-age not resolved. It is recommended that a data exchange with updated age readings take place between Germany and Greenland in order to resolve the issue.

16.3 Tagging

An extensive analysis of tagging results from the period 2003–2016 suggest that 50% of each year class in East Greenland migrate to Iceland (Hedeholm, 2018). This has been incorporated in the assessment (ICES, 2018).

16.4 Methods

The stock was benchmarked in 2018 (ICES, 2018). It was decided to use the SAM model and perform an analytical assessment. Hence, the assessment was upgraded from a category 3 (Data Limited Stock) to a category 1 stock. This is considered a vast improvement, as all data are now utilized, and the assessment is presented with uncertainty estimates and multiple catch options.

16.5 Reference points

Reference points were defined at IBPGCod (ICES, 2018). The estimations were conducted in EQSIM according to ICES guidelines (see ICES (2018) for details). The reference points are shown in Table 16.5.1.

16.6 State of the stock

The offshore component has been decreasing the last six years. However, the surveys indicate an improvement in recruitment with all year classes since 2002 and estimated at sizes above the very small year classes seen in the 1990s. These YC's has led to a stock increase during the 00s and an increase in catches. Since 2017 the spawning stock biomass (SSB) has decreased. The number of recruits estimated by SAM in 2020 is higher than the three previous years.

According to the results from the SAM model $F_{5–10}$ has been below F_{MSY} during the last two to three decades. The spawning-stock biomass (SSB) was just above MSY $B_{trigger}$ in 2014 and has then decreased but is still above MSY $B_{trigger}$.

16.7 Short term forecast

The State-space model (SAM) was applied for the offshore cod stock in ICES Division 14. and NAFO Division 1F (Riget *et al.*, 2021).

Input data

The SAM model provides predictions that carry the signals from the assessment into the short-term forecast. The forecast procedure starts from the last year's estimate of the state (log(N) and log(F)). One thousand replicates of the last state are simulated from the estimated joint distribution. Each of these replicates are then simulated forward according to the assumptions and parameter estimates found by the assessment model.

In the forward simulations a 5-year average (up to the assessment year) is used for catch mean weight, stock mean weight, proportion mature, and natural mortality. Recruitment is re-sampled from the entire time series. In each forward simulation step the fishing mortality is scaled, such that the median of the distribution is matching the requirement in the scenario (e.g. hitting a specific mean F value, a specific catch or level of SSB).

Results

Number at age and F at age estimated by SAM are shown in Table 16.7.1 and 16.7.2, respectively. The TAC for 2021 are set to 26 091 t and we assumed that managers will keep the already set TAC rather than following the advice. However, catching 26 091 t in 2021 implies a F of 1.03 which may be unrealistic high. Therefore, the catch will be followed through the year and if necessary, a new national advice will be given. The forecasts for the assumption Catch = TAC_{2021} (26 091 t) from the different scenarios are presented in Table 16.7.3.

16.8 Long term forecast

No long-term forecast was performed for this stock.

16.9 Uncertainties in assessment and forecast

There is no incentive to discard fish or misreport catches under the current management system. In 2018 no survey data were available, and in 2019 German survey data were available but no Greenland survey data. This adds uncertainties to the assessment. Both Greenland and German survey were available for 2020.

The model fits the data relatively well Figure 16.9.1. Figure 16.9.2-4 shows the retrospective plots of SSB, $F_{5\text{-}10}$ and recruits. The retrospective runs show relative high values of Mohn's rho (F5–10 0.416 and SSB -0.424. It is likely linked to the lack of surveys in 2018 and lack of the Greenland survey in 2019 combined with a changing fishing pattern with a higher part of the catch taken at the slopes of Dohrn Banke close to EEZ border between East Greenland and Iceland. These catches compose of old and large cod that may move back and forth between East Greenland and Iceland waters. Furthermore, leaving out the German survey results in SSB being outside the confidence limits (Figure 16.9.5)

It should be noted that the bias of the SSB is upwards so the advice is likely precautionary and that a full benchmark is planned for 2022.

At the NWWG meeting an alternative setup of the SAM model was presented (Riget et al, 2021). In the benchmarked SAM, M is set to 0.2 from age 1 to age 4 and increased to 0.3 for age 5, 0.4 for age 6 and 0.5 for age 7 to 9 to account for a historical well documented emigration. By changing M from year 2012 and onward for all ages to 0.2 (no emigration), the Mohn's rho were reduced to 0.2 ($F_{5\text{–}10}$) and -0.08 (SSB). It should not be considered as the cod had "stopped migrating" but rather that an increasing part of the catch taken at the slope of Dohrn Bank, where cod may migrate back and forth. Furthermore, the leave out plots also improved. However, changing the emigration pattern had to be accepted and the group found that the assessment should be based on the benchmarked setup of SAM.

16.10 Comparison with previous assessment and forecast

The analytical assessment model (SAM) was accepted at the benchmark January 2018 (ICES 2018) and only three years of the analytical assessment exist. In the years before the advice was based on a DLS assessment. Compared to last year's assessment the SSB annual estimates has been up-scaled for the last 10-12 years equivalent to a year class passing through the assessment. Some up-scaling has also happened in the number of recruits especially large year classes such as the 2003-year class. Furthermore, the values of Mohn's rho of the retrospective have increased in this year's assessment. This has resulted in a relative high increase (32%) of the MSY based advice and assuming the catch in 2021 equal to the TAC.

16.11 Implemented management measures for 2021

The offshore quota for the total international fishery is set at 26 091 t. The following table shows the distribution of the TAC across management areas and countries.

Area	TAC (tons)	Countries
Dohrn Bank	20 000	Greenland (17 800 t), EU (1950 t), Norway (250 t)
South and East Greenland	6 091	Greenland (2691 t), Faeroese Island (2500 t), Norway (1100 t)

To protect the spawning stock, no fishing is allowed from 1 March to 31 May in a square in and around Kleine Bank (see figure below).

16.12 Management plan

In 2021, a management plan was implemented for the offshore cod fishery in Greenland but it has not been evaluated by ICES. The management plan distinguished between 3 areas: NorthEast Greenland (east of 27’00°W), Dohrn Bank and South of Dohrn Bank. The management plan tries to take the scientific advice, migration between the Dohrn Bank region and Iceland and protection of spawning grounds into account. In order to protect the spawning stock, it is not allowed to fish from 1 March to 31 May in a square comprising Kleine Bank (shaded black in the figure below):

TAC is set by the following rules:

Area	TAC (tons)
NorthEast Greenland west of 27’00°W	Free
Dohrn Bank	20 000
South and East Greenland (South of Dohrn Bank)	TAC (year) = 0.5*TAC (year-1) + 0.5*ICES advice (year)

16.13 Management considerations

Larger and older fish (8+ year old) are located furthest to the north in the Dohrn Bank area, whereas younger fish dominate in the South (5–6 year old). This reflects the eastward migration behaviour towards the spawning grounds in East Greenland and Iceland. Further, the genetic studies combined with tagging results suggest that the spawning stock component in East

Greenland is associated with the offshore spawning population in Iceland, and the two stock cannot be genetically separated. Tagging suggest that a substantial part of the cod in East Greenland migrate to Iceland. Since 2018 a considerable part of the fishery (70%) has taken place on the continental slope south of Dohrn Bank close to the EEZ to Iceland. It is speculated that a migration back and forth between Iceland and Greenland exist in this region. It has however not been scientifically proven.

16.14 Basis for advice

The State-space model (SAM) was applied for the offshore cod stock in ICES Division 14. and NAFO Division 1F (Riget *et al*., 2021).

16.15 Benchmark 2022

The main aim of the benchmark is to move away from using the current simplified geographical borders to separate the three cod stocks in Greenland waters. This will be done by developing a modelling approach that can use genetic data based on samples covering the distribution of the three stocks (Buch et al. 2021). The model will utilize the spatial resolution of the genetics data to estimate the split between the stocks along a spatial gradient. The catch and survey data will then be split into separate stocks and used as input into an analytical assessment models for each stock. This would account for differences in stock dynamics between stocks and may improve the understanding of migration patterns.

The benchmark also aims to improve the estimation of the survey indices available for the stocks. There are currently two offshore surveys in Greenland waters. One Greenlandic survey, covering the West and East coast up to and including the Dohrn bank area. One German survey covers a similar area on the east coast and some of the west coast. A spatial model will be developed to allow combination of the survey data and allow incorporation of spatial patterns. The new model will also be able to better account for occasionally large catches.

16.16 Recommendations

Based on genetic analysis it is not possible to distinguish between an East Greenland and Icelandic offshore stock and especially the East and South Greenland area is highly influenced by the inflow of egg and larvae from the spawning grounds in Iceland. To gain further insight into stock structure and migration patterns across areas targeted work using both genetic and tagging data is needed.

The Greenland and German trawl surveys are fundamental to the assessment of cod in East Greenland. The two surveys provide similar signals and similar age compositions, but the mean weights-at-age differ considerably. A workshop in 2019 identified wrong age-readings in the German survey, but even after age-readings in the German survey have been corrected the difference in mean weight-at-age persist. In addition, several inconsistencies in survey calculations have been identified in the German survey. A dedicated workshop prior to the benchmark to identify and solve these data issues is strongly recommended.

16.17 Inter-benchmark and updated stock assessment, September 2021

Please note that the assessment of cod in ICES Subarea 14 and NAFO Division 1F (East Greenland, Southwest Greenland) presented to NWWG in April 2021 was rejected by the Advice Drafting Group due to violation of the predefined limits for retrospective bias (Mohn's ro > 0.2). ICES therefore arranged an Interbenchmark of the stock (IBPGCOD2; ICES, 2021) that was performed in August 2021. The IBPGCOD2 decided on a short term technical fix to solve the assessment problems until the next benchmark. The fix was to alter the natural mortality (M) since 2016 and to remove the correlation structure in F between ages. This was done to account for changes in the interaction between immigration/emigration and distribution of the fishery.

The assessment problems could be solved with this technical fix and the retrospective pattern was improved considerably. Biological reference points for the stock were updated. Results were presented to NWWG on 23 August 2021. No additional concerns were raised by the group and the new assessment was approved and suggested as the basis for advice for fishing opportunities in 2022. Therefore, Sections 16.5–16.10 in the current report are outdated. For more information on the alterations and outcome of the assessment, see the IBPGCOD2 report (ICES, 2021).

16.18 References

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16.19 Tables

Table 16.2.1. Offshore catches (t) divided into NAFO divisions in West Greenland and East Greenland (ICES 14.b). 1924–1995: Horsted 2000, 1995–2000: ICES Catch Statistics, 2001–present: Greenland Fisheries License Control.

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1924							200		
1925							1871		
1926							4452		
1927							4427		
1928							5871		
1929							22304		
1930							94722		
1931							120858		
1932							87273		
1933							54351		
1934							88422		
1935							65796		
1936							125972		
1937							90296		
1938							90042		

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1939							62807		
1940							43122		
1941							35000		
1942							40814		
1943							47400		
1944							51627		
1945							45800		
1946							44395		
1947							63458		
1948							109058		
1949							156015		
1950							179398		
1951							222340		
1952	0	261	2996	18188	707	37905	257488		
1953	4546	46546	10611	38915	932	25242	98225		
1954	2811	97306	18192	91555	727	15350	60179	4321	23759*
1955	773	50106	32829	87327	3753	4655	68488	5135	11567*
1956	15	56011	38428	128255	8721	4922	66265	12887	19189*

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1957	0	58575	32594	62106	29093	16317	47357	10453	30659*
1958	168	55626	41074	73067	21624	26765	75795	10915	46972*
1959	986	74304	10954	30254	12560	11009	67598	19178	35500*
1960	35	58648	18493	35939	16396	9885	76431	23914	39219*
1961	503	78018	43351	70881	16031	14618	90224	19690	40212*
1962	1017	122388	75380	57972	25336	17289	125896	17315	41874*
1963	66	70236	73142	76579	46370	16440	122653	23057	46626*
1964	96	49049	49102	82936	33287	13844	99438	35577	55451*
1965	385	80931	66817	71036	15594	15002	92630	17497	38063*
1966	12	99495	43557	62594	19579	18769	95124	12870	38956*
1967	361	58612	78270	122518	34096	12187	95911	24732	40738*
1968	881	12333	89636	94820	61591	16362	97390	15701	37844*
1969	490	7652	31140	65115	41648	11507	35611	17771	31879*
1970	278	3719	13244	23496	23215	15519	18420	20907	40023*
1971	39	1621	28839	21188	9088	20515	26384	32616	59789*
1972	0	3033	42736	18699	7022	4396	20083	26629	32188*
1973	0	2341	17735	18587	10581	2908	1168	11752	14725*
1974	36	1430	12452	14747	8701	1374	656	6553	7950*

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1975	0	49	18258	12494	6880	3124	549	5925	9091*
1976	0	442	5418	10704	8446	2873	229	13025	15922*
1977	127	301	4472	7943	8506	2175	35477 1	18000 2	23455*
1978	0	0	11856	2638	3715	549	34563 1	26000 2	27561*
1979	0	16	6561	4042	1115	537	51139 1	34000 2	36775*
1980	0	1800	2200	2117	1687	384	7241 1	12000 2	12724*
1981	0	0	4289	4701	4508	255	0	16000 2	16255
1982	0	133	6143	10977	11222	692	1174	27000 2	27720*
1983	0	0	717	6223	16518	4628	293	13378	18054*
1984	0	0	0	4921	5453	3083	0	8914	11997
1985	0	0	0	145	1961	1927	2402	2112	5187*
1986	0	0	0	2	72	24	1203	4755	5074*
1987	0	0	5	815	67	43	3041	6909	7093*
1988	0	0	919	17463	10913	6466	8101	9457	17388*
1989	0	0	0	11071	48092	14248	2	14669	28917
1990	0	0	2	563	21513	10580	7503	33508	46519*
1991	0	0	0	0	104	1942	0	21596	23538
1992	0	0	0	0	0	0	0	11349	11349

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
1993	0	0	0	0	0	0	0	1135	1135
1994	0	0	0	0	0	0	0	437	437
1995	0	0	0	0	0	0	0	284	284
1996	0	0	0	0	0	0	0	192	192
1997	0	0	0	0	0	0	0	355	355
1998	0	0	0	0	0	0	0	345	345
1999	0	0	0	0	0	0	0	116	116
2000	0	0	0	0	0	0	0	152	152
2001	0	0	0	0	0	0	0	125	125
2002	0	0	0	0	0	0	0	401	401
2003	0	0	0	0	0	0	0	485	485
2004	0	0	0	5	3	1	0	774	775
2005	0	0	1	0	0	71	0	819	890
2006	0	0	0	0	0	414	0	2042	2456
2007	0	0	0	31	435	20113	0	3194	5205
2008	0	0	0	23	526	113703	0	3258	14628
2009	0	0	0	0	6	33233	0	1642	4965
2010	0	0	0	0	2	281	0	2388	2669

Year	NAFO 1A	NAFO 1B	NAFO 1C	NAFO 1D	NAFO 1E	NAFO 1F	Unknown NAFO div.	ICES 14.b	NAFO 1F + ICES 14.b
2011	0	0	0	0	8	542	0	4571	5113
2012	0	0	1	95	236	1470	0	3941	5411
2013	0	0	0	209	270	1405	0	4104	5509
2014	0	0	30	68	18	1833	0	6060	7893
2015	0	0	341	954	3564	3984	0	11771	15755
2016	0	0	67	1911	1762	2335	0	12483	14818
2017	0	1	1442	730	852	2560	0	13740	16300
2018	0	0	1989	678	1520	1819	0	13249	15068
2019	0	0	654	57	186	916	0	17158	18074
2020	0	0	102	0	1	675	0	15258	15933

1) **Estimates for assessment include estimates of unreported catches. The total estimated value for West Greenland (inshore + offshore) was 73 000 t in 1977 and 1978, 1979: 99 000 t, 1980: 54 000 t. The value given in the table are these values minus the inshore catches minus known offshore NAFO Division catches.**

2) **Estimates for assessment include estimates of unreported catches in East Greenland.**

3) **Include catches taken with small vessels and landed to a factory in South Greenland (Qaqortoq), 2007: 597 t, 2008: 2262 t, 2009: 136 t.**

***)** **Unknown NAFO Division catches added accordingly to the proportion of known catch in NAFO Division 1F to known total catch in all NAFO divisions.**

Table 16.2.2: Cod catches (t) by area and month. East Greenland (14.b) divided into five areas. NQ1 furthest to the north.

ICES/NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	%
14.b (NQ1)								1	1	14			16	0%
14.b (Q1Q2)	1126	1298		7	2	1348	2338	538	1238	1059	467	1038	10459	66%
14.b (Q3Q4)	25	808	462	1715	1385	116	9	31		0.2	75	56	4682	29%
14.b (Q5Q6)	1	1	0.1	24	5	63	4				3		101	1%
1F									8		140	527	675	4%
Total	1152	2107	462	1746	1392	1527	2351	570	1247	1073	685	1621	15933	
%	7%	13%	3%	11%	9%	10%	15%	4%	8%	7%	4%	10%		

Table 16.2.3: Cod catches (t) by gear, area and month. East Greenland (14.b) divided into five areas. NQ1 furthest to the north.

Gear	ICES/NAFO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Longline	14.b (NQ1)								1	1	14			16
	14.b (Q1Q2)	64	105		7		4	43	28	75	181	217	147	871
	14.b (Q3Q4)	25		362	1715	1379	101	3					37	3622
	14.b (Q5Q6)				24									24
	1F													
	Total	89	105	362	1746	1379	105	46	29	76	195	217	184	4533
Trawl	14.b (NQ1)													
	14.b (Q1Q2)	1062	1193			2	1344	2295	510	1163	878	250	891	9588
	14.b (Q3Q4)		808	100		6	15	6	31		0.2	75	19	1060
	14.b (Q5Q6)	1	1	0.1		5	63	4				3		77
	1F									8		140	527	675
	Total	1063	2002	100	0	13	1422	2305	541	1171	878	468	1437	11400

Table 16.2.4. Cod in Greenland. Catch at age ('000) and Weight at age (kg) for offshore fleets in East Greenland (ICES 14.b + NAFO 1F).

	Catch at age							
Year/age	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2005	5	33	57	103	94	57	16	7
2006	232	376	135	175	115	14	1	0
2007	49	1529	668	158	124	120	18	15
2008	77	586	6015	2417	592	44	26	12
2009	307	1287	1231	434	119	28	16	2
2010	10	87	331	193	334	58	8	5
2011	3	70	137	425	355	371	96	31
2012	13	109	471	281	258	253	148	59
2013	0	36	127	615	237	226	153	104
2014	1	4	279	434	658	335	173	131
2015	3	57	457	1554	1324	828	242	182
2016	4	33	343	736	1130	766	427	257
2017	6	15	137	519	1214	1432	527	251
2018	7	27	67	217	498	1023	855	496
2019	0	150	331	358	426	679	948	1090
2020	6	14	701	545	374	429	463	913

Weight at age								
2005	0.354	0.717	1.073	1.963	2.737	3.699	5.271	7.366
2006	1.323	1.602	2.349	3.608	4.420	5.440	7.191	8.127
2007	0.387	0.917	1.597	3.294	6.092	8.524	11.114	14.435
2008	0.359	0.644	1.266	1.799	3.025	4.936	5.840	8.290
2009	0.489	0.776	1.396	2.797	4.634	6.453	7.804	9.993
2010	0.699	1.125	1.636	2.494	3.354	5.334	8.063	10.475
2011	0.553	1.026	1.541	2.297	3.377	4.685	6.285	10.022
2012	0.502	0.892	1.440	2.380	3.570	5.142	7.172	11.417
2013	0.480	0.998	1.698	2.272	3.408	4.745	6.827	9.024
2014	0.564	1.163	1.853	2.603	3.636	4.732	6.400	8.841
2015	0.484	0.833	1.435	2.097	3.460	4.699	6.846	9.115
2016	0.406	0.845	1.420	2.135	3.267	4.693	6.693	10.071
2017	0.392	0.711	1.641	2.213	3.063	4.167	6.094	8.034
2018	0.378	0.812	1.258	2.032	2.948	4.561	5.663	7.135
2019	0.307	1.168	1.775	2.687	3.257	4.052	5.291	6.601
2020	0.613	1.247	2.102	3.373	4.079	4.898	5.816	6.878

Table 16.2.5. Cod in Greenland. Catch at age (‘000) for offshore fleets by area (ICES 14b + NAFO 1F). Q1Q2 furthest to the north in East Greenland. NAFO 1F + 14b(Q5Q6) = South Greenland.

	Catch at age							
Area/age	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
14.b (Q1Q2)	1	8	250	291	218	223	260	585
14.b (Q3Q4)	4	3	252	181	126	183	186	316
14.b (Q5Q6)			30	9	3	2	2	2
NAFO 1F	1	3	169	64	27	21	15	10

Table 16.2.6. Number of hauls in the Greenland Shrimp and Fish survey in ICES 14.b and NAFO 1F.

	ICES 14.b						NAFO	
Year/Strata	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total
1992							15	
1993							13	
1994							9	
1995							11	
1996							11	
1997							19	
1998							14	
1999							17	
2000							29	
2001							26	
2002							27	
2003							22	
2004							34	
2005							23	
2006							31	
2007							39	
2008	8	6	12	7	7	11	47	98

	ICES 14.b						NAFO	
Year/Strata	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total
2009	22	11	25	20	6	13	48	145
2010	19	14	24	9	6	10	40	122
2011	20	11	21	12	7	14	25	110
2012	20	16	28	13	7	15	26	125
2013	25	12	22	14	5	14	28	120
2014	22	14	12	9	8	16	32	113
2015	26	11	24	12	8	14	36	131
2016	29	10	26	13	7	16	36	137
2017	2	4	7	6	6	11	35	71
2018	0	0	0	0	0	0	35	
2019	0	0	0	0	0	0	24	
2020	23	13	27	13	7	16	43	142

Table 16.2.7 Cod abundance indices ('000) from the Greenland Shrimp and Fish survey by year and strata divisions in ICES 14.b and NAFO 1F. Q1 being the northern strata in East Greenland. * Incomplete coverage in strata Q1–Q4.

	ICES 14.b						NAFO		
Year	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total	CV
1992							8		
1993							18		
1994							0		
1995							39		
1996							107		
1997							0		
1998							3		
1999							0		
2000							189		
2001							313		
2002							457		
2003							211		
2004							1610		
New survey Gear Introduced									
2005							86410		
2006							39475		

	ICES 14.b						NAFO		
Year	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total	CV
2007							32575		
2008	5456	1361	13043	1975	1635	7958	22887	54314	22
2009	14304	2191	28539	4374	548	4753	1776	56486	15
2010	5844	732	30042	3975	115	4633	6557	51897	45
2011	7843	1357	5178	7733	1470	19072	6330	48983	22
2012	5475	2164	3658	2453	352	8635	21238	43975	20
2013	11102	1420	5667	17360	537	27145	49874	113104	32
2014	4168	3445	2622	19267	493	5412	22702	58106	36
2015	6396	4074	6941	3093	231	8322	34032	63090	28
2016	8338	909	9737	1031	233	3412	4393	28052	16
2017*	7429	4559	5242	5816	627	18694	12466	54833	28
2018							5302		
2019							5233		
2020	11061	1204	19578	406	138	3613	21690	57690	23

Table 16.2.8. Cod biomass indices (tonnes) from the Greenland Shrimp and Fish survey by year and strata divisions in ICES 14.b (Q1–Q6) and NAFO 1F. * Incomplete coverage in strata Q1–Q4.

	ICES 14.b						NAFO		
Year	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total	CV
1992							2		
1993							5		
1994							0		
1995							4		
1996							49		
1997							0		
1998							3		
1999							0		
2000							46		
2001							100		
2002							150		
2003							46		
2004							305		
New survey Gear Introduced									
2005							56163		
2006							16828		
2007							23346		

	ICES 14.b						NAFO		
Year	Q1	Q2	Q3	Q4	Q5	Q6	1F	Total	CV
2008	8692	2430	24101	1482	2173	8838	21236	68952	23
2009	10844	8874	27251	7827	252	3094	503	58645	28
2010	16014	3151	81064	6202	23	4203	3142	113799	51
2011	27064	8128	5561	12486	5235	22664	3280	84418	19
2012	24736	10058	9347	5802	160	14322	16213	80638	16
2013	45018	9639	15017	48518	977	40319	47818	207306	22
2014	17182	20637	15574	90795	734	8884	30754	184560	45
2015	33105	13803	27050	11609	513	18724	49931	154735	20
2016	40580	4831	33065	4841	426	5670	4671	94084	18
2017	45774	27405	18257	4777	1749	31635	7823	137420	41
2018							8498		
2019							3841		
2020	49921	2185	33763	584	262	5478	24780	116973	18

Table 16.2.9: Abundance indices ('000) by age from the Greenland Shrimp and Fish survey by year in ICES 14.b + NAFO 1F. *Incomplete coverage. Indices for 2019 is for NAFO 1F only.

East Greenland											
Year/age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2008	4355	326	1168	7460	6937	24058	5279	2227	613	1225	671
2009	14970	7642	8019	4504	5378	5664	6610	2537	225	554	385
2010	150	2436	3959	5759	3253	12785	7969	11264	2958	450	914
2011	315	162	5682	8288	16346	5409	4707	2226	3382	1834	634
2012	0	258	1208	12748	7154	12041	4155	2428	1345	1849	790
2013	0	157	1432	1954	44843	25373	26654	5209	3440	1852	2190
2014	692	15	207	1849	1558	21863	8805	12411	2875	3790	4041
2015	0	86	38	1259	4916	11445	29010	7407	4793	1954	2181
2016	279	3847	1818	998	555	2089	2399	6779	4874	3398	1018
2017*	242	111	14938	5234	6797	4470	5791	4307	7746	4352	845
2018					No	survey					
2019					No	survey					
2020	267	1169	957	3879	8018	23647	12195	1557	1094	1528	3378

Table 16.2.10: Mean weight (kg) at age from the Greenland Shrimp and Fish survey by year in ICES 14.b + NAFO 1F.

East Greenland											
Year/age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2008	0.003	0.019	0.088	0.262	0.520	1.067	1.982	3.385	5.699	8.447	8.564
2009	0.004	0.059	0.140	0.452	0.976	1.730	2.977	4.186	5.447	7.423	10.800
2010	0.002	0.041	0.206	0.406	0.823	1.728	2.499	3.496	5.480	7.363	10.686
2011	0.001	0.017	0.152	0.366	0.783	1.408	2.209	3.891	5.711	7.218	10.859
2012		0.025	0.201	0.367	0.916	1.519	2.634	4.068	5.658	7.565	10.000
2013		0.020	0.194	0.450	0.771	1.396	2.353	3.663	5.140	7.062	10.354
2014	0.001	0.003	0.129	0.360	0.773	1.402	2.758	4.145	5.173	6.217	9.060
2015		0.017	0.100	0.357	0.697	1.194	1.808	3.241	4.835	6.809	10.000
2016	0.001	0.025	0.116	0.327	0.831	1.623	2.245	3.557	5.299	6.879	9.973
2017	0.001	0.047	0.186	0.369	0.782	1.485	2.338	3.995	5.714	8.168	10.674
2018			No			survey					
2019			No			survey					
2020	0.002	0.022	0.123	0.441	0.677	1.522	2.371	4.093	5.285	6.995	7.610

Table 16.2.11 ***German survey*****. Numbers of valid hauls by stratum in South and East Greenland, stratum 9 furthest to the north.**

	NAFO 1 F		ICES 14.b						
year	Str 4.1	Str 4.2	Str 5.1	Str 5.2	Str 7.1	Str 7.2	Str 8.2	Str 9.2	Sum
1981	1	2	2	12	4	12	19	10	62
1982	13	2	.	12	1	9	15	15	67
1983	18	4	1	26	8	14	25	10	106
1984	20	4	4	5	1	5	7	2	48
1985	21	4	5	22	11	26	35	18	142
1986	20	3	2	27	11	14	31	34	142
1987	21	5	16	25	7	21	26	11	132
1988	18	2	20	19	10	13	36	9	127
1989	25	3	37	.	20	.	26	4	115
1990	21	6	15	24	4	6	15	12	103
1991	14	5	9	18	11	7	45	13	122
1992	7	5	.	.	.	.	4	2	18
1993	7	.	9	9	5	5	15	10	60
1994	7	5	.	.	.	.	.	6	18
1995	10	5	8	8	5	4	16	8	64
1996	10	5	7	9	5	3	13	6	58
1997	8	5	5	6	4	1	9	5	43
1998	10	5	5	9	6	2	12	6	55
1999	9	3	5	7	4	4	10	6	48
2000	9	5	6	7	8	4	12	9	60
2001	11	6	5	8	8	2	17	12	69
2002	8	4	6	7	5	2	10	7	49
2003	7	5	5	5	5	1	12	10	50
2004	9	5	7	7	8	3	13	11	63
2005	6	5	6	7	8	4	12	9	57
2006	8	5	3	1	5	4	11	7	44
2007	9	5	4	6	4	3	13	8	52

	NAFO 1 F		ICES 14.b						
year	Str 4.1	Str 4.2	Str 5.1	Str 5.2	Str 7.1	Str 7.2	Str 8.2	Str 9.2	Sum
2008	7	6	6	8	4	3	10	8	52
2009	5	5	2	5	5	4	9	8	43
2010	10	6	1	3	8	3	14	8	53
2011	6	6	5	8	6	4	14	9	58
2012	10	6	6	7	8	3	12	9	61
2013	9	6	5	9	7	5	15	9	65
2014	10	6	5	7	10	6	20	11	75
2015	8	6	6	8	9	10	19	9	75
2016	11	6	5	8	8	6	13	6	63
2017	7	.	3	2	6	6	13	9	46
2018				No survey					
2019	16	7	3	8	8	9	19	8	78
2020	6		8	5	8	2	16	8	53

Table 16.2.12 ***German survey*****. Cod abundance indices ('000) from the German survey in South and East Greenland by year and stratum. Incomplete coverage in 2017.**

	NAFO 1F		ICES 14.b							
year	str4_1	str4_2	str5_1	str5_2	str7_1	str7_2	str8_2	str9_2	Sum	SD
1982	8540	1245	.	366	297	1493	664	385	12990	4973
1983	5267	2870	209	715	149	564	529	726	11029	3796
1984	3296	42	1268	413	138	750	173	333	6413	3845
1985	3492	1164	920	166	560	1554	401	310	8567	1978
1986	8967	492	3509	359	776	2641	1207	337	18288	5097
1987	23219	306	5655	4145	399	6298	1293	234	41549	14816
1988	28259	17	2590	2073	302	1175	738	601	35755	16719
1989	31810	31442	9979	.	880	.	2128	639	76878	42682
1990	7052	6306	2808	1155	861	4295	2799	468	25744	7720
1991	1367	233	790	937	122	368	652	510	4979	1548
1992	113	134	.	.	.	.	228	367	842	192
1993	0	.	613	62	127	317	114	148	1381	521
1994	44	12	.	.	.	.	.	234	290	135
1995	27	8	89	25	450	3082	77	91	3849	1314
1996	156	0	109	0	37	279	29	160	770	173
1997	49	0	25	17	200	54	145	1107	1597	479
1998	40	8	97	0	57	57	24	266	549	142
1999	155	0	198	8	165	1267	116	105	2014	582
2000	76	13	348	15	431	180	25	143	1231	251
2001	343	3	319	27	309	299	204	1071	2575	544
2002	1739	0	116	273	769	459	186	875	4417	1352
2003	840	8	199	183	1250	1399	1100	1438	6417	1004
2004	10902	107	1684	133	285	1817	1401	1073	17402	8499
2005	24438	1399	16577	3078	718	7157	1580	2070	57017	11411
2006	28894	486	14733	3686	6044	7378	2779	2700	66700	15653
2007	67049	772	2283	3256	758	5363	2080	2093	83654	56843
2008	18730	292	2036	4898	2203	9460	1285	2678	41582	10268

	NAFO 1F		ICES 14.b							
year	**str4_1**	**str4_2**	**str5_1**	**str5_2**	**str7_1**	**str7_2**	**str8_2**	**str9_2**	**Sum**	**SD**
2009	1286	283	1017	567	3129	8755	1566	3275	19878	3581
2010	2372	141	532	1703	1101	8875	933	1748	17405	2958
2011	7547	162	3027	1326	868	1971	1243	2816	18960	3196
2012	23964	132	5689	167	901	2117	1114	3982	38066	22168
2013	41722	1947	2193	818	874	3121	1157	1342	53174	43105
2014	73612	111	8612	4013	228	1089	1436	5461	94562	77704
2015	3187	361	1186	267	113	834	2265	3395	11833	3703
2016	2875	361	1186	267	113	793	2152	4086	9114	1647
2017	1499	104	1498	262	336	1126	1126	3307	12421	3727
2018					No survey					
2019	11679	17	416	550	122	350	305	2123	15564	
2020	9824	.	1696	43	57	1004	282	2231	15137	

Table 16.2.13 ***German survey*****. Cod biomass indices (tonnes) from the German survey in South and East Greenland by year and stratum. Incomplete coverage in 2017.**

	NAFO 1F		ICES 14.b							
year	**str4_1**	**str4_2**	**str5_1**	**str5_2**	**str7_1**	**str7_2**	**str8_2**	**str9_2**	**Sum**	**SD**
1982	14607	3690	.	1201	1036	3342	2576	1900	28352	8415
1983	9797	6219	653	2209	402	2294	2605	4442	28621	8201
1984	5326	82	3115	1444	346	1782	540	2553	15188	6650
1985	2942	1976	1812	803	1393	3875	1187	1605	15593	3099
1986	8005	943	1044	873	2537	3921	2301	709	20333	6054
1987	17186	276	2889	3735	504	10243	4558	1414	40805	16521
1988	26349	17	2812	4605	964	2297	3475	2012	42531	18651
1989	36912	35281	23605	.	2518	.	6889	2174	107379	61579
1990	9212	5897	5361	3215	2517	10386	6551	1620	44759	10905
1991	2088	200	1465	2759	196	1008	2610	2100	12426	4657
1992	79	50	.	.	.	.	171	734	1034	286
1993	0	.	431	73	247	532	254	547	2084	588

	NAFO 1F		ICES 14.b							
year	str4_1	str4_2	str5_1	str5_2	str7_1	str7_2	str8_2	str9_2	Sum	SD
1994	2	7	.	.	.	.	.	779	788	514
1995	6	4	32	62	166	11744	250	123	12387	5550
1996	101	0	63	0	109	708	99	511	1591	333
1997	53	0	18	20	358	70	337	4017	4873	1800
1998	12	11	29	0	87	122	123	986	1370	554
1999	39	0	24	1	162	2229	492	201	3148	1184
2000	13	9	132	17	206	616	75	540	1608	366
2001	88	5	130	19	345	382	387	3005	4361	1593
2002	976	0	38	224	1547	531	541	2214	6071	1306
2003	361	17	121	266	3787	2440	1716	4169	12877	2817
2004	1945	177	359	55	957	2319	3264	3240	12316	3070
2005	9055	1870	8135	2537	3155	17882	3590	6806	53030	7772
2006	31616	681	8616	4130	3557	10291	6084	11567	76542	24680
2007	74671	1045	3749	5042	1363	14456	5374	8540	114240	58452
2008	18543	344	3630	9790	5075	26506	3772	11908	79568	12433
2009	583	277	1361	1726	10145	28613	6351	15520	64576	13358
2010	3629	273	741	5085	5244	31745	4282	10932	61931	11626
2011	12398	385	5839	4364	1658	8051	5735	17487	55917	10240
2012	33871	370	15679	579	2596	6245	5445	26885	91670	30054
2013	74193	6525	6672	2737	2577	9752	4853	7575	114884	75148
2014	132706	428	31885	15935	1060	4322	6480	29358	222174	132209
2015	10777	1534	3938	1804	522	3346	9396	24306	55623	17157
2016	4521	305	7360	1727	2129	6341	4906	9367	36656	6954
2017	5836	.	7687	0	616	9704	4067	31088	58998	20593
2018					No survey					
2019	19292	32	1927	1245	397	685	1610	11072	36260	11857
2020	25442	.	4677	140	255	1260	1270	14764	47808	12299

Table 16.2.14 German survey, South and East Greenland (NAFO 1F and ICES 14.). Age disaggregate abundance indices ('1000). Incomplete coverage in 201

Year	0	1	2	3	4	5	6	7	8	9	10	11+
1982		23	214	2500	1760	4451	1952	793	223	927	57	74
1983												
1984	23	8	54	1134	507	2434	582	1242	229	125	17	49
1985	279	2521	242	160	1658	947	1439	344	831	96	27	27
1986		3367	9255	1128	273	1631	603	1300	165	473	31	58
1987		4	10193	24656	2689	720	1368	296	966	80	487	49
1988	6	18	335	9769	23391	876	200	559	83	337	31	146
1989	12	2	111	732	23945	49864	1007	44	756	70	282	76
1990	58	36	58	715	706	11679	12101	139	15	74		148
1991		73	150	171	539	102	2128	1762	31	11	3	9
1992	214	10	196	103	61	53	67	67	51			21
1993		4	15	869	152	95	97	31	83	34		2
1994		71	5	16	84	39	22	38		8		0
1995		1	621	347	260	1399	372	120	403	32	192	102
1996		0	0	353	130	131	110	23	25			0
1997		0	12	17	687	557	191	78	48			5
1998	51	73	39	4	11	173	138	48	10			0
1999	105	426	389	346	118	257	174	156		29	16	0

Year	0	1	2	3	4	5	6	7	8	9	10	11+
2000		202	243	323	208	40	72	20	46	61	15	0
2001		166	568	493	631	362	190	60	50	18	10	2
2002	40	1	395	2119	601	477	454	217	61	21	11	7
2003	579	629	53	553	1761	1026	1015	541	220	37	.	4
2004	386	10687	1770	448	617	1667	921	620	228	39	10	8
2005	80	1603	39549	8091	1250	2819	2549	727	189	40		0
2006	80	439	3375	48140	9269	1328	2404	1309	193	30	9	0
2007	128	154	2007	5149	65974	8166	713	658	634	70		0
2008	14	265	513	8213	4401	22939	4201	516	220	199	44	29
2009	98	322	1057	391	1620	2863	11241	1964	111	134	64	17
2010	22	700	1425	1388	845	2887	2518	5707	1362	236	163	139
2011		120	1246	3475	4874	2402	2949	1179	2324	310	23	49
2012	6	50	1624	10093	10233	9846	2827	1778	1166	379	35	5
2013		17	35	4312	27014	11146	7455	1314	517	291	126	68
2014		7	55	602	20847	58174	9275	3284	1316	494	441	52
2015	105	37	68	341	752	3688	3598	1881	644	187	106	160
2016	35	419	98	56	255	677	874	3325	1741	1072	199	209
2017		8	1650	479	190	549	1243	2341	3640	1356	533	195

Year	0	1	2	3	4	5	6	7	8	9	10	11+
2018						No survey						
2019	52	.	.	679	8296	2301	516	468	554	820	626	2255
2020	332	196	198	424	821	6816	2193	811	880	709	857	896

Table 16.2.15 *German survey*, The abundance indices (‘000) by year class/age, 2019. South and East Greenland (NAFO 1F (Strat 4) and ICES 14.b, Strat 9 furthest to the north).

year	stratum	index0	index1	index2	index3	index4	index5	index6	index7	index8	index9	index10	index11+
2020	4.1	16	91	23	195	650	5218	1285	449	687	428	552	229
2020	4.2	0	0	10	13	88	1022	450	68	11	5	8	20
2020	5.1	0	0	0	4	7	13	6	3	4	2	3	2
2020	5.2	3	1	0	0	1	15	12	8	3	3	4	8
2020	7.1	313	104	162	204	63	0	0	17	16	31	29	64
2020	7.2	0	0	0	0	0	100	87	41	11	12	14	22
2020	8.2	0	0	3	8	12	450	355	225	148	228	247	554
2020	9.2	16	91	23	195	650	5218	1285	449	687	428	552	229

Table 16.5.1. Reference point.

Reference point	Value	Technical basis
F_{MSY}	0.46	Equilibrium scenarios using segmented regression and capped by F_{p05}
F_{LIM}	2.34	Equilibrium scenarios prob (SSB < B_{lim}) < 50% with stochastic recruitment
F_{PA}	1.33	F_{lim} / e $^{1.645\sigma}$, σ = 0.34
B_{LIM}	10354 t.	Average of SSB 2002, 2003 and 2004
B_{PA}	14803 t	B_{lim}×e $^{1.645\sigma}$, σ = 0.217
MSY $B_{trigger}$	14803 t.	B_{PA}

Table 16.7.1. Estimated stock numbers at age.

Year Age	1	2	3	4	5	6	7	8	9	10
1973	45847	11697	6831	4612	20517	3791	2809	674	2632	4195
1974	236077	34450	9576	6254	3255	14265	2376	1423	321	2815
1975	33589	233235	25886	7671	6434	2352	9478	1356	701	1280
1976	12948	26102	230427	19010	5410	4706	1448	5053	671	985
1977	13056	10081	20284	160121	17476	3716	2492	698	1722	781
1978	30124	10236	7848	16689	93868	13865	1937	832	239	958
1979	7859	27644	8025	8542	11758	44948	8145	1258	255	224
1980	18936	5728	25369	7291	7074	5589	20492	2433	243	76
1981	4888	17426	4174	17862	6107	5428	3502	10106	820	128
1982	5249	3714	16037	3040	14391	5349	3845	2024	3800	332
1983	2822	5189	2668	15418	3250	11618	2657	1142	362	787
1984	4624	2180	5129	2753	9624	1860	5287	721	343	346
1985	183709	4727	1973	4280	2341	6164	785	1916	175	237
1986	144596	160785	4707	1152	3776	1579	4062	390	1072	154
1987	3275	108467	133049	3696	809	2658	853	2348	201	852
1988	2764	3576	67900	112421	2270	448	1761	408	1011	440
1989	772	2525	3262	43041	82871	1154	163	803	179	496
1990	1724	754	2335	2600	26533	40444	450	53	257	153
1991	2871	1121	647	1901	1250	10830	11005	134	28	79

Year Age	1	2	3	4	5	6	7	8	9	10
1992	1014	1896	556	467	741	307	2548	1642	37	11
1993	864	751	1020	410	236	345	63	236	167	5
1994	4311	740	689	731	271	138	226	31	61	59
1995	250	3704	1035	438	658	211	90	166	20	68
1996	325	207	2291	774	360	327	120	52	92	49
1997	1705	247	172	1395	662	278	167	76	29	82
1998	6273	1422	186	156	701	399	165	70	40	61
1999	12828	4808	1355	226	194	335	222	91	35	52
2000	16591	7478	3195	1124	236	167	159	112	62	51
2001	10030	12687	4768	2318	1009	272	131	89	56	63
2002	1559	7318	9779	3347	1793	917	268	94	50	71
2003	43033	1849	5131	6782	2503	1303	683	184	55	69
2004	433254	31820	2477	3903	4830	1717	768	399	97	71
2005	81109	327668	22441	3155	3419	3255	1016	332	208	96
2006	39711	50097	194033	19968	3021	2716	2020	409	93	182
2007	16974	30121	28107	90917	13899	2208	1302	1025	224	181
2008	23704	12635	20811	14338	38863	8708	1659	563	408	182
2009	60498	23141	11971	13741	9537	12780	3175	504	362	163
2010	60944	33606	16145	7389	10022	5952	8022	1828	330	241
2011	11068	45917	20922	17816	6192	6534	3522	3505	1038	350
2012	6534	10865	42595	20700	18296	5150	3584	1911	1456	656
2013	2948	5086	8875	40597	17903	16403	3841	2125	1097	1017
2014	989	2191	4979	6969	31762	12972	9463	2376	1360	1054
2015	5494	980	2279	5124	8002	18528	8414	4267	1184	1126
2016	56429	6105	1498	1977	4209	5727	10056	4560	2170	1166
2017	3915	45588	6722	2134	2518	4295	5767	6609	2751	1446
2018	9302	3990	28559	6988	2259	2391	3373	4113	3509	2100
2019	8071	8028	4067	25470	6810	2165	1883	2212	2329	2856
2020	27958	6146	6929	4023	20595	5810	1584	1139	1172	2079

Table 16.7.2. Estimated fishing mortality at age.

Year Age	1	2	3	4	5	6	7	8	9	10
1973			0.001	0.023	0.045	0.075	0.142	0.267	0.355	0.355
1974			0.001	0.016	0.032	0.055	0.103	0.204	0.269	0.269
1975			0.003	0.039	0.078	0.114	0.168	0.269	0.258	0.258
1976			0.004	0.046	0.102	0.183	0.279	0.476	0.417	0.417
1977			0.003	0.054	0.133	0.236	0.372	0.626	0.618	0.618
1978			0.002	0.039	0.113	0.180	0.283	0.679	1.002	1.002
1979			0.003	0.058	0.173	0.256	0.544	1.201	1.304	1.304
1980			0.002	0.019	0.050	0.078	0.185	0.461	0.510	0.510
1981			0.001	0.006	0.024	0.064	0.175	0.447	0.495	0.495
1982			0.001	0.010	0.060	0.242	0.660	1.236	1.065	1.065
1983			0.005	0.054	0.210	0.471	0.736	0.850	0.699	0.699
1984			0.014	0.099	0.234	0.445	0.606	0.722	0.593	0.593
1985			0.024	0.093	0.174	0.250	0.262	0.268	0.247	0.247
1986			0.013	0.060	0.124	0.194	0.215	0.203	0.175	0.175
1987			0.007	0.050	0.103	0.176	0.261	0.334	0.419	0.419
1988			0.009	0.097	0.200	0.324	0.415	0.442	0.627	0.627
1989			0.007	0.104	0.227	0.336	0.448	0.446	0.850	0.850
1990			0.011	0.261	0.488	0.612	0.600	0.418	0.872	0.872
1991			0.015	0.481	1.015	1.108	1.285	0.931	1.481	1.481
1992			0.007	0.238	0.645	1.119	1.950	1.931	1.781	1.781
1993			0.003	0.041	0.107	0.200	0.329	0.606	0.609	0.609
1994			0.025	0.095	0.141	0.151	0.154	0.201	0.158	0.158
1995			0.016	0.035	0.058	0.055	0.053	0.077	0.070	0.070
1996			0.012	0.033	0.058	0.059	0.062	0.089	0.074	0.074
1997			0.012	0.045	0.086	0.094	0.108	0.152	0.117	0.117
1998			0.009	0.042	0.086	0.100	0.123	0.178	0.130	0.130
1999			0.003	0.018	0.034	0.039	0.050	0.075	0.058	0.058
2000			0.003	0.017	0.033	0.041	0.060	0.090	0.066	0.066
2001			0.001	0.010	0.020	0.026	0.041	0.062	0.045	0.045

Year Age	1	2	3	4	5	6	7	8	9	10
2002			0.001	0.016	0.034	0.049	0.080	0.116	0.077	0.077
2003			0.001	0.011	0.025	0.038	0.069	0.102	0.065	0.065
2004			0.001	0.010	0.025	0.043	0.089	0.131	0.074	0.074
2005			0.000	0.009	0.024	0.048	0.114	0.165	0.083	0.083
2006			0.001	0.018	0.046	0.063	0.078	0.060	0.026	0.026
2007			0.002	0.023	0.067	0.102	0.156	0.140	0.086	0.086
2008			0.005	0.060	0.198	0.254	0.300	0.163	0.087	0.087
2009			0.010	0.081	0.142	0.083	0.079	0.061	0.033	0.033
2010			0.001	0.012	0.038	0.042	0.052	0.046	0.029	0.029
2011			0.000	0.005	0.028	0.067	0.115	0.142	0.108	0.108
2012			0.000	0.004	0.027	0.069	0.113	0.166	0.136	0.136
2013			0.000	0.001	0.010	0.039	0.081	0.148	0.152	0.152
2014			0.000	0.001	0.011	0.040	0.089	0.167	0.171	0.171
2015			0.001	0.009	0.060	0.129	0.202	0.290	0.273	0.273
2016			0.002	0.016	0.090	0.163	0.200	0.265	0.278	0.278
2017			0.001	0.008	0.061	0.147	0.222	0.285	0.277	0.277
2018			0.000	0.004	0.036	0.111	0.198	0.302	0.340	0.340
2019			0.001	0.006	0.055	0.176	0.313	0.462	0.559	0.559
2020			0.001	0.005	0.042	0.136	0.301	0.494	0.611	0.611

Table 16.7.3. Short-term forecast for 2020 assuming that Catch = TAC_{2021} (26 091 t)

Variable	Value
$F_{ages\ 5–10}$ (2021)	1.03
SSB (2022)	42236
$R_{age\ 1}$ (2022)	9302
Total catch (2021)	26091 t

Rationale	Catch (2022)	F (2022)	SSB (2023)	% SSB change *	% advice change **	% TAC change ***
ICES advice basis						
MSY approach: F_{MSY}	8469	0.46	36643	-13%	+39%	-68%
Other scenarios						
F = 0	0	0	49226	+17%	-100%	-100%
F = F_{2020} (*status quo*)	14783	1.03	29061	-31%	+143%	-43%

16.20 Figures

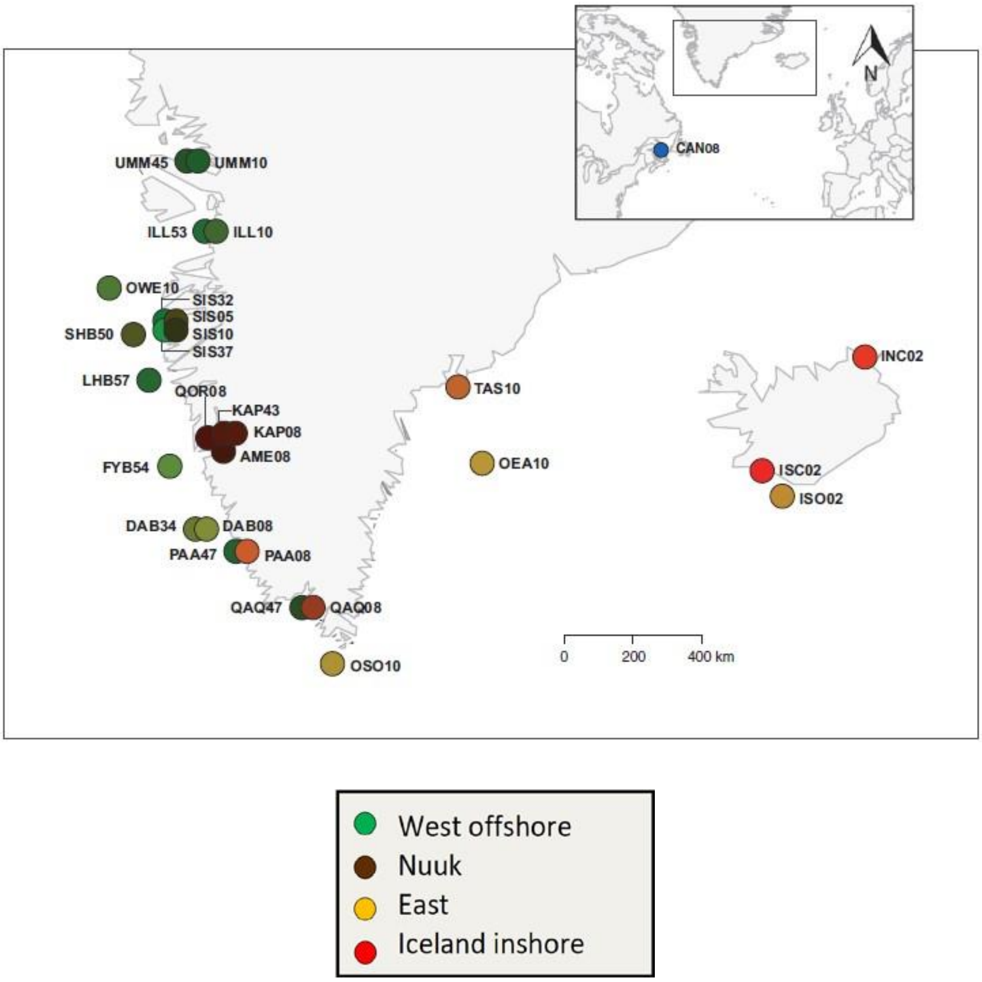

Figure. 16.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen *et al.*, 2013.

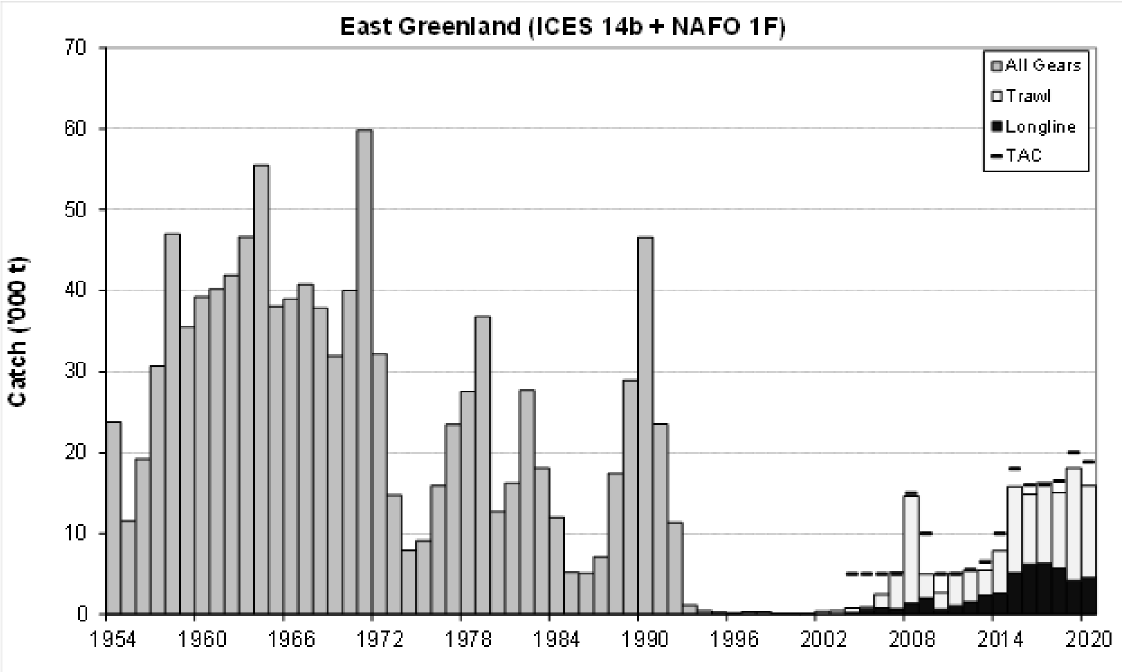

Figure 16.2.1. Annual total catch in South and East Greenland (NAFO Subarea 1F and ICES Subarea 14.b). From 2001 divided into gear. TAC until 2013 is for all the offshore area including West Greenland (NAFO Subarea 1A–1E).

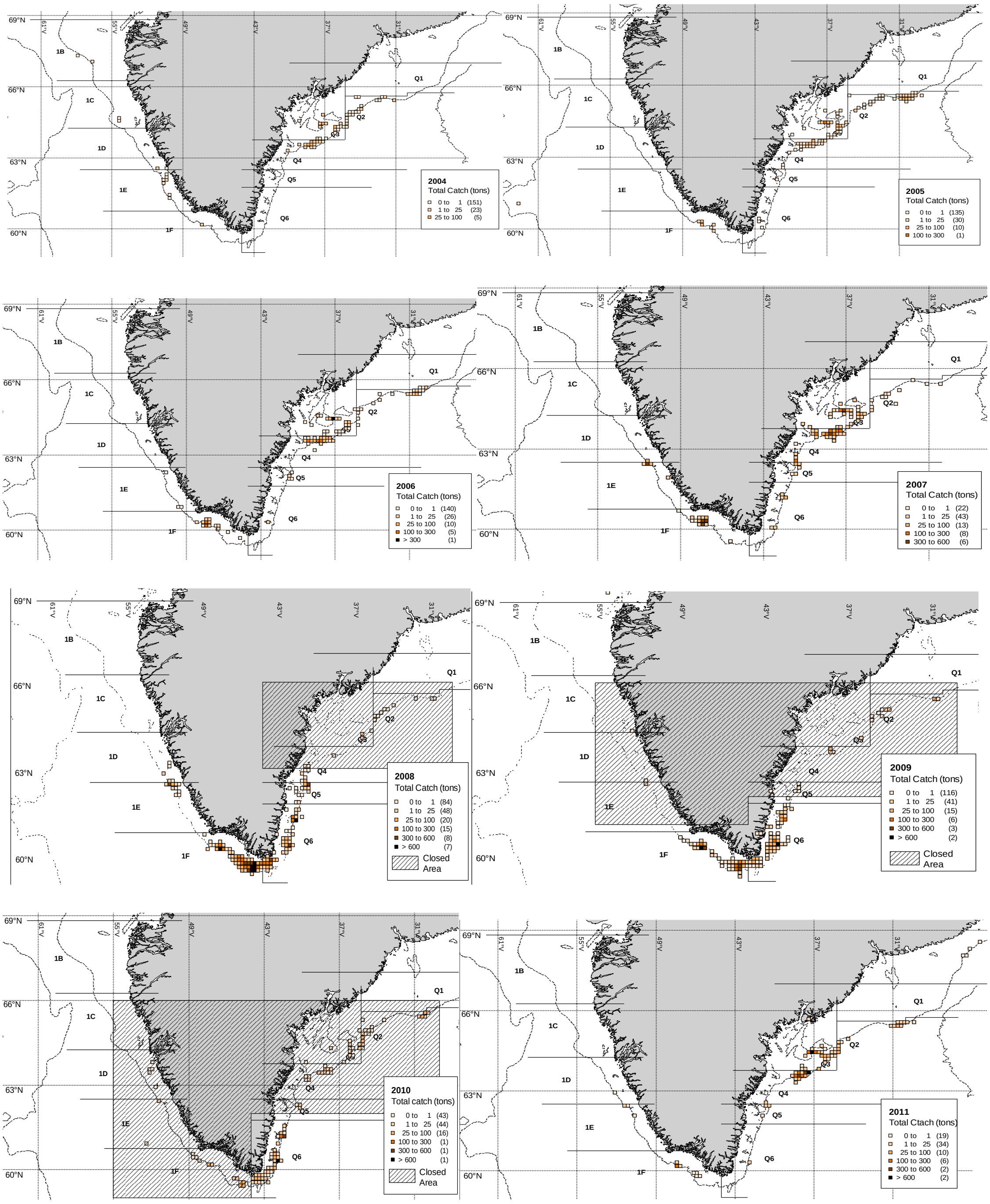

Figure 16.2.2: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

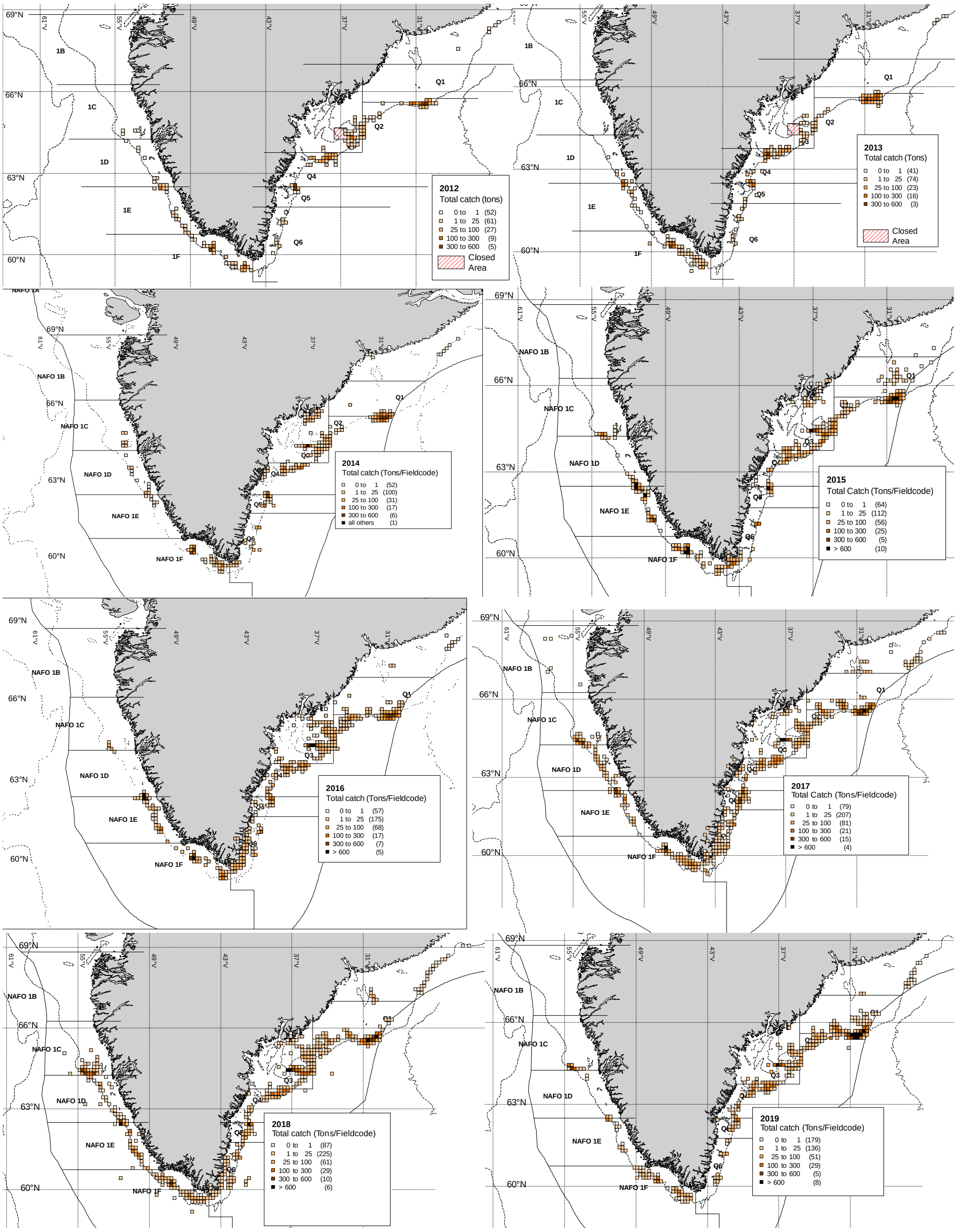

Figure 16.2.2: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

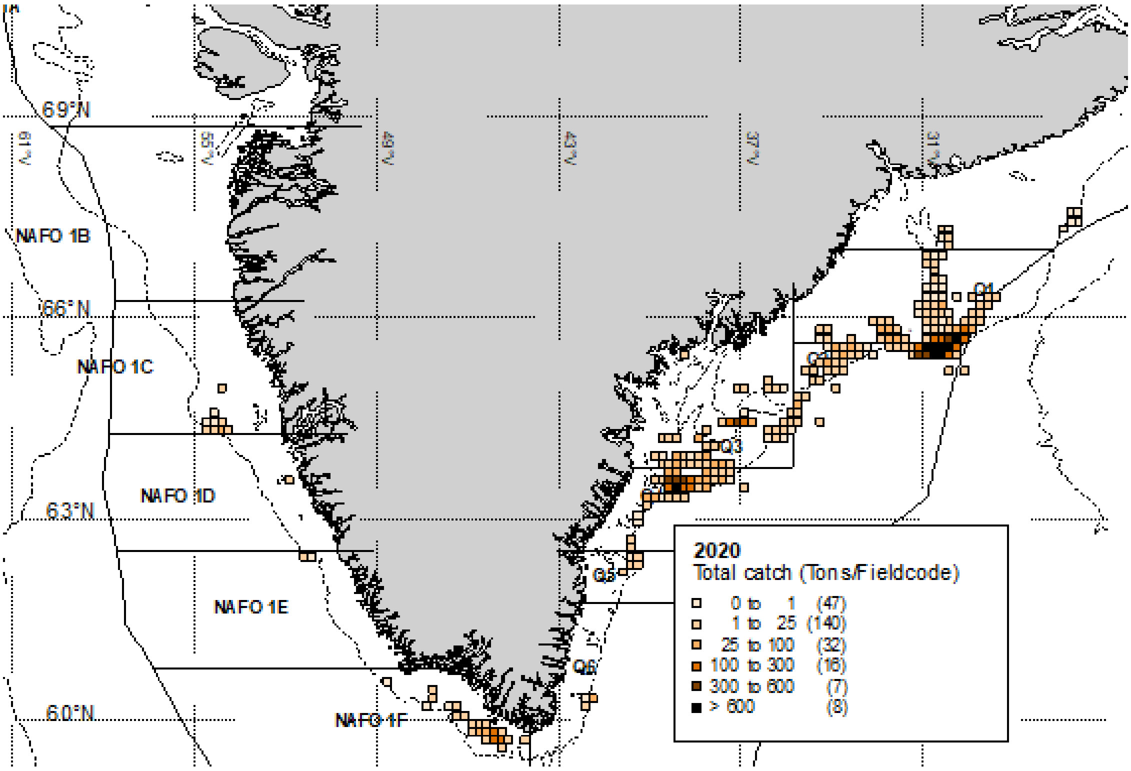

Figure 16.2.2: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

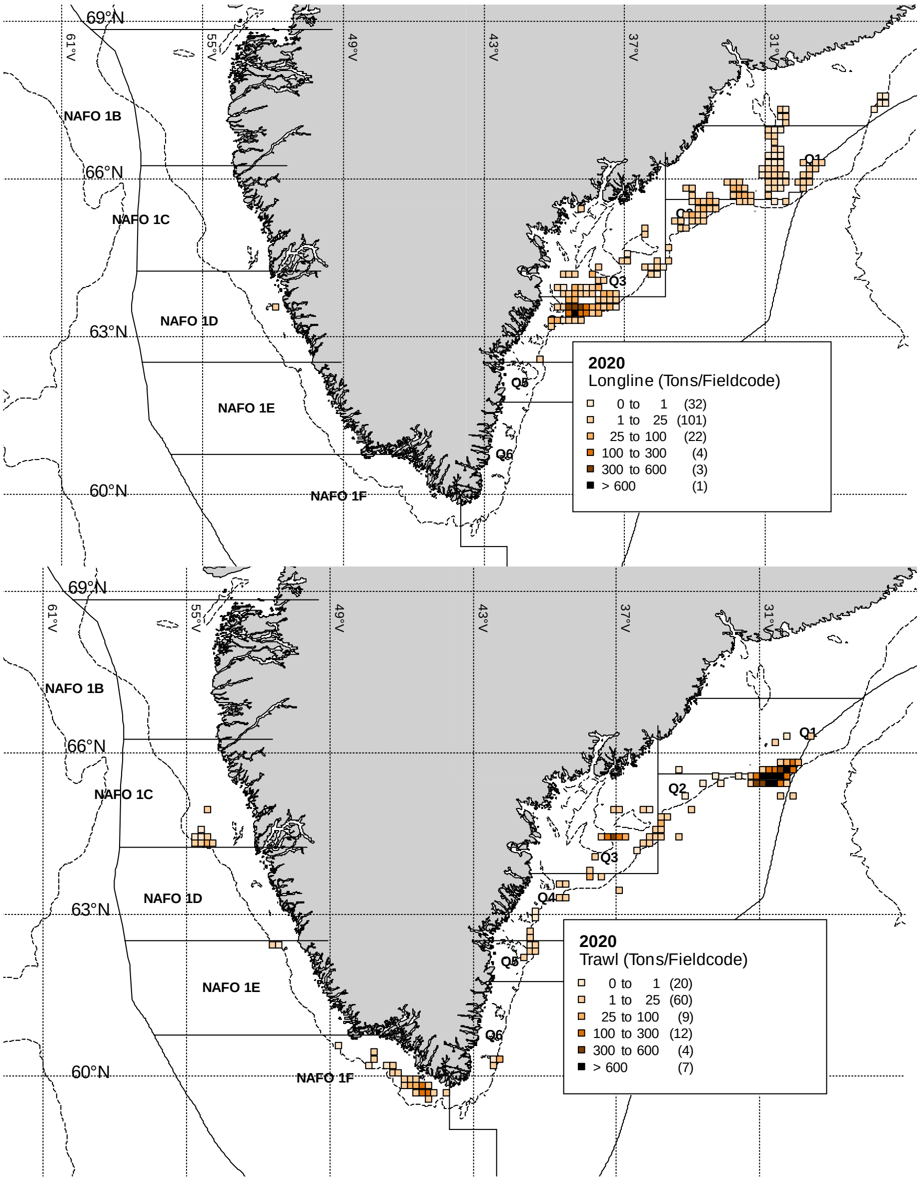

Figure 16.2.3: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

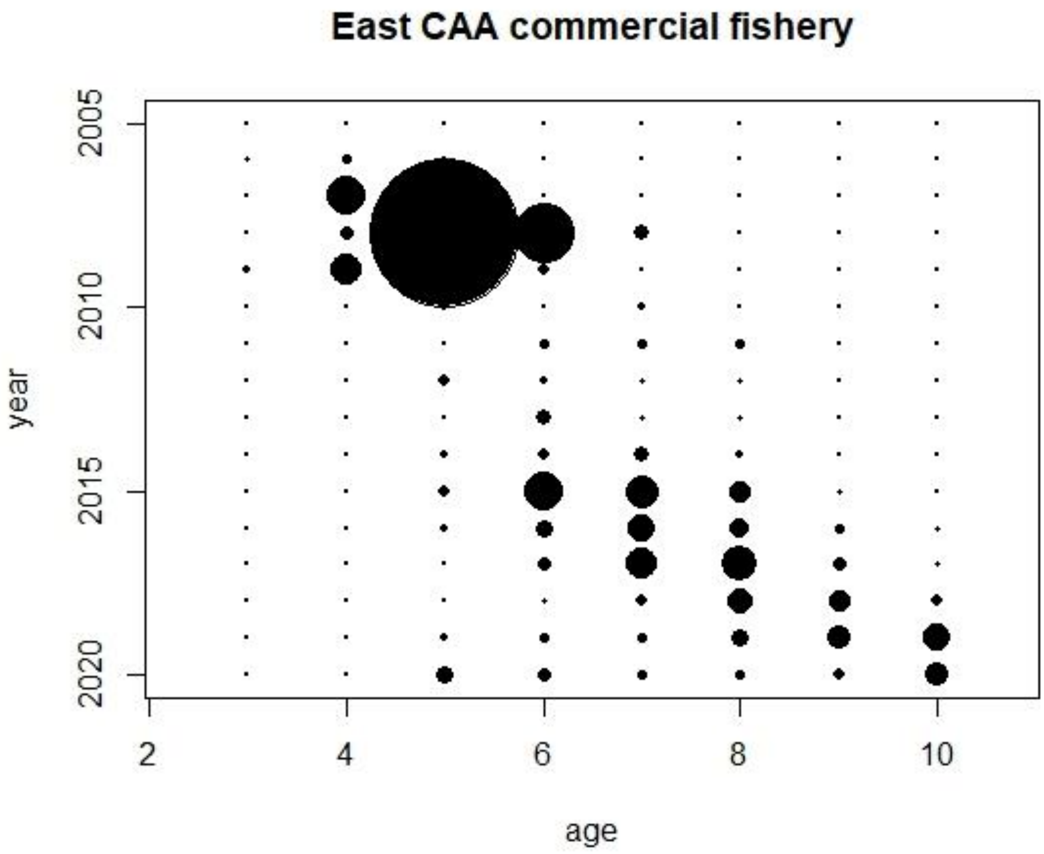

Figure 16.2.4: Catch at Age in the East Greenland (ICES 14. + NAFO 1F) commercial fishery. Size of circles represents size of catch numbers.

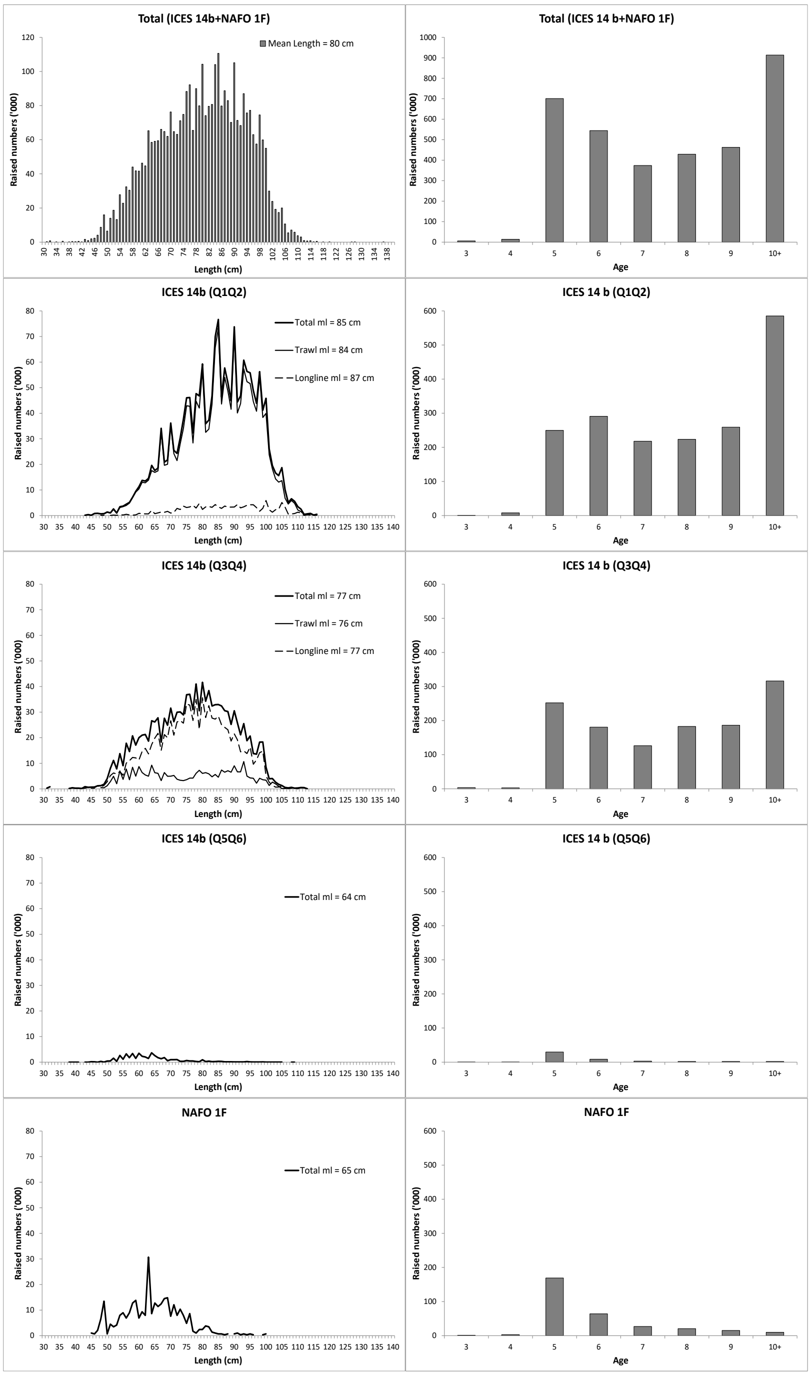

Figure 16.2.5. Age and Length distributions total and by gear of commercial cod catches in 4 management areas of South (ICES 14b (Q5Q6) + NAFO 1F) and East Greenland (Q1Q2 furthest north).

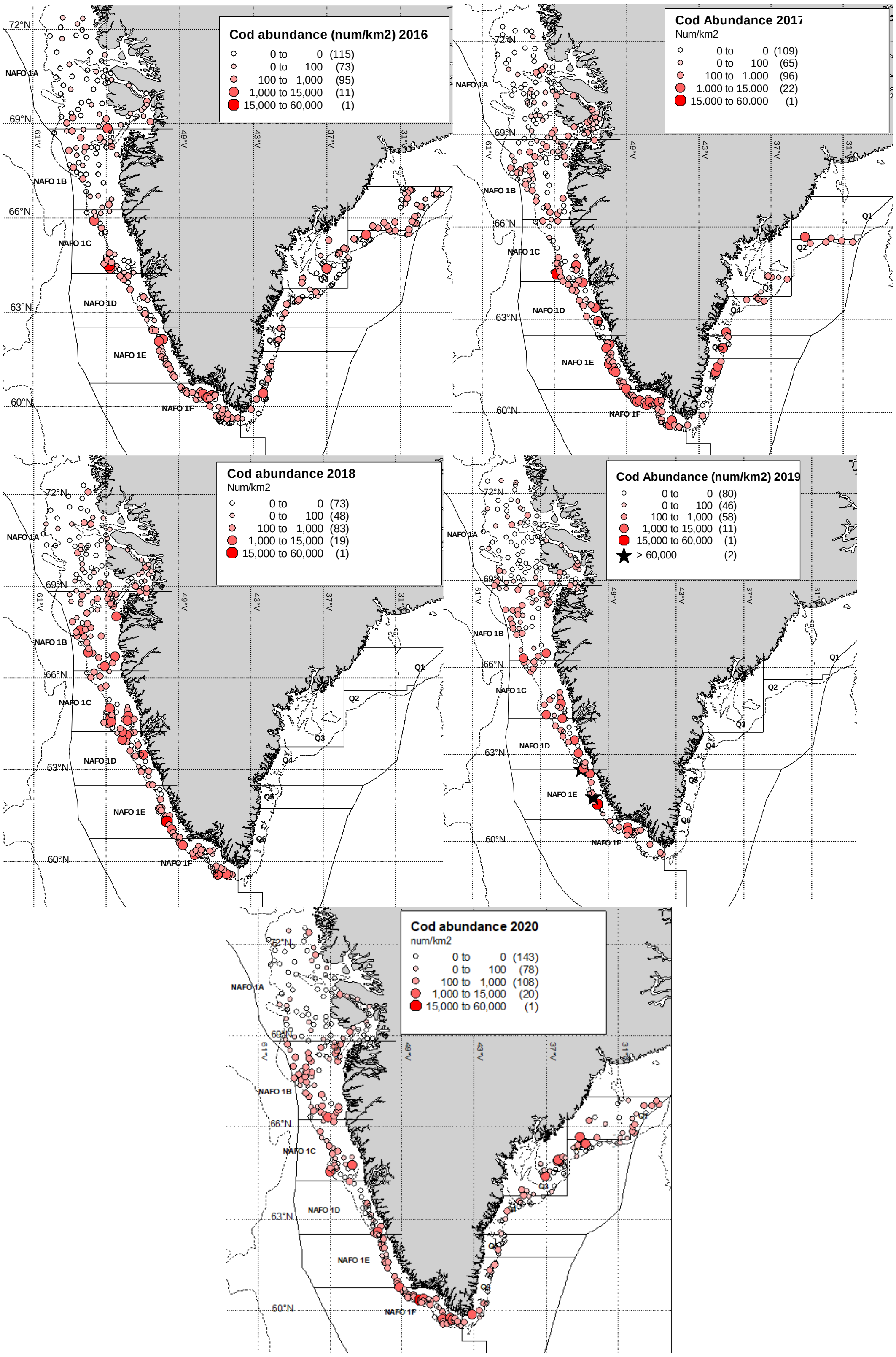

Figure 16.2.6. Greenland shrimp and fish survey. Abundance per km².

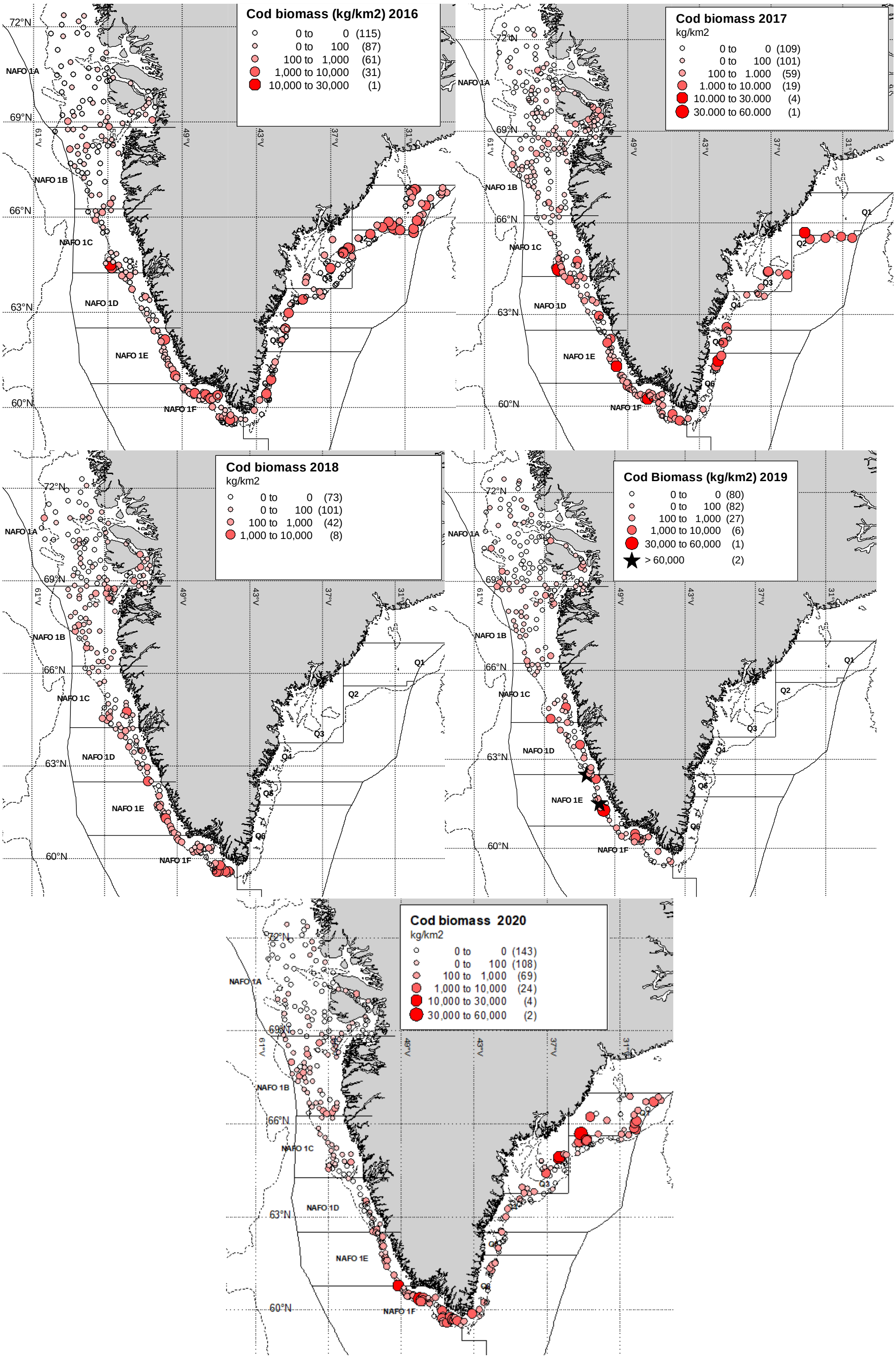

Figure 16.2.7. Greenland shrimp and fish survey. Catch weight kg per km²

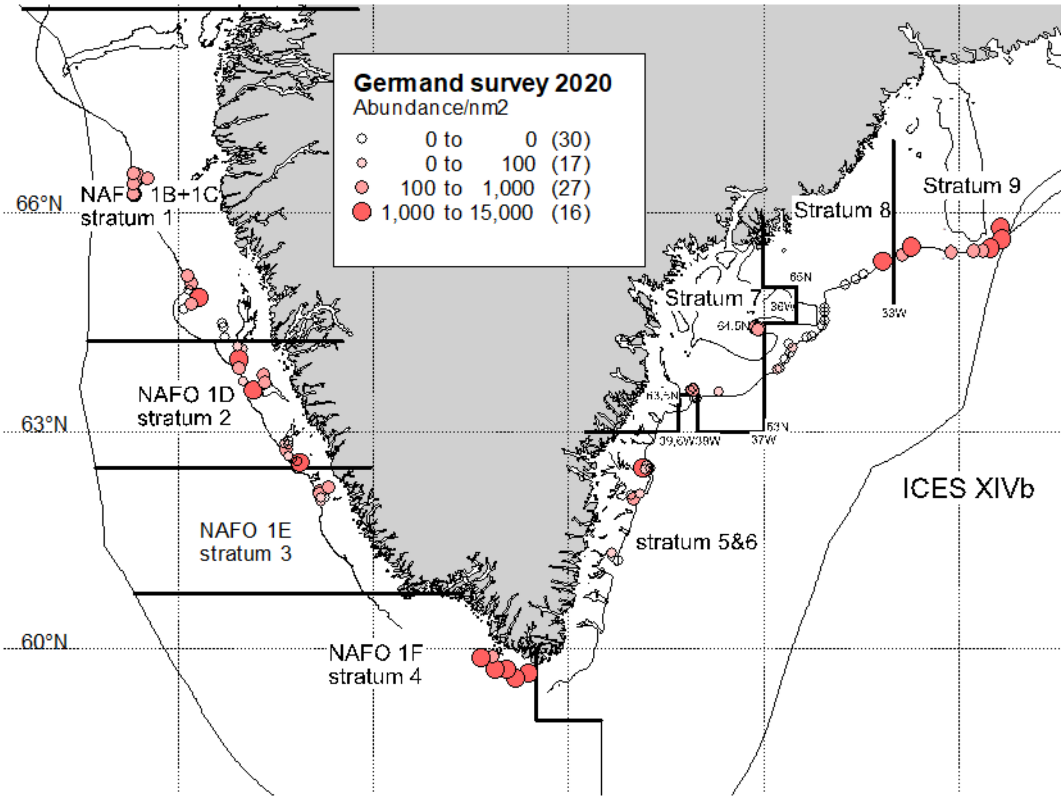

Figure 16.2.8. German ground fish survey. Abundance per nm².

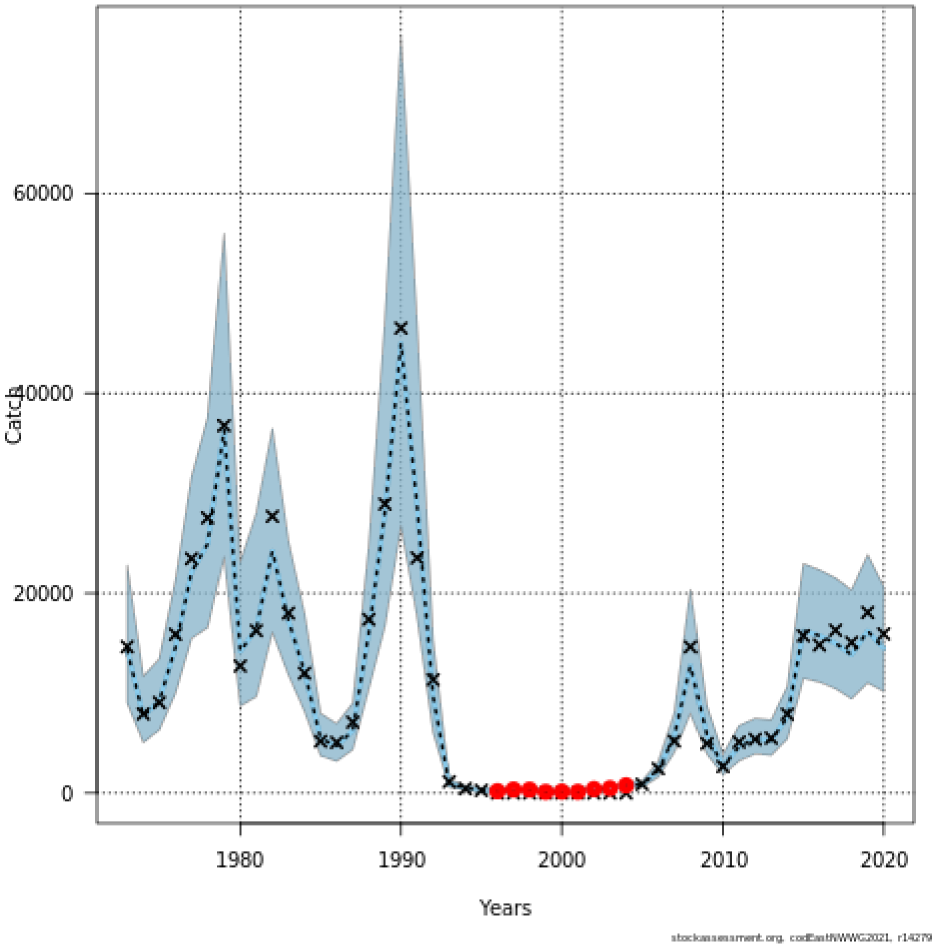

Figure 16.9.1. Estimated catch and with observed catch shown as crosses. Note the period 1996–2004 with near zero catches because no age disaggregated catch data were available.

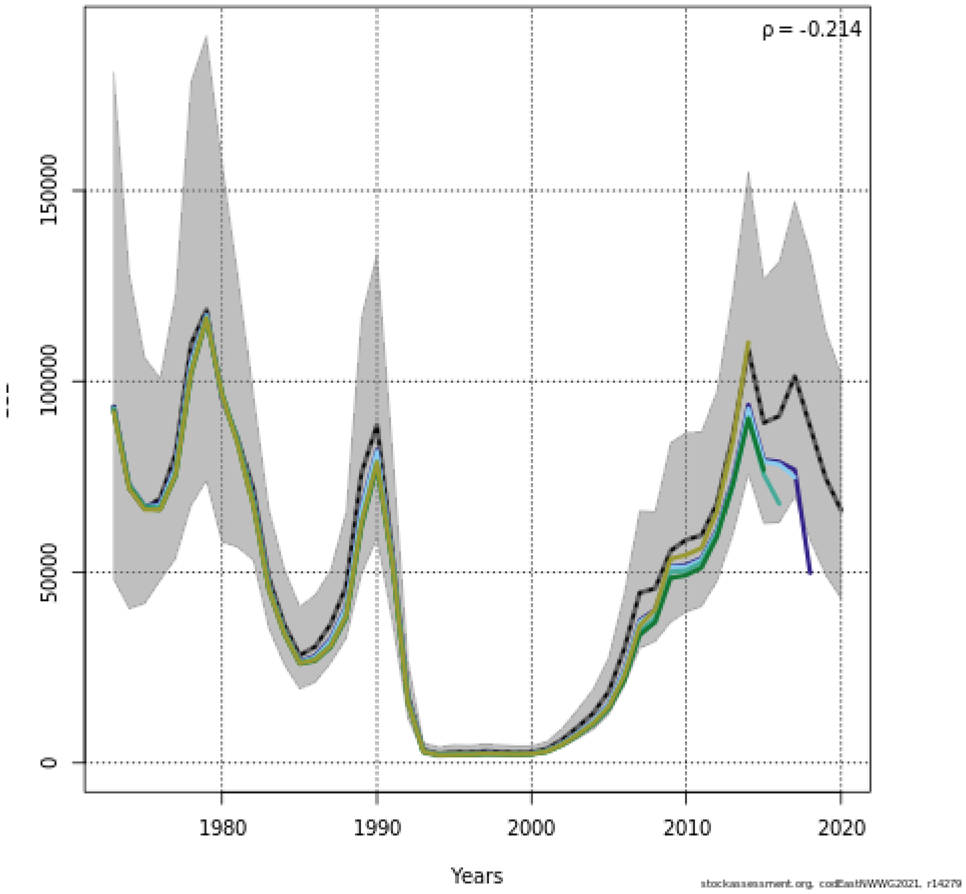

Figure 16.9.2. Retrospective plot of SSB.

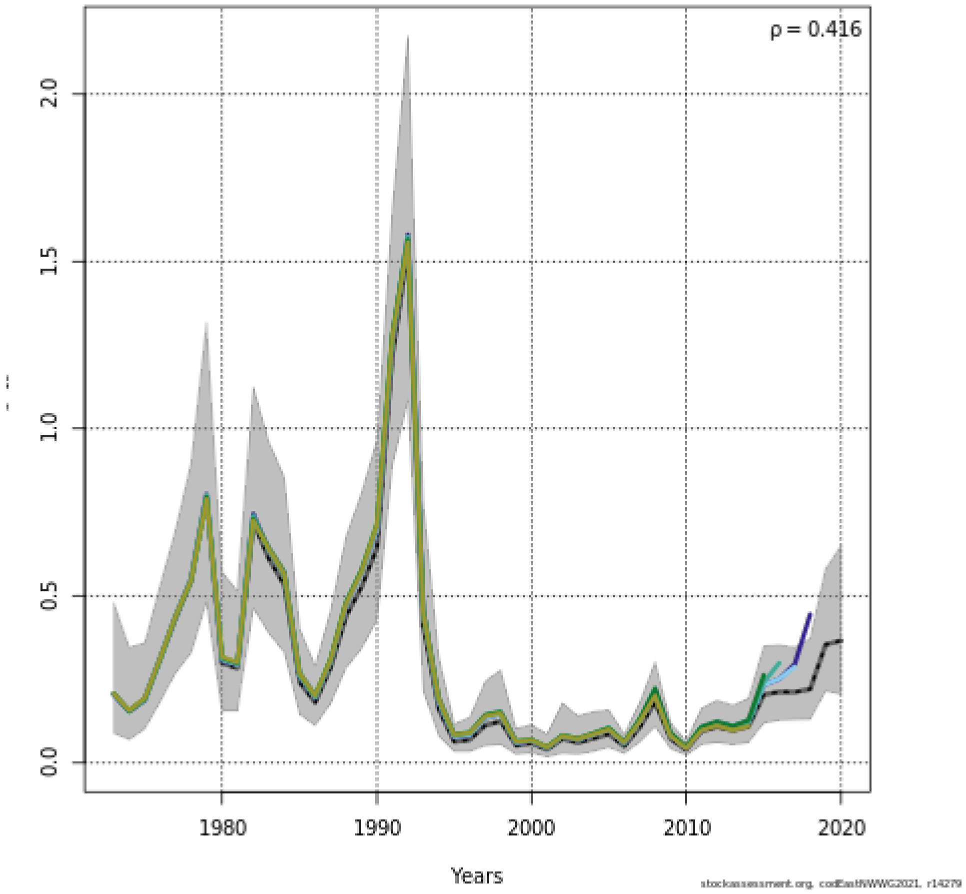

Figure 16.9.3. Retrospective plot of F5-10.

