NORTHWESTERN WORKING GROUP (NWWG)

Please note: The Executive Summary was updated and sections 2-6 were added in November/ December 2022.

VOLUME 4 | ISSUE 42

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371

ICES Scientific Reports

Volume 4 | Issue 42

NORTHWESTERN WORKING GROUP (NWWG)

Recommended format for purpose of citation:

ICES. 2022. Northwestern Working Group (NWWG).
ICES Scientific Reports. 4:42. 755 pp. http://doi.org/10.17895/ices.pub.19771381

Editor

Teunis Jansen

Authors

Karolin Adorf • Elzbieta Baranowska • Birkir Bardarson • Höskuldur Björnsson • Jesper Boje • Tanja B. Buch • Bjarki Þór Elvarsson • Einar Hjörleifsson • Teunis Jansen • Kristján Kristinsson • Lísa Anne Libungan • Julius Nielsen • Søren Post • Anja Retzel • Luis Ridao Cruz • Frank Farsø Rigét • Petur Steingrund • Helga Bára Mohr Vang • Karl-Michael Werner

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

Contents

i Executive summary

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 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.

In February 2022, MFRI advised a final TAC of 869 600 t for 2021/2022 based on acoustic surveys in January-February 2022. 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 2021/2022 amounted to 689 000 tonnes (preliminary data). All catches were caught in Autumn and winter months (October 2021–March 2022).

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 2021 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 and 2021, 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 survey was performed in 2021.

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.

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 13 500 tonnes in 2021. TAC in 2021 and 2022 is reduced to 21 000 tonnes.

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

New reference points were defined at an interim benchmark in august 2021.

Fishing mortality (F_{5-10}) was below F_{MSY} (0.29) since 1994 and was low until 2010 where F gradually increased. Since 2019 F is above F_{MSY}. SSB has been declining since 2014 but is still above MSY $B_{trigger}$ (18 146 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. There may be several reasons for the pattern.

Tagging shows substantial spawning emigration to Iceland that this 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 Division 14.b) 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.

From 2021, East Greenland was split into two management areas, the Dohrn bank area (east of 35°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 as TAC (year) = 0.5*TAC (year-1) + 0.5*ICES advice (year) resulting in a TAC of 7430 t for 2022. Total TAC in 2022 is therefore 27 430 t.

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

Icelandic saithe

Annual landings in the fishing year 2020/2021 are estimated to be 56 333 tonnes or 72% of the TAC of 78 574. Since the fishing year 2014/2015 around 85% of the annual TAC has usually been caught on the average.

The assessment has since 2010 been based on an assessment 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 four assessments but the stock size is still estimated to be above average. Mohns rho based on last five assessments is 0.25 for B4+ ending in the assessment year. The retrospective pattern for the last 5 years is caused by a very high 2018 survey index and again relatively high index in 2021. Last year, Mohns rho was 0.05. The difference in Mohns rho compared to the last assessment is due to a downward revision of the stock few years back because of slow convergence of the assessment and a change in the assessment years considered in the 5 years peel from 2017–2021 to 2018–2022.

Investigation of alternative model setup shows the adopted assessment to be in the middle of plausible values and the range of results was not very wide. Still, 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 indications 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 2022/23 should be no more than 71 300 tonnes.

Icelandic cod

The results of this year's assessment show that the spawning stock in 2022 is estimated to be 356.697 kt. The values estimated in recent years are higher than have been observed during the last five decades. The reference biomass B_{4+} in 2022 is estimated to be 976.590 kt. Year classes since the mid-1980s are estimated to be relatively stable but with the mean around 35% lower than observed in the period 1955 to 1985.

The TAC for the current fishing year (2021/2022) based on last years assessment was 222.737 kt.

Following the current HCR, the catch for the coming fishing year (2022/2023) should be 209.028 kt based on the following:

The input in the analytical age-based assessment are catch at age 1955–2021 (age 3 to 14) and ages 1 to 14 (from the 1985–2022 spring (often referred to as SMB in this report) and ages 3 to 13 from the 1996–2021 fall groundfish surveys (often referred to as SMH in this report).

The reference biomass (B_{4+}) upon which the TAC in the fishing year is set is derived from population numbers in the beginning of the assessment year and catch weights in that year. The catch weights are not known and hence need to be predicted. An alternative model to the current catch weight prediction model was explored and the WG concluded that it was an improvement. However, under current ICES protocol a working group is not allowed to deviate from the benchmark protocol unless an interbenchmark process or an independent review is called for, a system that is now already in overload. The WG thus proceeded reluctantly with the current model and will patiently wait for passing the alternative model through the next benchmark, that for this stock will most likely occur in 2026 or 2027.

Icelandic summer spawning herring

The total reported landings in 2021/22 fishing season were 70.1 kt (including summer fishery 2021) although the TAC was set at 72.2 kt. Analyses of biological samples from the past fishing season indicate the continuation of new infection by *Ichthyophonus* in the stock in the coming fishing year 2022/23.