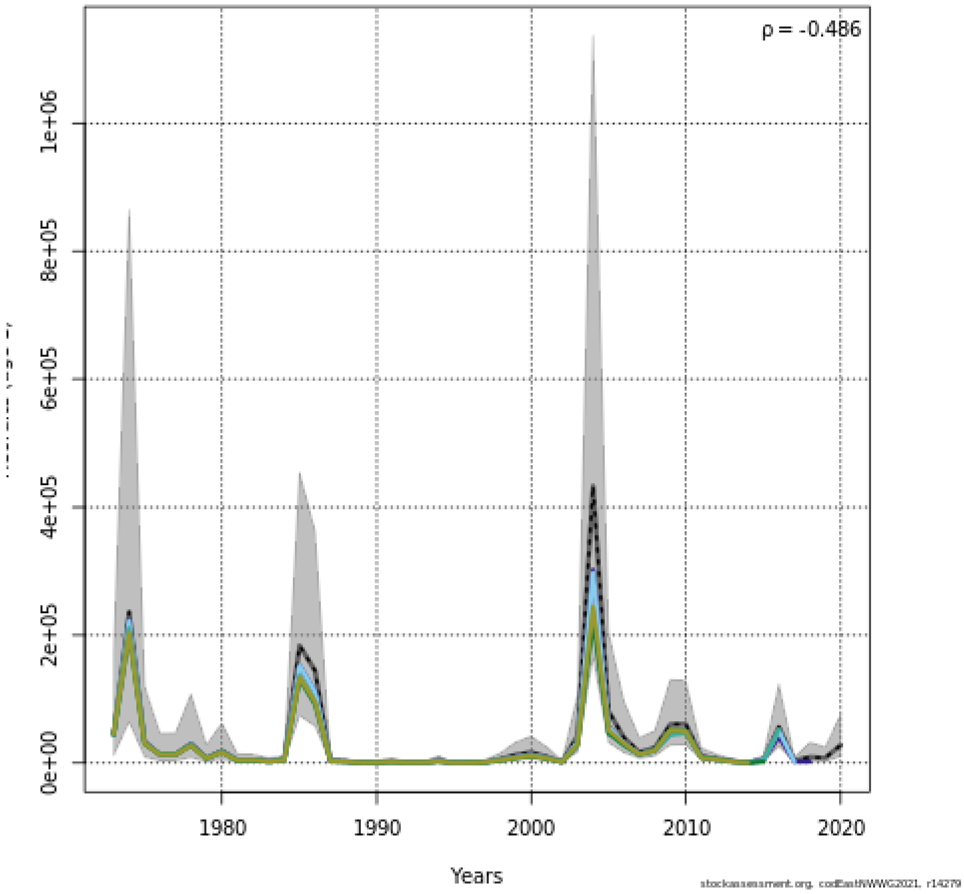

Figure 16.9.4. Retrospective plot of Recruits.

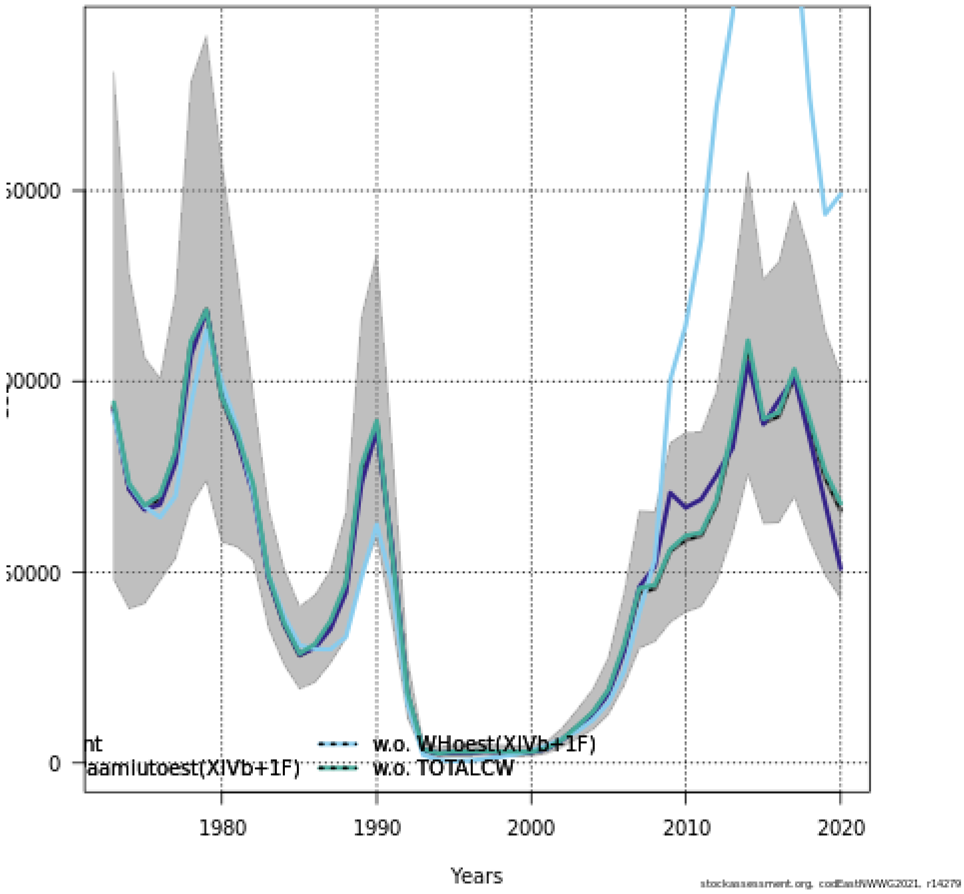

Figure 16.9.5. Leave out plot of SSB.

17 Greenland Halibut in Subareas 5, 6, 12, and 14

Greenland halibut in ICES Subareas 5, 6, 12 and 14 are assessed as one stock unit although precise stock associations are not known.

17.1 Catches, Fisheries, Fleet and Stock Perception

17.1.1 Catches

Total annual catches in Divisions 5.a, 5.b, and Subareas 6, 12 and 14 are presented for the years 1981–2020 in Tables 17.2.1–17.2.6 and since 1961 in Figure 17.2.1. Catches decreased in 2020 by 4% to 22 669 t. Landings in Iceland waters (usually allocated to Division 5.a) have historically predominated the total landings in areas 5+14, but since the mid-1990s also fisheries in Subarea 14 and Division 5.b have developed. Total landings have since 1997 been between 20 and 31 kt.

17.1.2 Fisheries and fleets

In 2020 quotas in Greenland EEZ and Iceland EEZ were almost utilized as in the preceding fishing years. In the Faroe EEZ the fishery is regulated by a fixed number of licenses and technical measures like by-catch regulations for the trawlers and depth and gear restrictions for the gillnetters. Catches in 5b decreased slightly in 2020 from 1986 t to 1919 t.

Most of the fishery for Greenland halibut in Divisions 5.a, 5.b and 14.b is still a directed trawl fishery, but a gillnet fishery has gained importance in Iceland where the proportions of both gillnets and longlines have increased especially in the northern area, where the catches in gillnets are now more than 50% of the catches in 5a. Only minor catches in 5a and 14b are taken as by-catches in a redfish fishery (see section 22 on Greenland slope redfish). No or insignificant discarding has been observed in this fishery.

Spatial distribution of the 2020 fishery and historic effort and catch in the trawl fishery in Subareas 5, 6, 12 and 14 is provided in Figures 17.2.2–3. Fishery in the entire area did in the past occur in a more or less 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 deeper than 1000 m at East Greenland (Figure 17.2.4). In recent years and in 2020 the distribution of the fishery covered all areas but bottom trawling has moved towards a more discontinuous distribution. Catches by gillnets has increased substantially in 5.a, north of Iceland and in 2019-20 a significant part of the landings were from gillnets (Figure 17.2.5).

In 2001–2008 a directed and a by-catch fishery by Spain, France, Lithuania, UK and Norway developed in the Hatton Bank area of Division 6.b, however, most of these fisheries ceased after 2008. Presently UK and France have a small fishery in the area. All catches in Subareas 6 and 12 are assumed to derive from the Hatton Bank area (Tables 17.2.5–17.2.6).

17.1.3 By-catch and discard

The Greenland halibut trawl fishery is mostly a clean fishery with little by-catches. Eventual by-catches are mainly redfish and cod. Southeast of Iceland the cod fishery and a minor Greenland halibut fishery are coinciding spatially. In East Greenland where fishery is located on the steep slope, fishing grounds for cod and redfish are close to the Greenland halibut fishing grounds, but nevertheless the catches from single hauls are clean catches of Greenland halibut.

The mandatory use of sorting grids in the shrimp fishery in Iceland since the late 1980s and in Greenland since 2002 was observed to have reduced by-catches considerably. Based on few samplings in 2006–2007, scientific staff observed by-catches of Greenland halibut to be less than 1% compared to about 50% by weight observed before the implementation of sorting grids (Sünksen, 2007). No information has since been available but the fishery in Division 14b generally report discard rates less than 1% by weight in logbooks.

17.2 Trends in Effort and CPUE

17.2.1 Division 5.a

Indices of CPUE for the Icelandic trawl fleet directed at Greenland halibut for the period 1985–2020 is provided in Table 17.3.1 and Figures 17.3.1–2. The overall CPUE index for the Icelandic fishery is compiled as the average of the standardised indices from four areas.

Catch rates of Icelandic bottom trawlers decreased for all fishing grounds during 1990–1996 (Figure 17.3.1), but have since peaked in 2001 and have in recent years been variable without a trend. The overall tendency is the same for four areas in 5a (Figure 17.3.2). In 2020 all areas but the southeast area increased significantly. The southeast area had a decrease in CPUE, however since this is only based on 4 hauls, the southeast area was omitted from the average calculation (used as input to the assessment).

17.2.2 Division 5.b

Information from logbooks from the Faroese otterboard trawl fleet (>1000 hp) was available for the years 1995-2020 (Table 17.3.1, Figure 17.3.3.). The bulk of the fishery has historically been on the south-east slope of the Faroe Plateau. CPUE has decreased drastically since 2009 coinciding with a significant increase in effort. Since a record low CPUE in 2018, catch rates have slightly increased in 2019 and 2020.

17.2.3 Division 14.b

CPUE and effort from logbooks in area 14 are provided in Table 17.3.1 and Figure 17.3.4–5. Following a period with relatively low After a record high in 2016 CPUE slightly decreased in 2017-2020 although still high.

CPUE series from Divisions 5a, 5b and 14b show different trends over the time indicating that the populations/areas could have different dynamics.

17.2.4 Divisions 6.b and 12.b

Since 2001 a fishery developed in Divisions 6.b and 12.b in the Hatton Bank area by Spain, UK and France. The recent catches are stable but small. Limited fleet information is available from this area (ICES WGDEEP).

17.3 Catch composition

Length compositions of catches from the commercial trawl fishery in Division 5a are rather stable from year to year. In Figure 17.3.1 length distributions are shown since 1996 from Icelandic trawlers. Norwegian length measurements are available for Subarea 14 and France has provided length measurements from Division 6.a.

17.4 Survey information

Three surveys are conducted in the distribution area of the Greenland halibut stock; in East Greenland (14.b), in Iceland waters (5.a) and in Faroese waters (5.b). The total surveyed area is provided in Figure 17.4.1. The two surveys in 5.a and 14.b are combined to one index and used as biomass index input for the assessment model. Since the Greenland survey in 14.b has not been conducted since 2016, the index from 2016 are used onwards. The distribution of the historic catch rates from the two surveys are provided in Figure 17.4.2.

17.4.1 Division 5.a

Since 2006 the total biomass of Greenland halibut has increased significantly in Icelandic waters until 2017 (Figure 17.4.3). In 2018 and 2019 the total biomass decreased significantly mainly due to lower abundance of smaller fish (less than 40 cm), but in 2020 biomass increased again (Figures 17.4.3 and 17.4.4). Given the continued low abundance of smaller fish, a decrease in total biomass is expected in the near future.

Catch composition data is available from the survey in Icelandic waters are illustrated in Figures 17.4.4 (size) and 17.4.5 (age).

17.4.2 Division 5.b

The catch rates from the available time series of the Faroese survey have declined from a record high level in 2012–13 to low levels in recent years. (Figure 17.4.6). Decreasing catch rates are also seen for the southeastern part of Iceland waters adjacent to division 5.b indicating a declining stock in this eastern part of its distribution area.

17.4.3 Division 14.b

The Greenland survey have not been conducted since 2016 due to out phasing of old research vessel and lack of ability to get vessel replacement for the years since then. It is expected that a new research vessel will be in operation in 2022. From 1995 to 2016 the total biomass index from this survey in 14.b did show a decreasing trend. The stock annex provides more extensive descriptions of all surveys.

17.5 Stock Assessment

17.5.1 Stock production model

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.

17.5.1.1 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 (Table 17.5.1). 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 1985–2020, $CPUE_t$, and a combined trawl-survey biomass index (5a and 14b) for 1996–2020, $Isur_t$,. From 2017 to 2020 the survey index is based on the Icelandic survey and the 2016 values from the Greenland survey due to lack Greenland survey data (see section 17.4.3). This is a necessary approach since the combined survey index is a sum of the two indices.

Total reported catch or WGs best estimates in ICES Subareas 5, 6, 12 and 14 1961–2020 was used as yield data (Table 17.5.1, Figure. 17.2.1). Since the fishery has no major discarding problems or misreporting, the reported catches were entered into the model as error-free.

17.5.1.2 Model performance

The model parameters were estimated (posterior) based on the prior assumptions (Table 17.5.2–3 and Figure 17.5.1). 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 (Figure 17.5.1). 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 703–1042 kt (Table 17.5.3).

The posterior for MSY was positively skewed with upper and lower quartiles at 27 kt and 39 kt (Table 17.5.3). As mentioned above, MSY was relatively insensitive to changes in prior distributions.

The model was able to produce a reasonable simulation of the observed data (Figure 17.5.2). The probabilities of getting more extreme observations than the realized ones given in the data series on stock size were in the range of 0.04 to 0.95 i.e. the observations did not lie in the extreme tails of their posterior distributions (Table 17.5.4). Exceptions are observed for the survey in 1997 ($p = 0.95$) and in 2019 ($p = 0.04$). The 2020 observations have, however, high residuals for both indices (-8% and 24%) both outside or at the quartiles of the model estimate (Figure. 17.5.2).

The retrospective runs suggest high consistency for both biomass and fishing mortality within +- 20% (range 3% - 4.3%, Figure 17.5.3).

17.5.1.3 Assessment results

The time series of estimated median biomass-ratios starts in 1960 as a virgin stock at K (2xB_{MSY}, Figure. 17.5.4–5). 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, B_{MSY}. 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 increased to nearly 80% of B_{MSY}. The median fishing mortality ratio (F/F_{MSY}) has exceeded F_{MSY} since the 1990s, but has in recent years decreased and are in 2020 below F_{MSY} (Figures 17.5.4–5 and Table 17.5.5–6). 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.

17.5.2 Short-term forecast and management options

The assumed catches for the intermediate year (2021) is 25 000 t based on agreed TACs for Iceland and Greenland EEZ and a continued catch level in Faroese waters.

Assuming catches of 25 000 t in 2021, a fishery at F_{MSY} ($F / F_{MSY} = 1$) in 2022 will lead to catches of 26 650 t (Table 17.5.7). Fishing at this level in 2022 will result in a 1% increase in biomass in 2023 and an increase in advice of 13%.

Biomass scenarios at various catch options are provided in Figures 17.5.6–7. Catches below 30 kt is estimated to lead to an increase in biomass, while catches of 30 kt will remain biomass at current level over the next decade (Figure 17.5.7). Only catches of less or equal to 20 kt will lead the biomass to reach BMSY within the next decade (Figure 17.5.6).

The risk trajectory associated with ten-year projections of stock development assuming a maintained annual catch in the entire period ranging from 0 to 30 kt were investigated (Figure 17.5.6.–7). The calculated risk is a result of the projected development of the stock and the increase in uncertainty as projections are carried forward. It must be noted that a catch scenario of a maintained constant catch over a decade without considering arrival of new biological information and advice is unrealistic.

Scenarios of fixed levels of fishing mortality ratios within the range of 0.3 to 1.7 were conducted and are shown in Figure 17.5.8. Present biomass is above the MSY $B_{trigger}$ (50% of B_{MSY}) and a fishery at F_{MSY} is advised according the ICES MSY advice rule. Fishing at F_{MSY} will result in slowly increasing yield the next decade.

17.5.3 Reference points

Reference points are unchanged from last benchmark in 2013 (WKBUT, ICES 2013).

17.6 Management considerations

Available biological information and information on distribution of the fisheries suggest that Greenland halibut in East Greenland, Iceland and Faroe Islands might be separated into subpopulations but that they do mix between these. Recent information of tagging experiments in the Barents Sea suggests high mixing be- tween the Barents Sea and Iceland. This connectivity is not accommodated for in the present assessment. At the forthcoming planned benchmark of the Greenland halibut stocks in this area (5,6,12 and 14) and the North East Arctic (1+2) scheduled for 2023, the stock identity of both stocks will be evaluated based on ongoing research projects.

A bilateral agreement between Iceland and Greenland since 2014 have limited the overall catches in recent years and assured that fishing pressure is around F_{MSY}. This agreement is no longer in place; however, Iceland and Greenland are following the agreement at large when setting TACs.

17.7 Data consideration and Assessment quality

The Icelandic CPUE series has for many years been used as a biomass indicator in the assessment of the stock. The CPUE of the Greenlandic trawlers and the biomass indices from the Faroese waters have not been used in the assessment, mainly because the stock production model is not able to accommodate contrasting indices (Icelandic CPUE and Greenlandic/Icelandic autumn surveys). A common analysis of all CPUE data from the stock area should possibly be utilized for a combined standardised CPUE index for the assessment. Likewise, the Faroese survey should be merged into a combined survey index. This lack of optimal usage of available information need to be solved at the next benchmark. Further work should also investigate effects of the changes in effort in 5.a as the proportion of landings from and distribution of effort of bottom trawls has been substantially reduced.

With the foreseen change to an age-based assessment more requirements will be put on biological sampling and sampling from the fisheries.

17.8 Research needs and recommendations

Stock structure and connectivity between the main fishing areas remains unquantified. Basic biological information on spawning and nursery grounds for the juveniles also remains poorly known. Trends of biomass indices over the entire assessment area are not similar and may suggest different dynamics between areas. Further, tagging experiments in the Barents Sea suggest a high connectivity with Iceland waters. Therefore, a compilation of present knowledge of stock identification for Greenland halibut in the East Greenland, Iceland, Faroese and Norwegian waters are being reviewed. Ongoing projects with trans-Atlantic participation from major fishery research institutes is presently analysing historic tag-recapture data with the objective to outline stock structure with focus on evaluating present stock entities in the entire North Atlantic. Further, stock structure are being investigated with several methods, such as. genetics, tagging, otolith microstructure, drift modelling and use of survey and fisheries data. These projects are running until 2022 and is expected to contribute with valuable biological information for the scheduled benchmark in 2023.

A number of issues on the quality of the input biomass indices to the present assessment model are questioned. The Icelandic CPUE series that is based on the principal trawler fleet is assumed to have undergone marked changes with respect to management regulations and spatial distribution. The possibility to estimate these effects by standardization of catch rates should be explored. Similar analyses should be conducted on the remaining CPUE series, in order to evaluate them as indicative of biomass development.

The present assessment model, a stock production model in Bayesian framework, is criticized for its behaviour in relation to the biomass indices. The models use of process error and sensitivity to various priors should be further scrutinized.

At the benchmark in 2013 (WKBUT, ICES 2013) an alternative assessment model, Gadget, was presented. Presently input to the Gadget model is not complete and the approach need further exploration and especially age data from the entire stock distribution area is required. The Gadget model will be a first alternative assessment model to the present stock production model at the next benchmark.

Ageing of Greenland halibut ceased for many of the marine institutes in Greenland, Iceland, Faroe Island and Norway around 2000 due to reading difficulties and lack of inter-calibration. A new method has been agreed upon and cooperation between institutes has been initiated in 2016 on age calibration. With respect to the Greenland halibut stock in 5,6,12 and 14 Iceland has now progressed so far that the 6 previous years otolith samplings has been read. The Greenland institute of Natural Resources has not yet begun ageing of otoliths from this stock. With an ALK some years back and assumptions on constant growth initial exercises with age-based assessment models should be conducted.

17.9 References

ICES. 2013. Report of the Benchmark Workshop on Greenland Halibut Stocks (WKBUT), 26–29 November 2013, Copenhagen, Denmark. ICES CM 2013/ ACOM:44. 367 pp.

ICES. 2017. Report of the Workshop on age reading of Greenland halibut 2 (WKARGH2), 22-26 August 2016, Reykjavik, Iceland. ICES CM 2016/SSGIEOM:16. 40 pp.

Sünksen, K. 2007. Bycatch in the fishery for Greenland halibut. WD 17, NWWG 2007.

17.10 Tables

Table 17.2.1 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Sub-areas 5,6,12 and 14 as officially reported to ICES and estimated by WG

Country	198	198	198	198	198	198	198	198	198	1
Denmark	-	-	-	-	-	-	6	+	-	-
Faroe Islands	76	1,53	1,146	2,50	1,05	85	1,09	1,37	2,31	1,
France	8	2	236	48	84	5	1	2	-	-
Germany	3,00	2,58	1,142	93	86	85	56	63	49	3
Greenland	+	1	5	1	8	17	15	3	1	40
Iceland	15,45	28,30	28,36	30,08	29,23	31,04	44,78	49,04	58,33	36,
Norway	-	-	2	2	3	+	2	1	3	50
Russia	-	-	-	-	-	-	-	-	-	-
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-	27
UK (Scotland)	-	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-	
Total	19,23	32,44	30,89	34,02	32,07	32,98	46,62	51,11	61,15	38,
Working Group estimate	-	-	-	-	-	-	-	-	61,39	39,

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Denmark	-	-	-	-	-	1	-			0
Faroe Islands	1,566	2,128	4,405	6,241	3,763	6,148	4,971	3,817	3,884	-
France	-	3	2	-	-	29	11	8	-	2
Germany	303	382	415	648	811	3,368	3,342	3,056	3,082	3,265
Greenland	66	437	288	867	533	1,162	1,129	747	200	1,740
Iceland	34,883	31,955	33,987	27,778	27,383	22,055	18,569	10,728	11,180	14,537
Norway	34	221	846	1,173 [1]	1,810	2,164	1,939	1,367	1,187	1,750
Russia	-	5	-	-	10	424	37	52	138	183
Spain								89		779
UK (Engl. and Wales)	38	109	811	513	1,436	386	218	190	261	370
UK (Scotland)	-	19	26	84	232	25	26	43	69	121
United Kingdom									-	166
Total	36,890	35,259	40,780	37,305	36,006	35,762	30,242	20,360	20,226	22,913
Working Group estimate	37,950	35,423	40,817	36,958	36,300	35,825	30,309	20,382	20,371	26,644

Country	2001	2002	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2007 [1]	2008 [1]	2009 [1]	2010 [1]
Denmark	-	-	-	-	-	-	-	-	-	-
Estonia	-	8	-	-	5	3	-	-	-	-
Faroe Islands	121	334	458	338	1,150	855	1,142	-	270	1,408
France	32	290	177	157	-	62	17	114	-	-
Germany	2,800	2,050	2,948	5,169	5,150	4,299	4,930	4,846	427	5,287
Greenland	1,553	1,887	1,459	-	-	-	155	-	2,819	-
Iceland	16,590	19,224	20,366	15,478	13,023	11,798	9,567	11,671	-	13,293
Ireland	56	-	-	-	-	-	-	-	-	-
Lithuania	-	-	2	1	-	2	3	566		-
Norway	2,243	1,998	1,074	1,233	1,124	1,097	78	639	124	233
Poland	2	16	93	207	-	-	-	1,354	988	960
Portugal	6	130	-	-	-	1,094	-	-	-	-
Russia	187	44	-	262	-	552	501	799	762	1,070
Spain	1,698	1,395	3,075	4,721	506	33	-	-	-	-
UK (Engl. and Wales)	227	71	40	49	10	1	-	-	-	-
UK (Scotland)	130	181	367	367	391	1	-	-	-	-
United Kingdom	252	255	841	1,304	220	93	17	422	581	577
Total	25,897	27,609	30,900	29,286	21,579	19,890	16,410	20,411	5,974	22,901
Working Group estimate	20,703	19,714	20,680	27,102	24,978	21,466	21,402	15,379	28,197	25,995

Country	2011 [1]	2012 [1]	2013 [1]	2014	2015 [1]	2016 [1]	2017 [1]	2018 [1]	2019 [1]	2020 [1]
Estonia	-	-	-	429	-	-	-	-	-	
Faroe Islands	1,705	2,811	2,788	3,393	3,214	4,656	3,999	2,949	1,973	1,888
France	150	67	133	-	117	88	51	71	78	97
Germany	5,782	4,620	3,814	3,701	3,808	4,420	2,994	4,463	4,483	4,769
Greenland	3,415	5,239	3,251	1,897	3,642	1,511	2,692	2,970	2,999	1,992
Iceland	13,192	13,749	14,859	9,861	12,400	12,652	11,926	15,214	12,390	12,535
Ireland	-	-	-	-	-	-	-	-	-	-
Lithuania	-	99	-	-	-	-	-	-	-	-
Norway	171	856	614	764	1,126	1,007	1,002	937	995	813
Poland	-	786	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-
Russia	1,095	1,168	1,369	587	600	600	599	400	398	399
Spain	-	-	-		110	2,105	114	125	82	100
United Kingdom	323	12	95		127	348	90	13	29	76
Total	25,693	29,407	26,923	20,743	25,145	27,388	23,466	27,142	23,428	22,669
Working Group estimate	26,347			21,069	25,677	25,397				

1) Provisional data

Table 17.2.2 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Division 5a, as officially reported to ICES and estimated by WG.

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989
Faroe Islands	325	669	33	46			15	379	719
Germany									
Greenland									
Iceland	15,455	28,300	28,359	30,078	29,195	31,027	44,644	49,000	58,330
Norway			+	+	2				
Total	15,780	28,969	28,392	30,124	29,197	31,027	44,659	49,379	59,049
Working Group estimate									59,272 [2]

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Faroe Islands	739	273	23	166	910	13	14	26	6
Germany					1	2	4		9
Greenland					1				
Iceland	36,557	34,883	31,955	33,968	27,696	27,376	22,055	16,766	10,580
Norway									
Total	37,296	35,156	31,978	34,134	28,608	27,391	22,073	16,792	10,595
Working Group estimate	37,308 [2]	35,413 [2]							

Country	1999	2000	2001	2002	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2,007 [1]
Faroe Islands	9		15	7	34	29	77	16	26
Germany	13	22	50	31	23	10	6	1	228
Greenland									155
			2,310 **	2,277 **	20,360	15,478	13,023	11,798	9,567
Norway							100		77
UK (E/W/I)	26	73	50	21	16	8	8	1	
UK Scotland	3	5	12	16	5	2	27	1	
UK									1
Total	11,138	14,607	2,437	2,352	20,438	15,527	13,241	11,817	10,054
Working Group estimate		14,607	16,752	19,714	20,415	15,477	13,172	11,817	10,054

Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]	2014 [1]	2015 [1]	2016 [1]
Faroe Islands	26	93	37	123	585	103	30	18	15
Germany	4	423	797	576	269	386	587	265	
Greenland	224	1285	64	157		92		1	
Iceland	11,671	15,765	13,293	13,192	6,459	14,859	9,859	12,309	12,652
Norway	15		39						
Russia	4								
Poland	3	270							
UK	179								
Total	12,126	17,837	14,230	14,048	7,313	15,440	10,476	12,593	12,667
Working Group estimate	11,859	15,782	14,230	14,048	14,603 [3]	15,440	10,476	12,593	12,667

Country	2017 [1]	2018 [1]	2019 [1]	2020 [1]
Faroe Islands	17	31		
Germany	246	552	259	
Greenland	3		1	110
Iceland	11,926	15,214	12,390	12,535
Norway				
Russia				
Poland				
UK	15			
Total	12,207	15,797	12,649	12,645
Working Group estimate				

1) Provisional data
2) Includes 223 t catch by Norway.
3) Includes 7290 t taken in SA14 in Iceland EEZ

Table 17.2.3 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Division 5b as officially reported to ICES and estimated by WG.

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989
Denmark	-	-	-	-	-	-	6	+	-
Faroe Islands	442	863	1,112	2,456	1,052	775	907	901	1,513
France	8	27	236	489	845	52	19	25	...
Germany	114	142	86	118	227	113	109	42	73
Greenland	-	-	-	-	-	-	-	-	-
Norway	2	+	2	2	2	+	2	1	3
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-
Total	566	1,032	1,436	3,065	2,126	940	1,043	969	1,589
Working Group estimate	-	-	-	-	-	-	-	-	1,606 [2]

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Denmark	-	-	-	-	-	-	-	-	
Faroe Islands	1,064	1,293	2,105	4,058	5,163	3,603	6,004	4,750	3,660
			3 [1]	2	1	28	29	11	8 [1]
Germany	43	24	71	24	8	1	21	41	
Greenland	-	-	-	-	-	-	-	-	
Norway	42	16	25	335	53	142	281	42 [1]	114 [1]
UK (Engl. and Wales)	-	-	1	15	-	31	122		
UK (Scotland)	-	-	1	-	-	27	12	26	43
United Kingdom	-	-	-	-	-				
Total	1,149	1,333	2,206	4,434	5,225	3,832	6,469	4,870	3,825
Working Group estimate	1,282 [2]	1,662 [2]	2,269 [2]	-	-		-	-	-

Country									
Denmark									
Country	1999	2000[1]	2001[1]	2002[1]	2003[1]	2004[1]	2005[1]	2006[1]	2007[1]
Denmark									
Faroe Islands	3873		106	13	58	35	887	817	1,116
France		1	32	4	8	17		40	9
Germany	22								
Norway	87	1	2	1	1		1		1
UK (Engl. and Wales)	9	35	77	50	24	41	2		
UK (Scotland)	66	116	118	141	174	87	204		
United Kingdom								19	1
Total	4057	153	335	209	265	180	1,094	876	1,127
Working Group estimate	0 [2]	5079	3,951	0	265	1,771	892	873	1,060

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016
Denmark									
Faroe Islands			1,037	1,476	2,149	2,560	2,953	3,139	4,633
France	36		35	1	13	20		28	16
Germany									
Iceland								45	
Ireland									
Norway	1	1	5				3	10	8
United Kingdom	32	117	336	11		2	2	9	
Total	69	118	1,413	1,489	2,162	2,582	2,958	3,231	4,658
Working Group esti-	1,759	1,739	1,413	1,489	2,162	2,582	2,958	3,231	4,658

Country	2017 [1]	2018 [1]	2019 [1]	2020 [1]
Denmark				
Faroe Islands	3,548	2,903	1,973	1,888
France	7	8	7	18
Germany				
Iceland				
Ireland				
Norway	6	5	1	2
United Kingdom	15	1	5	10
Total	3,576	2,917	1,986	1,919
Working Group estimate				

1) Provisional data

2) WGestimate includes additional catches as described in Working Group reports for each year and in the report from 2001.

Table 17.2.4 GREENLAND HALIBUT. Nominal landings (tonnes) by countries, in Sub-area 14 as officially reported to ICES and estimated by WG.

Country	1981	1982	1983	1984	1985	1986	1987	1988	1989
Faroe Islands	-	-	-	-	-	78	74	98	87
Germany	2,893	2,439	1,054	818	636	745	456	595	420
Greenland	+	1	5	15	81	177	154	37	11
Iceland	-	-	1	2	36	17	136	40	+
Norway	-	-	-	+	-	-	-	-	-
Russia	-	-	-	-	-	-	-	-	+
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-
Total	2,893	2,440	1,060	835	753	1,017	820	770	518
Working Group estimate	-	-	-	-	-	-	-	-	-
Country	1990	1991	1992	1993	1994	1995	1996	1997	1998
Denmark	-	-	-	-	-	-	1	+	+
Faroe Islands	-	-	-	181	168	147	130	148	151
Germany	293	279	311	391	639	808	3,343	3,301	3,399
Greenland	40	66	437	288	866	533	1,162	1,129	747 [1,7]
Iceland	-	-	-	19	82	7	-	1,803	148
Norway	8	18	196	511	1,120	1,668	1,881	1,897 [1]	1,253 [1]
Russia	-	-	5	-	-	10	424	37	52
UK (Engl. and Wales)	27	38	108	796	513	1405	264	218	190
UK (Scotland)	-	-	18	26	84	205	13		
United Kingdom	-	-	-	-	-	-	-		
Total	368	401	1,075	2,212	3,472	4,783	7,218	8,533	5,940
Working Group estimate	736 [2]	875 [3]	1,176 [4]	2,249 [5]	3,125 [6]	5,077 [7]	7,283	8,558	
Country	1999	2000	2001 [1]	2002 [1]	2003 [1]	2004 [1]	2005 [1]	2006 [1]	2007 [1]
Denmark									
Faroe Islands	2			274	366	274	186	22	
Germany	3,047	3,243	2,750	2,019	2,925	5,159	5,144	4,298	4,702
Greenland	200 [1,4]	1,740	1,553	1,887	1,459				
Iceland	93	30	14,280	16,947	6				
Ireland			7						
Norway	1,100	1,161	1,424	1,660	846	1,114	1,023	1,094	
Poland						205			
Portugal			6	130				1,094	
Russia	138	183	186	44		261		505	500
Spain		8	10		2,131	3,406	2		
UK (Engl. and Wales)	226	262	100						
UK (Scotland)				24	188	278	160		
United Kingdom				178	799	1,294			
Total	4,806	6,627	20,316	22,889	8,720	11,991	6,515	7,013	5,202
Working Group estimate	0	6958	0 [6]	0 [6]	0	9,854	10,185	8,589	10,261
Country	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]	2014 [1]	2015 [1]	2016 [1]
Estonia							429		
Faroe Islands		270	333		77	125	409	57	7
Germany	4,842	4	4,490	5,206	4,351	3,428	3,114	3,543	4,420
Greenland		2,819		3,258	5,239	3,159	1,897	3,641	1,511
Iceland					7,290		3	46	
Ireland									
Norway	637	29	226	164	853	613	761	1,115	996
Poland	1,354	718	960		786				
Portugal									
Russia	763		1,070	1,095	1,168	1,369	587	600	600
Spain									
United Kingdom	131	452	229	309	1	1			0
Total	7,727	4,292	7,308	10,032	19,765	8,694	7,200	9,002	7,534
Working Group estimate	9,005	9,805	10,402	10,761	12,475		7,526	9,534	7,534

Country	2017 [1]	2018 [1]	2019 [1]	2020 [1]
Estonia				
Faroe Islands	434	15	0	
Germany	2,747	3,911	4,225	4,769
Greenland	2,689	2,970	2,999	1,882
Iceland				
Ireland				
Norway	995	931	993	811
Poland				
Portugal				
Russia	599	400	398	399
Spain				
United King-	1	1	0	3
Total	7,466	8,228	8,615	7,864
Working Group	0	0	0	

1) Provisional data
2) WG estimate includes additional catches as described in working Group reports for each year and in the report from 2001.
3) Includes 125 t by Faroe Islands and 206 t by Greenland.
4) Excluding 4732 t reported as area unknown.
5) Includes 1523 t by Norway, 102 t by Faroe Islands, 3343 t by Germany, 1910 t by Greenland, 180 t by Russia, as reported to Greenland authorities.
6) Does not include most of the Icelandic catch as those are included in WG estimate of Va.
7) Excluding 138 t reported as area unknown.

Table 17.2.5 GREENLAND HALIBUT. Nominal landings (tonnes) by countries in Sub-area 12, as officially reported to the ICES and estimated by WG.

Country	1996	1997	1998	1999	2000	2001	2002	2003[1]	2004[1]
Faroe Islands		47					40		
France					1			4	30
Ireland						49			
Lithuania								2	1
Poland						2		2	1
Spain[2]	2	42	67	137	751	1338	28	730	1145
UK					7	5			
Russia									
Norway	2				553	500	316	201	119
Estonia									
Total	4	89	67	137	1,312	1,894	384	939	1,296
WG estimate									

Country	2005[1]	2006[1]	2007[1]	2008[1]	2009[1]	2010[1]	2011[1]	2012[1]	2013[1]
Faroe Islands							106		
France									
Ireland									
Lithuania		2	3	566				97	
Poland									
Spain[2]	501								
UK	3								
Russia		46	1		762				
Norway					94				
Estonia		2							
Total	504	50	4	566	856	0	106	97	0
WG estimate	504	50	4	566	856	0	106	97	0

Country	2014[1]	2015[1]	2016[1]	2017[1]	2018[1]	2019[1]	2020[1]
Faroe Islands							
France							
Ireland							
Lithuania							
Poland							
Spain[2]	67	91	78	74	95	62	75
UK							
Russia							
Norway			0				
Estonia							
Total	67	91	78	74	95	62	75
WG estimate	67	91	78	74	95	62	

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.2.6 GREENLAND HALIBUT. Nominal landings (tonnes) by countries in Sub-area 6, as officially reported to the ICES and estimated by WG.

Country	1996	1997	1998	1999	2000	2001	2002	2003 [1]	2004 [1]
Estonia							8		
Faroe Islands									
France							286	165	110
Poland							16	91	1
Spain [2]			22	88	20	350	1367	214	170
UK					159	247	77	42	10
Russia						1			1
Norway					35	317	21	26	
Total	0	0	22	88	214	915	1775	538	292
WG estimate									

Country	2005 [1]	2006 [1]	2007 [1]	2008 [1]	2009 [1]	2010 [1]	2011 [1]	2012 [1]	2013 [1]
Estonia	5	1							
Faroe Islands						1			0
France		22	8	114		38	8	54	113
Poland									
Spain [2]	3	33							
UK	217	74	15	80	12	11	3	11	93
Russia		1		32					
Norway		3		1	3	2	7	3	1
Lithuania				968				2	
Total	225	134	23	1195	15	52	18	70	207
WG estimate	225	134	23	1195	15	52	18	70	207

Country	2014 [1]	2015 [1]	2016 [1]	2017 [1]	2018 [1]	20191	20201
Estonia							
Faroe Islands	1		1				
France		89	72	44	63	71	79
Poland							

Spain [2]		18	17	39	30	21	25
UK	42	119	348	58	12	24	63
Russia						0	
Norway	0	1	3	1	0	0	
Lithua-nia							
Total	43	227	440	142	105	117	167
WG estimate	43	227	440	142	105	117	167

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.3.1. CPUE indices from trawl fleets in Division 5.a, 5.b and 14.b as derived from GLM multiplicative models.

area	year	rel. CPUE	% change in CPUE between years	landings (tonnes)	relative derived effort	% change in effort between years
Iceland 5a	1985	1.00		29,197	29	
	1986	0.98	-2	31,027	32	8
	1987	0.93	-5	44,659	48	52
	1988	0.88	-5	49,379	56	17
	1989	0.78	-11	59,272	76	35
	1990	0.75	-4	37,308	50	-34
	1991	0.74	-1	35,413	48	-4
	1992	0.67	-9	31,978	48	0
	1993	0.53	-21	34,134	64	34
	1994	0.44	-18	28,608	65	2
	1995	0.35	-20	27,391	78	19
	1996	0.30	-14	22,073	73	-7
	1997	0.32	6	16,792	52	-28
	1998	0.51	57	10,595	21	-60
	1999	0.57	12	11,138	20	-6
	2000	0.60	6	14,607	24	24
	2001	0.62	2	16,752	27	12
	2002	0.49	-21	19,714	41	49
	2003	0.36	-26	20,415	57	41
	2004	0.30	-17	15,477	52	-9
	2005	0.28	-6	13,172	47	-10
	2006	0.38	34	11,817	31	-33
	2007	0.47	25	10,525	22	-29
	2008	0.40	-13	9,580	24	5
	2009	0.42	4	15,782	37	58
	2010	0.42	-1	13,565	33	-13
	2011	0.44	4	14,048	32	-1
	2012	0.46	5	7,312	16	-50
	2013	0.47	2	15,439	33	107
	2014	0.43	-7	10,475	24	-27
	2015	0.46	8	12,593	27	12
	2016	0.45	-3	12,667	28	4
	2017	0.43	-5	12,207	29	1
	2018	0.41	-4	15,797	39	35
	2019	0.51	24	12,649	25	-36
	2020			12,645		
Greenland 14b	1991	1.0		875	1	
	1992	1.0	-3	1,176	1	39
	1993	2.5	157	2,249	1	-26
	1994	3.3	32	3,125	1	6
	1995	3.2	-1	5,077	2	64
	1996	3.1	-3	7,283	2	49
	1997	3.2	3	8,558	3	14
	1998	3.1	-3	5,940	2	-28
	1999	2.4	-24	5,376	2	19
	2000	2.1	-10	6,958	3	43
	2001	2.3	6	7,216	3	-2
	2002	2.4	8	6,621	3	-15
	2003	2.5	0	8,017	3	21
	2004	2.3	-7	9,854	4	32
	2005	3.2	40	10,185	3	-26
	2006	3.3	4	8590	3	-19
	2007	3.1	-6	10261	3	26
	2008	3.1	0	8,952	3	-13
	2009	2.6	-17	10,567	4	41
	2010	2.7	4	10,402	4	-5
	2011	2.7	0	10,761	4	4
	2012	3.2	17	12,475	4	-1
	2013	3.0	-8	12,476	4	8
	2014	3.1	5	7,526	2	-43
	2015	3.5	12	9,534	3	13
	2016	4.4	26	7,534	2	-37
	2017	4.2	-3	7,466	2	3
	2018	4.1	-3	8,228	2	14
	2019	4.0	-3	8,615	2	8
	2020	3.8	-5	7,864	2	-4
Faroe Islands 5b	1995	1.0		3,832	4	
	1996	1.0	-2	6,469	7	72
	1997	1.0	-1	4,870	5	-24
	1998	0.9	-3	3,825	4	-19
	1999	1.0	4	4,057	4	2
	2000	1.0	-1	5,079	5	26
	2001	1.0	0	3,951	4	-22
	2002	0.9	-6	209	0	-94
	2003	1.0	6	265	0	19
	2004	0.9	-6	1,771	2	609
	2005	0.9	1	892	1	-50
	2006	0.9	1	873	1	-3
	2007	0.9	-4	1,060	1	27
	2008	1.0	6	1,759	2	57
	2009	1.0	3	1,739	2	-4
	2010	0.9	-5	1,413	2	-14
	2011	0.9	1	1,489	2	4
	2012	1.0	3	2,162	2	41
	2013	0.9	-8	2,582	3	30
	2014	0.9	6	2,958	3	8
	2015	0.9	-5	3,231	4	15
	2016	0.9	1	4,658	5	42
	2017	0.9	-6	3,576	4	-18
	2018	0.8	-6	2,917	4	-13
	2019	0.8	3	1,986	2	-34
	2020	0.8	2	1,919	2	-5

Table 17.5.1. Assessment input data series: Catch by the fishery; three indices of stock biomass – a standardized catch rate index based on fishery data (CPUE) from the Iceland EEZ, a combined Icelandic and Greenland research survey index.

Year	Catch (ktons)	CPUE (index)	Survey (ktons)
1960	0	-	-
1961	0.029	-	-
1962	3.071	-	-
1963	4.275	-	-
1964	4.748	-	-
1965	7.421	-	-
1966	8.030	-	-
1967	9.597	-	-
1968	8.337	-	-
1969	26.200	-	-
1970	33.823	-	-
1971	28.973	-	-
1972	26.473	-	-
1973	20.463	-	-
1974	36.280	-	-
1975	23.494	-	-
1976	6.045	-	-
1977	16.578	-	-
1978	14.349	-	-
1979	23.622	-	-
1980	31.157	-	-
1981	19.239	-	-
1982	32.441	-	-
1983	30.891	-	-
1984	34.024	-	-
1985	32.075	1.76	-
1986	32.984	1.73	-
1987	46.622	1.63	-
1988	51.118	1.55	-
1989	61.396	1.84	-
1990	39.326	1.32	-
1991	37.950	1.31	-
1992	35.487	1.18	-

1993	41.247	0.94	-
1994	37.190	0.77	-
1995	36.288	0.62	-
1996	35.932	0.54	63.8
1997	30.309	0.57	81.1
1998	20.382	0.89	90.4
1999	20.371	1.00	87.9
2000	26.644	1.06	91.4
2001	27.291	1.08	104.0
2002	29.158	0.86	60.8
2003	30.891	0.63	48.8
2004	27.102	0.52	34.9
2005	24.249	0.49	54.7
2006	21.432	0.66	36.1
2007	20.957	0.82	46.9
2008	22.169	0.71	54.1
2009	27.349	0.74	78.4
2010	25.995	0.74	54.2
2011	26.424	0.77	67.3
2012	29.309	0.81	79.1
2013	27.045	0.82	83.8
2014	21.069	0.76	73.3
2015	25.677	0.82	78.7
2016	25.397	0.79	72.2
2017	23.466	0.75	84.0
2018	27.141	0.73	58.8
2019	23.428	0.85	45.8
2020	22.669	0.94	58.5
2021*	25.000		

*assumed

Table 17.5.2. Priors used in the assessment model. ~ means "distributed as..", dunif = uniform-, dlnorm = lognormal-, dnorm= normal- and dgamma = gammadistributed. Symbols as in text.

Parameter		Prior	
Name	Symbol	Type	Distribution
Maximal Suatainable Yield	*MSY*	reference	dunif(1,300)
Carrying capacity	*K*	low informative	dnorm(750,300)
Catchability Iceland survey	q_{Ice}	reference	$\ln(q_{Ice})$~dunif(-3,1)
Catchability Greenland survey	q_{Green}	reference	$\ln(q_{Green})$~dunif(-3,1)
Catchability Iceland CPUE	q_{cpue}	reference	$\ln(q_{cpue})$~dunif(-10,1)
Initial biomass ratio	P_1	informative	dnorm(2,0.071)
Precision Iceland survey	$1/\sigma^2_{Ice}$	low informative	dgamma(2.5,0.03)
Precision Greenland survey	$1/\sigma^2_{Green}$	low informative	dgamma(2.5,0.03)
Precision Iceland CPUE	$1/\sigma^2_{cpue}$	low informative	dgamma(2.5,0.03)
Precision model	$1/\sigma^2_P$	reference	dgamma(0.01,0.01)

Table 17.5.3. Summary of parameter estimates: mean, standard deviation (sd) and 25, 50, and 75 percentiles of the posterior distribution of selected parameters (symbols as in the text).

	Mean	sd	25%	Median	75%
MSY (ktons)	32.45	9.22	26.79	32.08	37.77
K (ktons)	876	240	703	867	1042
r	0.16	0.07	0.12	0.15	0.20
q_{cpue}	0.003	0.001	0.002	0.003	0.003
q_{Survey}	0.24	0.09	0.18	0.22	0.28
P_{1985}	1.56	0.11	1.48	1.56	1.64
P_{2020}	0.82	0.18	0.70	0.81	0.93
σ_{cpue}	0.09	0.02	0.08	0.09	0.10
σ_{Survey}	0.21	0.03	0.18	0.20	0.23
σ_P	0.15	0.02	0.13	0.15	0.17

Table 17.5.4. Model diagnostics: residuals (% of observed value), probability of getting a more extreme observation (p.extreme; see text for explanation).

	CPUE		Survey	
Year	resid (%)	Pr	resid (%)	Pr
1985	-2.88	0.59		-
1986	-1.25	0.54		-
1987	1.03	0.46		-
1988	3.02	0.40		-
1989	-8.81	0.77		-
1990	3.43	0.38		-
1991	-2.04	0.57		-
1992	-3.15	0.61		-
1993	0.41	0.49		-
1994	0.70	0.48		-
1995	4.81	0.35		-
1996	11.55	0.17	-20.55	0.82
1997	14.48	0.11	-36.16	0.95
1998	-2.69	0.60	-19.71	0.82
1999	-1.70	0.56	-4.30	0.58
2000	-1.69	0.56	-2.39	0.54
2001	-4.61	0.65	-16.27	0.77
2002	-4.35	0.64	14.81	0.25
2003	0.91	0.47	11.02	0.31
2004	1.93	0.43	26.27	0.12
2005	8.47	0.23	-17.87	0.79
2006	-7.41	0.73	37.38	0.04
2007	-12.75	0.86	27.67	0.11
2008	0.33	0.48	12.05	0.29
2009	1.57	0.45	-19.56	0.81
2010	-0.48	0.52	15.26	0.24
2011	0.66	0.48	-1.33	0.52
2012	1.24	0.46	-11.83	0.71
2013	1.07	0.47	-16.50	0.77
2014	4.17	0.36	-7.72	0.64
2015	0.47	0.49	-10.93	0.69
2016	1.33	0.46	-5.07	0.59

	CPUE		Survey	
Year	resid (%)	Pr	resid (%)	Pr
2017	4.01	0.37	-22.81	0.85
2018	2.38	0.42	8.65	0.35
2019	-7.37	0.73	39.01	0.04
2020	-8.12	0.74	23.80	0.14

Table 17.5.5. Stock status for 2020 and predicted to the end of 2021 assuming catches of 25000 t in 2021.

Status	2020	2021
Risk of falling below B_{lim} (0.3B_{MSY})	0%	0%
Risk of falling below B_{MSY}	100%	79%
Risk of exceeding F_{MSY}	59%	44%
Risk of exceeding F_{lim} (1.7F_{MSY})	9%	9%
Stock size (B/Bmsy), median	0.78	0.80
Fishing mortality (F/Fmsy),	1.02	0.94
Productivity (% of MSY)	95%	96%

Table 17.5.6. Summary of assessment. High and low refer to 95% confidence limits.

Year	B/Bmsy	high	low	Catch (ktons)	F/Fmsy	high	low
1960	2.001	2.142	1.861	0.000	0.000	0.000	0.000
1961	2.001	2.134	1.864	0.029	0.000	0.001	0.000
1962	2.001	2.131	1.868	3.071	0.047	0.104	0.028
1963	1.993	2.122	1.862	4.275	0.066	0.146	0.039
1964	1.983	2.113	1.855	4.748	0.074	0.162	0.043
1965	1.974	2.105	1.847	7.421	0.116	0.255	0.068
1966	1.960	2.092	1.834	8.030	0.126	0.277	0.074
1967	1.947	2.080	1.820	9.597	0.152	0.333	0.089
1968	1.932	2.067	1.804	8.337	0.133	0.291	0.077
1969	1.923	2.058	1.794	26.200	0.421	0.920	0.244
1970	1.871	2.016	1.735	33.823	0.560	1.218	0.322
1971	1.809	1.967	1.654	28.973	0.498	1.075	0.282
1972	1.768	1.933	1.601	26.473	0.467	1.007	0.262
1973	1.739	1.908	1.566	20.463	0.367	0.796	0.204
1974	1.726	1.896	1.554	36.280	0.655	1.434	0.363
1975	1.677	1.860	1.490	23.494	0.438	0.958	0.240
1976	1.665	1.849	1.476	6.045	0.113	0.250	0.062
1977	1.696	1.870	1.515	16.578	0.304	0.683	0.166
1978	1.698	1.871	1.513	14.349	0.263	0.596	0.143
1979	1.705	1.876	1.515	23.622	0.430	0.985	0.235
1980	1.688	1.864	1.494	31.157	0.573	1.318	0.312
1981	1.654	1.841	1.454	19.239	0.361	0.834	0.195
1982	1.653	1.843	1.448	32.441	0.609	1.417	0.328
1983	1.620	1.821	1.408	30.891	0.592	1.384	0.316
1984	1.594	1.805	1.374	34.024	0.663	1.559	0.351
1985	1.564	1.787	1.332	32.075	0.638	1.510	0.334
1986	1.545	1.963	1.230	32.984	0.664	1.582	0.334
1987	1.486	1.919	1.166	46.622	0.975	2.319	0.490
1988	1.441	1.873	1.128	51.118	1.102	2.623	0.553
1989	1.523	1.984	1.173	61.396	1.258	3.003	0.618
1990	1.231	1.612	0.960	39.326	0.993	2.353	0.495
1991	1.158	1.510	0.900	37.950	1.022	2.427	0.507
1992	1.032	1.344	0.801	35.487	1.072	2.543	0.532
1993	0.851	1.107	0.665	41.247	1.509	3.598	0.754

Year	B/Bmsy	high	low	Catch (ktons)	F/Fmsy	high	low
1994	0.699	0.913	0.548	37.190	1.654	3.920	0.825
1995	0.586	0.770	0.460	36.288	1.919	4.559	0.970
1996	0.545	0.724	0.428	35.932	2.040	4.850	1.029
1997	0.592	0.793	0.463	30.309	1.586	3.776	0.795
1998	0.782	1.024	0.611	20.382	0.814	1.921	0.401
1999	0.887	1.152	0.694	20.371	0.716	1.693	0.356
2000	0.941	1.220	0.736	26.644	0.883	2.098	0.438
2001	0.931	1.211	0.724	27.291	0.915	2.173	0.451
2002	0.743	0.961	0.581	29.158	1.222	2.909	0.609
2003	0.574	0.742	0.451	30.891	1.674	3.999	0.840
2004	0.478	0.619	0.375	27.102	1.761	4.206	0.891
2005	0.481	0.628	0.378	24.249	1.566	3.730	0.789
2006	0.554	0.715	0.429	21.432	1.207	2.884	0.600
2007	0.653	0.847	0.501	20.957	1.003	2.387	0.494
2008	0.643	0.830	0.503	22.169	1.205	2.866	0.603
2009	0.678	0.880	0.532	27.349	1.255	2.983	0.627
2010	0.664	0.860	0.521	25.995	1.216	2.887	0.609
2011	0.699	0.906	0.549	26.424	1.177	2.785	0.588
2012	0.739	0.961	0.580	29.309	1.235	2.922	0.616
2013	0.748	0.975	0.587	27.045	1.126	2.666	0.560
2014	0.713	0.935	0.560	21.069	0.918	2.181	0.457
2015	0.743	0.967	0.584	25.677	1.075	2.552	0.534
2016	0.722	0.939	0.567	25.397	1.095	2.593	0.545
2017	0.703	0.920	0.554	23.466	1.038	2.456	0.516
2018	0.674	0.874	0.529	27.141	1.252	2.978	0.627
2019	0.714	0.922	0.550	23.428	1.024	2.443	0.508
2020	0.785	1.025	0.595	22.669	0.901	2.181	0.440
2021	0.803	1.226	0.527				

Table 17.5.7. Catch forecast. Assumptions for 2020 and catch scenarios for 2021.

Variable		Value		Notes	
F (2021) (F/F_{MSY})		0.94		F/Fmsy set eq to catches of	
Biomass (2022) (B/B_{MSY})		0.833		B/BMSY when fishing at F/FMSY=0.94	
Total catch (2021)		25000 t		Based on TACs of Iceland, Greenland, and	
Basis	Total catch (2022)	F_{total} (2022) F/F_{MSY}	Biomass (2023) B/B_{MSY}	% Biomass change	% advice change*
ICES advice basis					
MSY approach:	26650	1.0	0.84	1.22	13.26
Other scenarios					
F = 0	0	0	0.89	6.47	-100
$F = F_{2020}$	25380	0.94	0.85	2.12	7.86
$F = F_{lim}$	45310	1.70	0.80	-4.451	92.6

17.11 Figures

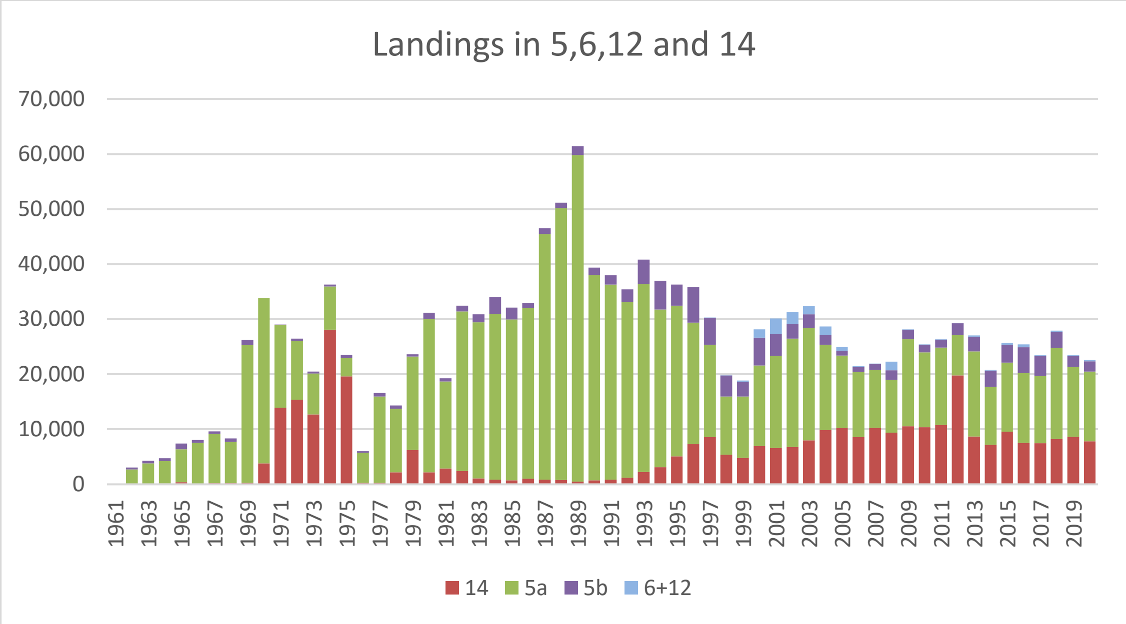

Fig. 17.2.1. Landings of Greenland halibut in Divisions 5, 6, 12 and 14. As the landings within Icelandic waters, since 1976, have not officially been separated and reported according to the defined ICES statistical areas, they are set under area 5a by the NWWG. In 2012 Icelandic landings in Div 14 were only partly recorded in 14, while for remaining years all landings are recorded in 5a.

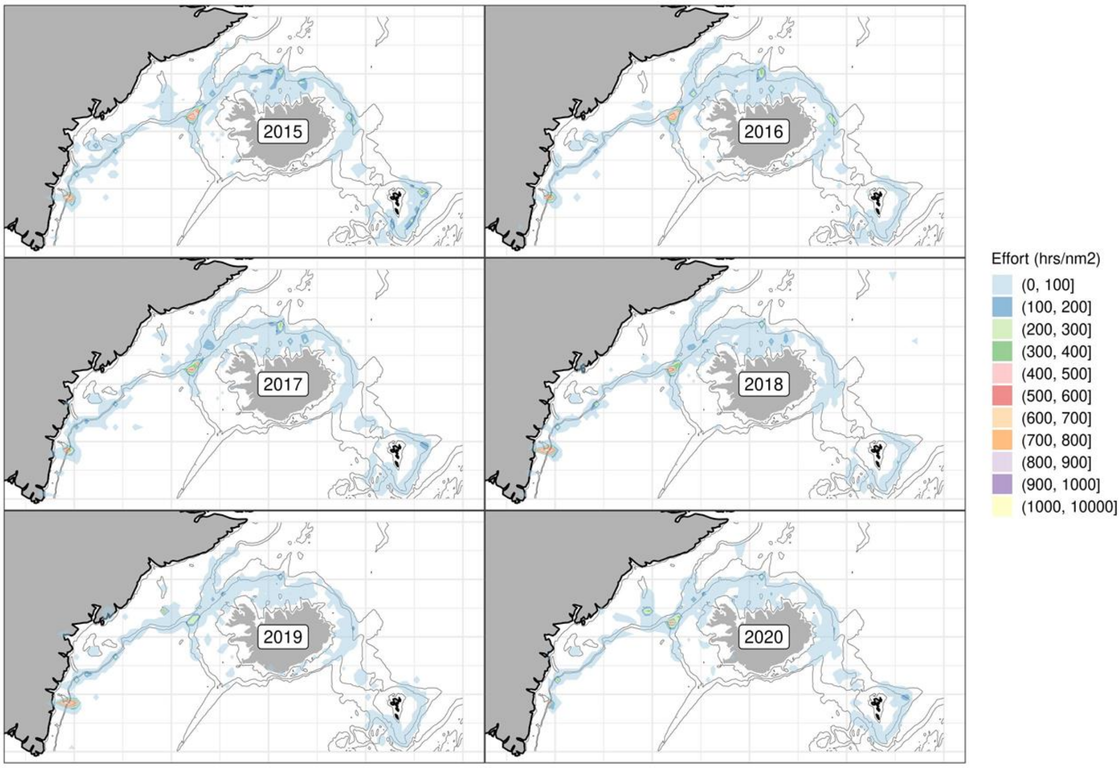

Fig. 17.2.2 Greenland halibut 5+14. Distribution of fishing effort 2015-2020. 500m and 1000 m depth contours are shown.

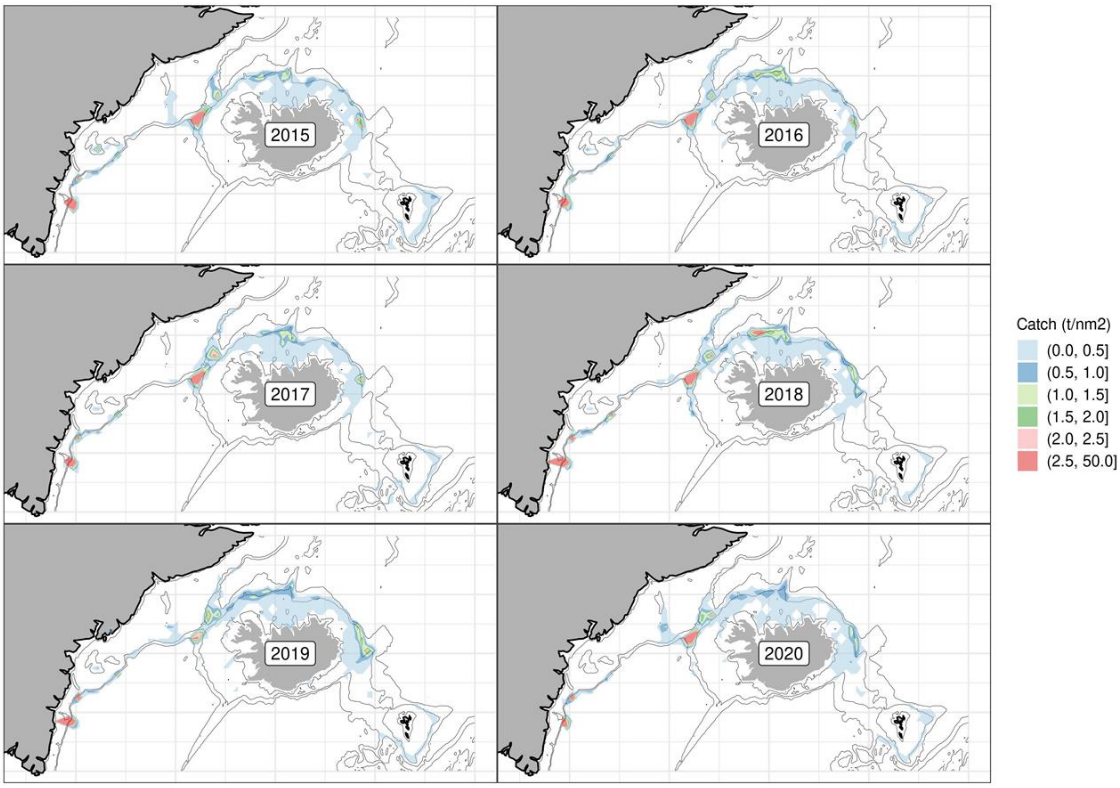

Fig. 17.2.3. Greenland halibut V+XIV. Distribution of catches in the fishery 2015-2020. 500m and 1000 m depth contours are shown.

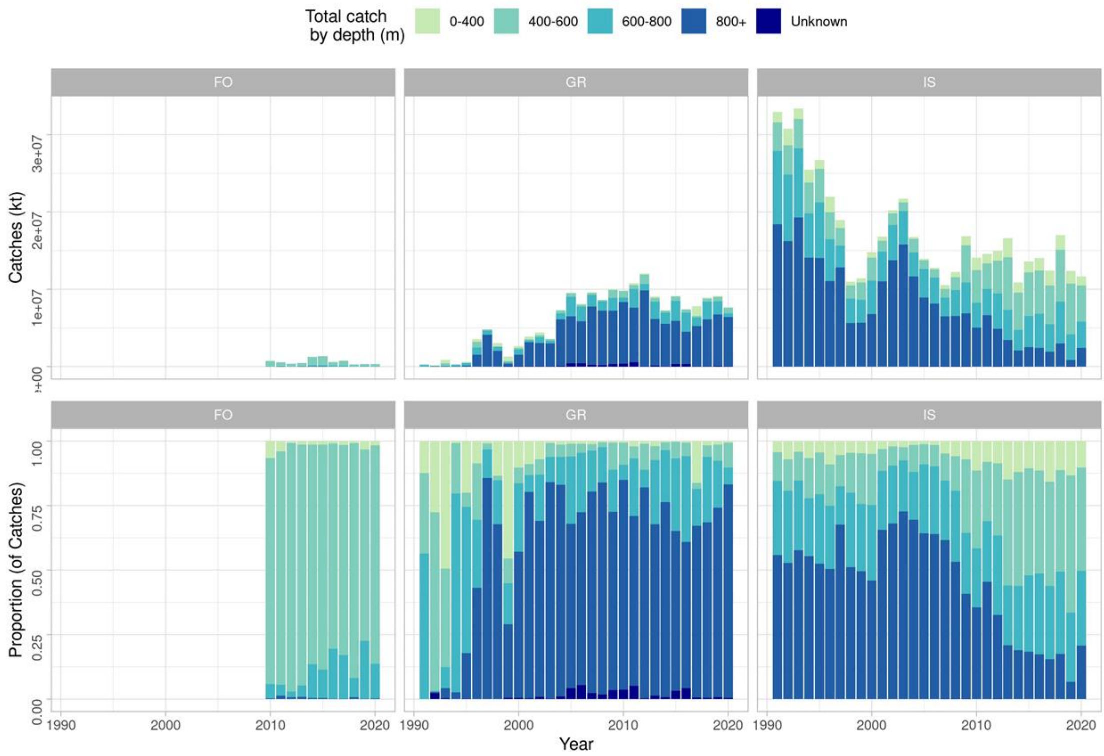

Fig 17.2.4. Greenland halibut 5+14. Depth distribution by EEZ from 1990 to 2020.

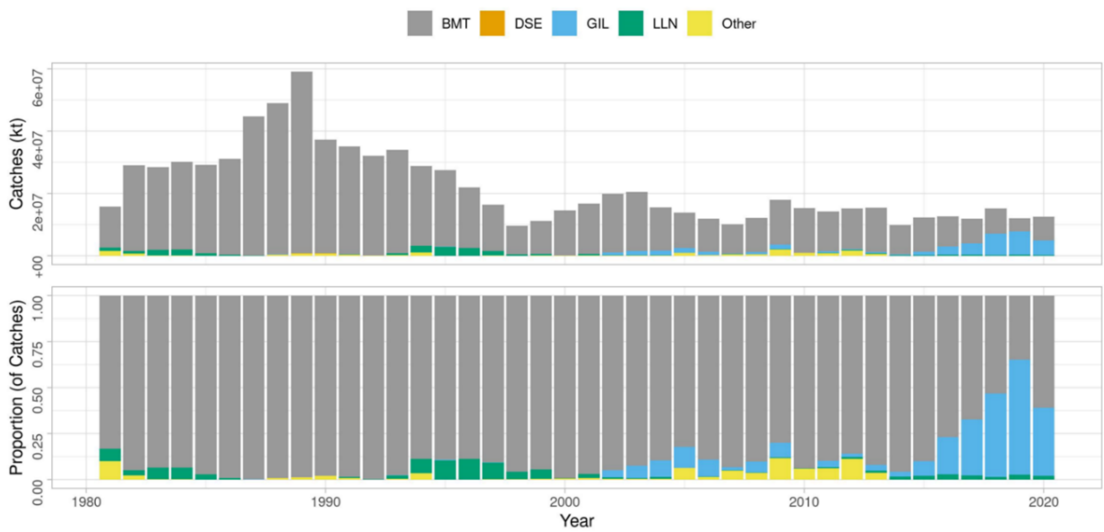

Fig. 17.2.5. Greenland halibut 5+14. Division of landings by gear in 5a.

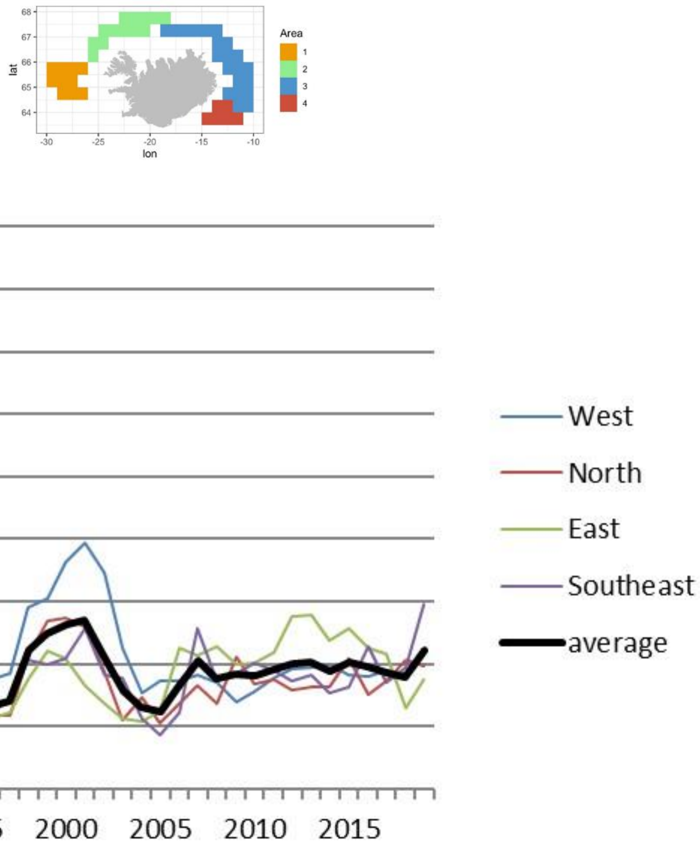

Fig. 17.3.1. Standardised CPUEs from the Icelandic trawler fleet in 5a. Area 1-4 are west, north, east and south-east, respectively. The average index of the four areas is used as biomass indicator in the stock production model.

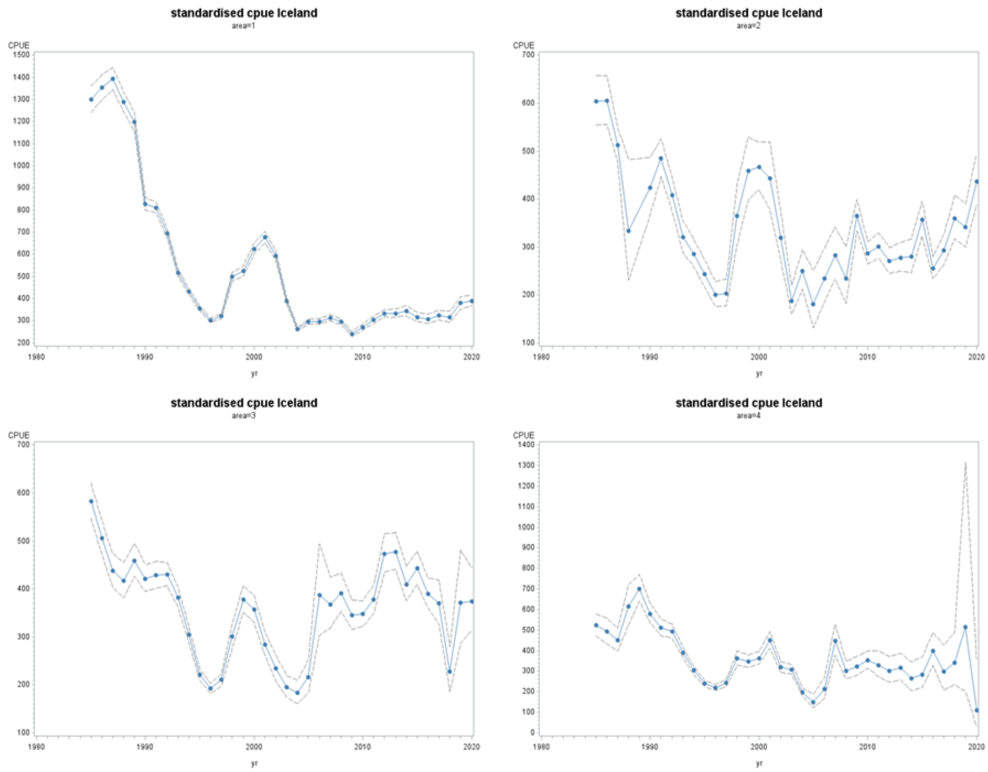

Fig. 17.3.2 Standardised CPUE from the Icelandic trawler fleet in Div 5a by four main fishing areas in 5a. 95% CI indicated. Areas 1-4 are West, North, East and South-east of Iceland, respectively.

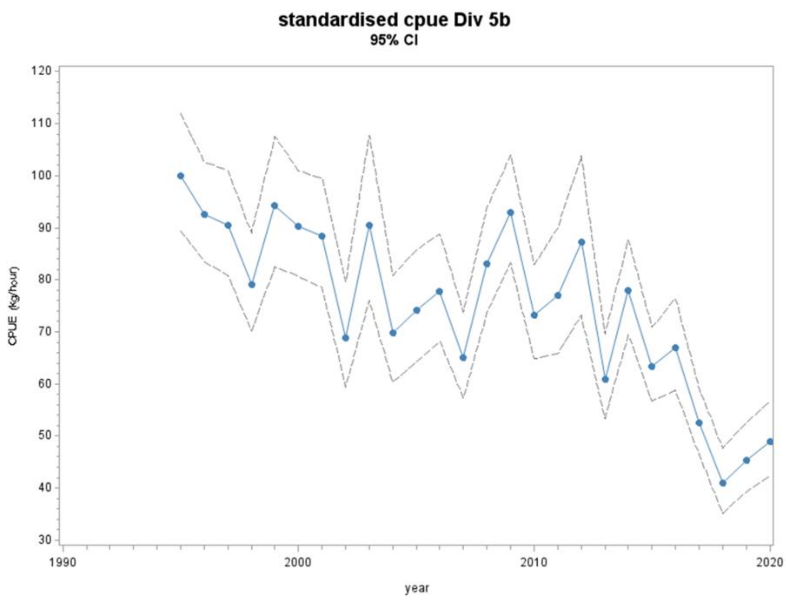

Figure 17. 3.3. Standardised CPUE from the Faroese trawler fleet. 95% CI indicated

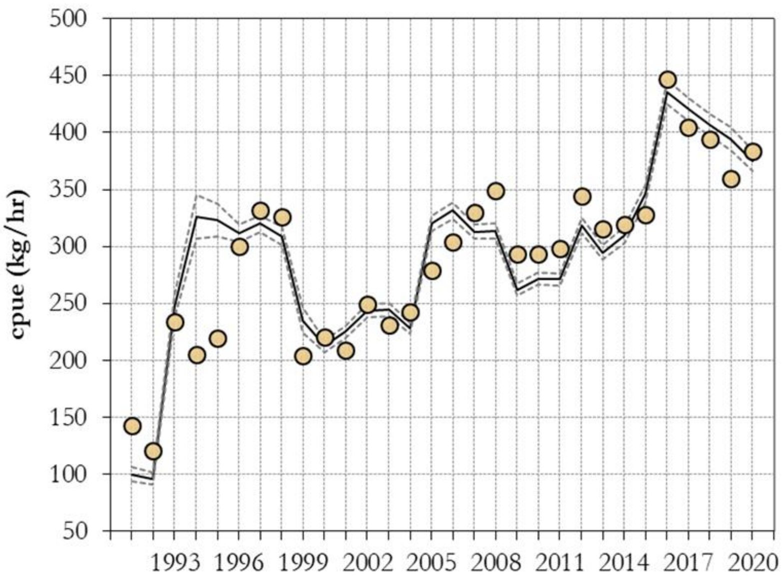

Fig. 17.3.4. Standardised CPUE from trawler fleets in 14b. 95% CI and observed CPUE (avg) indicated.

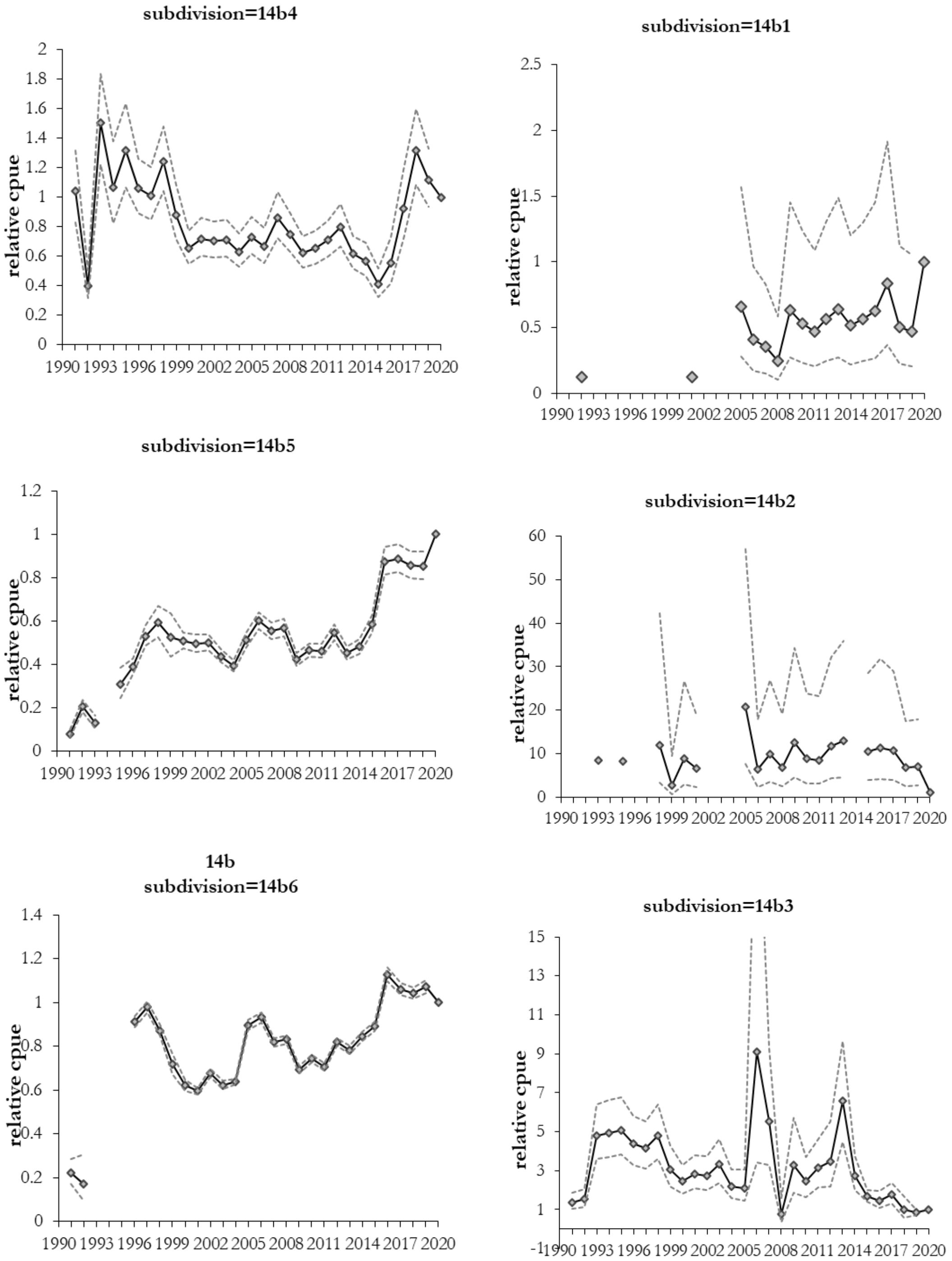

Fig. 17.3.5. Standardised CPUE from trawler fleets in 14b shown by subdivisions in a north-south direction. 95% CI indicated.

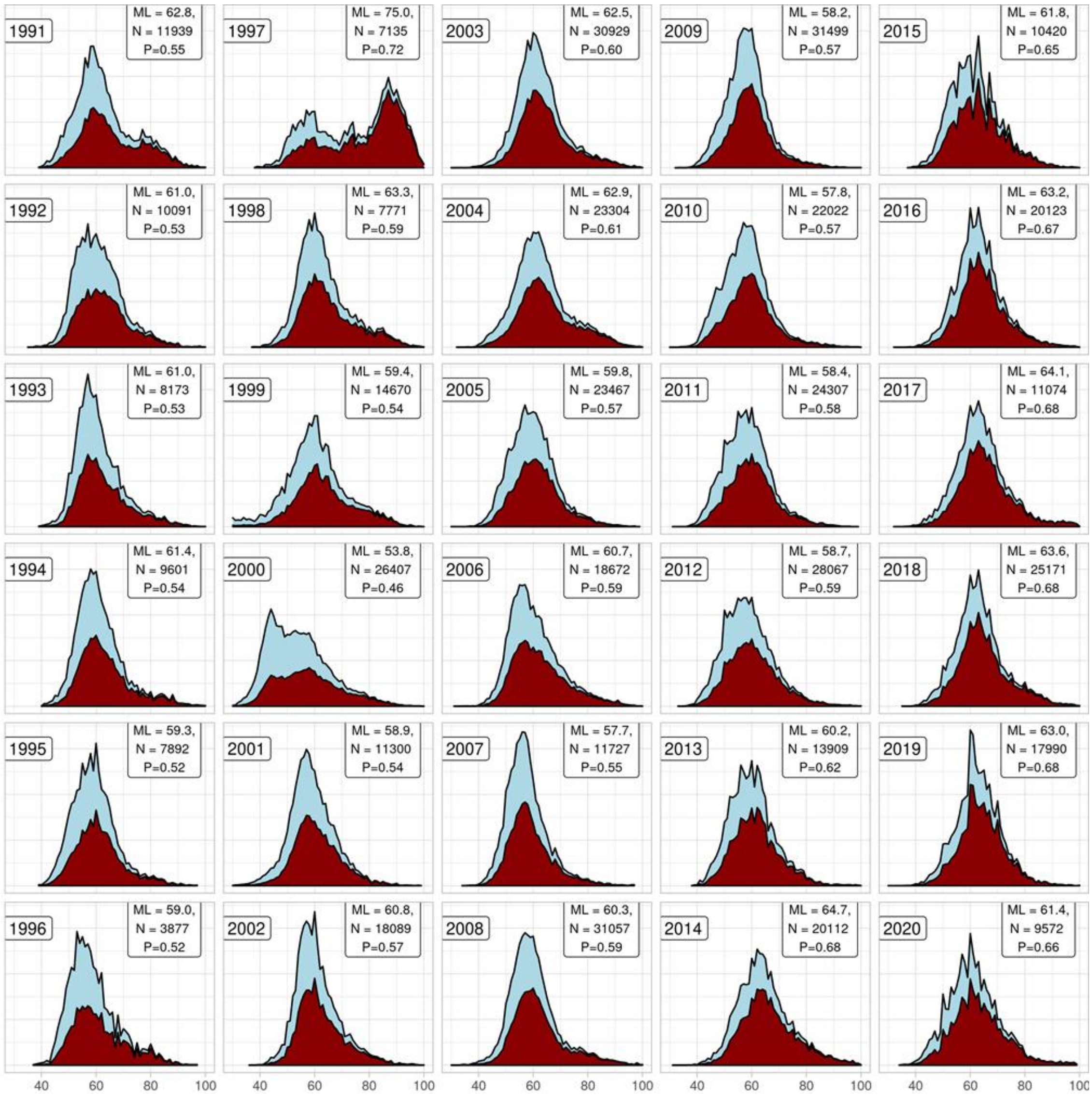

Fig. 17.3.1. Length distributions from the commercial trawl fishery in the western fishing grounds of Iceland (5a) in the years 2002-2019. Blue indicate males and red indicates females.

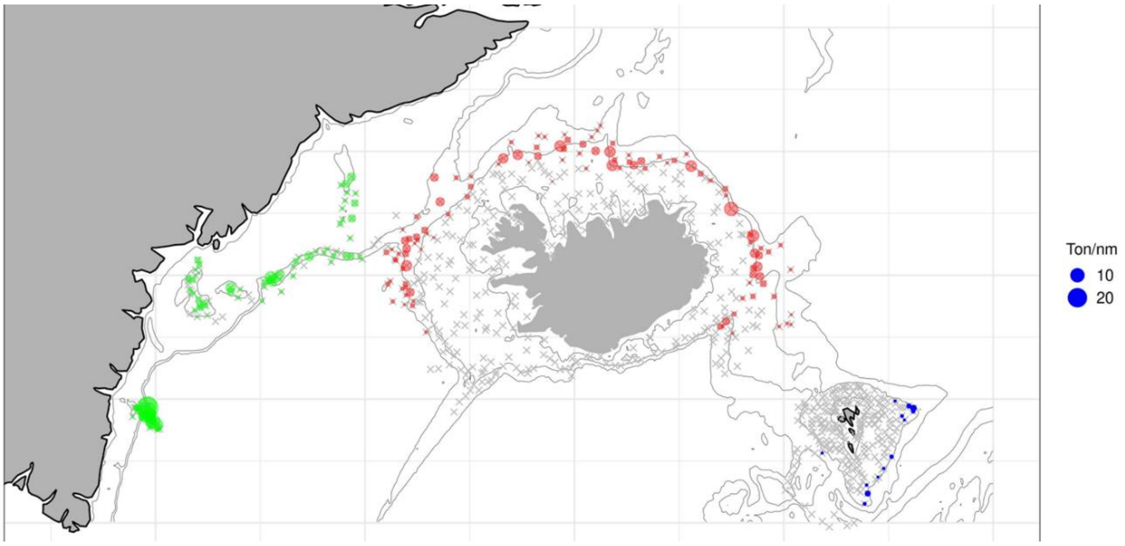

Fig. 17.4.1. Stations covered by scientific surveys in SA 5 and 14 in 2020 by Iceland (n=203). Red indicate Iceland survey, green is Greenland survey and blue is Faroe survey. Size of circles indicate catch rates and grey crosses are zero catches. The Greenland survey has not been conducted since 2016 and 2016 values are shown here.

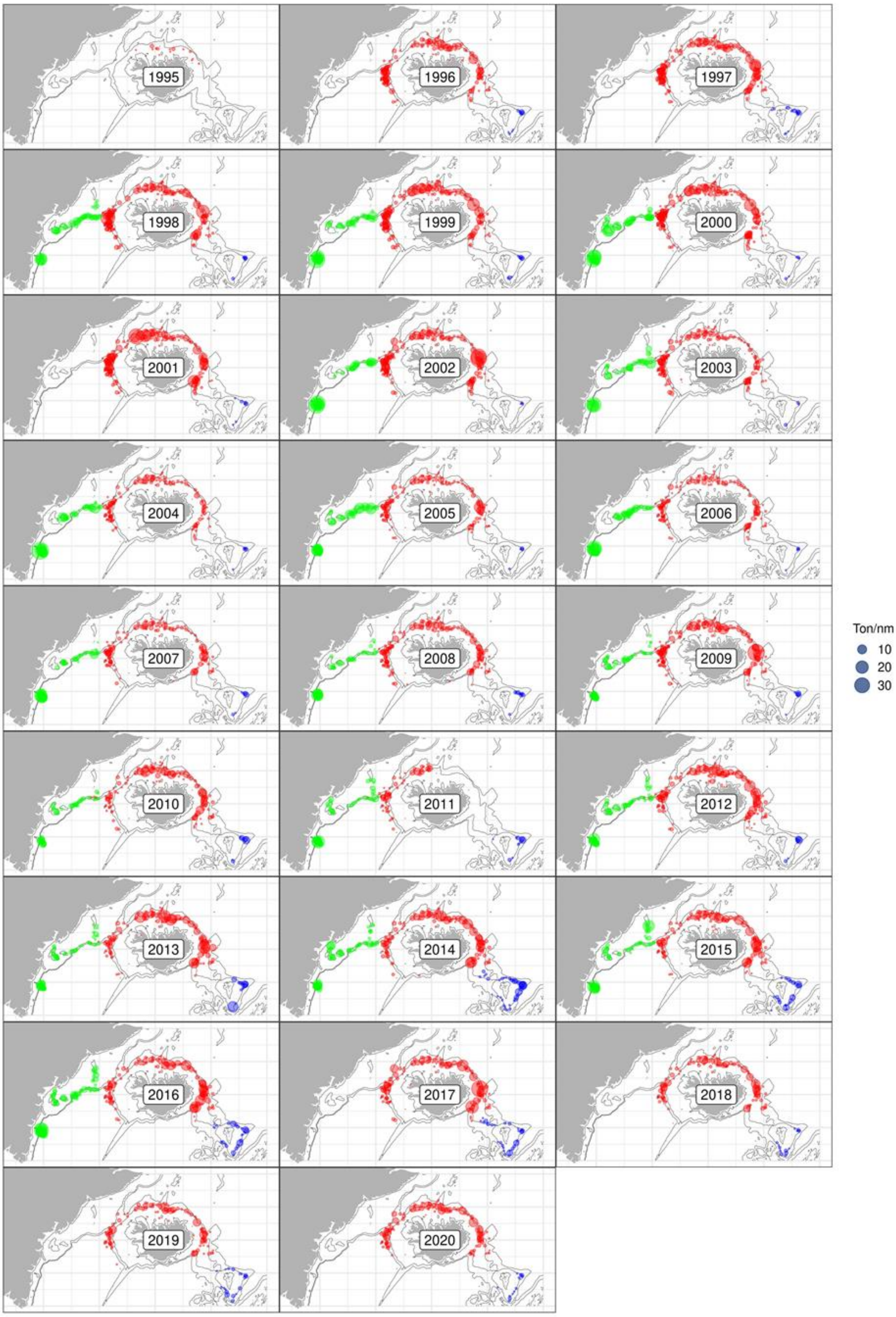

Fig. 17.4.2. Distribution of Greenland halibut catch rates from the combined Greenland-Icelandic fall survey since 1996.

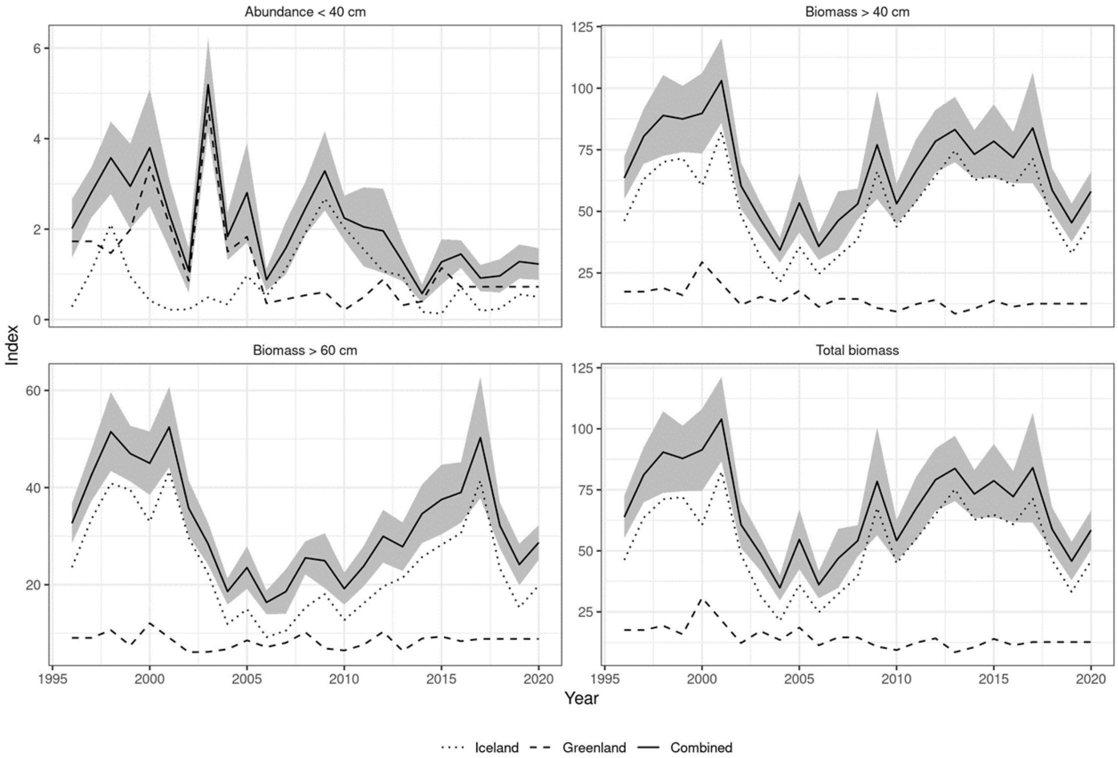

Fig. 17.4.3. Index of Greenland halibut in the Iceland, Greenland and the combined survey. No Iceland survey was conducted in 2011 and Greenland survey ceased in 2016. Greenland survey values are considered constant since 2016.

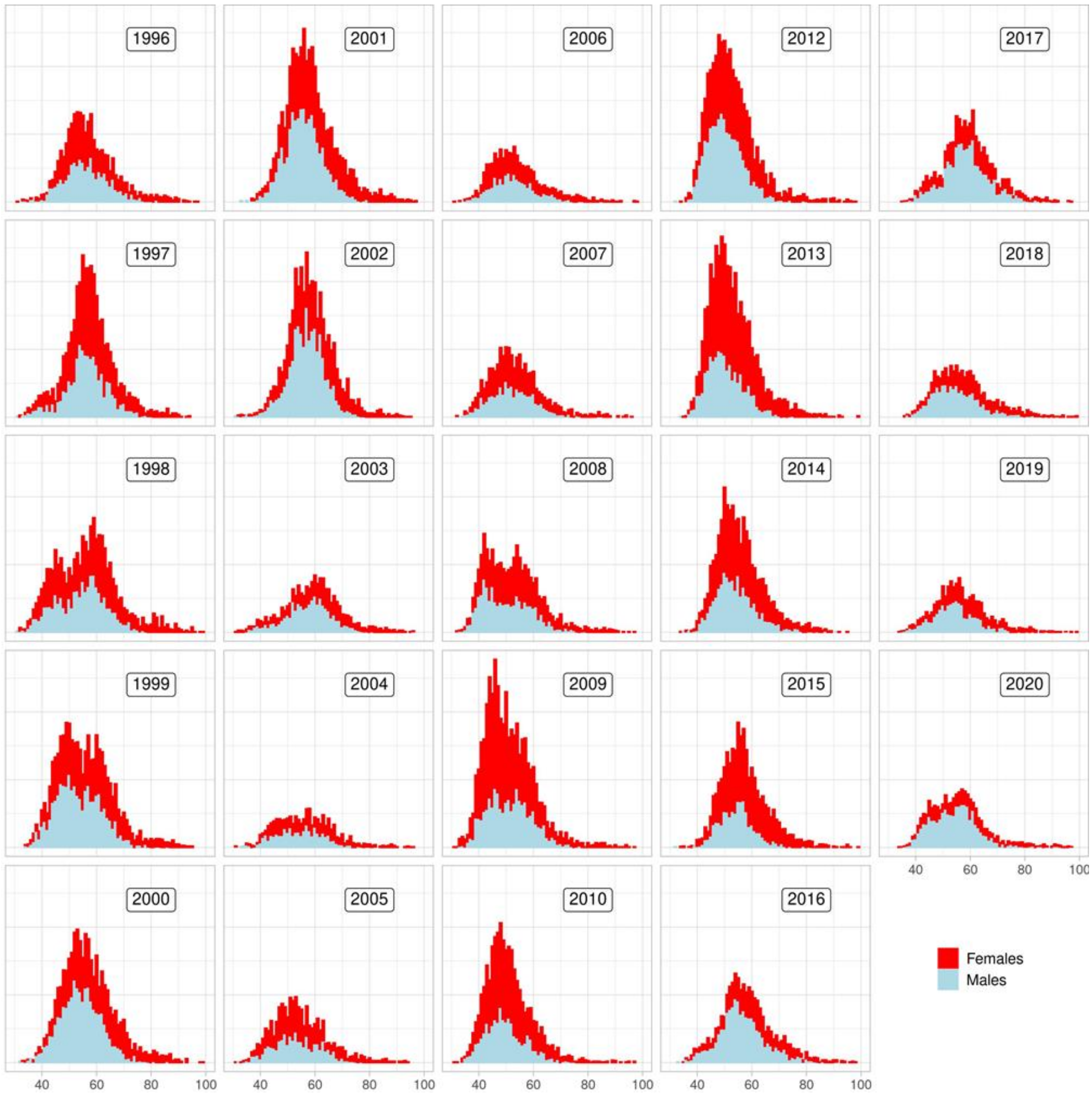

Fig. 17.4.4. Abundance indices by length for the Icelandic fall survey 1996-2020. No survey was conducted in 2011.

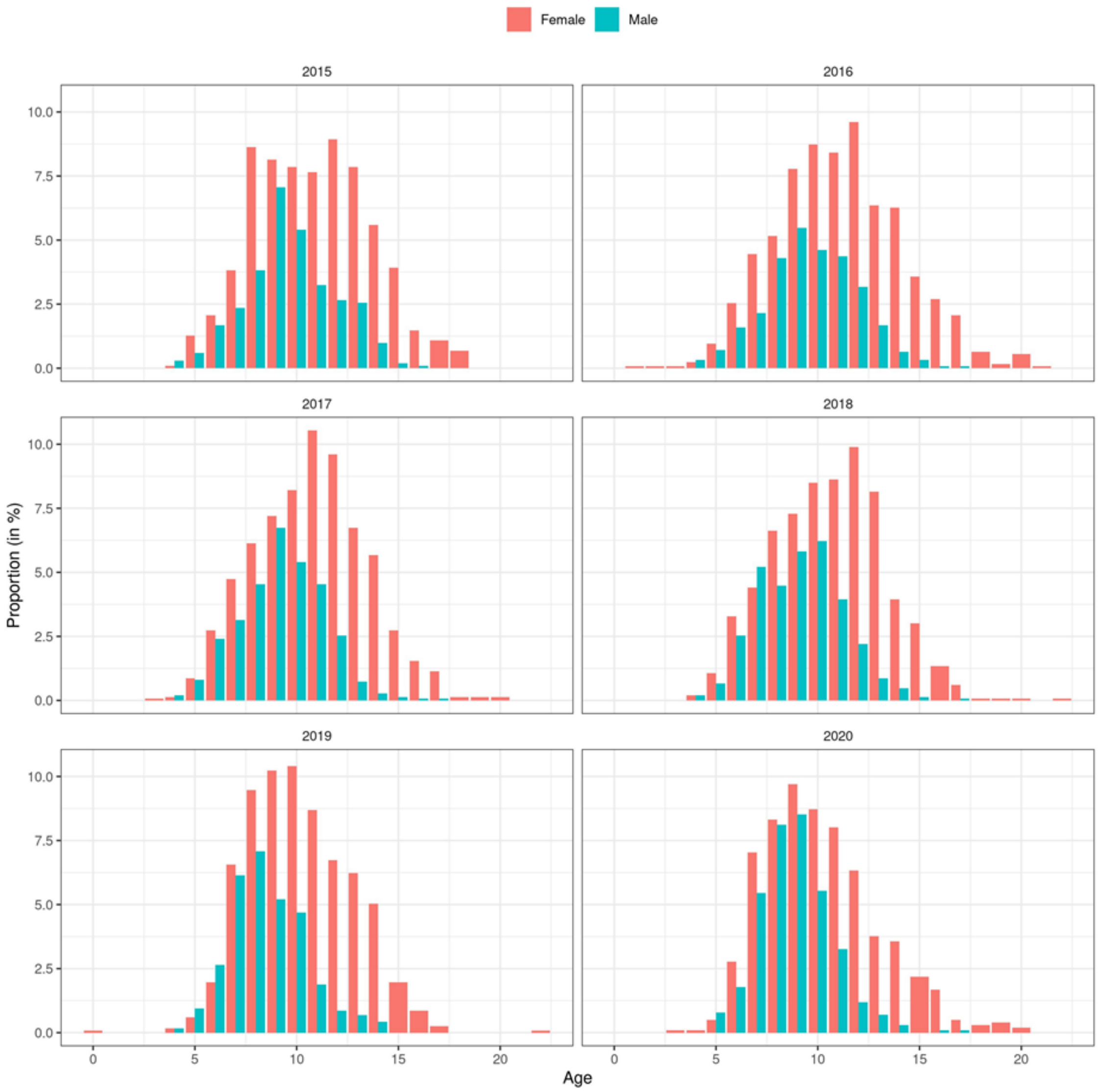

Figure 17.4.5. Age/sex distribution from Icelandic fall survey 2015-2020.

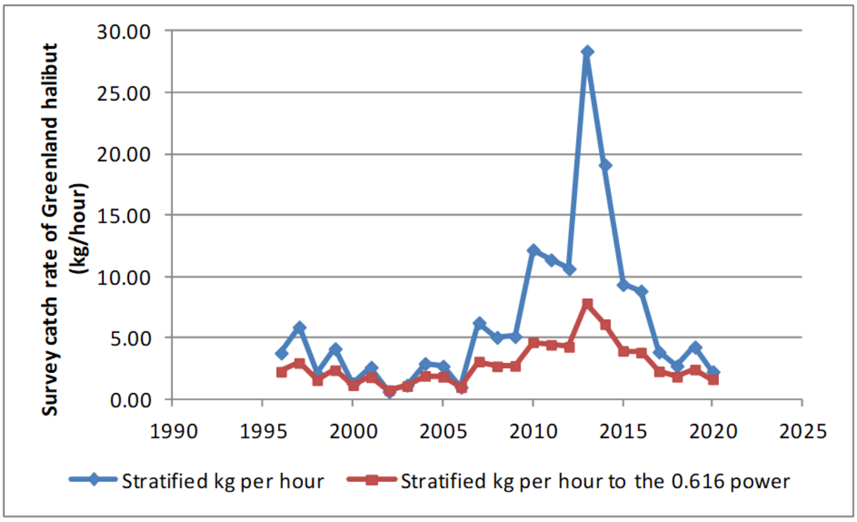

Figure 17.4.6. Standardised catch rates from a combined survey/fisherman's survey in 5b..

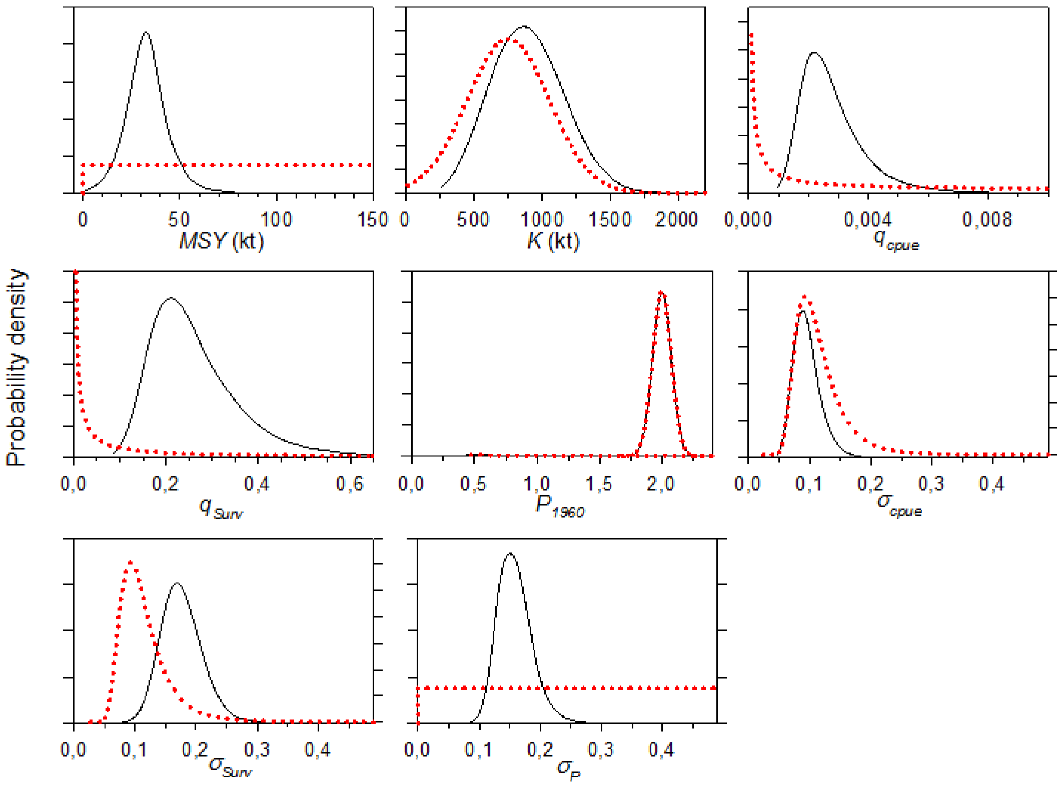

Figure 17.5.1. Probability density distributions of model parameters: estimated posterior (solid line) and prior (broken line) distributions.

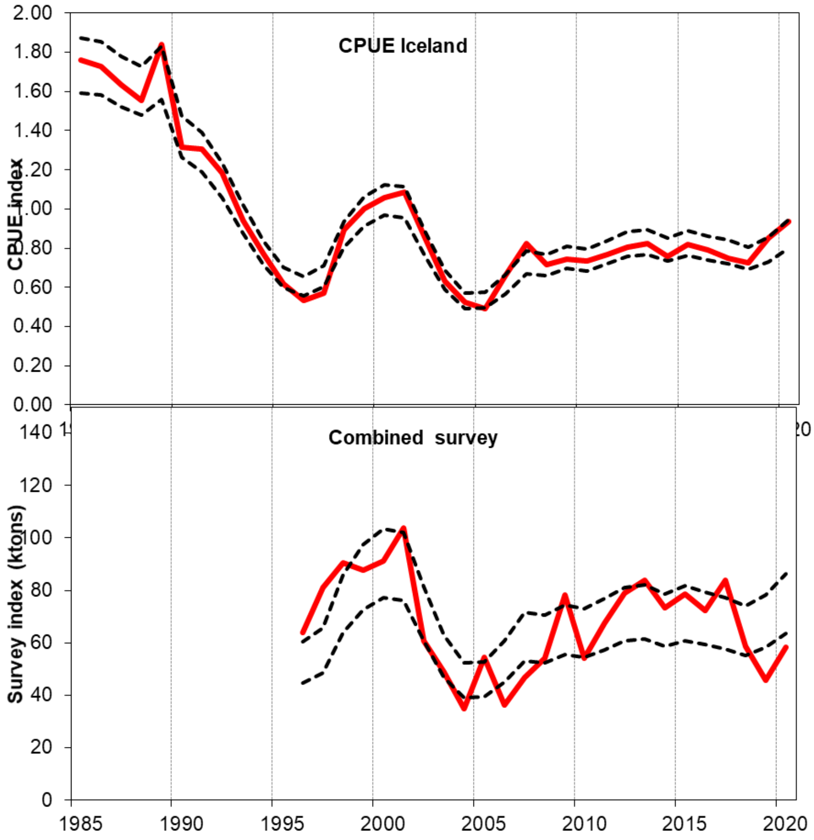

Figure 17.5.2. Observed (red curve) and predicted (dashed lines) series of the two biomass indices input to the model. Dashed lines are inter-quartile range of the model estimates.

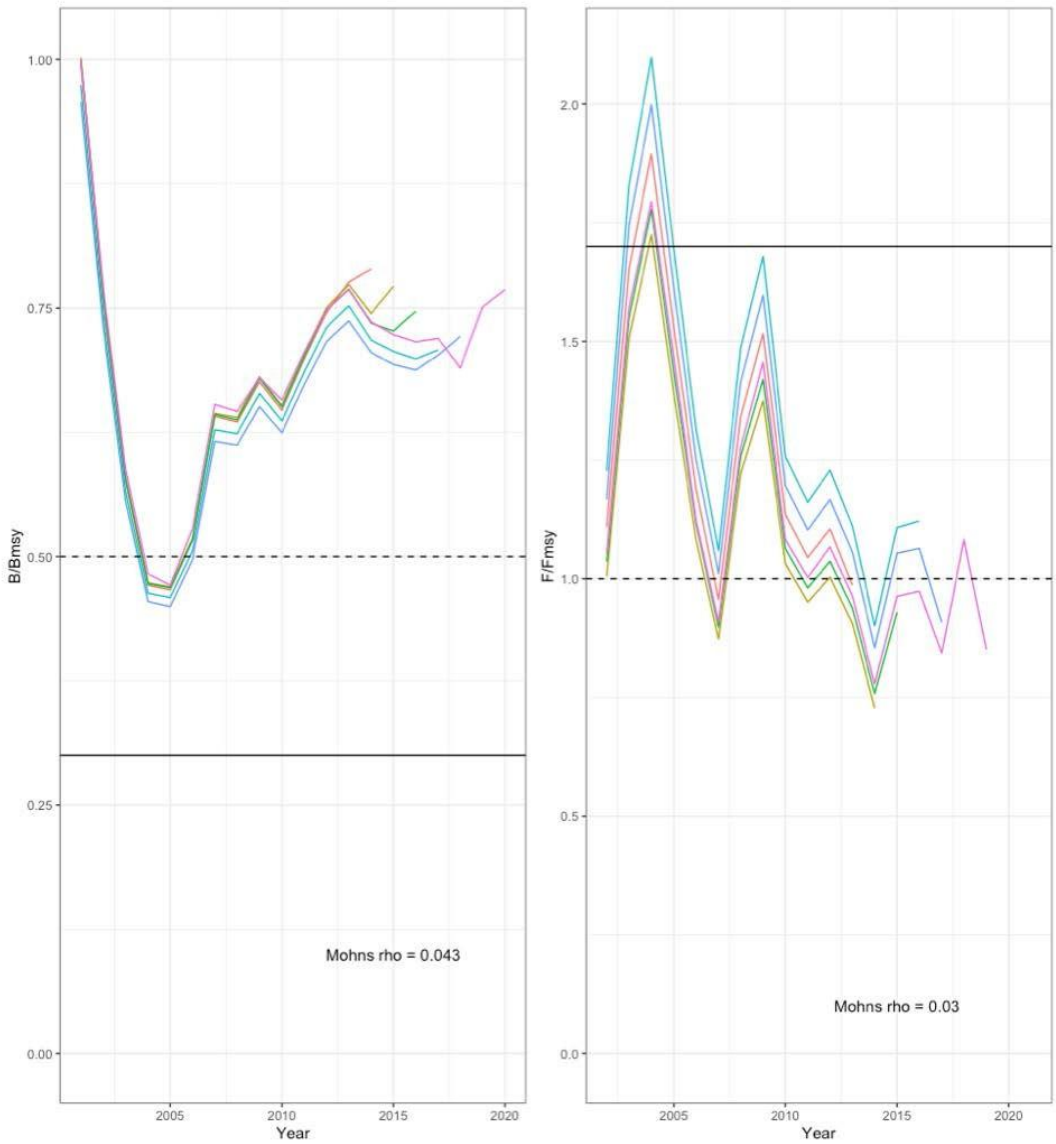

Figure 17.5.3. Retrospective analyses of medians of relative biomass (*B/Bmsy*) and fishing mortality (*F/Fmsy*)

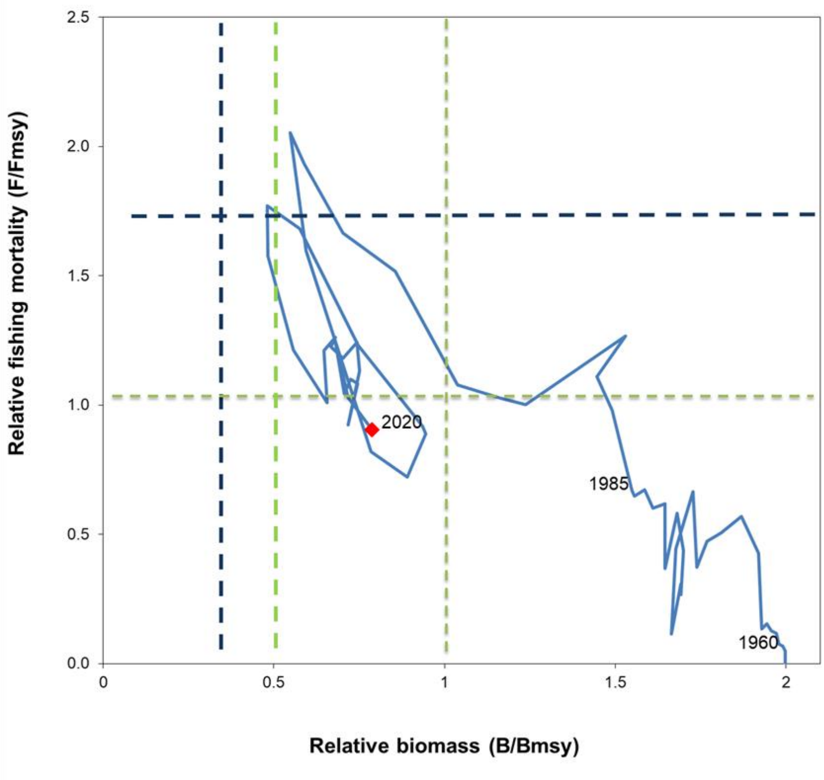

Figure 17.5.4. Stock trajectory 1960-2020. Estimated annual median biomass-ratio (B/BMSY) and fishing mortality-ratio (F/FMSY). B_{lim}, MSY $B_{trigger}$ and F_{lim} are indicated.

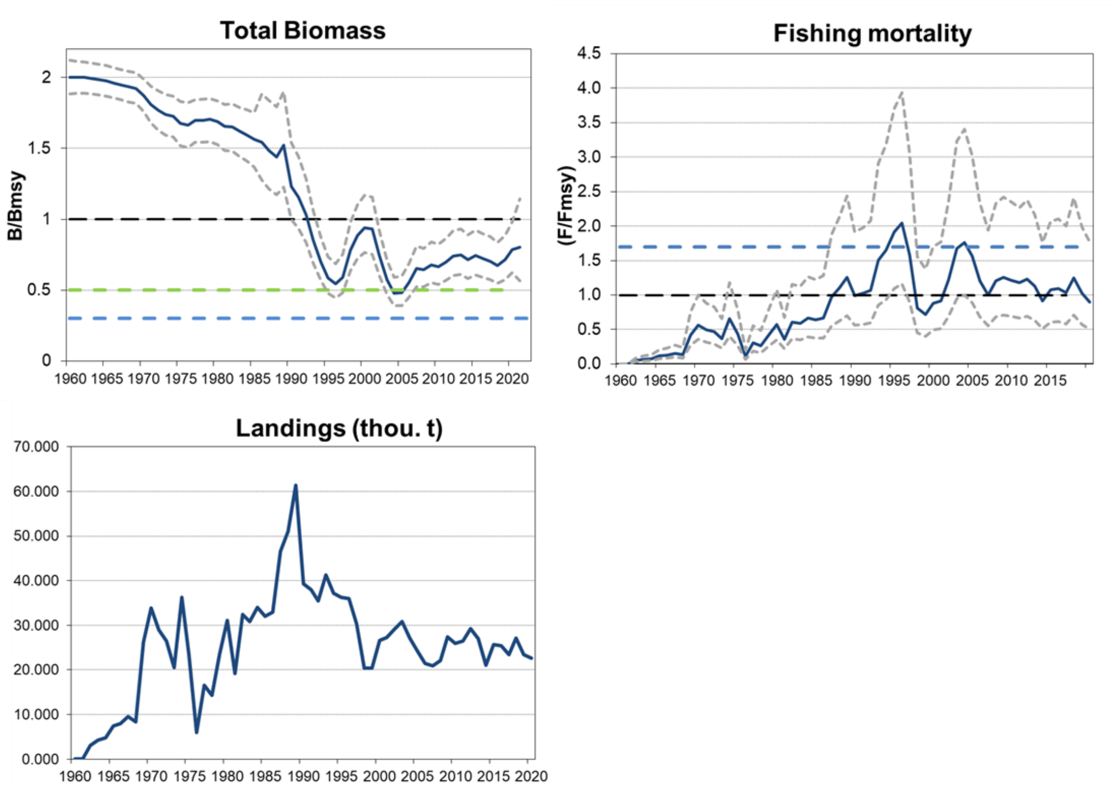

Figure 17.5.5. Stock summary, upper panel right: fishing mortality (F/Fmsy) and 95% conf limits, left: total biomass (B/Bmsy) and 95% conf limits and lower panel is landings since start of the fishery. MSY $B_{trigger}$ (green dashed line), B_{lim} and F_{lim} (blue dashed lines) are indicated.

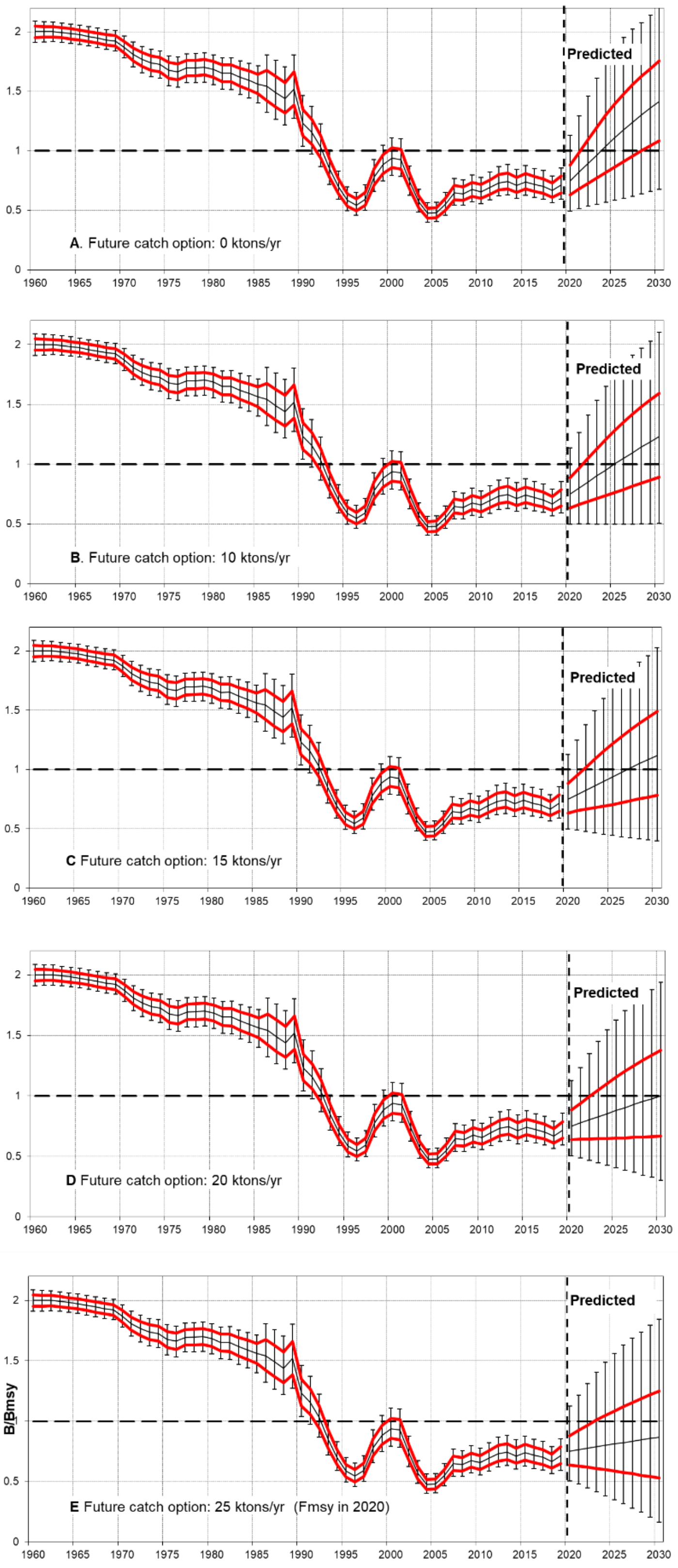

Fig. 17.5.6 Estimated time series of relative biomass (B_t/B_{msy}) under different catch option scenarios: 0, 10, 15, 20 and 25 kt catch from upper to lower panel. Bold red lines are inter-quartile ranges and the solid black line is the median; the error bars extend to cover the central 90 per cent of the distribution.

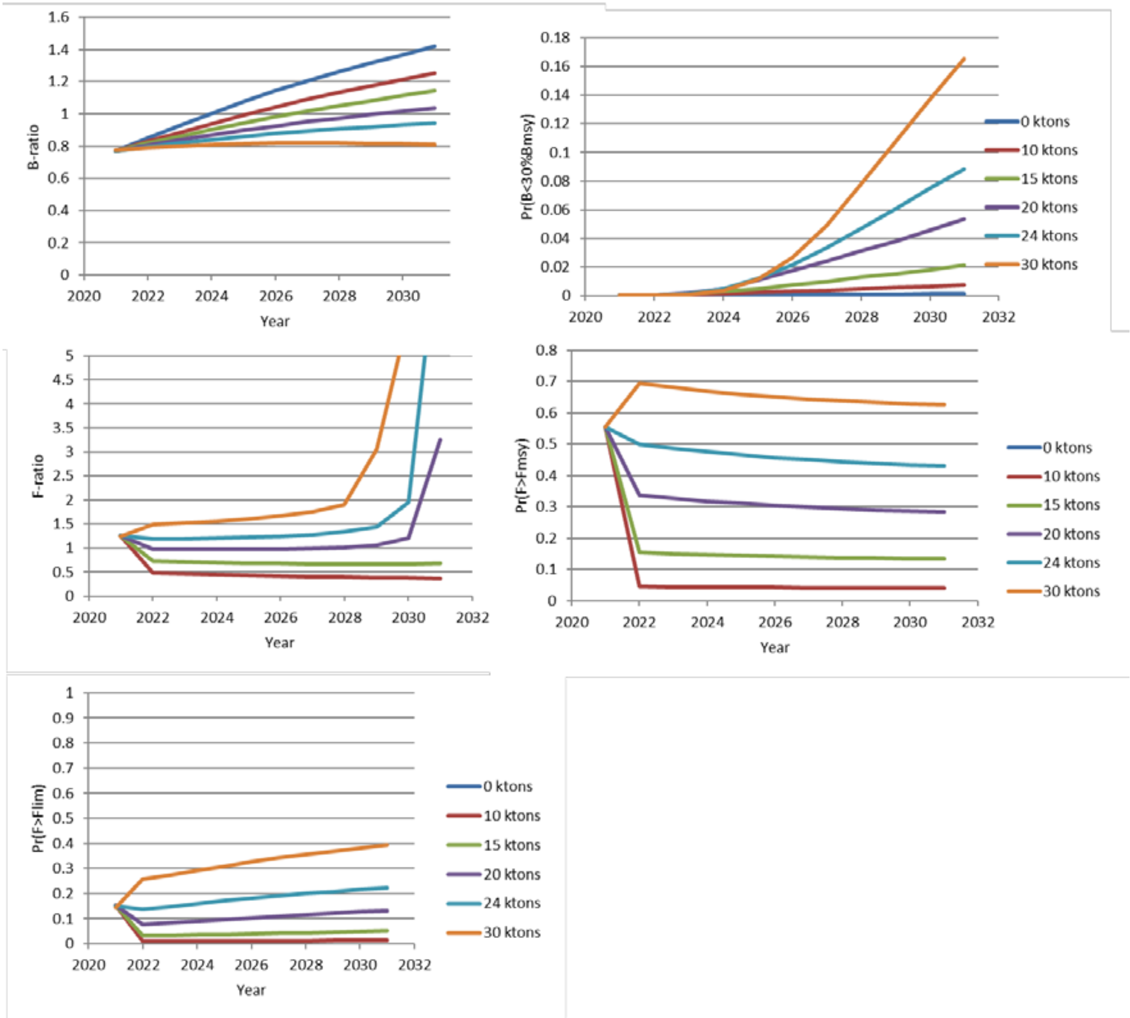

Figure 17.5.7. Projections: Medians of estimated posterior biomass- and fishing mortality ratios; estimated risk of exceeding F_{msy} or going below and $B_{MSYtrigger}$ given catch ranges at 0 -30 ktons.

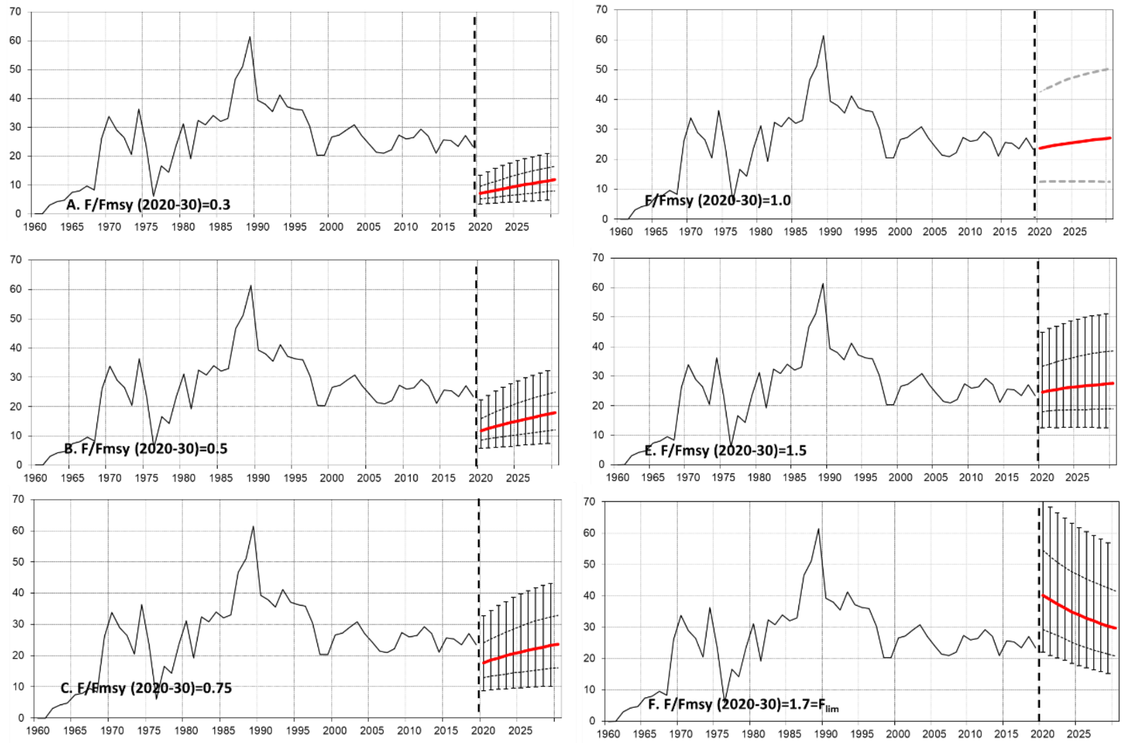

Figure 17.5.8. Historic landings and projected landings 2020-2030 under various F ratio options from 0.3-1.7 F/Fmsy Solid red line is median, quartiles and 90% conf limit indicated.

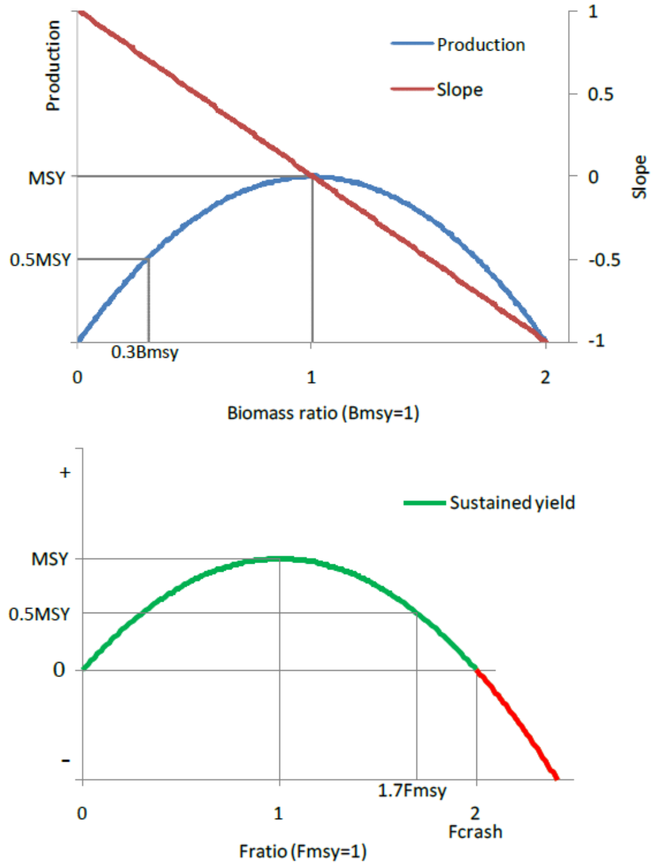

Figure 17.5.9. The logistic production curve in relation to stock biomass (B/Bmsy) (*upper*) and fishing mortality (F/Fmsy) (*lower*). *Upper*: points of maximum sustainable yield (MSY) and corresponding stock size are shown as well as the slope (red line) of the production curve (blue line); *lower*: points of MSY and corresponding fishing mortality and Fcrash (F≥Fcrash do not have stable equilibriums and will drive the stock to zero).

18 Redfish in subareas 5, 6, 12 and 14

This chapter deals with fisheries directed to *Sebastes* species in subareas 5, 6, 12 and 14 (sections and 18.7), and the abundance and distribution of juveniles (Section 18.2.1), among other issues.

The "Workshop on Redfish Stock Structure" (WKREDS, 22–23 January 2009, Copenhagen, Denmark; ICES 2009) reviewed the stock structure of *Sebastes mentella* in the Irminger Sea and adjacent waters. ACOM concluded, based on the outcome of the WKREDS meeting, that there are three biological stocks of *S. mentella* in the Irminger Sea and adjacent waters:

- a 'Deep Pelagic' stock (NAFO 1–2, ICES 5, 12, 14 >500 m) – primarily pelagic habitats, and including demersal habitats west of the Faeroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1–2, ICES 5, 12, 14 <500 m) – extends to ICES 1 and 2, but primarily pelagic habitats, and includes demersal habitats east of the Faeroe Islands;
- an 'Icelandic Slope' stock (ICES 5.a, 14) – primarily demersal habitats.

This conclusion is primarily based on genetic information, i.e. microsatellite information, and supported by analysis of allozymes, fatty acids and other biological information on stock structure, such as some parasite patterns. The Russian Federation maintains the point of view that there is only one stock of *S. mentella* in the pelagic waters of the Irminger Sea. Accordingly, the Russian Federation presented alternative approaches to stock assessment as well as environmental influence on stock dynamics. Briefly, it is claimed that the current survey-based assessment does not adequately reflect stock status and that environmental factors – temperature causes major distributional changes of redfish – affect stock status more than fisheries and the use of the current management areas is rejected (see WD22, WD23 and Annex 7). The other NWWG members did not agree with the Russian Federation's view on stock structure and did not consider the presented assessment approach sufficiently documented.

The adult redfish on the Greenland shelf has traditionally been attributed to several stocks, and there remains the need to investigate the affinity of adult *S. mentella* in this region. Recent studies confirm the connectivity between *S. mentella* in East-Greenland and other areas (Saha *et al.,* 2016). Further studies are needed to understand e.g. the connection between the slope stocks in both East-Greenland, Iceland and the Faroe Islands.

ICES past advice for *S. mentella* fisheries was provided for two distinct management units, i.e. a demersal unit on the continental shelves and slopes and pelagic unit in the Irminger Sea and adjacent waters. However, based on the new stock identification information, ICES recommended three potential management units that are geographic proxies for biological stocks that were partly defined by depth and whose boundaries are based on the spatial distribution pattern of the fishery to minimize mixed stock catches (Figure 18.1.1):

- Management Unit in the northeast Irminger Sea: ICES subareas 5.a, 12, and 14.
- Management Unit in the southwest Irminger Sea: NAFO Areas 1 and 2, ICES subareas 5.b, 12 and 14.
- Management Unit on the Icelandic slope: ICES subareas 5.a and 14, and to the north and east of the boundary proposed in the MU in the northeast Irminger Sea.

The pelagic fishery in the Irminger Sea and adjacent waters shows a clear distinction between two widely separated grounds fished at different seasons and depths. Spatial analysis of the pelagic fishery catch and effort by depth, inside and outside the boundaries proposed for the management units in the northeast Irminger Sea, indicate that the boundaries effectively delineate the pelagic fishery in the northeast Irminger Sea from the pelagic fishery in the southwest Irminger Sea, with a small portion of mixed-stock catches. In the last decade the majority (more than 90%) of the catches have been taken in the northeast Irminger Sea. The northeastern fisheries on the pelagic *S. mentella* occur at the start of the fishing season at depths below 500 m and overlap to some extent with demersal fisheries on the continental slopes of Iceland (Sigurdsson *et al.*, 2006).

A schematic illustration of the relationship between the management units and biological stocks is given in Figure 18.1.2.

For the above mentioned reasons, the group now provides advice for the following *Sebastes* units:

- the *S. norvegicus* on the continental shelves of ICES divisions 5.a, 5.b and subareas 6 and 14 (Section 19);
- the demersal *S. mentella* on the Icelandic slope (Section 20);
- the shallow and deep pelagic *S. mentella* units in the Irminger Sea and adjacent waters (sections 21 and 22, respectively);
- the Greenland shelf *S. mentella* (Section 23).

18.1 Environmental and ecosystem information

Species of the genus *Sebastes* are common and widely distributed in the North Atlantic. They are found off the coast of Great Britain, along Norway and Spitzbergen, in the Barents Sea, off the Faroe Islands, Iceland, East and West Greenland, and along the east coast of North America from Baffin Island to Cape Cod. All *Sebastes* species are viviparous. Copulation occurs in autumn-early winter and larvae extrusion takes place in late winter–late spring/early summer. Little is known about the copulation areas.

The increase of water temperature in the Irminger Sea may have an effect on spatial and vertical distribution of *S. mentella* in the feeding area (Pedchenko, 2005). The abundance and distribution of pelagic *S. mentella* in relation to oceanographic conditions were analyzed in a special multi-stage workshop (ICES, 2012). Based on 20 years of survey data, the results reveal the average relation of pelagic redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58°N, 40°W, 300 m, 34.89 and 4.4°C, respectively. The spatial distribution of *S. mentella* in the Irminger Sea mainly in waters <500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (>4.5°C and >34.94) in the northeastern Irminger Sea, which may cause displacement of the fish towards the southwest, where fresher and colder water occurs.

Results based on international redfish survey data suggest that the interannual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES, 2012).

18.2 Environmental drivers of productivity

18.2.1 Abundance and distribution of 0 group and juvenile redfish

Available data on the distribution of juvenile *S. norvegicus* indicate that the nursery grounds are located in Icelandic and Greenland waters. No nursery grounds have been found in Faroese waters. Studies indicate that considerable amounts of juvenile *S. norvegicus* off East Greenland are mixed with juvenile *S. mentella* (Magnússon *et al.*, 1988; 1990, ICES CM 1998/G:3). The 1983 Redfish Study Group report (ICES CM 1983/G:3) and Magnússon and Jóhannesson (1997) describe the distribution of 0-group *S. norvegicus* off East Greenland. The nursery areas for *S. norvegicus* in Icelandic waters are found all around Iceland but are mainly located west and north of the island at depths between 50 and 350 m (ICES CM 1983/G:3; Einarsson, 1960; Magnússon and Magnússon 1975; Pálsson *et al.* 1997). As they grow, the juveniles migrate along the north coast towards the most important fishing areas off the west coast.

Indices for 0-group redfish in the Irminger Sea and at East Greenland areas were available from the Icelandic 0-group surveys from 1970–1995. Thereafter, the survey was discontinued. Above average year class strengths were observed in 1972, 1973–1974, 1985–1991, and in 1995.

There are very few juvenile demersal *S. mentella* in Icelandic waters (see Section 20), and the main nursery area for this species is located off East Greenland (Magnússon *et al.*, 1988, Saborido-Rey *et al.*, 2004). Abundance and biomass indices of redfish smaller than 17 cm from the German annual groundfish survey, conducted on the continental shelf and slope of West and East Greenland down to 400 m, show that juveniles were abundant in 1993 and 1995–1998 (Figure 18.2.1). The 1999–2006 survey results indicate low abundance and were similar to those observed in the late 1980s. Since 2008, the survey index has been very low and was in 2013–2016 the lowest value recorded since 1982. Juvenile redfish were only classified to the genus *Sebastes* spp., as identification of small specimens to species level is difficult due to very similar morphological features. Observations on length distributions of *S. mentella* fished deeper than 400 m indicate that a part of the juvenile *S. mentella* on the East Greenland shelf migrates into deeper shelf areas and into the pelagic zone in the Irminger Sea and adjacent waters (Stransky, 2000), with unknown shares.

18.3 Ecosystem considerations

Information on the ecosystems around the Faroe Islands is given in Section 2, in Icelandic waters in Section 7 and Greenland waters in Section 13.

Analysis of the oceanographic situation in the Irminger Sea during the 2013 international survey and long-term data including 2003, allows the following conclusions:

Strong positive anomalies of temperature observed in the upper layer of the Irminger Sea with a maximum in 1998 are related to an overall warming of water in the Irminger Sea and adjacent areas in 1994–2013. These changes were also observed in the Irminger Current above the Reykjanes Ridge (Pedchenko, 2000), off Iceland (Malmberg *et al.*, 2001) and in the Labrador Sea water (Mortensen and Valdimarsson, 1999). Thus, temperature and salinity in the Irminger Current have increased since 1997 to the highest values seen for decades.

The 2003 survey detected high temperature anomalies within the 0–200 m layer in the Irminger Sea and adjacent waters. At 200–500 m depth and deeper waters, positive anomalies were observed in most of the surveyed area. However, increasing temperature as compared to the survey in June–July 2001 was detected only north of 60°N in the flow of the Irminger Current above the Reykjanes Ridge and the northwestern part of the Irminger Sea. These changes in oceanographic conditions might have an effect on the seasonal distribution of redfish and its aggregations in the layer shallower than 500 m in the survey area (ICES, 2003).

In June/July 2005 and 2007, water temperature in the shallower layer (0–500 m) of the Irminger Sea was higher than normal (ICES, 2005; ICES, 2007). As in the surveys 1999–2003, the redfish were aggregating in the southwestern part of the survey area, partly influenced by these hydrographic conditions. Favourable conditions for aggregation of redfish in an acoustic layer have been marked only in the southwestern part of the survey area with temperatures between 3.6–4.5°C, as confirmed by the survey results obtained in 2009 (ICES, 2009b). The hydrography in the survey of June/July 2013 shows that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013a).

18.4 Description of fisheries

There are three species of commercially exploited redfish in ICES subareas 5, 6, 12, and 14: *S. norvegicus* (in publication both names *S. norvegicus* and *S. marinus* can be found, but according to Fernholm and Wheeler (1983) the first name is the correct name), *S. mentella* and *S. viviparus*.

S. viviparus has only been of a minor commercial value in Icelandic waters and it is exploited in two small areas south of Iceland at depths of 150–250 m. The landings of *S. viviparus* decreased from 1160 t in 1997 to 2–9 t in 2003–2006 (Table 18.4.1) due to decreased commercial interest in this species. The landings in 2009 amounted to 37 t, more than a twofold increase in comparison with 2008. After a directed fishery developed in 2010, with a total catch of 2600 t, the MRI (now MFRI) advised on a 1500 t TAC for the 2012–2013 fishing year. Annual catches 2012–2015 were about 500 t but have since then decreased and were 117 t in 2018.

The group has in the past included the fraction of *S. mentella* that are caught with pelagic trawls above the western, south-western and southern continental slope of Iceland as part of the landing statistics of the demersal *S. mentella*. This practice has been in accordance with Icelandic legislation, where captains are obligated to report their *S. mentella* catch as either "pelagic redfish" or as "demersal redfish/Icelandic slope *S. mentella*" depending in which fishing area they fish. According to this legislation, all catch outside the Icelandic EEZ and west of the ‘redfish line’ (red line shown in Figure 18.1.1, which is drawn approximately over the 1000 m isoclines within the Icelandic EEZ) shall be reported as pelagic *S. mentella*. All fish caught east of the ‘redfish line’ shall be reported as Icelandic slope *S. mentella*. Most of the catches since 1991 have been taken by bottom trawlers along the shelf west, southwest, and southeast of Iceland at depths between 500 and 800 m. The Group accepts this praxis as a pragmatic management measure but notes that there is no biological information that could support this catch allocation.

As the Review Group in 2005 noted that this issue needed more elaboration, detailed portrayals of the geographical, vertical, and seasonal distribution of the Icelandic slope *S. mentella* fisheries with different gears are presented here, as done previously (see below). Quantitative information on the fractions of the pelagic catches of Icelandic slope *S. mentella* is given in chapter 20. The proportion of the total Icelandic slope *S. mentella* catches taken by pelagic trawls has ranged since 1991 between 0% and 44% (Table 20.3.2) and is on average 15%. With exception of 2007, no Icelandic slope *S. mentella* has been caught with pelagic trawls since 2004. The geographic distribution of the Icelandic fishery for *S. mentella* since 1991 was in general close to the redfish line, off South Iceland, and has expanded into the NAFO Convention Area since 2003 (Figure 18.4.1). The pelagic catches of Icelandic slope *S. mentella* were taken in similar areas and depths as the bottom trawl catches (Figure 18.4.2). The vertical and horizontal distribution of the pelagic catches focused, however, on smaller areas and shallower depth layers than the bottom trawl catches. The seasonal distribution by depth (Figure 18.4.3) shows that the pelagic catches of Icelandic slope *S. mentella* were in general taken in autumn and overlapped in June with the traditional pelagic fishery only in 2003 and 2007. The bottom trawl catches of the Icelandic slope *S. mentella* were mainly taken in the first quarter of the year and during autumn/winter. The length distributions of the Icelandic slope *S. mentella* catches in Iceland by gear and area are given in Figure 18.4.4. During 1994–1999 and in 2003, the fish taken with pelagic trawls were considerably larger than the fish caught with bottom trawls, but they were of similar length during 2000–2002. The fish caught in the north-eastern area were on average about 5 cm larger than those caught in the south-western area. The length distribution also shows that the fish caught in north-east area since 2011 is smaller than during the period 1998–2010 and have now a size similar to that registered in the beginning of the fishery.

18.5 Russian pelagic *S. mentella* fishery

Russia's position regarding the structure of redfish stock in the Irminger Sea remains unchanged and it has been expressed in previous reports (ICES, 2009a; ICES, 2013b; Makhrov *et al*., 2011; Zelenina *et al*., 2011; see also Annex 7 in NWWG 2019 report). The Russian Federation still maintains its point of view that there is only one stock of beaked redfish *S. mentella* in the pelagic waters of the Irminger Sea and that is why no split catches information about the fisheries is presented to the NWWG. Russia reiterates its standpoint that studies of the redfish stock structure should be continued (Artamonova *et. al.,* 2013) with the aim of developing agreed recommendations using all available scientific and fisheries data as a basis.

The Russian fishery in 2020 is described in WD02. In 2020, the Russian fishery was conducted from April to October in ICES Subareas 12 and 14 and NAFO Division 1F.

18.6 Biological sampling

Biological samples are taken both in national and international surveys and from the commercial catches. They consist of length measurements, otolith collection, stomach contents, sex and maturity stages. The following samples were taken by several nations during 2020:

Country	Area	No. of samples	No. of fish measured
Russia	14	150	4 400
Russia	12	300	11 216
Russia	NAFO 1F	570	24 488

18.7 Demersal *S. mentella* in 5b and 6

18.7.1 Demersal *S. mentella* in 5b

18.7.1.1 Surveys

The Faroese spring and summer surveys in Division 5.b are mainly designed for species inhabiting depths down to 500 m and do not cover the vertical distribution of demersal *S. mentella* fully. Therefore, the surveys are not used to evaluate the stock status.

18.7.1.2 Fisheries

In Division 5.b, landings gradually decreased from 15 000 t in 1986 to about 5000 t in 2001 (Table 18.6.1). Between 2002 and 2011 annual landings varied between 1100 and 4000 t. In 2012, landings decreased drastically from 1126 t in 2011 to 263 t but has since then increased and were 432 t in 2020.

Length distributions from the landings in 2001–2018 indicate that the fish caught in 5.b in 2018 are between 35–50 cm and the mode of the distribution is around 42 cm (Figure 18.7.1).

Non-standardized CPUE indices in Division 5.b were obtained from the Faroese otter board (OB) trawlers (> 1000 HP) towing deeper than 450 m and where demersal *S. mentella* composed at least 70% of the total catch in each tow. The OB trawlers have in recent years landed about 50% of the total demersal *S. mentella* landings from 5b. CPUE decreased from 500 kg/hour in 1991 to 300 kg/hour in 1993 and remained at that level until 2013, when it reached a historical low (Figure 18.7.2). The CPUE has since remained at that level. Data for 2018–2020 were not available.

Fishing effort has decreased since the beginning of the time series and has remained very low since 2008.

18.7.2 Demersal *S. mentella* in 6

18.7.2.1 Fisheries

In Subarea 6, the annual landings varied between 200 t and 1100 t in 1978–2000 (Table 18.6.1). The landings from 6 in 2004 were negligible (6 t), the lowest recorded since 1978. They increased again to 111 t in 2005 and 179 t in 2006. The reported landings in 2008 were 50 t and no catches have been taken since 2009.

18.8 Regulations (TAC, effort control, area closure, mesh size etc.)

Management of redfish differs between stock units and is described in sections 19.14 for *S. norvegicus*, Section 20.7 for Icelandic slope *S. mentella*, Section 21.10 for shallow pelagic *S. mentella*, Section 22.10 for deep pelagic *S. mentella*, and Section 23 for Greenland slope *S. mentella.*

The allocation of Icelandic *S. mentella* catches to the pelagic and demersal management unit has been based on the "redfish line" (see Section 18.4).

18.9 Mixed fisheries, capacity, and effort

The official statistics reported to ICES do not divide catch by species/stocks, and since the Review Group in 2005 recommended that "multispecies catch tables are not relevant to management of redfish resources", these data are not given here and the best estimates on the landings by species/stock unit are given in the relevant chapters. Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faced problems in obtaining catch data, especially with respect to pelagic *S. mentella*. Detailed descriptions of the fisheries are given in the respective sections: *S. norvegicus* in Section 19.3, Icelandic slope *S. mentella* in Section 20.3, shallow pelagic *S. mentella* in Section 21.2, deep pelagic *S. mentella* in Section 22.2 and Greenland slope *S. mentella* in Section 23.3.

Information from various sources is used to split demersal landings into two redfish species, *S. norvegicus* and *S. mentella* (see stock annexes for Icelandic slope *S. mentella* and *S. norvegicus*). In Division 5.a, if no direct information is available on the catches for a given vessel, the landings are allocated based on logbooks and samples from the fishery. According to the proportion of biological samples from each cell (one fourth of ICES statistical square), the unknown catches within that cell are split accordingly and raised to the landings of a given vessel. For other areas, samples from the landings are used as basis for dividing the demersal redfish catches between *S. norvegicus* and *S. mentella*.

18.10 References

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18.11 Tables

Table 18.4.1. Landings of *S. viviparus* in Division 5.a 1996–2020.

Year	Landings (t)
1996	22
1997	1159
1998	994
1999	498
2000	227
2001	21
2002	20
2003	3
2004	2
2005	4
2006	9
2007	24
2008	15
2009	37
2010	2602
2011	1427
2012	535
2013	532
2014	550
2015	468
2016	234
2017	161
2018	117
2019	143
2020	118

Table 18.6.1. Nominal landings (tonnes) of demersal *S. mentella* 1978–2020 in ICES divisions 5.b and 6.

Year	5.b	6
1978	7767	18
1979	7869	819
1980	5119	1109
1981	4607	1008
1982	7631	626
1983	5990	396
1984	7704	609
1985	10560	247
1986	15176	242
1987	11395	478
1988	10488	590
1989	10928	424
1990	9330	348
1991	12897	273
1992	12533	134
1993	7801	346
1994	6899	642
1995	5670	536
1996	5337	1048
1997	4558	419
1998	4089	298
1999	5294	243
2000	4841	885
2001	4696	36
2002	2552	20
2003	2114	197
2004	3931	6
2005	1593	111
2006	3421	179

Year	5.b	6
2007	1376	1
2008	750	50
2009	1077	0
2010	1202	0
2011	1126	0
2012	263	0
2013	398	0
2014	370	0
2015	537	0
2016	717	0
2017	372	0
2018	521	0
2019	646	0
2020[1)]	432	0

1) Provisional

18.12 Figures

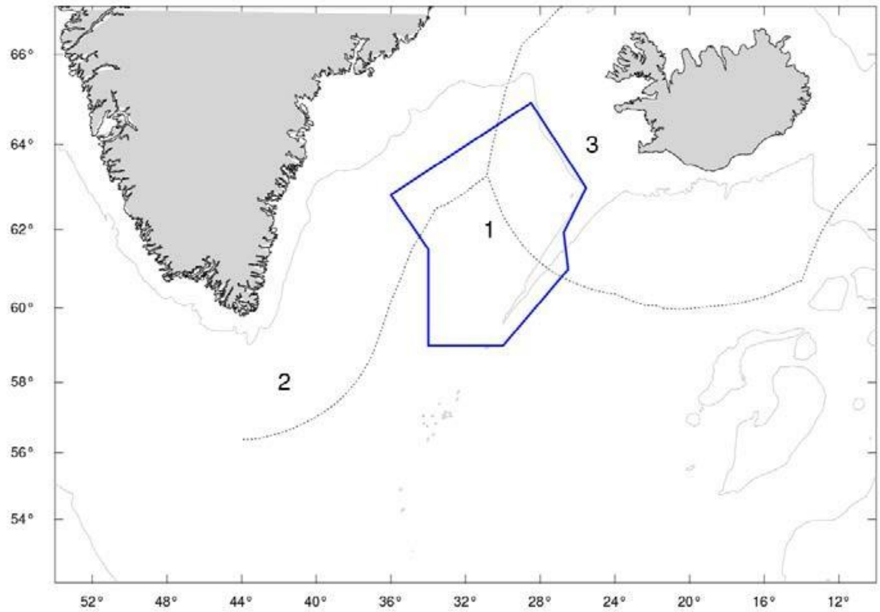

Figure 18.1.1 Potential management unit boundaries. The polygon bounded by blue lines, i.e., 1, indicates the region for the 'deep pelagic' management unit in the northwest Irminger Sea, 2 is the "shallow pelagic" management unit in the southwest Irminger Sea, and 3 is the Icelandic slope management unit.

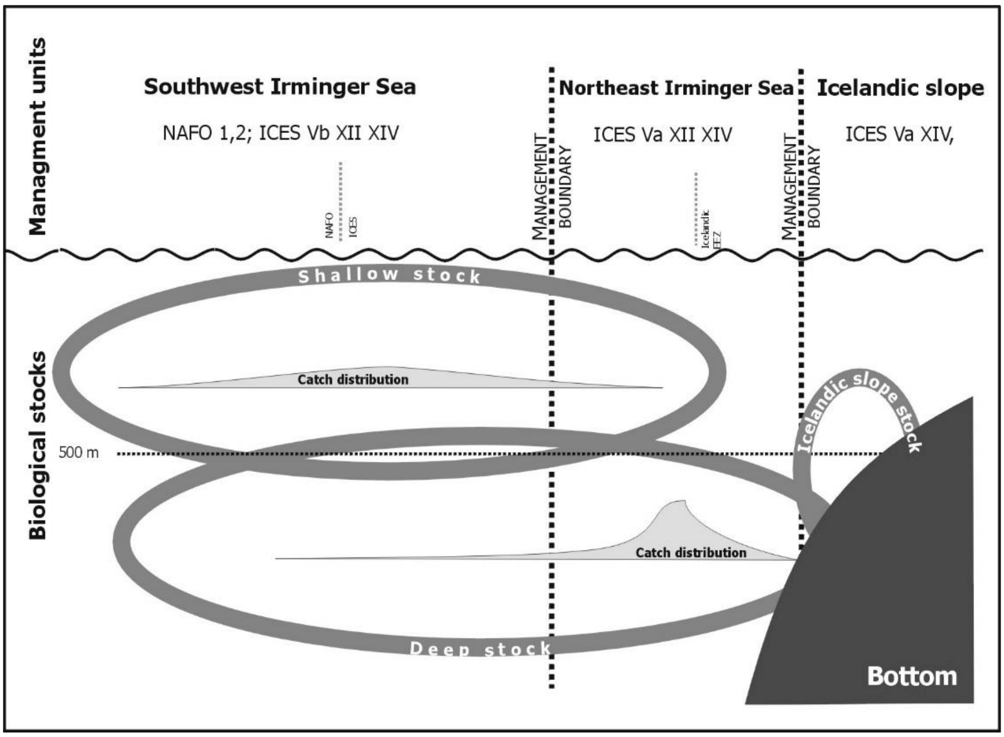

Figure 18.1.2 Schematic representation of biological stocks and potential management units of *S. mentella* in the Irminger Sea and adjacent waters. The management units are shown in Figure 18.1.1. Included is a schematic representation of the geographical catch distribution in recent years. Note that the shallow pelagic stock includes demersal *S. mentella* east of the Faroe Islands and the deep pelagic stock includes demersal *S. mentella* west of the Faroe Islands.

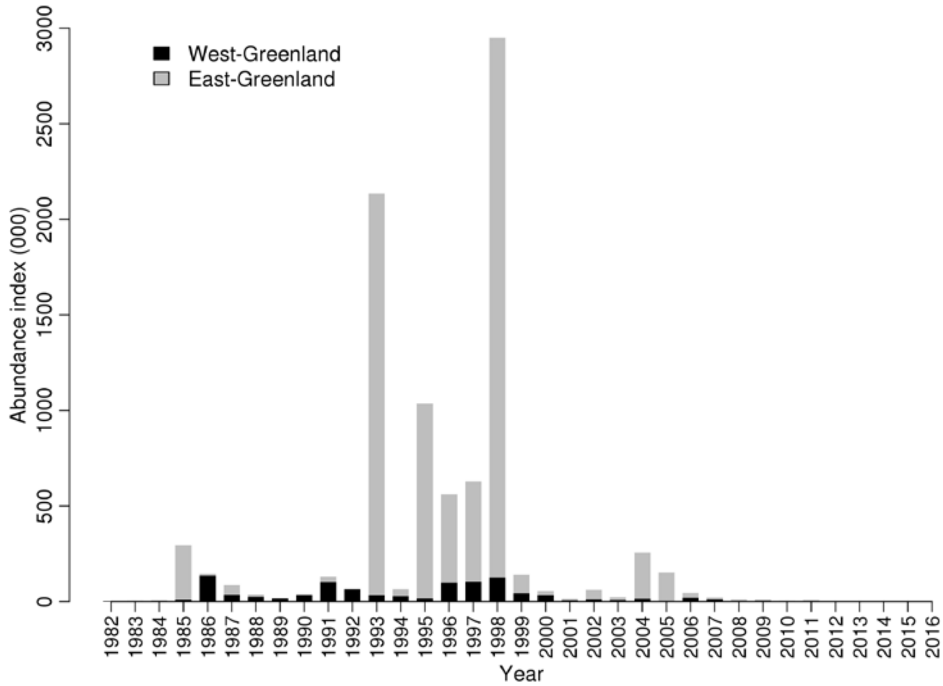

Figure 18.2.1 Survey abundance indices of *Sebastes spp.* (<17 cm) for East and West Greenland from the German groundfish survey 1982–2016. No data were available in 2017-2020.

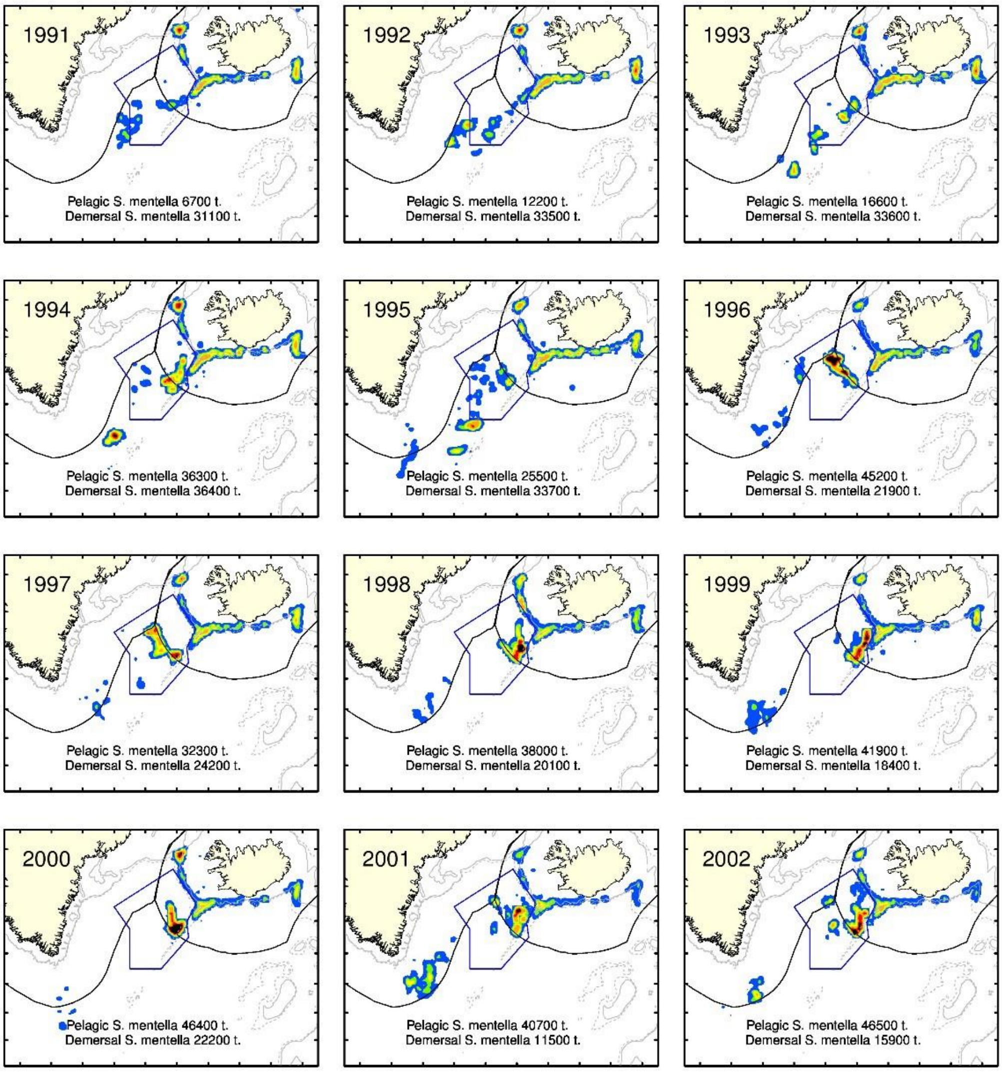

Figure 18.4.1Geographical distribution of the Icelandic catches of *S. mentella* 1991–2002. The colour scale indicates catches (tonnes per NM2). Not updated for 2019-2020.

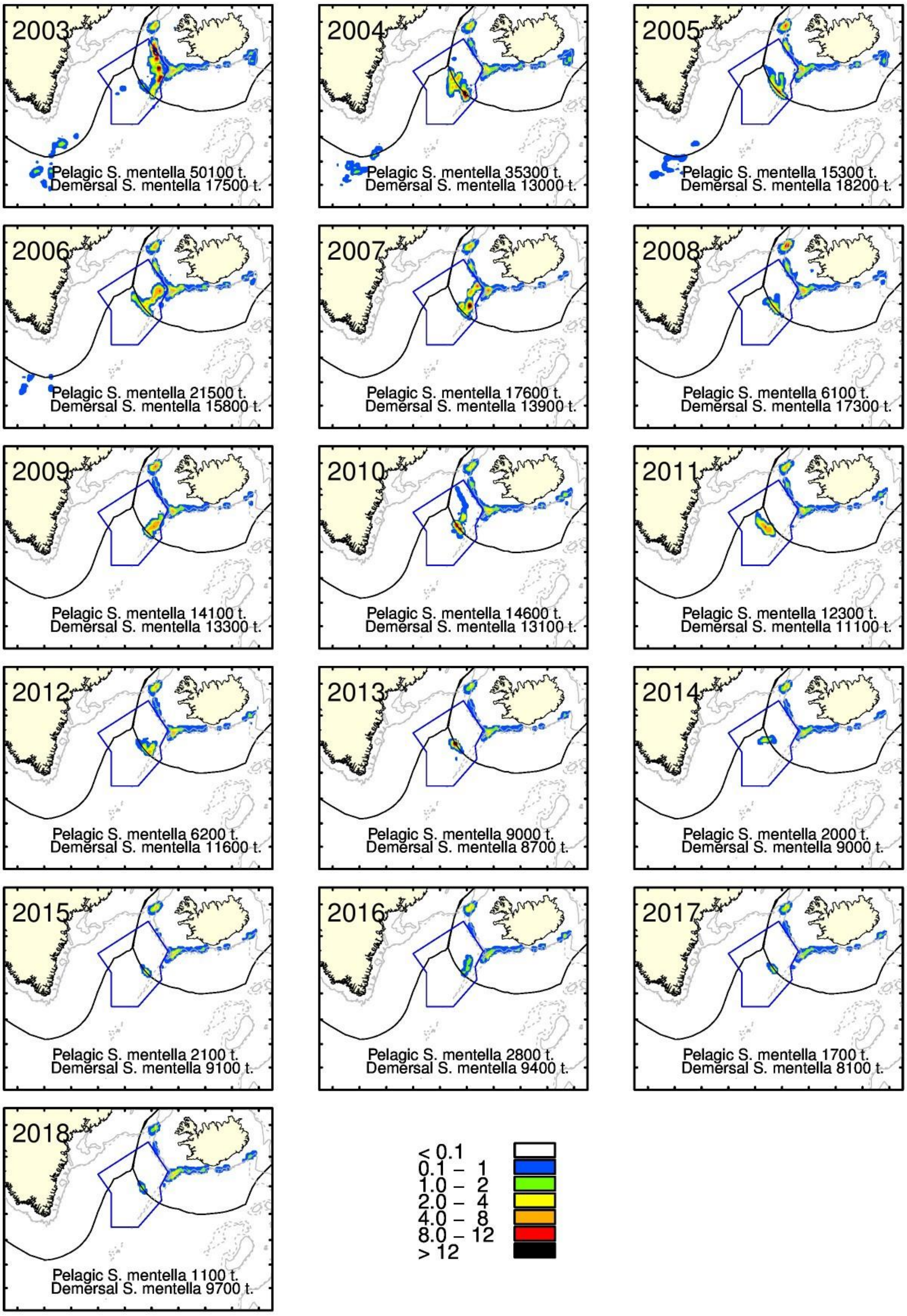

Figure 18.4.1 *cont.* Geographical distribution of the Icelandic catches of *S. mentella* 2003–2018. The colour scale indicates catches (tonnes per NM²). Not updated for 2019-2020.

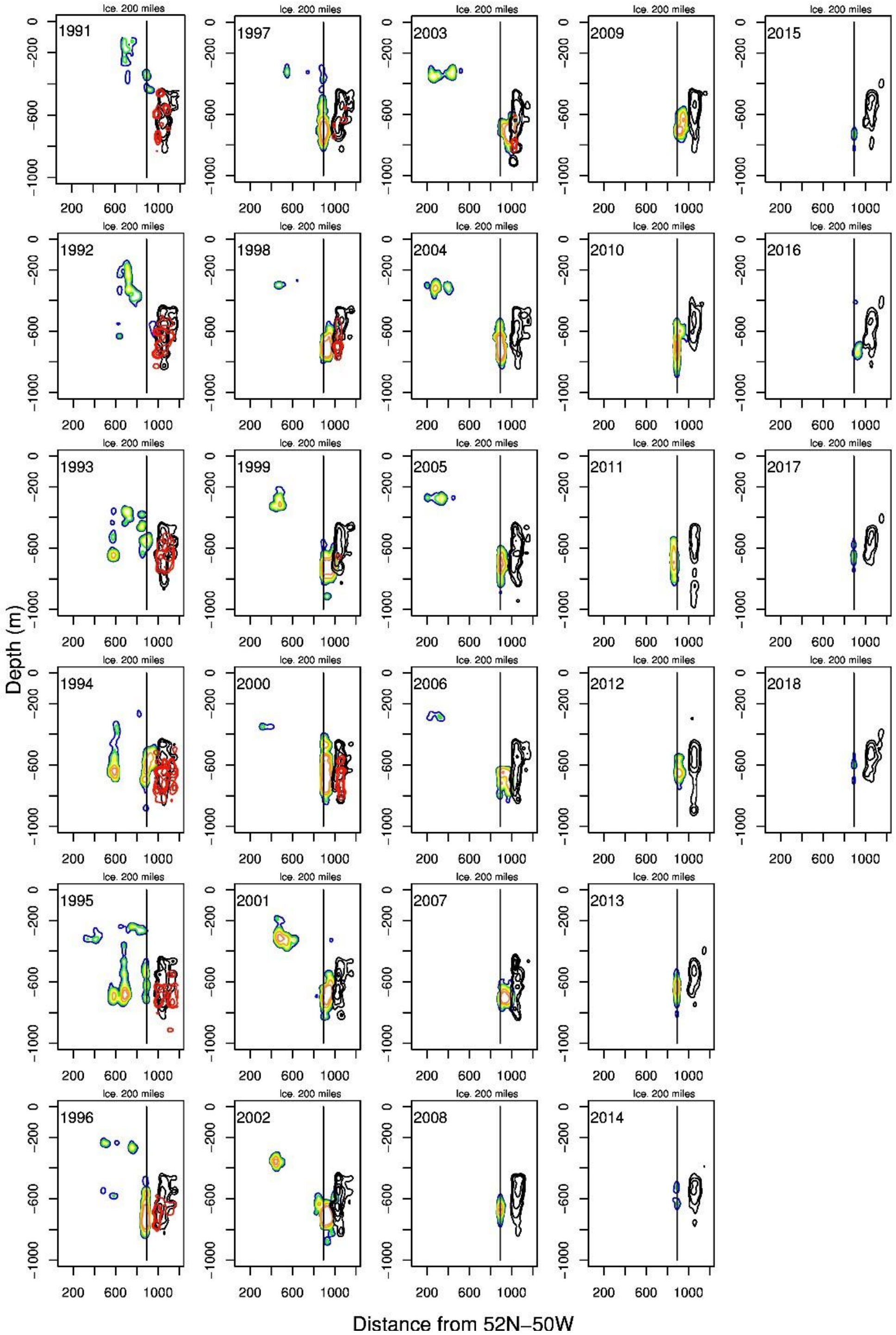

Figure 18.4.2 Distance-depth plot for Icelandic *S. mentella* catches, where distance (in NM) from a fixed position (52°N 50°W) is given. The contour lines indicate catches in a given area and distance. The coloured contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls. Not updated for 2019-2020.

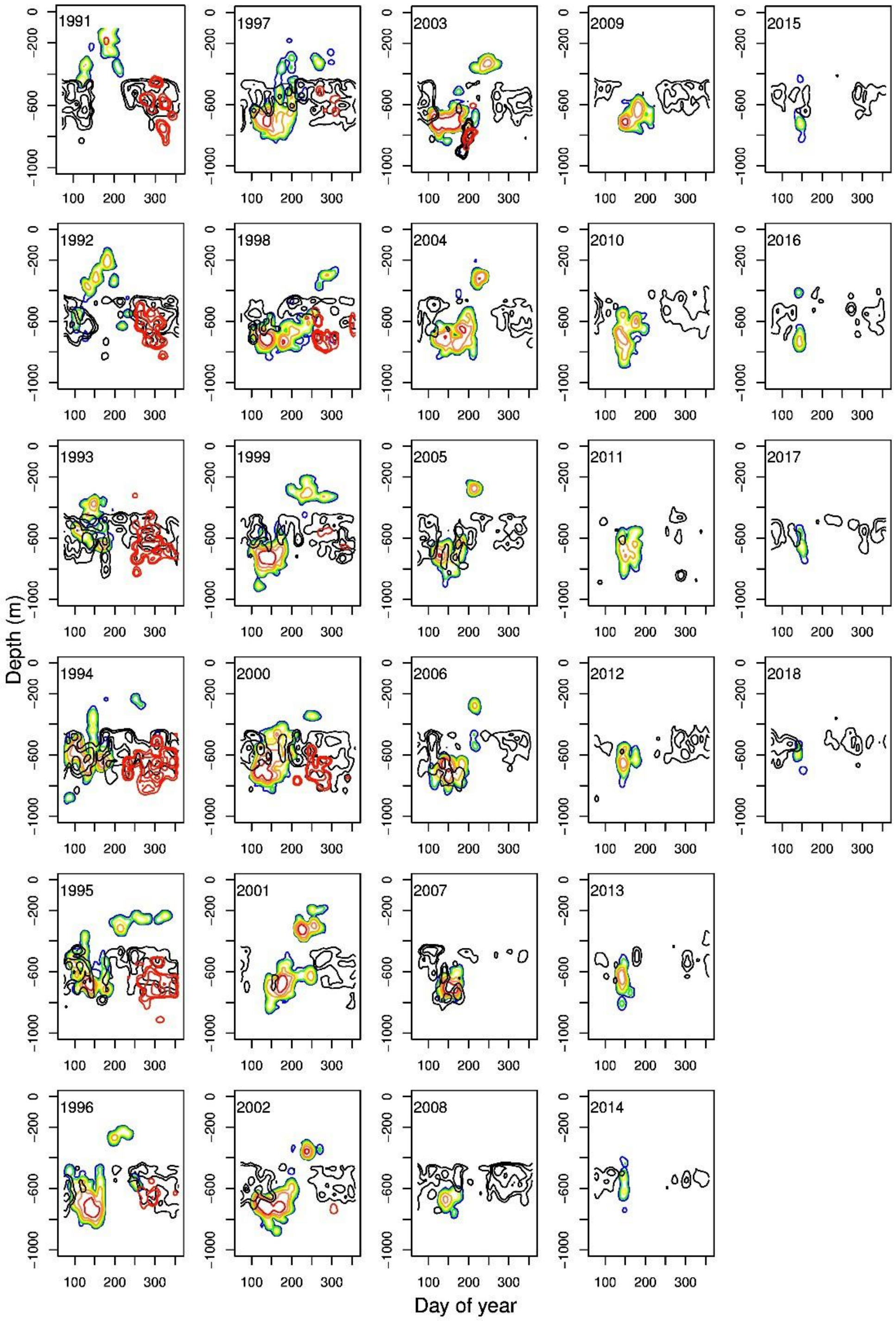

Figure 18.4.3 Depth-time plot for Icelandic *S. mentella* catches 1991–2016 where the y-axis is depth, the x-axis is day of the year and the colour indicates the catches. The coloured contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls. Not updated for 2019-2020.

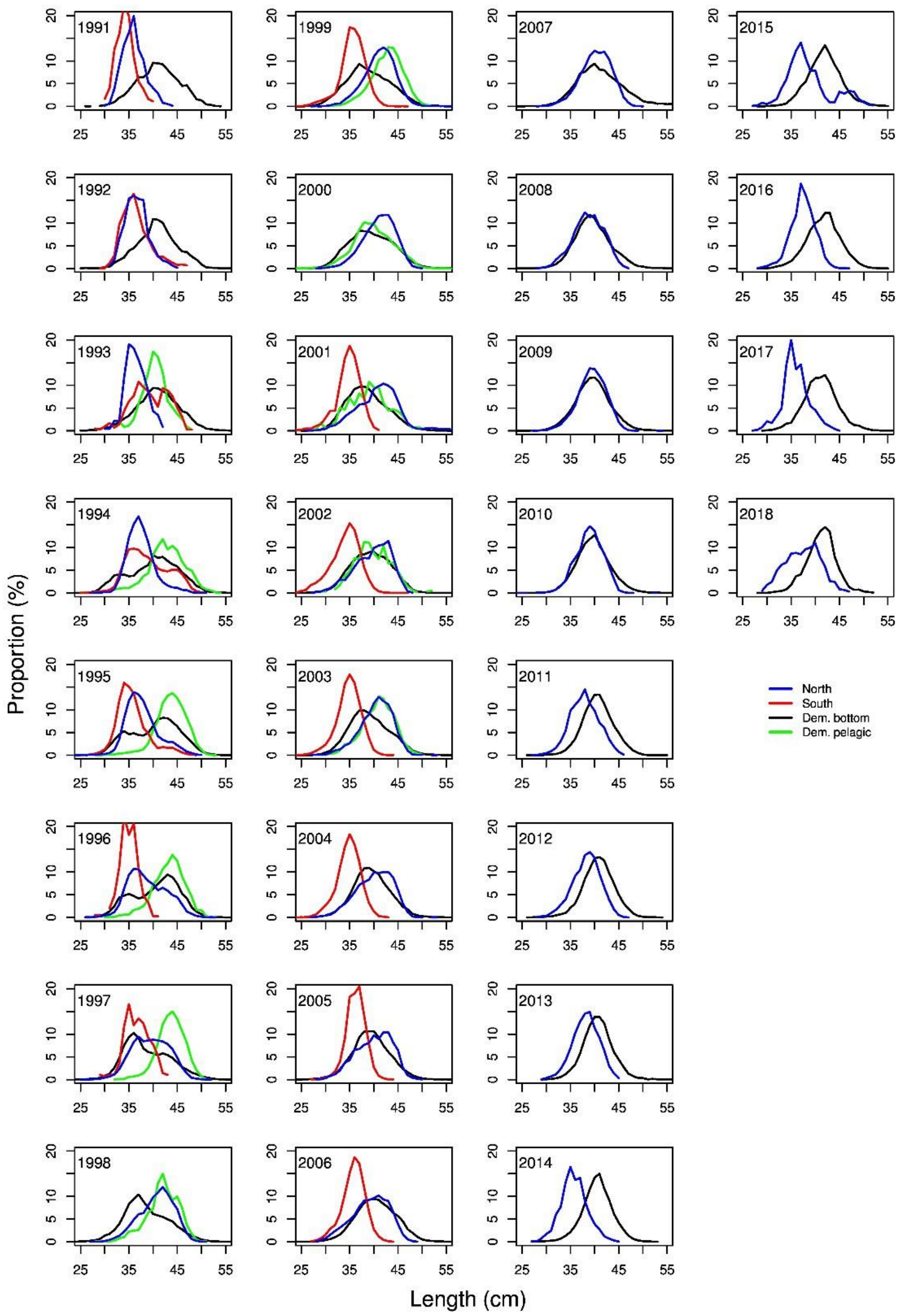

Figure 18.4.4 Length distributions from different Icelandic *S. mentella* fisheries, 1991–2018. The blue lines represent the fishery on pelagic *S. mentella* in the northeastern area, the red lines the pelagic fishery in the southwestern area, the black lines indicate bottom trawl catches of demersal *S. mentella*, and the green lines represent catches of demersal *S. mentella* taken with pelagic trawls. Not updated for 2019-2020.

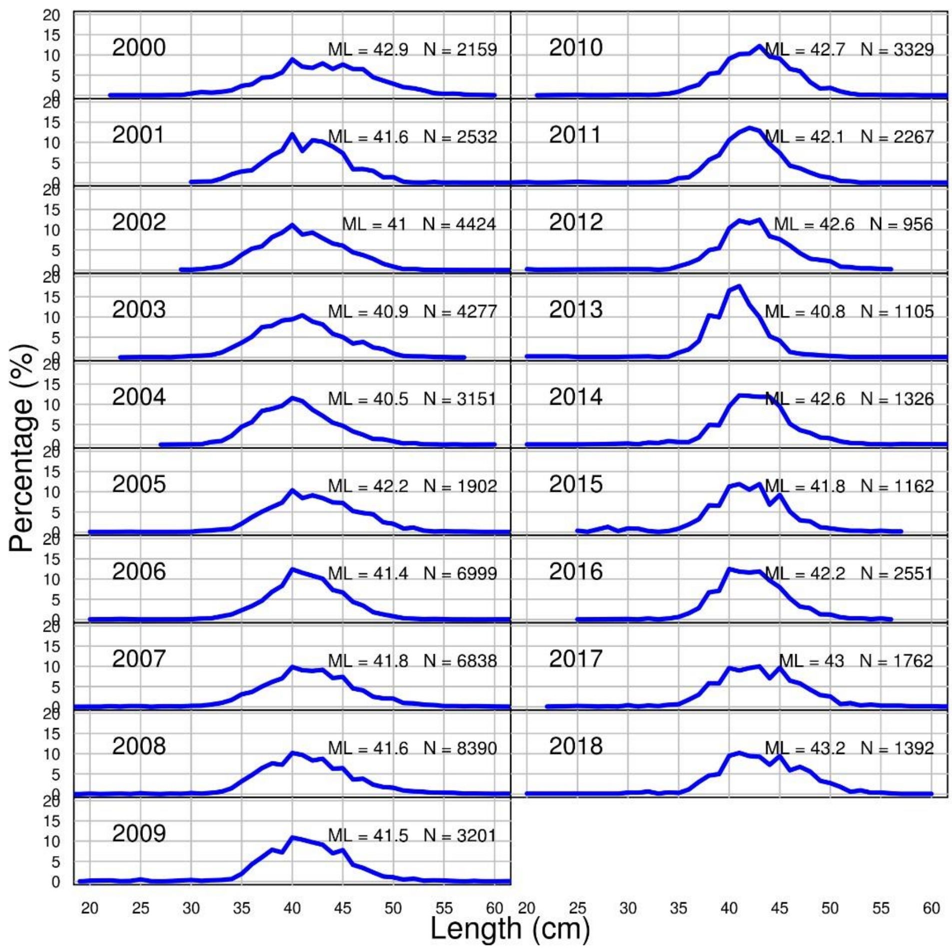

Figure 18.7.1 Length distribution of demersal *S. mentella* from landings of the Faeroese fleet in Division 5.b 2000–2018. Not updated for 2019 and 2020.

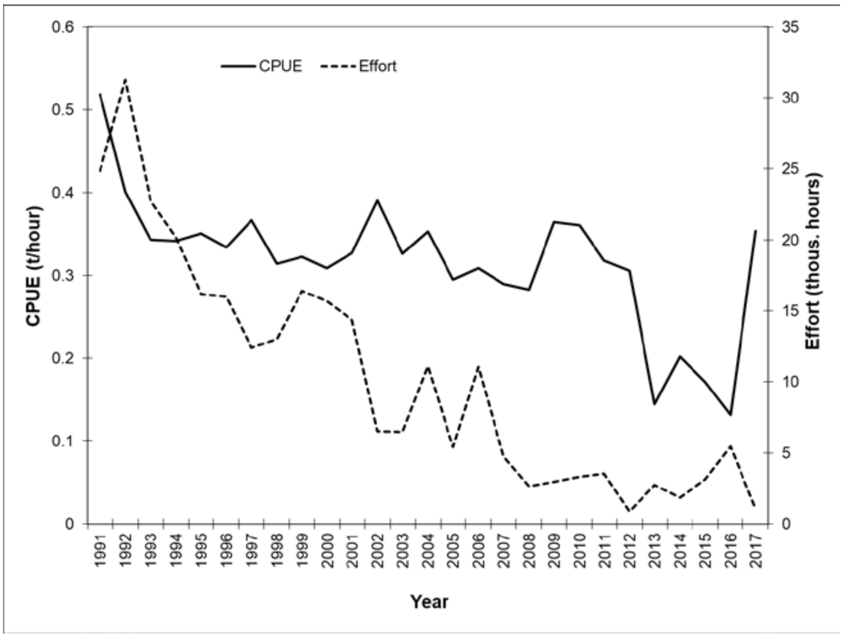

Figure 18.7.2 Demersal *S. mentella*, CPUE (t/hour) and fishing effort (in thousands hours) from the Faeroese CUBA fleet 1991–2017 and where 70% of the total catch was demersal *S. mentella*. Not updated for 2018-2020.

19 Golden redfish (*Sebastes norvegicus*) in subareas 5, 6 and 14

19.1 Stock description and management units

Golden redfish (*Sebastes norvegicus*) in ICES subareas 5 and 14 have been considered as one management unit. Catches in ICES Subarea 6 have traditionally been included in this report and the group continues to do so. Data from ICES Subarea 6 is, however, not used in the assessment.

19.2 Scientific data

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

19.2.1 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 has been conducted annually in October since 1996. The autumn survey was not conducted in 2011. Description of the Icelandic bottom trawl surveys and the calculation of the survey indices for golden redfish in ICES 5.a. are given in the Stock Annex (smr-5614_SA). 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 19.2.1 and Table 19.2.1). 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 2019-2021 similar as in 2014 and 2015. The CV of the measurement error has been considerably higher after 2002.

The total biomass index from the autumn survey shows similar trend as in the spring survey when the index gradually increased from 2000 to the highest value in the time series in 2014. The total biomass index in 2015-2019 fluctuated around the 2014 level but decreased sharply in 2020 (Figure 19.2.1 and Table 19.2.1).

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 cohort) and then in 1991–1992 (the 1990 cohort), reached the fishable stock approximately 10 years later (Figure 19.2.2). The increase in the survey index between 1995 and 2005 reflects the recruitment of these two strong year classes. During the 1999–2008 period the abundance of small redfish was lower than in 1986–1990, highest in 2000-2003 (Figure 91.2.1). In 2009-2021, very little of small redfish has been observed in the spring survey (Figure 19.2.1). In recent years, the modes of the length distribution in both surveys have shifted to the right and is 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 19.2.1, 19.2.2 and 19.2.3).

Age disaggregated abundance indices from the autumn survey are shown in Figure 19.2.4 and in Table 19.2.2. 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 in the stock. The age disaggregated abundance indices indicate that all year-classes since 2009 are small.

19.2.2 Division 5.b

In Division 5.b, CPUE of golden redfish were available from the Faeroes spring groundfish survey from 1994–2021 and the summer survey 1996–2020 (see smr-5614 SA). Both surveys show similar trends in the indices from 1998 onwards with sharp declines between 1998 and 1999 (Figure 19.2.5). CPUE in the spring survey since 2000 has been stable at low level. The CPUE index in the summer survey shows similar trend as in the spring survey and has gradually decreased and is at the lowest level recorded.

19.2.3 Subarea 14

The German groundfish survey has been conducted annually in the autumn from 1982 to 2017 and in 2019-2020 covering shelf areas and the continental slopes off West and East Greenland. Description of the survey and the re-stratification in 2013 is found in the Stock Annex (smr-5614 SA). 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 19.2.6. 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 19.2.6). 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 2017-2020 to similar level as in 2006 (Figure 19.2.6a). It should be noted that the CV for the indices is high and the increase is driven by few very large hauls. In 2010–2020, the biomass of pre-fishery recruits (17–30 cm) has decreased compared to previous five years and in 2017-2020 very little of 17–30 cm fish was observed (Figure 19.2.6*c*).

Abundance indices of redfish smaller than 18 cm from the German annual groundfish survey show that juveniles were abundant in 1993 and 1995–1998 (see Figure 18.2.1). Since 2008, the survey index has been very low and in recent years at the lowest value recorded since 1982. Juvenile redfish were only classified to the genus *Sebastes* spp., as species identification of small specimens is difficult due to very similar morphological features. The 1999–2020 survey results indicate low abundance and are like those observed in the late 1980s. The Greenland shrimp and fish shallow water survey 2008-2020 (no survey conducted 2017–2019) also shows very little juvenile redfish (<18 cm, not classified to species) were present (see Figure 23.2.6).

19.3 Information from the fishing industry

19.3.1 Landings

Total landings of golden redfish decreased gradually by more than 70% in 1982-1994 or from 130 429 t in 1982 to 43 515 t in 1994 (Table 19.3.1 and Figure 19.3.1). Since then, the annual landings of the stock have varied between 33 451 t and 59 698 t. The total landings in 2020 were 45 893 t, which is 2 753 t less than in 2019. About 90–98% of the golden redfish catch has been taken in Icelandic Waters (ICES Division 5.a).

Landings of golden redfish in Division 5.a (Icelandic waters) declined from 97 899 t in 1982 to 38 669 t in 1994 (Table 19.3.1). Since then, landings have varied between 31 686 t and 54 041 t, highest in 2016. The annual landings since 2016 have decreased and were 40 688 t in 2020, 4 058 t less than in 2019. The landings were 5% higher than allocated quota of 38 896 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. Detailed description of the Icelandic ITQ system is found in the Stock Annex for the species (smr-5614_SA).

Between 90–95% of the golden redfish catch in Division 5.a is taken by bottom trawlers targeting redfish. The remaining catches are caught as bycatch in the gillnet, long-line, and lobster fisheries. In 2020, as in previous years, most of the catches were taken along the shelf southwest, west, and northwest of Iceland (Figure 19.3.2). Higher proportion of the catches is now taken along the shelf northwest of Iceland and less south and southwest.

In Division 5.b (Faroese waters), annual landings decreased from 9194 t in 1985 to less than 700 t in the 2006-2016 period (Table 19.3.1). In 2017 landings increased to 1397 t, the highest landings since 2005. The landings in 2020 was 1297 t. 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 19.3.1 and Table 19.3.1). During the period 1985–1994, the annual landings 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 increase 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 2020 were 4105 t, 1440 t more than in 2019.

Annual landings from Subarea 6 increased from 1978 to 1987 followed by a gradual decrease to 1992 (Table 19.3.1). From 1995 to 2004, annual landings have ranged between 400 and 800 t, but decreased to 137 t in 2005. Little or no landings of golden redfish were reported from Subarea 6 in 2006–2020 and were 100 t in 2020.

19.3.2 Discard

Comparison of sea and port samples from the Icelandic discard sampling program does not indicate significant discarding due to high grading in recent years (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 when sorting grids became mandatory. Since then, the discard has been insignificant both due to the sorting grid and much less abundance of small redfish in the region.

Discard of redfish species in the shrimp fishery in ICES Division 14.b is currently considered insignificant (see Section 18).

19.3.3 Biological data from commercial fishery

The table below shows the fishery related sampling by gear type and ICES divisions in 2020. Sampling in 5.a was in 2020 considerably less than in previous years because of the COVID-19.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	40 688	65	9 191	834
5.b	Faroe Islands	Bottom trawl	1 297		116	
14	Greenland	Bottom trawl	4 105			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976–2020 show that most of the fish caught is between 30 and 45 cm (Figure 19.3.3). The modes of the length distributions range between 35 and 40 cm and has over the past decade shifted to the right. The length distributions in 2012–2020 are narrower than previously, with less than average of small fish (<35 cm) caught, and the mean length has increased by almost 4 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 19.3.4 and Table 19.3.2). The strong 1990 cohort dominated the catch in 2003–2007 contributing between 25–30% of the total catch in weight. In 2007–2010 the 1996–1999 cohorts dominated in the catches but are now gradually decreasing. The 2003–2008 cohorts (ages 12–17) were the most dominant year classes in the fishery in 2020. 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 19.3.5) is about 0.20 for age 13 years and older.

Length distribution from the Faroese commercial catches 2001–2020 shows that the fish caught are on average larger than 40 cm with modes between 45 cm and 50 cm (Figure 19.3.6).

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

19.3.5 CPUE

The un-standardized CPUE index from the Icelandic bottom trawl fleet operating in Division 5.a has increased sharply since 2006 and is at the highest level in the time-series. Effort towards golden redfish has gradually decreased since 1986 and is now at the lowest level recorded (Figure 19.3.7). CPUE derived from logbooks is not considered indicative of stock trends however the information contained in the logbooks on effort, spatial and temporal distribution the fishery is of value.

CPUE from other areas are not available. This is because no separation of S. *norvegicus*/*S. mentella* is made in the catches.

19.4 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. The settings are described in the Stock Annex.

19.4.1 Gadget model

19.4.1.1 Data and model settings

Below is a brief description of the data used in the model and model settings is given. A more detailed description is given in the Stock annex.

Data used in the Gadget model are:

- Length disaggregated survey indices 19–54 cm in 2 cm length increments from the Icelandic groundfish survey in March 1985–2021 and the German survey in East Greenland 1984–2020. 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 19.4.2) and the German survey gets half the weight compared to what is presented in Figure 19.2.6. 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 19.2.6, each station in the German survey would get 2.5 times more weight compared to the Icelandic survey.
- Length distributions from the Icelandic (1972-2021), Faroe Islands (1980-2020) 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 1996–2020.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995–2020.

Model settings:

- The simulation period is from 1970 to 2025 using data until the first half of 2021 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 (53 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 2022 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 2021 were set as the sum of expected landings, accounting for interannual transfer from 2020. Previously, the catches in the first time-step in 2021 (first 6 months) were set at the same as in the first time-step of 2020 for all the fleets; in step 2 in 2021 and onwards the model was run at fixed effort corresponding to $F_{9–19}$ = 0.097. The NWWG concluded during the meeting in 2021 that the previous method of catch assumption in the intermediate year was seldom fulfilled as overshooting (catch exceeding the advice), especially in Icelandic waters, has ranged between 5-15% in recent years.
- The estimated selection pattern from the Icelandic fleet was used for projections.