In this update assessment, where the 2021/22 catch and survey data have been added to the input data, additional natural mortality was applied for 2022 because of the *Ichthyophonus* infection in the stock. The same approach was used as for 2009–2011 and 2017–2021 where the applied mortality corresponds to a 30% of the infected herring.

The results from the analytical assessment model, NFT-Adapt, indicate that the stock size remains similar to last year's assessment, with the large 2017-year class which entered the fishery at age 4 last autumn and a 2018-year class predicted to be high. Spawning stock biomass in the beginning of the fishing season 2022 is estimated 421.1 kt and the reference biomass of age 4+ (B_{Ref}) is 441.3 kt in the beginning of the year 2022. As the SSB will be above MGT $B_{trigger}$ = 200 kt, the catches in 2022/23 according to the Icelandic Management Plan would be $HR_{MGT} \times B_{Ref}$ = 0.15 × 441 299 tonnes = 66 195 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 2021 were 43 426 tonnes, which is 2771 tonnes less than in 2020. About 95% of the catches were taken in Division 5.a.

The assessment results of 2022 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 2022 SSB was estimated at 220 056 tonnes.

The stock is planned to be benchmarked in 2023.

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

Total landings of demersal *S. mentella* in Icelandic waters in 2021 were 10 588 tonnes, a slight decrease from 2020. 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 2023.

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 2021, total landings of demersal *S. mentella* were 1302 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). In 2021, neither the Greenland nor German surveys were conducted.

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 has been proposed for benchmark in 2024.

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 substantially exceeded 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 2022/2023 are therefore based on TAC constraint.

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 23 802 t in 2021 which is a 5% increase in total catches compared to 2020. The biomass indices used as input to the assessment (combined survey index from Greenland and Iceland, with Greenland index fixed values since 2016, when the last survey took place) showed a similar increasing trend while logbook information from Iceland trawler fishery showed a slight decreasing trend. The increase in survey biomass index was due to increase of fish larger than 40 cm.

A logistic production model in a Bayesian framework is 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 but since 2004/2005, the stock has increased slowly and is in 2022 at 80% of B_{MSY}. Fishing mortality has since 2013 been close and above F_{MSY} but is in 2021 below F_{MSY} (94% of F_{MSY}). The remaining available tuning indices are currently not used in the analytical assessment due to conflicting signals (logbook information from East Greenland and Faroese trawl fishery, and biomass index from a Faroese survey). The Greenland fishery in Division 14.b suggest a high but y declining biomass while the Faroese indices suggest a significantly lower but increasing biomass in the eastern areas of the stock distribution. From Icelandic waters survey estimates of 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 but is presently being investigated and this will be an important issue in a forthcoming benchmark in 2023.

Icelandic plaice

Icelandic plaice fishery in 5.a has been considered stable in the last two decades and annual total landings have been between 5 and 8 thousand tonnes during this period. In 2021, landings were 8677 tonnes, approximately 1170 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.

An analytical age-based stock assessment model using catch in numbers and age-disaggregated indices from the spring survey was benchmarked in 2022. A management plan for plaice was evaluated at the same time. The model runs from 1981 onwards and ages 3–12 are tracked by the model, where age 12 is a plus group. Natural mortality is set to 0.15 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 size is stable and the fishing pressure is in-line with the goals of the management plan, where the target F is set as 0.3.

Faroe Plateau cod

This section will be updated in November 2022

Faroe Haddock

This section will be updated in November 2022

Faroe saithe

This section will be updated in November 2022

ii Expert group information

Expert group name	Northwestern Working Group (NWWG)
Expert group cycle	Annual
Year cycle started	2022
Reporting year in cycle	1/1
Chair	Teunis Jansen, Greenland and Denmark
Meeting venues and dates	2-7 May 2022, Copenhagen, Denmark and online (hybrid meeting), 18 participants
	24-27 October 2022, online, 11 participants

1 Introduction

1.1 Terms of Reference (ToR)

1.1.1 Specific ToR

2021/2/FRSG05 The **North-Western Working Group** (NWWG), chaired by Teunis Jansen, Denmark, will meet in ICES HQ, Copenhagen, Denmark 2–7 May 2022 to:

a) Address generic ToRs for Regional and Species Working Groups for all stocks, except stocks mentioned in ToRs c)
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 24–27 October 2022 to:

c) 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 2022 ICES data call.

NWWG will report by 19 May and 10 November 2022 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 2022 work in relation to the generic ToR

At the end of March, 2022, ICES Council placed a temporary suspension of Russian participation in all ICES activities. Hence, no experts representing the Russian Federation was at the NWWG meeting or took part in the reporting. The official statement from ICES is stated below:

Since the start of the ongoing war in Ukraine, a number of Member Countries have instructed their scientists and representatives to either boycott or avoid engagement in activities where representatives of the Russian Federation (one of ICES member countries) are present.

ICES is governed through an international convention and includes the 20 coastal states that border the North Atlantic, including the Baltic Sea. Multinational participation in the processes which provide science, data, and advice in support of our mission is essential to our integrity. ICES mission is to advance and share scientific understanding of marine ecosystems and the services they provide and to use this knowledge to generate state-of-the-art advice for meeting conservation, management, and sustainability goals.