19.4.1.2 Results of the assessment model

Summary of the assessment is shown in Figure 19.4.3 and Table 19.4.1. 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 (at age 5) after 2013 is at record low levels for the time series.

Assumptions about the cohorts after the 2015 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 19.4.4).

19.4.1.3 Mohn's rho

The retrospective pattern of the assessment (Figure 19.4.5) and the Mohn's rho values. The default five-year peels resulted in the following values:

Variable	Value
F_{bar}	-0.0533
SSB	0.0352
Rec.	0.501

The Mohn's rho values for F_{bar} and SSB are low (-5% and 3% respectively) but indicates that fishing mortality has consistently been underestimated and SSB been overestimated (Figure 19.4.5). Mohn's rho for recruitment is on the other hand high (50%) and indicates that recruitment has in previous assessments been overestimated. This value needs though to be taken with caution as recruitment estimates of the five-year peels is very low compared to previous years and any deviation from previous year may have relatively high impact. Extending the peel to, for example 10 years, may result in different value.

19.4.1.4 Diagnostics

Observed and predicted proportion by fleet: Trends in different likelihood components (Figure 19.4.6) shows how the fit to survey length distributions has become worse in recent years. This can also be seen in Figure 9.4.7 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 19.4.8).

The fit between predicted and observed age distributions is better than for the length distributions (Figures 19.4.9 and 19.4.10). The model uses the data as age-length keys in 2 cm intervals for tuning.

Model fit: In Figure 19.4.11 the length disaggregated indices are plotted against the predicted numbers in the stock as a time-series. 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 number 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.

As the model converges slowly, predicted indices could change several years back when more data are added. However, it is not the magnitude of the residuals but rather the temporal pattern that is worrying (Figure 19.4.12). 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 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. 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, indicates narrower length distributions in the survey than predicted (Figure 19.4.12).

19.4.2 Advice for 2021 (Last year's advice)

The management plan is based on $F_{9\text{–}19}$ = 0.097 reducing linearly if the spawning stock is estimated below 220 000 t ($B_{trigger}$). B_{lim} was proposed as 160 000 t, lowest SSB in the 2012 run. The 2020 SSB was estimated at 280 100 t, and according to the management plan the TAC advice for 2021 was 38 343 t.

19.5 Reference points

Harvest control rule (HCR) was evaluated at WKREDMP in January 2014 (ICES, 2014) based on stochastic simulations using the Gadget model. Considering conflicting information by different data continuing for many consequent years (Section 19.4), the simulations were conducted using large assessment error with very high autocorrelation (CV = 0.25, rho = 0.9).

Yield-per-recruit analysis show that when average size at age 5 was allowed to change after year class 1996, $F_{9\text{–}19,MAX}$ changed from 0.097 to 0.114. The proposed fishing mortality of 0.097 is therefore around 85% of F_{MAX} with current settings. Stochastic simulations indicate that it leads to very low probability of spawning stock going below $B_{trigger}$ and B_{lim}, even with relatively large autocorrelated 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 show that F_{lim} = 0.226 and F_{pa} is then 0.226/exp(1.645*0.2) = 0.163 (Figure 19.5.1). 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 increased again gradually because of improved recruitment and lower F (Figure 19.5.1).

The probability of current SSB < $B_{trigger}$ is estimated 2.7%. For simplicity, the action of $B_{trigger}$ is not included in the simulations since Gadget is not keeping track of "perceived spawning stock". Analysis of the stochastic prediction in R shows that if SSB is below $B_{trigger}$ it will only be noted in < 15% of the cases. The reason is that the spawning stock is only likely to go below $B_{trigger}$ in periods of severe overestimation of the stock that occur due to the assumed high autocorrelation in assessment error. This situation differs from that of the stock going below $B_{trigger}$ due to poor recruitment (worse than observed in recent decades). In this case the spawning stock should still have a resilient age structure (as discussed above) and this could reduce the need to take further action below $B_{trigger}$.

Figure 19.5.2 shows the development of $F_{9\text{–}19}$ based on $F_{9\text{–}19}$ = 0.097. F is expected to be within the range of the fifth and 95th quantile and the 16th and 84th quantile.

19.6 State of the stock

The results from Gadget indicate that fishing mortality has been low since 2009 but above F_{MSY} (Figure 19.4.3). Total biomass and SSB has been decreasing since 2016 (Table 19.4.1) 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.

19.7 Short term forecast

The Gadget model is length based where growth is modelled based on estimated parameters. The only parameters needed for short term forecast are assumptions about size of those cohorts that have not been seen in the surveys. These year classes were assumed to be the average of five smallest year classes in 1980–2007 (Figure 19.4.3).

The results from the short-term simulations based on $F_{9\text{–}19}$ is shown in Figure 19.4.3 and from short term prognosis with varying fishing mortality in 2022 and 2023 in Table 19.4.2. The results indicate that when fishing according to the management plan the SSB is expected to decrease further and to be close to MSY $B_{trigger}$ in 2023 (Table 19.4.2).

19.8 Medium term forecast

No medium-term forecast was carried out.

19.9 Uncertainties in assessment and forecast

Various factors regarding the uncertainty and modelling challenges are listed in the WKRED 2012 (ICES, 2012) and WKREDMP-2014 (ICES, 2014) reports. In addition, this subject is discussed in Section 19.4.

19.10 Basis for advice

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

19.11 Management consideration

In 2009 a fishery targeting redfish was initiated in Subarea 14 with annual catches of between 6000 and 8500 t in 2010–2020, 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 2016–2020.

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

No formal agreement on the management of *S. norvegicus* exists among the three coastal states, Greenland, Iceland, and the Faroe Islands. However, an agreement was made between Iceland and Greenland in October 2015 on the management of the golden redfish fishery based on the management plan applied in 2014. The agreement 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 Faeroe Islands by effort limitation. The regulation schemes of those states have previously resulted in catches more than TACs advised by ICES.

Since 2009, surveys of redfish in the stock area have consistently shown very low abundance of young redfish (< 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 the future productivity of the stock.

19.12 Ecosystem consideration

Not evaluated for this stock.

19.13 Regulation and their effects

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 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, there in the early 1990s, observers report small redfish as being negligible in the Icelandic shrimp fishery. If the sorting grids work where the abundance of redfish is high is a question but not a relevant problem now in 5.b as abundance of small redfish is low and shrimp fisheries limited.

There is no minimum landing size of golden redfish in Division 5.a. However, if more than 20% of a catch observed on board is below 33 cm a small area can be closed temporarily. A large area west and southwest of Iceland is closed for fishing to protect young golden redfish.

There is no regulation of the golden redfish in Division 5.b.

Since 2002 it has been mandatory in the shrimp fishery in Subarea 14 to use sorting grids to reduce bycatches of juvenile redfish in the shrimp fishery.

19.14 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.

19.15 Changes in the environment

No information available.

19.16 Benchmark

Benchmark meeting for golden redfish, scheduled in 2020 was delayed because of lack of resources within the ICES system. The group recommended that the stock should be benchmarked in 2023.

Golden redfish was last benchmarked in 2014 and the group thinks that benchmarking the stock is of high importance. 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. Underutilized data sources from ICES 5.b and 14.b, mainly relevant survey and commercial samples of age and length. Biological reference points will need to be redefined depending on the assessment method, especially in relation to the Fp0.5. 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.

19.17 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.

19.18 Tables

Table 19.2.1 Survey indices and CV of golden redfish from the spring survey 1985–2021 and the autumn survey 1996–2020.

Year	Spring Survey		Autumn Survey	
	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	199,793	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

Year	Spring Survey		Autumn Survey	
	Biomass	CV	Biomass	CV
2011	401,358	0.235		
2012	461,928	0.204	343,163	0.225
2013	457,448	0.177	317,125	0.156
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	244,099	0.159
2021	441,208	0.194		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in millions) from the autumn groundfish survey 1996–2020. The survey was not conducted in 2011.

Year/Age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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	0.4
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	0.2
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	1.0
4	1.6	1.6	2.3	1.5	1.6	2.4	6.1	1.1	1.8	1.0	0.5	1.1	2.7	4.4	0.3		1.4	0.2	0.1	0.3	1.8	0.2	0.1	0.8	0.7
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	1.3
6	40.0	6.9	3.5	2.8	7.9	2.1	11.8	17.7	28.6	4.8	6.8	10.4	7.9	11.6	14.2		3.1	4.1	1.8	1.2	0.8	1.3	3.0	0.9	0.8
7	11.3	22.5	16.6	10.5	6.7	10.8	3.3	38.2	36.7	39.7	15.6	26.0	39.2	13.9	15.1		23.5	3.0	12.8	7.6	3.9	1.6	2.5	15.3	0.7
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	10.9
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	3.9
10	28.9	11.1	26.1	43.7	95.0	17.3	16.6	12.7	45.6	24.9	85.7	37.4	106.4	58.7	69.0		62.9	56.3	151.8	86.4	48.1	93.8	36.7	20.3	7.4
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	18.4
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	41.0
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	39.1
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	24.3
15	33.9	7.2	7.6	6.0	51.4	9.2	9.8	10.8	13.6	82.1	18.3	6.8	9.1	18.3	9.1		19.6	31.7	27.0	40.3	35.8	27.4	27.3	45.4	39.0
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	25.7
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	10.5

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	2020
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	12.1
19	4.3	2.0	0.5	8.4	4.6	3.6	3.0	4.5	21.6	5.0	2.8	4.5	6.2	28.4	6.6		3.9	5.2	6.0	10.0	16.1	14.7	12.9	22.1	12.0
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	11.1
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	6.9
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	4.6
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	4.1
24	4.6	0.8	0.4	0.6	1.0	0.5	0.4	0.3	0.0	0.9	1.0	1.3	1.4	10.2	0.7		2.0	2.6	12.7	1.1	2.8	4.8	2.8	3.7	3.3
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	2.5
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	1.8
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	1.9
28	0.8	0.4	0.5	1.5	0.7	0.5	0.2	0.0	0.2	0.2	0.2	0.0	0.6	0.2	0.7		0.4	8.7	0.5	1.6	1.0	1.7	11.5	1.7	0.8
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	1.3
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	9.6
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	297.4

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978–2020 as officially reported to ICES. Landings statistics for 2020 are provisional.

Year	Area				Total
	5.a	5.b	6	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

Year	Area				Total
	5.a	5.b	6	14	
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	44 746	1 053	101	2 665	48 464
20201)	40 688	1 297	100	4 105	46 190

1) Provisional

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995–2020. It should be noted that the catch-at-age results for 1996 are only based on three samples, which explains that there are no specimens older than 23 years.

Year/Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
7	46	0	33	24	6	38	125	127	191	226	227	176	135	215	103	60	138	68	30	235
8	321	389	226	280	342	62	143	884	201	855	755	987	446	1,057	936	359	558	612	555	475
9	1,432	867	481	586	1,592	825	402	736	1,312	501	1,877	2,134	1,727	2,164	1,689	2,218	1,626	1,603	2,197	1,752
10	8,598	3,887	1,039	1,193	1,252	4,180	1,653	808	1,080	2,107	1,496	3,605	2,442	5,006	3,059	2,725	4,772	3,444	3,886	6,176
11	2,570	9,575	2,708	1,118	1,843	1,843	7,768	3,192	1,160	828	3,093	2,017	3,319	3,997	4,964	2,786	5,699	6,725	5,952	6,751
12	1,286	2,170	11,609	3,221	2,521	2,224	1,810	10,955	3,863	989	1,899	2,789	1,911	4,682	4,457	4,921	4,899	7,345	9,488	5,807
13	3,616	1,354	2,828	12,425	2,447	1,665	1,930	3,012	9,576	2,017	1,366	1,624	3,068	2,297	3,430	3,895	6,235	4,021	6,896	5,809
14	5,787	1,523	1,366	2,068	15,536	2,329	1,243	2,548	2,304	8,612	3,021	1,275	1,050	2,819	1,848	2,740	3,772	4,721	4,032	4,776
15	6,229	4,293	3,106	2,020	1,242	14,598	826	1,805	1,932	2,148	11,840	2,818	955	1,546	2,008	1,378	2,501	2,668	4,466	3,061
16	1,833	5,033	3,579	2,394	1,250	1,752	11,487	2,998	1,202	1,656	2,073	10,318	2,168	1,067	1,247	1,201	1,309	1,525	3,043	2,538
17	912	954	2,968	3,404	1,795	1,170	515	11,726	2,231	870	1,447	2,074	9,337	1,804	681	820	981	820	1,720	1,921
18	395	372	869	2,029	2,619	1,602	769	2,054	6,494	1,381	1,243	1,191	1,329	8,188	1,502	648	602	813	1,205	1,245
19	1,244	252	616	1,013	2,194	2,400	1,025	1,150	784	5,065	1,241	722	741	1,503	6,158	1,086	691	492	764	464
20	1,232	343	919	723	1,237	2,141	1,684	622	390	1,093	6,387	956	717	966	970	4,980	987	808	488	1,202
21	549	1,059	440	528	452	538	916	1,360	585	342	387	5,524	876	567	654	901	5,052	627	510	438
22	674	698	534	397	211	438	386	982	840	464	456	552	4,765	831	576	762	1,056	3,512	772	425
23	1,521	790	641	426	326	283	399	697	788	599	758	226	732	4,231	342	519	753	477	3,298	486

Year/Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
24	695	0	567	660	215	63	155	352	426	528	591	396	113	382	2,561	665	204	324	183	2,929
25	777	0	703	536	810	408	119	270	307	239	417	457	599	254	98	2,151	134	225	199	183
26	396	0	263	382	264	361	109	176	71	94	94	97	329	433	97	199	1,336	237	171	195
27	372	0	135	432	592	220	265	80	74	187	253	254	345	337	199	348	77	1,326	108	142
28	799	0	186	358	227	520	182	287	26	123	161	200	199	169	94	131	201	198	918	57
29	0	0	137	54	105	379	142	469	95	127	28	168	36	171	359	155	44	72	37	674
30+	230	0	388	501	745	1,152	1,015	1,280	643	636	1,484	962	1,024	851	411	507	145	426	414	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

Year/Age	2015	2016	2017	2018	2019	2020
7	14	49	0	0	214	0
8	563	751	104	51	144	507
9	902	2,717	949	212	64	288
10	3,154	3,713	4,503	2,279	1,227	575
11	7,118	8,111	3,523	4,890	4,678	2,185
12	7,104	9,393	7,077	4,812	6,176	4,928
13	5,553	6,688	8,748	6,507	4,028	4,154
14	5,673	4,705	5,370	7,779	5,710	3,148
15	4,774	4,024	3,790	4,278	5,127	8,115
16	3,015	2,629	3,576	3,243	4,006	5,032
17	2,651	2,729	3,012	2,748	2,607	2,253
18	1,861	2,013	1,866	2,614	2,301	1,545
19	780	1,724	1,412	1,282	1,376	1,329
20	1,192	663	1,187	1,347	1,512	1,564
21	288	536	990	1,211	1,147	788
22	275	350	438	629	508	970
23	196	223	489	496	518	522
24	424	241	313	277	161	600
25	1,816	304	324	336	56	82
26	243	1,335	148	167	184	45
27	214	176	1,265	35	350	62
28	189	29	87	1,663	103	122
29	87	25	192	26	1,161	162
30+	682	907	756	1,133	1,387	1,713
Total	48,770	54,043	50,117	48,015	44,745	40,689

Table 19.4.1 Results from the Gadget model of total biomass, spawning stock biomass, recruitment at age 5 (in thousands), catch and fishing mortality. All weights are in thousand tonnes.

Year	Biomass	SSB	$R_{(age5)}$	Catches	$F_{9\text{-}19}$
1971	592,688	385,364	224.6	67,880	0.097
1972	585,040	366,016	194.6	50,890	0.076
1973	596,246	363,465	449.8	43,719	0.067
1974	647,827	371,946	210.0	50,598	0.075
1975	678,100	380,040	126.0	61,920	0.089
1976	691,360	384,693	208.0	94,420	0.136
1977	681,081	368,349	194.7	53,753	0.081
1978	712,262	391,917	124.3	48,736	0.067
1979	741,928	424,207	159.3	77,212	0.101
1980	744,944	435,865	105.5	89,143	0.115
1981	728,026	437,113	75.1	101,966	0.136
1982	690,292	425,061	63.5	130,322	0.185
1983	616,389	383,937	67.6	106,050	0.163
1984	561,081	355,600	73.6	95,288	0.155
1985	512,208	329,523	131.3	78,531	0.132
1986	483,029	311,358	121.2	76,908	0.140
1987	453,283	290,108	64.5	76,559	0.152
1988	416,486	264,653	41.0	89,804	0.205
1989	360,837	224,158	44.7	56,645	0.145
1990	335,904	208,638	351.9	66,314	0.192
1991	333,916	184,710	58.6	56,015	0.180
1992	317,701	168,464	39.8	55,826	0.198
1993	298,393	152,681	53.3	50,179	0.196
1994	284,236	142,758	63.1	42,520	0.174
1995	277,249	140,425	332.4	44,263	0.184
1996	297,955	138,562	85.7	35,595	0.146
1997	307,793	144,271	39.9	38,996	0.155
1998	308,836	148,107	40.6	39,694	0.155

Year	Biomass	SSB	$R_{(age5)}$	Catches	$F_{9\text{-}19}$
1999	307,147	152,416	79.6	42,463	0.165
2000	304,501	155,307	50.1	42,607	0.161
2001	297,015	157,792	106.8	36,744	0.133
2002	305,139	164,665	116.6	50,730	0.183
2003	300,878	159,968	170.5	38,219	0.138
2004	318,857	165,141	105.5	32,766	0.115
2005	334,915	175,637	161.7	46,619	0.161
2006	346,600	177,029	160.3	42,108	0.149
2007	370,004	185,676	104.2	39,154	0.134
2008	387,798	199,490	127.4	46,195	0.151
2009	402,766	211,267	198.1	39,301	0.121
2010	438,971	232,027	163.9	38,504	0.109
2011	472,705	256,507	90.3	45,146	0.118
2012	486,828	277,152	127.3	45,423	0.112
2013	505,856	298,153	75.8	53,223	0.125
2014	506,254	311,737	29.8	50,697	0.114
2015	497,121	323,870	9.6	51,621	0.113
2016	478,180	330,363	12.2	59,697	0.129
2017	446,064	323,901	35.2	56,334	0.123
2018	417,018	313,496	4.4	53,368	0.121
2019	381,530	298,408	10.0	48,484	0.116
2020	348,080	281,111	20.4	46,110	0.118
2021	315,798	260,093	33.2		

Table 19.4.2 Assumption and output from short term prognosis. All weights are in tonnes.

Biomass (2021)	SSB (2021)	F_{9-19} (2021)	Landings (2021)	Biomass (2022)	SSB (2022)
315 798	260 093	0.121	43 222	286 276	237 099

Basis	Total catch (2022)	F_{9-19} (2022)	Biomass 5+ (2023)	SSB (2023)
Management plan	31 855	0.1	269 968	221 719
Other catch options				
F_{MSY}	30 833	0.097	270 949	222 608
F_0	0	0	302 091	250 829
$F_{sq} = F_{2020}$	37 170	0.118	264 609	216 864

19.19 Figures

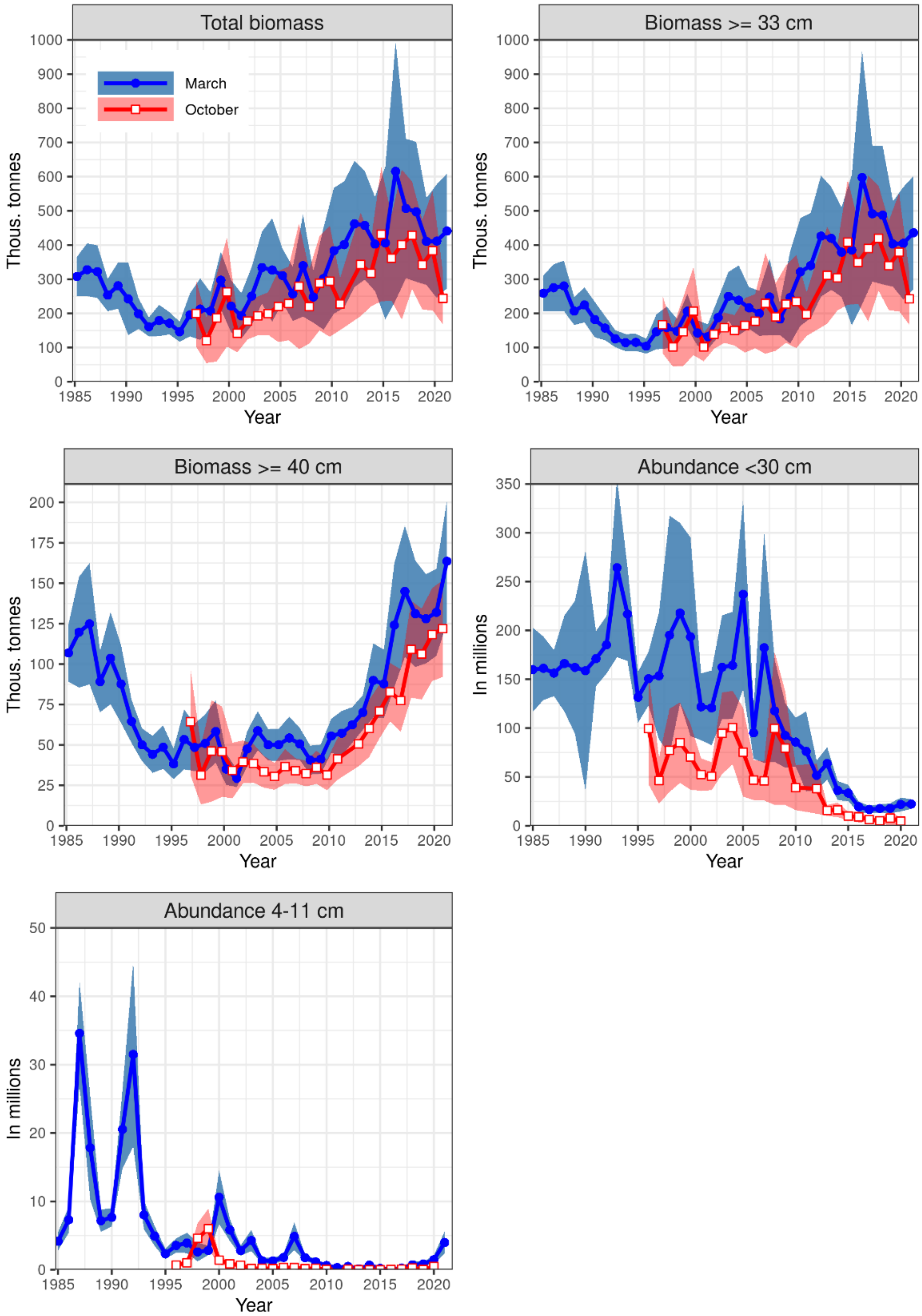

Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985–2021 (blue line and shaded area) and October 1996–2020 (red lines and shaded areas). The shaded areas represent 95% CI.

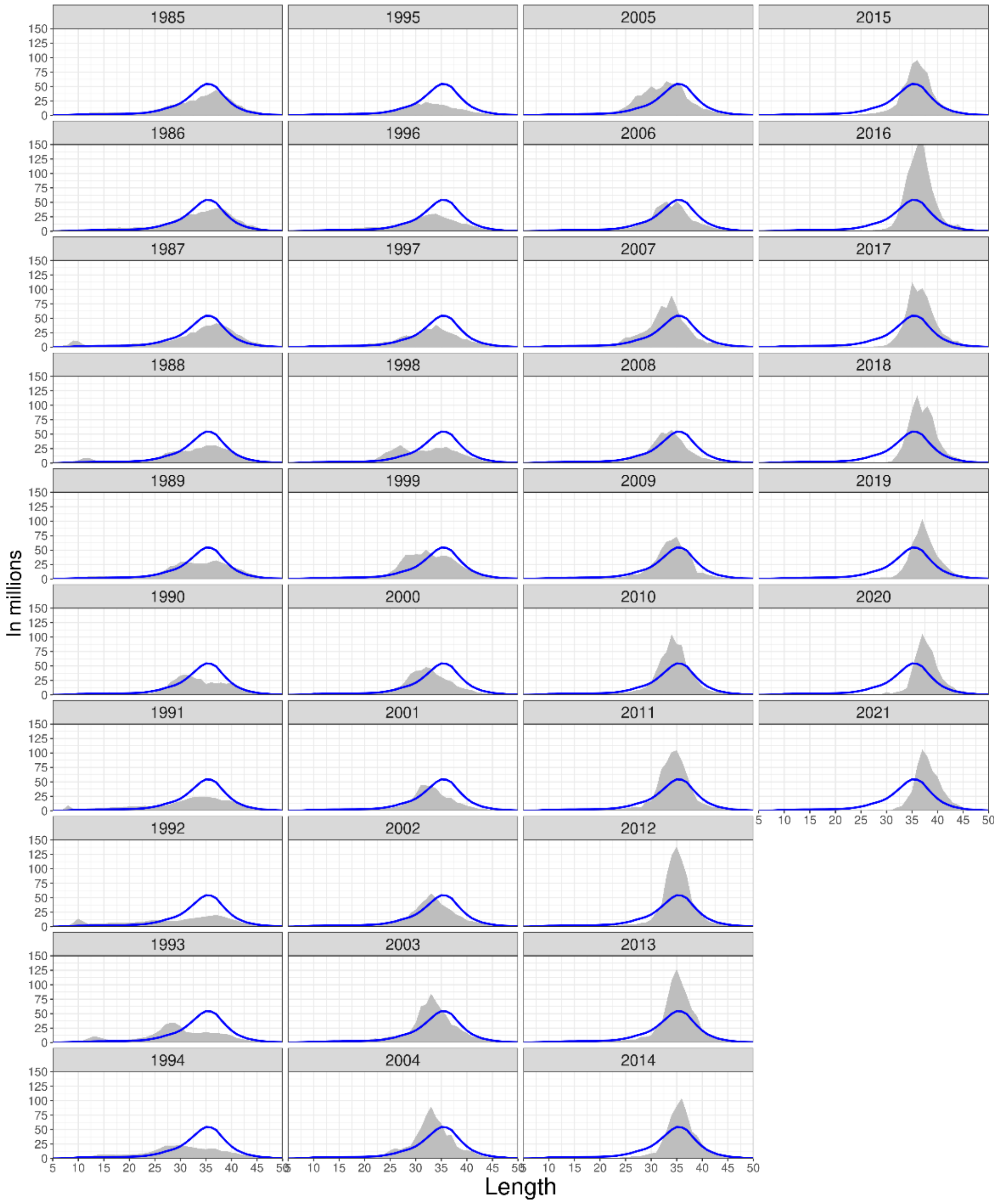

Figure 19.2.2. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in March 1985–2021 conducted in Icelandic waters. The blue line is the mean of total indices 1985–2021.

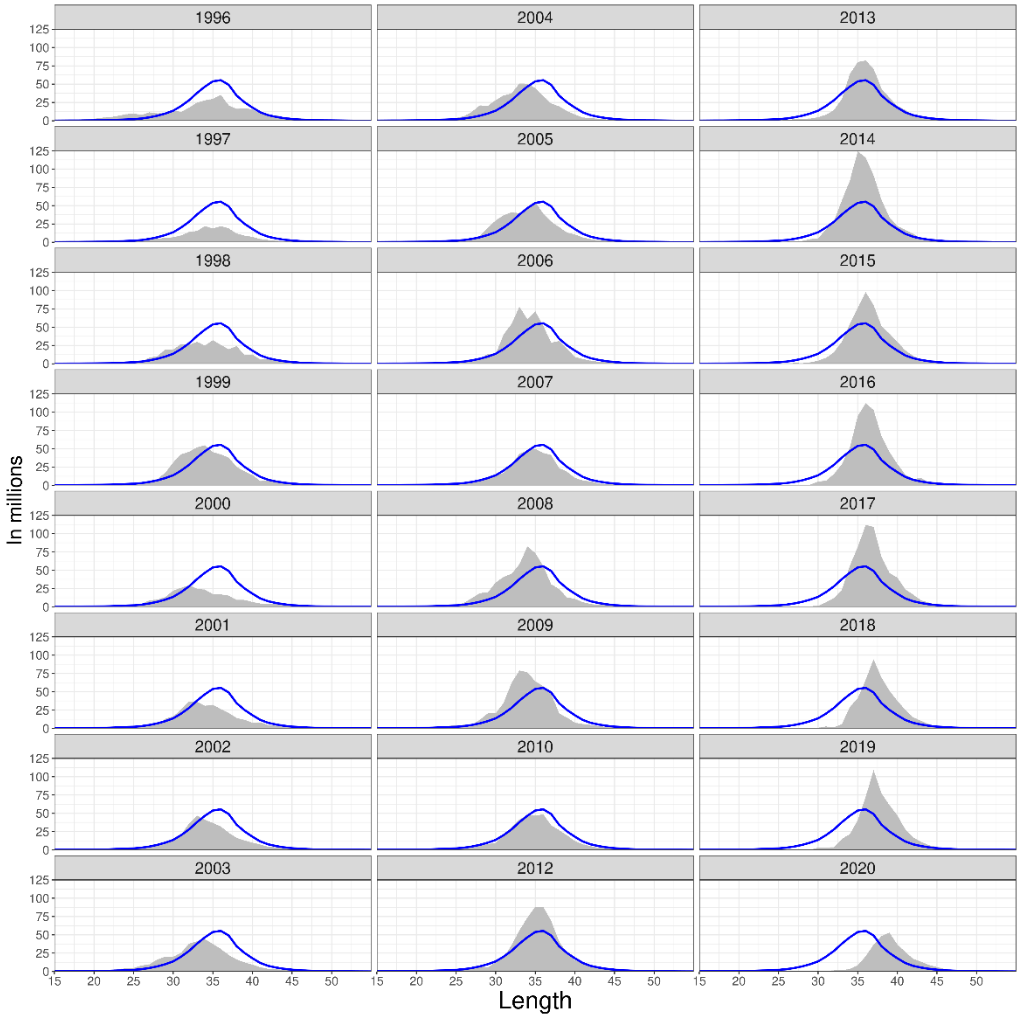

Figure 19.2.3. Length disaggregated abundance indices of golden redfish from the bottom trawl survey in October 1996–2020 conducted in Icelandic waters. The blue line is the mean of total indices 1996–2020. The survey was not conducted in 2011.

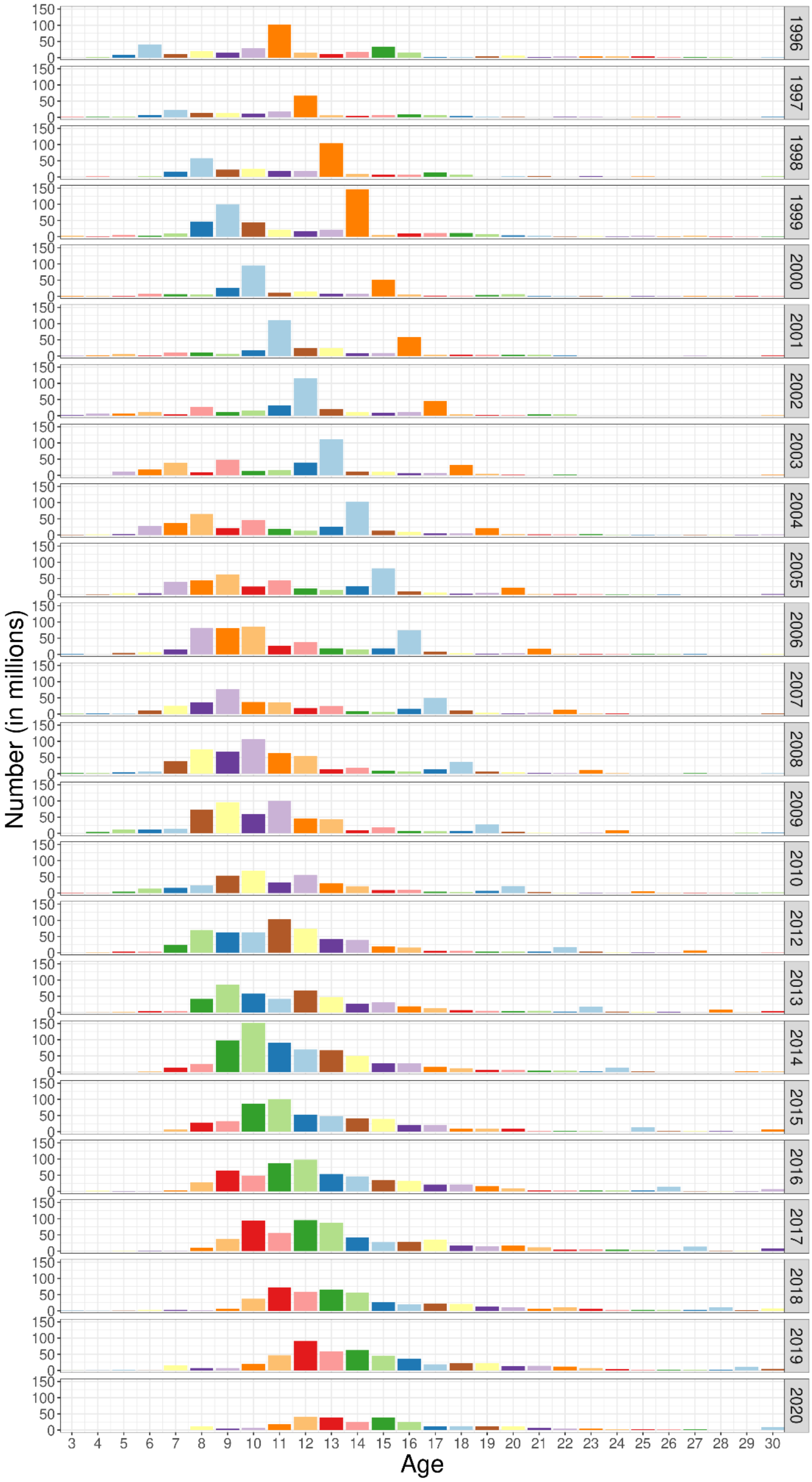

Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996–2020. The survey was not conducted in 2011.

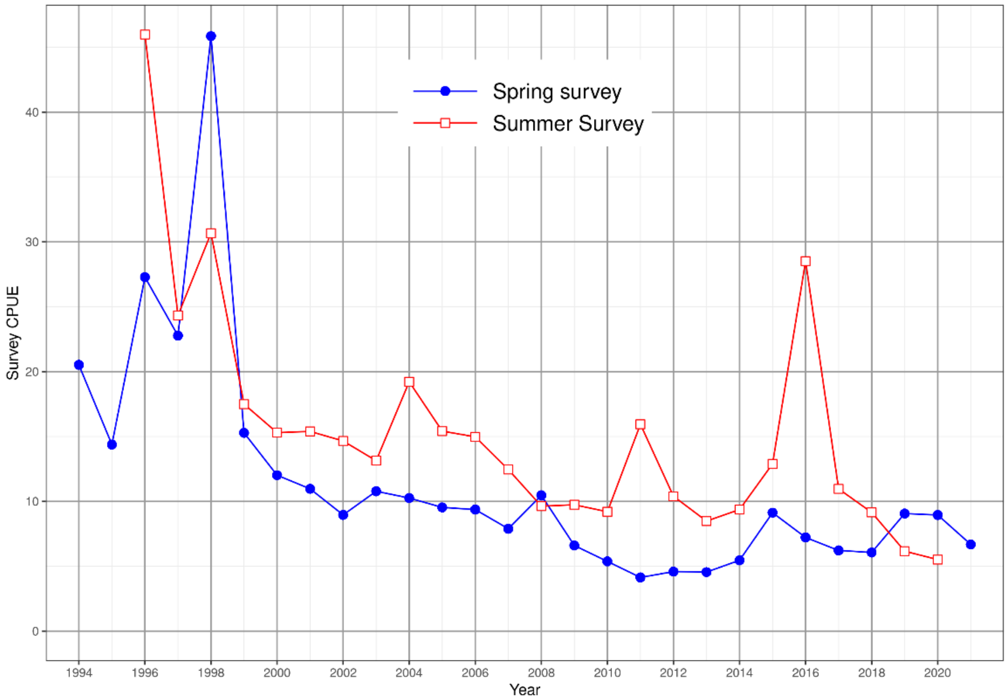

Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994–2021 (blue line) and the summer groundfish survey 1996–2020 (red line) in ICES Division 5.b.

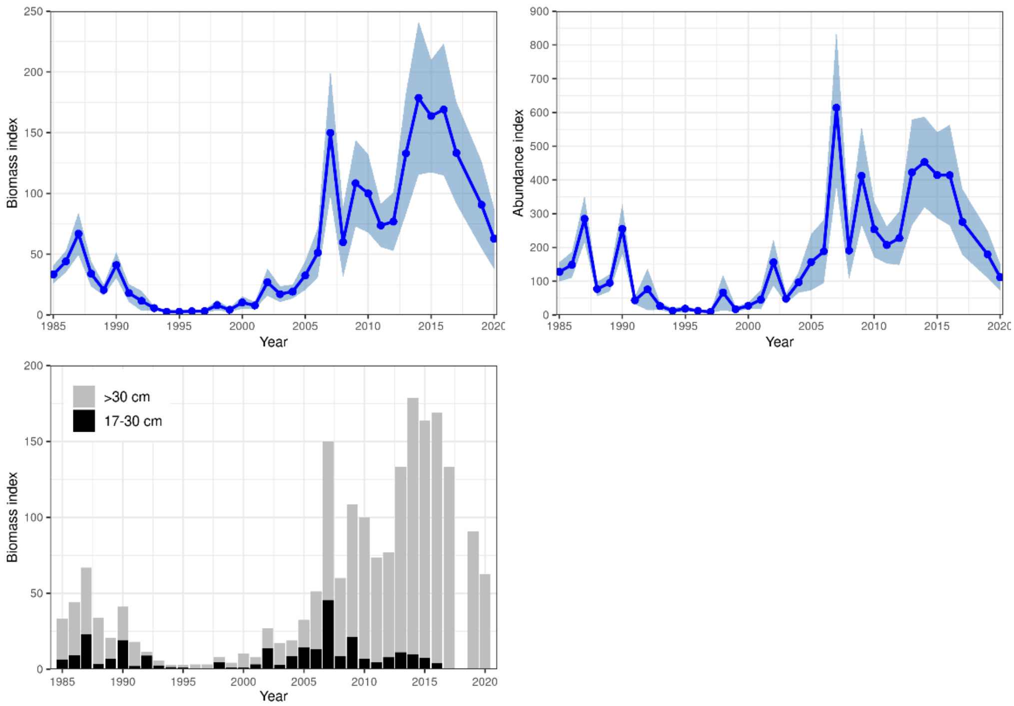

Figure 19.2.6 Golden redfish (> 17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985–2020. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17–30 cm and > 30 cm). The survey was not conducted in 2018.

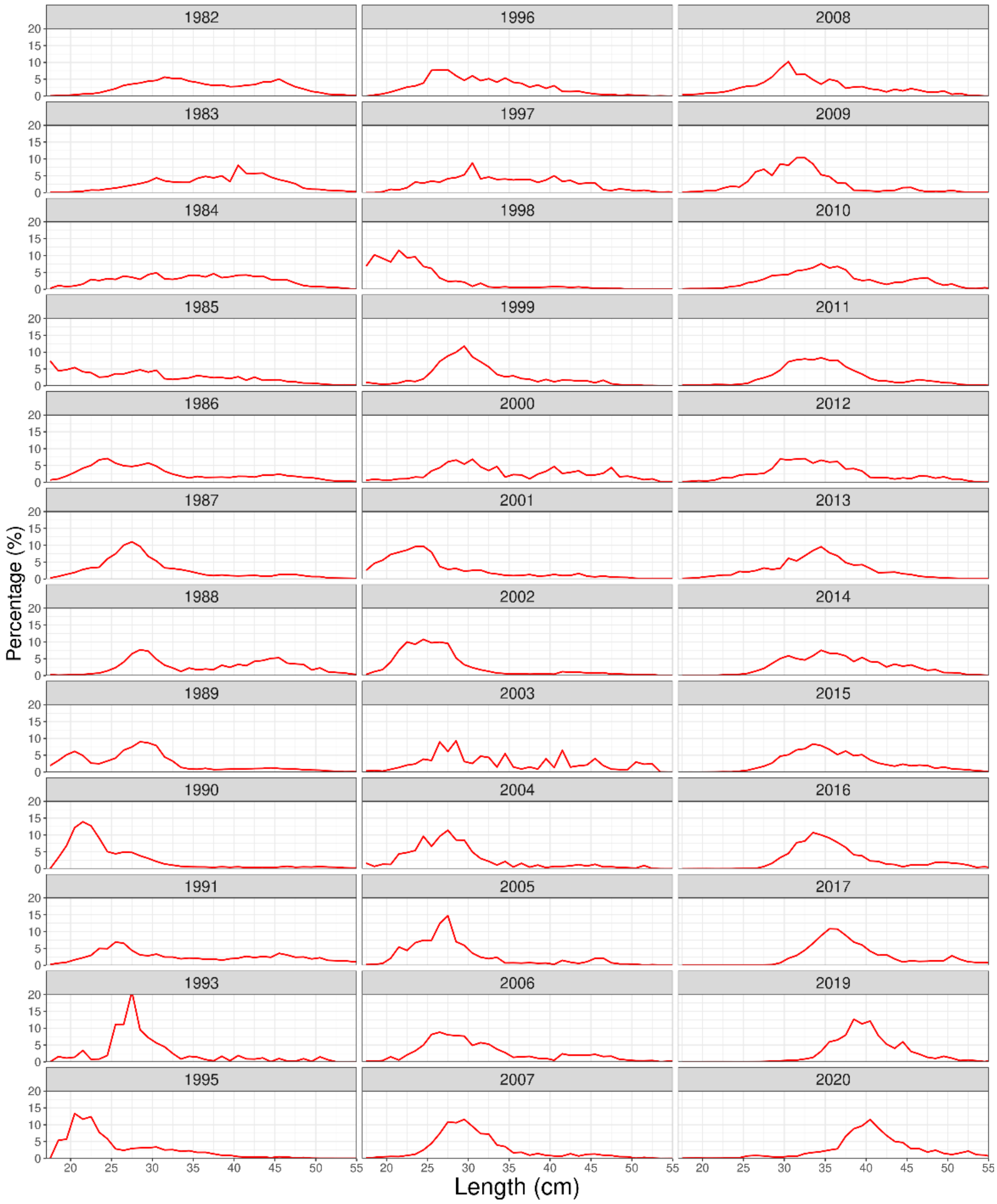

Figure 19.2.7 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982–2020. The survey was not conducted in 2018.

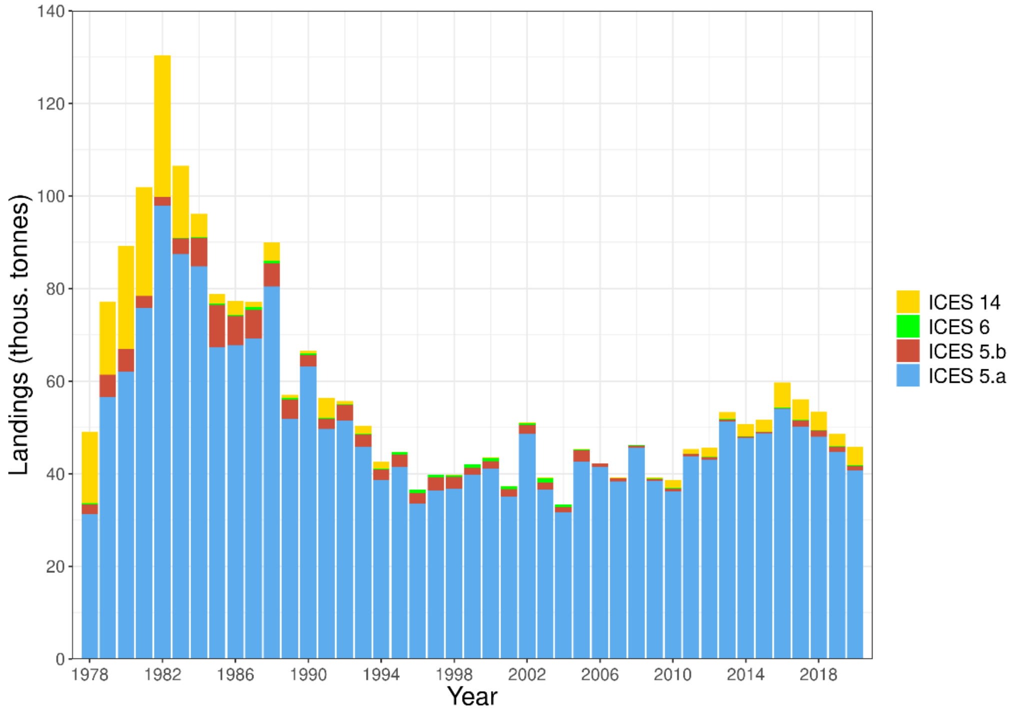

Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978–2020. Landings statistics for 2020 are provisional.

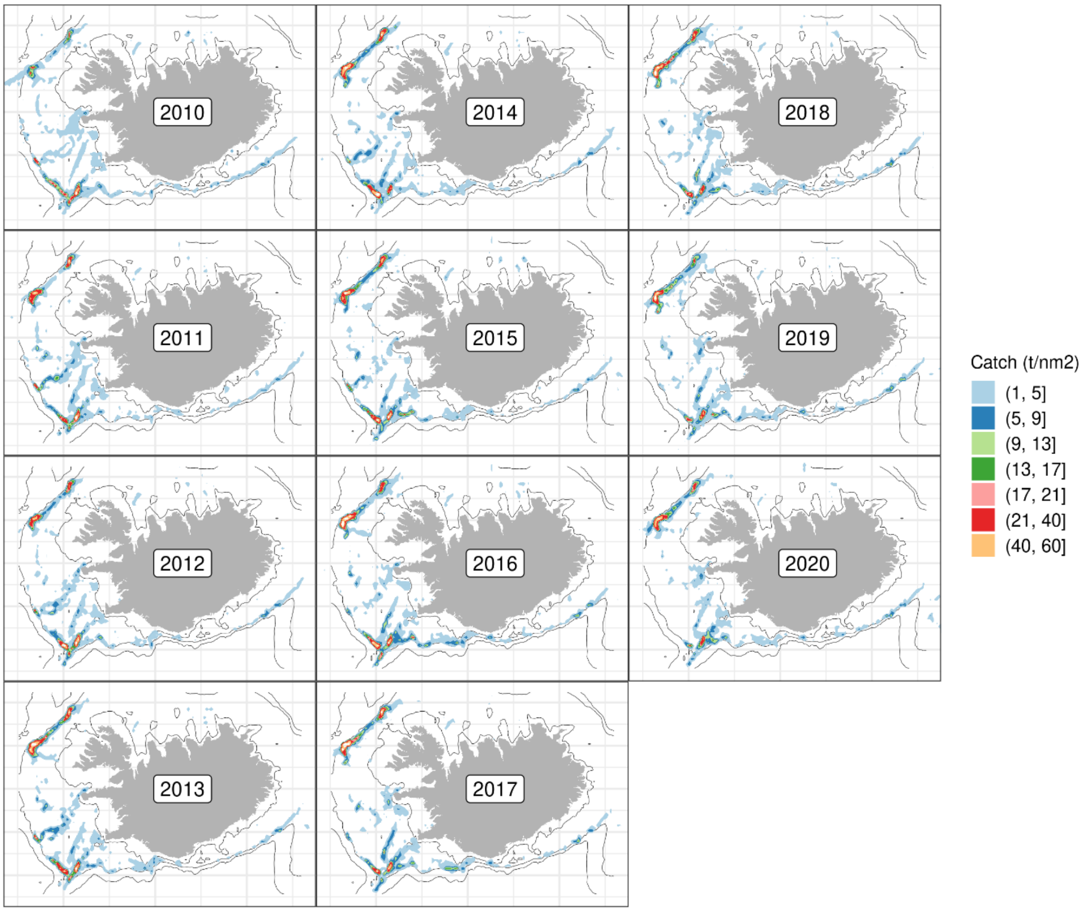

Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2010–2020.

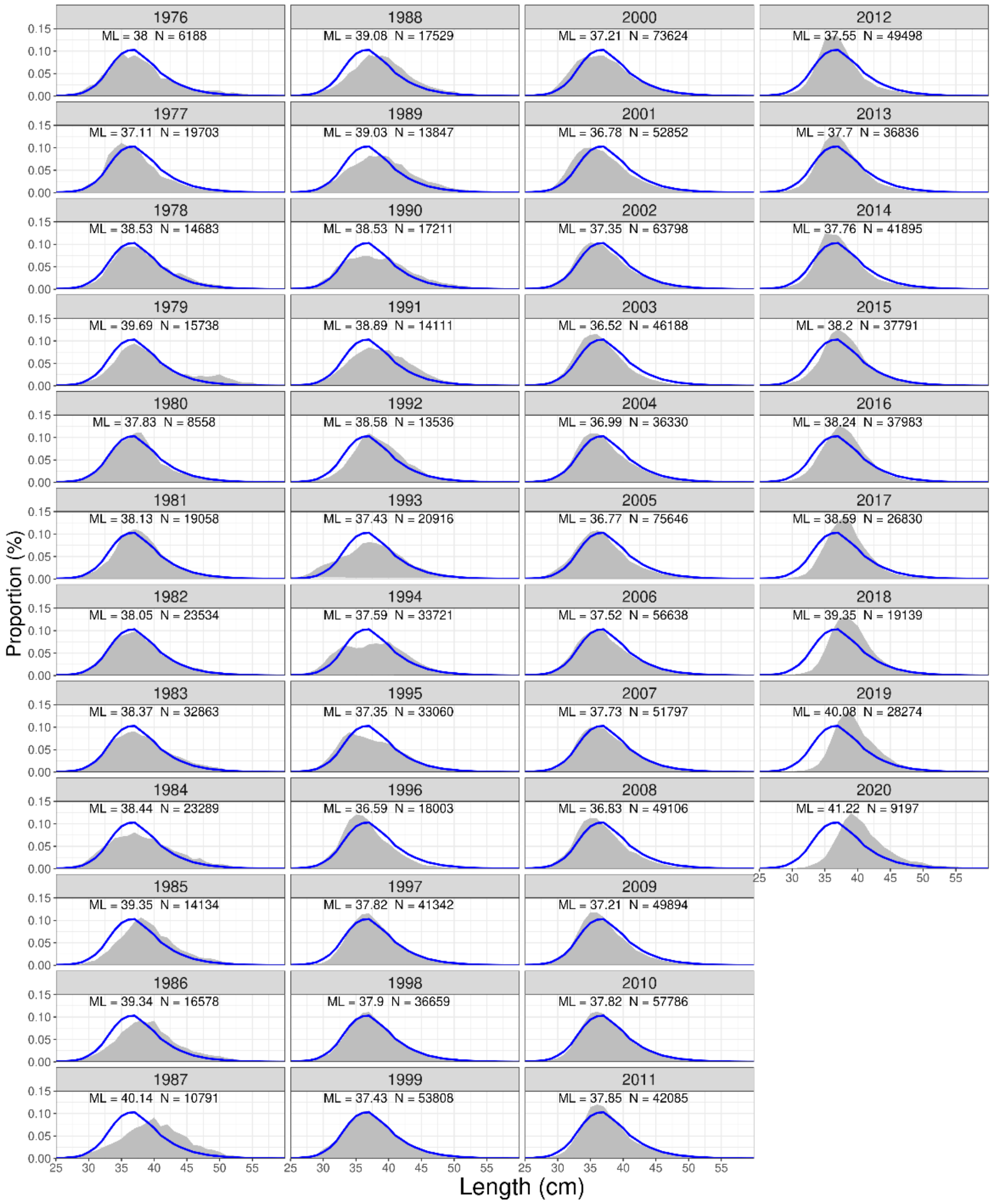

Figure 19.3.3 Length distribution (grey shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976–2020. The blue line is the mean of the years 1976–2019.

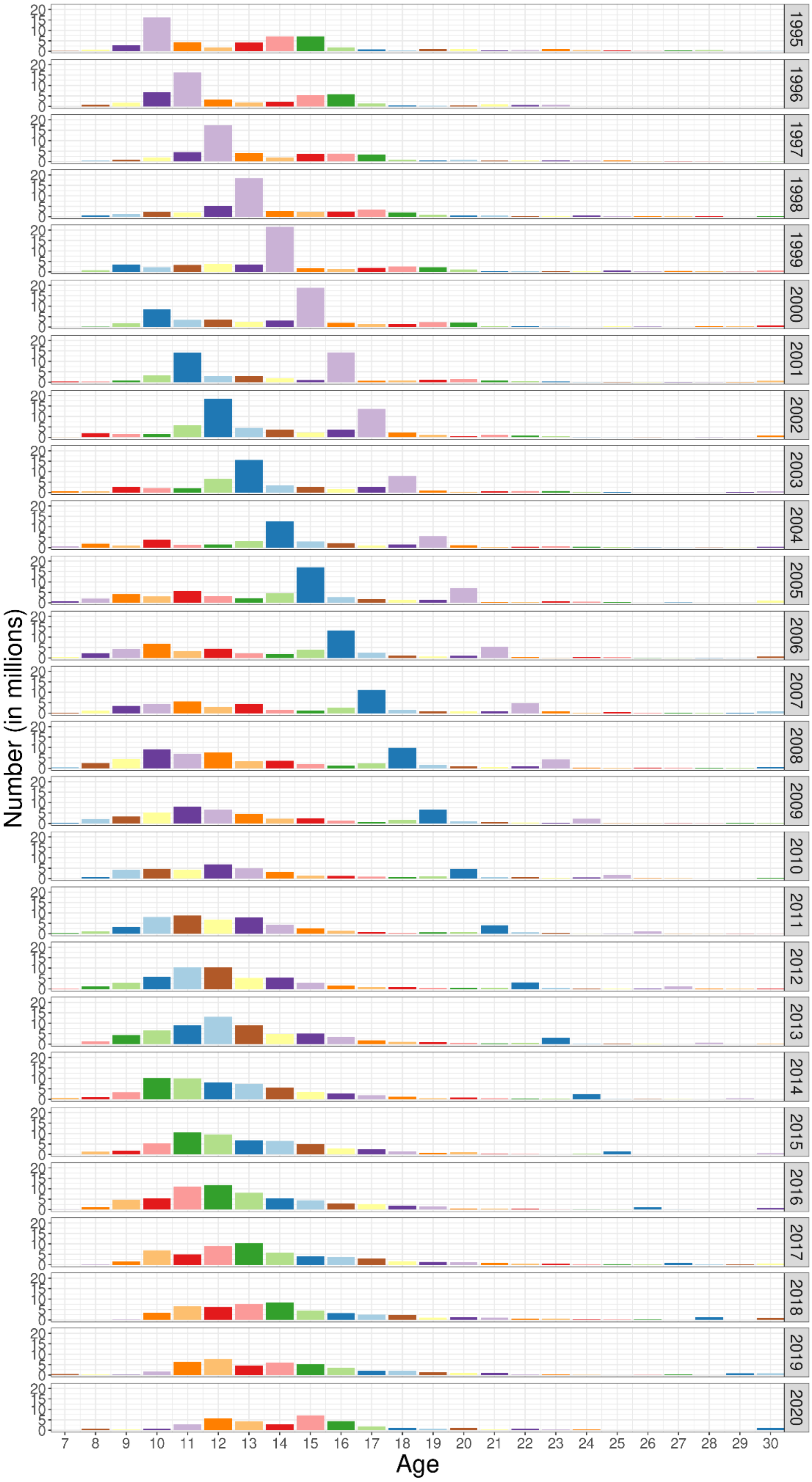

Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Division 5.a 1995–2020.

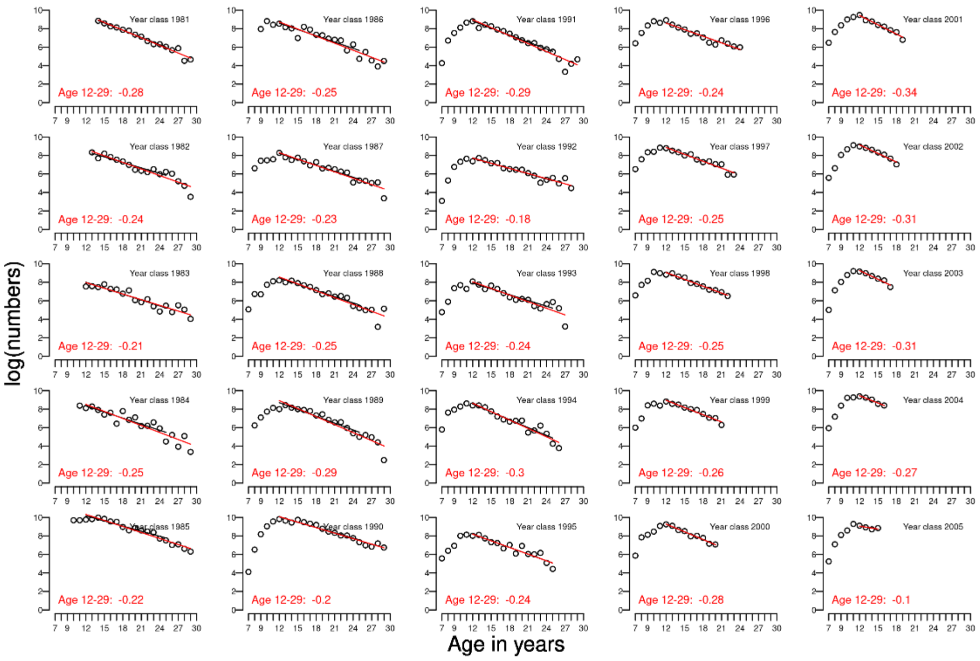

Figure 19.3.5 Catch curve of the 1981–2005 year-classes of golden redfish based on the catch-at-age data in ICES Division 5.a 1995–2020.

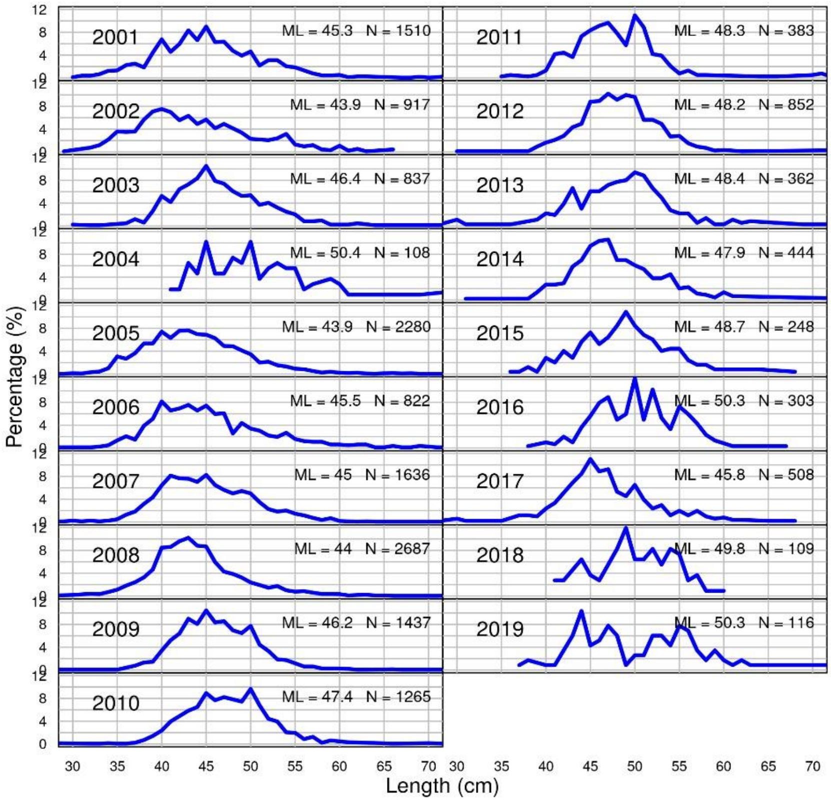

Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001–2019.

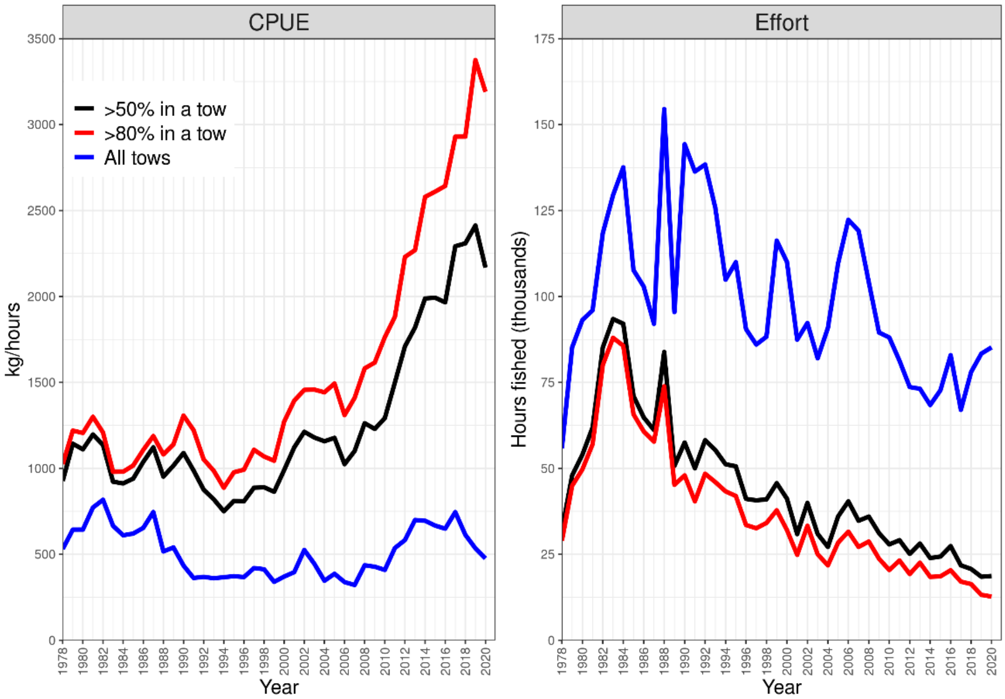

Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978–2020 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

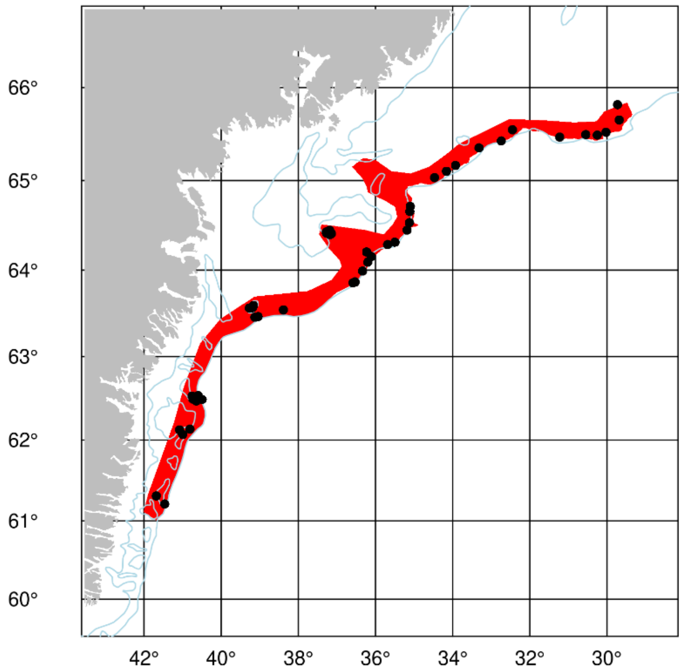

Figure 19.4.1 Stations in the German survey in East Greenland in 2020 with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

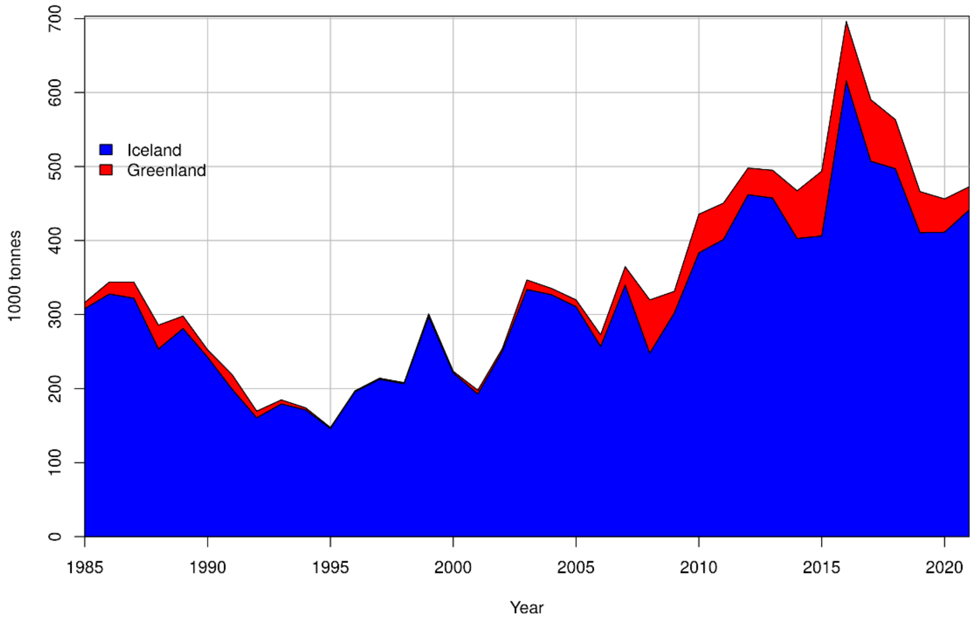

Figure 19.4.2 Biomass index from Iceland (blue) and Greenland (red), based on weighting the German survey data in Figure 19.2.7 by 0.5. In 2019, the survey index is based on the Icelandic survey and the average of the 2017 and 2019 values from the German survey in Greenland because it was not conducted in 2018.

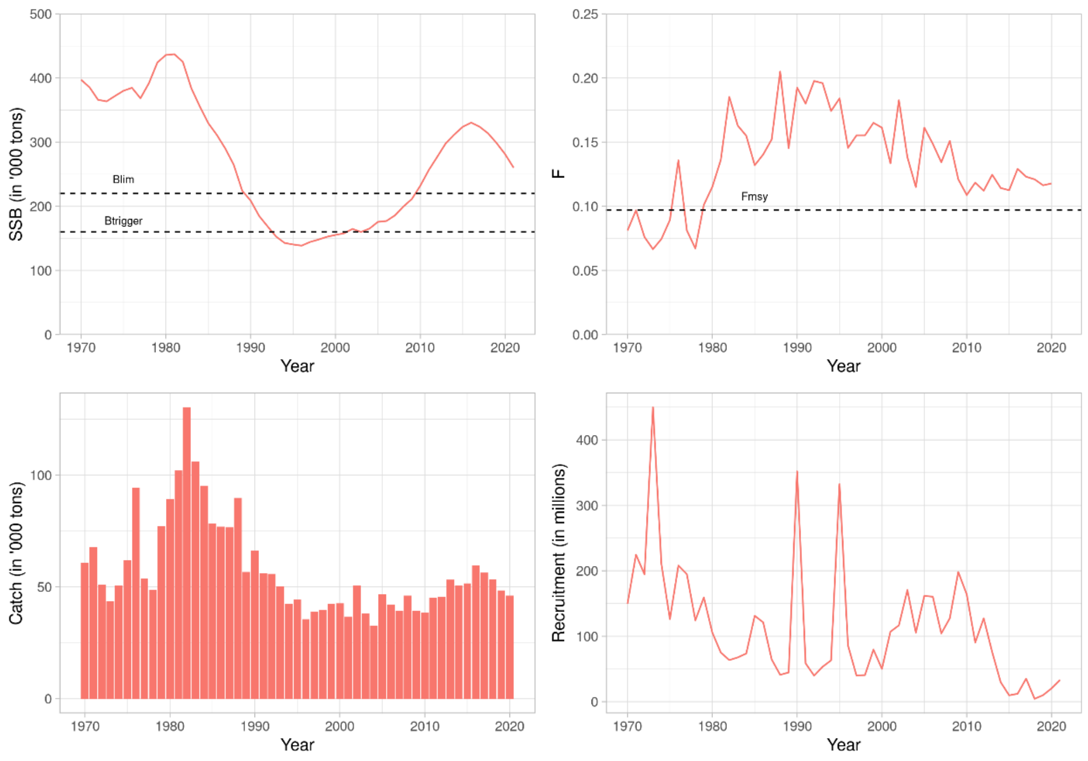

Figure 19.4.3. Summary from the assessment in 2021.

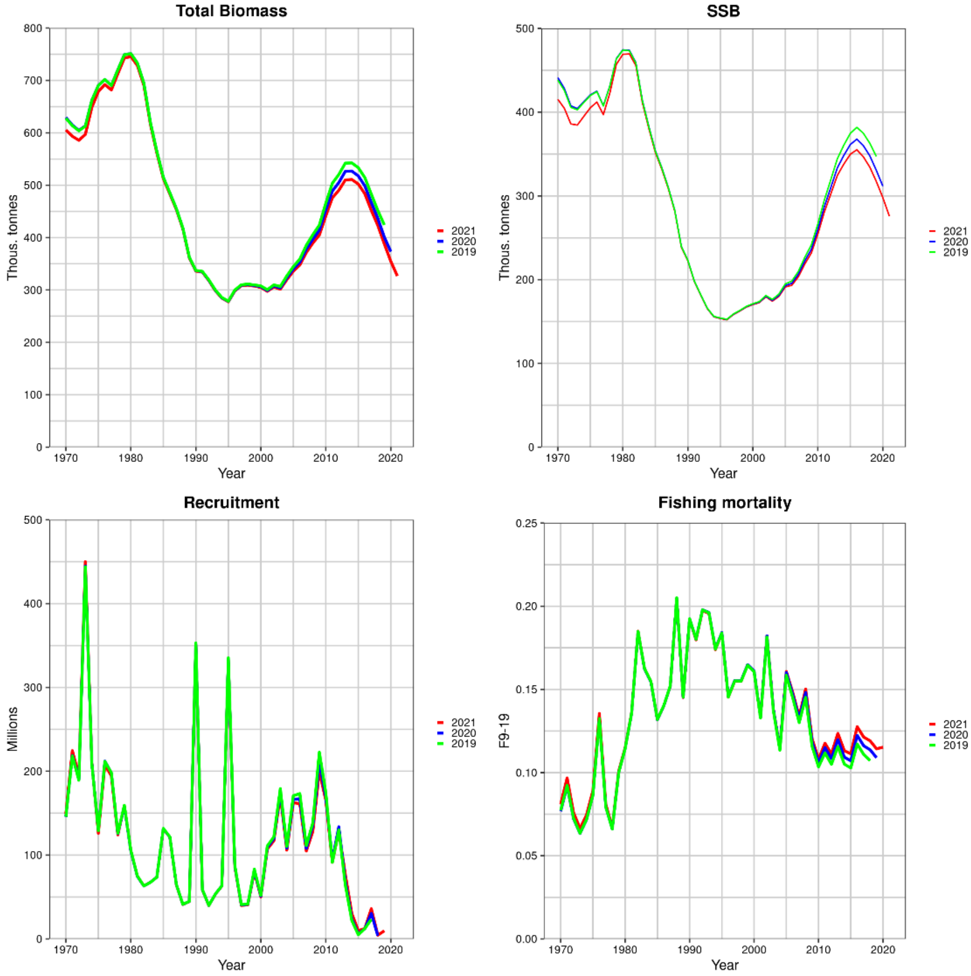

Figure 19.4.4. Comparison of the current assessment (red line) and the same assessment done in 2019 (green line) and 2020 (blue line) for the total biomass, spawning stock biomass, fishing mortality and recruitment.

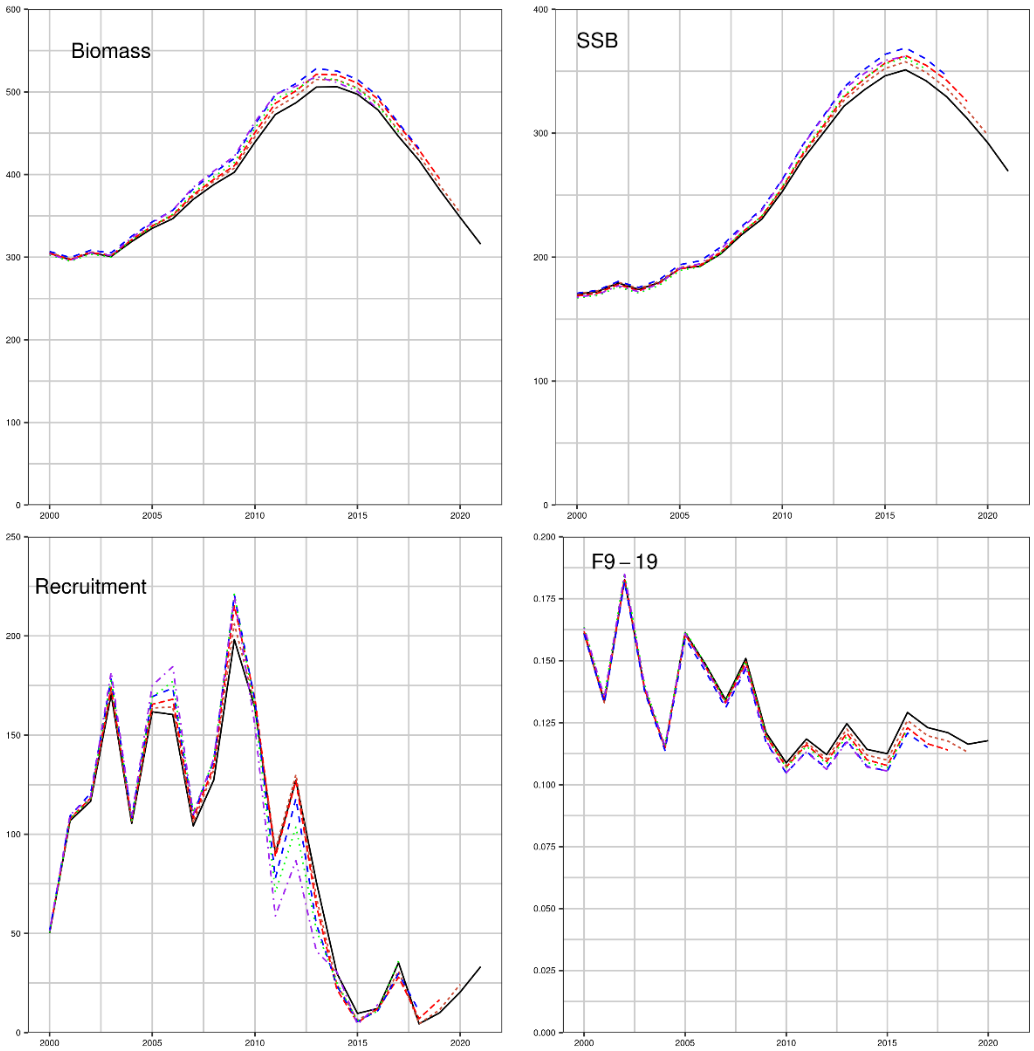

Figure 19.4.5. Analytical retrospective pattern of the base run. Recruitment is at age 5 and F shows the development of ages 9–19.

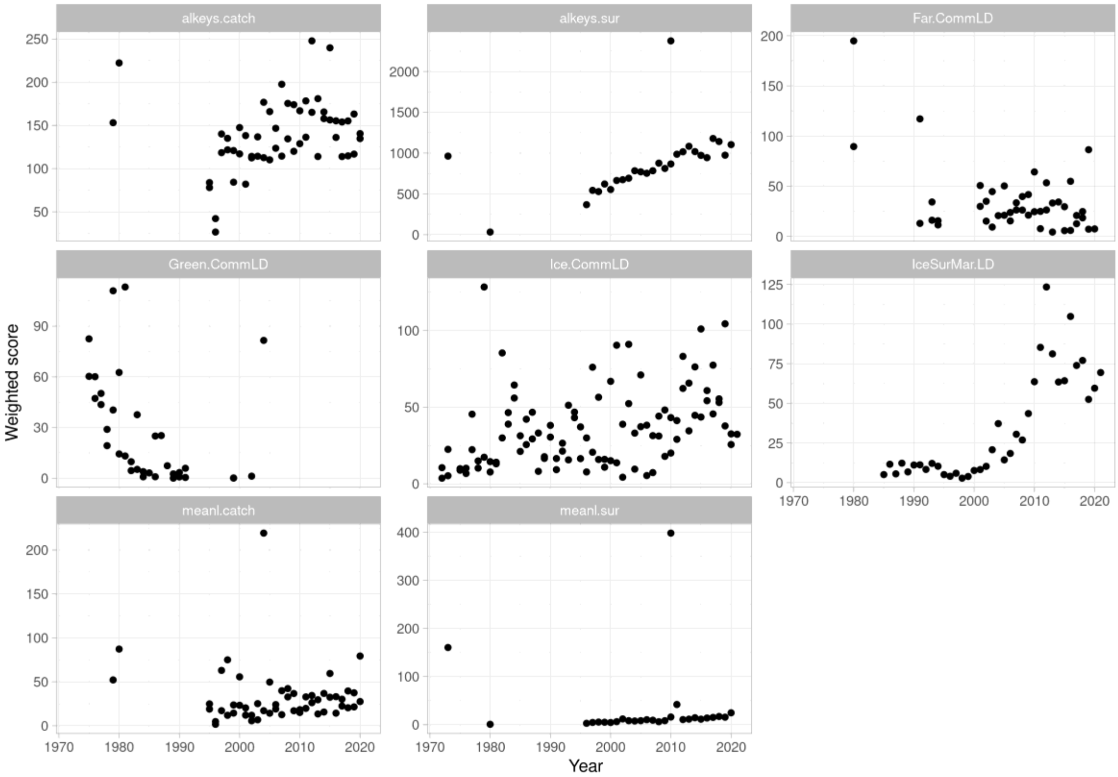

Figure 19.4.6. Development of component of the objective function with time.

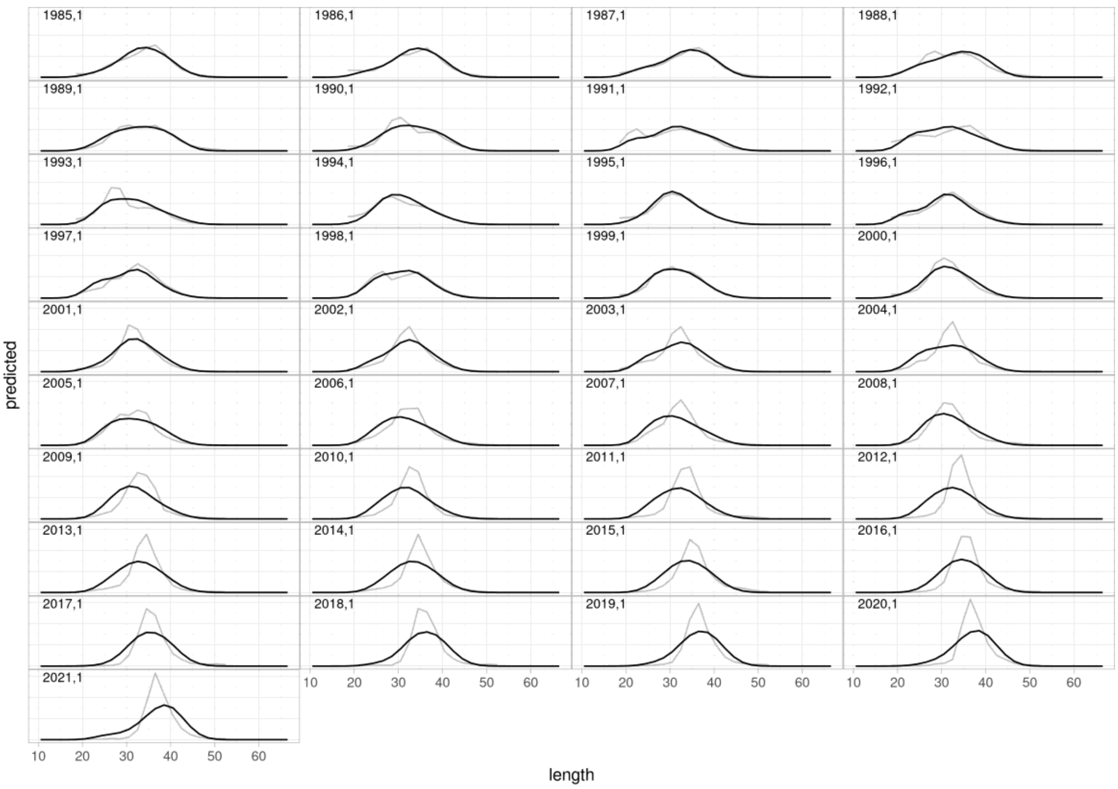

Figure 19.4.7. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines).

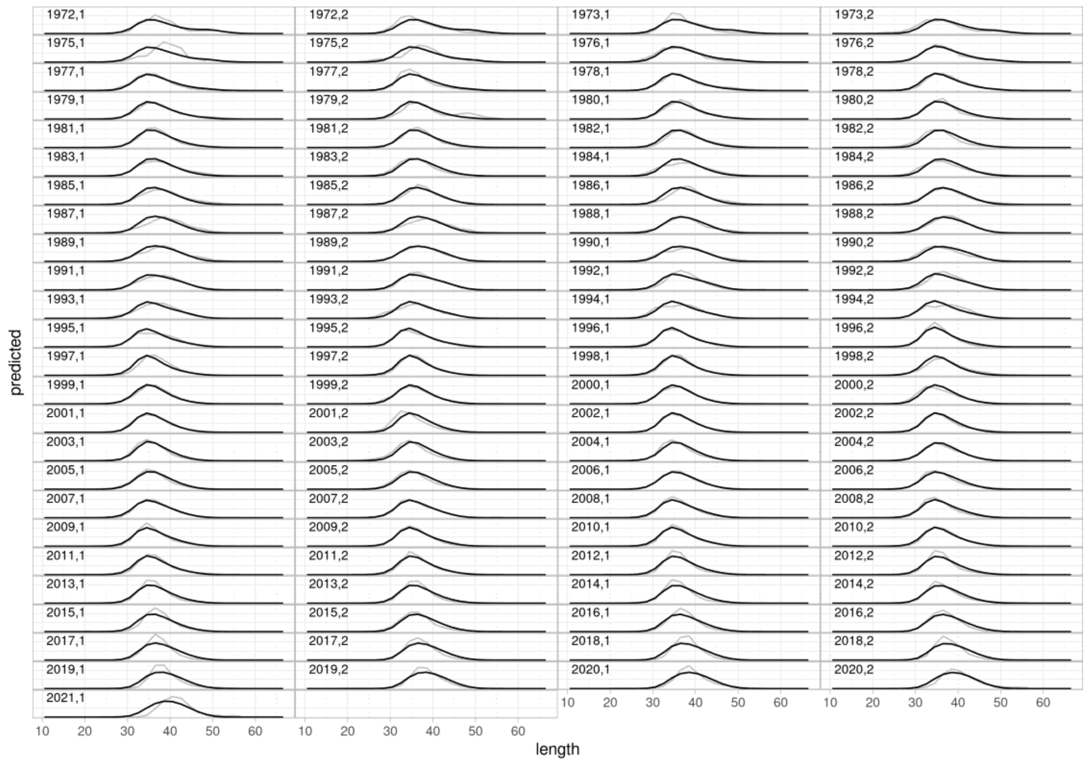

Figure 19.4.8. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

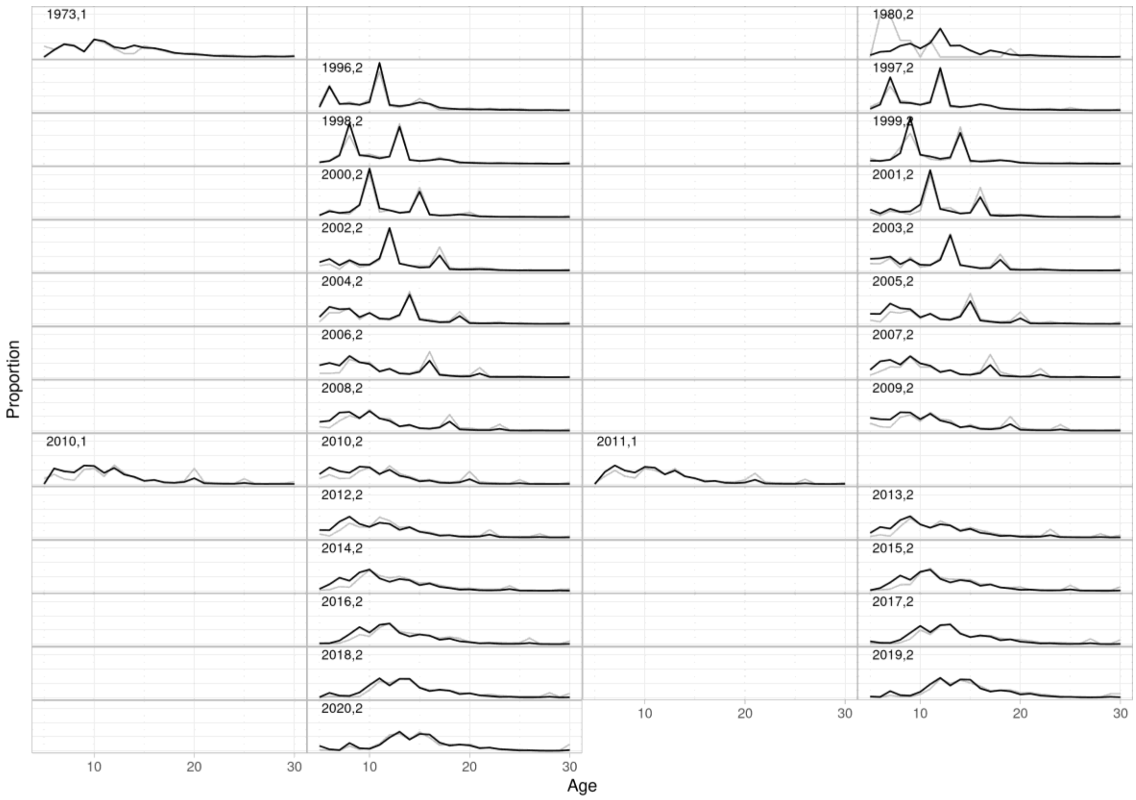

Figure 19.4.9. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey (grey lines).

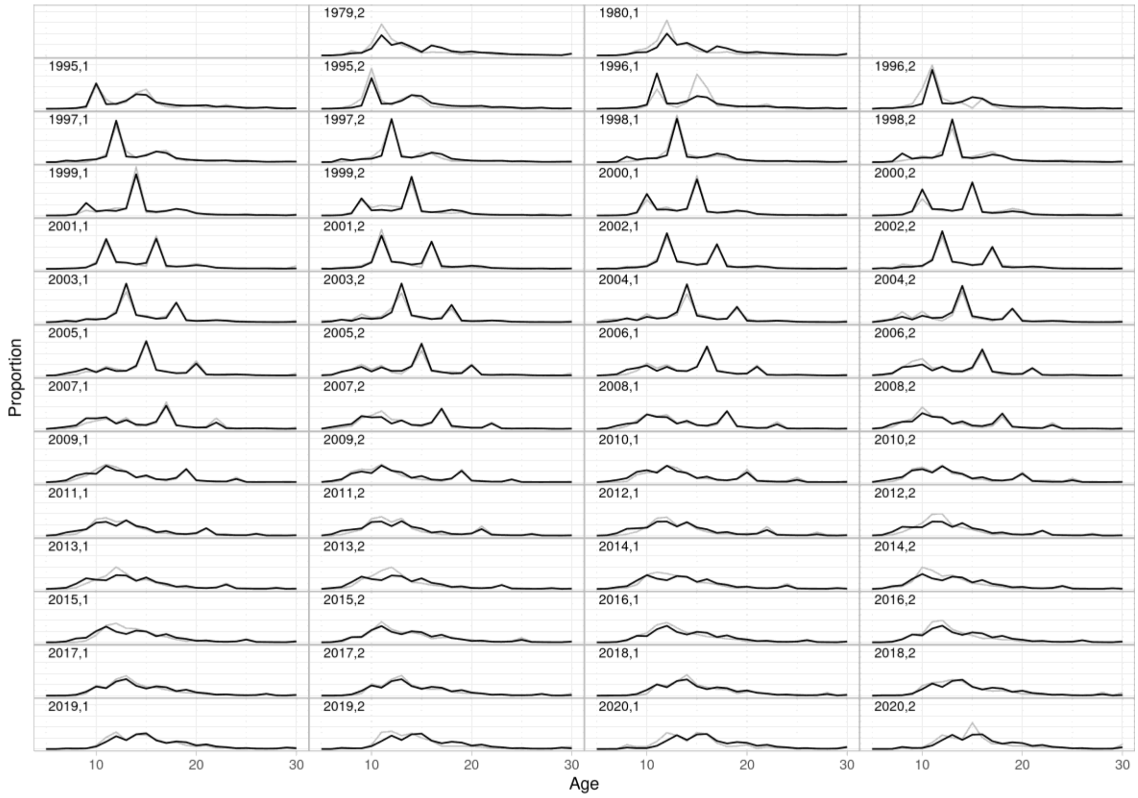

Figure 19.4.10. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

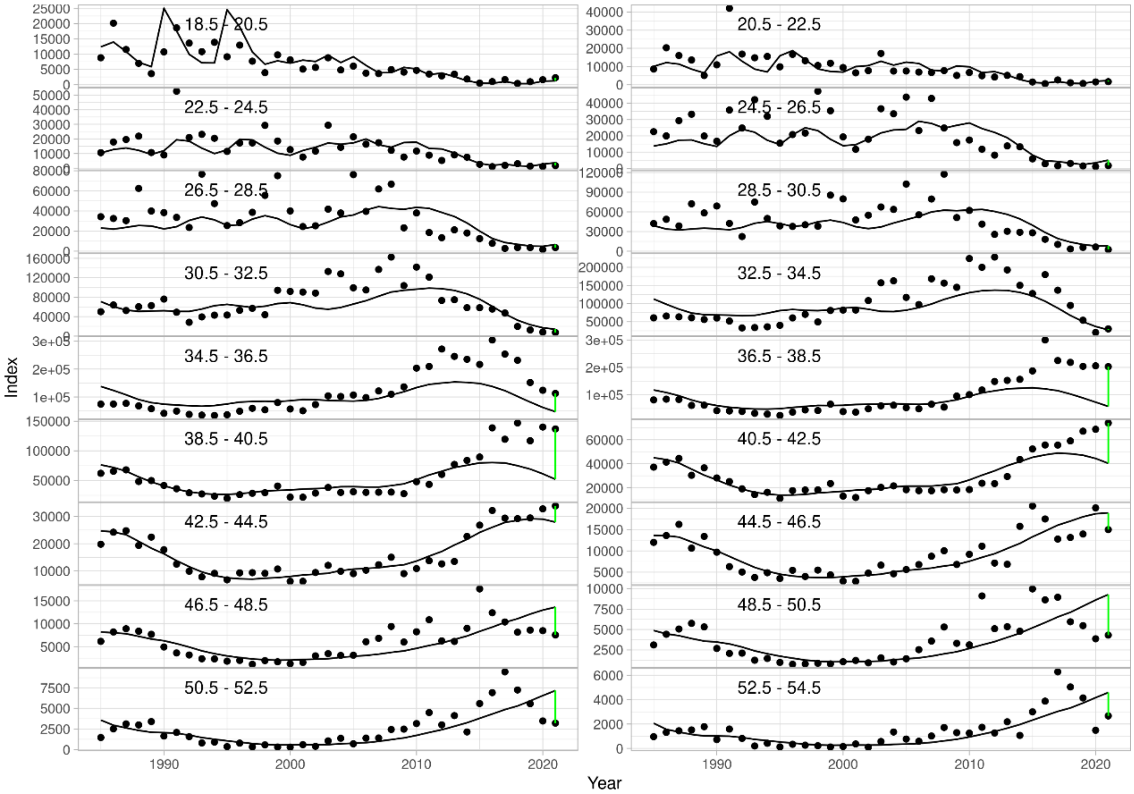

Figure 19.4.11 Gadget fit to indices from disaggregated abundance by length indices from the spring survey.

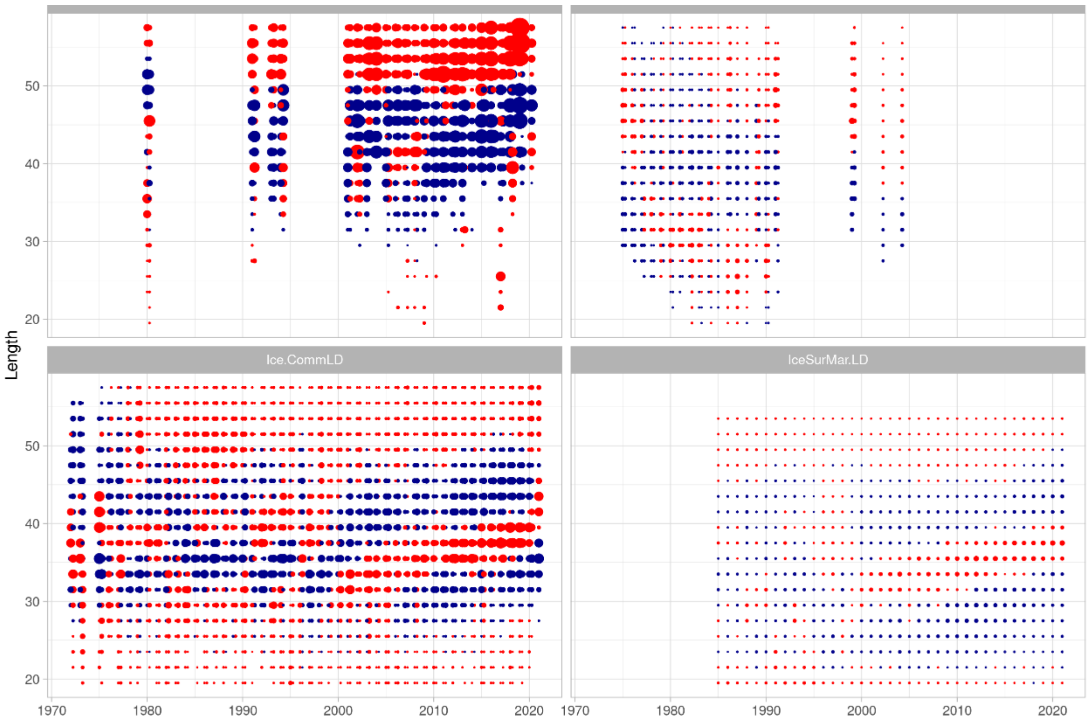

Figure 19.4.12. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

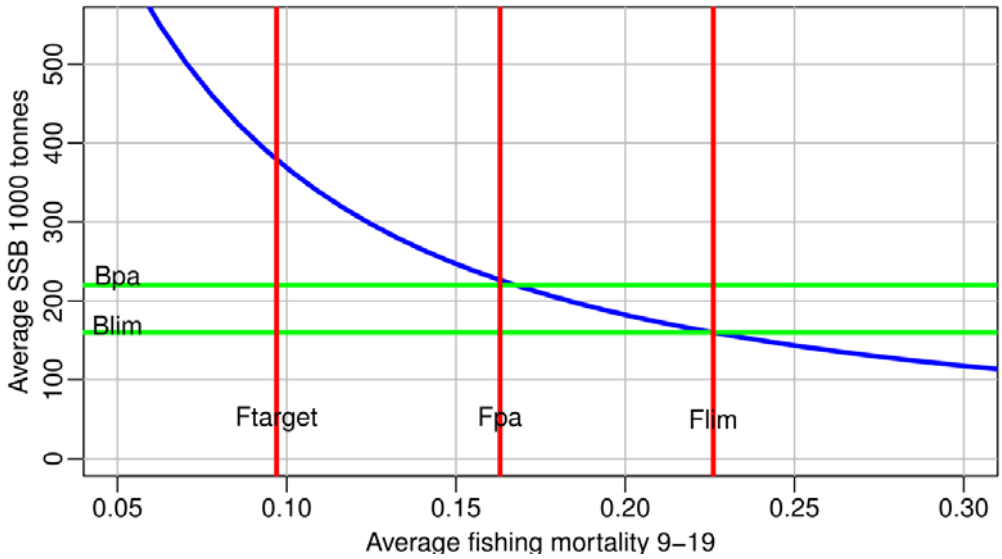

Figure 19.5.1. Average SSB against average fishing mortality and defined reference points.

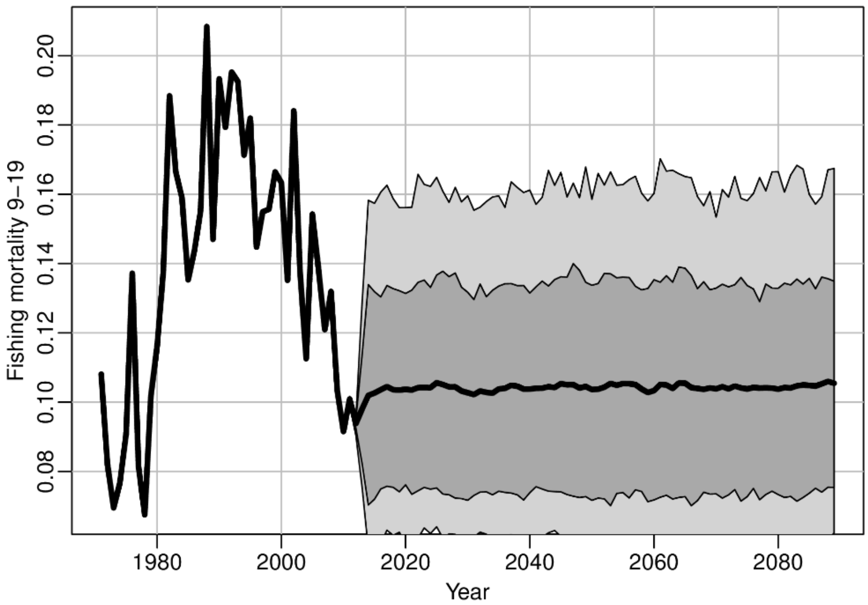

Figure 19.5.2. Development of $F_{9–19}$ based on F_{9-19} = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.

20 Icelandic slope *Sebastes mentella* in 5.a and 14

20.1 Stock description and management units

The stock structure of *Sebastes mentella* in the Irminger Sea and adjacent water is described in Chapter 18 and Stock Annex (smn-con_SA). The *S. mentella* on the continental shelf and slope of Iceland (the Iceland Sea ecoregion, which is defined to be within the Icelandic 200 NM EEZ and includes 5.a and part of Subarea 14; see figure 20.1.1) is treated as separate biological stock and management unit. Only the fishable stock (mainly fish larger than 30 cm) of Icelandic slope *S. mentella* is found in Iceland Sea ecoregion. The East Greenland shelf is most likely a common nursery area for the three biological stocks described in Chapter 18, including the Icelandic slope one.

20.2 Scientific data

The Icelandic autumn survey (IS-SMH) on the continental shelf and slope in Icelandic waters covers depths down to 1500 m. Data for Icelandic slope *S. mentella* is available from 2000–2020. No survey was conducted in 2011. A description of the autumn survey is given in Stock Annex (smn-con_SA).

The total biomass and abundance indices were highest in 2000 and 2001, declined in 2002 and have been at that level since then (Table 20.2.1 and Figure 20.2.1). The biomass index of fish 45 cm and larger shows different trend where the index increased from the lowest value in 2007 to a high level in 2015 and has since then fluctuated without clear trend (Figure 20.2.1). The abundance index of fish 30 cm and smaller (recruits) has been at very low level since 2007 (Figure 20.2.1).

The length of the Icelandic slope *S. mentella* in the autumn survey is between 25 cm and more than 50 cm. Since 2000, the mode of the length distribution has shifted to the right or from 36-39 cm in 2000 to about 42-45 cm in 2012-2020 (Figure 20.2.2). Much less fish smaller than 35 cm was observed in the surveys after 2010 compared to previous years.

Otoliths from the autumn survey have been sampled since 2000 and otoliths from the 2000, 2006, 2009, 2010 and 2017-2019 surveys have been age read (Figure 20.2.3). The age reading shows that the stock consists of many cohorts and the age ranges from 5 to over 50 years. The 1985 and 1990 cohorts were large and were still relatively strong in the 2019 survey. In the 2017-2019 surveys the 2003-2004 cohorts (seen as 15- and 16-years old fish) were most abundant.

20.3 Information from the fishing industry

20.3.1 Landings

Total annual landings of Icelandic slope *S. mentella* from the Icelandic Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1950–2020 are presented in Table 20.3.1 and Figure 20.3.1.

During the 1950-1977 period, before the extension of the Icelandic EEZ to 200 NM, Icelandic slope *S. mentella* was mainly fished by West-Germany. The catches peaked in 1953 to about 87 000 t but gradually decreased to about 23 000 t in 1977. After the extension of the Icelandic EEZ in 1978 the fishery has almost exclusively been conducted by Icelandic vessels. Annual landings gradually decreased from 57 000 t in 1994 to 17 000 t in 2001. Landings in 2001-2010 fluctuated between 17 000 and 20 500 t except in 2003 and 2008 when annual landings were 28 500 and 24 000 t, respectively. Annual landings in 2011-2020 were between 8300 and 12 000 t. The total catch in 2020 were 11 375 t.

20.3.2 Fisheries and fleets

The fishery for Icelandic slope *S. mentella* in Icelandic waters is a directed bottom trawl fishery along the shelf and slope west, southwest, and southeast of Iceland at depths between 500 and 800 m (Figure 20.3.2). The proportion of Icelandic slope *S. mentella* catches taken by pelagic trawls 1991-2000 varied between 10 and 44% of the total landings (Table 20.3.2). In 2001-2020, no pelagic fishery occurred, or it was negligible except in 2003 and 2007 (see Stock Annex).

20.3.3 Sampling from the commercial fishery

The table below shows the 2020 biological sampling from the catch and landings of Icelandic slope *S. mentella* in Icelandic waters. Number of samples and hence, number of fish length measured, have decreased in recent years. The reason is reduced sampling effort of onboard observers from the Directorate of Fisheries, but the Covid-19 in 2020 also played part in decreased sampling effort.

Otoliths from the commercial catch have been collected, but no systematic age reading is done.

Division/ Subarea	Nation	Gear	Landings (t)	No. samples	No. length measured
5.a/14	Iceland	Bottom trawl	11 375	27	5 408

20.3.4 Length distribution from the commercial catch

Length distributions of Icelandic slope *S. mentella* from the bottom trawl fishery show an increase in the number of small fish in the catch in 1994 compared to previous years (Figure 20.3.3). The peak of about 32 cm in 1994 can be followed by approximately 1 cm annual growth in 1996—2002. The fish caught in 2004—2020 peaked around 39—42 cm. The length distribution of Icelandic slope *S. mentella* from the pelagic fishery, where available, showed that in most years the fish was on average bigger than taken in the bottom trawl fishery (Figure 20.3.3).

20.3.5 Catch per unit effort

Trends in non-standardized CPUE (kg/hour) and effort (thousand hours fished) are shown in Figure 20.3.4. The figure shows CPUE and effort in all bottom trawl tows where of Icelandic slope *S. mentella* was caught and were more than 50% and 80% of individual tows. CPUE of tows where more than 50% and 80% gradually decreased from 1978 to a record low in 1994. Since then, CPUE has been steadily increasing and was in 2020 highest level in the time series. From 1991 to 1994, when CPUE decreased, the fishing effort increased drastically. Since then, effort has decreased and is now at similar level as in 1980.

20.3.6 Discard

Although no direct measurements are available on discards, it is believed that there are no significant discards of Icelandic slope *S. mentella* in the Icelandic redfish fishery.

20.4 Management

The Icelandic Ministry of Industries and Innovation (MII) is responsible for management of the Icelandic fisheries, including the Icelandic slope beaked redfish fishery, and for the implementation of the legislation in the Icelandic Exclusive Economic Zone (EEZ). There is, however, no explicit management plan for the Icelandic slope beaked redfish.

The Ministry issues regulations for commercial fishing for each fishing year (1 September–31 August), including allocation of the TAC for each of the stocks subject to such limitations. Redfish (golden redfish (Chapter 19) and Icelandic slope *S. mentella*) has been within the ITQ system from the beginning. Icelandic authorities gave, however, until the 2010/2011 fishing year a joint quota for these two species, and Icelandic fishermen were not required to divide the redfish catch into species. MFRI has since 1994 provided a separate advice for the species. The separation of quotas was implemented in the fishing year that started September 1, 2010.

20.5 Methods

No analytical assessment was conducted on this stock.

20.6 Reference points

There are no reference points defined for the stock.

20.7 State of the stock

The Group concludes that the state of the stock is on a low level. With the information at hand, current exploitation rates cannot be evaluated for the Icelandic slope *S. mentella* in Icelandic waters.

The fishable biomass index of Icelandic slope *S. mentella* from the Icelandic autumn survey shows that the biomass index in the 2004-2020 period has been at the same level.

CPUE indices show a reduction from highs in the late 1980s, but there is an indication that the stock has started a slow recovery since the middle of 1990s, when CPUE was close to 50% of the maximum. The CPUE index gradually increased from 1995–2020 to the highest level in the time series. It is, however, not known to what extent CPUE series reflect change in stock status of Icelandic slope *S. mentella*. The nature of the redfish fishery is targeting schools of fish using advancing technology. The effect of technological advances is to increase CPUE but is unlikely to reflect biomass increase.

In 2000–2008, good recruitment was observed in the German survey on the East Greenland shelf (growth of about 2 cm/yr) which is assumed to contribute to both the Icelandic slope and pelagic stock at unknown shares. The German survey and the Greenland shrimp and fish shallow water survey both show no new recruits (>18 cm), and no juveniles are present (<18 cm). This suggests that the fishery in coming years will be based on the same cohorts.

20.8 Management considerations

S. mentella is a slow growing, late maturing deep-sea species and is therefore considered vulnerable to overexploitation and advice must be conservative.

The advice is given by calendar year, though the fishing year runs from 1 September to 31 August of the following year.

20.9 Basis for advice

Icelandic slope *S. mentella* is considered a data limited stock (DLS) and follows the ICES framework for such (Category 3.2; ICES 2012). Below is the description of the formulation of the advice.

Based on the North Western Working Group recommendation, the stock is treated as a stock with survey data, but no proxies for MSY $B_{trigger}$ or F values are known. The IS-SMH survey index was used as an indicator of stock development. The advice is based on a comparison of the two latest index values with the three preceding values, combined with the latest catch advice This means that the catch advice is based on the survey adjusted status quo catch equation:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

where I is the survey index, x is the number of years in the survey average, $z > x$, and C_{y-1} is the advice last year. In this case, $x = 2$, which is the average of the two latest index values, and $z = 5$ the total number of survey values.

20.10 Regulation and their effects

There are no explicit management for Icelandic slope *S. mentella*. The species is managed under the ITQ system. A general description of management and regulation of fish populations in Icelandic waters is given in the stock annex for the stock (smn-con_SA) with emphasis on Icelandic slope *S. mentella* where applicable.

Icelandic authorities gave until the 2010/2011 fishing year a joint quota for golden redfish (*S. norvegicus*) and Icelandic slope *S. mentella*. The separation of quotas was implemented in the fishing year that started September 1, 2010.

20.11 Benchmark in 2022

The stock will be benchmarked in early 2022. The aim of the benchmark is to apply an analytical assessment model (Gadget) and move the stock from category 3 to category 1. Furthermore, the aim is to define reference points for the stock. In Chapter 20.12, an exploratory analytical assessment model (Gadget) is presented. Below is a table indicating issues that will be discussed during the benchmark meeting.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified	Underutilised data from the area.	Collection of relevant survey data and commercial samples	These data sets are available	Kristján Kristinsson	
Tuning series	One survey, the Icelandic autumn survey.		Survey data 2000-2020 is available.	Kristján Kristinsson	
Bycatch/misreporting					
Biological Parameters	Ageing/growth: Ageing from the autumn survey is done systematically. Age disaggregated data is now available for 7 years. This will allow use of length/agebased assessment model (Gadget).	Continuation of ageing.	Otoliths are available from the autumn survey 2000-2020.	Kristján Kristinsson	
	Stock ID; The stock structure of beaked redfish is complicated. The stock/fishery of this stock is covering the Icelandic Waters Ecoregion where only adult population is found. Information suggest that recruitment comes coming from East Greenland. Furthermore, there is indication of two different ecotypes of beaked redfish co-occurring in the area (slope and deep pelagic).	Continue genetic studies.	Initiatives are being taken by several institutes and collaboration is ongoing. Expected results in 2021.	Kristján Kristinsson	
Fisheries & ecosystem issues and data	Low recruitment in recent years				
Assessment method	No analytical assessment model. Currently, the stock is a category 3 stock, where assessment is based on survey trends. A length/age based model (Gadget) has been under development in order to utilize more biological information.	1) Continuation of the ageing programme. 2) Analysis of growth from age data. 3) Explore assessment models which includes data of different ecotypes and from different areas (inclusion of data	All data which are available. Age data for some years from the Icelandic autumn survey is now available.	Kristján Kristinsson Bjarki Elvarsson	

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
		from East Greenland and the deep pelagic beaked redfish stock in the Irminger Sea).			
Biological Reference Points	No biological reference points defined	Should be defined in accordance with a new model approach		Kristján Kristinsson Bjarki Elvarsson	
Other					

20.12 Exploratory analytical assessment with Gadget

No analytical assessment is conducted on this stock. In this chapter, preliminary run and analysis of a Gadget model is presented. The purpose is to explore assessment methods as a potential category 1 assessment. Current assessment (based on survey trends) is not considered to capture true state of the stock.

Model settings and results from a run that was done in 2020 are presented.

20.12.1 Data used and model settings

Beaked redfish is a long-lived species, and the maximum age is set at 50 years as a plus group. Simulation begins in 1970, but the fishery started in 1950. No biological data are available prior to 1970. The immature stock matures at age 20 at the latest. Recruitment to the immature stock component occurs at age 3. The length range in the model ranged between 10 and 55 cm (with no mature individual <18 cm). An overview of the data sets and model parameters used in the model study is shown in Table 20.12.1.

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

Model settings:

- The simulation period is from 1970 to 2024 using data until the end of 2019 for estimation.
- Four time-steps (3-month period) are used each year.
- The ages used were 3 to 50 years, where the oldest age is treated as a plus group (fish 50 years and older).
- Modelled length ranged between 10-60 cm.
- The length increments in the survey were 10-20 cm, 21-25 cm, 26-30 cm … 41-45 cm and 46-55 cm. The survey vas not conducted in 2011.
- One commercial fleet (bottom trawl). Survey catch distribution data are modelled as a separate fleet.
- Recruitment was set at age 3.

List of parameters in the Gadget model:

- Natural mortality, M_a, fixed at 0.05 for all ages. The value chosen was based on settings in other redfish stocks.
- Length-based Von Bertalanffy growth function, k, L_∞, informed by age–length frequencies.
- Parameter β of the beta-binomial distribution controlling the spread of the length distribution.
- Logistic fleet selection, b_f, $l_{50,f}$; one set for each of the fleets (Autumn survey or Commercial).
- Initial abundance at ages 3-50 in 1970 by η_{sa} and $a \in (3, 50^+)$. σ_a^2, i.e. variance in initial length at age a was fixed and based on length distributions obtained in the autumn survey. Initial lengths at age were defined based on the growth function.
- Initial guess of the logistic maturity ogive, λ, l_{50}, was estimated from survey data.
- Length at recruitment, l_0, σ_0: mean length (at age 3) and std. deviation in length at recruitment.
- Number of recruits by year, R_y, and y ∈ (1970, 2019).
- Length-weight relationship μ_s, ω_s, were fixed based on the means of log-linear regression of survey data.
- Scalars, R_c, $I_{c,s}$, F_0 : recruitment scalar (multiplied against all R_y to help optimization), initial numbers at age scalars (by stock s, multiplied against all η_{sa} to help optimization) and

initial fishing mortality (applied to all age groups and all years, steepens initial numbers at age distribution to reflect previous effects of fishing).

20.12.2 Diagnostics

Survey indices can be variable for Icelandic slope beaked redfish due to its tendency to be influenced by a few very large hauls. The index data used as input here are the total raw numbers of fish caught (within length slices) in the entire autumn survey. Although they are expected to represent the entire stock, they are also expected to be highly variable because no treatment or data pre-processing has been performed to reduce this variability. This variability is reflected in the model's fit to the survey index data (Figure 20.12.1). In general, the model appears to follow the stock trends historically except for the 25-30 cm and 30-35 cm length groups. In these length groups model underestimates the first three years. Furthermore, the terminal estimate is not seen to deviate substantially from the observed value for most length groups, except for the largest one, 45-55 cm, with model overestimating the abundance.

Model fits to the age-length distribution data from the autumn survey show that the fit is not particularly good for the oldest ages (30+) where the model underestimates these ages (Figure 20.12.2). Furthermore, the model overestimates certain age classes which can be followed through years, first in 2009 as 12-19 years old fish and then again in 2017 and 2018 as 20–28 year old fish.

The main portions of the length distributions appear to have a reasonable fit (Figure 20.12.3). In some years, the overall fit to the predicted proportional length distributions in the survey is smaller to the observed for fish with the greatest density within the fished population (ca. 40-45 cm fish).

Length distributions from the commercial catch does usually show good fit (Figure 20.12.5) the fit between predicted and observed age distributions is much worse and could be related to few age readings in each time step (Figures 20.12.4).

Residual plots generally show the same trends in fits to the length data of the commercial and survey data with an underestimation of the smallest fish (roughly < 20 cm), good estimation of the sizes contributing most to the exploitable fishery (roughly 30-50 cm), and an underestimation of the largest fish (roughly >50 cm (Figures 20.12.6 and 20.12.7). Because inter-age and inter-length correlations are not included in Gadget, some blocks of similar residuals can be seen, and are more pronounced in the length bubble plot because of its finer resolution.

20.12.3 Retrospective plots

In Figure 20.12.8, the results of an analytical retrospective analysis are presented. The analysis indicates that there was an upward revision of biomass over the first 4 years of the 5-year peel followed by a downward revision of biomass (SSB) over the last year, and subsequently a downward then upward revision of F. Estimates of recruitment are all over the place in the beginning but are since 2000 decently stable for the first 4 years of the 5-year peel. The last year is though strange.

Growth patterns predicted by the model does not follow closely to the data of fish 10 years old and younger (Figure 20.12.9).

20.12.4 Model results

Summary of the assessment is shown in Figure 20.12.10. The spawning stock has since 1990 decreased and has since 2010 been below B_{lim} (defined as the median SSB for 2000-2005). The total biomass has also decreased and is now at similar level as the SSB indicating very few immature fish in the stock. Fishing mortality has decreased substantially from highest level in the late 1990s. Fishing mortality were relatively stable around F_{lim} in 2013-2019, but above F_{MSY}. Recruitment after 2010 is record low for the time series.

The relationship between spawning stock and recruitment at age 3 is shown, with a minimum spawning stock biomass in 2019 (Figure 20.12.11). Spawning stock biomass has decreased since the 1990 with correspondent decrease in recruitment.

20.12.5 Reference points

From the Gadget model it is possible to define reference points for this stock (Table 20.12.2 and Figure 20.12.13).

Stochastic simulations show that the F_{MSY} = 0.06. B_{lim} = 169 200 t is defined as the median of SSB in 2000-2005 when the stock was stable at low levels. B_{pa} was defined as 236 880 t by adding precautionary buffer to the proposed B_{lim} * 1.4 (approximation of 169000*exp(0.2*1.645). The plot of the average spawning stock against fishing mortality show that F_{lim} = 0.08 and F_{pa} is then 0.08/exp(1.645*0.2) = 0.058 (Figure 20.12.13)

20.13 References

ICES. 2012. Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68.

Table 20.2.1 Total biomass index of Icelandic slope *S. mentella* in the Icelandic Autumn Groundfish survey 2000–2020. No survey was conducted in 2011.

Year	Biomass	lower 5th percentile	upper 95th percentile
2000	135,994	96,811	175,176
2001	161,733	104,040	219,427
2002	95,059	68,975	121,143
2003	63,188	47,459	78,916
2004	96,465	64,134	128,797
2005	109,196	55,690	162,702
2006	123,018	82,993	163,043
2007	82,035	52,610	111,459
2008	80,011	57,899	102,123
2009	93,653	61,714	125,592
2010	77,800	54,317	101,283
2011	0	0	0
2012	74,604	53,402	95,806
2013	69,935	48,552	91,319
2014	103,051	64,473	141,629
2015	107,423	70,788	144,059
2016	80,855	61,363	100,348
2017	125,611	83,265	167,957
2018	122,292	72,196	172,387
2019	85,157	61,456	108,858
2020	90,371	64,687	116,054

Table 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* 1950–2020 from the Iceland Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ).

Year	Iceland	Others	Total
1950	1 458	36 269	37 727
1951	1 944	45 825	47 769
1952	885	55 554	56 439
1953	658	86 011	86 669
1954	577	75 972	76 459
1955	654	52 784	53 438
1956	674	40 047	40 721
1957	558	35 993	36 551
1958	409	43 820	44 229
1959	398	40 175	40 573
1960	407	38 428	38 836
1961	307	31 534	31 841
1962	264	35 122	35 386
1963	456	38 338	38 794
1964	362	45 414	45 776
1965	473	55 930	56 403
1966	332	47 491	47 823
1967	357	47 313	47 670
1968	494	50 892	51 386
1969	486	38 358	39 345
1970	500	35 800	36 300
1971	495	34 376	34 871
1972	593	39 874	40 468
1973	794	35 251	36 045
1974	806	32 103	32 909
1975	1 404	29 301	30 705
1976	715	28 632	29 346
1977	590	22 427	23 018
1978	3 693	209	3 902
1979	7 448	246	7 694
1980	9 849	348	10 197
1981	19 242	447	19 689
1982	18 279	213	18 492
1983	36 585	530	37 115
1984	24 271	222	24 493
1985	24 580	188	24 768
1986	18 750	148	18 898
1987	19 132	161	19 293
1988	14 177	113	14 290

Year	Iceland	Others	Total
1989	40 013	256	40 269
1990	28 214	215	28 429
1991	47 378	273	47 651
1992	43 414	0	43 414
1993	51 221	0	51 221
1994	56 674	46	56 720
1995	48 479	229	48 708
1996	34 508	233	34 741
1997	37 876	0	37 876
1998	32 841	284	33 125
1999	27 475	1 115	28 590
2000	30 185	1 208	31 393
2001	15 415	1 815	17 230
2002	17 870	1 175	19 045
2003	26 295	2 183	28 478
2004	16 226	1 338	17 564
2005	19 109	1 454	20 563
2006	16 339	869	17 208
2007	17 091	282	17 373
2008	24 123	0	24 123
2009	19 430	0	19 430
2010	17 642	0	17 642
2011	11 738	0	11 738
2012	11 965	0	11 965
2013	8 761	0	8 761
2014	9 500	0	9 500
2015	9 311	0	9 311
2016	9 536	0	9 536
2017	8 371	0	8 371
2018	9 995	0	9 995
2019	8 716	0	8 716
2020[1)]	11 375	0	11 375

1) Provisional

Table 20.3.2 Proportion of the landings of Icelandic slope *S. mentella* taken in the Iceland Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) by pelagic and bottom trawls 1991–2020.

Year	Pelagic trawl	Bottom trawl
1991	22%	78%
1992	27%	73%
1993	32%	68%
1994	44%	56%
1995	36%	64%
1996	31%	69%
1997	11%	89%
1998	37%	63%
1999	10%	90%
2000	24%	76%
2001	3%	97%
2002	3%	97%
2003	28%	72%
2004	0%	100%
2005	0%	100%
2006	0%	100%
2007	17%	83%
2008-2020	0%	100%

Table 20.12.1: Overview of the likelihood data used in the model. Survey indices are calculated from the length distributions and are disaggregated (sliced) into seven groups. Number of data-points refer to aggregated data used as inputs in the Gadget model and represent the original dataset. All data obtained from the Marine and Freshwater Research Institute, Iceland.

Component name	Qarters	Year range	N	Delta 1	Type
aldist.aut	4	2000-2019		1 cm	Age- length distribution
aldist.comm	All quarters	1998-2018		1 cm	Age- length distribution
ldist.aut	4	2000-2019		1 cm	Length distribution
ldist.comm	All quarters	1976-2019		1 cm	Length-distribution
matp.aut	4	2000-2019			Ratio of immature:mature by length group
si.10-20.aut	4	2000-2019		10-20 cm	Survey indices
si.20-25.aut	4	2000-2019		20-25 cm	Survey indices
si.25-30.aut	4	2000-2019		25-30 cm	Survey indices
si.30-35.aut	4	2000-2019		30-35 cm	Survey indices
si.35-40.aut	4	2000-2019		35-40 cm	Survey indices
si.40-45.aut	4	2000-2019		40-45 cm	Survey indices
si.45-55.aut	4	2000-2019		45-55 cm	Survey indices

Table 20.12.1: Reference points from stochastic simulations.

Framework	Reference points	Value	Technical basis
MSY approach	MSY $B_{trigger}$	236 880 t	B_{pa}
	HR_{MSY}	0.06	F_{MSY}
	F_{MSY}	0.06	Stochastic simulations.
Precautionary approach	B_{lim}	169 200 t	Median SSB for 2000-2005
	B_{pa}	236 880 t	B_{lim}* 1.4
	HR_{lim}	0.08	F_{lim}
	F_{lim}	0.08	Equilibrium F that will maintain the stock above B_{lim} with a 50% probability
	F_{pa}	0.058	F_{lim}/exp(0.2*1.645)
	HR_{pa}	0.055	F_{pa}

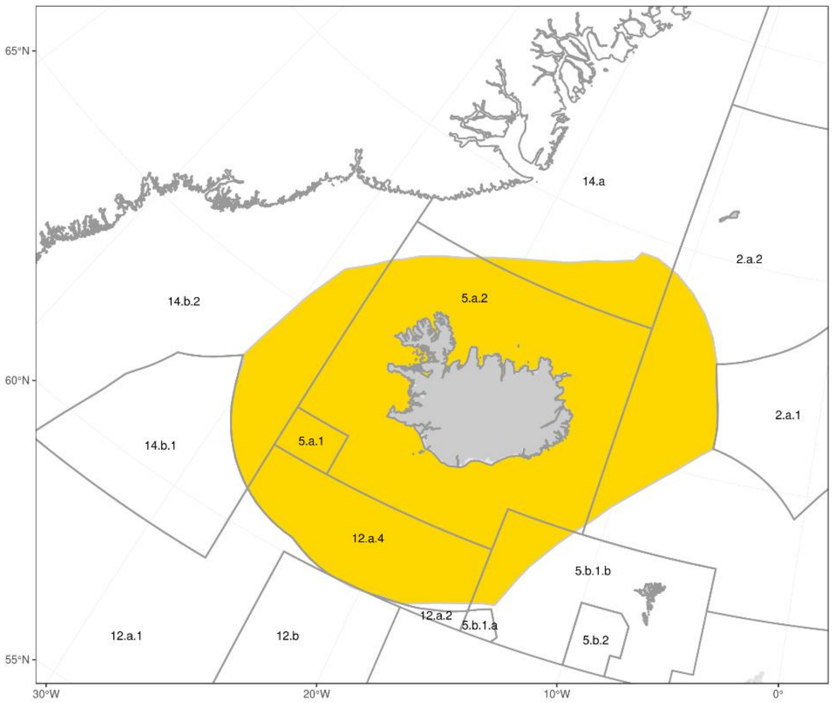

Figure 20.1.1 The Iceland Sea ecoregion (in yellow) as defined by ICES. The relevant ICES statistical areas are shown.

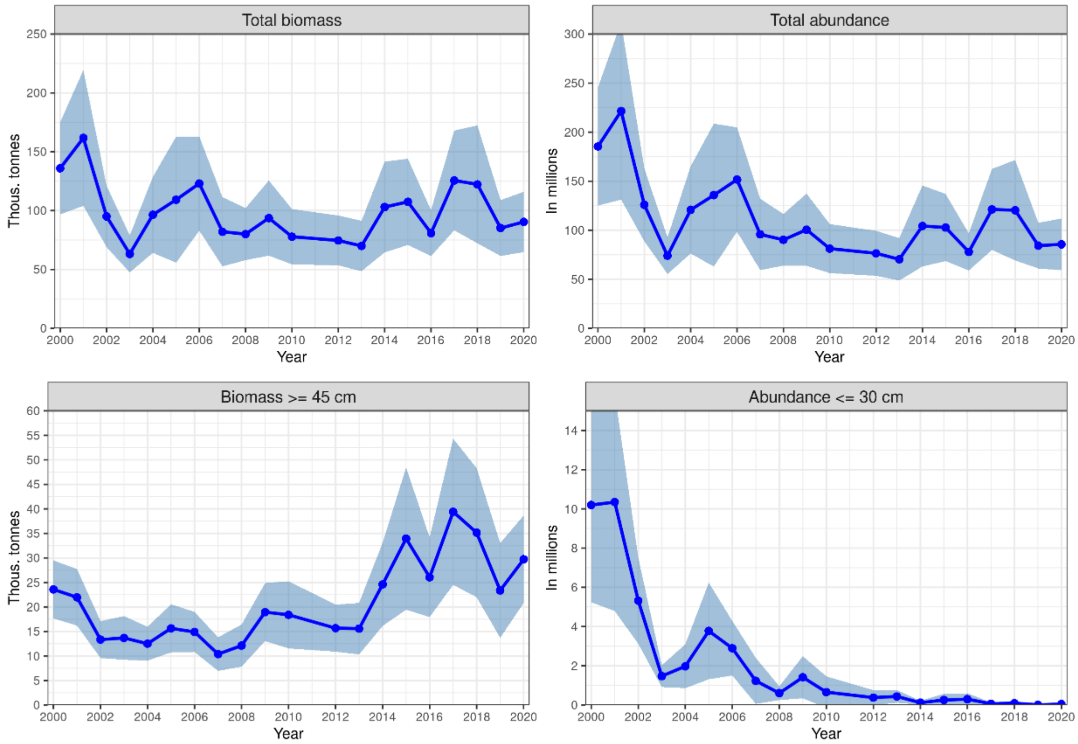

Figure 20.2.1 Survey indices of the Icelandic slope *S. mentella* in the autumn survey in Icelandic waters (ICES Division 5.a and part of Subarea 14) 2000–2020. No survey was conducted in 2011. The figure shows the total biomass index, total abundance index in millions of fish, biomass index of fish 45 cm and larger and abundance index of fish 30 cm and smaller.

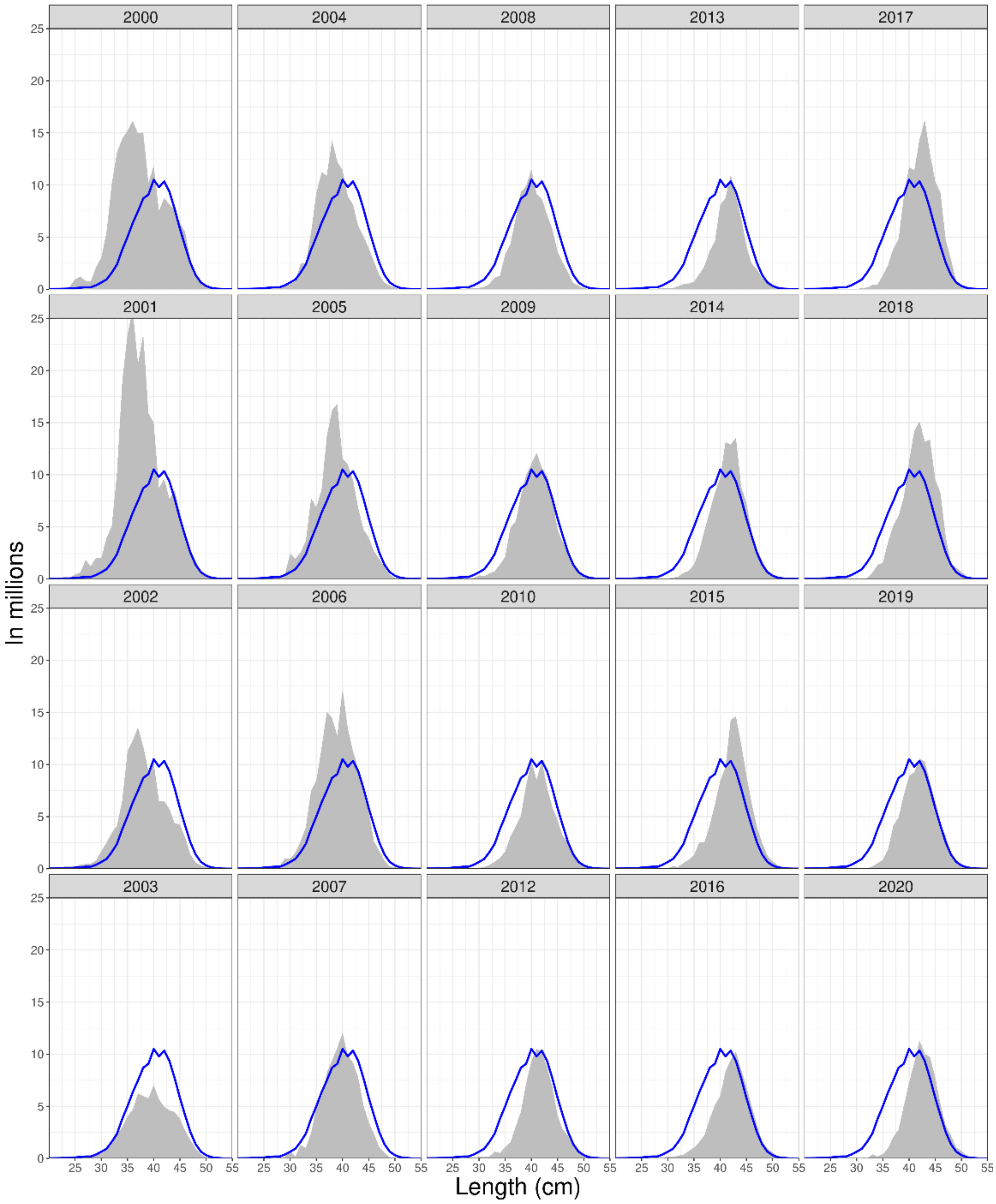

Figure 20.2.2 Length distribution of Icelandic slope *S. mentella* in the Autumn Groundfish Survey in October 2001–2020 in Icelandic waters (ICES Division 5.a and part of Subarea 14). No survey was conducted in 2011. The blue line is the mean of 2000–2020.

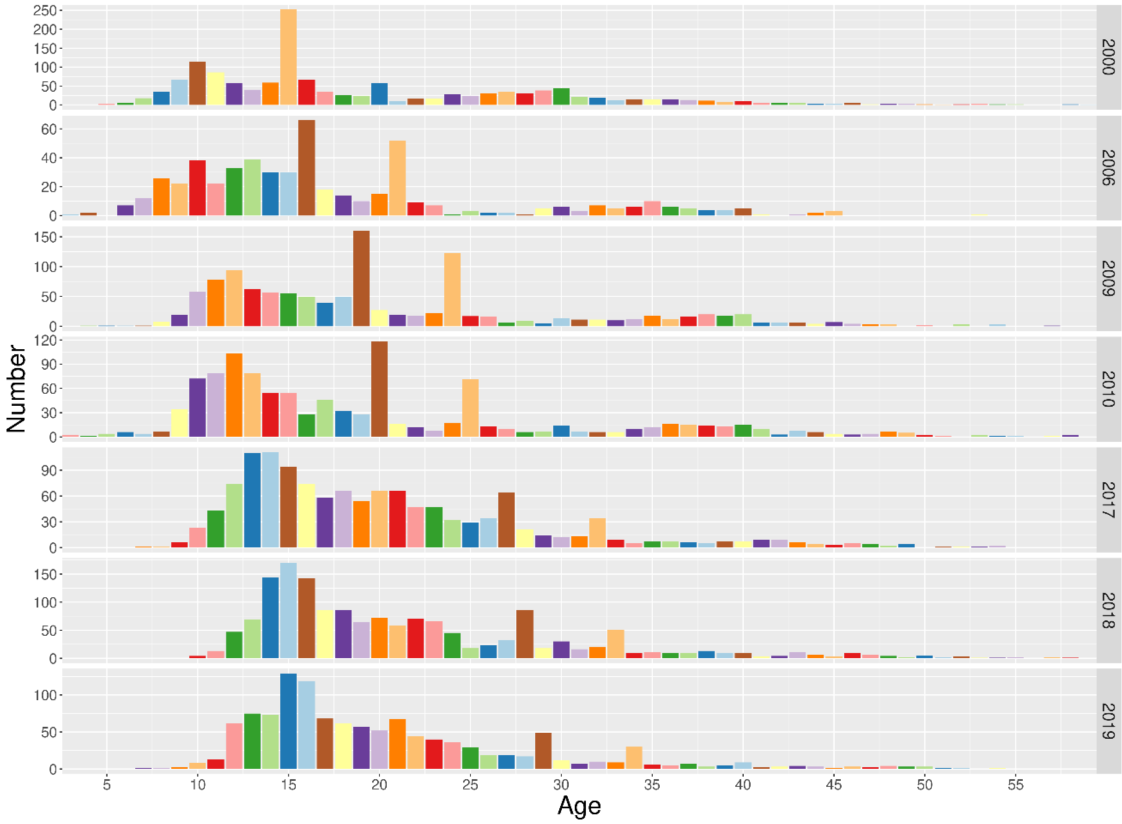

Figure 20.2.3 Age distribution of Icelandic slope *S. mentella* from the Autumn Survey in 2000 (n = 1 405), 2006 (n = 536), 2009 (n = 1 205), 2010 (n = 1 099), 2017 (n = 1 298), 2018 (n = 1 568), and 2019 (n = 1 176). The age class 60 are the combined age-classes of 60 years and older.

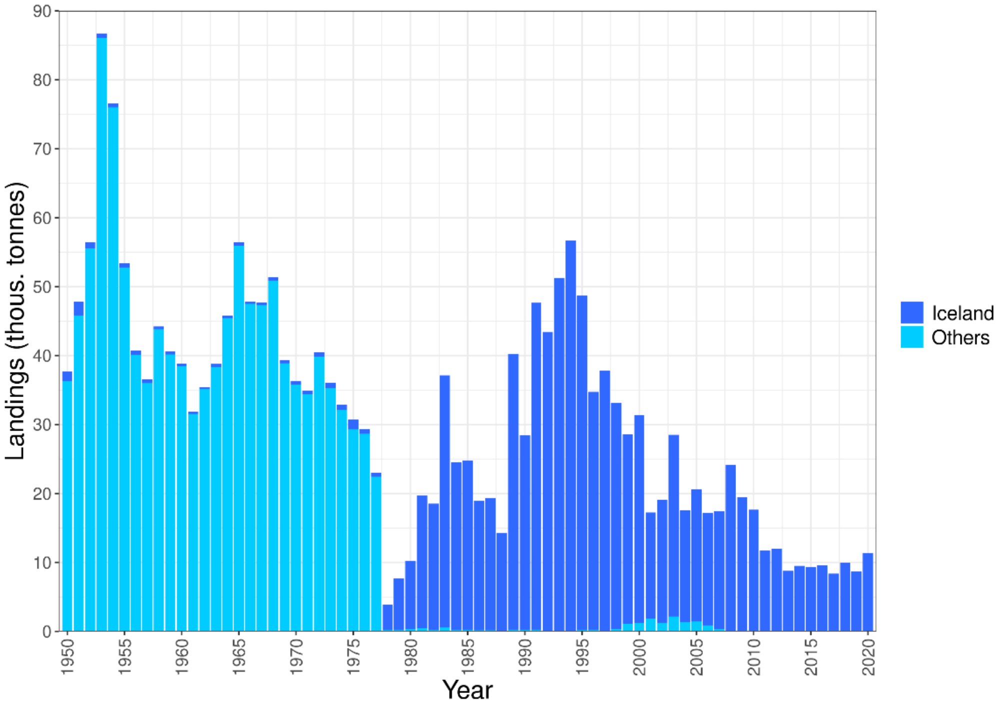

Figure 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* from Icelandic waters (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1950–2020.

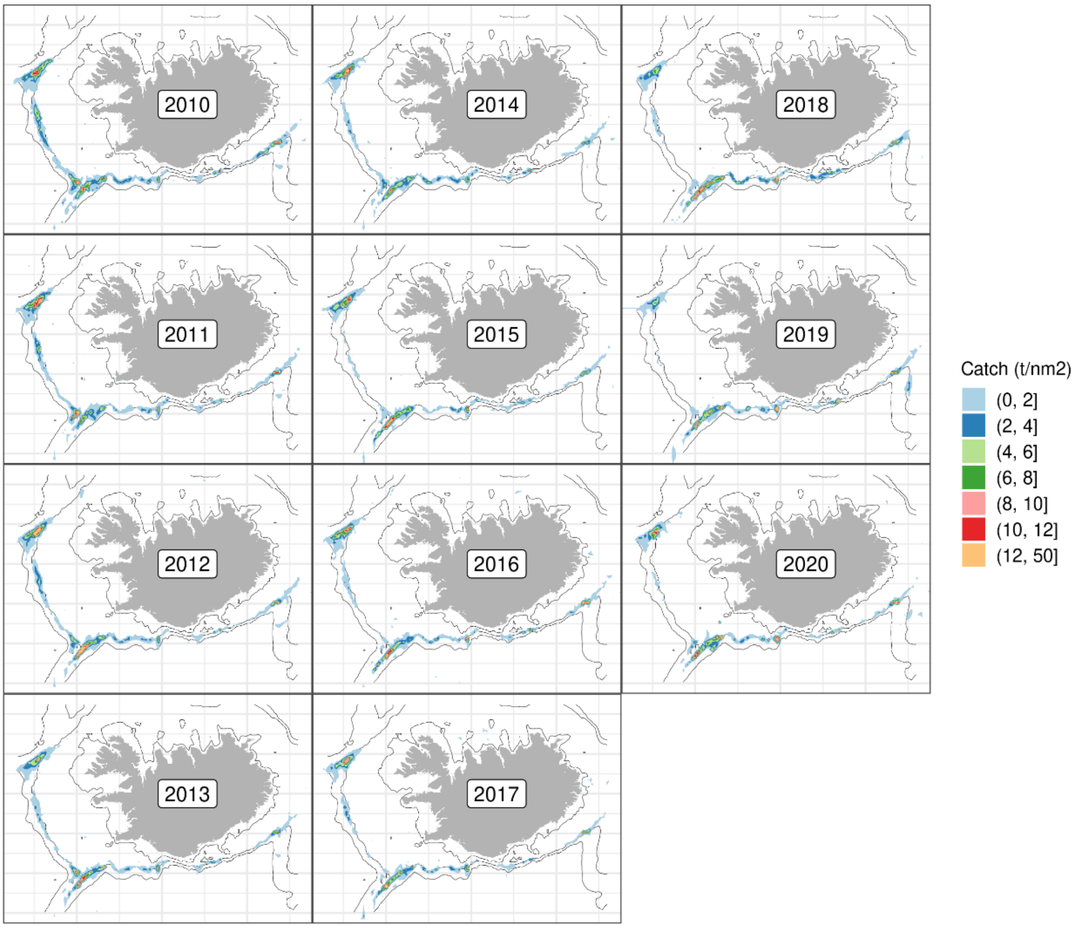

Figure 20.3.2 Geographical location of the Icelandic slope *S. mentella* catches (t/nmi², coloured area) in Icelandic waters (ICES Division 5.a and Subarea 14 and within the Icelandic EEZ) 2010–2020 as reported in logbooks (rep. catch) of the Icelandic fleet using bottom trawl. The black solid line indicates the boundaries of the Icelandic EEZ.

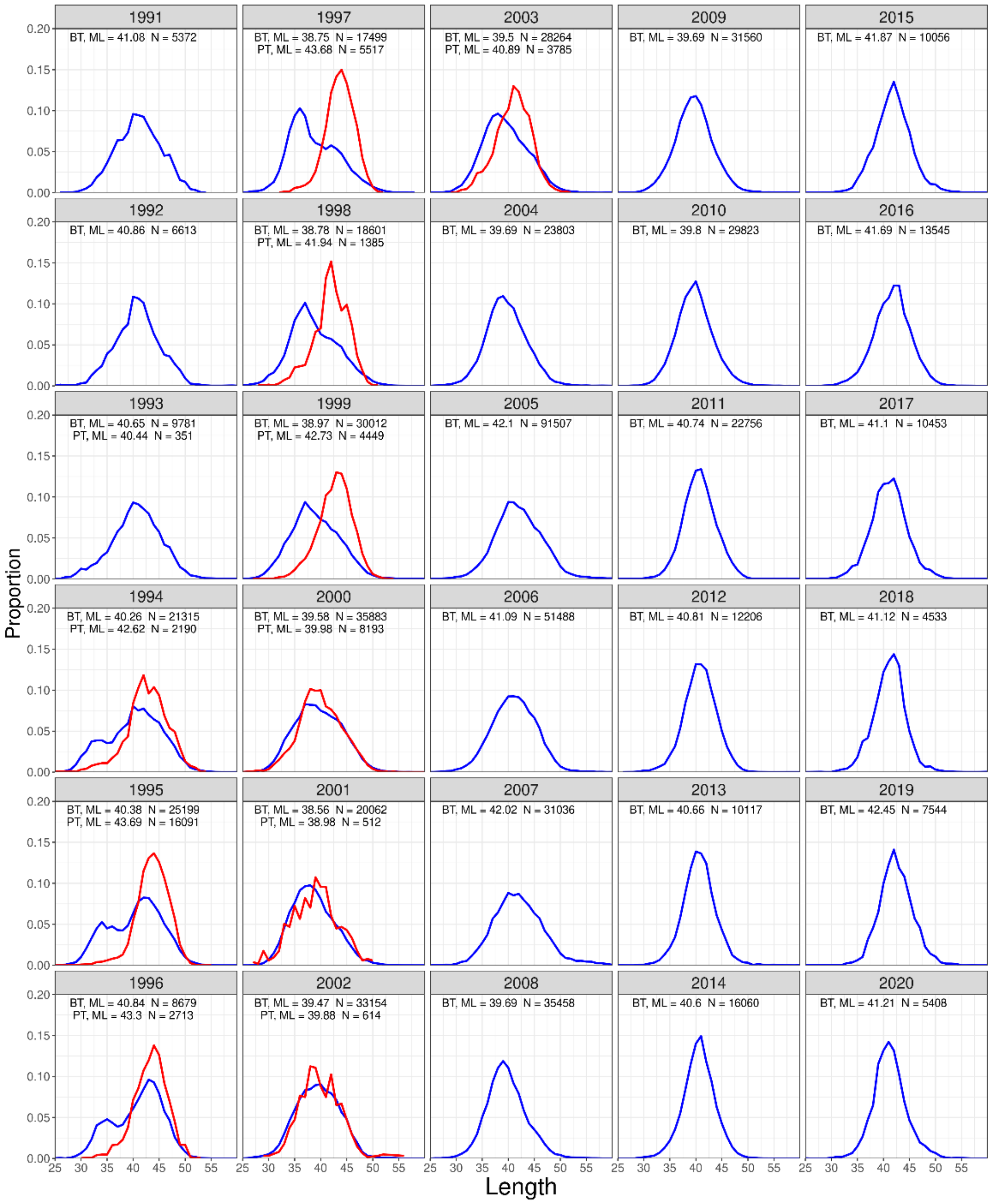

Figure 20.3.3Length distributions of Icelandic slope *S. mentella* from the Icelandic landings taken with bottom trawl (blue line) and pelagic trawl (red line) in Icelandic waters (ICES Division 5.a and Subarea 14) 1991–2020.

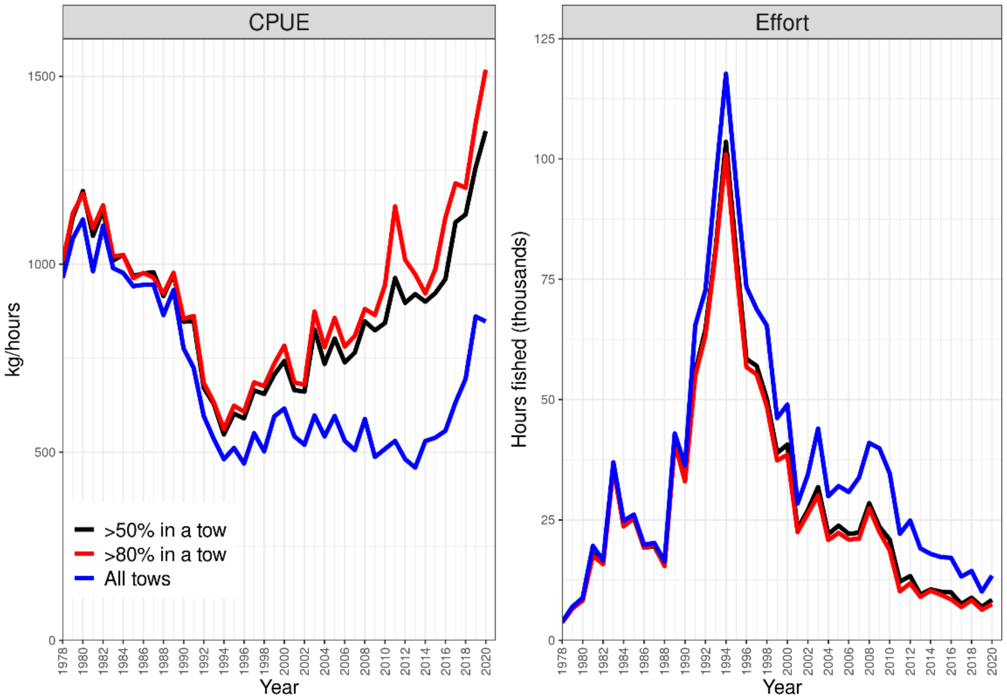

Figure 20.3.4 Non-standardized CPUE (kg/hour) and effort (thousand hours fished) of Icelandic slope *S. mentella* from the Icelandic bottom trawl fishery in Icelandic waters (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1978–2020. The black lines show CPUE/effort where more than the 50% of the catch in individual tows were Icelandic slope *S. mentella*, the red lines where more than 80% of the catch in individual tows were Icelandic slope *S. mentella*, and the blue lines all tows were Icelandic slope *S. mentella* was caught.

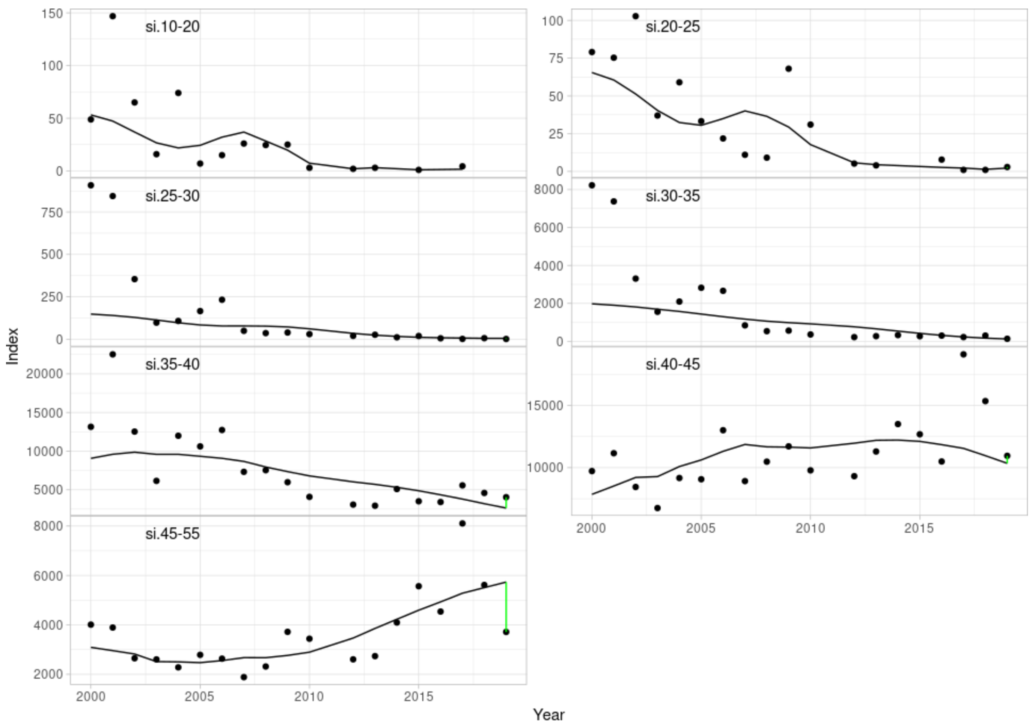

Figure 20.12.1. Icelandic slope beaked redfish. Autumn survey index number fits (lines) to data (points). The green line indicates the difference between model and data values in the last year.

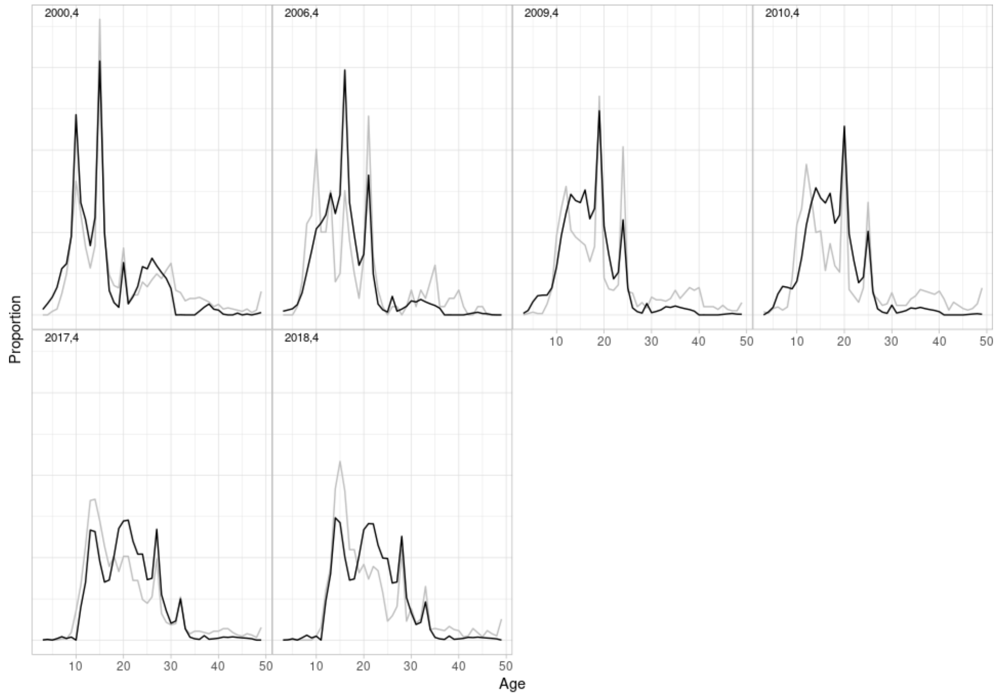

Figure 20.12.2. Icelandic slope beaked redfish. Comparison of autumn survey age distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

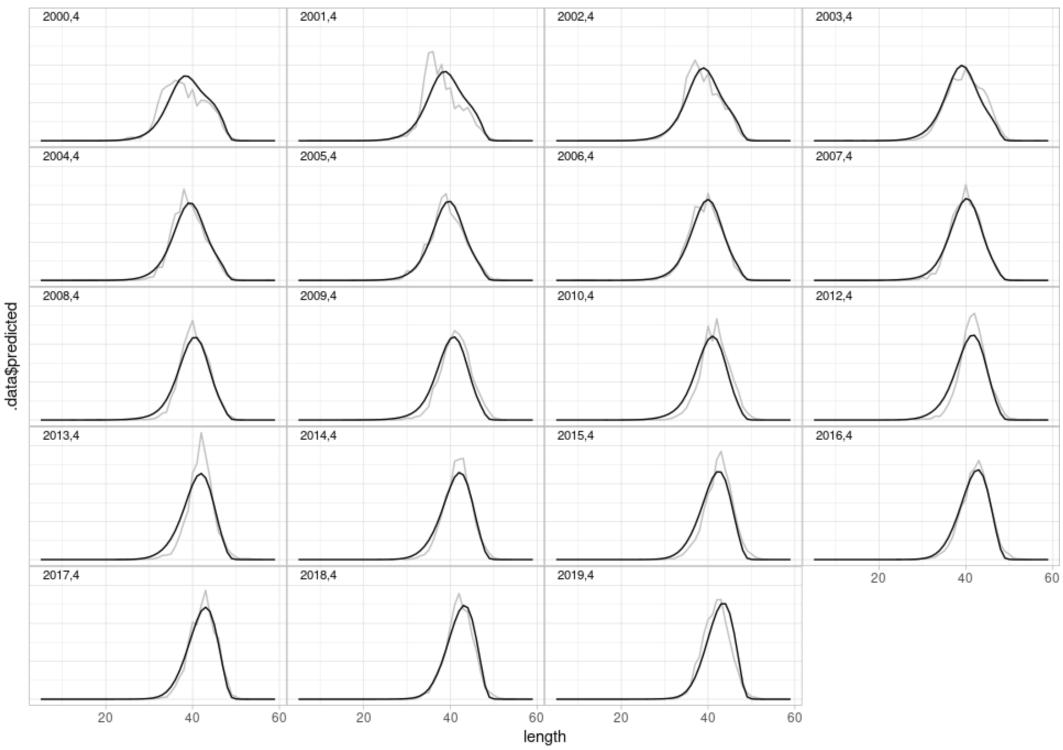

Figure 20.12.3. Icelandic slope beaked redfish. Comparison of autumn survey length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

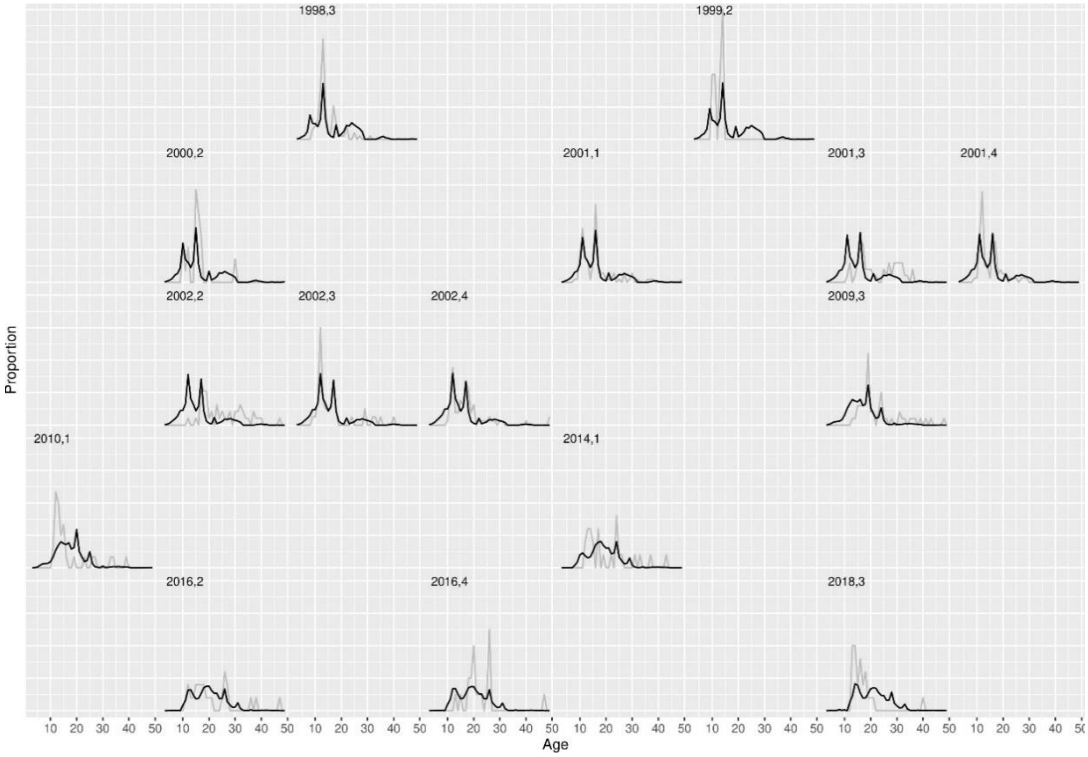

Figure 20.12.4. Icelandic slope beaked redfish. Comparison of commercial sample age-length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

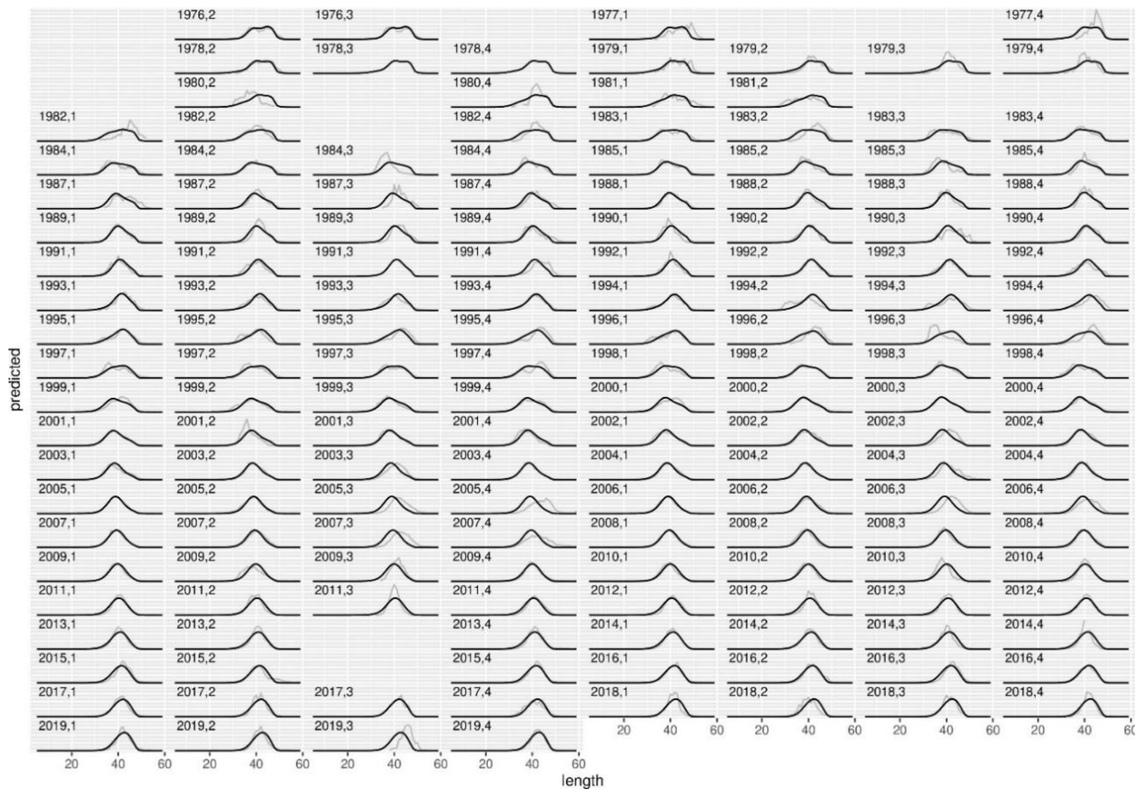

Figure 20.12.5. Icelandic slope beaked redfish. Comparison of commercial sample length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

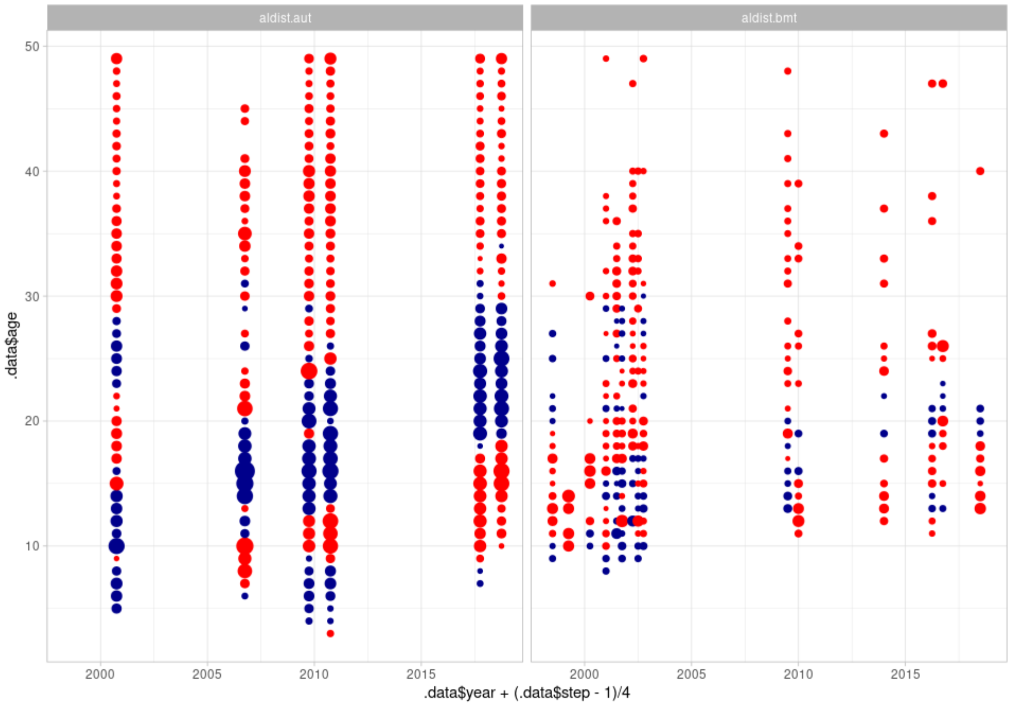

Figure 20.12.6. Icelandic slope beaked redfish. Bubble plots illustrating age-length distribution residuals between model predictions and data. Red bubbles indicate positive residuals (underestimation); blue bubbles indicate negative residuals (overestimation).

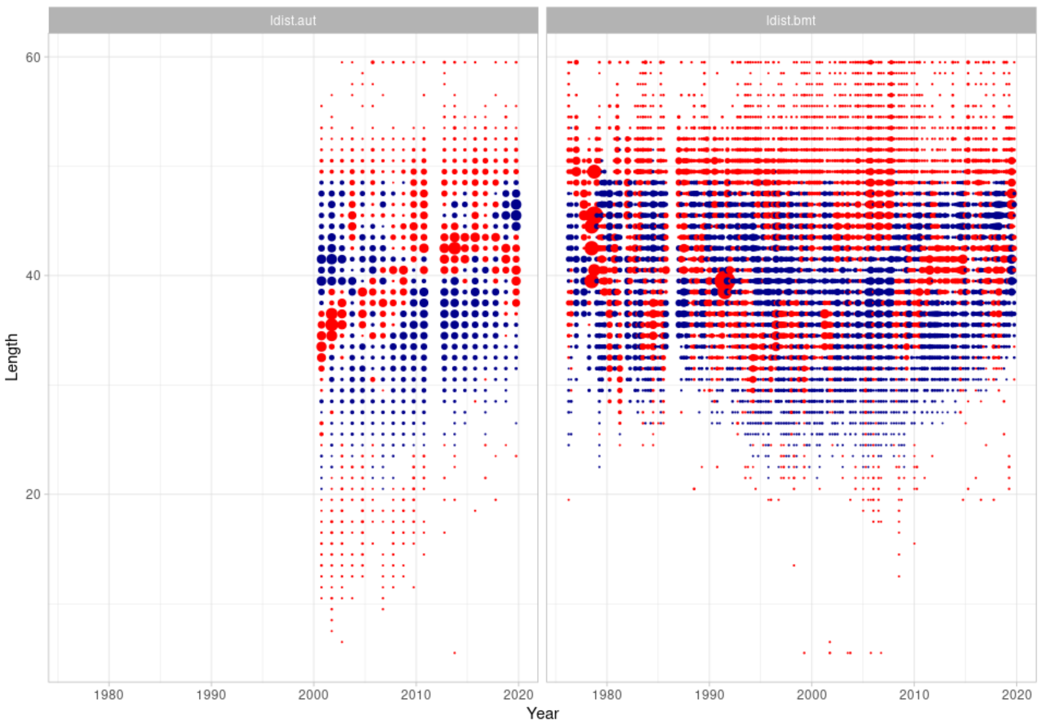

Figure 20.12.7. Icelandic slope beaked redfish. Bubble plots illustrating length distribution residuals between model predictions and data. Red bubbles indicate positive residuals (underestimation); blue bubbles indicate negative residuals (overestimation).

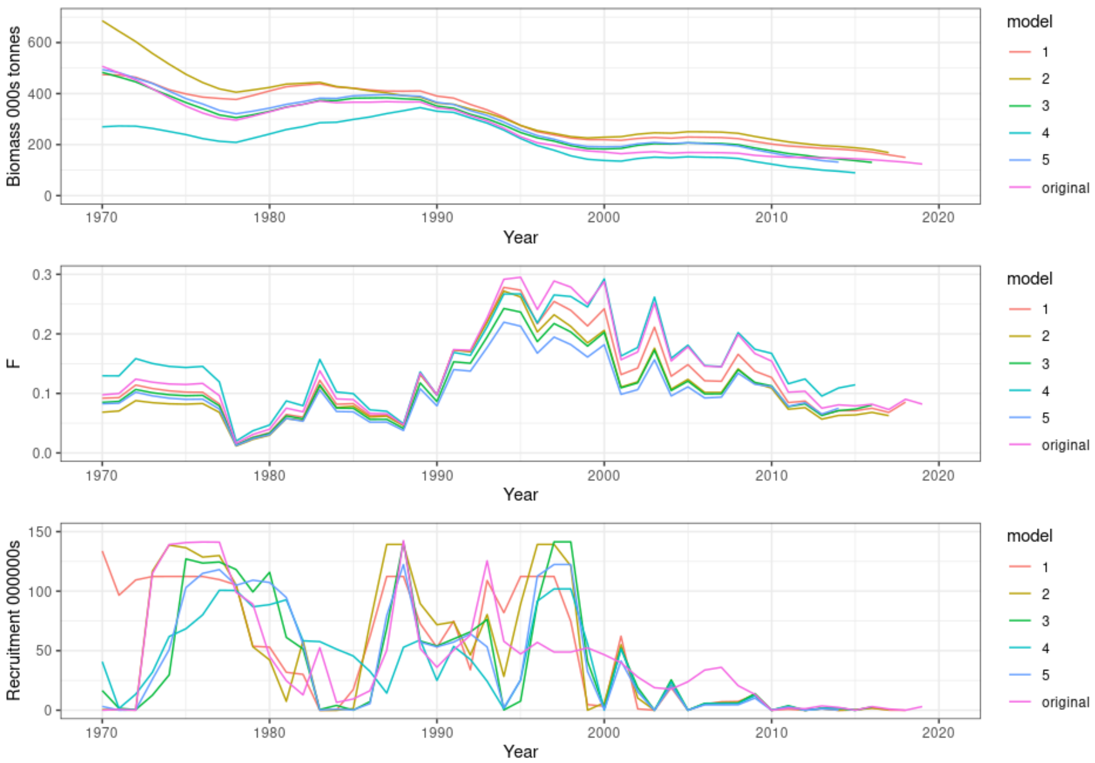

Figure 20.12.8. Icelandic slope beaked redfish. Retrospective plots illustrating stability in model estimates over a 5-year ‘peel’ in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

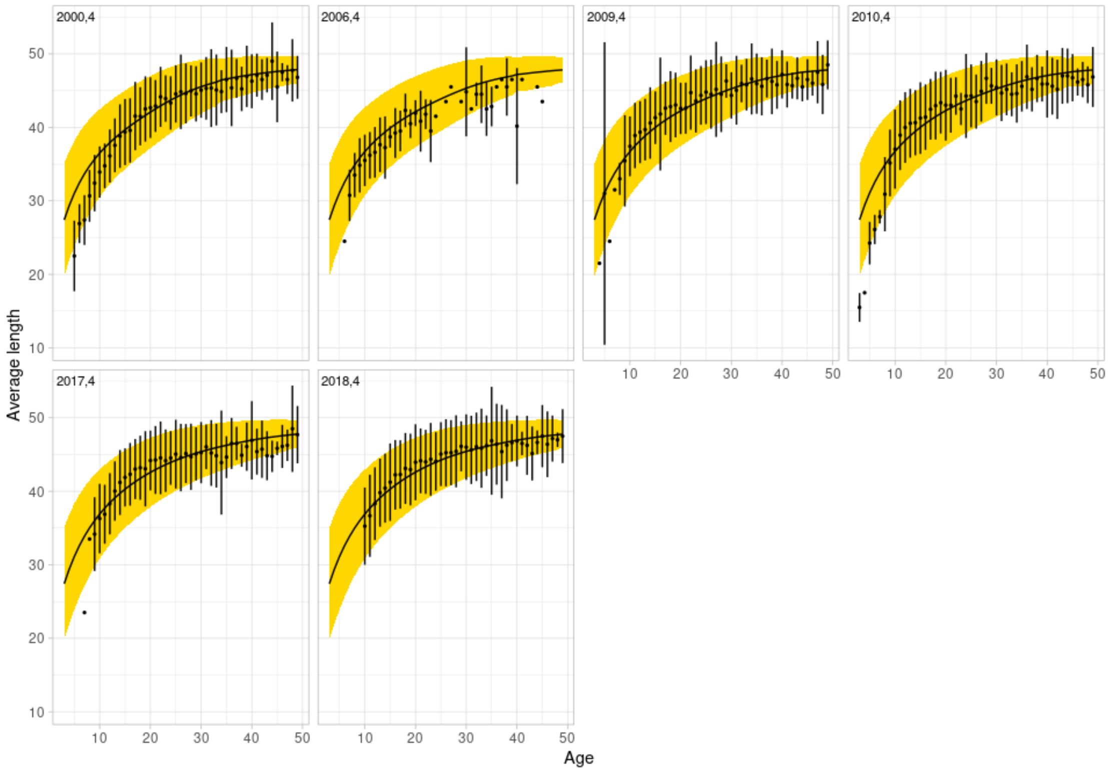

Figure 20.12.9. Icelandic slope beaked redfish. Growth estimations by fleet from the Gadget model. Yellow bands and the black line show where the mean and 95% confidence intervals of the of model predictions, whereas the points and error bars show the mean and 95% confidence intervals of the data.

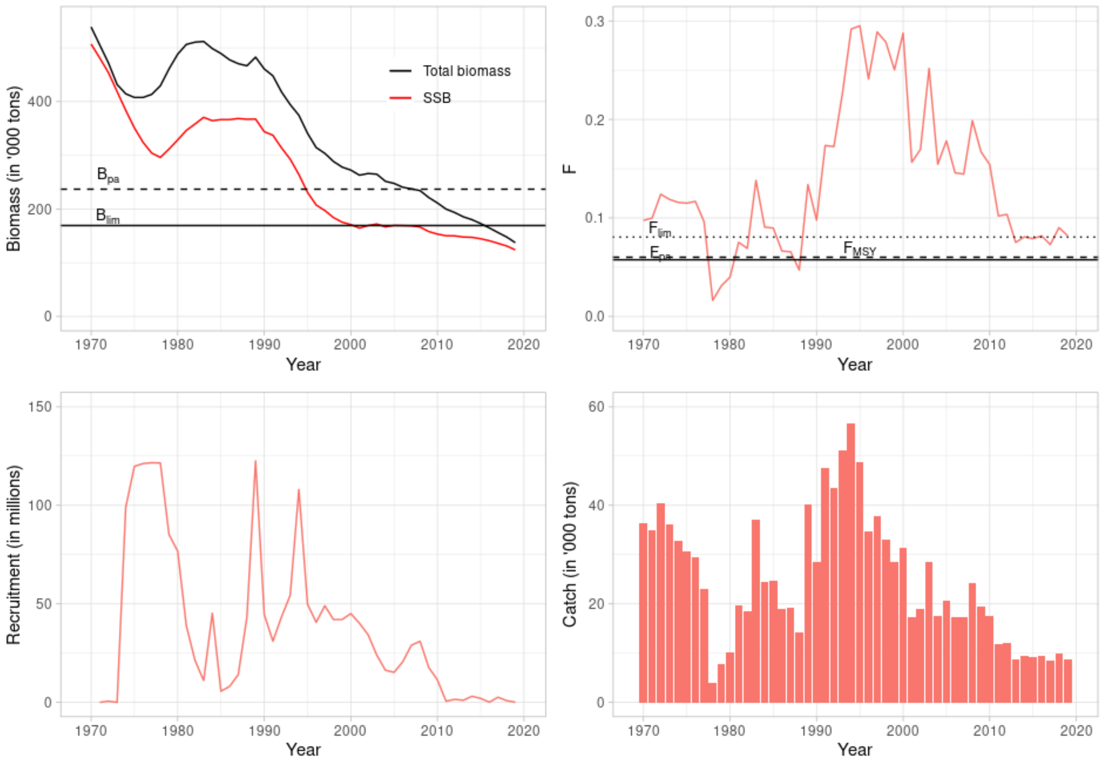

Figure 20.12.10. Icelandic slope beaked redfish. Summary from the assessment 2020.

Figure 20.12.11. Icelandic slope beaked redfish. Plots of the estimated recruitment age 3 versus spawning stock biomass (lagged by 1 year).

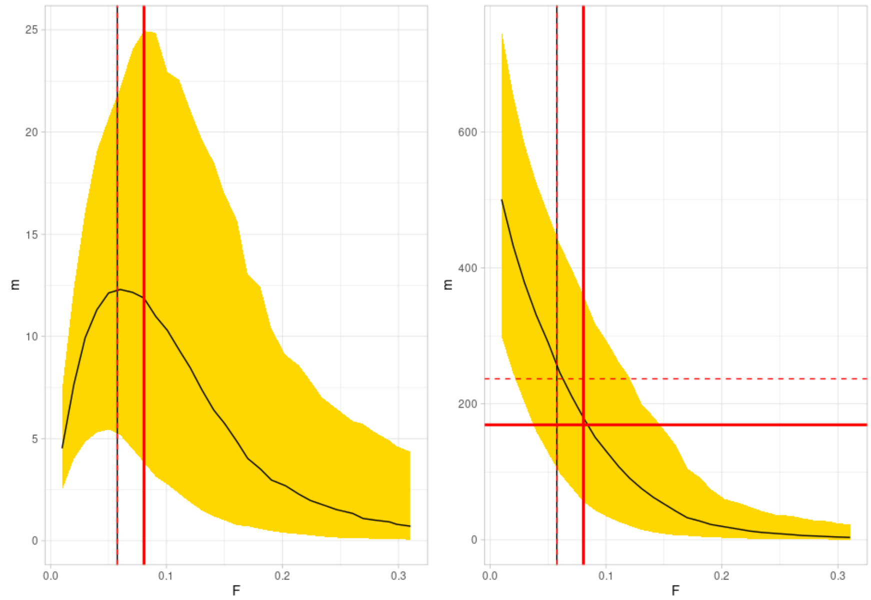

Figure 20.12.12. Icelandic slope beaked redfish. Yield-per-recruit (left) and average SSB against average fishing mortality (right). Also shown are the defined reference points.

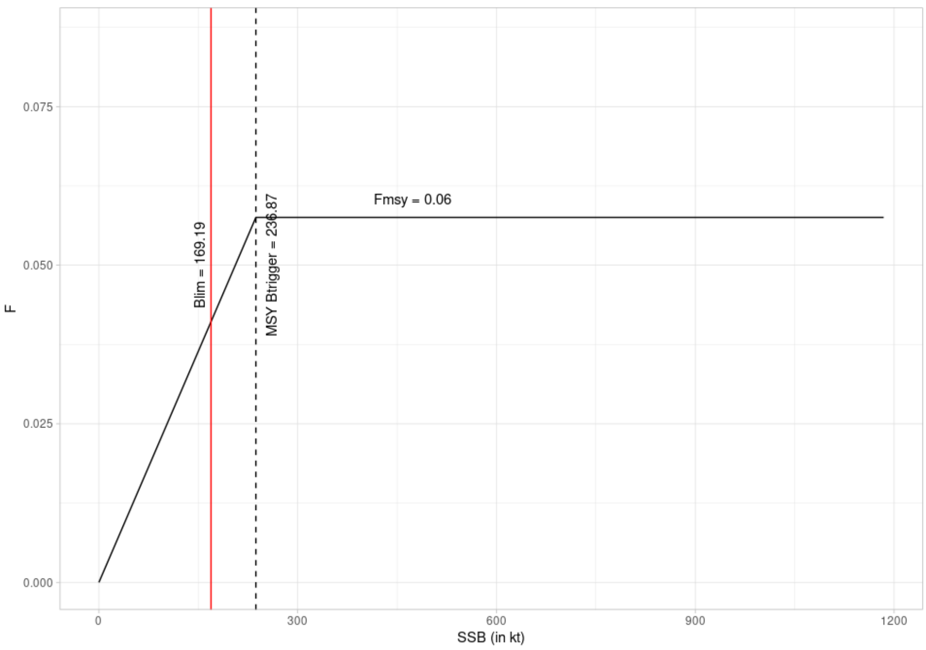

Figure 20.12.13. Icelandic slope beaked redfish. Proposed management plan.

21 Shallow Pelagic *Sebastes mentella*

21.1 Stock description and management unit

This section addresses the fishery for shallow pelagic *S. mentella* in the Irminger Sea and adjacent areas (parts of Division 5a, subareas 12 and 14; eastern parts of NAFO divisions 1F, 2H and 2J) at depths shallower than 500 m. No information was available on number of vessels participating in the fishery in 2017–2020.

21.2 Summary of the development of the fishery

The historic development of the fishery can be found in the Stock Annex. The clear changes in the spatial pattern of the fishery can be seen in Figure 21.2.1, based on logbook data from the Faroe Islands, Greenland, Iceland and Norway. A summary of the catches by ICES Divisions/NAFO regulatory area as estimated by the Working Group is given in Table 21.2.1 and Figure 21.2.2. The estimated catch for 2020 is 6152 t compared to 3184 t caught in 2019 (Tables 21.2.1 and 21.2.2).

There are no CPUE data for 2017-2020. The standardized CPUE index trend for the period 1994–2006 is shown in Figure 21.2.3. This standardized CPUE series includes data from Faroe Islands, Iceland, Germany, Greenland, and Norway, and it is estimated with a GLM model including the factors year, ship, month, and towing time. The model residuals are in Figure 21.2.4.

21.3 Biological information

There are no new data. The length distributions for the period 1989–2006 of biological stocks based on Icelandic data are shown in Figure 21.3.1. The length of the largest proportion of caught fish oscillates around 35 cm for the whole period.

21.4 Discards

Redfish form aggregations composed of individuals with a narrow size range, which results in very clean catches. Thus, discards are negligible according to available data from various institutes.

21.5 Illegal Unregulated and Unreported Fishing (IUU)

The Group had again difficulties in obtaining catch estimates from several fleets. Furthermore, there are problems with misreported catches from some nations. The Group requests NEAFC and NAFO to provide ICES in time with all the necessary information.

21.6 Surveys

The last international trawl-acoustic survey for the shallow pelagic stock was carried out in June–August 2021 and it is described in detail in ICES WGRS Report 2021 (ICES, 2021). Only one vessel from Russia participated in the survey. Iceland informed WGIDEEPS in December 2020 that it would not participate, and Germany had to withdraw its participation because of a broken vessel. Russia therefore surveyed the German part and were able to cover Subareas A, B, and E

(Figures 21.6.5 and Figures 21.6.6). The coverage of the shallow pelagic stock was considered adequate and most of the distribution area covered, except in the western and southern part (Figure 21.6.1).

21.6.1 Survey acoustic data

Since 1994, the results of the acoustic survey show a drastic decreasing trend from 2.2 million t to 600 000 t in 1999 and fluctuated with decreasing trend between 700 000 t–90 000 t in 2001–2013 (Table 21.6.1). The 2003 estimate, however, was inconsistent with the time series due to a shift in the timing of the survey.

The most recent trawl-acoustic survey on pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters that covers the whole distribution of the stock was carried out by Iceland, Germany, and Russia in June/July 2013. Approximately 341 000 NM^2 were covered. Figures 20.6.1 and 20.6.2 show the biomass estimates for depth shallower than the DSL (Depth Scattering Layer). A total biomass of 91 000 t was estimated acoustically in the layer shallower than the DSL (Table 21.6.1 and Figure 21.6.4). The results showed a substantial biomass decline in subarea B compared to 2011 but in other areas the biomass was similar as in 2011 (Table 21.6.2 and Figure 21.6.5 for area definition).

The survey in 2021 (ICES, 2021) covered Subareas A, B and E (Figures 21.6.5 and 21.6.6) and 242 000 NM^2 was covered compared to only 103 000 NM^2 in 2018 (when only Subarea A was covered) and 341 000 NM^2 in 2013 (Table 21.6.1). An estimate of 490 000 t was measured acoustically in the layer shallower than the DSL which is the highest value observed since 2005 (Table 21.6.2). This is a substantial increase in biomass estimates compared to previous surveys. The biomass estimates in Subarea A is the highest since 1996 and in Subarea B the highest since 2001, while the biomass estimates in Subarea E is among the highest value observed in the time series (Table 21.6.2). It is likely that the whole distribution area of the stock was not covered by the survey, that is, areas south and west of Subarea E. Biological samples from the acoustic estimate above the DSL a mean length of 34.3 cm in all areas which is 1.7 cm smaller fish than caught in 2013.

21.6.2 Survey trawl estimates

In addition to the acoustic measurements, redfish biomass was estimated by correlating catches and acoustic values at depths shallower than 500 m at 352 000 t, the highest value since 2001 (Table 21.6.1 and Figure 21.6.4). Figure 21.6.3 shows the distribution of the redfish catches within the DSL and shallower than 500 m.

The trawl biomass estimates in Subarea A in 2021 was 221 000 t which is the highest value observed in this subarea since the beginning of the time series in 2001 (Table 21.6.3). In Subarea E, the trawl biomass was 91 000 t, the highest in the time series, but in Subarea B, only 40 000 t were estimated which is among the lowest values.

The obtained correlation was used to convert the trawl data at greater depths to acoustic values and from there to abundance. For that purpose, standardized trawl hauls were carried out at depth 350–500 m, evenly distributed over the survey area (Figure 21.6.3). For the time being, the correlation between the catch and acoustic values is based on few data points only and it is highly variable. It is also assumed that the catchability of the trawl is the same, regardless of the trawling depth, thus the abundance estimate obtained is questionable and must only be considered as a rough attempt to measure the abundance within the DSL. Evaluation on the consistency of the method must wait until more data points are available.

Biological samples from the trawls within the DSL and shallower than 500 m showed a mean length of 34.4 cm, which is about 1 cm smaller fish than caught in 2015, but larger than in 2018. Figure 21.6.3 shows the spatial distribution of samples used in the survey and Figure 21.6.7 shows the corresponding length distribution.

The 2021 survey, therefore, indicates a decrease in the average total length in Shallow Pelagic *S. mentella* in the area observed. Despite no indication of young juvenile redfish on the Greenlandic or Icelandic shelf in the last 5–10 years (ICES, 2018) this may give an indication of recruitment of juvenile fish into the adult population of Shallow Pelagic *S. mentella* in the Irminger Sea.

21.7 Methods

The assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, CPUE and biological data. See Stock Annex and Section 21.6 for details.

21.8 Reference points

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is carried out due to data uncertainties and the lack of reliable age data. Thus, no reference points can be derived.

21.9 State of the stock

21.9.1 Short term forecast

For pelagic redfish in the Irminger Sea and adjacent waters, no analytical assessment is carried out due to data uncertainties and the lack of reliable age data. Thus, no short-term forecasts can be derived.

21.9.2 Uncertainties in assessment and forecast

21.9.2.1 Data considerations

Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faces problems to obtain reliable catch data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries. There are indications that reported effort (and consequently landings) could represent only around 80% of the real effort in certain years (see Section 20.3.3 in the 2008 NWWG report, ICES, 2008). No new data in IUU have been available since 2008.

As in previous years, detailed descriptions on the horizontal, vertical, and seasonal distribution of the fisheries were given.

The need for and importance of having catch and biological data disaggregated by depth from all nations taking part in the fishery cannot be stressed strongly enough, and the Group urges all nations involved on supplying better data. With this need in mind, ICES sent a data call to all EU countries participating in the redfish fishery, encouraging stockholders to deliver detailed catch data before the WG would meet, but the response was very limited.

21.9.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in section 21.6. Given the high variability in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is considered high.

The survey carried out in 2021 covered most of the geographical distribution of the shallow pelagic stock. A decreasing trend in the relative biomass indices in the acoustic layer was observed 1991–2013. In 2021, there was a sharp increase in the biomass of the shallow pelagic stock, both in the acoustic and DLS layers.

It is not known to what extent CPUE reflects changes in the stock status of pelagic *S. mentella*, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not indicate or reflect actual trends in stock size, although decreasing CPUE indices are likely to reflect a decreasing stock. The new data available to the NWWG were insufficient to estimate the CPUE since 2013.

NEAFC set for 2015–2021 a 0 TAC for Shallow Pelagic *S. mentella*. However, the Russian Federation decided on a unilateral annual quota of 27 300 t in 2015 and 2016 and 24 900 in 2017–2020. This quota was taken from both Shallow and Deep pelagic stocks since the Russian Federation does not agree on the division of the *S. mentella* management units and stock structure.

21.9.3 Comparison with previous assessment and forecast

The data available for evaluating the stock status are similar as in 2013.

21.9.4 Management considerations

The Group needs more and better data and requests that NEAFC and NAFO provide ICES with all information leading to more reliable catch statistics.

The main feature of the fishery since 1998 is a clear distinction between two widely separated fishing grounds with pelagic redfish fished at different seasons and different depths. Since 2000, the southwestern fishing grounds extended also into the NAFO Convention Area. Biological data, however, suggest that the aggregations in the NAFO Convention Area do not constitute a separate stock. The NAFO Scientific Council agreed with this conclusion (NAFO, 2005). The Group concludes that currently there are not enough scientific bases available to propose an appropriate split of the total TAC among the two fisheries/areas.

21.9.5 Ecosystem considerations

The fisheries on pelagic redfish in the Irminger Sea and adjacent waters are generally regarded as having negligible impact on the habitat and other fish or invertebrate species due to very low bycatch and discard rates, characteristic of fisheries using pelagic gear.

21.9.6 Changes in the environment

The hydrography in the June/July 2013 survey show that temperature in the survey area is above average but it was lower than in 2011 in most of the surveyed area, except for the Irminger Current (ICES, 2013).

The increase of water temperature in the Irminger Sea may have an effect on spatial and vertical distribution of *S. mentella* in the feeding area (Pedchenko, 2005). The abundance and distribution of *S. mentella* in relation to oceanographic conditions were analysed in a special multistage workshop (WKREDOCE1-3). Based on 20 years of survey data, the results reveal the average relation of redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58°N, 40°W, 300 m, 34.89 and 4.4°C, respectively. The spatial distribution of S. mentella in the Irminger Sea mainly in waters <500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (>4.5°C and >34.94) in the north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES, 2012b).

Results based on international redfish survey data suggest that the interannual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES, 2012b).

21.10 References

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Table 21.2.1 Shallow Pelagic *S. mentella* (stock unit <500 m). Catches (in tonnes) by area as used by the Working Group.