In order to fulfil our mission and obligations to requesters of ICES Advice, we require broad participation of essential experts in our activities. The war in Ukraine is undermining this broad participation in many multilateral science organizations, including ICES.

ICES Council of Delegates has voted to place a temporary suspension on all Russian Federation delegates, members, and experts from participation in ICES activities. This suspension will begin on 30 March 2022. ICES Bureau (Executive Committee) will monitor the situation and, when appropriate, recommend a reversal of this suspension.

Because of the disruptions caused by COVID 19 in 2022 the meeting in April was held as a hybrid meeting with most participants attending physically at ICES HQ in Copenhagen while some attended 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 for all stocks.

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 was discussed during the meeting. 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	-0.024	-0.166	-0.483
East Greenland, South Greenland cod	cod.2127.1f14	2020	5	-0.122	-0.149	-0.383
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	2022	5	-0.0141	0.0059	0.704
Icelandic summer spawning herring	her.27.5a	2021	5	1.03	-0.11	-0.13
Icelandic plaice	ple.27.5a	2021	5	0.06750	-0.07730	-0.02310

1.4 NWWG 2022 work in relation to the specific ToR

The group will meet two times in 2022 (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*
Faroe Bank cod	DLS category 3	Survey
Faroe Plateau cod	SAM	Survey
Faroe haddock	SAM	Survey
Faroe saithe	SAM	CPUE

Stock	Assessment model	Input*
Iceland saithe	ADCAM (statistical catch-at-age)	Survey
Iceland cod	ADCAM (statistical catch-at-age)	Survey
Iceland haddock	Adapt type model	Survey
Iceland herring	NFT-Adapt	Survey
Icelandic plaice	SAM	Survey
Capelin	Linear regression	Survey
Inshore West Greenland cod	SAM	Survey
East and South Greenland cod	SAM	Survey
Offshore West Greenland cod	Descriptive	Survey
Greenland halibut	Stock production model (Bayesian)	Survey + CPUE
Golden redfish	GADGET (age-length based cohort model)	Survey
Iceland slope *S. mentella*	DLS category 3.2	Survey
Deep pelagic *S. mentella*	Gadget	Survey
Shallow pelagic *S. mentella*	DLS category 3	Survey
Greenland Slope *S. mentella*	DLS category 3.2	Survey

*** Catches or catches 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

The recommendations were included in a dedicated ICES database and passed on to relevant recipients.

1.8 Benchmarks and workshops

Benchmark of golden redfish, Icelandic slope beaked redfish and Greenland halibut will be take place in 2023 (WKNORTH).

The East Greenland, inshore and offshore West Greenland cod stocks are to be benchmarked in 2023 (WKGREENCOD). A substantial issue lists has been prepared and work has been initiated. Main pillars of the work were presented and discussed during the meeting. A dedicated workshop will take place in September 2022 to advance the method to be applied to split catches and survey data into the separate stocks.

Icelandic summer spawning herring was last benchmarked in January 2011 and therefore it is recommended that the stock will be benchmarked in 2024. A few issues were discussed at the meeting, for example that it would be ideal to use StoX and the SAM model similarly to what is used for the Norwegian spring spawning herring. An issue list will be put together before autumn 2022.

The capelin benchmark will be finalized in 2022 (WKCAPELIN).

Furthermore, an inter-benchmark will take place later in autumn 2022 for the Faroese stocks to incorporate in-year catches into the stock assessments. Results will be ready to be implemented in preparation for the ICES catch advice for fishing opportunities in 2023.

1.9 Chair

This was the second of three years for the 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 2022.

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 (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. Trawlers and longliners fish in different regions (Figure 2.1).

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 was closed since 1 January 2009 for all gears except for a minor jigging fishery during summertime. Faroe Bank was opened to a limited commercial fishery with longlines in 2022.

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 higher than the F_{MSY} reference points that were defined for cod, haddock and saithe in 2017–2019 and in 2022. 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 or even increased after 2005. 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, especially after 2005, 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 has increased by a factor of 2–3 over the years. The productive period in 2016–2017 also seems not to have led to any marked recovery of cod, but probably more so for haddock.

When the natural production of cod/haddock is split between juvenile and adult fish it is remarkable that the juvenile fish have a much larger production than adult fish (Figure 2.5). The calculation of production is based the on August survey abundances scaled up to reflect abundances in the nature (a scaling factor from survey abundances to population abundances for ages 5+ and an additional scaling factor for younger fish assuming the same total mortality as for adult fish). The abundances for each age were then multiplied by the growth of the same age from the last year to the current year (from the weights-at-age table). A very strong positive correlation was observed between the amount of sandeels and the production of age 1–2 cod/haddock (Figure 2.6, Figure 2.7). This indicates that the amount of sandeels controls the survival of age 1–2 cod/haddock. When the food becomes scarce after a boom in sandeels the carrying capacity of the system may not be able to support the strong year classes that originated from high-sandeel years. These year classes may then experience high mortality and be downscaled and it might affect the condition factor and probably mortality of adult fish as well. If there are density dependent mechanisms between adult and juvenile fish, a large biomass of adult fish could prevent the juvenile fish to become so abundant and this could in turn result in more food for adult fish and less downscaling of year classes. Hence, large biomasses of adult cod/haddock could result in higher and more stable recruitment.

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 2.8). 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 2.8).

2.1.5 Reference points for Faroese stocks

Reference points were calculated in connection with benchmarks/interbenchmarks in 2017-2019 and also in 2022. 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 2.9). Sandeels are abundant at times with strong cod and haddock recruitment (age 1) and sandeels together with pelagic fish larvae/juveniles 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 were 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 fishery for cod on Faroe Plateau, however, lost the MSC-certification in September 2022 because the cod stock was assessed to be below B_{lim}.

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 2.10) – cod and probably haddock prey preferably on sandeels and, if they are scarce, on other prey items like longline baits. Also, the recruitment at age 1 of cod and haddock, as observed in the assessment model, is positively correlated with sandeel abundance (Figure 2.11). 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 and 2022 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. A migration from Faroe Plateau to Faroe Bank seems unlikely since cod, if they stay close to bottom, would have to cross the Faroe Bank Channel where the maximum water depth is 800 m and the temperature close to zero degrees Celcius. In case of a pronounced migration of e.g. 2–3 year-old fish from Faroe Plateau to Faroe Bank this would be detected in the weights-at-age as observed on the groundfish surveys. A 3 year-old cod on Faroe Plateau is 50 cm long and on Faroe Bank 70 cm long.

2.1.8 References

ICES. 2013b. Report of the North-Western Working Group (NWWG), 26 April - 3 May 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:07. 1425 pp.

ICES. 2016. Report of the North-Western Working Group (NWWG), 27 April–4 May, 2016, ICES Headquarters, Copenhagen. ICES CM 2016/ACOM:08.

ICES 2017. Report of the North Western Working Group (NWWG). ICES CM 2017/ACOM:08.

Gaard. E., Hansen, B., Olsen, B and Reinert, J. 2001. Ecological features and recent trends in physical environment, plankton, fish stocks and seabirds in the Faroe plateau ecosystem. In: K- Sherman and H-R Skjoldal (eds). Changing states of the Large Marine Ecosystems of the North Atlantic.

Hátún, H., Sandø, A.B., Drange, H., Hansen, B., and Valdimarsson, H. 2005. Influence of the Atlantic subpolar gyre on the thermohaline circulation. Science, vol 309, 1841-1844.

Hátún, H., and Chafik, L. 2018. On the recent ambiguity of the North Atlantic subpolar gyre index. Journal of geophysical research: Oceans, commentary. 10.1029/2018JC014101.

Steingrund, P., and Gaard, E. 2005. Relationship between phytoplankton production and cod production on the Faroe Shelf. ICES Journal of Marine Science, 62: 163–176.

Steingrund, P., Gaard, E., Reinert, J., Olsen, B., Homrum, E., and Eliassen, K. 2012. Trophic relationships on the Faroe Shelf ecosystem and potential ecosystem states. In: Homrum, E., 2012. The effects of climate and ocean currents on Faroe Saithe. PhD-thesis, 2012.

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
2022 cal year	1744	4731	2320	2484		1427	9954	22660	12706

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.

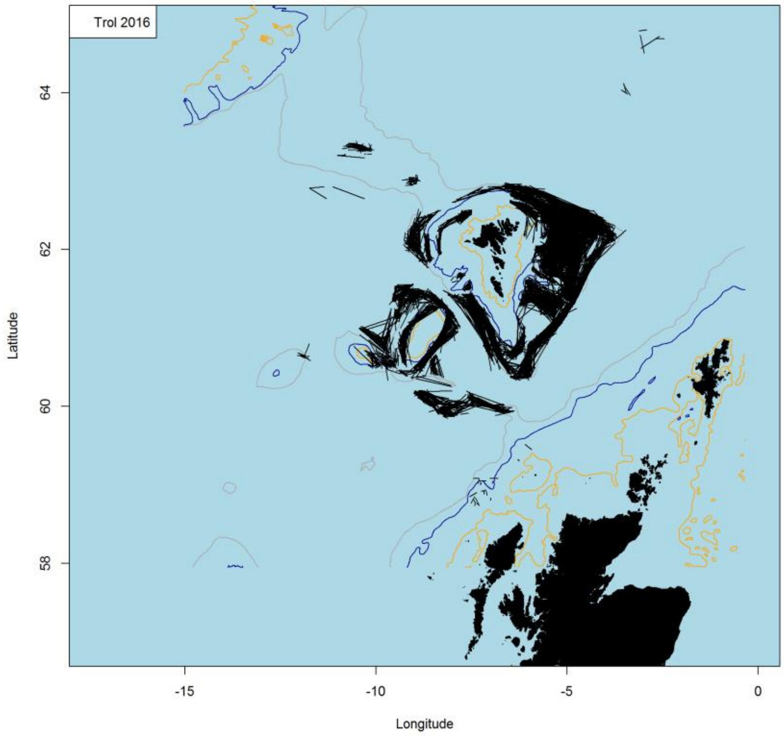
	Number of used days									
	2 outer	2 inner	3	4 A	4 B	4 T	5 A	5 B	Total days	Total 2-4
1996/1997										
1997/1998		6211	2469	2619	3983					15282
1998/1999		5907	2309	2147	3715					14078
1999/2000		6497	2207	2255	3995					14954
2000/2001		6065	2469	2733	4435					15702
2001/2002		5643	2494	2454	4450					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	789	3254	1382	740		1143	3143	1542	11993	7308
2022 cal year, estim.	460	2684	1438	768		1102	1994	2111	10557	10557