Year	5.a	12	14	NAFO 1F	NAFO 2J	NAFO 2H	Total
1982	0	39 783	20 798	0	0	0	60 581
1983	0	60 079	155	0	0	0	60 234
1984	0	60 643	4189	0	0	0	64 832
1985	0	17 300	54 371	0	0	0	71 671
1986	0	24 131	80 976	0	0	0	105 107
1987	0	2 948	88 221	0	0	0	91 169
1988	0	9 772	81 647	0	0	0	91 419
1989	0	17 233	21 551	0	0	0	38 784
1990	0	7 039	24 477	385	0	0	31 901
1991	0	9 684	17 037	458	0	0	27 179
1992	106	22 969	39 488	0	0	0	62 564
1993	0	66 461	34 310	0	0	0	100 771
1994	665	77 211	18 992	0	0	0	96 869
1995	77	78 898	21 160	0	0	0	100 136
1996	16	22 544	19 210	0	0	0	41 770
1997	321	18 211	9 213	0	0	0	27 746
1998	284	22 002	1 864	0	0	0	24 150
1999	165	23 713	1 101	534	0	0	25 512
2000	3 375	17 491	1 298	11 052	0	0	33 216
2001	228	32 164	2 383	5 290	1 751	8	41 825
2002	10	24 025	336	15 702	3 143	0	43 216
2003	49	24 211	132	26 594	5 377	325	56 688
2004	10	7 669	1 158	20 336	4 778	0	33 951
2005	0	6 784	281	16 260	4 899	5	28 229
2006	0	2 094	94	12 692	593	260	15 734
2007	71	378	98	2 843	2 561	175	6 126
2008	32	25	422	1 580	0	0	2 059
2009	0	210	2 170	0	0	0	2 380
2010	15	686	423	1 074	0	0	2 198
2011	0	0	234	0	0	0	234
2012	28	0	0	3 113	32	0	3 173
2013	32	13	40	1 443	1	0	1 529
2014	153	5 068	489	713	0	0	6 423
2015	161	2 281	0	3 119	34	0	5 595
2016	235	1 671	0	61	0	0	1 967
2017	81	10	10	0	0	0	101

Year	5.a	12	14	NAFO 1F	NAFO 2J	NAFO 2H	Total
2018	0	2 203	0	2 396	0	0	4 599
2019	0	1 799	0	1 385	0	0	3 184
2020	0	2 532	0	3 620	0	0	6 152

1982–1991 All pelagic catches assumed to be of the shallow pelagic stock

1992–1996 Guesstimates based on different sources (see text)

1997–2020 Catches from calculations based on jointed catch database and total landings

Table 21.2.2 Shallow pelagic *S. mentella* catches (in tonnes) in ICES Div. 5a, subareas 12, 14 and NAFO Div. 1F, 2H and 2J by countries used by the Working Group. * Prior to 1991, the figures for Russia included Estonian, Latvian and Lithuanian catches.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Green-land	Iceland	Japan	Latvia	Lithuania	Nether-lands	Norway	Poland	Portugal	Russia*	Spain	UK	Ukraine	Total
1982														581		60 000				60 581
1983						155										60 079				60 234
1984	2 961					989								239		60 643				64 832
1985	5 825					5 438								135		60 273				71 671
1986	11 385			5		8 574								149		84 994				105 107
1987	12 270			382		7 023								25		71 469				91 169
1988	8 455			1 090		16 848										65 026				91 419
1989	4 546			226		6 797	567	3 816						112		22 720				38 784
1990	2 690					7 957		4 537					7 085			9 632				31 901
1991			2 195	115		201		8 724					6 197			9 747				27 179
1992	628		1 810	3 765	2	6 447	9	12 080		780	6 656		14 654			15 733				62 564
1993	3 216		6 365	6 812		16 677	710	10 167		6 803	7 899		14 112			25 229			2 782	100 771
1994	3 600		17 875	2 896	606	15 133		5 897		13 205	7 404		6 834		1510	16 349			5 561	96 869
1995	2 660	421	11 798	3 667	158	10 714	277	8 733	841	3 502	16 025	9	4 288		2170	28 314	4 327		2 230	100 136
1996	1 846	343	3 741	2 523		5 696	1866	5 760	219	572	5 618		1 681		476	9 348	1 671	137	273	41 770
1997		102	3 405	3 510		9 276		4 446	28				330	776	367	3 693	1 812			27 746
1998			3 892	2 990		9 679	1161	1 983	30		1 734		701	12	60	89	1 819			24 150
1999			2 055	1 190		8 271	998	3 662					2 098	6	62	6 538	447	183		25 512
2000			4 218	486		5 672	956	3 766			430		2 124		37	14 373	1 154			33 216
2001			9	4 364		4 755	1083	14 745			8 269		947		256	5 964	1 433			41 825
2002				719		5 354	657	5 229		1 841	12 052		1 094	428	878	13 958	1 005			43 216
2003				1 955		3 579	1047	4 274		1 269	21 629		3 214	917	1926	15 418	1 461			56 688

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Green-land	Iceland	Japan	Latvia	Lithuania	Nether-lands	Norway	Poland	Portugal	Russia*	Spain	UK	Ukraine	Total
2004				777		1 126	750	5 728		1 114	3 698		2 721	1018	2133	13 208	1 679			33 951
2005				210		1 152		3 086		919	1 169		624	1170	2780	15 562	1 557			28 229
2006				334		994		1 293		1 803	466		280	663	1372	4 953	3 576			15 734
2007			209	98		0		71		186	467			189	529	4 037	339			6 126
2008				319				63			8					1 597	73			2 059
2009				93				5		59	138					649	1 438			2 380
2010				653				22			551		12		377	567	16			2 198
2011				162				72												234
2012								28								3 145				3 173
2013								72								1 457				1 529
2014								355			287					5 781				6 423
2015								161								5 434				5 595
2016								235								1 732				1 967
2017								91								10				101
2018																4 599				4 599
2019																3 184				3 184
2020																6 152				6 152

Table 21.6.1 Shallow Pelagic *S. mentella*. Results for the acoustic survey indices 1991–2021 from shallower than the scattering layer, trawl estimates within the deep scattering layer and shallower than 500 m, and area coverage of the survey in the Irminger Sea and adjacent waters. No estimates are available for 2015 and only Subarea A (Figure 21.6.5) was surveyed in 2018.

Year	Area covered (1,000 NM^2)	Acoustic estimates (1,000 t)	Trawl estimates (1,000 t)
1991	105	2,235	
1992	190	2,165	
1993	121	2,556	
1994	190	2,190	
1995	168	2,481	
1996	253	1,576	
1997	158	1,225	
1999	296	614	
2001	420	716	565
2003*	405	89*	92*
2005	386	552	392
2007	349	372	283
2009	360	108	331
2011	343	123	361
2013	340	91	200
2015**	-	-	69**
2018***	103***	82****	171***
2021	242	490	352

*** The 2003 biomass estimate is considered as inconsistent as the survey was carried out about one month earlier than usual, and a marked seasonal effect was observed.**

**** The 2015 biomass estimate is considered partial as only Subareas A and B were surveyed (Figure 21.6.5).**

***** The 2018 biomass estimate is considered partial as only Subareas A was surveyed (Figure 21.6.5).**

Table 21.6.2. Results (acoustic biomass in ´000 t) for the international surveys conducted since 1994, for redfish shallower than the DSL for each subarea (see Figure 21.6.5 for area definition) and the total biomass. No total biomass estimate was available in 2015 (no data) and in 2018 only Subarea A was surveyed.

Year	Subarea						Total
	A	B	C	D	E	F	
1994	673	1,228	-	63	226		2,190
1996	639	749	-	33	155		1,576
1999	72	317	16	42	167		614
2001	88	220	30	267	103	7	716
2003*	32	46	1	2	10	0	89
2005	121	123	0	87	204	17	552
2007	80	95	0	53	142	3	372
2009	39	48	4	1	15	1	108
2011	5	74	0	3	40	1	123
2013	9	33	2	5	42	0	91
2015	-	-	-	-	-	-	-
2018	82	-	-	-	-	-	82
2021	144	150	-	-	196	-	490

*** The 2003 biomass estimate is considered as inconsistent as the survey was carried out about one month earlier than usual, and a marked seasonal effect was observed.**

Table 21.6.3. Biomass estimates (trawl biomass in ´000 t) within the DSL layer and shallower than 500 m by Subarea (see Figure 26.6.5 for area definition) from the international redfish surveys in the Irminger Sea and adjacent waters. No biomass estimates are available for 2005 and 2007.

Year	Subarea						Total
	A	B	C	D	E	F	
2001	23	40	45	399	54	5	565
2003*	25	46	3	4	14	0	92
2005	55	66	1	45	114	2	283
2007	69	117	1	27	110	8	332
2009	136	68	0	25	48	0	278
2011	69	185	1	30	76	0	309
2013	71	94	0	9	26	1	201
2015**	31	38	-	-	-	-	69
2018***	171	-	-	-	-	-	171
2021	221	40	-	-	91	-	352

*** The 2003 biomass estimate is considered as inconsistent as the survey was carried out about one month earlier than usual, and a marked seasonal effect was observed.**

**** The 2015 biomass estimate is considered partial as only Subareas A and B were surveyed (Figure 21.6.5).**

***** The 2018 biomass estimate is considered partial as only Subareas A was surveyed (Figure 21.6.5).**

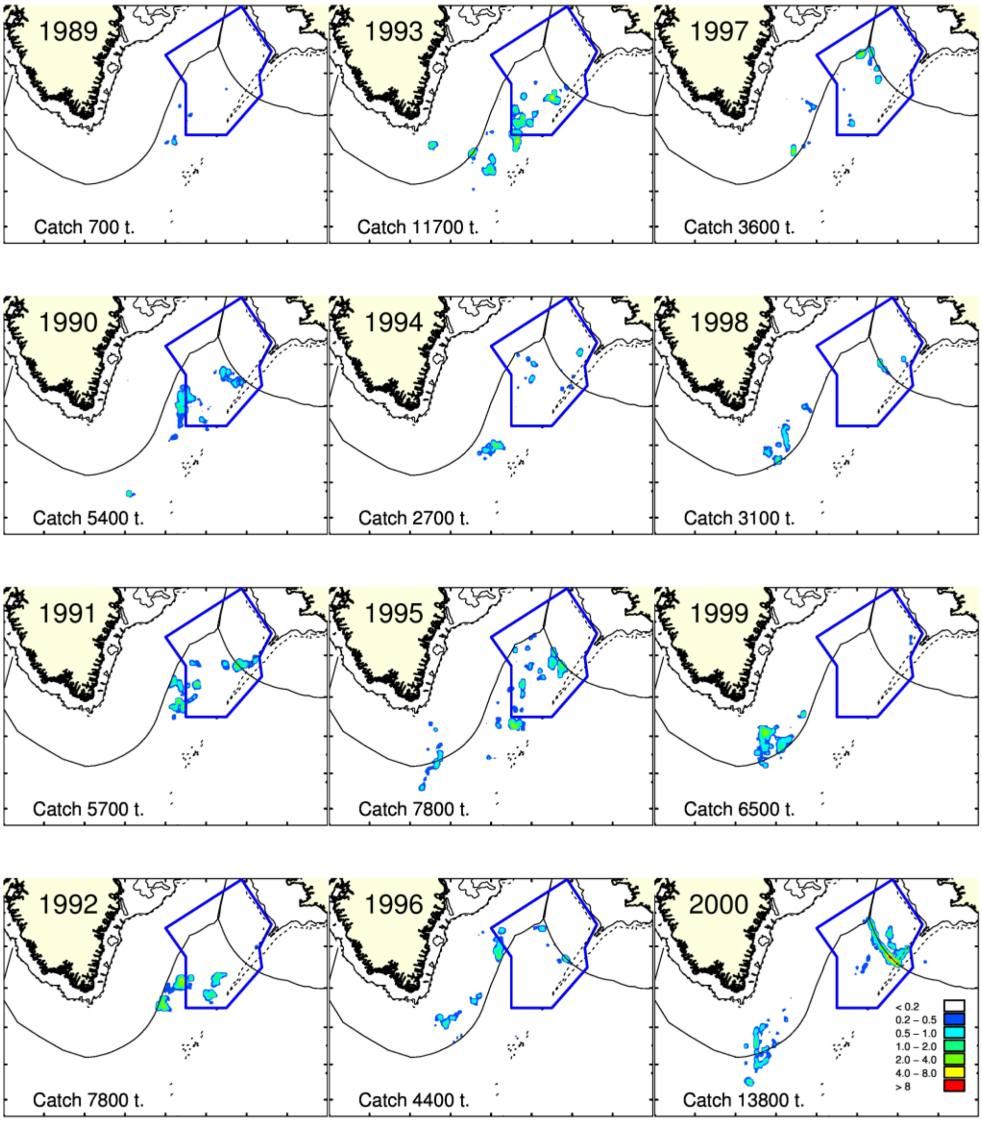


Figure 21.2.1 Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989–2012. Data are from the Faroe Islands (1995–2012), Iceland (1989–2012) and Norway (1992–2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

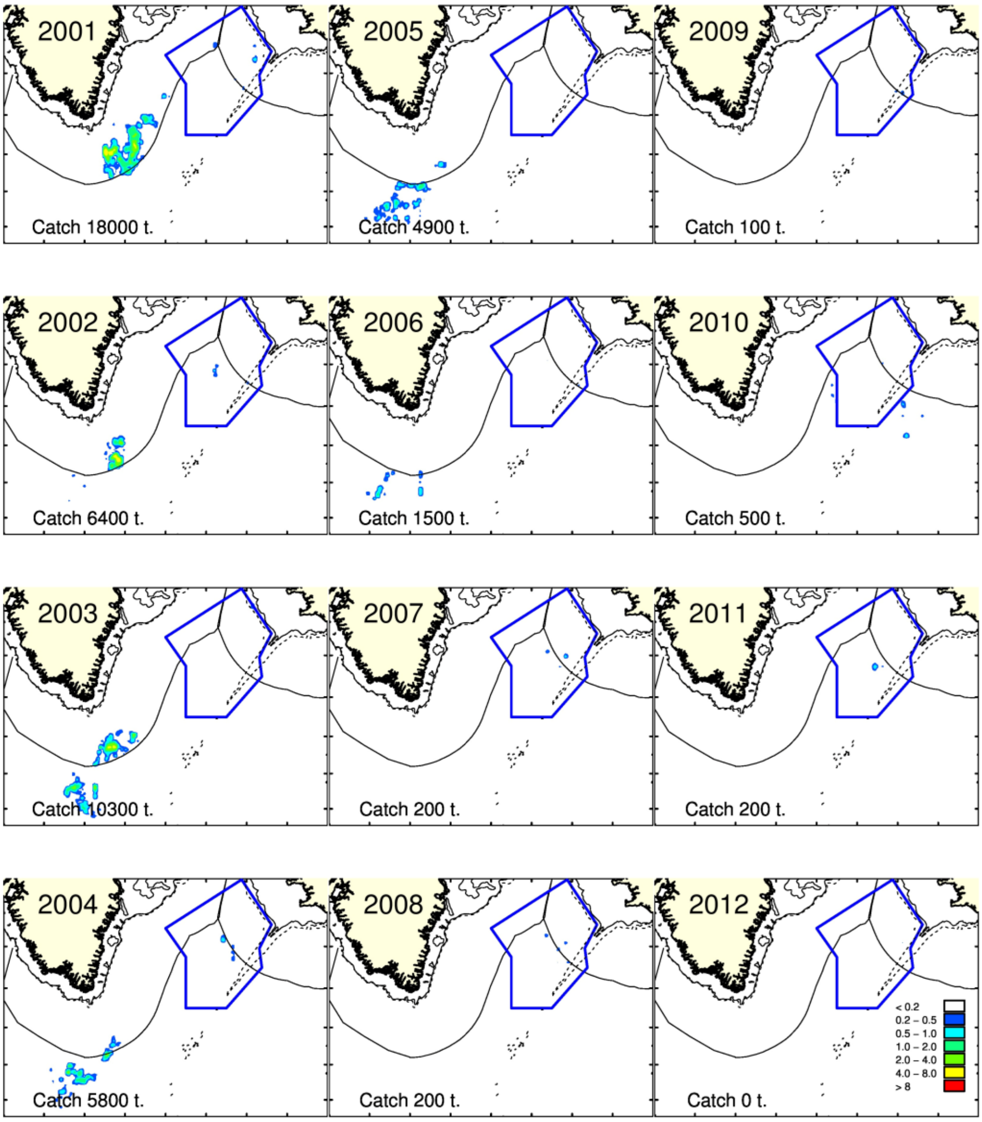


Figure 21.2.1 (Cont.) Fishing areas and total catch of pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1989–2012. Data are from the Faroe Islands (1995–2012), Iceland (1989–2012) and Norway (1992–2003). The catches in the legend are given as tonnes per square nautical mile. The blue box represents the management unit for the northern fishing area.

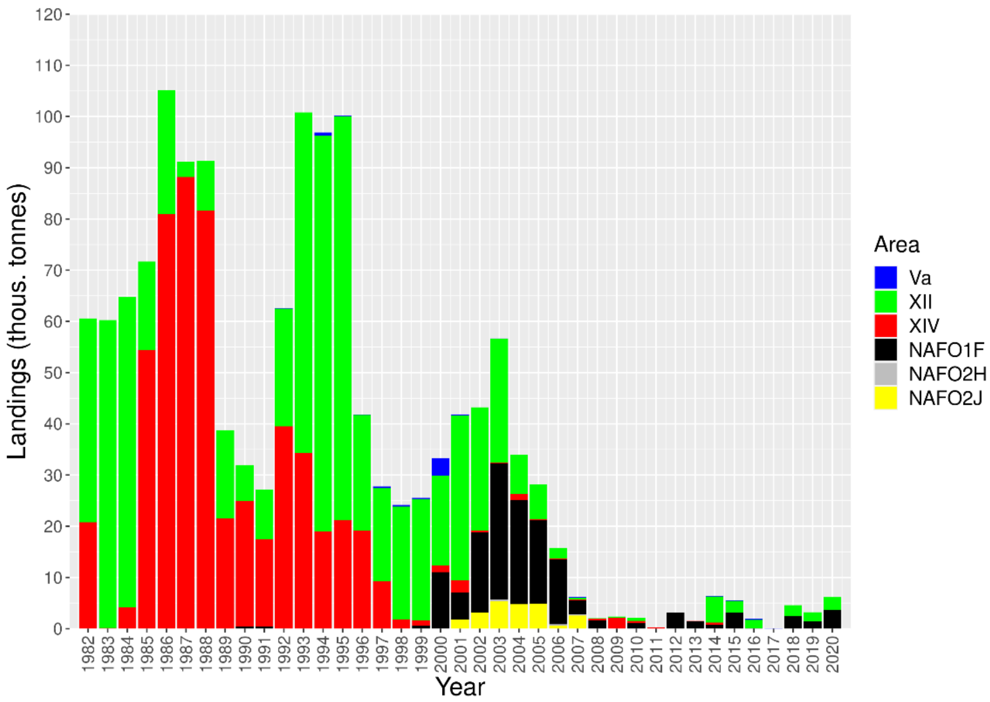


Figure 21.2.2 Landings of shallow pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

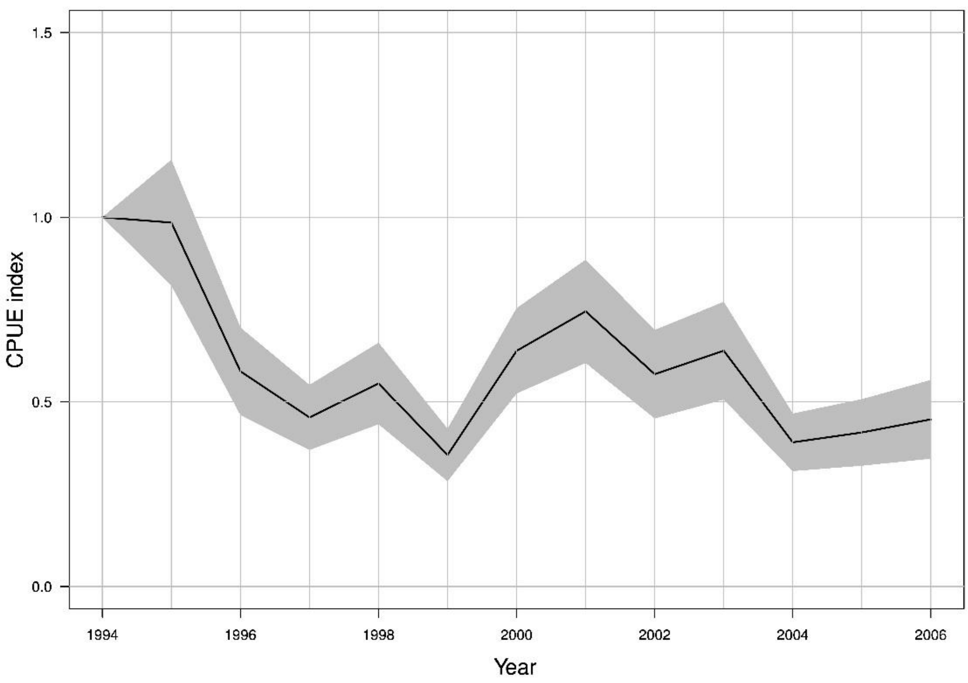


Figure 21.2.3 Trends in standardized CPUE of the shallow pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroes, Iceland, Norway, and Greenland.

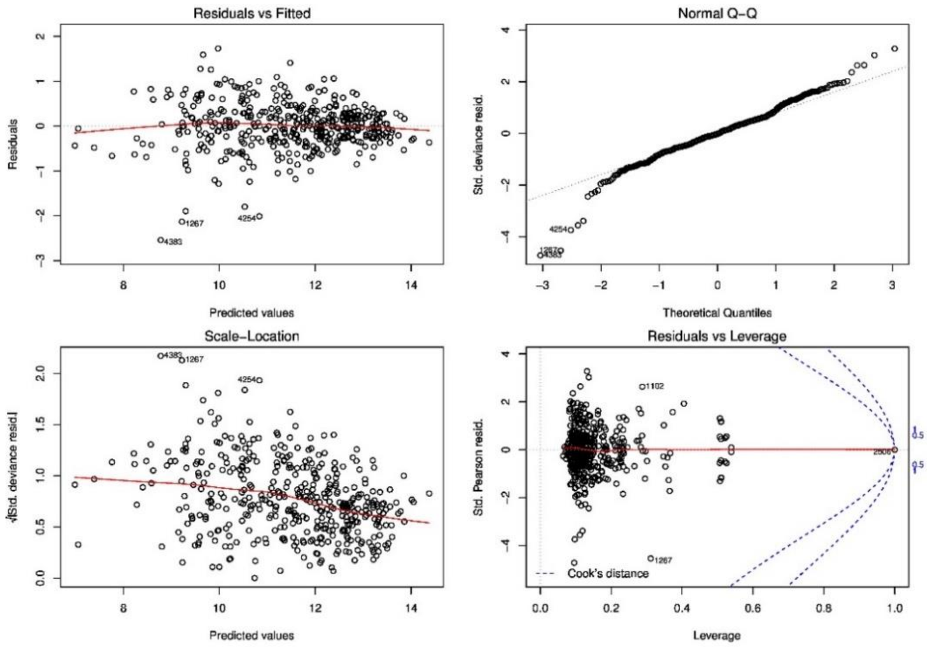


Figure 21.2.4 Residuals from the GLM model used to standardize CPUE, based on log-book data from Faroe Islands, Iceland, Greenland and Norway.

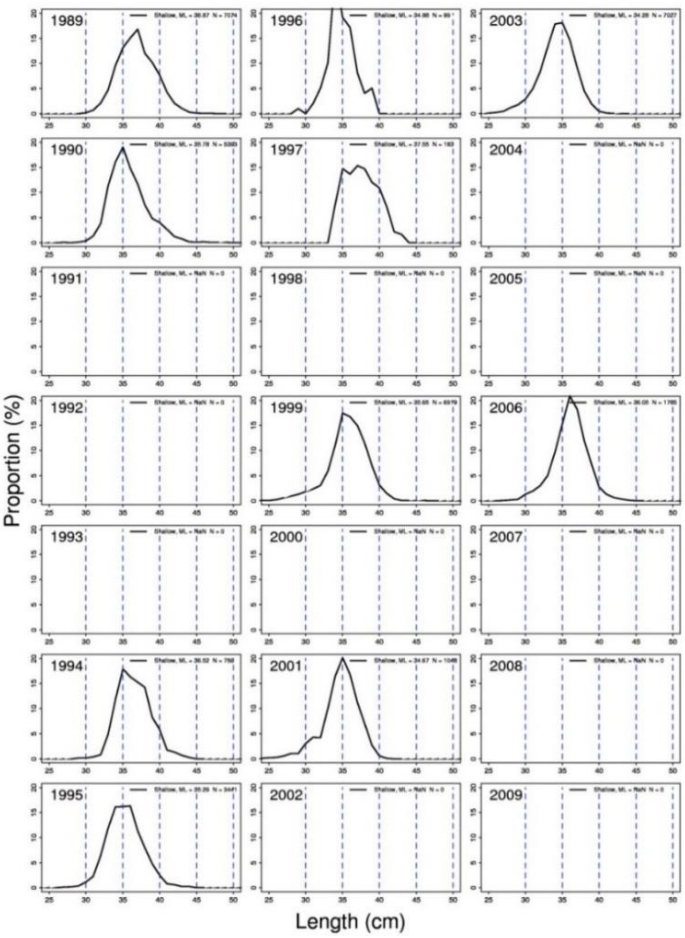


Figure 21.3.1 Length distribution from Icelandic landings of shallow pelagic *S. mentella.*

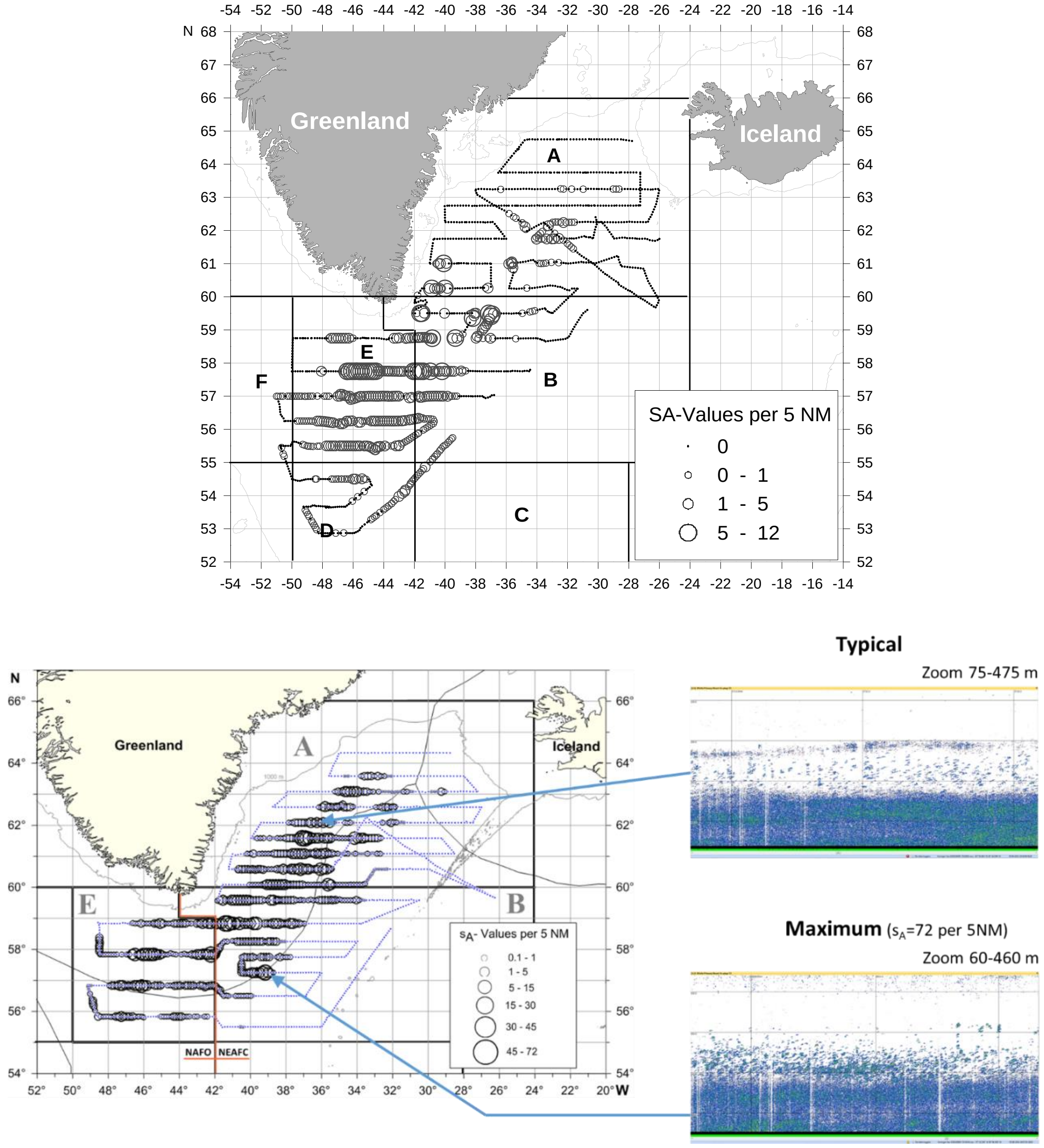
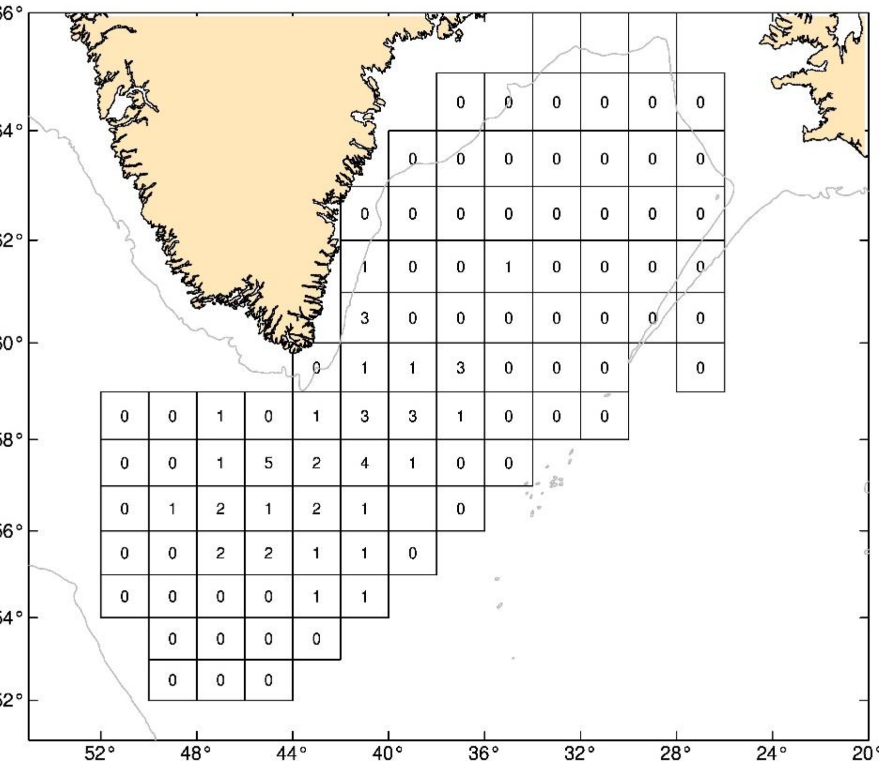


Figure 21.6.1 Pelagic *S. mentella*. Acoustic estimates (average s_A values by 5 NM sailed) shallower than the deep-scattering layer (DSL) from the joint trawl-acoustic survey in June/July 2013 (upper) and 2021 (lower).



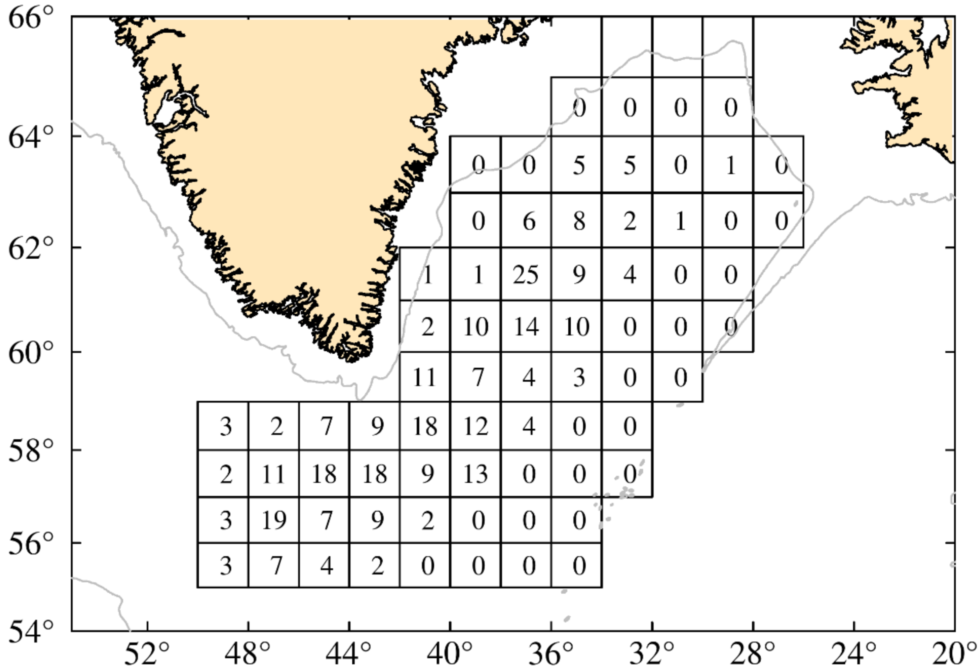


Figure 21.6.2. Redfish acoustic estimates shallower than the DSL (ca. 0–350 m) during the joint international redfish survey in 2013 (upper) and 2021 (lower). The figure shows average s_A values within statistical rectangles.

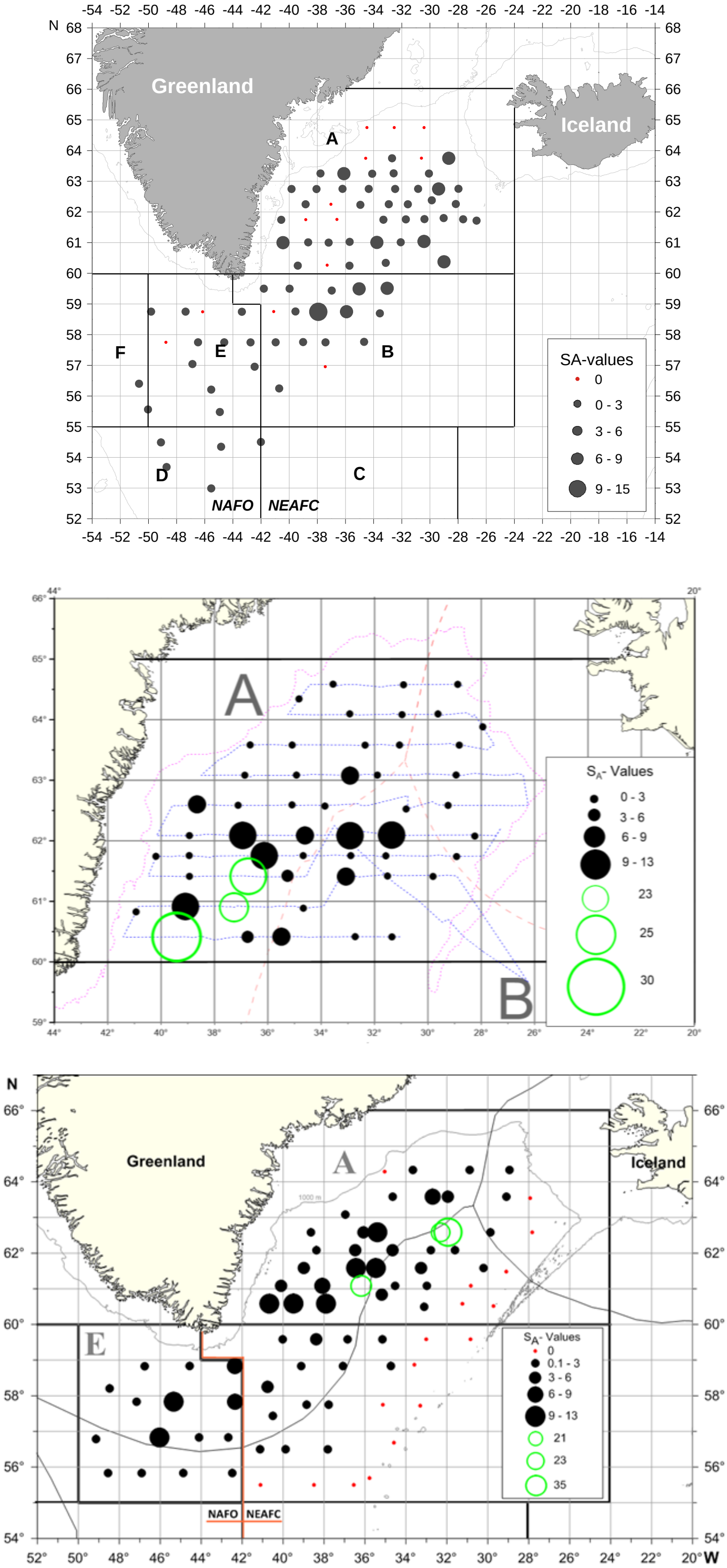


Figure 21.6.3 Redfish trawl estimates within the DSL shallower than 500 m during the joint international redfish survey in 2013 (upper), 2018 (middle), and 2021 (lower). s_A values calculated by the trawl method (Section 21.6.2).

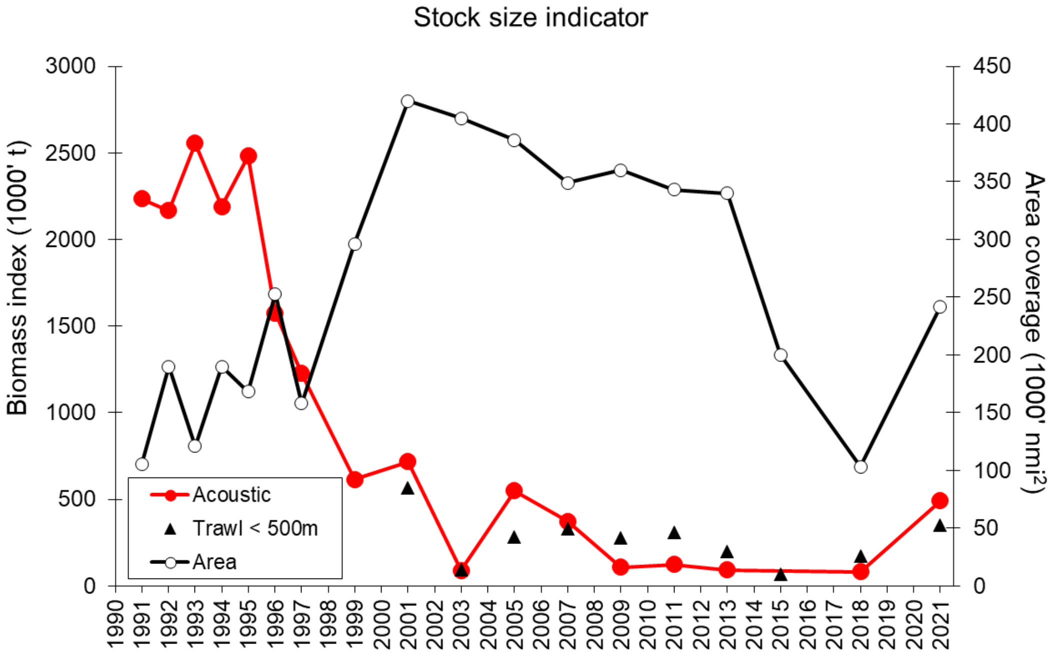


Figure 21.6.4. Overview of acoustic survey indices (thousand tonnes) from above the scattering layer (red filled circle), trawl estimates within the scattering layer and shallower than 500 m (black triangle), and aerial coverage (nmi²) of the survey (black open circle) in the Irminger Sea and adjacent waters.

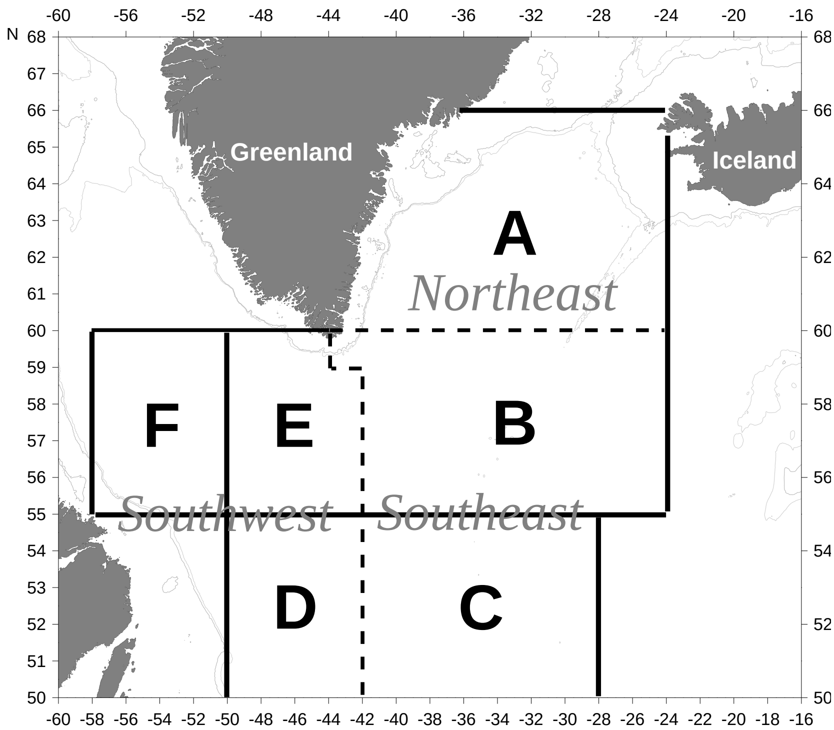


Figure 21.6.5 Subareas A–F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines).

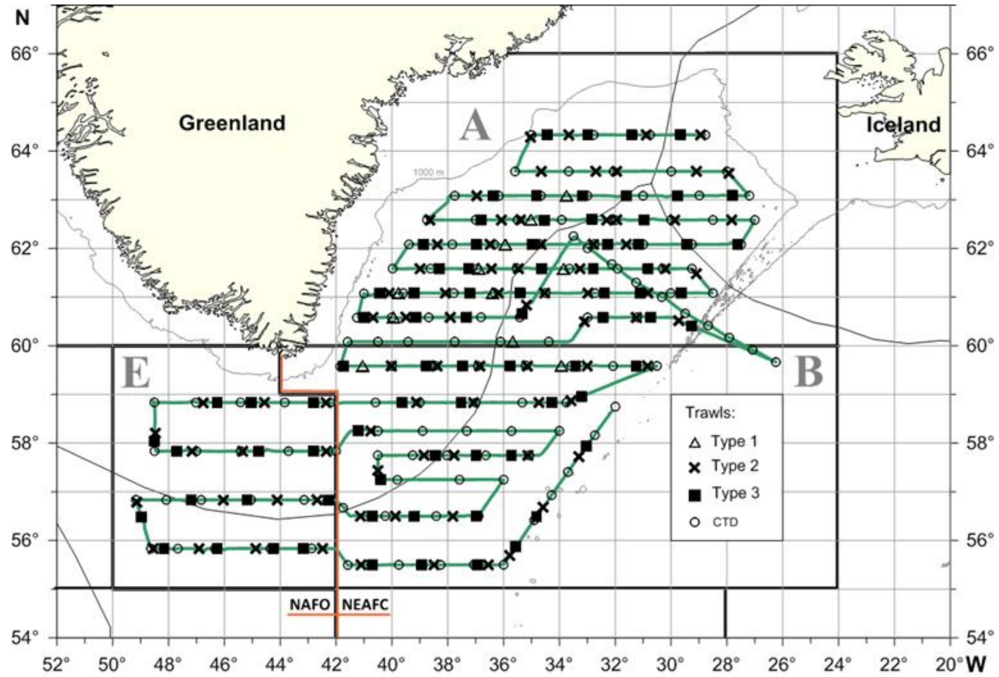


Figure 21.6.6. Cruise tracks and stations taken in the joint international redfish survey in June–August 2021.

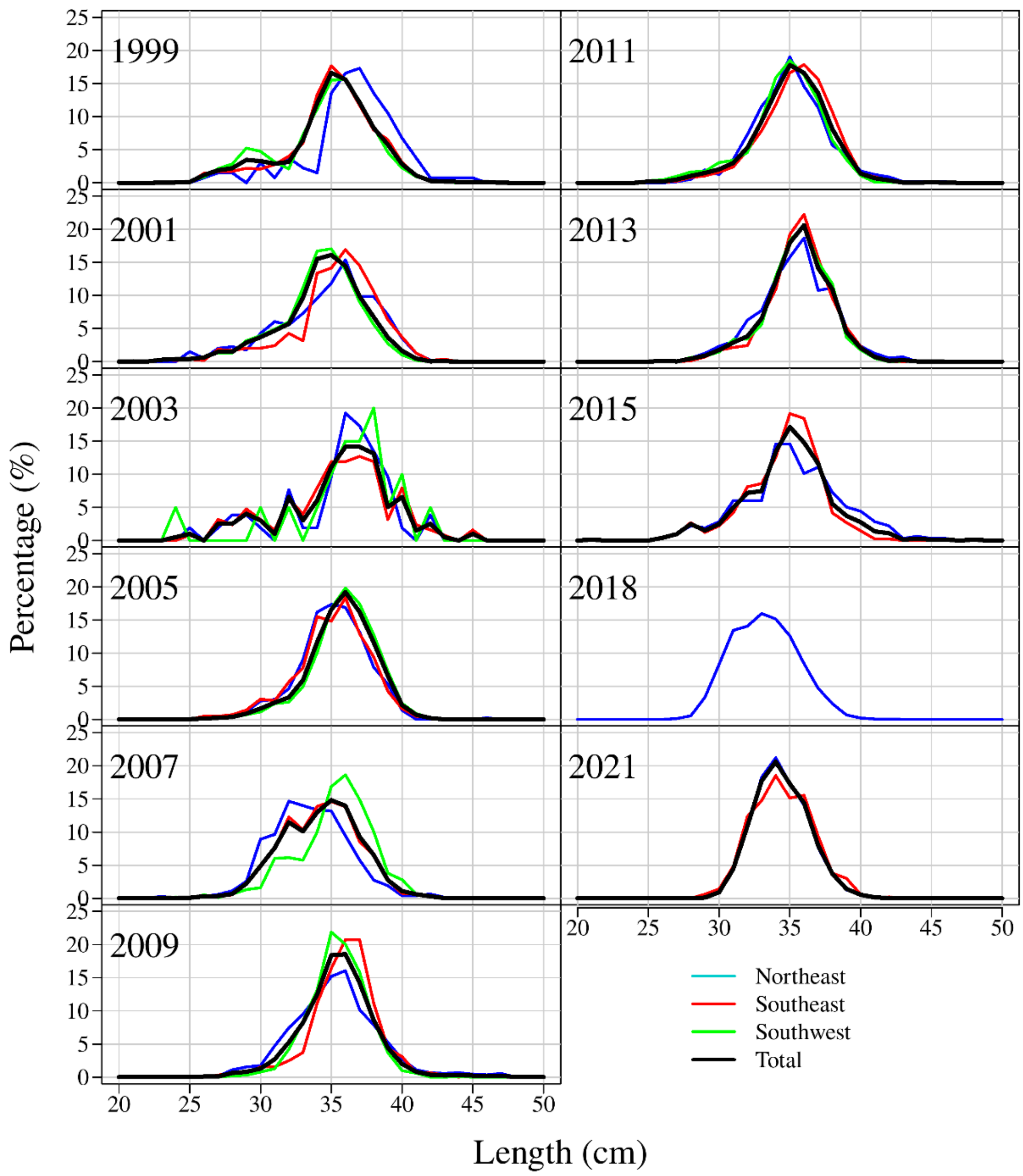


Figure 21.6.7. Length distribution of redfish in the trawls, by geographical areas and the total, from fish caught shallower than 500 m 1999–2021.

22 Deep Pelagic *Sebastes mentella*

22.1 Stock description and management unit

This section addresses the fishery and assessment for the biological stock deep pelagic *S. mentella* in the Irminger Sea and adjacent areas: NAFO 1-2, ICES 5, 12, and 14 at depths >500 m, including demersal habitats west of the Faeroe Islands. This stock corresponds to the management unit in the northeast Irminger Sea (ICES areas 5.a, 12 and 14).

The following text table summarizes the available information from fishing fleets in the Irminger Sea and adjacent waters in 2020. No information was available from Russia about number of factory trawlers participating in the fishery. It should be noted that some of these fleets are also fishing the Shallow Pelagic stock.

Country	Number of trawlers
Germany	1 factory trawler
Lithuania	1 factory trawler
Norway	1 factory trawler
Russia	? factory trawlers
Spain	1 factory trawler
Total	**? factory trawlers**

22.2 The fishery

The historic development of the fishery can be found in the Stock Annex. Tables 22.2.1 and 22.2.2 show annual catches, as estimated by the Working Group, disaggregated by ICES and NAFO regulatory areas and by country, respectively.

The changes in the spatial pattern of the fishery for the period 1992–2018 are shown in Figure 22.2.1, and annual catches are presented in Figure 22.2.2. Catches decreased by 4988 t in 2018 to 24 903 t (Table 22.2.2).

Standardized CPUE series for Faroe Islands, Iceland, Greenland, and Norway 1994–2018 are estimated with a GLM model including the factors year, ship, month, and towing time. The results from the model show that the CPUE oscillates without trend since 1995 (Figure 22.2.3).

22.3 Biological information

Age reading of deep pelagic beaked redfish in the Irminger Sea and adjacent waters has not been systematic. Age data are available from Iceland and Norway for some years during 1996–2013 period. Most of the age data come from the commercial catch except in 1999 where 797 age readings come from the international redfish survey (note: as the age readings from the survey correspond to a similar depth range and location as other samples, they have been included together with the commercial fishery samples). In total, 6566 otoliths have been age read. The number of age readings by year and nation is given in Table 22.3.1. Age distributions for the Icelandic data are shown in Figure 22.3.1 and for the Norwegian data in Figure 22.3.2.

Length data are available from the international redfish survey (see Section 22.6) and from the Icelandic commercial fishery. Biological information is collected from commercial catches from other nations (Russia, Norway, Spain, and other EU countries). However, the data were not available to the group.

The length data from the Icelandic commercial fishery is considered to provide a reasonable representation for all nations participating in the fishery, as the fishery is conducted in a concentrated area along the Icelandic EEZ (Figure 22.2.1) in a relatively short period (mainly May and June).

The length samples from the Icelandic commercial catch are either collected by observers on board or by the fishers who send samples for further analysis to the MFRI (Marine and Freshwater Research Institute, Iceland). The number of fish measured for length and the number of hauls sampled are given in Table 22.3.2. In each sample 100–200 fish are length measured. Length distributions are shown in Figure 22.3.3 and indicate that the bulk of the catches is at around 35–45 cm of length. Data was not available for 2020 as Iceland did not participate in the fishery.

22.4 Discards

Discards are not considered to be significant for the time being, according to available data from various institutes.

22.5 Illegal, Unregulated and Unreported Fishing (IUU)

The Group had again difficulties in obtaining catch estimates from several fleets. Furthermore, there are problems caused by misreported catches. The Group requests NEAFC and NAFO to provide ICES in time with all the necessary information.

22.6 Redfish surveys

The international trawl-acoustic redfish survey for the deep pelagic beaked redfish in the Irminger Sea and adjacent waters has been conducted since 1999. In 1999–2015 it was conducted biennially but since then triennially.

In 2021, only one vessel from Russia participated in the survey as Germany cancelled their participation (ICES, 2021). A bilateral agreement with financial compensation between Russia and Germany was reached, providing that Russia should take over the German part of the survey. Since the Russian and the German survey parts had to be carried out one after the other, the survey was extended from mid-June to mid-August 2021. The survey is usually conducted from mid-June to mid-July. Subareas A, B and E were surveyed (Figure 22.6.1) covering the geographical distribution of deep pelagic *S. mentella*.

22.6.1 Survey trawl estimates

Considering the conclusion of WKREDS (ICES, 2009a) and the recommendation of ICES on stock structure of redfish in the Irminger Sea and adjacent waters, the Group decided in the planning meeting (ICES, 2009b) to sample redfish separately above and below 500 m, i.e., to sample redfish as was done in the 1999, 2001 and 2003 surveys. The deep identification hauls covered the depth layers (headline) 550 m, 700 m, and 850 m. The description of the survey index calculation is found in the stock annex for the stock.

The most recent trawl-acoustic survey on pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters was carried out by Russia in June/August 2021. Approximately 242 000 NM^2 was surveyed (Subareas A, B, and E) compared to 103 000 NM^2 in 2018 (where only Subarea A was surveyed), 200 000 NM^2 in 2015 (Subareas A and B), and 340 000 NM^2 in 2013. A total biomass of 154 000 t was estimated in these three areas. This is the lowest biomass estimate since the survey started in 1999 and is only 15% compared to the highest value observed in 2001 (Table 22.6.2). The results also show that biomass of the redfish distributed below 500 m in Subarea A decreased by approximately 15% in 2018 compared to 2015 and is the lowest since the commence of the survey in 1999 (see Figure 22.6.1 for area definition) (Table 21.6.2). The mean length was 35.4 cm, which was 0.7 cm smaller than in 2018, and compared to 38.6 cm mean length in 2015. Figure 22.6.2 shows the spatial distribution of samples used in the survey and Figure 22.6.3 shows the corresponding length distribution.

22.7 Methods

The stock was benchmarked in August 2016 (The Workshop on Assessment and Catch Advice for Deep Pelagic Redfish in the Irminger Sea – WKDEEPRED, ICES 2016). At the WKDEEPRED meeting a Gadget model for deep pelagic beaked redfish in the Irminger Sea was proposed as an assessment model. A description of the model setup, data, results, diagnostics and recommendations for data and model needs are found in the WKDEEPRED report (ICES, 2016). A detailed description of Gadget and references to published papers can be found in the Stock Annex for deep pelagic redfish (reb.2127.dp).

An age-length structured stock assessment model was developed with Gadget; this model also used age and length composition data. The inclusion of these data in the assessment lent stability to the assessment results and no strong retrospective pattern emerged. Fits to the data were considered overall adequate and WKDEEPRED concluded that this model provides an appropriate way of assessing the stock at this time. Although the Gadget assessment appears to capture trends on stock biomass and fishing mortality reliably, some aspects of the assessment still require further exploration, the data currently available cover only a short period relative to the lifespan of the species, and additional age data that might bring in additional insights are expected to become available over the next few years. WKDEEPRED therefore concluded that at present, this assessment should be considered as a Category 2 (instead of Category 1) assessment.

In the survey conducted in June/July 2018, only part of the survey area was covered, and the biomass estimate is not considered adequate. In the assessment, the 2018 estimate was scaled to the area of the 2015 survey by the proportion of biomass found outside of the 2018 survey area. In the 2015 survey, 78.1% of the total biomass observed in Subarea A and 21.9% in Subarea B. By scaling the observed biomass estimate in Subarea A in 2018, the total biomass estimate used in the current assessment was 166 kt.

22.7.1 Diagnostics

Figure 22.7.1 shows the model fit to the biomass index. The model appears to capture sufficiently the downward trend in the survey biomass index. The fitted values fall outside the estimated range of two data points, the 2011 and 2015 survey estimates, although the model-fitted trajectory falls between these points. These discrepancies are considered to be within reasonable limits, as the model also takes into account the information provided by the length and age-length data.

The length distributions from the international redfish survey, shown in Figure 22.7.2, are well captured by the model. Similarly, the model fit to the commercial length distributions are satisfactory, although discrepancies can be seen in the early years of the fishery; this is illustrated in Figure 22.7.3, which shows that fitted mean length in the fishery is substantially higher than observed in the fishery in the first years of commercial activities. This effect is more pronounced in the first two years, and hardly present in the samples from 1998 and onwards. During those first years the commercial effort was more dispersed spatially, possibly reflecting a learning period for the fishery, before it became more concentrated.

Figure 22.7.4 compares the fitted age structure in the catch to the observed proportions at age (from the age-length composition dataset) in the commercial catches. The fit to the age data is considered acceptable, particularly in the later years of the model time. Note that the number of samples varies considerably between years and quarters, e.g., in 2003 only 74 otoliths have been analysed whereas in 2012, 1300 otoliths have been read (see Table 22.3.1). The model appears to follow the strong 1985- and 1990-year classes, present in the observed catches since the early/mid 2000s, adequately.

In this model, age composition data are important indicators of past recruitment. For ages 1 to 10 data are sparse. The youngest fish recorded in the catches (in 2004) was 5 years old; However the information on recruitment is only considered reliably available approximately 10 years after spawning.

The age–length frequencies also provide information on fish growth. Figure 22.7.5 shows a comparison between the model-fitted mean–length-at-age and the length-at-age observations from the commercial catches. The model appears to follow the general tendency of the data and to capture the spread in lengths-at-age. In most cases, however, the mean length of fish older than 30 years as well as the mean length of the youngest age classes are overestimated. This overestimation of mean length is considered to be a model artefact, as the model effectively forces all fish towards L_∞ as the fish grow older

Table 22.7.1 and Figure 22.7.6 illustrate the estimated trajectories from the Gadget model. The biomass estimates refer to biomass at the start of the year, catches are the total annual landings, recruitment is the number of 5-year-old fish that enter the model during the 1st quarter of the year, and the annual fishing mortality is the average of the quarterly apical fishing mortalities. The model estimates that the total biomass peaked in the early 1990s but has been on a steady decline since then and is now below B_{lim} of 559 kt (Figure 22.7.6). Although catches have decreased, the fishing mortality has increased substantially since the late 1990s, with the fishing mortality ranging between five to ten times the natural mortality. Fishing mortality has exceeded F_{lim} (0.057) since 1994. Recruitment of 5-year-old fish into the stock has been relatively stable between 1985 and 2006. Estimates of recruitment after 2006 (i.e., after year class 2001) are considered unreliable as the fish do not consistently enter the fishery and the survey until they are 15 years old. Therefore, recruitment from 2009 onwards was fixed in the projections to the geometric mean recruitment (at age 5) of the years 1985–2008. The estimates of recruitment could potentially be improved with more recent data on age composition of the catches.

22.8 Reference points

WKDEEPRED (ICES, 2016) also derived precautionary and MSY reference points (B_{lim}, B_{pa}, F_{lim}, F_{pa}, F_{MSY} and MSY $B_{trigger}$) following the ICES technical guidelines for the calculation of reference points.

Below is a summary of reference points agreed by WKDEEPRED (ICES, 2016). Note: the reference point values in the ICES advice sheet will be presented as relative values with respect to the average of the F and SSB estimates over the stock assessment series, as corresponds to Category 2 assessments.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	782 kt	B_{pa}
	F_{MSY}	0.041	F that maximizes median long-term catch in stochastic simulations with recruitment drawn from 1985–2006 estimates while incorporating a factor to gradually reduce recruitment when SSB < SSB(2001) (where SSB(2001) is the B_{loss} from the converged stock–recruitment period). F_{MSY} is constrained not to exceed F_{pa}.
Precautionary approach	B_{lim}	559 kt	B_{pa} / 1.4
	B_{pa}	782 kt	SSB(2001), corresponding to B_{loss} from the years with converged SSB and recruitment estimates (year classes 1990–2001)
	F_{lim}	0.057	F corresponding to 50% long-term probability of SSB > B_{lim}.
	F_{pa}	0.041	F_{lim} / 1.4

22.9 State of the stock

22.9.1 Short term forecast

During WKDEEPRED (ICES, 2016) the workshop agreed settings to conduct short-term projection based for 2019 and 2020 as follows. The model used was the same age-length structured population dynamics model used in the stock assessment (implemented in Gadget). The results are as follows:

<u>Assumptions needed for projections:</u>

Recruitment (age 5) in 2019–2021 was assumed to be equal to the geometric mean of the estimated recruitment during 1985–2008, i.e., 67 million fish.

Catch in 2021 was assumed to be 17 kt, based on the catch fished by the Russin Federation in 2020, as Russia was the only nation that participated in the fishery. This assumption about catch results in F(2020) = 0.520 and SSB(2021) = 130 kt (which is below B_{lim}).

Projections at different values of F in 2022–2024 are given in Table 22.9.1.

22.9.2 Uncertainties in assessment and forecast

22.9.2.1 Data considerations

Preliminary official landings data were provided by the ICES Secretariat, NEAFC and NAFO, and various national data were reported to the Group. The Group, however, repeatedly faces problems to obtain reliable catch data due to unreported catches of pelagic redfish and lack of catch data disaggregated by depth from some countries.

As in previous years, detailed descriptions on the horizontal, vertical, and seasonal distribution of the fisheries are given.

The need for and importance of having catch and biological data disaggregated by depth from all nations taking part in the fishery cannot be stressed strongly enough, and the Group urges all nations involved on supplying better data. With this need in mind, ICES sent a data call to all EU countries participating in the redfish fishery, encouraging stockholders to deliver detailed catch data before the WG would meet, but the response was very limited.

Additional age composition data could be available from currently un-aged otoliths sampled from Icelandic commercial catches and should be explored for possible incorporation in future assessments.

22.9.2.2 Assessment quality

The results of the international trawl-acoustic survey are given in Section 22.6. Given the high variability in the correlation between trawl and acoustic estimates as well as the assumptions that need to be made about constant catchability across depth and areas, the uncertainty of these estimates is very high. Furthermore, there are high uncertainties regarding the biomass estimates due to low area coverage, especially in 2018.

The reviewers of WKDEEPRED (ICES, 2016) recommend that in the future the survey procedures and gear standardization should be considered, and data should be examined to determine if the mean catch rate is better estimated across countries or by country.

An age–length-based assessment model was applied in 2016 to give relative estimates of abundance and exploitation rates for this stock. This model utilizes age and length information from the fishery in addition to the biomass index and lengths from the trawl–acoustic survey. Even though the time-series available from the fishery and the survey are short relative to the lifetime of the species, the assessment captures trends in stock biomass and fishing mortality reliably and this framework is considered a major improvement to the quality of the assessment. As some aspects of the assessment and short-term forecast still require further exploration and the data presently available cover only a short period relative to the lifespan of the species, ICES presently consider this assessment to be in Category 2.

Recruitment (age 5) estimates from the assessment take about 8–10 years to stabilize. For this reason, the original recruitment estimates obtained from the assessment model for the years 2009 and onwards have been replaced with the geometric mean of the estimates from 1985–2008. This has resulted in a 13% increase in the SSB and 43% increase in harvestable biomass estimates in 2018 in comparison with the estimates obtained from the assessment model without replacing recruitment. The assumed year classes, corresponding to fish at ages less than or equal to 15 in 2019, constitute approximately 67% of the SSB and 45% of the harvestable biomass in 2019. While this indicates uncertainty in the catch and SSB values presented in the catch options table (Table 22.9.1). The conclusion that the SSB will remain below B_{lim} even without any catches in 2022–2024 is still valid.

It is not known to what extent CPUE reflect changes in the stock status of pelagic *S. mentella*, since the fishery focuses on aggregations. Therefore, stable or increasing CPUE series might not indicate or reflect actual trends in stock size, although decreasing CPUE indexes are likely to reflect a decreasing stock.

22.9.3 Comparison with previous assessment and forecast

An analytical retrospective analysis for the base model going back between 1 and 10 years was conducted. Figure 22.7.7 shows how the estimates of the spawning stock biomass, recruitment, fishing mortality and the fit to the survey biomass series changes for each year which is omitted from the model. Notably, the recruitment estimates decrease substantially as the data available is decreased in a somewhat clustered fashion. Model runs omitting the 2013 age data show substantially fewer recruits, and similarly the three runs omitting the 2009 age data have even fewer recruits.

Fishing mortality and spawning stock biomass appear to be adjusted with each new year of data as the biomass estimate needs to be adjusted with each new data point in the survey biomass series.

The results presented here show some downwards revision of the assessment in 2016 in addition to an even more pessimistic view of recent recruitment. This revision is a response to an even lower survey biomass estimate in 2021 than the value that the 2019 assessment would have predicted. There is, as noted above, uncertainty in the survey biomass estimate in 2018 due to survey coverage.

As mentioned in Section 22.7 the stock was benchmarked in 2016 (ICES, 2016) and the age-length based stock assessment model was applied for the first time to give relative estimates of abundance and exploitation rates for this stock. Previously, the assessment of pelagic redfish in the Irminger Sea and adjacent waters is based on survey indices, catches, CPUE and biological data.

22.9.4 Management considerations

The Group needs more and better data and requests that NEAFC and NAFO provide ICES with all information leading to more reliable catch statistics.

The main feature of the fishery since 1998 is a clear distinction between two widely separated fishing grounds with pelagic redfish fished at different seasons and different depths. Since 2000, the southwestern fishing grounds extended also into the NAFO Convention Area. Biological data, however, suggest that the aggregations in the NAFO Convention Area do not constitute a separate stock. The NAFO Scientific Council agreed with this conclusion (NAFO, 2005). The Group concludes that at that time there is not enough scientific basis available to propose an appropriate split of the total TAC among the two fisheries/areas.

The 5500 t TAC recommended by NEAFC for 2020 was overshot by 13 788 t. This excess is due to the unilateral decision of the Russian Federation to self-allocate an annual TAC, which was 24 900 t for 2020. It was taken from both Shallow and Deep pelagic (total catch for both stocks 23 161 t) stocks since the Russian Federation does not agree on the division of the *S. mentella* management units.

22.9.5 Ecosystem considerations

The fisheries on pelagic redfish in the Irminger Sea and adjacent waters are generally regarded as having negligible impact on the habitat and other fish or invertebrate species due to very low bycatch and discard rates, characteristic of fisheries using pelagic gear.

22.9.6 Changes in the environment

The hydrography in the survey in 2021 shows that temperature in the survey area increased compared to what was observed in recent surveys throughout studied water column (down to 1000 m) to the level of warm years.

The increase of water temperature in the Irminger Sea may influence spatial and vertical distribution of *S. mentella* in the feeding area (Pedchenko, 2005). The abundance and distribution of *S. mentella* in relation to oceanographic conditions were analysed in a special multistage workshop (WKREDOCE1-3, see ICES, 2012b). Based on 20 years of survey data, the results reveal the average relation of redfish to their physical habitat in shallow and intermediate waters: The most preferred latitude, longitude, depth, salinity and temperature for *S. mentella* are approximately 58°N, 40°W, 300 m, 34.89 and 4.4°C, respectively. The spatial distribution of *S. mentella* in the Irminger Sea mainly in waters <500 m (and thus mainly relating to the "shallow" stock) appears strongly influenced by the Irminger Current Water (ICW) temperature changes, linked to the Subpolar Gyre (SPG) circulation and the North Atlantic Oscillation (NAO). The fish avoid waters mainly associated with the ICW (> 4.5°C and salinity > 34.94) in the north-eastern Irminger Sea, which may cause displacing towards the southwest, where fresher and colder water occurs (ICES, 2012b).

Results based on international redfish survey data suggest that the inter-annual distribution of fish above 500 m will shift in a southwest/northeast direction depending on integrated oceanographic conditions (ICES, 2012b). Whether the results of the study mentioned are applicable to the conditions for the deep pelagic stock needs further investigation.

22.10 References

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Table 22.2.1 Deep Pelagic *S. mentella* (stock unit >500 m). Catches (in tonnes) by area as used by the Working Group.

Year	5.a	12	14	NAFO 1F	Total
1991	0	7	52	0	59
1992	1862	280	1257	0	3398
1993	2603	6068	6393	0	15064
1994	14807	16977	20036	0	51820
1995	1466	53141	21100	0	75707
1996	4728	20060	113765	0	138552
1997	14980	1615	78485	0	95079
1998	40328	444	52046	0	92818
1999	36359	373	47421	0	84153
2000	41302	0	51811	0	93113
2001	27920	0	59073	0	86993
2002	37269	2	65858	0	103128
2003	46627	21	57648	0	104296
2004	14446	0	77508	0	91954
2005	11726	0	33759	0	45485
2006	16452	51	50531	254	67 288
2007	17769	0	40748	0	58516
2008	4602	0	25443	0	30045
2009	16828	4658	32920	0	54406
2010	8552	0	50736	0	59288
2011	0	7	47326	0	47333
2012	5530	608	26668	0	32806
2013	5274	0	40778	0	46052
2014	603	0	23152	0	23755
2015	1821	0	25612	0	27433
2016	2601	0	26053	0	28654
2017	1639	0	28252	0	29891
2018	711	0	23742	0	24453
2019	236	0	24167	0	24403
2020	0	0	19288	0	19288

Table 22.2.2. Deep pelagic *S. mentella* catches (in tonnes) in ICES Div.5.a, subareas 12, 14 and NAFO Div. 1F, 2H and 2J by countries used by the Working Group.

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
1991								59												59
1992								3398												3398
1993				310		1135		12741					878							15064
1994						2019		47435					523		377	1465				51820
1995	1140	181	5056	1572	68	8271	1579	25898	396	1501	6868	4	3169		2955	15868	227		956	75707
1996	1654	307	3351	3748		15549	1671	57143	196	512	5031		5161		1903	36400	5558	123	245	138552
1997		9	315	435		11200		36830	3				2849		3307	33237	6895			95079
1998			76	4484		8368	302	46537	1		34		438		4073	25748	2758			92818
1999			53	3466		8218	3271	40261					3337		4240	11419	9885	5		84153
2000			7733	2367		6827	3327	41466			0		3108		3694	14851	9740			93113
2001			878	3377		5914	2360	27727			7515		4275		2488	23810	8649			86993
2002			15	3664		7858	3442	39263			9771		4197		2208	25309	7402			103128
2003				3938		7028	3403	44620			0		5185		2109	28638	9374			104296
2004				4670		2251	2419	31098			0		6277	1889	2286	31067	9996			91954
2005				1800		1836	1431	12919			1027		3950	1240	1088	16323	3871			45485
2006				3498		1830	744	20942			1294		5968	1356	1313	23670	6673			67288
2007				2902		1110	1961	18097		575	1394		4628	636	2067	21337	3810			58516
2008				2632			1170	6723			749		571	219	1733	15106	1142			30045
2009				3206			1519	15125		1355	2613			178	1596	25309	2907			54006
2010				3195			1932	14772		1963	2228		2388	3	2203	22803	7801			59288
2011				2028		1787		11994		845	1348		1066		1540	22364	4361			47333
2012				1438		1523		5912		724	558		3362		250	18377	632			32806

Year	Bulgaria	Canada	Estonia	Faroes	France	Germany	Greenland	Iceland	Japan	Latvia	Lithuania	Nederland	Norway	Poland	Portugal	Russia	Spain	UK	Ukraine	Total
2013				1882		1176		8545		1200	1163		2979			26463	2644			46052
2014				721		890		2081		867	1024		1965			15475	732			23755
2015				779		918		1968			330		1547		202	20214	1475			27433
2016				567		715		2601		549	803		1396			21619	404			28654
2017				559		772		1929			911		970			24355	395			29891
2018				438		357		1138		441	900		868			20113	198			24453
2019						531		236			911		700			21964	61			24403
2020						533					908		748			17009	90			19288

Table 22.3.1 Available age data (number of otoliths read) of deep pelagic beaked redfish in the Irminger Sea and adjacent waters.

Year	Iceland	Norway	Total
1996	304		304
1999	1052	258	1310
2001	158	758	916
2003		75	75
2004	399		399
2006	200		200
2009	783		783
2011	585		585
2012	672	628	1300
2013	535	159	694
Total	**4688**	**1878**	**6566**

Table 22.3.2 Number of length measurements of deep pelagic beaked redfish and number of hauls sampled from the Icelandic commercial fishery. Iceland did not participate in the fishery in 2020.

Year	Number of fish	Hauls sampled
1992	447	5
1994	6915	41
1995	8128	49
1996	12185	141
1997	19258	200
1998	10104	94
1999	16264	115
2000	11079	97
2001	10589	83
2002	3840	48
2003	6705	63
2004	14774	87
2005	5693	34
2006	15296	78
2007	14449	79
2008	4993	40
2009	9231	73
2010	4113	34
2011	7339	52
2012	9458	70
2013	4093	35
2014	2927	19
2015	998	6

Year	Number of fish	Hauls sampled
2016	4020	20
2017	3366	
2018	612	3
2019	490	
2020	-	-

Table 22.6.1 Deep pelagic *S. mentella*. Survey estimates for depth >500 m from trawl samples taken in 2021. Areas C, D and F (Figure 22.6.1) were not surveyed.

	A	B	C	D	E	F	Total
Area (NM^2)	95 159	88 128			588622		242 148
Mean length (cm)	35.7	34.9			34.6		35.0
Mean weight (g)	584	555			538		559
Biomass (t)	**85 909**	**38 377**			**29 221**		**153 527**

Table 22.6.2. Results (biomass in ´000 t) for the international redfish surveys conducted 1999–2021 for deep pelagic *S. mentella* for each Subarea (see Figure 22.6.1), the total biomass, and the total area coverage (thousand nmi^2). Areas C–F were not surveyed in 2015 and Areas B–F were not surveyed in 2018.

Year	Subarea						Total	Area (nmi^2)
	A	B	C	D	E	F		
1999	277	568	12	27	52	0	935	296
2001	497	316	28	79	64	18	1001	420
2003	476	142	20	13	27	0	678	405
2005	221	95	0	8	65	3	392	386
2007	276	166	1	5	62	11	522	349
2009	291	121	0	8	37	1	458	360
2011	342	112	0	1	18	0	474	343
2013	193	75	0	2	10	0	280	340
2015	153	43	-	-	-	-	196	201
2018	130	-	-	-	-	-	-	103
2021	86	38	-	-	29	-	154	242

Table 22.6.3. Area coverage (nmi²) in the international redfish survey 1999–2021 by subarea (see Figure 22.6.1). Blank cells mean that the area was not surveyed.

Year	A	B	C	D	E	F	Total	Reference
1999	110,524	124,014	8,403	4,201	27,435		274,577	ICES, 1999
2001	125,975	127,125	28,934	62,897	69,000	32,470	446,401	ICES, 2002
2003	114,289	120,561	31,931	41,128	62,742	8,217	378,868	ICES, 2003
2005	126,403	84,020	25,694	64,533	73,693	11,920	386,263	ICES, 2005
2007	129,614	106,594	8,464	33,855	62,623	8,052	349,202	ICES, 2007
2009	122,519	91,863	8,362	55,468	69,931	11,921	360,064	ICES, 2009c
2011	133,281	90,801	4,181	55,468	55,206	1,078	340,015	ICES, 2011
2013	125,531	83,385	4,181	51,185	67,730	15,683	347,695	ICES, 2013
2015	113,450	87,994					201,444	ICES, 2015
2018	103,075						103,075	ICES, 2018
2021	95,159	88,128			58,862		242,148	ICES, 2021

Table 22.7.1 Results from the Gadget model of total biomass, spawning stock biomass, recruitment at age 5 (in thousands), catch and fishing mortality. All weights are in tonnes.

Year	Biomass	SSB	$R_{(age5)}$	Catches	F_{9-19}
1985			1154		
1986			944		
1987			904		
1988			393		
1989			637		
1990			1476		
1991	1447061	1324872	838	59	0.000
1992	1439553	1340712	434	3398	0.004
1993	1424247	1344085	614	15064	0.017
1994	1370484	1335750	576	51820	0.060
1995	1343900	1288811	2249	75707	0.091
1996	1212974	1244723	773	138552	0.181
1997	1123235	1119481	648	95079	0.136
1998	1038107	1035972	686	92818	0.144
1999	965126	955767	761	84153	0.143
2000	880863	885906	636	93113	0.172
2001	808274	806193	773	86993	0.180
2002	718707	735546	685	103128	0.244
2003	631481	649096	739	104296	0.293
2004	553352	563896	575	91954	0.312
2005	523946	489685	625	45485	0.174
2006	469960	462191	506	67288	0.291
2007	417847	411984	255	58516	0.295
2008	388618	366543	70	30045	0.165

Year	Biomass	SSB	R(age5)	Catches	F9-19
2009	349967	345110	559	54406	0.339
2010	307245	306961	559	59288	0.453
2011	277128	264710	559	47333	0.441
2012	261937	234687	559	32806	0.347
2013	233952	219148	559	46052	0.599
2014	228525	191355	559	23755	0.339
2015	219609	185370	559	27433	0.429
2016	209672	176171	559	28654	0.510
2017	198683	166112	559	29891	0.611
2018	193235	155190	559	24453	0.486
2019	182738	149705	559	29658	0.721
2020	165719	139512		19288	0.520
2021		130008			0.462

Table 22.9.1: Short-term forecast. Values of catch and SSB are in tonnes.

Approach	F (2022–2024)	Catch 2022	SSB 2023	Catch 2023	SSB 2024	Catch 2024	SSB 2025
Zero catch	0.000	0	127250	0	132108	0	135920
Scale * F_{MSY}	0.008	305	126963	355	131484	406	134909
F_{MSY}	0.040	1429	125907	1642	129206	2060	131253
0.1 * Status quo	0.063	2240	125145	2551	127582	2853	128679
0.2 * Status quo	0.122	4299	123210	4779	123535	5219	122386
0.3 * Status quo	0.177	6193	121431	6734	119905	7193	116884
0.4 * Status quo	0.229	7939	119793	8455	116639	8848	112052
0.5 * Status quo	0.278	9549	118283	9974	113694	10245	107787
0.6 * Status quo	0.323	11036	116889	11320	111031	11429	104006
0.7 * Status quo	0.366	12409	115602	12516	108616	12438	100641
0.8 * Status quo	0.406	13680	114412	13582	106423	13301	97636
0.9 * Status quo	0.443	14856	113311	14535	104426	14044	94942
1 * Status quo	0.478	15945	112292	15389	102605	14685	92519

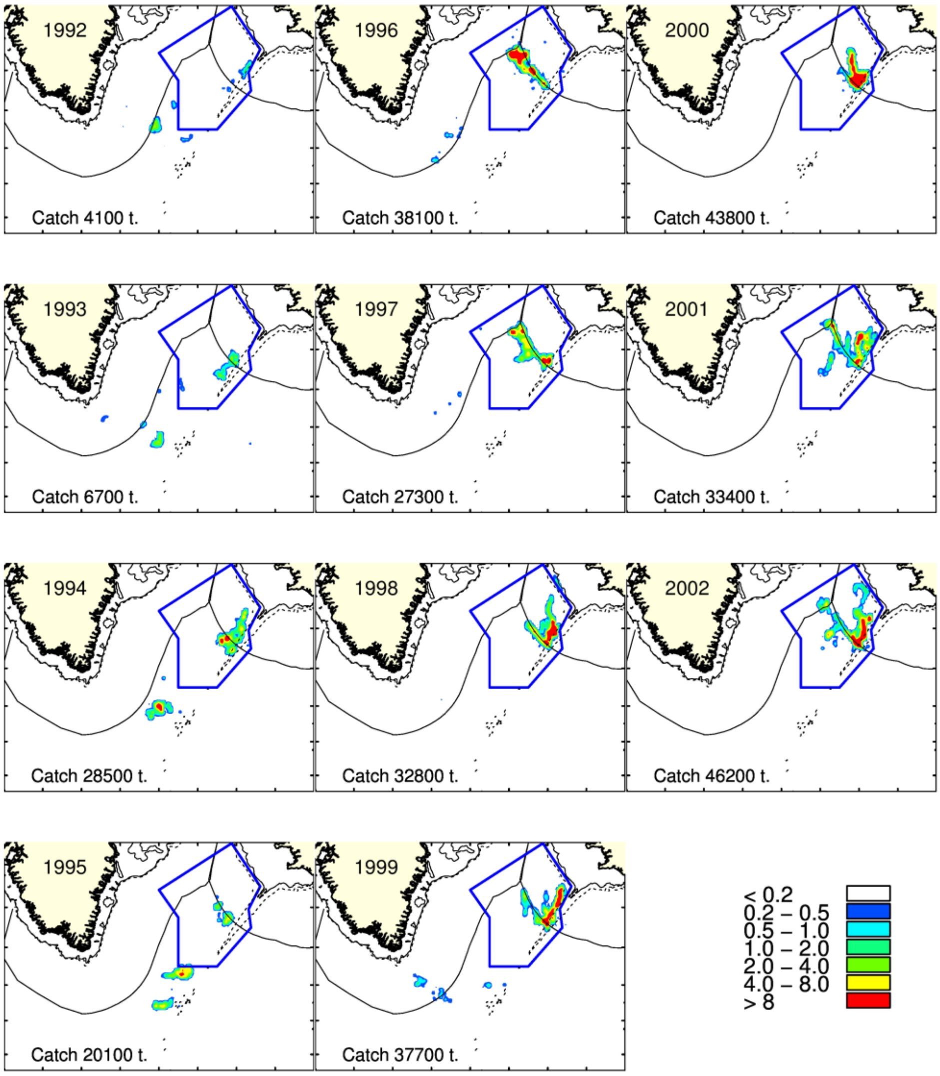

Figure 22.2.1 Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2017. Data are from the Faroe Islands (1995–2017), Germany (2011–2017) Greenland (1999–2003 and 2009–2010), Iceland (1995–2017), and Norway (1995–2003 and 2010–2017). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

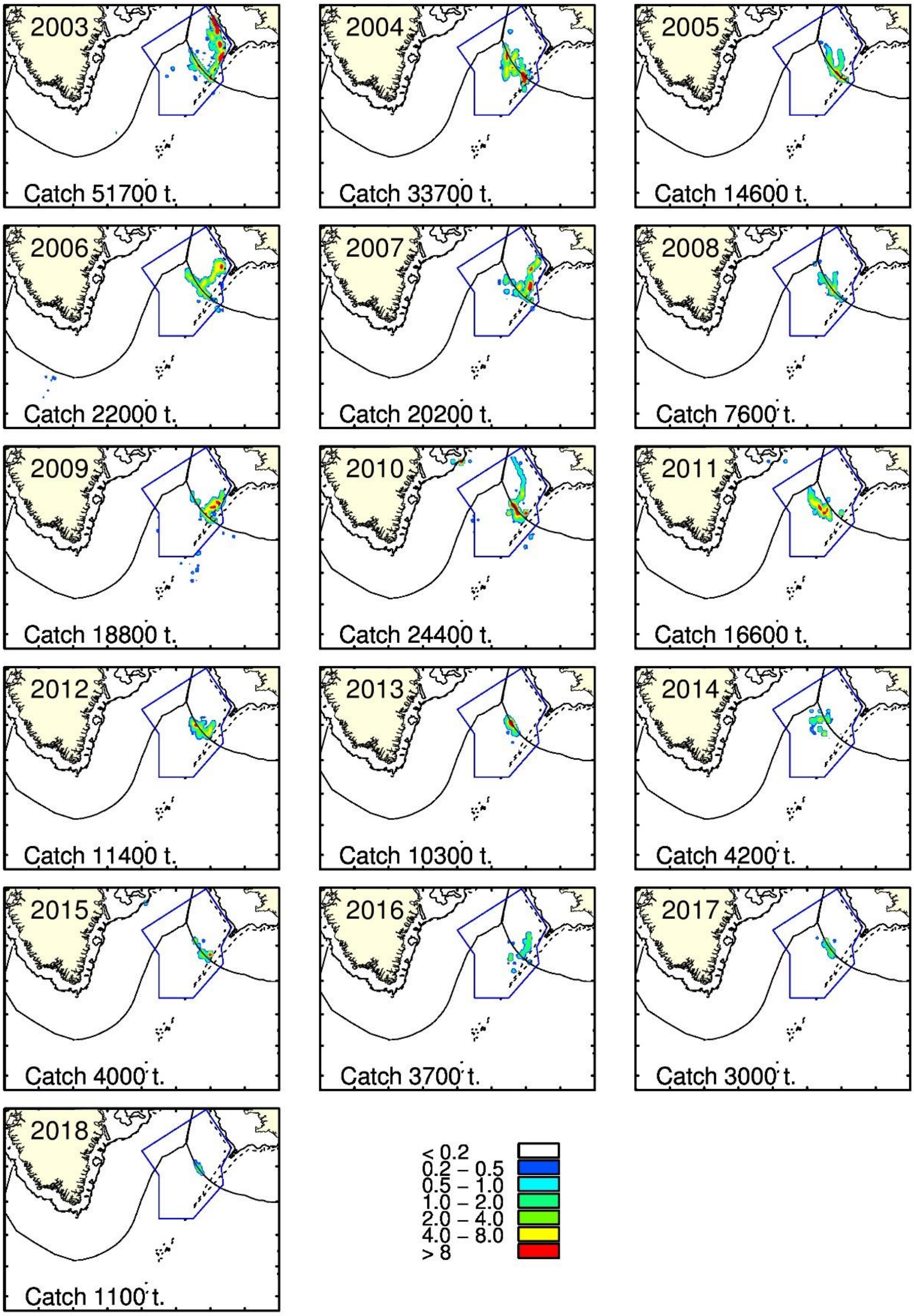

Figure 22.2.1 (Cont.) Fishing areas and total catch of deep pelagic redfish (*S. mentella*) in the Irminger Sea and adjacent waters 1992–2017. Data are from the Faroe Islands (1995–2017), Germany (2011–2017) Greenland (1999–2003 and 2009–2010), Iceland (1995–2017), and Norway (1995–2003 and 2010–2017). The catches in the legend are given as tones per square nautical mile. The blue box represents the proposed management unit.

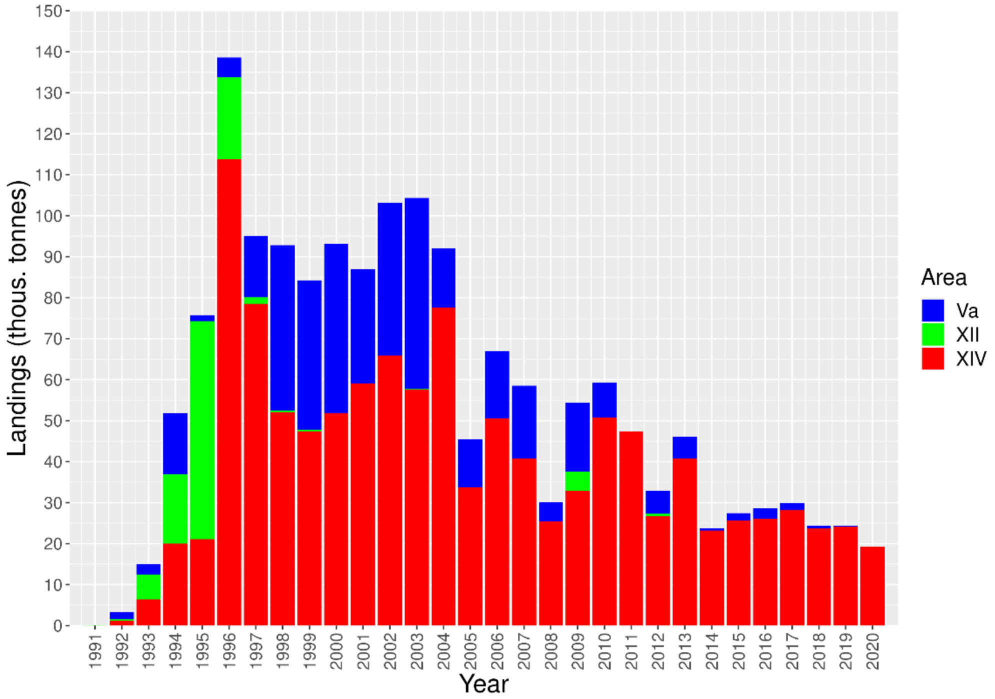

Figure 22.2.2 Landings of deep pelagic *S. mentella* (Working Group estimates, see Table 21.2.1).

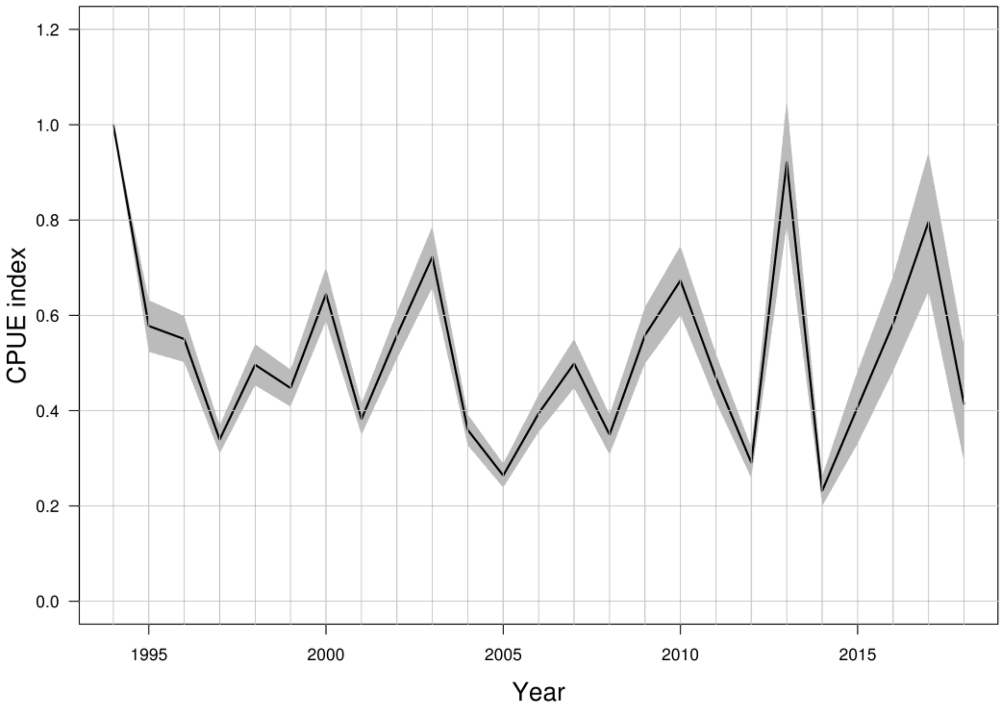

Figure 22.2.3 Trends in standardized CPUE of the deep pelagic *S. mentella* fishery in the Irminger Sea and adjacent waters, based on log-book data from Faroe Islands, Iceland, Germany, Greenland and Norway. Only data from Iceland were available in 2018.

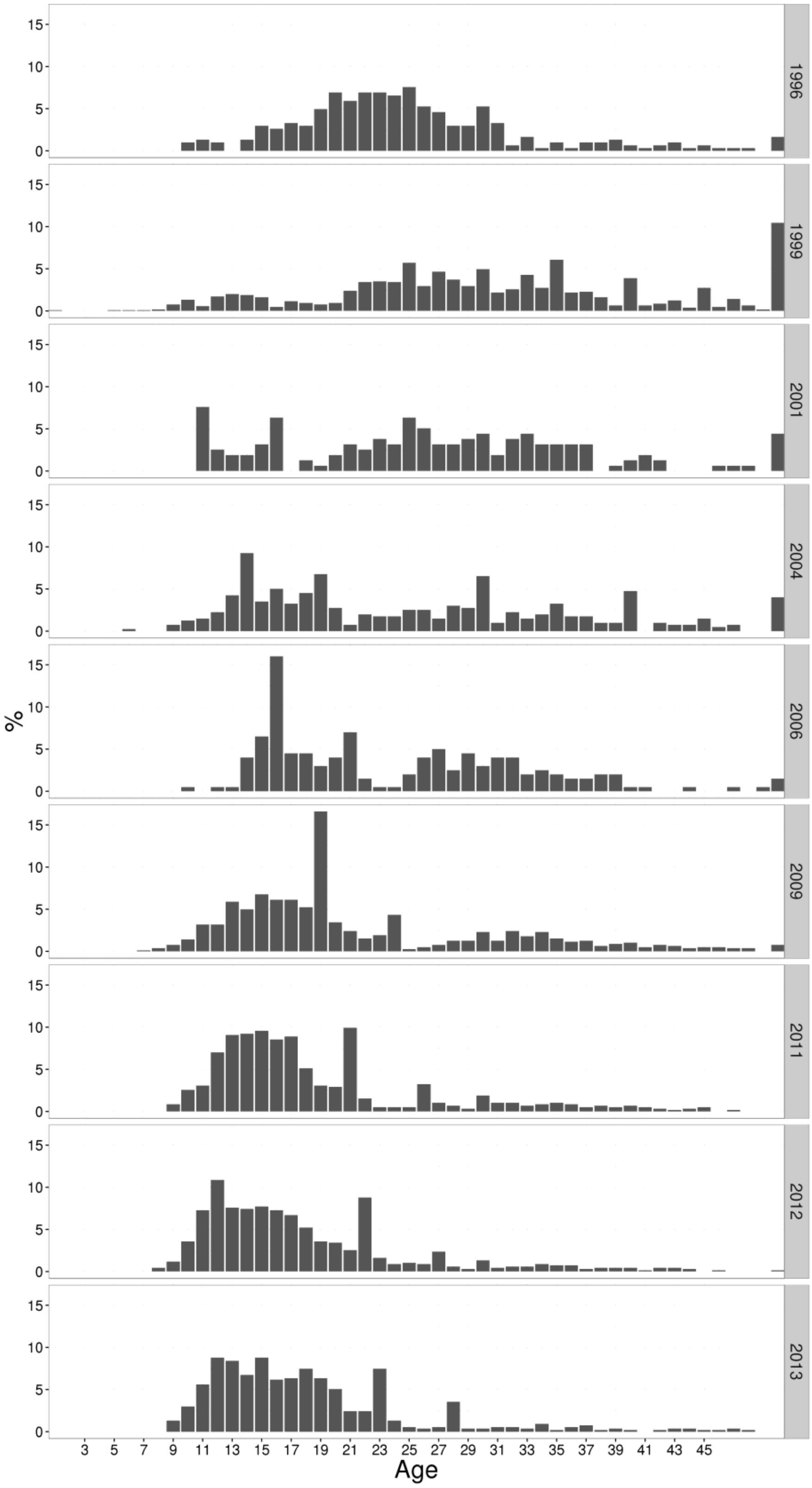

Figure 22.3.1 Age distribution of deep pelagic beaked redfish based on age reading from the Icelandic commercial catch.