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.	48	72	57	28		76	45	52	57

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 were fixed in 1997, but in group 5B a large number of additional licenses can be issued upon request. Group 4A and 4B were merged in 2021.

	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



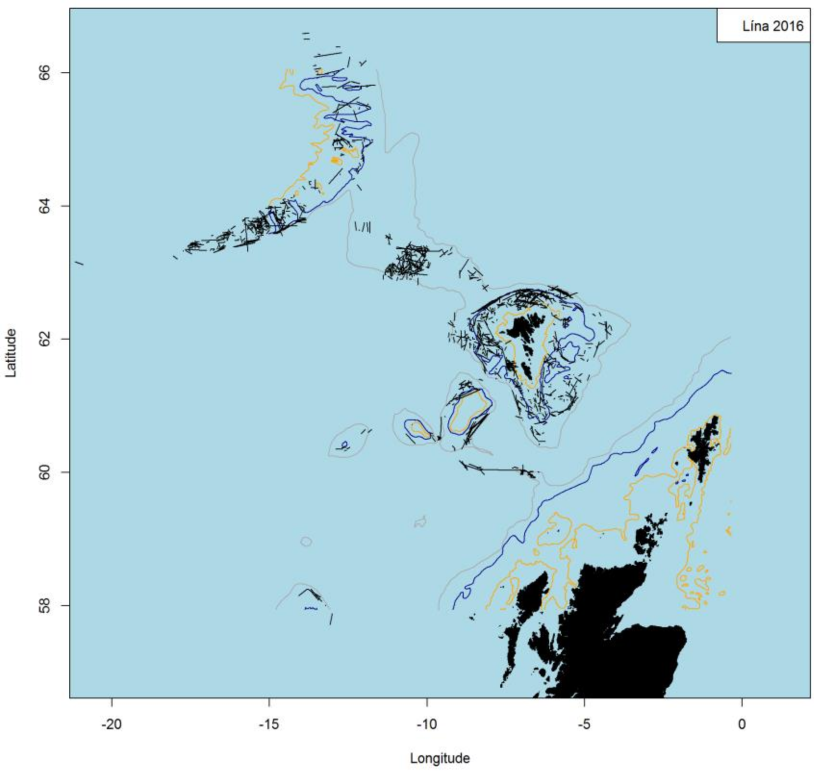


Figure 2.1. The 2016 distribution of fishing activities by some major fleets. From top: 1010HP, trap and trawl > Gillnet, longline. The longline fleet below 110 GRT is not shown here since they are not obliged to keep logbooks.

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

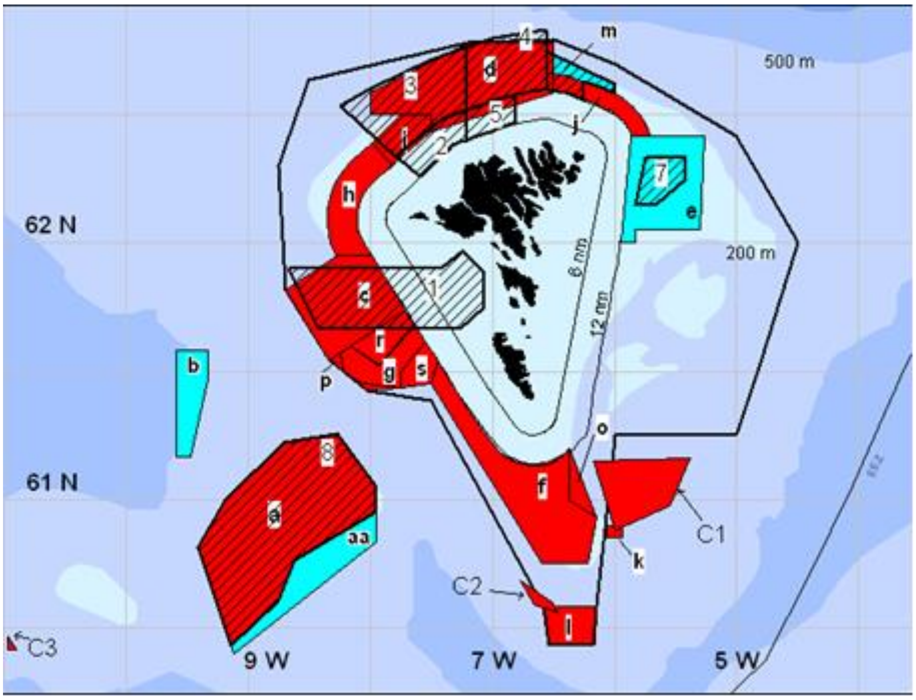


Figure 2.2. Fishing area regulations in Division 5.b. Allocation of fishing days applies to the area inside the outer thick line on the Faroe Plateau. Holders of effort quotas who fish outside this line can triple their numbers of days. Longliners larger than 110 GRT are not allowed to fish inside the 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.