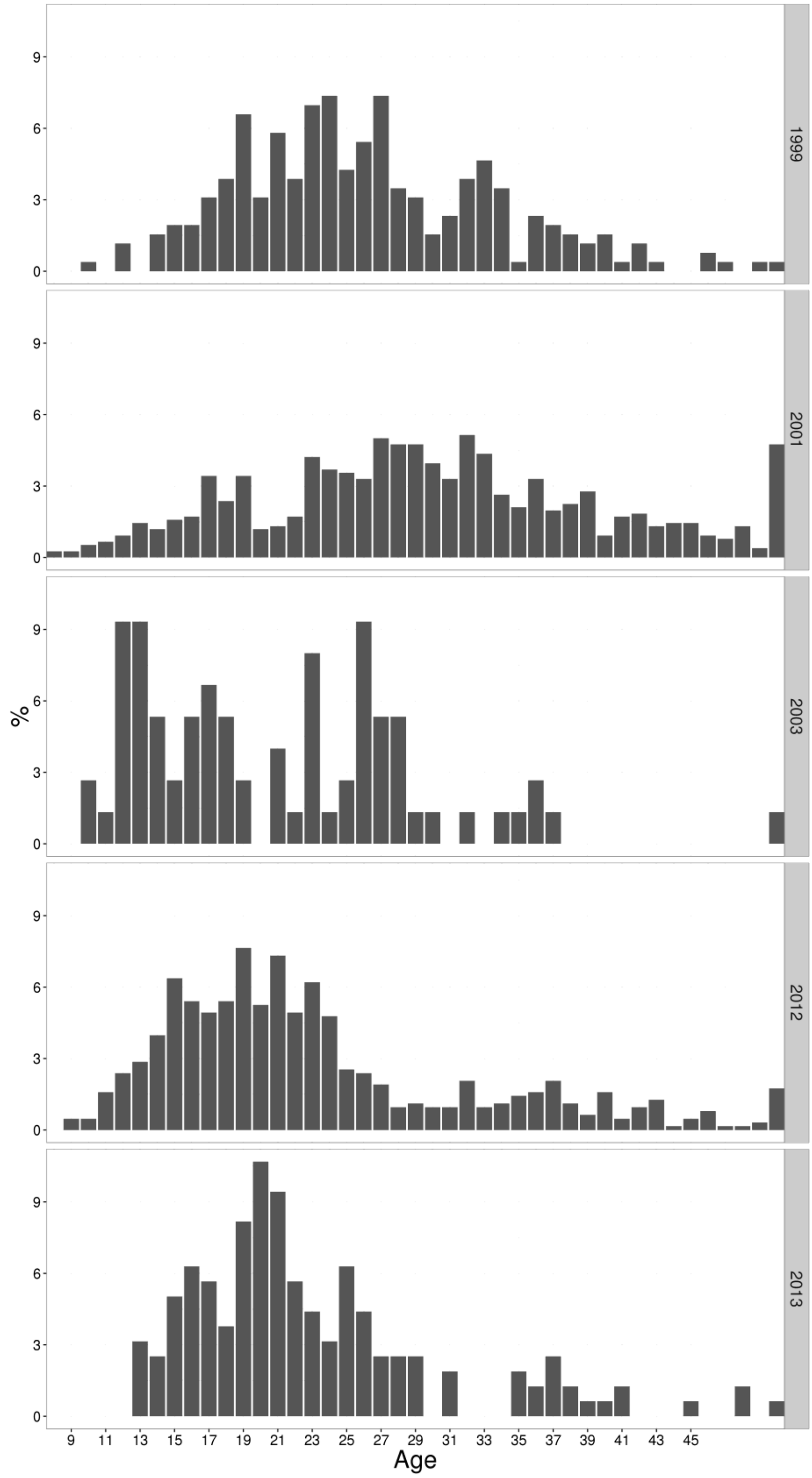

Figure 22.3.2 Age distribution of deep pelagic beaked redfish based on age reading from the Norwegian commercial catch.

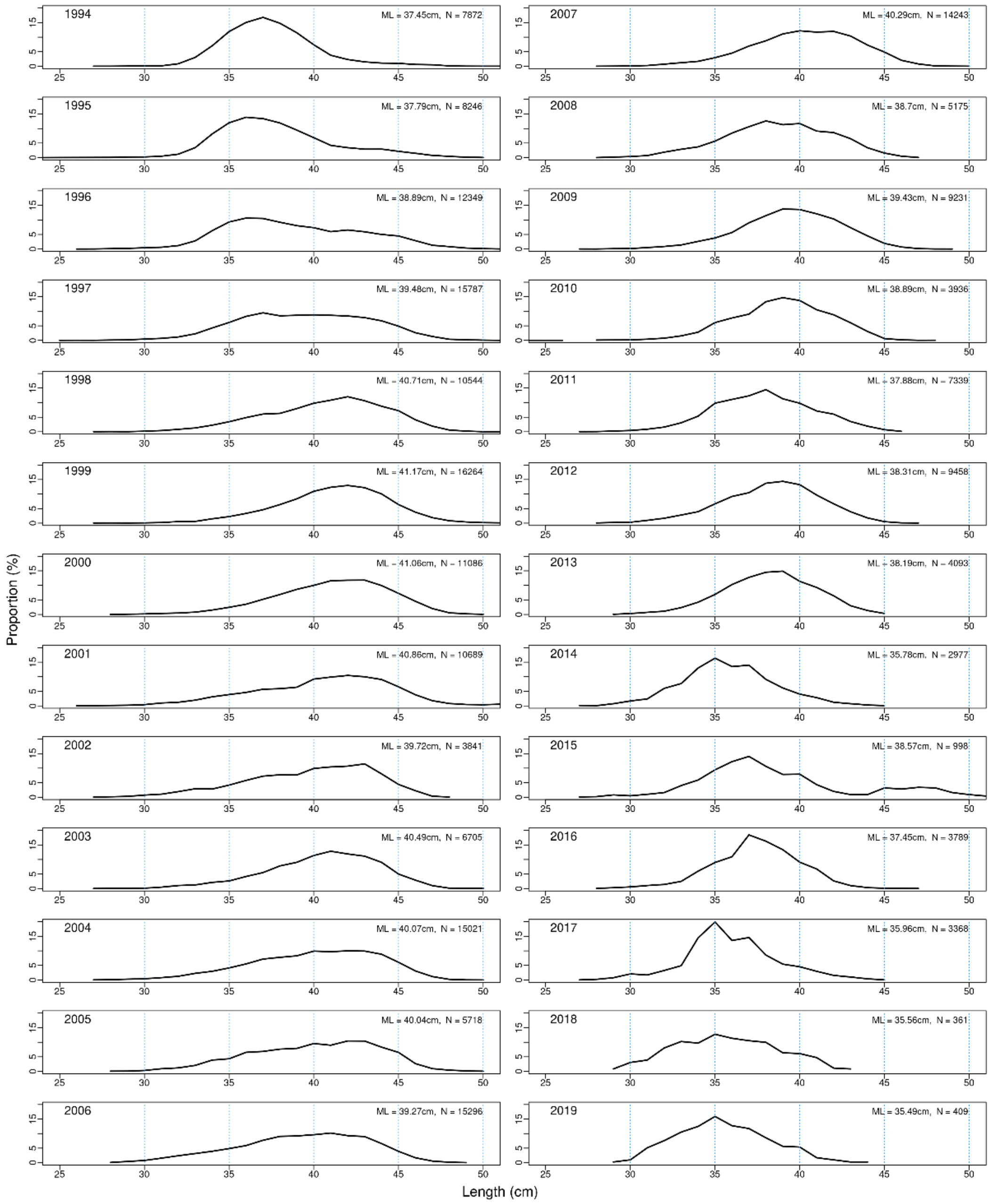

Figure 22.3.3 Length distribution from Icelandic landings of deep pelagic *S. mentella* 1994–2019. No data was available in 2020 as Iceland did not participate in the survey.

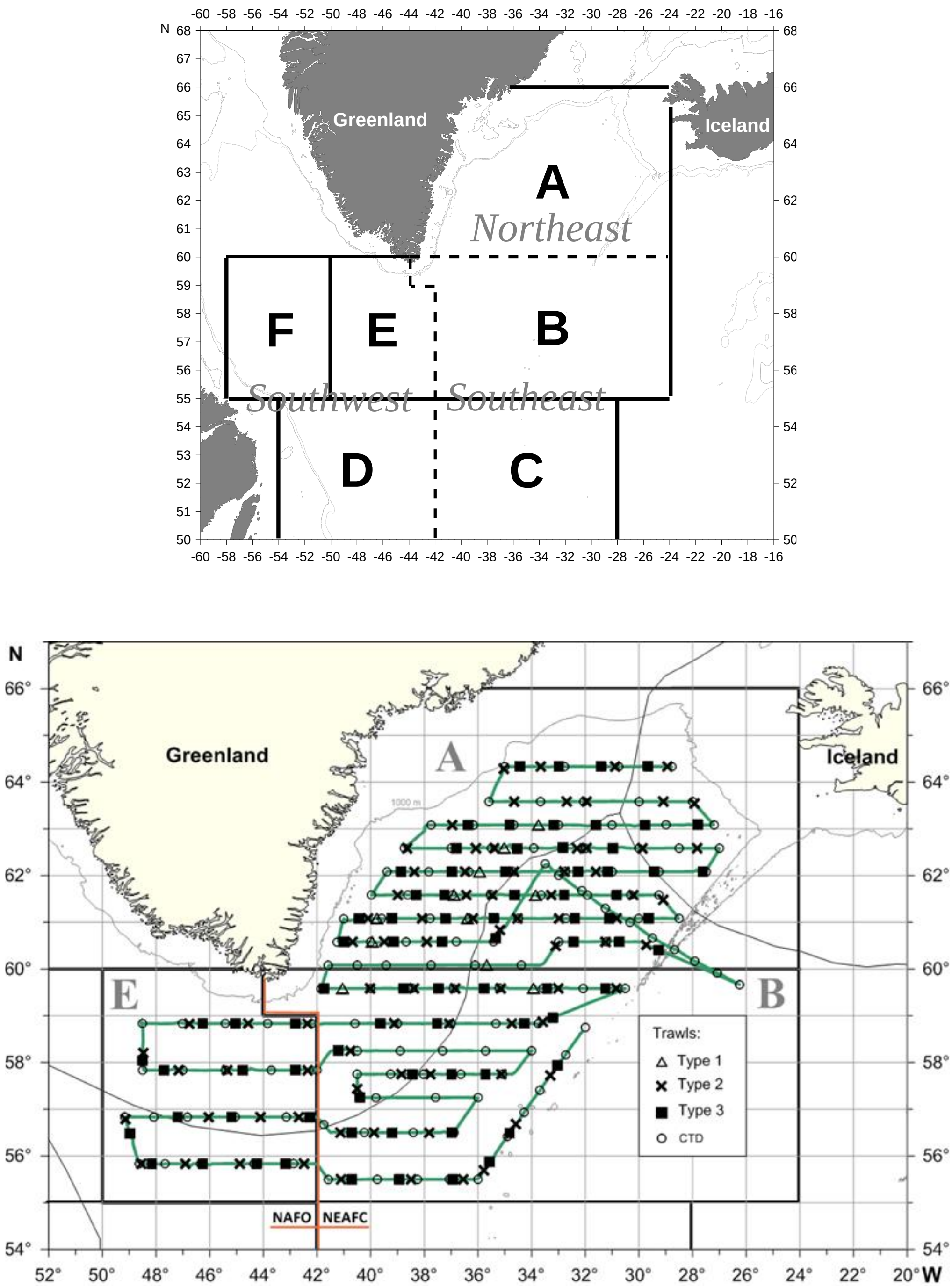

Figure 22.6.1 Upper: Subareas A-F used on international surveys for redfish in the Irminger Sea and adjacent waters, and divisions for biological data (Northeast, Southwest and Southeast; boundaries marked by broken lines). Lower: Cruise tracks and stations taken in the joint international redfish survey in June–August 2021. The areas A, B and E were surveyed.

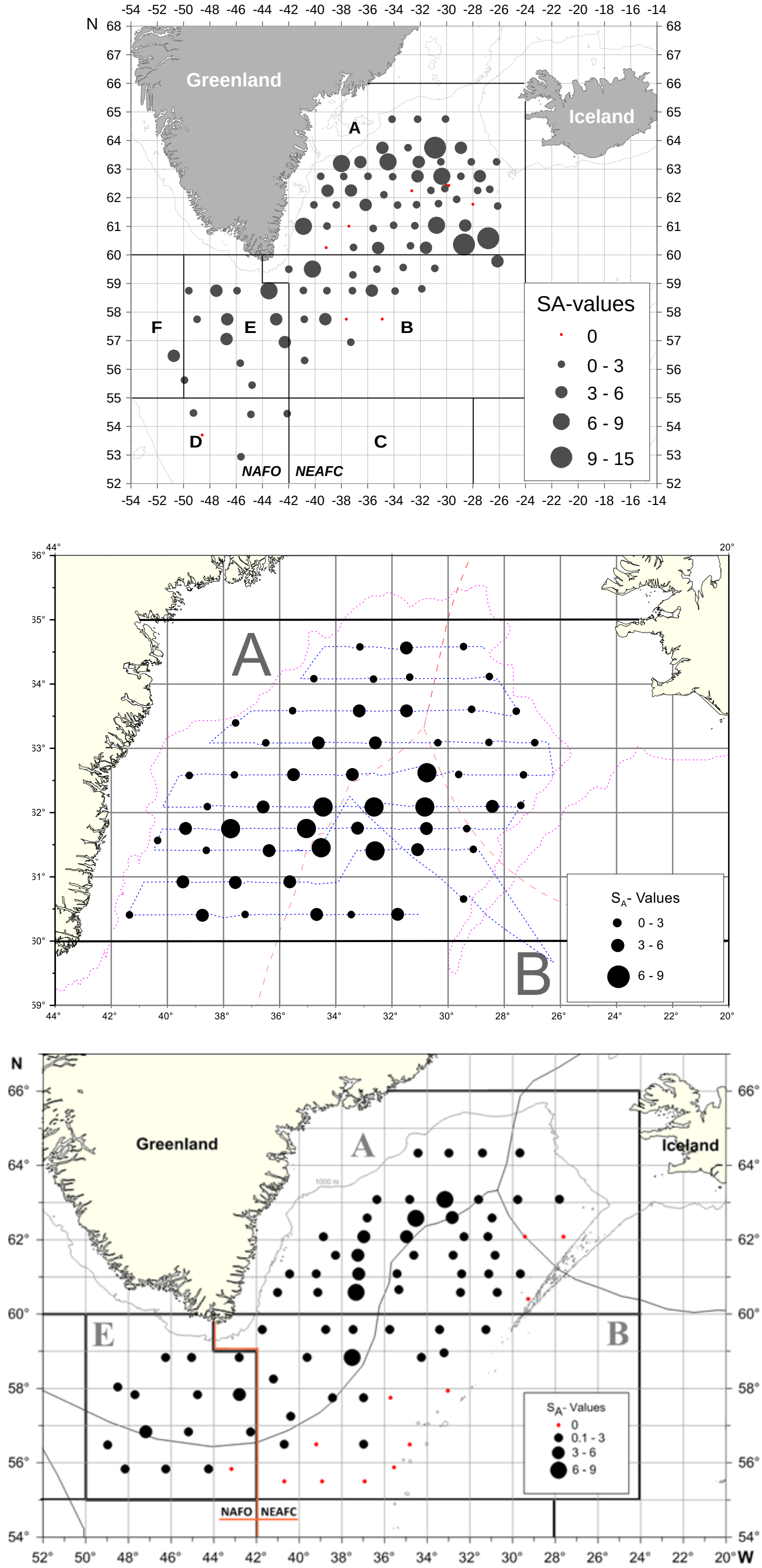

Figure 22.6.2. Redfish trawl estimates deeper than 500 m (type 3 trawls). sA values calculated by the trawl method (see WGRS Report, 2013) during the joint international redfish survey in June/July 2013 (top), June/July 2018 (middle) and June–August 2021 (bottom).

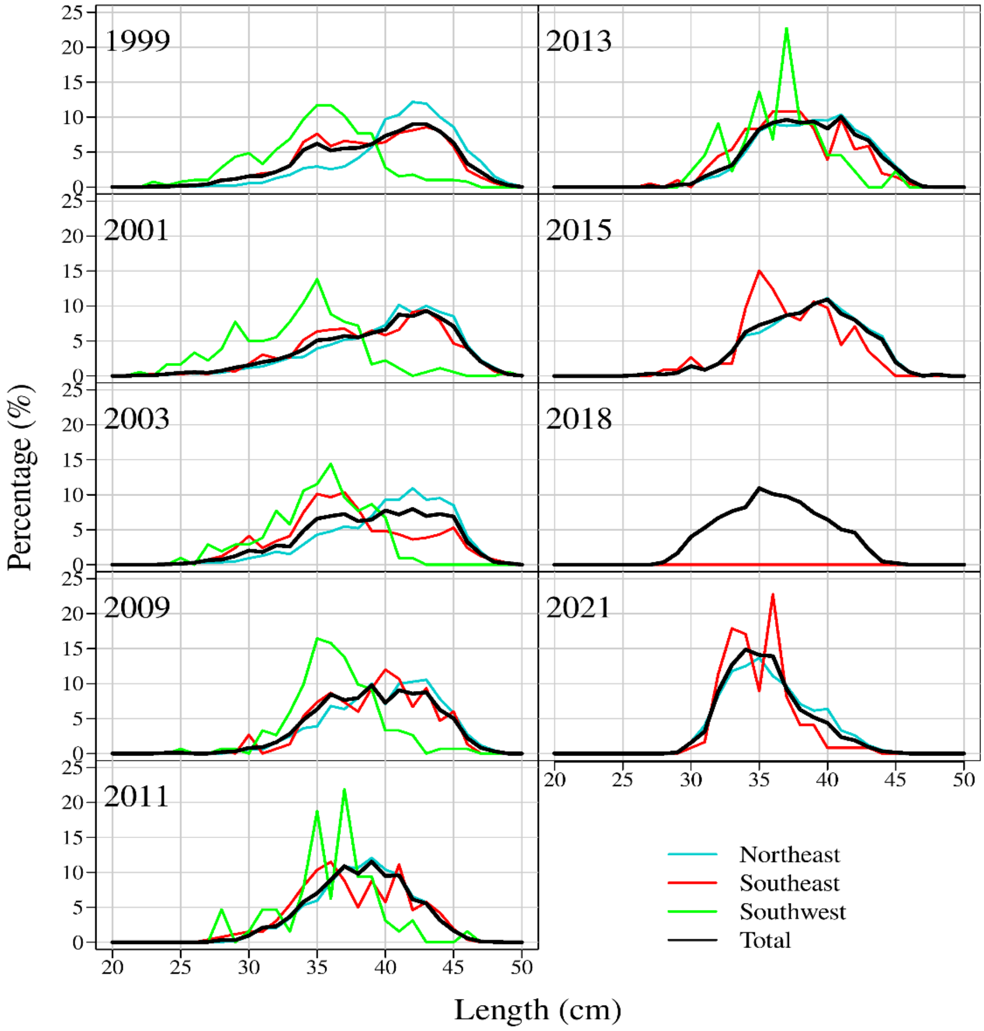

Figure 22.6.3 Length distribution of redfish by geographical areas (see Figure 22.6.1) and total, from fish caught deeper than 500 m 1999–2003 and 2009–2021 (in 2018, the survey only covered the northeast area).

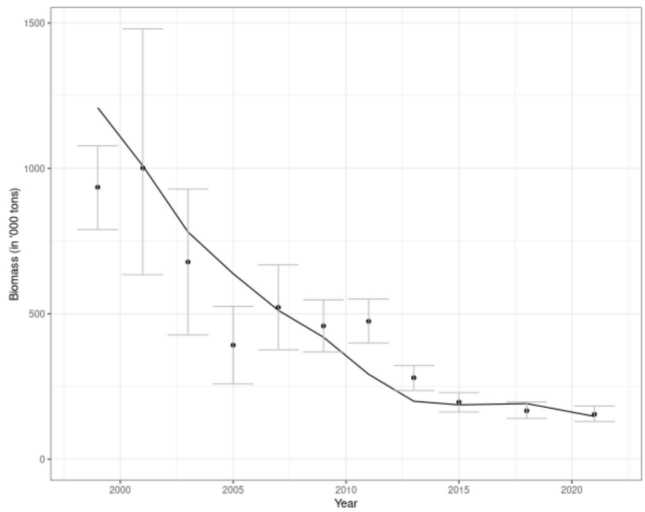

Figure 22.7.1. Deep-pelagic redfish in the Irminger Sea. Biomass index from the international redfish survey in the Irminger sea. Black line is the estimated trajectory from the stock assessment model, dots the observed values and error bars the 95% confidence interval for the observed values.

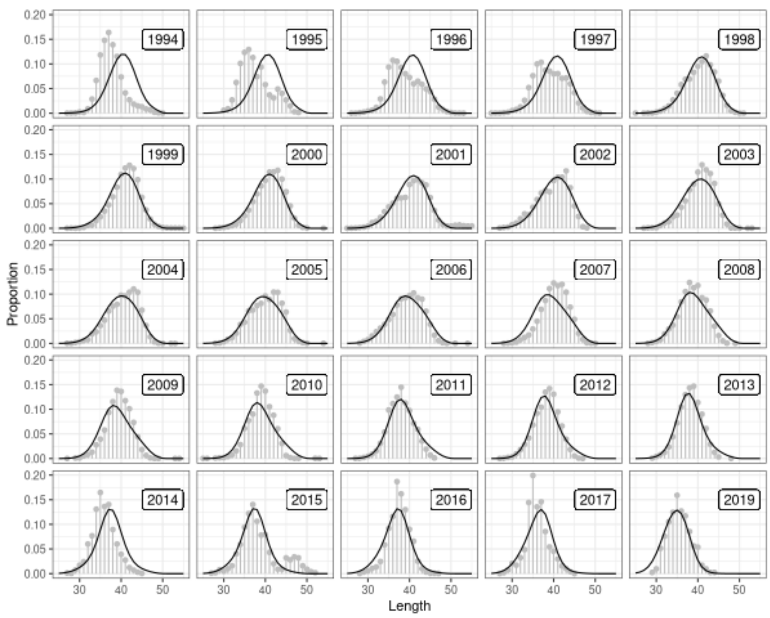

Figure 22.7.2. Deep-pelagic redfish in the Irminger Sea. Length distribution (proportions at length) from commercial redfish samples in the 2nd quarter, the fit to other quarters is omitted for brevity. Grey bars denote the observed values and solid black lines the predictions by the base model.

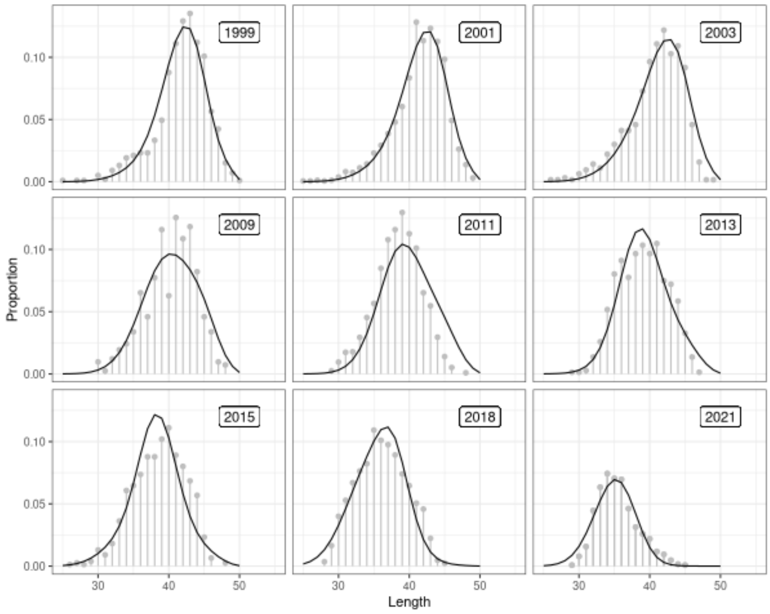

Figure 22.7.3. Deep-pelagic redfish in the Irminger sea. Length distributions (proportions at length) from the international redfish survey (ITAS). Grey bars denote the observed values and solid black lines the predictions by the base model.

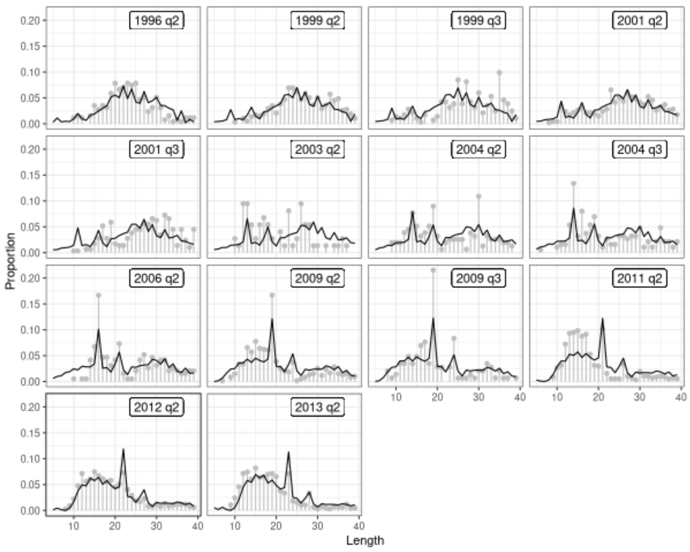

Figure 22.7.4. Deep-pelagic redfish in Irminger sea. Age distribution (proportions at age) from commercial redfish samples split by year and quarter. Grey bars denote the observed values and solid black lines the predictions by the base model.

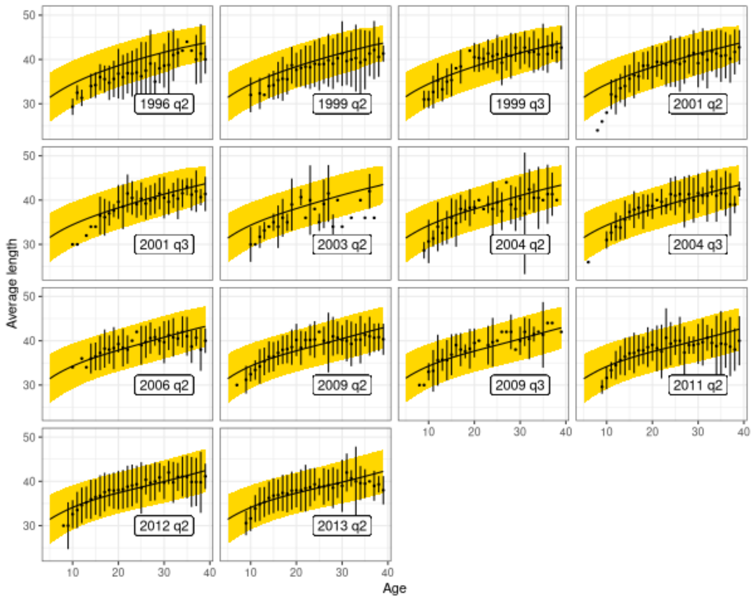

Figure 22.7.5. Deep-pelagic redfish in the Irminger Sea. Mean length-at-age by year and quarter from commercial catches. Black dots represent observed mean values, vertical bars 95% confidence range for the observations (where possible), solid line fitted mean and yellow ribbon the predicted 95% confidence limit.

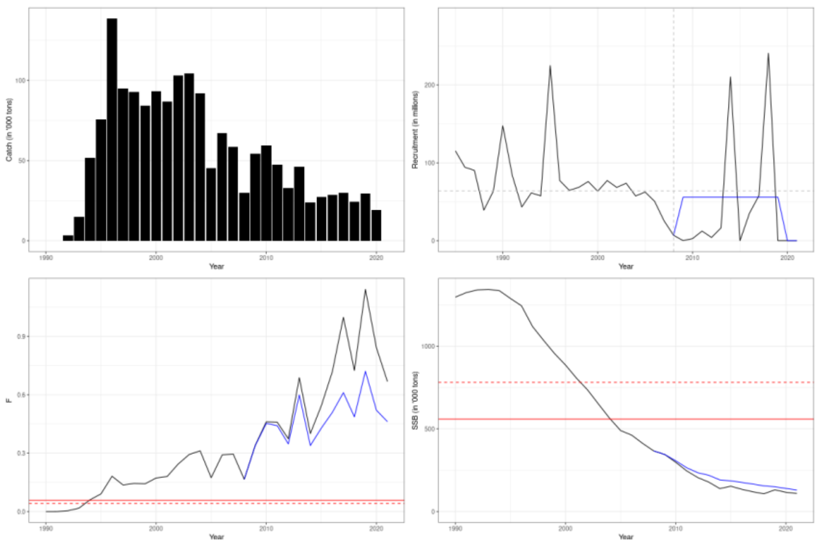

Figure 22.7.6: Summary of stock assessment agreed by WKDEEPRED, see Table 5.2.2 for a tabulation of results (to be presented as a Category 2 assessment, i.e., with Recruitment, F and SSB on relative, rather than absolute, scale). Recruitment after 2008 is not considered to be reliably estimated and has been replaced by the geometric mean of the estimated recruitment during 1985–2008 (blue line). SSB and F values after 2006 were recalculated accordingly, to match the observed catches in those years.

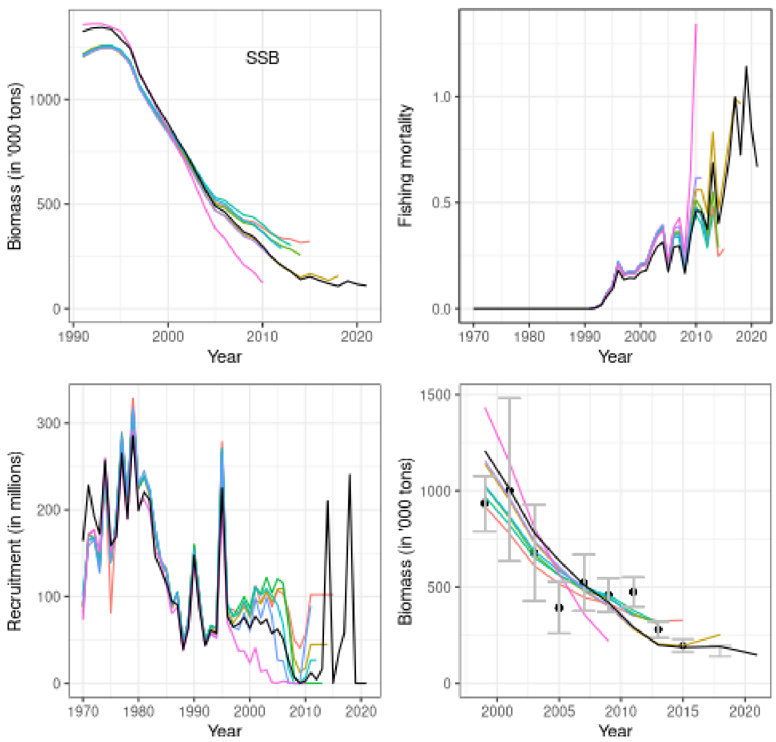

Figure 22.7.7: Deep-pelagic redfish in the Irminger Sea. Analytical retrospective estimates, for the last 10 years, of spawning-stock biomass, recruitment (age 5), fishing mortality (apical), and the fit the biomass index.

23 Beaked redfish (*Sebastes mentella*) in Division 14.b, demersal (Southeast Greenland)

23.1 Stock description and management units

See Section 18 for description of the stock structure of *S. mentella* in the Irminger Sea and adjacent waters. ICES has advised separately for *S. mentella* found demersal in ICES 14.b since 2011 and will do so until all available information on stock origin in this area is analysed and a new procedure is agreed upon.

23.2 Scientific data

Indices were available from three surveys in 14.b. A German survey directed towards cod in Greenlandic waters (0–400 m) (Fock et al., 2013), the Greenland deep-water survey (400–1500 m) targeting Greenland halibut and the Greenland shrimp and fish survey in shallow water (0–600 m), which has been conducted since 2008 (Christensen and Hedeholm, 2018). The Greenland shrimp and fish survey is used in the assessment but. was not conducted in 2017,2018 and 2019. The Greenland halibut survey has been conducted since 1998 but not since 2016. The German survey on the slope in 14.b has since 1982 been covering the slopes in East Greenland waters but was not conducted in 2018. This survey operates at depths of 400 m and shallower and does therefore not cover the full depth distribution of the species. The German survey was re-stratified in 2009 (see Stock Annex).

From 1993–1998 a large number of *Sebastes* spp. smaller than 17 cm was found in the German survey (data not shown). This coincided with a large increase in the amount of 17–30 cm large *S. mentella* from 1995–1998 (Figure 23.2.1). From 1998 to 2003 the total biomass increased as a result of many small fish (< 17 cm) in the German survey, followed by a few years of high biomass estimates for *S. mentella* from 2003–2009. This increase occurred in one particular stratum only (i.e. stratum 8.2). From 2009 onward, a declining trend in both biomass and abundance was observed, with 2015 representing the lowest biomass for the last 20 years (Figure 23.2.1). In the same period, the amount of small fish (17–30 cm) has steadily declined causing an increase in the amount of larger fish (Figure 23.2.1) until the overall biomass declines in 2010 and 2011. The depletion of the small size group has led to a progressive decline in the juvenile biomass index to a current low level, and no new recruits have been seen in the survey since 2012. This pattern is also reflected in the abundance estimates (Figure 23.2.1). The modal size of the adult fish has increased from 25 cm in 2001 to around 37 cm in 2010 but declined slightly in 2011. The distribution has become flat with no clearly defined mode in 2013–2019 (Figure 23.2.2).

The Greenland deep-water survey has since 1998, except in 2001, surveyed the slopes of East Greenland from 400 to 1500 m with the majority of stations deeper than 600 meters targeting Greenland halibut. The biomass indices in the Greenland deep-water survey peaked in 2012 and has been at a relatively constant level since 2010 (Figure 23.2.3). The overall length distribution from the entire area in 2013 and 2014 shows a mode around 31 cm. In 2015 and 2016, the mode increased slightly (Figure 23.2.4). The survey was aborted in 2017 due to vessel breakdown and in 2018-2020, there was no available research vessel for the survey. Therefore, no new data is available since 2016. The survey has not been used for calculating biomass index as the depth range is outside the depths of the targeted fishery.

The Greenland shrimp and fish survey in shallow water in East Greenland started in 2007, and surveys the East Greenland shelf and shelf edge at depths between 0–600 m. However, 2007 was mostly exploratory and is not reported. In general, survey estimates of schooling fish are associated with large uncertainties due to their patchy distribution. This, in conjunction with the relatively short time-series, makes overall conclusions regarding stock trends based solely on this survey tentative. It is however the survey with the best coverage of redfish depth distribution. The 2016 biomass estimate for *S. mentella* increased from 61 kt to 164 kt from 2015 to 2016 (Figure 23.2.5). However, the estimate has large uncertainties since one haul accounted for 70% of the total biomass estimate. The haul was taken in area Q2 close to Icelandic waters. In 2017, 2018 and 2019, surveys have been missing but in 2020 a full survey revealed the lowest biomass indices (18.4 kt) throughout the time series (Figure 23.2.5). The 2020 Greenland survey was carried out day and night, which is different from previous years where hauls were made only during daytime (08.00-20:00 UTC).

The German survey was in 2017 limited due to bad weather and only 46 out of an average of 75 stations were covered on the Greenland East coast. However, the most important Redfish strata were surveyed with a reasonable coverage, why the result is expected to be valid. In 2017 and 2019, the declining trend documented in the earlier years continues. The accuracy of the surveys as an indicator of recruitment is not known but recruitment is expected to be poor, and the abundance of juveniles is at the lowest level in the 30-year time-series. An experimental fishery in 2019 partly focusing on juvenile redfish confirmed that the abundance of juvenile redfish continues to be at a very low level (Christensen, 2020b). However, in 2020, juveniles are more abundant in the Greenland survey than they have been for a decade (Figure 23.2.6).

23.2.1 Landings

From the Greenland and German surveys, it is certain that the demersal redfish found on the Greenland slope is a mixture of *S. norvegicus* and *S. mentella*. Before 2016, *S. mentella* dominated the catches, but the proportion started to decline in 2014 (Figure 23.3.1.1) and in 2016, the split changed and for the first time *S. norvegicus* was dominating (Figure 23.3.1.1). In 2019, *S. mentella* was again dominating the catches estimated the logbooks. In 2020, *S. norvegicus* dominated again which was supported by Greenland shallow water survey (79:31), loogboks (60:40) as well as samples from the commercial fishery (71:29) analyzed at Greenland Institute of Natural Resources. Prior to 1974, all catches were reported as *S. norvegicus* and the split was determined by working groups on a yearly basis.

Catch depth has in the later years declined compared to earlier. In 2016, the catches were taken at a depth of 300–400 m. In 2017 and 2018 it declined even further and in 2019 an in-creasing part of the catch was taken down to 300 m. In 2011–2012 were caught at 350–400 m (Figure 23.3.1.2).

Total annual landings of demersal *S. mentella* from Division 14.b since 1974 are presented in Table 23.3.1.3. From 1976–1994 annual landings were at a relatively high level with landings ranging between 2000 and 20 000 tonnes with a very high peak at nearly 60 000 t in 1976. This fishery was ended abruptly in 1995, due to large amounts of very small redfish in the catches. From 1998–2002 the landings ranged from 1000 to 2000 tonnes and from 2003 to 2008 landings remained at lower levels (< 500 tonnes). In 2009, an exploratory fishery landed 895 tonnes of *S. mentella*. This was a large increase compared to 2008 and for the first time in ten years the fishery was limited by a TAC.

In 2010, a quota on 5000 tonnes demersal redfish (mixed *S. mentella* and *S. norvegicus*) was initially given and of these, 400 tonnes were allocated to the Norwegian fleet. After this amount was fished, a research quota of 1000 tonnes were given to a Greenland vessel. Since 2010, the catches have been around 8300 tonnes (*S. mentella* and *S. norvegicus* combined) (Figure 23.3.1.3). In

2017, total catches decreased to 7568 tonnes and in 2018 the catch de-creased further to 5976 tonnes. However, in 2019 a notable increase in the catches occurred and the total catch was 6663 tonnes (Figure 23.3.1.3). Since 2011 the mixed TAC has been 8500 tonnes until 2017 where the TAC started to decrease. In 2019, the mixed TAC was 5274 tonnes and in 2020 it was 5271 tonnes.

In 2010, there was no jurisdiction that clearly delimited the pelagic stocks from the redfish found on the shelf. A few vessels benefitted from this by fishing their pelagic quota on the shelf (2179 tonnes) making catches on the shelf exceed the TAC. This led to the introduction of a "redfish line" that separates the demersal slope stock from the pelagic stocks (see stock annex).

23.2.2 CPUE and bycatch CPUE

A redfish bycatch CPUE was introduced at the redfish 2012 benchmark (WKRED). This is based on catches from the Greenland halibut directed fishery and include both *S. mentella* and *S. norvegicus* (Christensen 2020a), which covers redfish distribution better than data from the red-fish directed fishery and covers a longer period (1999–2019). The Greenland halibut fishery is not as spatially restricted as the redfish fishery; thus, it will not be as sensitive to local changes as the redfish directed CPUE. The CPUE has very low values in the initial two years of the time-series, but following an increase in 2001, values have remained at the same level until 2006 after which a decline followed. Since 2011, the CPUE have been relatively stable with minor fluctuations (Figure 23.3.2.1). The increase in CPUE in 2016 and the decline in 2017 is reflected in the biomass index estimated based on the shallow water surveys in the same years (German).

The CPUE from the redfish directed fishery showed a decline from 2010 to 2015, while it increases in 2016 (1.7 t/h). in the later years the CPUE have been relatively stable yet with a slowly decreasing trend since 2010 (Figure 23.3.2.2). Until 2015, the fishery takes place in a geograph-ically limited area between 63.5°N and 65°N, where approximately 90% of the catches are taken. Thereafter it also include more southern areas (Figure 23.3.3.1). Accordingly, the CPUE series can only be used as an index on local stock development. Both the Greenland shallow water survey (0–600 m) and the German survey (0–400 m) show that the main fishing area coincides with the area of highest overall abundance.

23.2.3 Fisheries and fleets

The fishery for *S. mentella* on the slopes in 14.b is mainly conducted with bottom trawl, only about 1% were caught with longlines. The area where *S. mentella* is caught, is closely related to the area where fishery for Greenland halibut and cod takes place (Figure 23.3.3.1). The majority of the catches are taken at depths from 300 m to 400 m (Figure 23.3.1.2).

The directed fishery was stopped in 1995, but in 1998 Germany restarted a directed fishery for redfish with annual landings of approximately 1000 tonnes in 1998–2001 increasing to 2100 tonnes in 2002 (Bernreuther et al., 2013). Samples taken from the German fleet indicated that substantial quantities of the redfish caught, especially in 2002, were juveniles, i.e. fish less than 30 cm. There was very little demersal redfish fishery in 14.b in 2003–2004 (less than 500 tonnes). This continued in 2005–2008 and most *S. mentella* were caught as bycatch in the Greenland halibut fishery.

After the German fleet stopped fishing in 2002 the majority of the catches have been taken by the British, Faroese, Norwegian and Greenland fleet. The British fishery took place from 2001–2005 and since 2006 only Greenland, Norway and Germany have had any significant catches (Table 23.3.3.2).

In 2009, three Greenland vessels started a fishery targeting demersal redfish. Each was given an explorative quota of 250 tonnes. This fishery was very successful and led to an increased fishery in 2010 (seven boats), 2011 (15 boats) and 2012 (21 boats). However, in 2012, 95% of the catch was taken by six vessels and 97% by five vessels in 2013.

On the steep slopes very little horizontal distance separates the distribution of cod, redfish and Greenland halibut (Figure 23.3.3.2). The part of the fleet with both quotas for redfish and Greenland halibut takes advantage of this by shifting between very short hauls targeting redfish and long hauls directed to Greenland halibut. Thereby avoiding time where the vessel is not fishing due to processing of the catch.

23.2.4 Bycatch/discard in the shrimp fishery

To minimize bycatch of fish species in the fishery for shrimp the trawls have since 2002 been equipped with grid separators (G.H., 2001). However, the 22 mm spacing between the bars in the separator allows small fish to enter the codend. In a study on the amount of bycatch in the shrimp fishery the mean length of the redfish that entered the codend was 13–14 cm. The same study also documented that redfish by weight accounted for less than 1% of the amount of shrimp that were caught (Sünksen, 2007). Coincident with the introduction of these separator grids the amount of juvenile redfish caught by the shrimp fishery dropped from annual 100–200 tonnes to a lower level near 100 tonnes. Since 2006, limited shrimp fishery has taken place in ICES 14.b and the current level of bycatch must be considered negligible and have for the last two years been zero (Table 23.3.4.1). From 1999–2009, the fishery started in April–May due to poor winter conditions such as ice and wind that prevents fishing. Only in 2000 and 2002, the fishery started already in February (Table 23.3.4.2). Since 2010, the fishery has started already in January and in 2018 February was the month with the highest landings. In 2019, the fishery was relatively high already in March, but most of the catch was fished in May and June. In earlier year, June and July were the most important months today only catches in July are at the same level as earlier in the year (Table 23.3.4.2). The depth distribution of cod and redfish overlap (Figure 23.3.3.2) and therefore the fishery for redfish led to a bycatch of cod on 96 tonnes in 2013. The vessels are allowed a 10% bycatch of cod.

23.3 Methods

No analytical assessment was conducted.

23.4 Reference points

As described in Section 1.3, MSY proxy reference points needs to be defined for the Greenlandic *S. mentella* demersal stock. ICES suggested four methods for this purpose, and all methods were tested on the stock. The conclusion was that based on the caveats listed below and the declines seen in surveys, especially on recruitment over the past decade, the determination of the stock status in relation to reference points should not be based solely on any of the indicators presented here, but rather a holistic view combining surveys and expert judgment with the results presented in Hedeholm and Christensen (2017).

The caveats to consider in relation to the Greenlandic *S. mentella* demersal stock when concluding on the length-based indicators and the SPiCT model.

- If there are few year classes in the fishery, which is current for the present stock, the effect of overfishing the stock is more likely observed on biomass rather than length, especially on a slow growing species. There is no ageing done in this stock, why it is not possible to see if this is the case.

- *Sebastes mentella* is a slow growing species, thus the effect of the fishery on length may be very subtle. The relatively short time-series on length distributions available for this analysis and the limited number of samples per year entails that any effect is easily missed.
- The schooling behaviour of *S. mentella* in connection with the points made above means that the fishery can target a diminishing stock in a small area without seeing any effect on the length distribution. Indeed, the fishery is conducted with limited spatial extent.
- Several redfish stocks are present on the East Greenland slope, but in unknown quantities. Any changes in length could just as well be related to migration, timing of sampling, and latitude of sampling as to actual stock changes.
- Based on the three length-based methods the exploitation pattern appears reasonable. However, results from all three methods should be interpreted with some caution due to lack of knowledge of important input parameters (L_{inf}, M and k) for the specific stock (values from Fishbase are used).

23.5 State of the stock

The Greenland shrimp and fish survey in shallow waters and the German groundfish survey are the two main data sources for biomass indices of *S. mentella*. In addition, the Greenland deep water survey aimed for Greenland halibut is available for the deeper part of *S. mentella* distribution. The different survey's time series suffer from periods with no surveys (i.e. the Greenland survey) and insufficient depth coverage of the species distribution (i.e. German survey). CPUEs from the fishery is also available and shows relatively stable trends. CPUE are however considered less reliable as biomass indicator since the species tends to have a schooling behaviour, which enables the fishery to keep constant catch rates even when stock biomass is decreasing.

The shallow Greenland and German surveys show a decline in the *S. mentella* biomass since 2010 to record low levels in recent years (Fig. 23.2.1 and 23.2.5). In both surveys, there have been an absence of recruits (*Sebastes* spp.) since 2013 although signs of improved recruitment were detected in 2020 in the Greenland survey. Also, the CPUE in the redfish directed fishery has vaguely declined since 2010. Length distributions of survey and from samples of the commercial fishery confirm the low abundance of incoming fish to the fishery in coming years.

The signals from surveys and the fishery suggest a low stock and also that recruitment has been low for several years. Given the slow growth and late maturation of this species, the present exploitation is of concern. A complete cease of the fishery is therefore the only measure in order to evaluate any stock rebuilding in the coming years. A rebuilding will require more incoming year-classes to the stock.

The advice for demersal *S. mentella* in east Greenland has is based on the ICES category 3, Data Limited Stock approach (DLS) including biomass indices from the Greenland shrimp and fish survey. Due to the lack of a survey estimate from the Greenland Shallow Water survey in 2017–2019, the advice for 2020 was given based on a category 5 approach. In 2021, the advice follows the ICES framework for category 3 stocks with extremely low biomass (method 3.1.4), wherefore the advice is 0 catch in 2022. The stock will be benchmarked in 2023.

23.6 Management considerations

S. mentella is a slow growing, late maturing deep-sea species and is therefore considered vulnerable to overexploitation and advice must be conservative. The fact that the fishery is targeting a localized aggregation of fish is cause for concern as is the absence of juveniles in the area. Given the biology of the species and the uncertainty in the biomass trend, any advice should consider this a hot spot fishery as it is potentially detrimental to this local and potentially important aggregation of larger fish. The fishery should still be at a low level involving few vessels. This should be maintained until the effect of the fishery can be clarified.

23.7 References

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G.H. 2001. Hjemmestyrets bekendtgørelse nr. 39 af 6. december 2001 om regulering af fiskeri ved tekniske bevaringsforanstaltninger. Http://www.nanoq.gl/gh.gllove/dk/2001/bkg/bkg_nr_39-2001_dk.htm

Sünksen, K. 2007. Discarded bycatch in shrimp fisheries in Greenlandic offshore waters 2006–2007. NAFO SCR doc. 07/88.

23.8 Tables

Table 23.3.1.1 Nominal landings (tonnes) of demersal *S. mentella* 1974–2019 ICES division 14.b.

Demersal *S. mentella*			
1974	0	2013	6 761
1975	4 400	2014	4 608
1976	59 700	2015	5 977
1977	0	2016	3 061
1978	5 403	2017	3 027
1979	5 131	2018	1 972
1980	10 406	2019	3 998
1981	19 391	2020	1 677
1982	12 140		
1983	15 207		
1984	9 126		
1985	9 376		
1986	12 138		
1987	6 407		
1988	6 065		
1989	2 284		
1990	6 097		
1991	7 057		
1992	7 022		
1993	14 828		
1994	19 305		
1995	819		
1996	730		
1997	199		
1998	1 376		
1999	853		
2000	982		
2001	901		
2002	2109		
2003	446		
2004	482		
2005	267		
2006	202		
2007	226		
2008	92		
2009	895		
2010	6 613		
2011	7 376		
2012	6 243		

Table 23.3.3.2 Landings (tonnes) of demersal redfish (*S. mentella* and *S. norvegicus*) caught in ICES 14.b by nation.

Year	DEU	ESP	EU	FRO	GBR	GRL	ISL	NOR	POL	RUS	UNK	Sum
1999											853	853
2000	884		11			19		65			3	982
2001	782				11	9		99				901
2002	1703			48	16	246	29	32		36		2109
2003	3	2	2	20	155	232		32				446
2004	5	1	79	12	221	93		68	3			482
2005	2		4	38	96	72		56				267
2006	1					152		48				202
2007	7		15	138		35		30				226
2008	1		8	50	5	5		23				92
2009				203		822		93				1118
2010	10		12	381		5672		2190		1		8266
2011	1262		26	2		6757		334		1		8381
2012	1810		5	32		5964	1	403		1		8216
2013	1957			32	30	5863		356		8		8246
2014	1973		0.2	13		4611	98	613		5		7314
2015	1987			74		4979	208	822		469		8539
2016		-	1759	25	2	5859	-	858	-	-	-	8503
2017	1060		537	31		4736		787		418		7568
2018	418		1295	48		3276		489		450		5976
2019	976		1021	5		3410		985		266		6663
2020			2050	9		2399		1069		256		5782
Sum	14841	3	6824	1161	536	55211	336	9452	3	1911	856	91132

Table 23.3.4.1 Discarded bycatch (tonnes) of *Sebastes sp*. from the shrimp fishery in ICES 14.b.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1999	6	16	17	5	1	13	2	48	22	30	40	33	234
2000	10	3	31	17	15	4	21	78	28	18	9	6	239
2001	7	9	10	16	9	11	4	5	3	3	28	6	111
2002	3	11	9	6	1	0	0	5	4	8	3	5	55
2003	5	6	8	5	5	8	8	15	2	10	12	4	88
2004	7	10	17	13	4	2	27	20	7	2	9	0	118
2005	7	14	16	8	7	5	6	21	14	4	5	20	126
2006	6	2	4	1	3	5	2	4	4	0	0	4	35
2007	7	3	2	1	0	0	0	0	0	0	0	0	14
2008	0	2	2	0	0	1	0	0	0	0	0	1	7
2009	1	2	11	1	0	0	0	0	0	0	0	0	16
2010	1	2	2	1	1	0	1	0	0	0	0	2	10
2011	0	0	0	0	1	0	0	0	0	0	0	0	3
2012	0	0	1	1	1	0	0	0	0	0	0	0	4
2013	0	1	1	0	0	0	0	0	0	0	0	0	2
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	60	81	131	75	48	49	71	196	84	75	106	81	1056

Table 23.3.4.2 Landings (tonnes) of demersal redfish (*S. mentella* and *S. norvegicus*) caught in ICES 14.b. by month.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1999		10		108		4	42	10	15	34	481	149	853
2000	18	238	286	260	10	4	79	72	13	0	3		982
2001			1				108	2		184	369	236	901
2002		183	445	354	390	50	472	35	44	59	77		2109
2003			9	4	26	27	135	195	20	16	12		446
2004				35	41	63	75	48	64	96	25	35	482
2005			1	15	66	24	80	29	13	18	19		267
2006		3	7	50	14	39	20	61	2	1	1	2	202
2007	6	13	8	8	14	42	4	106	16	7	1	1	226
2008	4	3	1	6	12	11	31	12	10	2			92
2009				1	84	346	148	105	128		288	17	1118
2010	799	786	708	1058	2149	2100	108	134	88	301	36		8266
2011	419	1396	1661	1017	268	250	236	598	255	583	1223	475	8381
2012	899	2197	628	852	577	699	966	143	44	23	474	712	8215
2013			709	1290	925	1423	1218	1086	723	227	119	527	8246
2014	10	421	206	1210	1187	1709	231	401	376	448	632	479	7314
2015	543	786	1016	451	507	1611	1160	1024	504	393	74	467	8539
2016	306	214	1130	1185	1426	1864	1298	559	466	38	14	1	8501
2017	373	1977	1368	751	308	513	1111	249	38	651	102	124	7568
2018	798	1273	819	779	367	189	1049	22	176	234	225	45	5976
2019	23	211	1102	653	1359	1316	601	520	365	379	36	98	6663
2020	22	354	510	17	129	2189	731	705	439	309	310	67	5782
Sum	4220	10065	10616	10104	9859	14472	9904	6116	3798	4003	4521	3435	91129

23.9 Figures

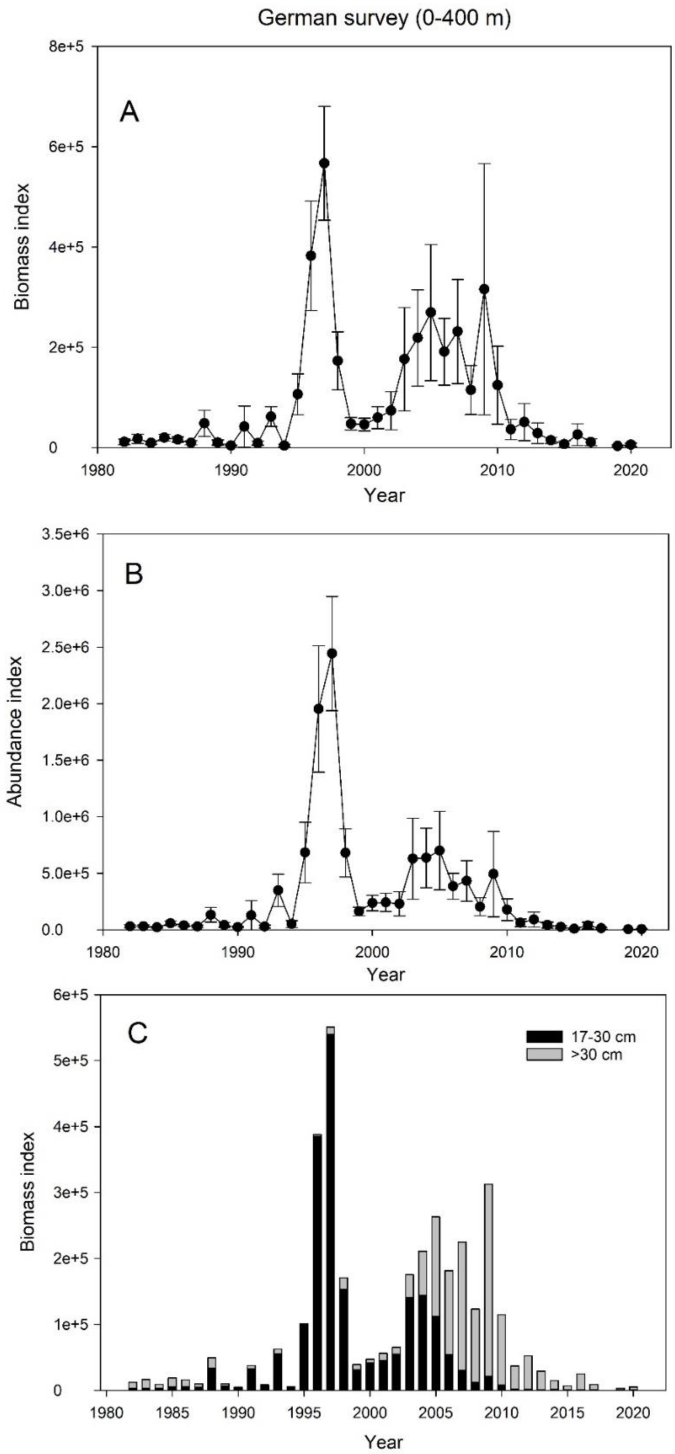

Figure 23.2.1. Indices from the German East Greenland survey of *S. mentella* larger than 17 cm. Biomass (A), abundance (B), and biomass split on length (C). On figure (C) the grey bars represent the biomass of *S. mentella* larger than 30 cm and the dark bars biomass in fish from 17–30 cm. No survey was conducted in 2018.

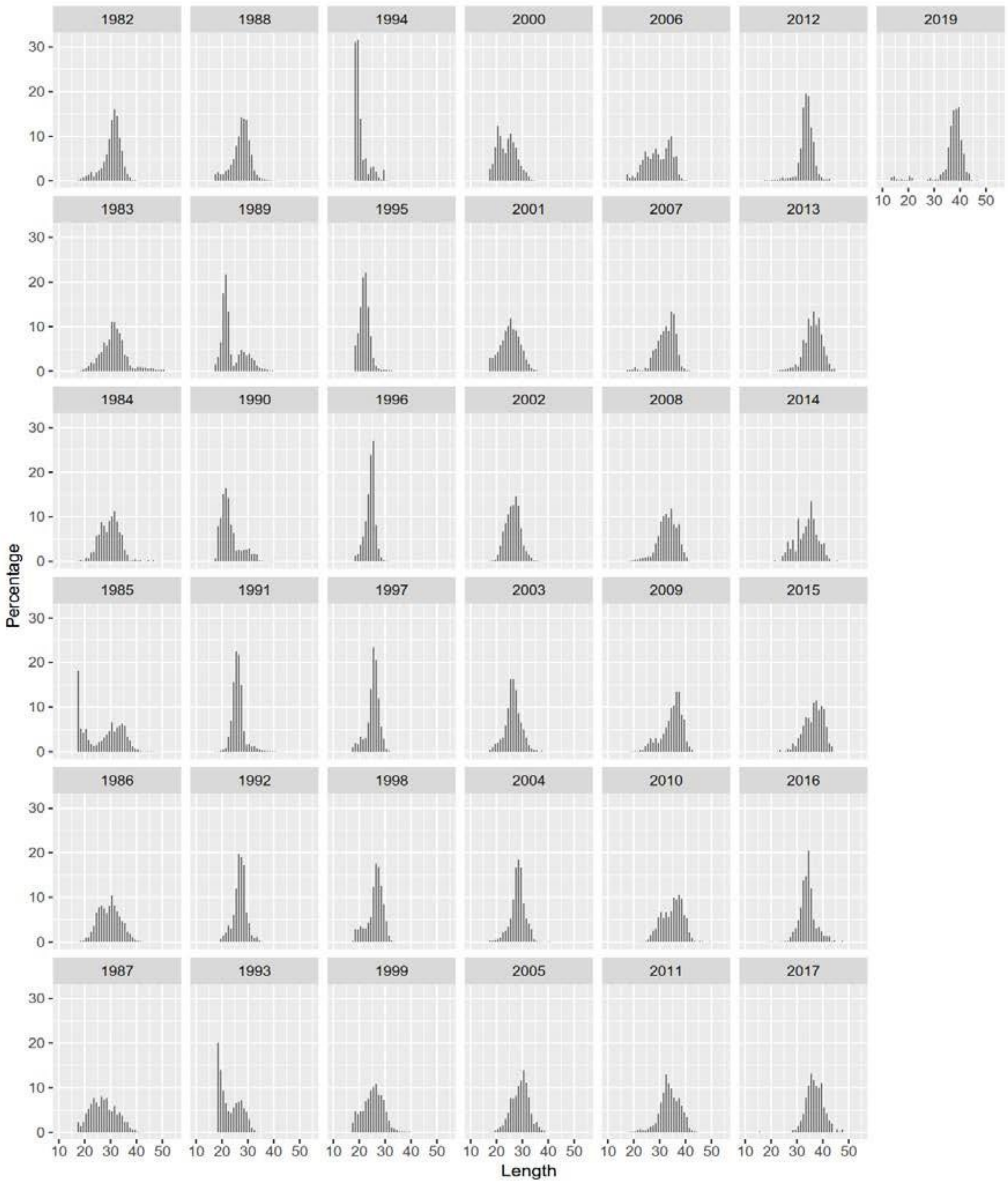

Figure 23.2.2. Length distributions from the German East Greenland survey 1985–2019. In 2018, the survey was not conducted due to break down of the German research vessel. Not updated for 2020.

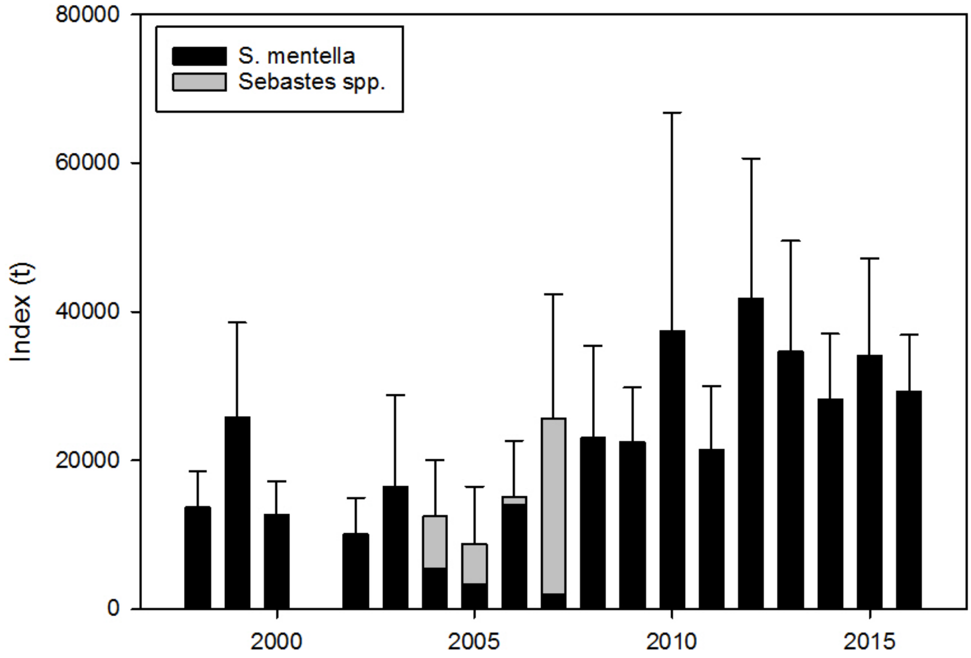

Figure 23.2.3. Biomass of *S. mentella* and *Sebastes* spp. derived from the Greenland deepwater survey. Bars indicate 2SE of the biomass of *S. mentella* including *Sebastes* spp. No survey in 2001. In 2004, 2005 and 2007 a large proportion of the redfish were not determined to species and only reported as "*Sebastes* spp". Considering the depth these are most likely *S. mentella*. In 2017, the survey was aborted due to vessel break down. In 2018 and 2019, no research vessel was available.

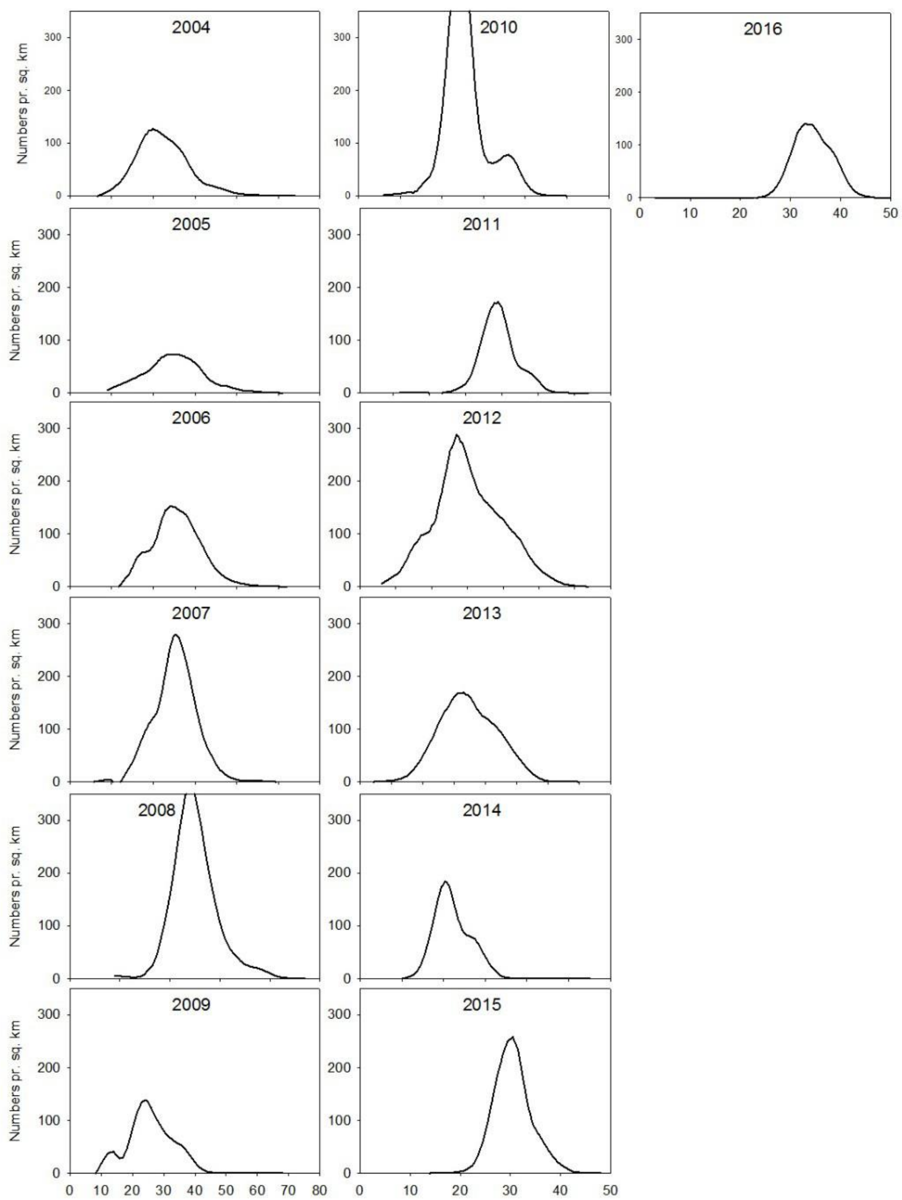

Figure 23.2.4. Overall length distribution of *Sebastes mentella* (number per km^2) from the deep Greenland survey. In 2017, the survey was aborted due to vessel break down. In 2018 and 2019, no research vessel was available and in 2020, only Greenland shallow survey was carried out. Therefore, no new data is available.

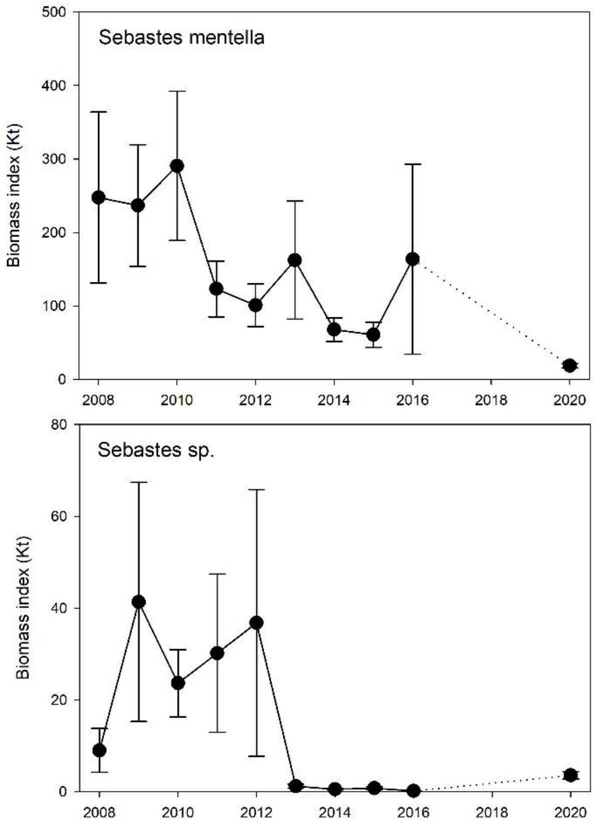

Figure 23.2.5: Biomass (kg*10^6, kt) (±CV%) indices for *S. mentella* (top) and *Sebastes* sp. (< 18 cm) (bottom) off East Greenland in 2008–2016 and in 2020 from the Greenlandic shallow water survey. All surveyed areas are combined (Q1–Q6). In 2017, the survey was aborted due to vessel break down. In 2018 and 2019, no research vessel was available. In 2020, a full survey was carried out.

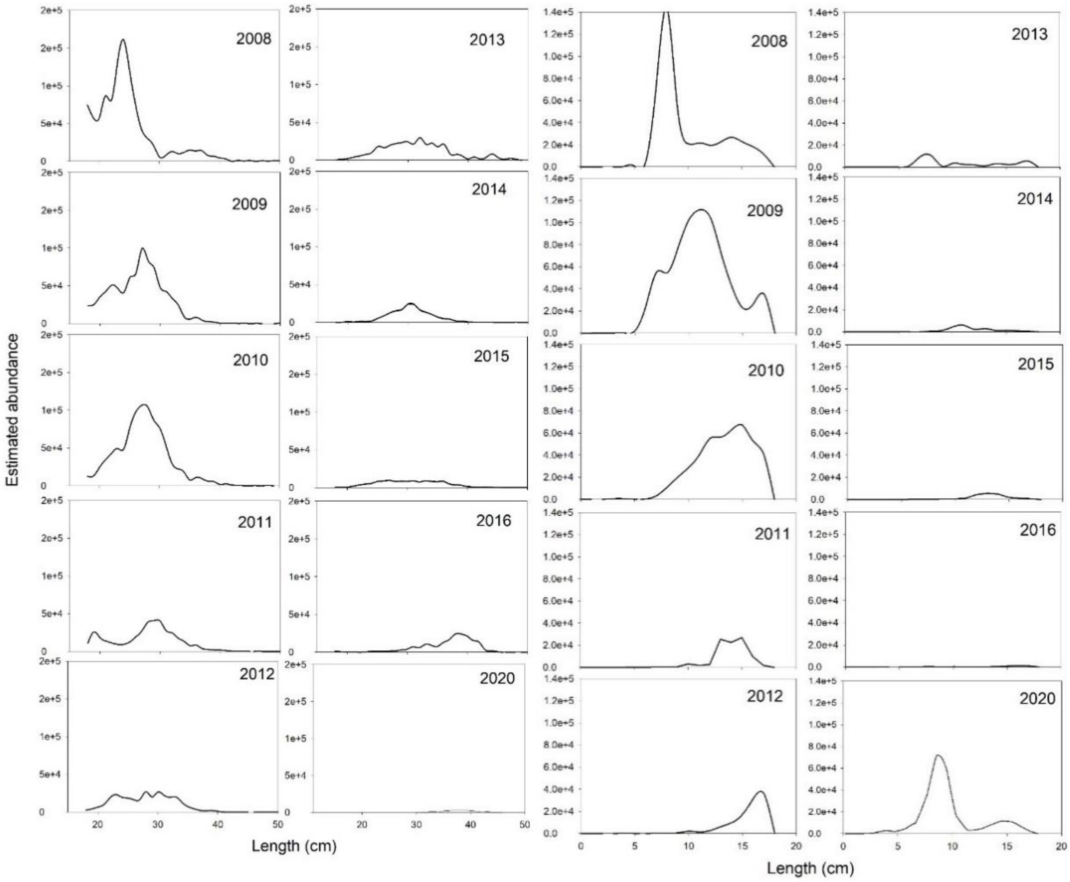

Figure 23.2.6. Overall length distributions for *S. mentella* (left) and *Sebastes spp.* < 18 cm (right) from the Greenland shallow water survey. All surveyed areas combined (Q1–Q6). In 2017, the survey was aborted due to vessel break down and in 2018 and 2019, no research vessel was available. In 2020, a full survey was conducted.

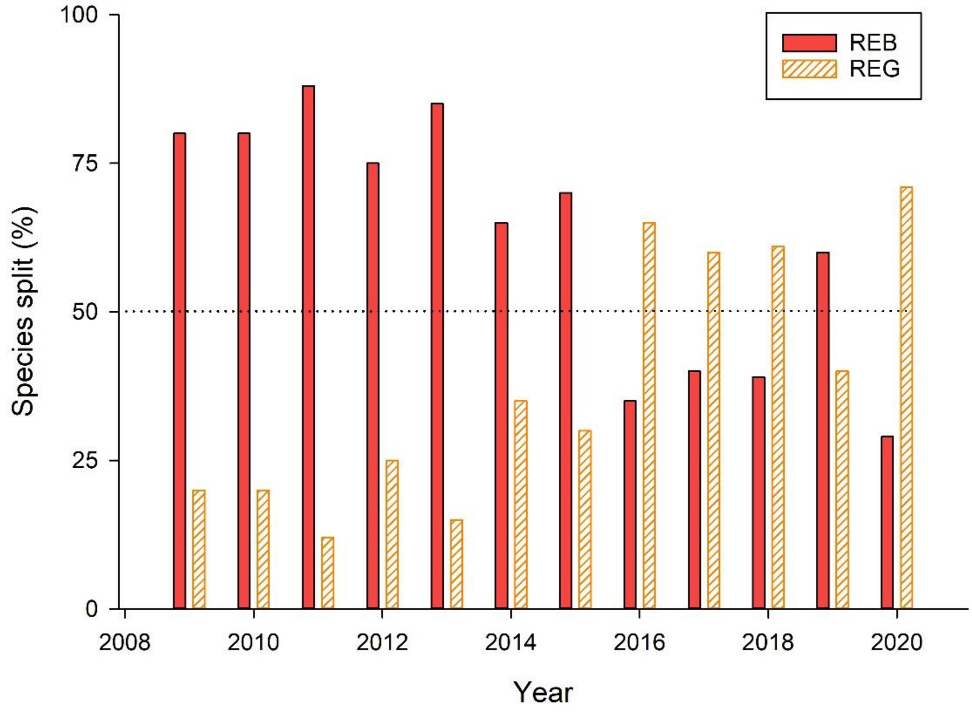

Figure 23.3.1.1. Development in split of *S. mentella* (REB) and *S. norvegicus* (REG) in the fisheries on the Greenland slope.

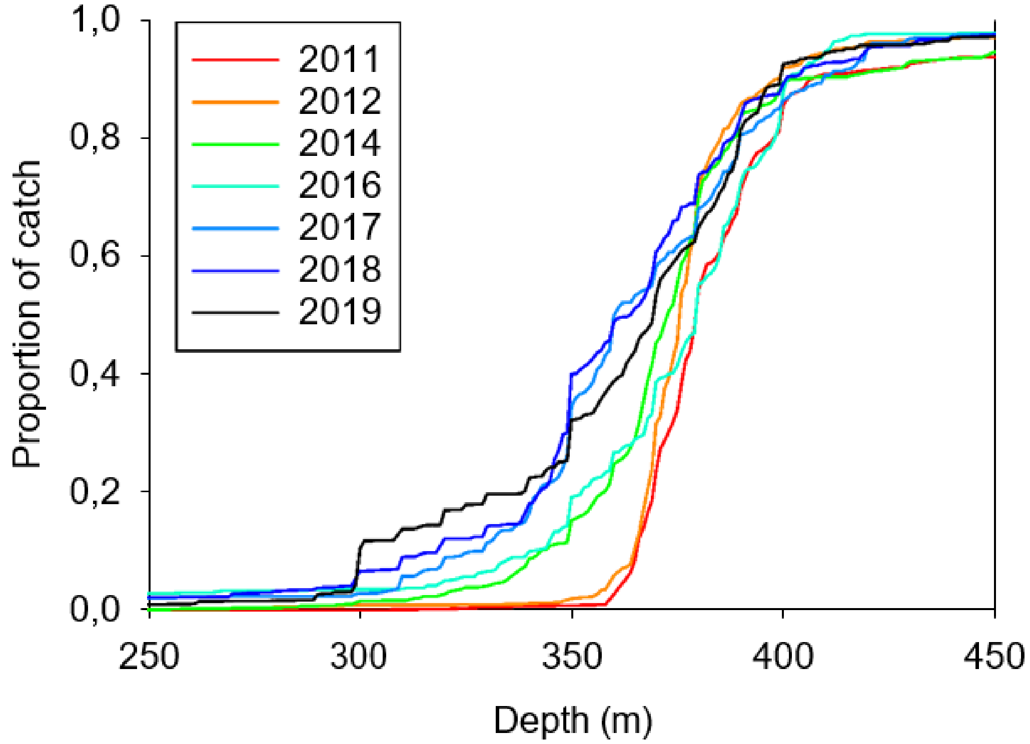

Figure 23.3.1.2 Development in catch depth of *Sebastes* (*S. mentella* and *S. norvegicus* combined). Not updated for 2020.

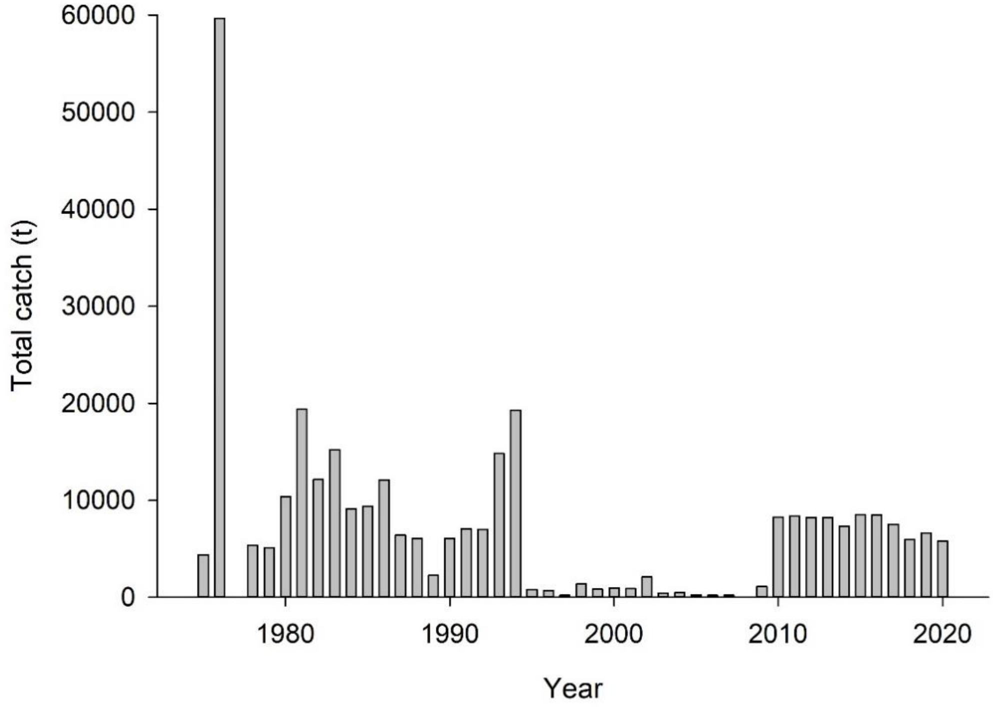

Figure 23.3.1.3 Landings of *S. mentella* in subarea 14.b. Landings of "redfish" have been split based on estimates from survey and commercial catches.

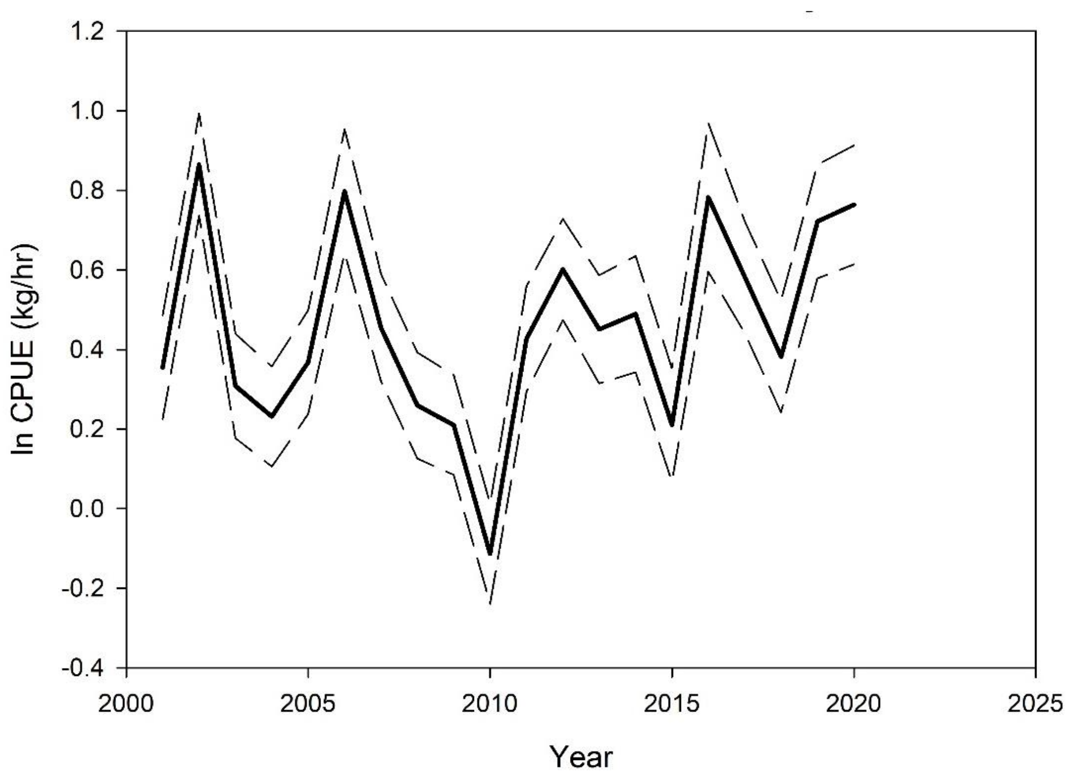

Figure 23.3.2.1 Standardized redfish bycatch CPUE in the directed fishery for Greenland halibut in ICES 14.b as a function of year. CPUE was estimated from the GLM model: lnCPUE = year + ICES Subdivision + depth. Bars represent standard error. Only hauls made below 1000m were used in the analyses.

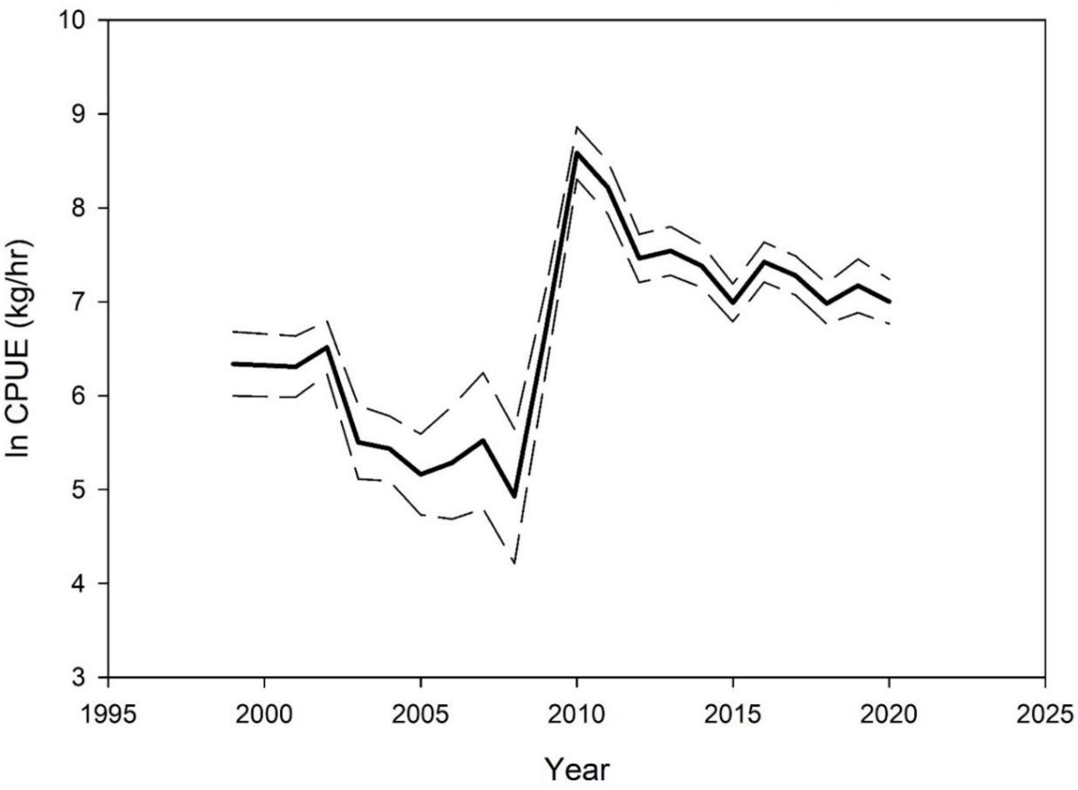

Figure 23.3.2.2 Standardized redfish CPUE in the redfish directed fishery ICES 14.b as a function of year. CPUE was estimated from the GLM model: lnCPUE = year + ICES Subdivision + depth. Dashed lines represent standard error.

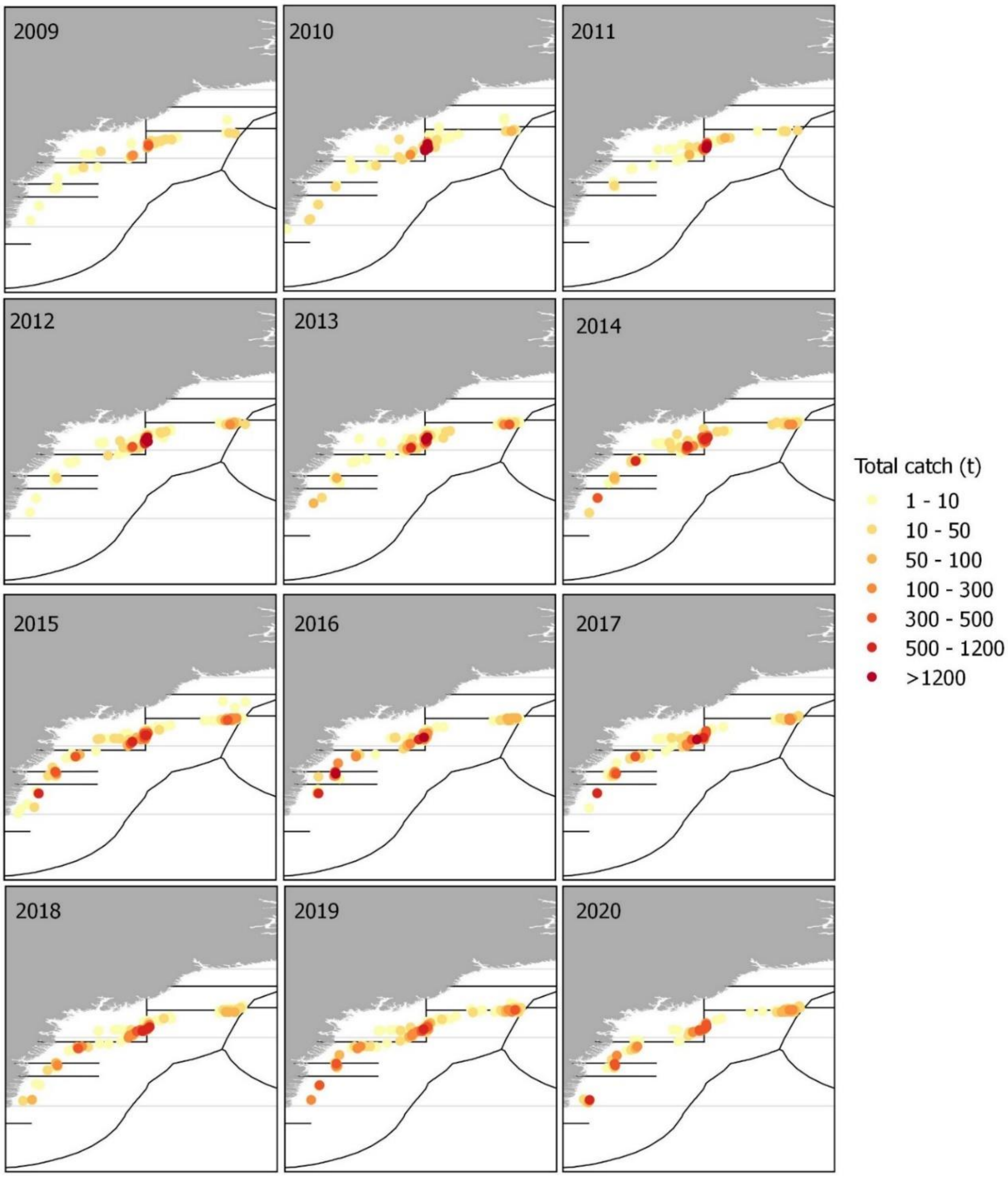

Figure 23.3.3.1 Distribution of catches of demersal redfish (*S. mentella* and *S. norvegicus*) between 2009 and 2020 in ICES 14.b.

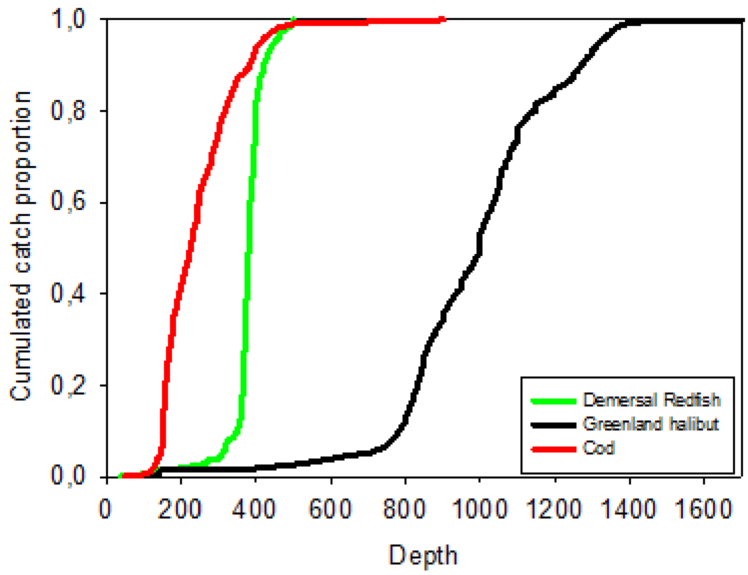

Figure 23.3.3.2. Lines represent the share of the total commercial catch caught at a given depth from 1999–2011 in *G. morhua*, demersal redfish (mixed *S. mentella* and *S. norvegicus)* and *R. hippoglossoides*.

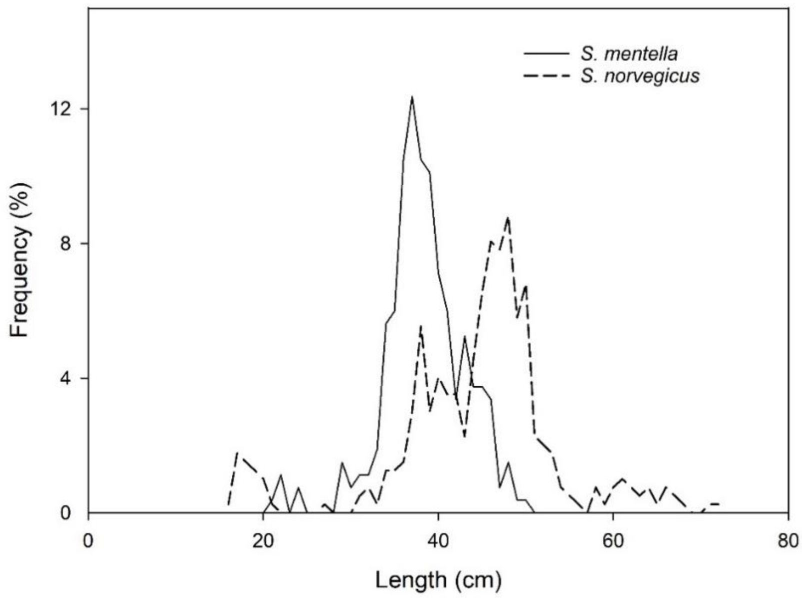

Figure 23.3.5.1: Length distribution of 672 redfish analysed by the Greenland Institute of Natural Resources in 2020 separated into *S. mentella* (N=273) and *S. norvegicus* (N=399).

24 Icelandic plaice in 5.a

24.1 General information

Icelandic plaice is found on the continental shelf around Iceland with the highest abundance in the southwest and west of the island. It is mainly found on a sandy or muddy substrate, occurring at depths ranging from the coast down to 200 meters, sometimes even deeper (Jónsson & Pálsson, 2013).

Sexual dimorphism occurs in plaice, as females grow larger than males and mature at larger size. Only a small proportion of males become longer than 45 cm, but about the same proportion of females grow larger than 55 cm. Size at sexual maturity differs between the sexes, whereas at the length of 33 cm about half the males have reached maturity, but females reach that level at 38 cm length. Spawning occurs mostly at 50–100 m depth in the relatively warm waters south and west of Iceland, but there is small-scale spawning off the northwest and north coast (Sigurðsson, 1989 and Sólmundsson *et al.*, 2005). After metamorphosis, the 0-group juveniles seek bottom in shallow waters and spend the first summer just below the tidemark (Pálsson & Hjörleifsson, 2001).

24.2 Fishery

Plaice fishery has been considered stable in last two decades and annual landings have been between 5 and 8 thousand tonnes (Figure 24.2.1 and Figure 24.2.3). Main fishing grounds for plaice are in the west and southwest of Iceland, with smaller fishing areas in the southeast and several fjords in the north (Figure 24.2.4 and Figure 24.2.5). Demersal seine is the main fishing gear for plaice (65–71% since 2011) in Iceland followed by demersal trawl (23–30%), while a small proportion of the catch is taken in gillnets and longline (Figure 24.2.3). Seiners dominate the coastal plaice fishery, but trawlers catch them deeper and further offshore. Plaice fishing grounds in 2012–2020, as reported by mandatory logbooks, are shown in Figure 24.2.5.

Since 2000, the main fishing grounds of plaice have been on the southwestern, western and north-western part of the Icelandic shelf (Figure 24.2.2). Spatial distribution of the Icelandic plaice fishery has been relatively stable, with around 60% of the plaice caught on the western and north-western part of the shelf. In the last decade, reported catches have increased in the southwestern part but decreased again last year to previous proportions. On the contrary, an increase in reported caches was observed in western and north-western part of the self in 2020. Plaice is caught in relatively shallow water, with most of the catch (60–80%) taken at depths of 21–80 m (Figure 24.2.2). Plaice is primarily caught in demersal seine and demersal trawl or around 95% of the total catch (Figure 24.2.3). This proportion has been relatively stable through the years, as well as the relative amount caught in other gear (predominantly gillnets) with around 5–10% of the catch since 2004.

Since 2000, the number of vessels reporting catches over 1000 kg of plaice in total annually has decreased, whereas total catches have been increasing in the past few years. This decrease is most noticeable in the demersal seiner fleet, where the number dropped from 92 vessels in 2004, to 41 in 2018. The number of trawlers has remained relatively stable since 2010 (Table 24.1.1). Total annual catch of plaice has been relatively stable (4900–8300 t) over the last 20 years. In 2020, a total of 7505 t of plaice were caught, about 675 t more than in 2019.

24.2.1 Landing trends

Landings of Icelandic plaice in 2020 are estimated to have been 7.5 thousand tonnes, see Figure 24.2.1 and Table 24.1.1. Landings in Division 5.a. have decreased from around 14.5 thous. tonnes in 1985, which historically was the maximum level observed to the current level which are almost the half of the highest landed catch.