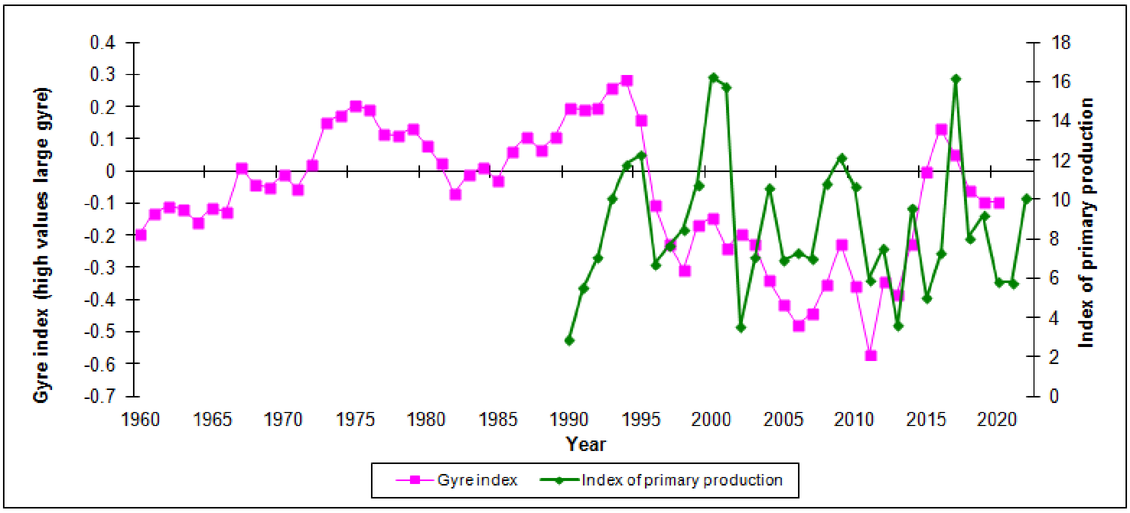


Figure 2.3. Temporal development of the phytoplankton index over the Faroe Shelf area (< 130 m) and the Subpolar Gyre index which may indicate productivity in the outer areas.

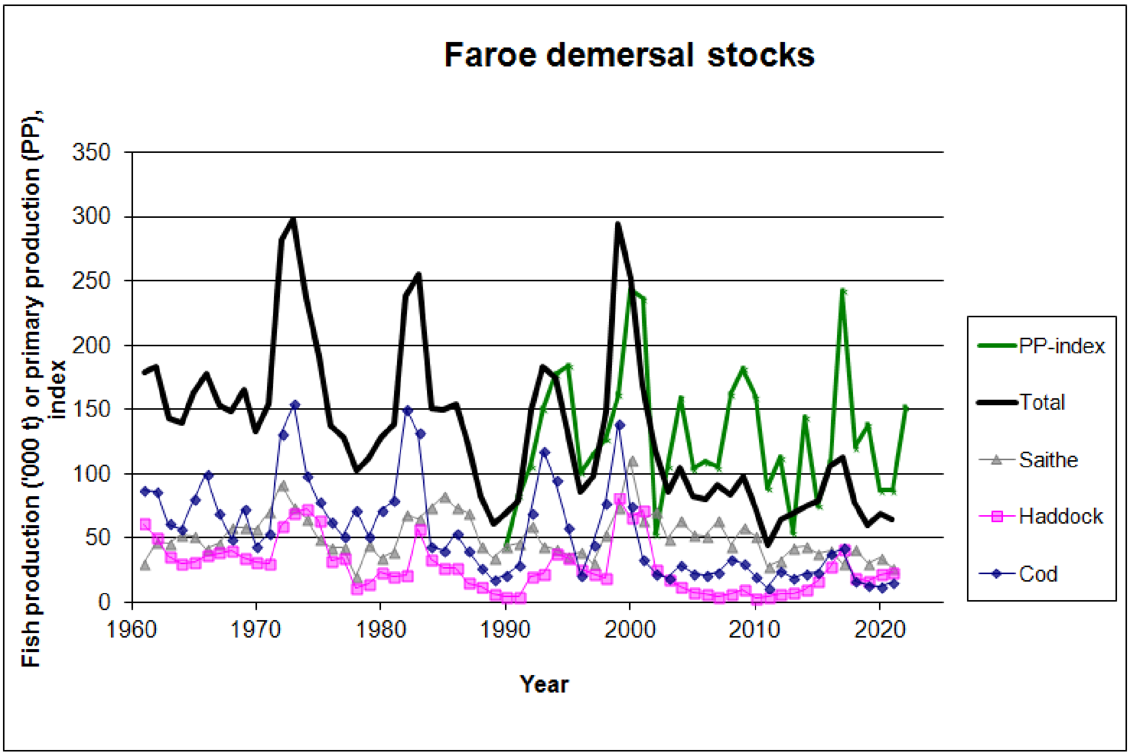


Figure 2.4. Temporal development of primary production and production of cod, haddock and saithe.