Landings by foreign vessels were considerable before the Icelandic EEZ was expanded to 200 nautical miles 1975, afterwards landings were primarily by the Icelandic fleet. Foreign vessels were the most significant with regards to landed plaice before WW2, but during the war period the Icelandic fleet picked up and took over the majority of fisheries in Icelandic waters. Through years 1946–1973 the landings were divided between both foreign and Icelandic fleet.

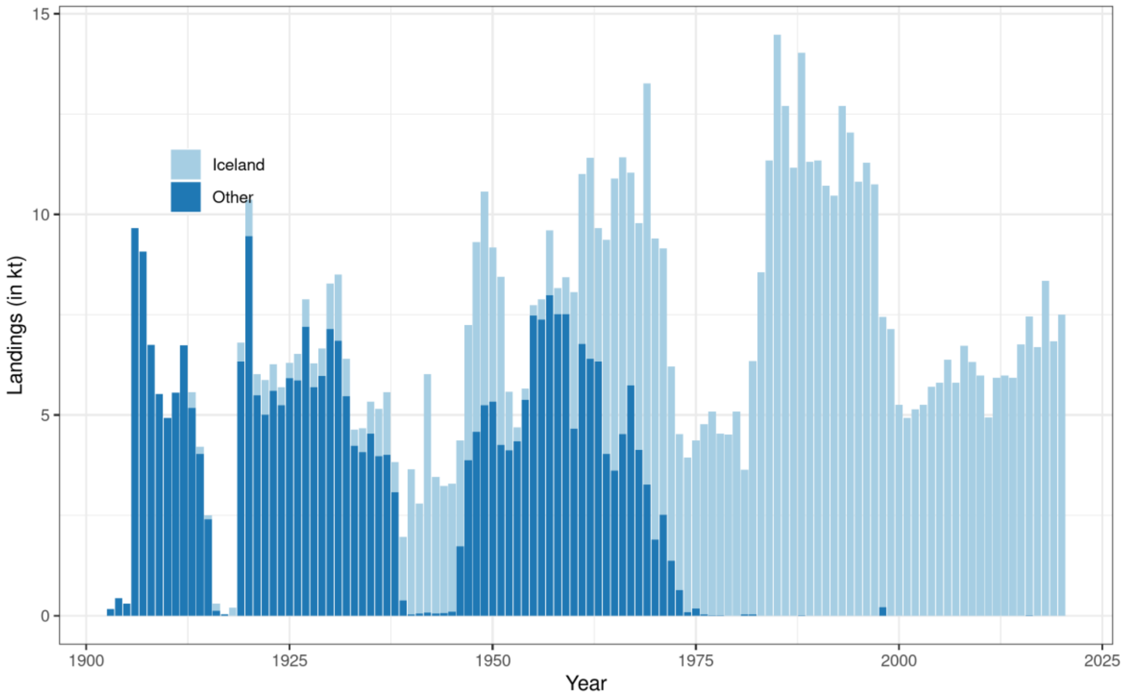

Figure 24.2.1: Plaice in Division 5.a. Recorded landings 1903–2020.

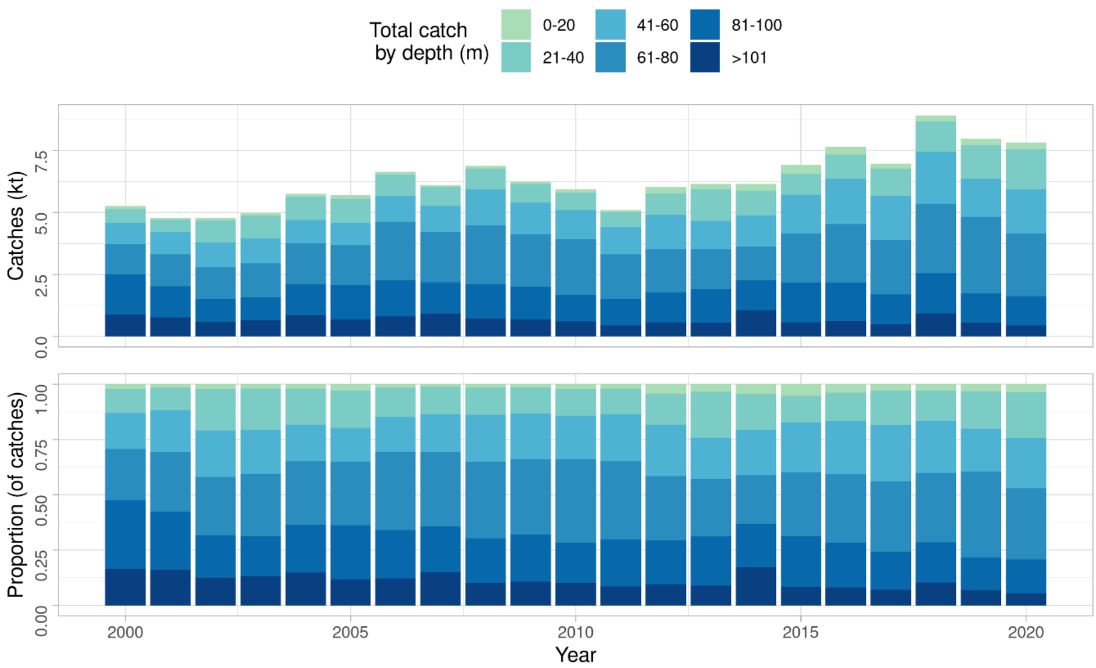

Figure 24.2.2: Plaice in 5.a. Depth distribution of plaice catches from bottom trawls and demersal seine according to Icelandic logbooks.

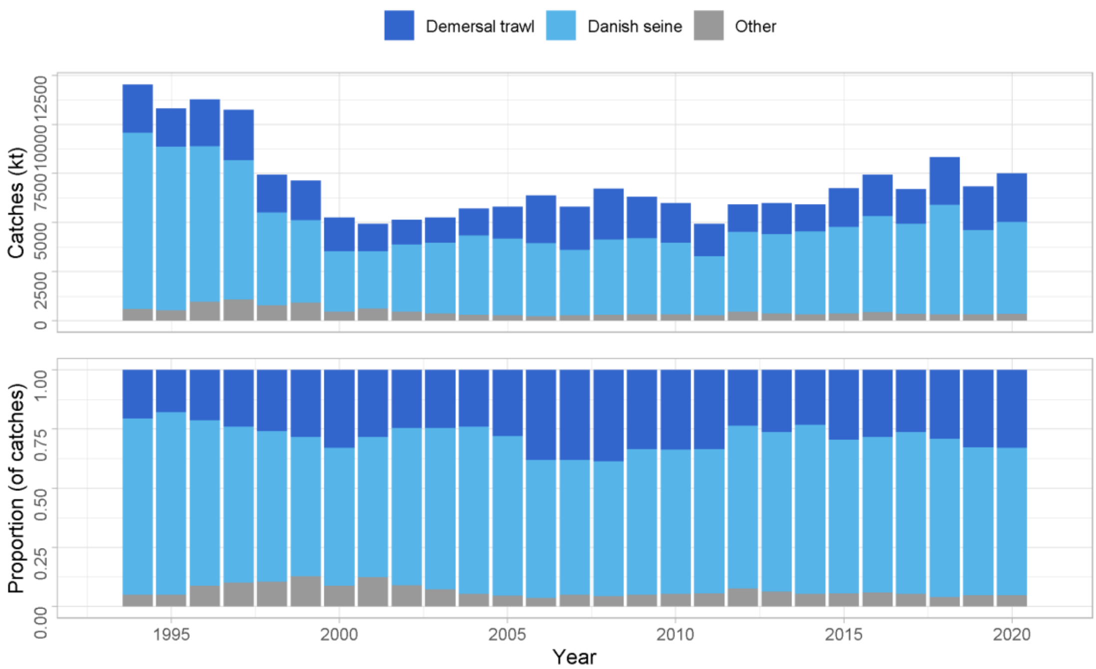

Figure 24.2.3: Plaice in Division 5.a. Landings in tons and percent of total by gear and year.

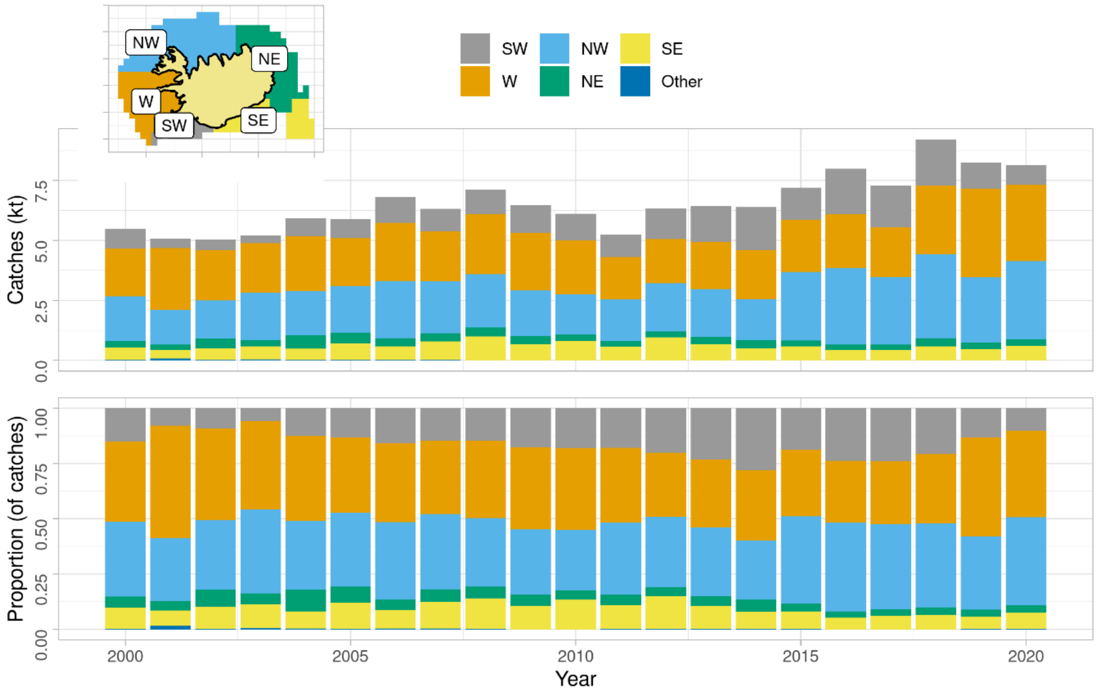

Figure 24.2.4: Plaice in 5.a. Changes in spatial distribution of plaice catches as recorded in Icelandic logbooks.

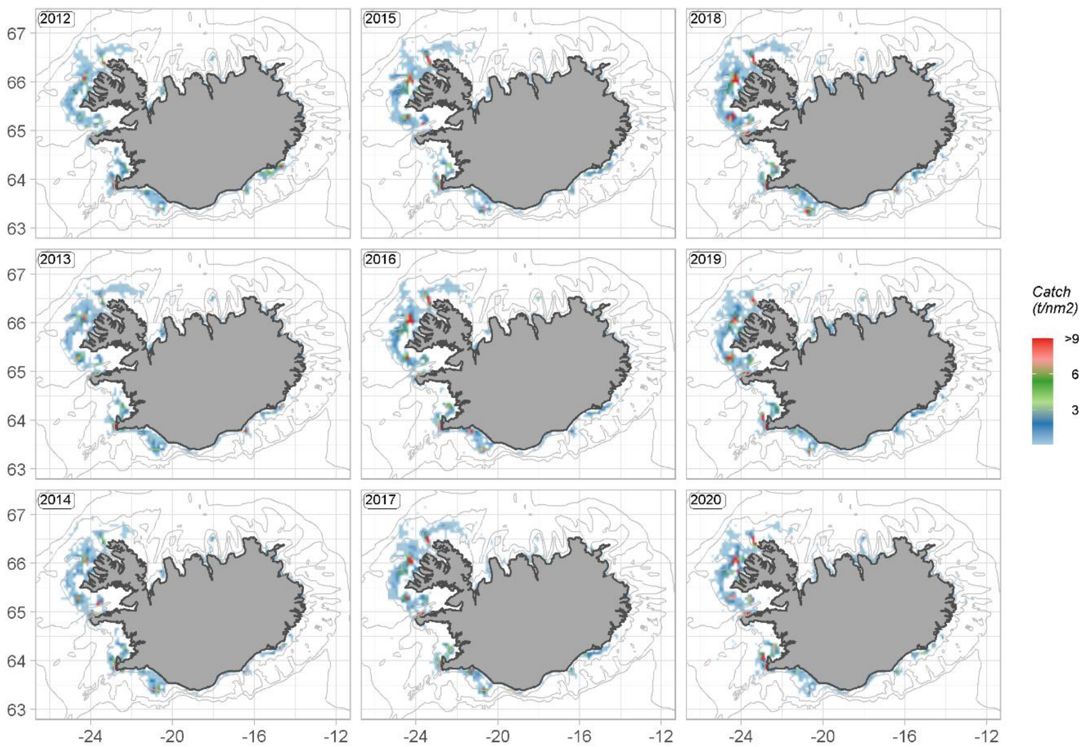

Figure 24.2.5: Plaice in 5.a. Spatial distribution of catches by all gears.

24.3 Management

The Ministry of Industries and Innovation (MII) 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. Plaice was included in the ITQ system in the 1991/1992 quota year and as such subjected to TAC limitations. For the first six years, the TAC was set higher than recommended by Marine Research Institute (MRI), but this practice stopped in the 2010/2011 quota year (Table 24.1.4). One reason is that no formal harvest rule exists for this stock. Through this time period the landings have been fluctuating between the over- or undershoot the set TAC and this is 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 effect of these species transformations and quota transfers is illustrated in Figure 24.3.1.

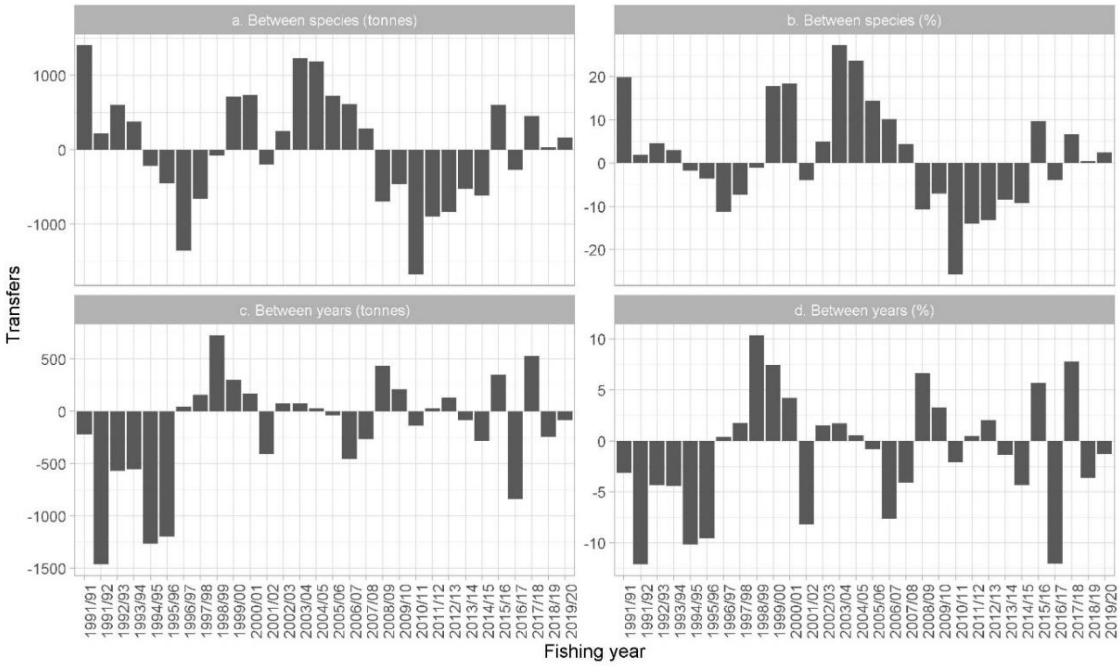

Figure 24.3.1: Plaice in 5.a. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

24.4 Data available

Sampling of biological data from main gears (Danish seine and bottom trawl) in commercial catches is considered good in general. The sampling does cover the spatial distribution of catches to a satisfactory extent. The sampling coverage by gear in 2020 is shown in Figure 24.4.1. Due to the COVID-19 pandemic in 2020, researchers from MRFI and inspectors from Directorate of Fisheries in Iceland had difficult time obtaining necessary samples for biological measurements from the fisheries, therefore sampling locations and numbers were fewer than usual during this year.

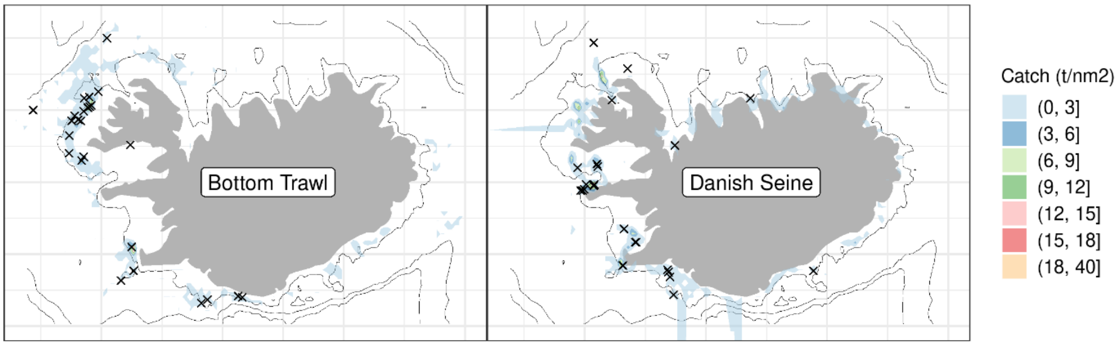

Figure 24.4.1: Plaice in 5.a. Fishing grounds in 2020 as reported in logbooks (colours) and positions of samples taken from landings (asterisks) by main gear types.

24.4.1 Landings and discards

All landings in 5.a before 1982 are derived from the STATLANT database, and also all foreign landings in 5.a 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 (Figure 24.2.1). Discarding is banned by law in the Icelandic demersal fishery. Discard rates in the Icelandic fishery for plaice are estimated negligible at least since 2001. 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/fisheries-management/statement-on-responsible-fisheries.

24.4.2 Length compositions

An overview of available length measurements from 5.a is given in Table 24.1.2. Most of the measurements are from the two main fleet segments, i.e. trawls and demersal seine.

Length distributions from the main fleet segments are shown in Figure 24.2.2. The sizes caught by the main gear types (bottom trawl and Danish seine) appear to be fairly stable, primarily catching plaice in the size range between 35 and 55 cm. There has been a shift towards larger fish in the length distribution. As a result, the average length in the samples taken from commercial catch has increased from 35 cm in 1991 to 43.1 cm in 2016 and was 42 cm in 2020.

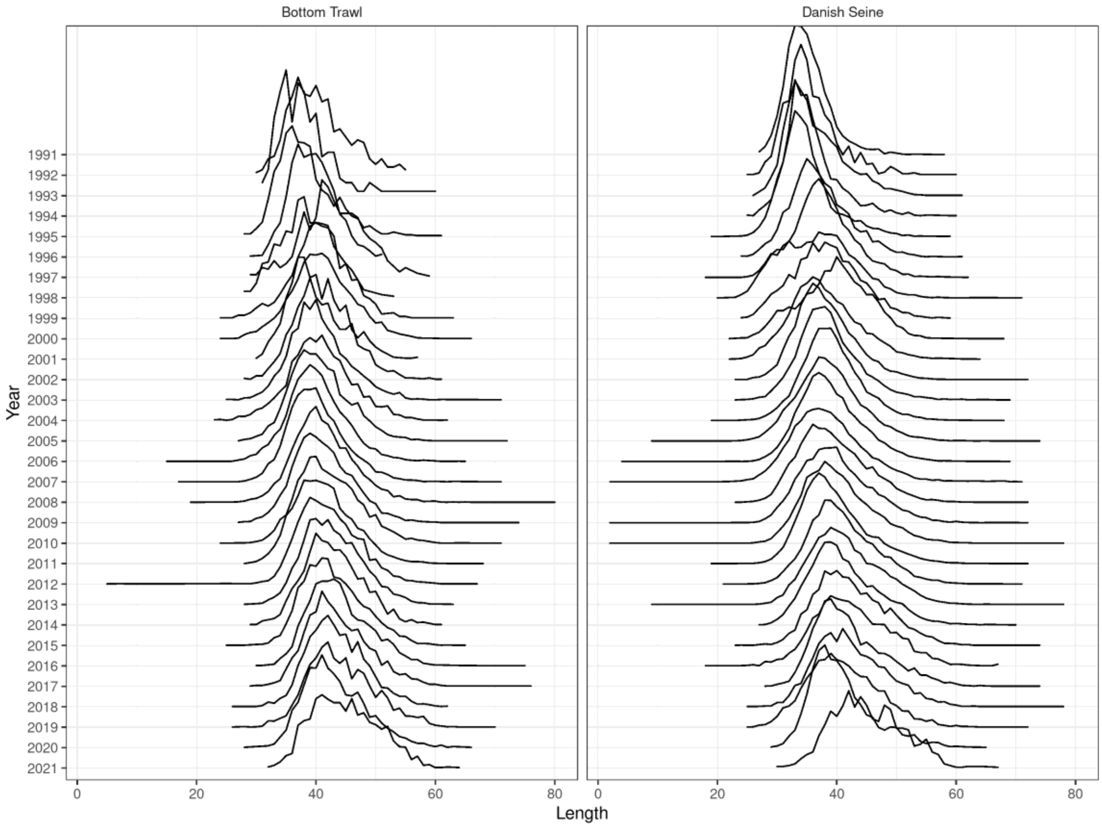

Figure 24.4.2: Plaice in 5.a. Commercial length distributions by gear and year.

24.4.3 Age compositions

Table 24.1.3 gives an overview of otolith sampling intensity by gear types in 5.a. In 2002–2005 the majority of the catch was 4–7 years old plaice, or about 60% of landings in terms of estimated numbers (Figure 24.4.2). The proportion of these age classes in the catch then decreased and for the last five years it has been 40–45%. Thus, plaice in the catch have gradually become older, and as an example the average age of plaice caught has increased from 6.3 years in 2001–2007 to 7.0 years in 2012–2016. In recent years, 2017–2019, the largest cohorts have been 6–8-year-old fish, however in last two years 4–7-year-old fish were most common, similar to 2001–2007.

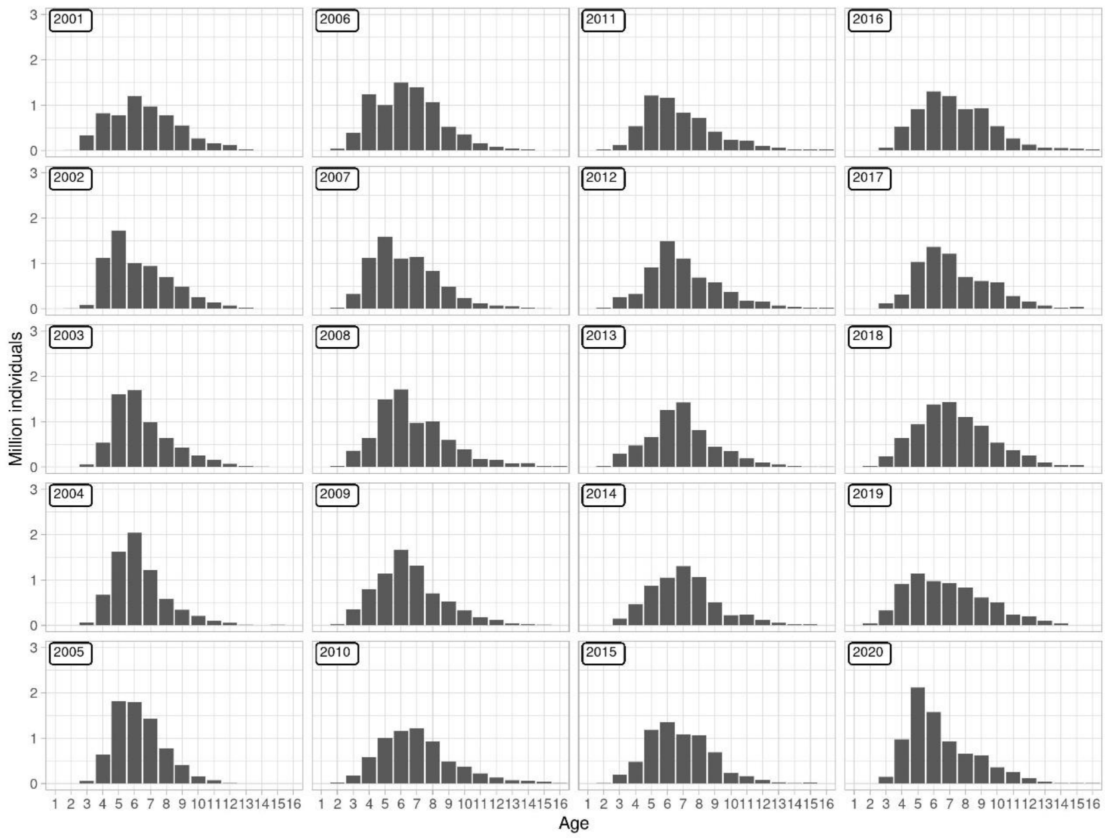

Figure 24.4.2: Plaice in 5.a. Estimated age distribution of landed catch based on landings and otoliths collected from landed catch.

24.4.4 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.

24.4.5 Catch, effort and research vessel data

24.4.5.1 Catch per unit of effort (CPUE) and effort data from commercial fisheries

CPUE estimates of plaice in Icelandic waters are not considered representative of stock abundance as changes in fleet composition and technical improvements have not been accounted for when estimating CPUE.

Non-standardised estimates of CPUE in demersal seine (kg/set) is calculated as the total weight in sets in which plaice was more than 10% of the catch. CPUE gradually increased from 250 kg/set to about 700 kg/set in 2016 (Figure 24.4.3). CPUE of plaice in demersal seine has been around that level since then with some fluctuations in last two years.

CPUE of demersal trawl (kg/hour), in hauls where plaice is more than 10% of the catch, remained relatively stable around 150 kg/hour until 2010. CPUE of plaice has in trawl, like in the demersal seine fishery, gradually increased from 120 kg/hour in 2000 to about 300 kg/hour in 2019 and stayed at that level in 2020.

Fishing effort for plaice in the demersal seine fishery is estimated as the number of sets where plaice was more than 10% of the total catch. Fishing effort by seiners was high but variable in 2000–2006, since that period the effort decreased continuously and reached the lowest level in 2020 (Figure 24.4.3). This is both because fewer seiners are fishing and CPUE is higher. Effort in the demersal trawl fishery (number of towing hours where plaice was 10% or more of the total catch) has gradually decreased from the peak in 2004 to the lowest value in 2020 (Figure 24.4.3).

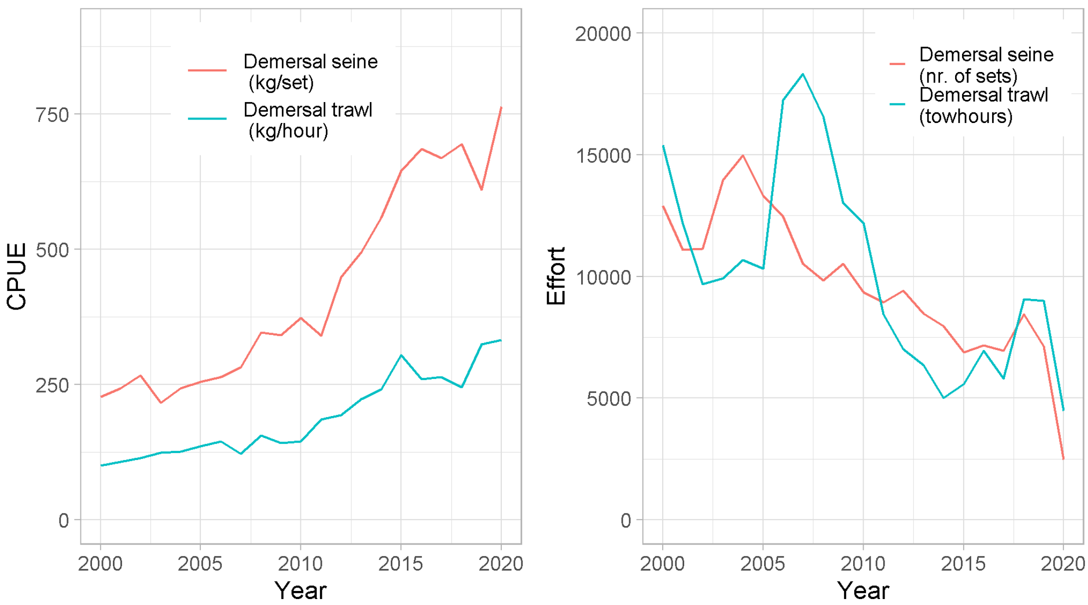

Figure 24.4.3: Plaice in 5.a. Non-standardised estimates of CPUE (left) and fishing effort (right) from demersal seine (kg/set or nr. of sets) in red and demersal trawl (kg/hour or towhours) in blue.

24.4.5.2 Icelandic survey data

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

The Icelandic spring groundfish survey, which has been conducted annually in March since 1985, covers the most important distribution area of the plaice fishery. In addition, the Icelandic autumn groundfish survey was commenced in 1996. The autumn survey was not conducted in 2011. The spring survey is considered to measure changes in abundance/biomass better than the autumn survey. It does not, however, adequately cover the main recruitment grounds for plaice, as recruitment takes place in shallow water in habitats unsuitable for demersal trawling. In addition to these two major surveys, there is a designated flatfish survey with beam trawl, conducted annually in July/August since 2016, with the aim to cover most of the recruitment grounds of plaice and other flatfish species. The plan is to incorporate this survey in the stock assessment for plaice in the future.

Figure 24.4.4 shows trends in various biomass indices and a recruitment index based on abundance of plaice smaller than 30 cm. Survey length-disaggregated abundance indices are shown in Figure 24.4.5 and Figure 24.4.6, and abundance and changes in spatial distribution in Figures 24.4.7–24.4.9. Results from the beam trawl survey are shown in Figures 24.4.10–24.2.12.

Total biomass index of plaice and plaice larger than 30 cm (harvestable part of the stock), decreased rapidly in the first years of the spring survey and were at the lowest level in 1997–2002. In 2003–2016 the indices gradually increased and stabilized. Since 2017 there have been minor annual fluctuation in the indices, but they are still fairly stable. This year's spring survey biomass index is in correspondence with the biomass from early 1990. The indices are now only one-third to half of what they were in the first four years of the time series. The index of plaice larger than 50 cm in the spring survey also decreased to lowest levels in 1997-2002 but has increased and has been in recent years at similar level as in the beginning of the time series. The index of juvenile abundance (<20 cm) has maintained at the low level since 1998 with occasional small peaks. Trends in the autumn survey are similar to those observed from the spring survey, but standard deviations in the measurements are higher.

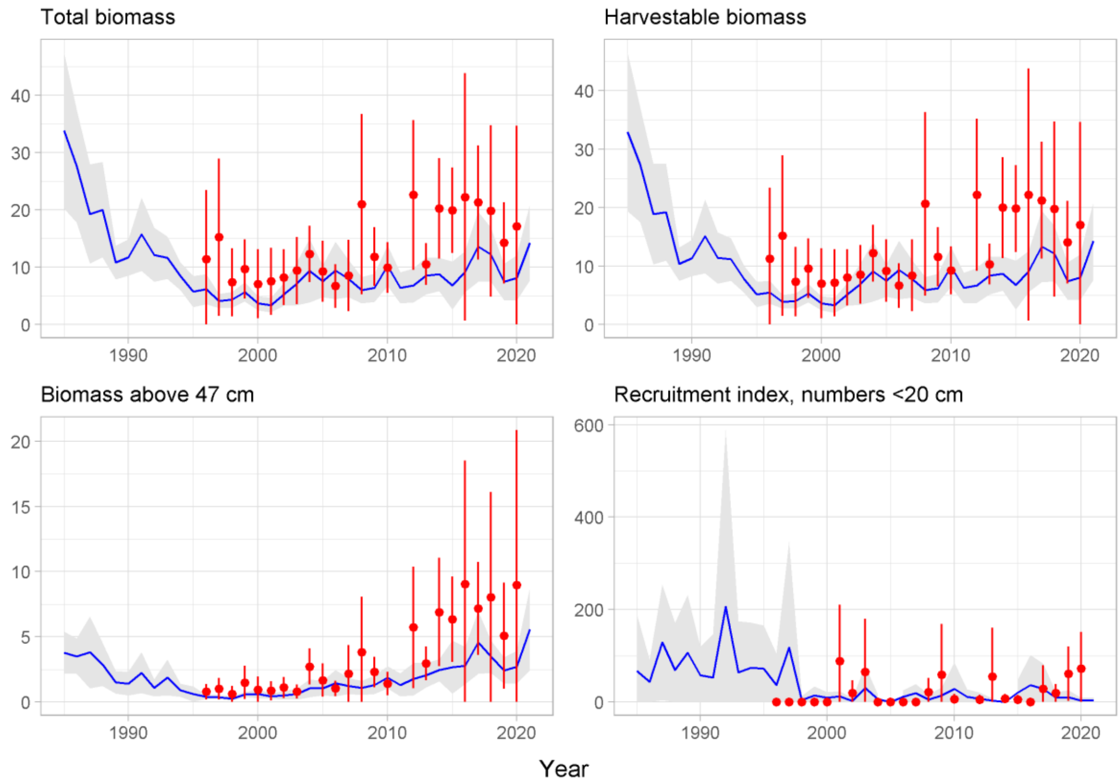

Figure 24.4.4: Plaice in 5.a. Indices in the Spring Survey (March) 1985 and onwards (blue line shaded area) and the autumn survey (red point ranges).

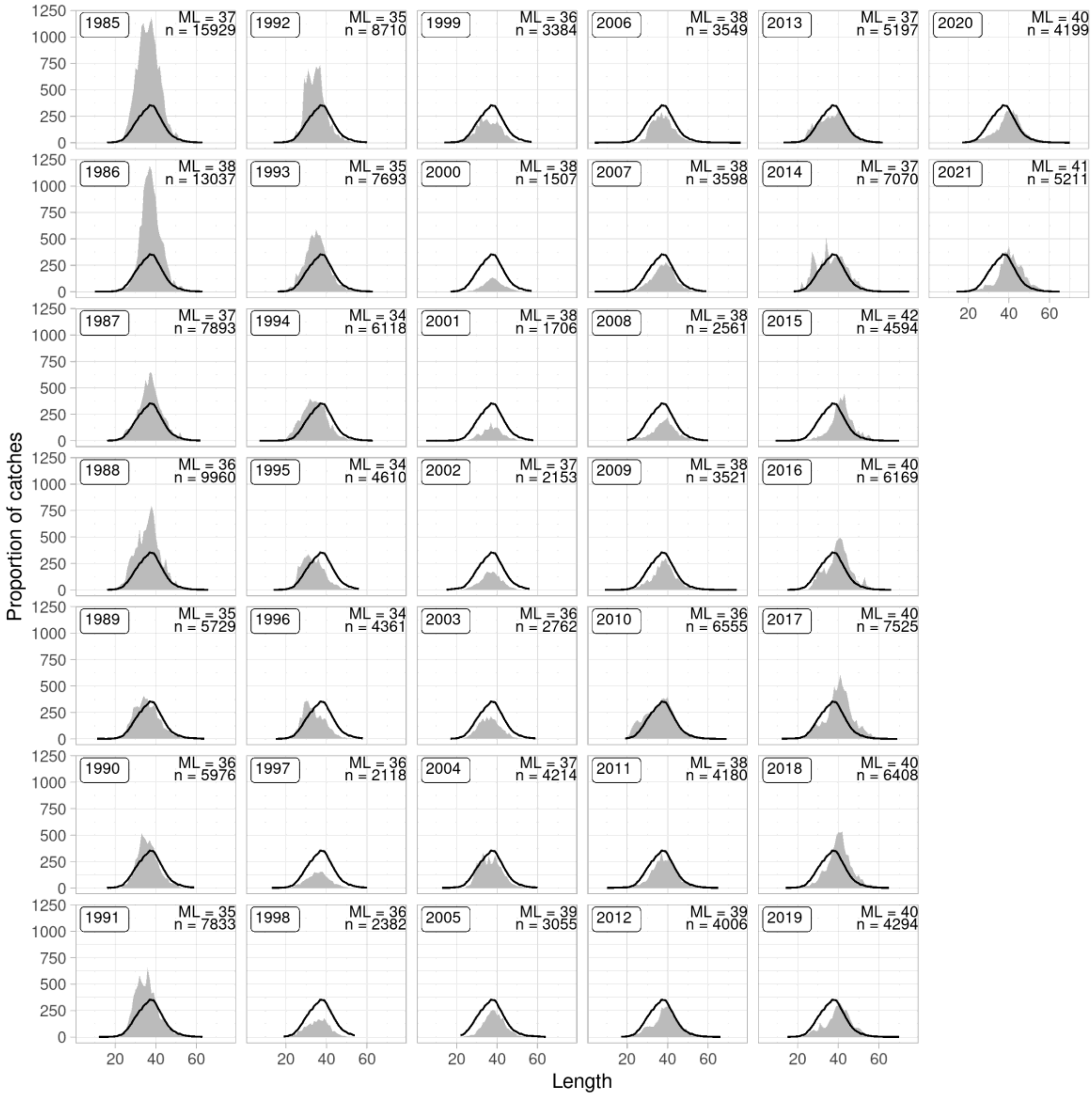

Figure 24.4.5: Plaice in 5.a: Length disaggregated abundance indices from the spring survey (March) 1985 and onwards.

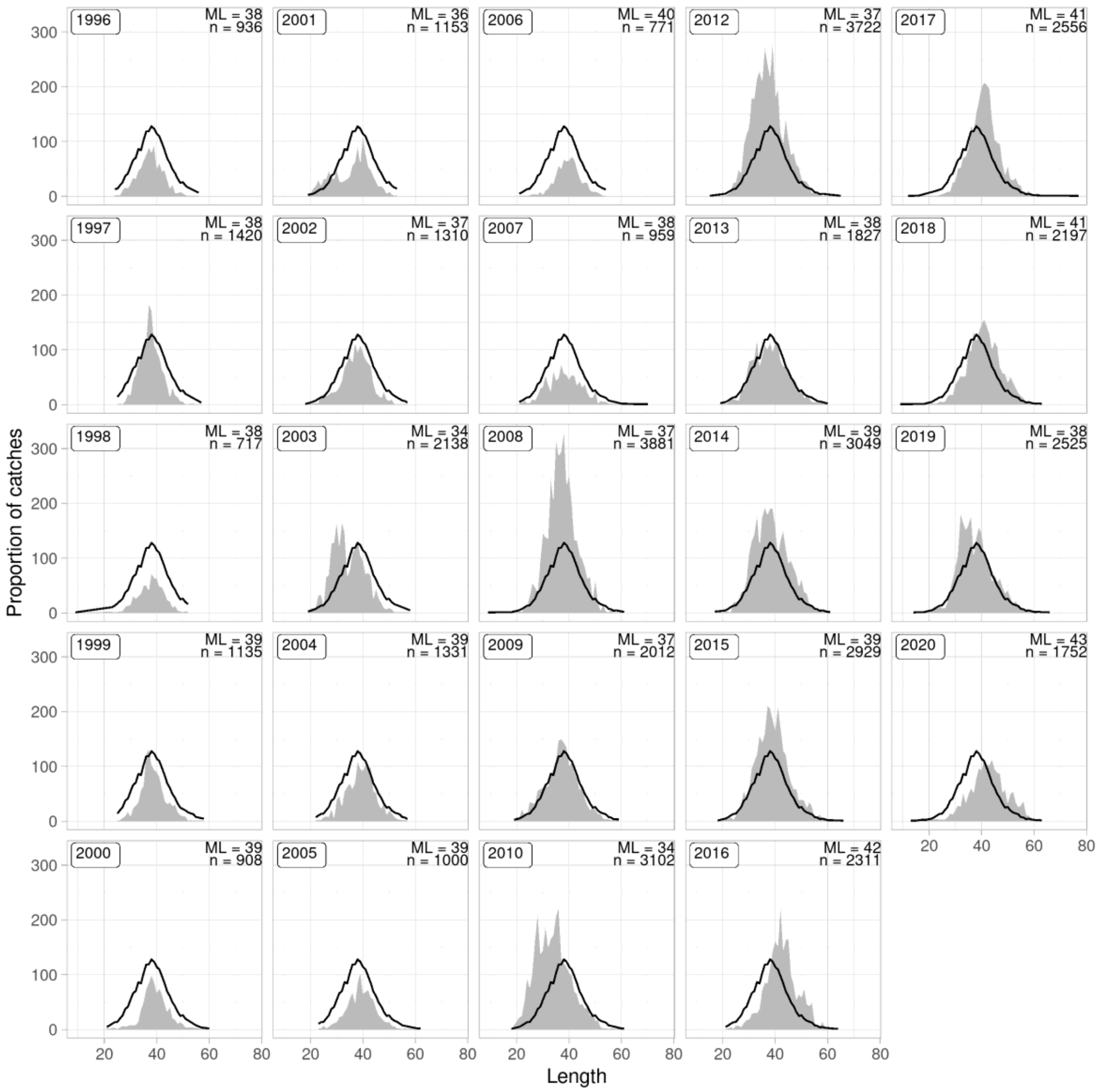

Figure 24.4.6: Plaice in 5.a: Length disaggregated abundance indices from the autumn survey (October) 1996 and onwards, except 2011.

Figure 24.4.7: Plaice in 5.a. Changes in geographical distribution of the survey biomass.

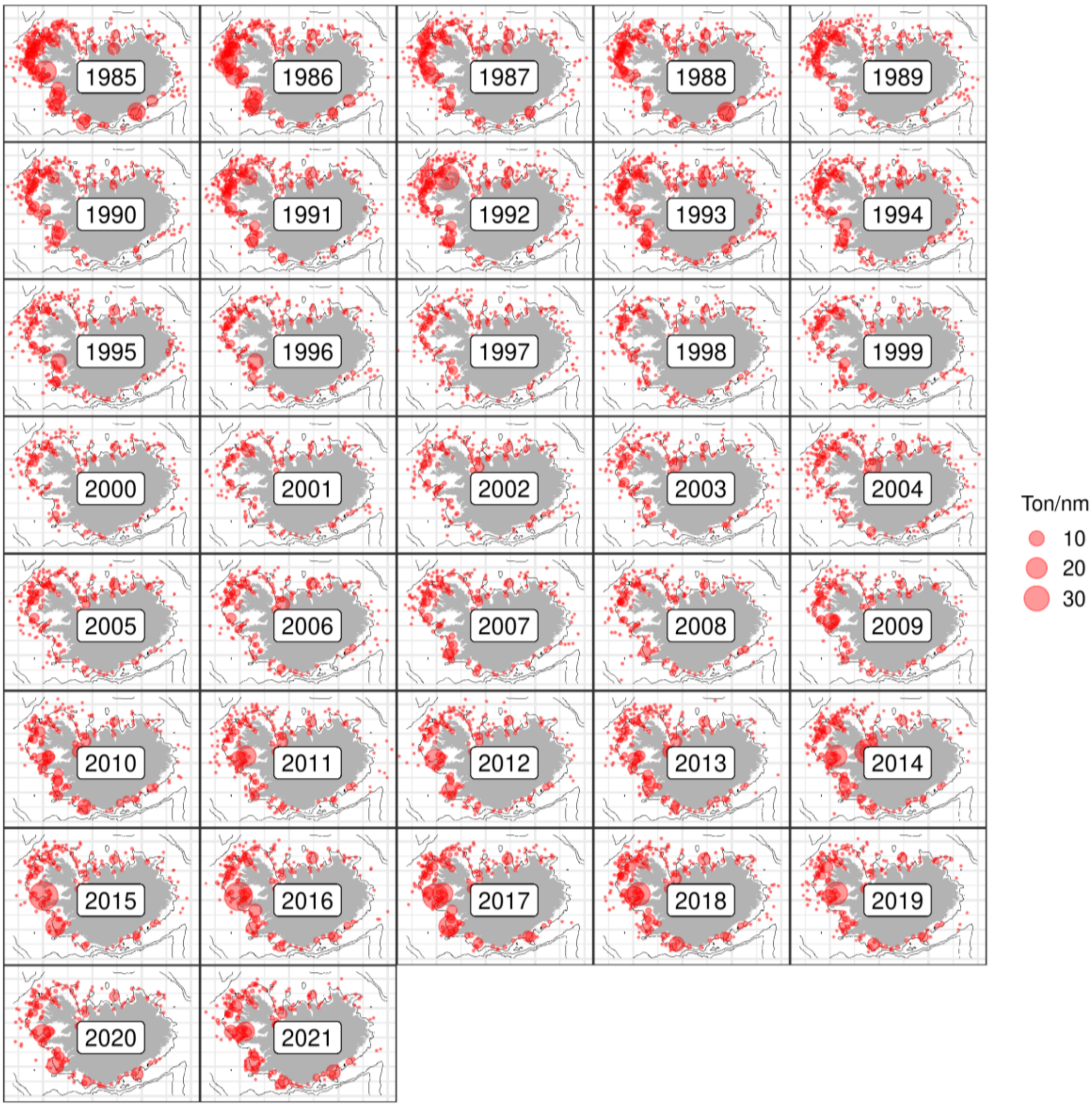

Figure 24.4.8: Plaice in 5.a. Location of plaice in the spring survey, bubble sizes are relative to catch sizes.

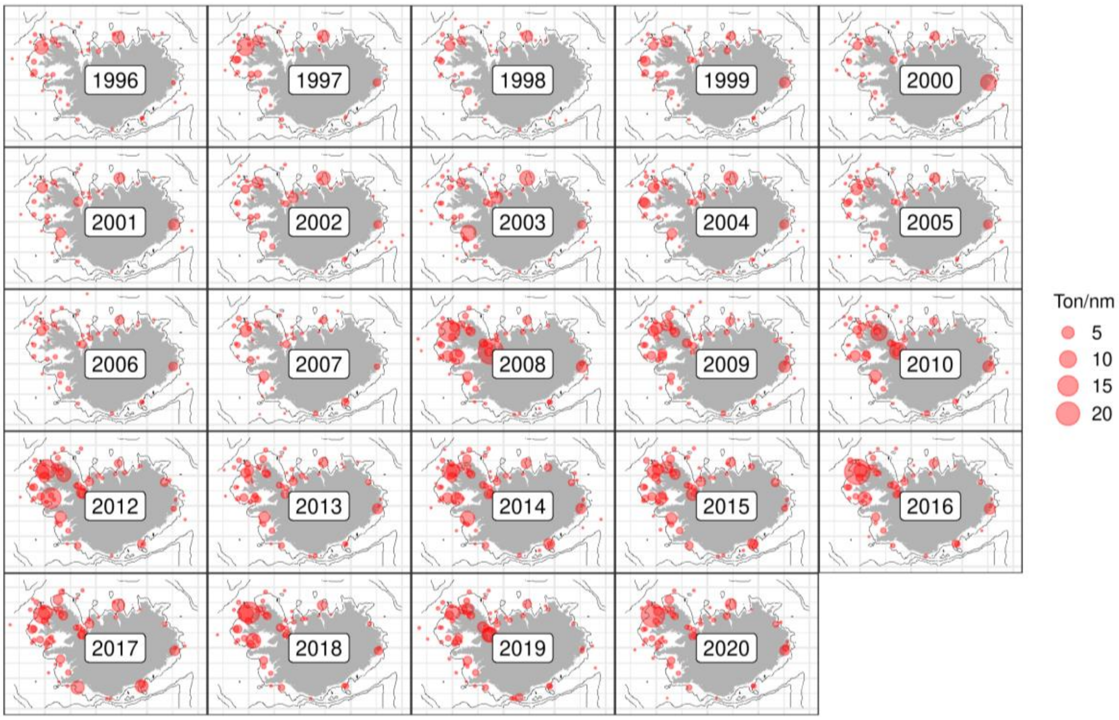

Figure 24.4.9: Plaice in 5.a. Location of plaice in the autumn survey, bubble sizes are relative to catch sizes.

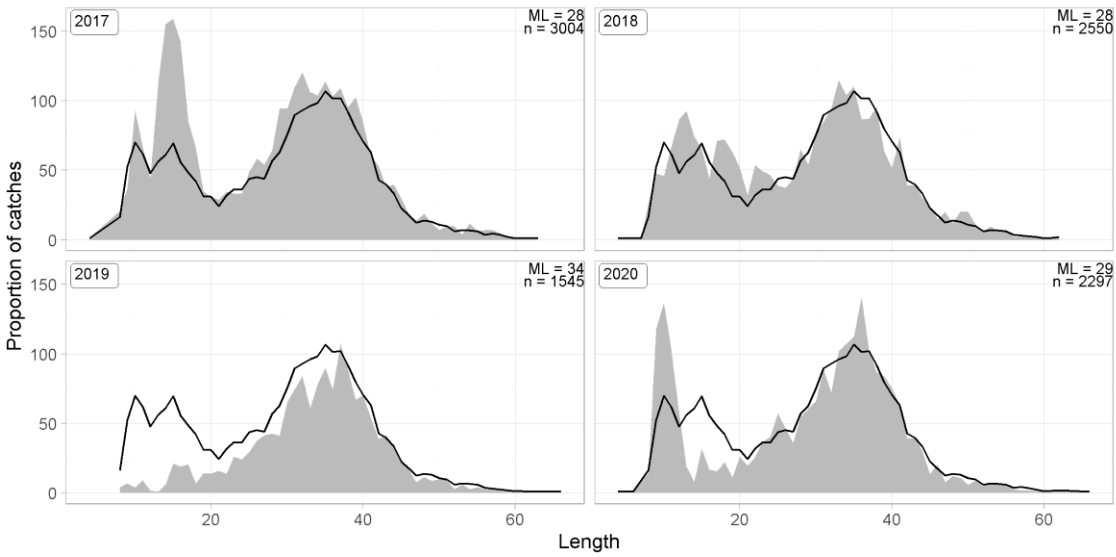

Figure 24.4.10: Plaice in 5.a. Length distribution from beam trawl survey. The black line shows the mean for all years.

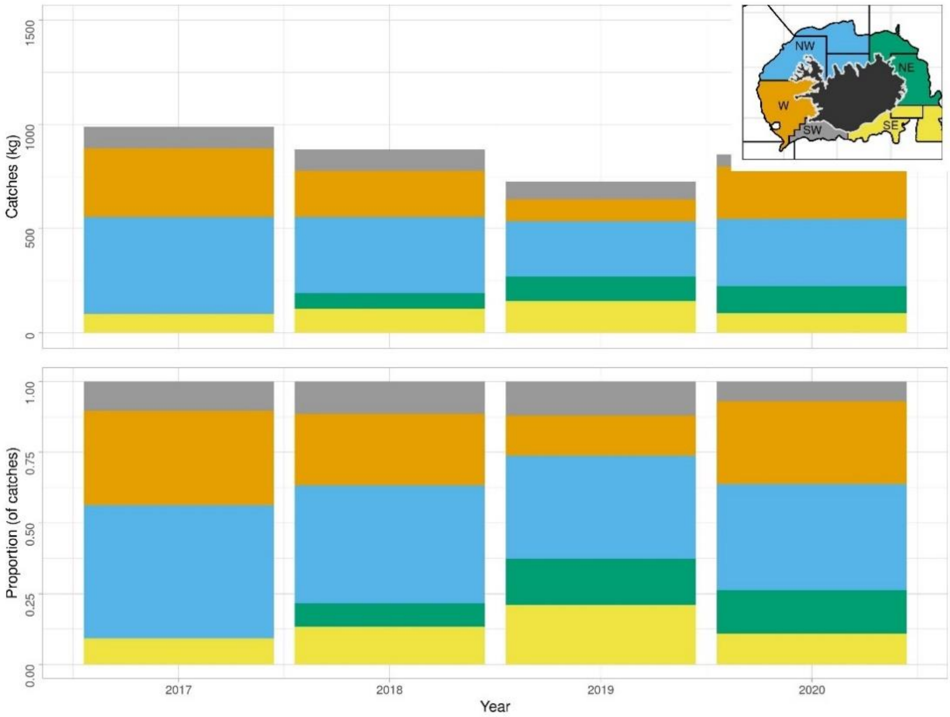

Figure 24.4.11: Plaice in 5.a. Changes in geographical distribution in the beam trawl survey.

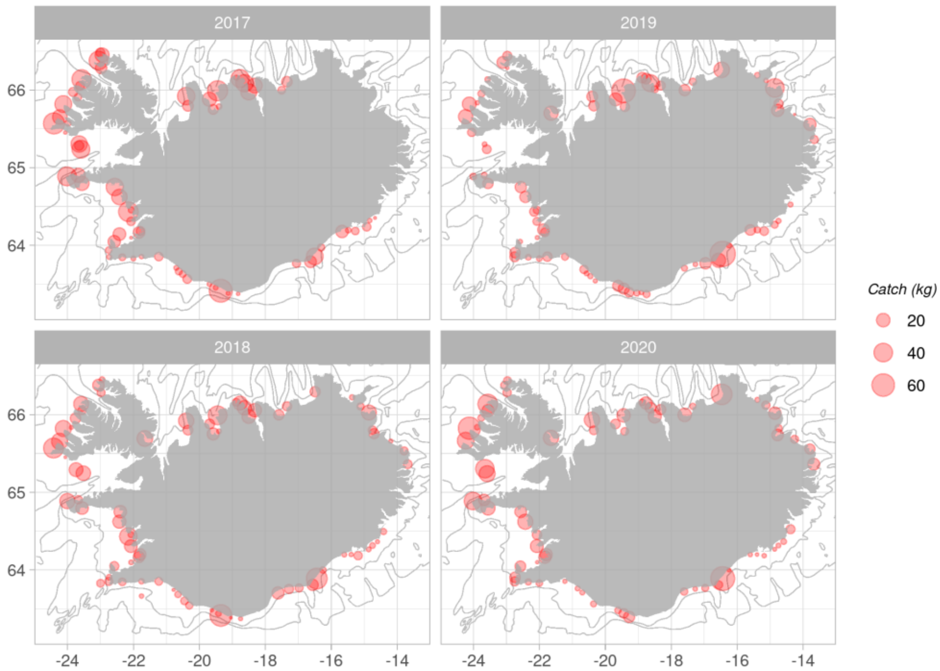

Figure 24.4.12: Plaice in 5.a. Spatial distribution in the beam trawl survey since 2017. The NE area was not sampled in 2017.

24.5 Data analyses

24.5.1 Analytical assessment

Analytical age-based stock assessment model using catch in numbers and age-disaggregated indices from the spring survey has been used since 2016. Input data for the stock assessment are shown in Figure 24.5.1. The model runs from 1991 onwards and ages 3–10 are tracked by the model, where age 10 is a plus group. Natural mortality is set to 0.2 for all age groups. Considerable uncertainty is present in the model due to limited information on recruitment, and the model has large residuals blocks, in particular for the survey data (Figure 24.5.2). The result of the assessment indicate that the stock is stable (Figure 24.5.3 and 24.5.4). Maximum sustainable yield is the basis for the advice, and the reference point is set as F = 0.22.

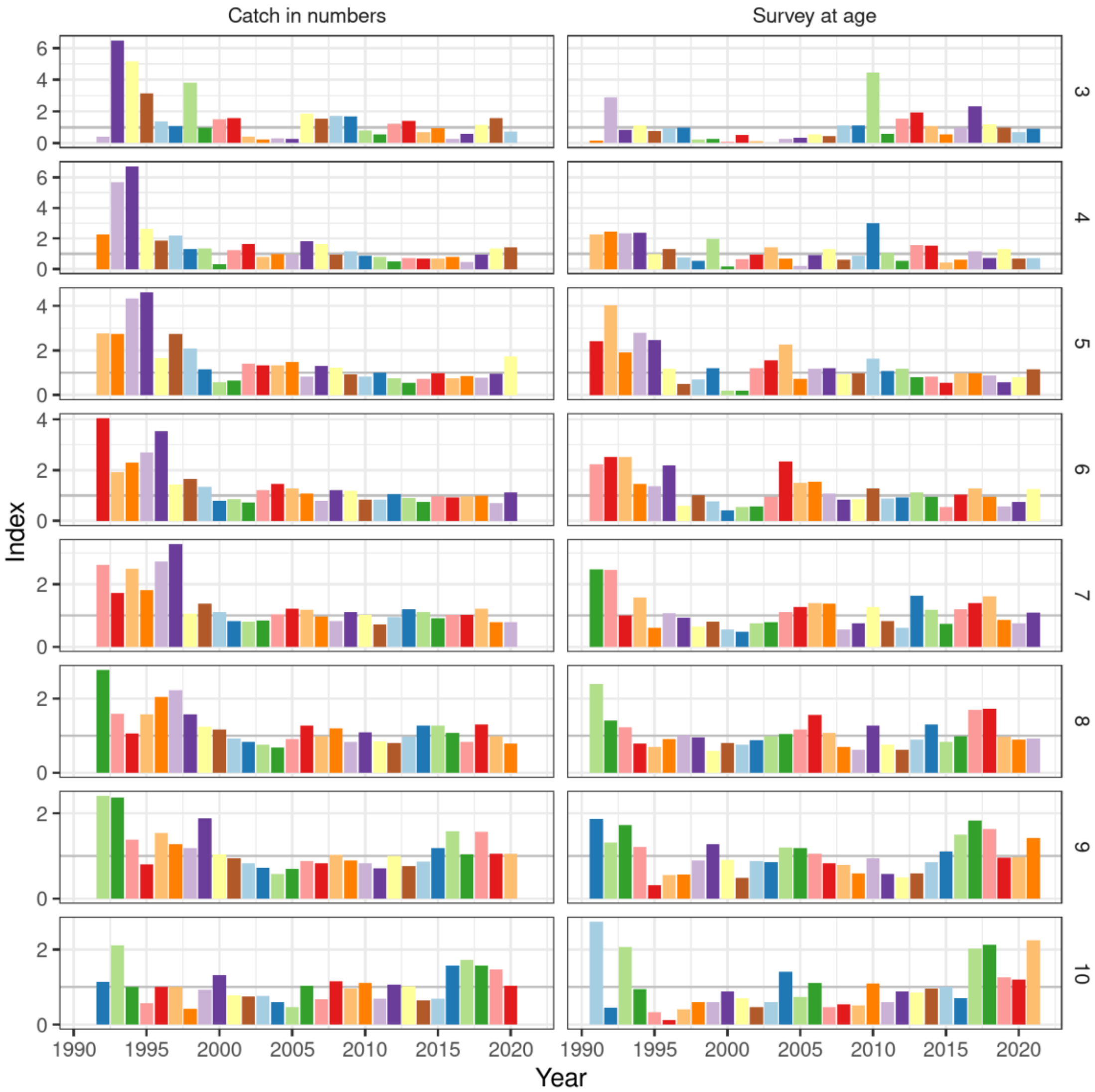

Figure 24.5.1: Plaice in 5.a. Estimated numbers of 3–10-year-old fish in the commercial catch (1992–2020) and age-disaggregated survey indices from the spring survey (1991–2021). Input data for the stock assessment.

Figure 24.5.2: Plaice in 5.a. Residuals of the model fit to spring survey indices and catch data by age.

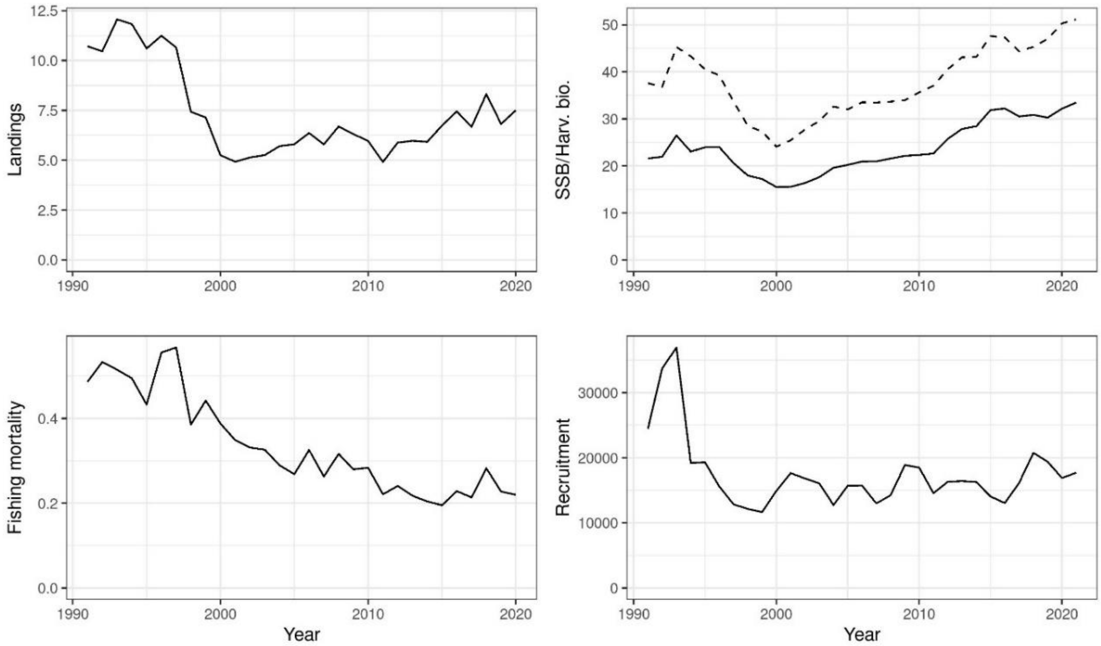

Figure 24.5.3: Plaice in 5.a. Summary from the assessment 2021. Results of spawning stock (SSB) and harvestable stock biomass, fishing mortality, and recruitment (age 3) are shown.

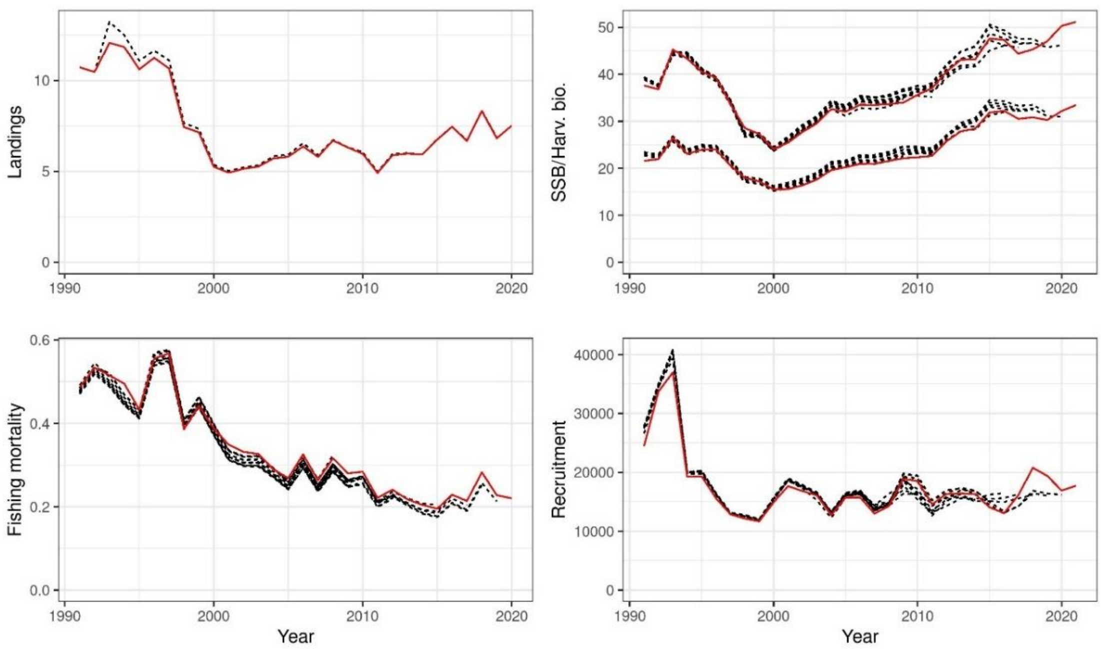

Figure 24.5.4: Plaice in 5.a. Analytical retrospective plots illustrating stability in model estimates over a 9-year 'peel' in data. Results of spawning stock (SSB) and harvestable stock biomass, fishing mortality, and recruitment (age 3) are shown.

Table 24.1.1: Plaice in 5.a. Number of Icelandic vessels landing catch of 1000 kg or more and all landed catch by fleet segment participating in the plaice fishery in 5.a.

	NUMBER OF VESSELS			CATCHES (TONNES)			
YEAR	*Trawlers*	*Seiners*	*Other*	*Demersal trawl*	*Demersal seine*	*Other*	*Sum*
2000	89	81	78	1759	3052	409	5220
2001	77	87	106	1393	2906	610	4909
2002	67	87	86	1257	3420	465	5142
2003	71	90	65	1288	3602	342	5232
2004	60	92	73	1368	4015	309	5692
2005	67	81	63	1637	3894	261	5792
2006	70	75	44	2443	3704	223	6370
2007	74	68	59	2242	3282	292	5816
2008	66	67	52	2600	3828	290	6718
2009	62	65	57	2121	3872	323	6316
2010	57	55	66	2033	3639	311	5983
2011	42	52	65	1658	3020	265	4943
2012	44	48	85	1402	4075	453	5930
2013	45	48	65	1559	4041	379	5979
2014	40	43	61	1374	4235	313	5922
2015	55	45	66	2001	4404	363	6768
2016	52	41	71	2118	4893	432	7443
2017	52	43	64	1762	4578	354	6694
2018	53	41	59	2436	5578	327	8341
2019	49	41	59	2231	4287	316	6834
2020	66	41	51	2475	4681	350	7505

Table 24.1.2: Plaice in 5.a. Number of available length measurements and samples from Icelandic commercial catches.

Year	Bottom Trawl	Danish Seine	Long Line
2000	4261/33	7185/49	0/0
2001	1003/9	7517/51	234/4
2002	2392/18	11263/69	3/1
2003	3278/21	13804/96	3/1
2004	3834/28	21216/150	0/0
2005	5251/35	20583/139	33/1
2006	8102/60	19222/135	108/1
2007	6837/49	17073/124	83/1
2008	11359/77	17471/129	0/0
2009	7201/50	19106/136	100/1
2010	9608/62	17387/126	0/0
2011	7609/55	16857/110	99/1
2012	5723/39	18329/129	0/0
2013	4688/31	16647/115	150/1
2014	2531/21	7271/53	217/1
2015	4142/33	5997/44	0/0
2016	4757/32	8075/58	0/0
2017	3527/28	6231/52	0/0
2018	3506/27	5666/46	0/0
2019	4838/36	5990/47	0/0
2020	2788/27	3031/24	0/0

Table 24.1.3: Plaice in 5.a. Number of available age measurements and samples from Icelandic commercial catches.

Year	Bottom Trawl	Danish Seine	Long Line
2000	1507/33	2400/49	0/0
2001	350/9	2250/51	50/4
2002	599/18	2424/69	0/1
2003	550/21	3149/96	0/1
2004	820/28	3701/150	0/0
2005	1000/35	3036/139	0/1
2006	1450/60	3200/135	0/1
2007	1500/49	3199/124	0/1
2008	1850/77	3099/129	0/0
2009	1250/50	3180/136	0/1
2010	2016/62	3951/126	0/0
2011	2452/55	4200/110	0/1
2012	1835/39	5199/129	0/0
2013	1350/31	5010/115	50/1
2014	575/21	900/53	0/1
2015	670/33	800/44	0/0
2016	573/32	1125/58	0/0
2017	550/28	974/52	0/0
2018	400/27	880/46	0/0
2019	476/36	750/47	0/0
2020	550/27	550/24	0/0

Table 24.1.4: Plaice in 5.a. Recommended TAC, national TAC set by the Ministry and official landings. All weights are in tonnes.

Fishing year	Rec. TAC	National TAC	Catch
1991/92	10000	11000	10200
1992/93	10000	13000	12400
1993/94	10000	13000	12300
1994/95	10000	13000	11100
1995/96	10000	13000	11000
1996/97	10000	12000	10345
1997/98	9000	9000	8083
1998/99	7000	7000	7452
1999/00	4000	4000	4907
2000/01	4000	4000	4921
2001/02	4000	5000	4402
2002/03	4000	5000	5402
2003/04	4000	4500	5844
2004/05	4000	5000	6184
2005/06	4000	5000	5647
2006/07	5000	6000	6149
2007/08	5000	6500	6620
2008/09	5000	6500	6361
2009/10	5000	6500	6389
2010/11	6500	6500	4843
2011/12	6500	6500	5822
2012/13	6500	6500	5932
2013/14	6500	6500	6030
2014/15	7000	7000	6237
2015/16	6500	6500	7619
2016/17	7330	7330	6369
2017/18	7103	7103	8208
2018/19	7132	7132	7096
2019/20	6985	6985	7177
2020/21	7037	7037	
2021/22	7805		

24.6 References

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Annex 1: List of participants

Northwestern Working Group 22–29 April 2021

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Annex 2: Resolutions

2020/2/FRSG05 The **North-Western Working Group** (NWWG), chaired by Teunis Jansen*, Denmark, will meet by correspondence on 22–29 April 2021 to:

a) Address generic ToRs for Regional and Species Working Groups for all stocks, except stocks mentioned in ToRs c) and d)
b) Compile and review available data and information on plaice in Division 5.a and prepare a road map and issue list for a future benchmark

and on 6–8 September 2021 to:

c) Address generic ToRs for Regional and Species Working Groups for beaked redfish (*Sebastes mentella*) in ICES subareas 5, 12, and 14 (Iceland and Faroe grounds, North of Azores, East of Greenland) and NAFO subareas 1 and 2 deep pelagic (> 500m) and shallow pelagic (< 500m) stocks.

and on 25–29 October to:

d) Address generic ToRs for Regional and Species Working Groups for Capelin (*Mallotus villosus*) in subareas 5 and 14 and Division 2.a west of 5°W, Cod (*Gadus morhua*) in Subdivision 5.b.1 (Faroe Plateau), Cod in Subdivision 5.b.2 (Faroe Bank,) Haddock (*Melanogrammus aeglefinus*) in Division 5.b (Faroes grounds) and Saithe (*Pollachius virens*) in Division 5.b (Faroes grounds).

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2021 ICES data call.

NWWG will report by 19 May, 10 September and 5 November 2021 for the attention of ACOM.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Annex 3: List of working documents (NWWG 2021)

Retzel, A. 2020. Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2019.

ICES North Western Working Group, 23-28 April 2020, WD 1. 16 pp.

Retzel, A. 2020. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2019. ICES North Western Working Group, 23-28 April 2020, WD 2. 20 pp.

Nielsen, J., Christensen, H. T. 2021. The fishery for demersal Redfish (*S. mentella*) in ICES Div. 14b in 2020. ICES North Western Working Group, 22-29 April 2021, WD 09. 15 pp.

Nielsen, J., Christensen, H. T. 2021. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Water in 2020. ICES North Western Working Group, 22-29 April 2021, WD 10. 18 pp.

Retzel, A. 2021. Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2020. ICES North Western Working Group, 22-29 April 2021, WD 3. 18 pp.

Retzel, A., Riget, F., 2021. Greenland Shrimp and Fish survey results for Atlantic cod in ICES subarea 14b (East Greenland) and NAFO subarea 1F (SouthWest Greenland) in 2020. ICES North Western Working Group, 22-29 April 2021, WD 4. 20 pp.

Retzel, A. 2021. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2020. ICES North Western Working Group, 22-29 April 2021, WD 5. 22 pp.

Retzel, A. 2021. West Greenland inshore survey results for Atlantic cod in 2020. ICES North Western Working Group, 22-29 April 2021, WD 6. 24 pp.

Retzel, A. 2021. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2020. ICES North Western Working Group, 22-29 April 2021, WD 7. 14 pp.

Retzel, A. and Riget, F. 2021. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) in 2020. ICES North Western Working Group, 22-29 April 2021, WD 8. 22 pp.

Riget, F., Retzel, A., Buch, T.B. 2021. A SAM assessment of the East Greenland cod stock. ICES North Western Working Group, 22-29 April 2021, WD 11. 22 pp.

Riget, F., Retzel, A., Buch, T.B. 2021. A SAM assesment of the West Greenland Inshore cod stock (cod 21.1). ICES North Western Working Group, 22-29 April 2021, WD 12. 32 pp.

Riget, F., Retzel, A., Boje, J., Buch T.B. 2021. Changing the migration pattern in the East Greenland cod stock SAM. ICES North Western Working Group, 22-29 April 2021, WD 13. 9 pp.

Buch, T. B., Retzel, A., Rigét, F., Jansen, T., Berg, C. 2021. DNA split of Atlantic cod (*Gadus morhua*) stocks in Greenland waters. An overview of data. ICES North Western Working Group, 22-29 April 2021, WD 14. 17 pp.

Steingrund, P. 2021. Survey biomass indices of Greenland halibut on the slopes of the Faroe Plateau 1983-2020. ICES North Western Working Group, 22-29 April 2021, WD 19. 9 pp.

Steingrund, P. 2021. Greenland halibut CPUE for the research vessel operating on the slope on the Faroe Plateau in May-June 1995-2020. ICES North Western Working Group, 22-29 April 2021, WD 21. 10 pp.

Steingrund, P. 2021. Greenland halibut CPUE for commercial trawlers operating on the slope on the Faroe Plateau 1991-2020. ICES North Western Working Group, 22-29 April 2021, WD 22. 16 pp.

Steingrund, P. 2021. A combined biomas index of Greenland halibut on the slopes of the Faroe Plateau 1983-2020. ICES North Western Working Group, 22-29 April 2021, WD 23. 3 pp.

Annex 4: List of stock annexes

The table below provides an overview of the NWWG Stock Annexes. Stock annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year, ecoregion, species*, and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
cap 27.2a5.14_SA	Capelin in the Iceland-East Greenland-Jan Mayen area)	January 2015	cap-icel_SA.pdf
cod.21.1_SA	Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West Greenland cod)	May 2021	cod.21.1_SA.pdf
cod.2127.1f14_SA	Cod (*Gadus morhua*) in ICES Subarea 14 and NAFO Division 1F (East Greenland, South Greenland)	February 2018	cod.2127.1f14_SA.pdf
cod.27.5b2_SA	Cod (*Gadus morhua*) in subdivision 5.b.2 (Faroe Bank)	April 2013	cod-farb_SA.pdf
cod.27.5b1_SA	Cod (*Gadus morhua*) in subdivision 5.b.1 (Faroe Plateau)	May 2017	cod-farp_SA.pdf
cod.27.5a_SA	Icelandic cod	April 2021	cod.27.5a_SA.pdf
cod.21.1a-e_SA	Cod (*Gadus morhua*) in NAFO divisions 1A-1E, offshore (West Greenland)	May 2016	cod-wgr_SA.pdf
ghl.27.561214_SA	Greenland halibut *(Reinhardtius hippoglossoides*) in Subareas 5,6,12 and 14 (Iceland and Faroes grounds, West of Scotland, North of Azores, East of Greenland)	December 2013	ghl-grn_SA.pdf
had.27.5b_SA	Haddock (*Melanogrammus aeglefinus*) in Division 5.b (Faroes grounds)	November 2021	had.27.5b_SA.pdf
had.27.5a_SA	Haddock (*Melanogrammus aeglefinus*) in Division 5.a (Iceland)	June 2021	had.27.5a_SA.pdf
her.27.5a_SA	Herring (*Clupea harengus*) in Division 5.a, summer-spawning herring (Iceland grounds)	April 2019	her.27.5a_SA.pdf
pok.275b_SA	Saithe (*Pollachius virens*) in Division 5.b (Faroes grounds)	November 2020	pok.27.5b_SA.pdf
pok.275a_SA	Saithe (*Pollachius virens*) in Division 5.a (Iceland grounds)	April 2019	pok.27.5a_SA.pdf
reb.27.14b_SA	Beaked redfish (*Sebastes mentella*) in Division 14.b, demersal (Southeast Greenland)	May 2017	reb 27.14b_SA.pdf
reb.27.5a14_SA	Icelandic slope beaked redfish *(Sebastes mentella)* in Divisions 5.a and 14.b	May 2013	smn-con_SA.pdf
reb.2127.dp_SA	Deep Pelagic beaked redfish *(Sebastes mentella*) in ICES	May 2012	smn-dp_SA.pdf

Stock ID	Stock name	Last updated	Link
reb.27.14b_SA	Beaked redfish *(Sebastes mentella*) in Division 14.b (Demersal) (Southest Greenland)	May 2016	smn-grl_SA.pdf
reb.2127.sp_SA	Shallow pelagic Beaked redfish (Sebastes mentella)	May 2012	smn-sp_SA.pdf
reg.27.561214_SA	Golden redfish in Subareas 5,6 12 and 14 (Iceland and Faroes grounds, West of Scotland, North of Azores, East of Greenland)	April 2019	reg.27.561214_SA.pdf

Annex 5: Audit reports

Review of ICES Scientific Report, (*NWWG*) *(2021*) (*22/4-6/5*)

Reviewers: Petur Steingrund

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

The stock will be benchmarked in 2023.

For single-stock summary sheet advice

Greenland halibut in ICES subareas 5ab and 14

Short description of the assessment:

1) Assessment type: Stock production model (stochastic version of the logistic production model and Bayesian inference).
2) Assessment: accepted.
3) Forecast: accepted.
4) Assessment model: Stock production model tuned by one commercial cpue index and one (combined) survey cpue index.
5) Consistency: The model has been very consistent for a decade.
6) Stock status: B/Bmsy 2020 = 0.78, B/Bmsy 2021 = 0.80, F/Fmsy 2020 = 1.02, F/Fmsy 2021 = 0.94, productivity (% of MSY) 2020: 95%, productivity (% of MSY) 2021: 96%. Nearly the same stock size and advice for a decade.
7) Management plan: There is no management plan but Greenland and Iceland largely follow an agreement from 2014 which keeps the fishing mortality on a nearly sustainable level.

General comments

The assessment may not be the best one but the advice seems to have worked well for a decade.

Technical comments

There was a modification of the commercial tuning index for the year 2020 because in one area only 4 hauls were conducted in 2020.

Review of ICES Scientific Report, NWWG, 2021, 22-29 April.

Reviewers: Kristján Kristinsson

Expert group Chair: Teunis Jansen, Denmark/Greenland

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

- Survey indices, which are used as basis for the advice, indicate that the stock is at very low level.
- The survey time series suffer from periods of no surveys and insufficient depth coverage.
- Recruitment in the area very low.
- Catches not split between the two redfish species found in East Greenland waters. Species split based on samples from the commercial fishery and from one survey.
- Recommended that the stock should be benchmarked in 2023.
    - The main goal to use underutilized data from various surveys conducted in the area.
    - Data not available to perform an analytical assessment

Stock**: Beaked redfish (*Sebastes mentella*) in Division 14.b, demersal (South-east Greenland) – reb.27.14b**

Short description of the assessment as follows (examples in grey text):

8) Assessment type: Category 3.2
9) Assessment: Survey trends, no analytical assessment.
10) Forecast: No forecast available.
11) Assessment model: Survey trend-based assessment from the Greenland Shallow Water survey (GRL-GFS).
12) Consistency: No survey data from the Greenland Shallow Water survey 2017-2019
13) Stock status: The biomass index has declined since 2010 and was in 2020 at very low levels (lowest in the time series).
14) Management plan: No management plan.

General comments: The assessment is based on survey trends from the Greenland Shallow Water survey (GRL-GFS). The biomass index from 2020 is below any candidate for biomass reference points. The survey was not conducted in 2017-2019 and prevents evaluation of stock development in these years. However, the German Groundfish survey in East Greenland (GER(GRL)-GFS-Q4) confirms the decreasing trend observed since 2011.

The survey's time series suffer from periods with no surveys and insufficient depth coverage of the species distribution. CPUEs from the fishery is also available but considered less reliable as biomass indicator since the species tends to have a schooling behaviour which enables the fishery to keep constant catch rates even when stock biomass is decreasing.

The absence of indications of incoming cohorts raises concerns about the future productivity of the stock. The Greenland Shallow Water survey and the German groundfish survey estimates have consistently shown very low abundance of juveniles. There are signs of improved recruitment of *Sebastes sp.* (<17 cm) observed in the Greenland Shallow Water survey in 2020. With the overall low abundance of juveniles in the past, the fishable biomass is likely not expected to increase in the coming years

Estimates of catches in 2020 are based on a species split (*S. norvegicus and S. mentella*) from the Greenland survey and from samples of the commercial fishery. This procedure on species allocation is expected to continue in the future. The sharp change in this ration between 2018 and 2019 raises question of the accuracy of the split.

Technical comments

The report is in accordance with the stock annex.
The advice sheet is consistent with the report.

Conclusions
The assessment has been performed correctly and in accordance with stock annex.

Review of ICES Scientific Report, (*expert group/workshop title*) (*year*) (*dates*)

Reviewers: Karl-Michael Werner

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

The stock was benchmarked in spring 2021 and is well carried out. I recommend to accept the assessment and the advice sheet. The stock assessor made the best out of the available data and carried out a careful and thorough assessment, which does, from my point of view, not leave much space for improvement.

For single-stock summary sheet advice

Iceland cod (iCod)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Statistical catch at age. ADCAM with a random walk on F (changes slowly through time and with ages).
5) Consistency: Stock benchmarked in spring 2021.
6) Stock status: Stock recently declining but still well above all biomass reference points.
7) Management plan: Iceland has a management plan for cod, which was evaluated by ICES and is considered precautionary. The management plan uses a catch stabilizer to limit catch fluctuations from year to year. The target harvest rate form the management plan is 0.2.

Review of ICES Scientific Report, (*expert group/workshop title*) *(year*) (*dates*)

Reviewers: Karl-Michael Werner

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

The fleet has historically never taken extremely high amounts of saithe due to low price and a high cost to catch it. Even when fisheries were not TAC limited, overfishing did not occur. Hence there is little fear and likely low risk of overfishing it. It seems that the stock is generally overestimated. This could be also due to changes in the fleet towards more longliners, which might also contribute to uncertainties in the assessment. The surveys do not capture the population dynamics very well, internal survey consistency of year classes is not always great. The surveys do not capture recruitment patterns well, likely because nursery grounds are shallow, where surveys don't go. The TAC has often not been caught in recent years and the harvest rate has been below the target rate of 0.2.

For single-stock summary sheet advice

Icelandic saithe

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Separable statistical catch-at-age model.
5) Consistency: last year's assessment accepted
6) Stock status: $B > B_{lim}$ and B > MSYBtrigger for a while; HR < HRlim and HR < HRmsy ; good recruitment in recent years
7) Management plan: The Icelandic ministry has a management plan on saithe in order to provide long-term maximum sustainable yield. The harvest rate according to the management plan is 0.2.

   This assessment is well carried out and from my point of view difficult to improve. The assessor used different models for comparison and carries out a careful data exploration in order to gain insights into stock dynamics. I think the stock assessor faces the difficulties and challenges and does his best to deal with them. I recommend to accept the assessment.

Review of ICES Scientific Report, (NWWG, 2021, 22-29 April).
Reviewers: Julius Nielsen

Expert group Chair: Teunis Jansen, Denmark/Greenland

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

Stock: Icelandic slope *Sebastes mentella* in 5.a and 14 – reb.27.5a14

General

- The precautionary advice is based on survey indices which indicate the stock levels are relatively low with no signs of recruitment.
- Because of COVID outbreak, the advice for 2021 was not issued by ICES.
- The stock will be benchmarked in 2022
    - To apply analytical assessment model (Gadget) and move the stock from category 3 to category 1.
- The stock assessment was conducted in accordance with the Stock annex

For single-stock summary sheet advice
Short description of the assessment as follows (examples in grey text):

15) Assessment type: Category 3.2 – update assessment with addition of 1 year of data
16) Assessment: Survey trends, no analytical assessment
17) Forecast: not presented
18) Assessment model: Survey trend-based assessment from the Icelandic Autumn Groundfish survey (IS-SMH)
19) Consistency: The advice has since 2014 been based on the DLS approach (category 3.2).
20) Stock status: The stock status cannot be evaluated in relation to MSY or PA reference points. However, survey biomass indices show that the stock is on a relatively low level since 2002 and is fluctuating without a clear trend. The stock is considered vulnerable due to the lack of recruitment.
21) Management plan: no management plan for this stock.

Generel comments
Sebastes mentella is a slow growing and late-maturing species and is therefore considered very vulnerable to overexploitation. Since 2007, survey estimates have shown low recruitment which raises concerns about the future productivity of the stock. All stated in the report.

Technical comments
It is known that species identification beaked and golden redfish can be difficult. However, nothing about this is mentioned in the report. The report however is in accordance with the stock annex and the advice sheet is in accordance with the report.

Conclusions
The assessment has been performed correctly and in accordance with the stock annex. No major issues were observed. Therefore, the updated assessment gives a valid basis for the advice.

Review of ICES Scientific Report , NWWG, 2021, 22-29 April.

Reviewers: Tanja Buch

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

Stock **Haddock in division 5.a (Iceland ground).**

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

- The stock was benchmarked in 2019 as well as management strategy evaluation which resulted in new reference points.
- Because of COVID outbreak, the advice for 2020/2021 was not issued by ICES.
- There was reduced sampling effort for the commercial fisheries in 2020 due to the COVID outbreak. However, the reduced number of samples are considered sufficiently representative of the fishing operations.
- The stock assessment was conducted in accordance with the Stock annex.

For single-stock summary sheet advice

Short description of the assessment as follows (examples in grey text):

22) Assessment type: Category 1, Statistical catch-at-age model.
23) Assessment: accepted
24) Forecast: presented
25) Assessment model: Muppet (Statistical catch-at-age model). Using catch-at-age and 2 survey indices for tuning.
26) Consistency: The model from the 2019 benchmark have been used in 2019 and this year. No advice was issues in 2020 due to the COVID outbreak. The TAC set for the fishing year 2020/2021 was produced by MFRI following benchmark procedures.
27) Stock status: Spawning size is above MSY $B_{trigger}$, B_{PA} and B_{lim}. Fishing pressure is above both HR_{MSY} and HR_{PA} and below HR_{blim}.
28) Management plan:.Management plan is consistent with both precautionary approach and the ICES MSY approach. The advice follow the management plan, the advice for 2021/2022 is 50429 tonnes which is an increase from the two previous years..

General comments

- The total landings are above the agreed TAC in recent years, this is due to transfer of TAC between years and between species.
- The fishing year starts at 1. September and advice TAC is for the period 1.9.2021 to 30.8.22.
- The TAC for the remainder of 2020/2021 fishing year was increased by 8000t by the Government of Iceland, this increase will be subtracted from the 2021/2022 TAC. This has not been included in the basis of the advice as it was made public during NWWG.

Technical comments

The report and advice sheet are in accordance with the stock annex.

Conclusions

The assessment has been performed correctly and in accordance with stock annex.

Review of ICES Scientific Report, NWWG, 2021, 22-29 April.

Reviewers: Luis Ridao Cruz

Expert group Chair: Teunis Jansen, Denmark/Greenland

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

- Stock benchmarked in 2018 using SAM as the basis for advice
- Mixing of the off-shore and in-shore components causes problems in the evaluation of the stock
- Genetic samples from the inshore survey suggest that the majority of cod in the northern area belong to the WestGreenland offshore stock component whereas further south the West-Greenland inshore stock is the dominant component.
- Steep decline in catches in the last 5 years.
- Catches comprised of relatively few year classes (5 and 6 years old individuals)

For single-stock summary sheet advice

Cod (*Gadus morhua*) in NAFO Subarea 1, inshore (West Greenland cod)

Short description of the assessment as follows (examples in grey text):

1) Assessment type: Category 1
2) Assessment: analytical assessment
3) Forecast: accepted
4) Assessment model: SAM – proposed by expert group, accepted by review group 2018 – tuning by two surveys
5) Consistency: assessment accepted for advice since benchmark in 2018. Uncertain due to stock mixing
6) Stock status: SSB >MSY $B_{trigger}$, B_{pa}, and B_{lim} ; F> Fmsy
7) Management plan: no management plan

General comments

The stock has increased since 2006 to historic high levels in 2016. Substantial drop in SSB in last 5 years although it is above reference points. Low recruitment since 2016 has affected the spawning stock biomass, which continues to decrease since 2016. . Fishing mortality has never been below F_{MSY} (0.27) and remains above. The mixing of cod from different stocks in the West Greenland inshore area adds uncertainty to the assessment. This is most pronounced in the poor model fit to catches, which is substantial in years with catches above 15 000 t. Management of the resource should take this issue into account when relating the ICES advice to the TAC setting.

TAC from 2016 to 2019 has only been fished in 2016. Since then, catches have decreased to 18 000 tons in 2020. TAC in 2021 is reduced to 21 000 tons.

The stock is for benchmark in 2022, where stock identities, based on new genetic data, will be the main issue.

Technical comments

The report is quite extensive. It may help to reduce size of tables (lower font, reducing cell size and so on) and figures.

Conclusions
The advice sheet is consistent with the report
The assessment has been performed in accordance with stock annex.

Reviewers: Einar Hjöleifsson

Expert group Chair: Teunis Jansen, Greenland

Secretariat representative: Ruth Fernandez

General

Areal management of the various cods found in Greenlandic waters may not be appropriate

Cod (*Gadus morhua*) in NAFO divisions 1A–1E, offshore (West Greenland)

Short description of the assessment as follows (examples in grey text):

1) Assessment type. Category 3
2) Assessment: Accepted
3) Forecast: None
4) Assessment model: Survey index
5) Consistency: Advice on this stock has been consistent
6) Stock status: No reference points
7) Management plan: No management plan

General comments

The temporal coverage of the main stock indicator (the Greenland survey) does not cover the last productivity spike of this stock. The advice sheet is augmented with German survey that started in 1982, covering the last catch productivity spike around 1990.

Technical comments

None

Conclusions

The advice is likely appropriate

Review of NWWG, Golden redfish 5,6,12, 14

Reviewers:Jesper Boje

Expert group Chair:Teunis Janssen

Secretariat representative: Ruth

General
The report is set up nicely and reads well except for some cleaning mentioned below.
The title of the stock includes subareas 5,6 and 14 while the stock acronym also contain subarea 12? (reg.27.561214) .

Section 19.8 on medium term forecast can be deleted: the section was relevant 15 yrs ago. Likewise for 19.12 Ecosystem considerations and 19.5 Changes in the environment.

For single-stock summary sheet advice

Stock **reg.27.561214**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: Gadget, using landings data and length distributions of catches from Iceland, Greenland, and the Faroes; survey data by length from IS-SMB (G3239) and German DTS(GFS)-Q4 (G3244), age data from Icelandic catches and IS-SMH (G4493).
5) Consistency: nice retro
6) Stock status: F> F_{MSY} and < F_{pa} and F_{lim}, and SSB> MSY $B_{trigger}$, B_{pa}, and B_{lim}.
7) Management plan: Greenland – Iceland management plan where Fmgt=Fmsy

General comments
none

Technical comments
Sampling in 5b and 14 is needed to cover entire stock.

Diagnostics from the Gadget model is difficult to evaluate wrt acceptance/rejection of modelrun. In example the model fit to the different length classes, what is the criteria for non-acceptable?(issue on agenda for next benchmark) Guidance is required.

Conclusions
None

Review of ICES Scientific Report, NWWG, 2021, 22-29 April

Reviewers: Birkir Bardarson

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

Audience to write for: advice drafting group, ACOM, and next year's expert group

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

- The stock was bencmarked in 2011 and the Stock annex has been updated since e.g. involving advancements in relation to *Ichthyophonus* infections and mortality. The NWWG dealt with the PA reference points in 2016 and revised them in accordance to the ICES Technical Guidelines. Management strategy evaluation took place in 2017.
- Because of COVID outbreak, the advice for 2020/2021 was not issued by ICES but surveys were conducted and TAC adviced by MFRI according to the Stock Annex.

For single-stock summary sheet advice

Stock **Herring (Clupea harengus) in Division 5.a, summer-spawning herring (Iceland grounds)**

Short description of the assessment as follows (examples in grey text):

1) Assessment type: update
2) Assessment: accepted
3) Forecast: accepted
4) Assessment model: NFT-ADAPT (VPA/ADAPT version 3.3.0 NOAA Fisheries Toolbox) age-based model. Tuning by catch in numbers and age disaggregated indices from acoustic surveys.
5) Consistency: The NFT-ADAPT model has been used as the basis for the assessments since 2005 and this year a comparison with a separate model (Muppet) gave very similar results. Retrospective analyses indicate a consistency over recent years, although, changes in stock distribution in the past are likely to have caused changes in survey catchability and Ichthyophonus pandemic has lead to uncertainties in mortality estimates. Advice has increased as a result of the upward revision in the stock size, due to a large 2017 year-class entering the fishery at age 4 this autumn.
6) Stock status: Fishing pressure is at F_{MSY}, HR4+ is below HRMGT, F_{pa} and F_{lim}. SSB above MSY $B_{trigger}$, B_{pa} and B_{lim}. The stock size was declining 2000-2018 due to a combination of *Ichthyophonus* mortality and series of below average and poor year classes entering the stock. Strong 2017 year class has appeared and will cause an upward revision from last year's assessment.
7) Management plan: Agreed by ICES in 2017.

   The TAC for the fishing year Y/Y+1 (1 September of year Y to 31 August of year Y+1) is calculated as follows:

   When SSB_Y is equal to or above MGT $B_{trigger}$: $TAC_{\frac{Y}{Y}+1} = HR_{MGT} \times B_{ref,Y}$

   When SSB_Y is below MGT $B_{trigger}$: $TAC_{Y/Y+1} = HR_{MGT} \times (\frac{SSB_Y}{MGT\ B_{trigger}}) \times B_{ref,Y}$

   The spawning-stock biomass trigger (MGT $B_{trigger}$) is defined as 200 000 tonnes, the reference biomass is defined as the biomass of herring of ages 4 and older, and the target harvest rate (HR_{MGT}) is set to 0.15.

General comments

The assessment of this stock has been and is likely to continue to be challenged by uncertainties in catch-ability due to distributional shifts (e.g. changed overwintering areas) that current survey strategy and coverage can have difficulties to observe. This uncertainty could be reduced by more extensive herring surveys. Further, there are uncertainties about M by the *Ichthyophonus* pandemic that could be improved by more accurate estimation of the infection mortality in future studies.

Technical comments

None

Conclusions

(Single tables or figures can be added in the text, longer texts should be added as annexes.)

The stock assessment was conducted in accordance with the Stock annex