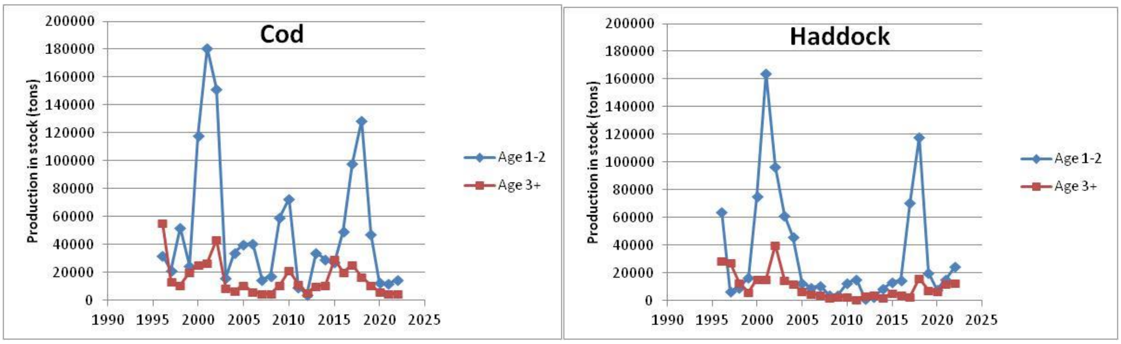


Figure 2.5. Production of cod and haddock for juvenile (ages 1–2) and adult (ages 3+) fish. Based on scaled August survey abundances.

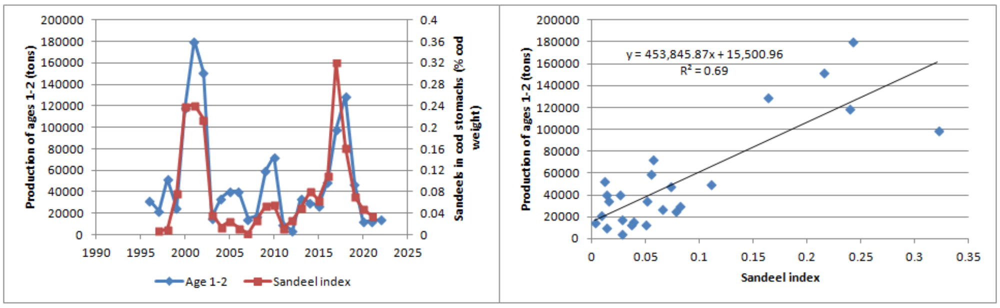


Figure 2.6. Production of juvenile cod (ages 1–2) based on scaled August survey abundances compared with the abundance of sandeels.

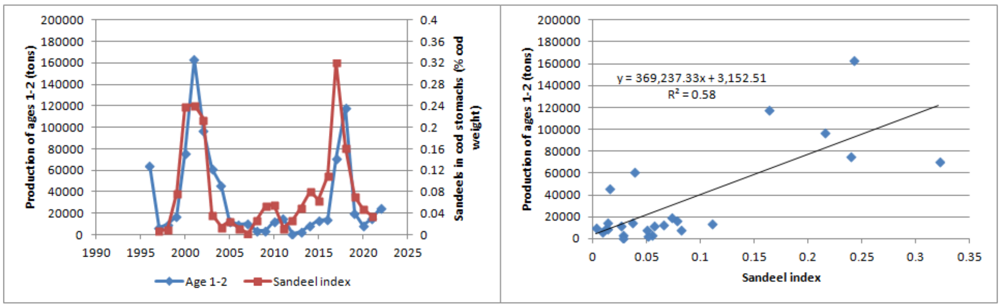


Figure 2.7. Production of juvenile haddock (ages 1–2) based on scaled August survey abundances compared with the abundance of sandeels.

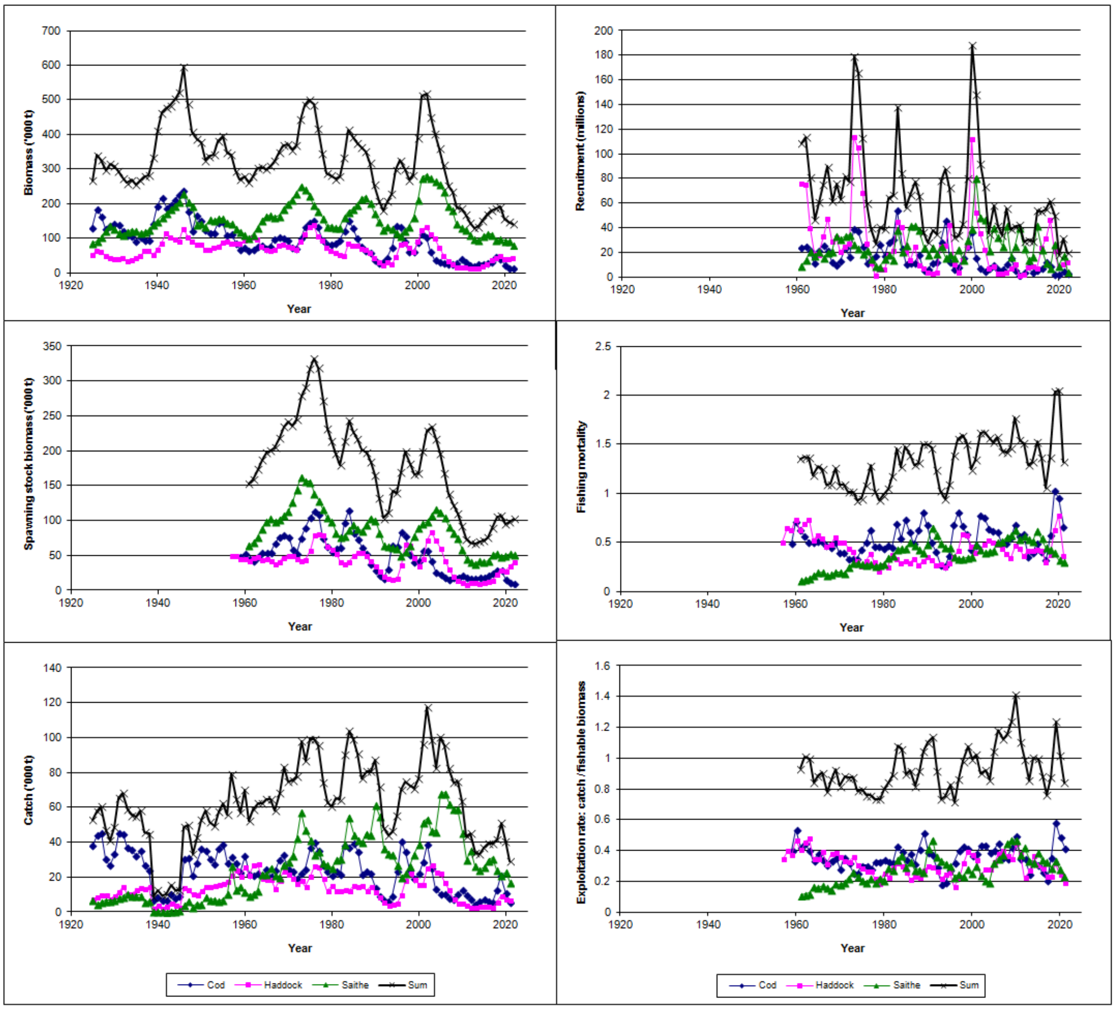


Figure 2.8. Summary of the stock dynamics for Faroe Plateau cod, Faroe haddock and Faroe saithe. Fishable biomass is age 3+ for cod and haddock and age 4+ biomass for saithe.

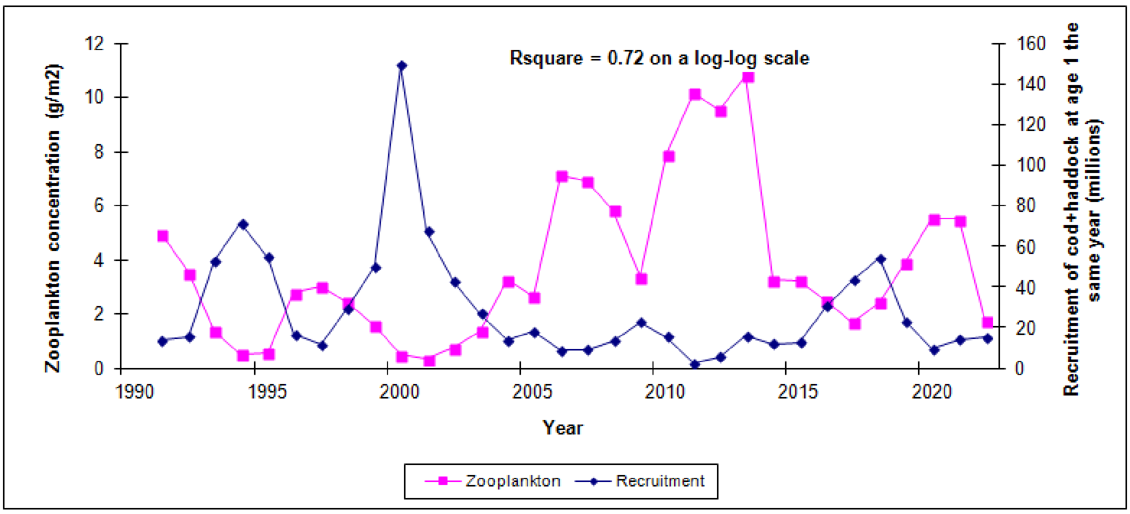


Figure 2.9. Relationship between zooplankton concentration in June/July and recruitment of cod and haddock on the Faroe Plateau.

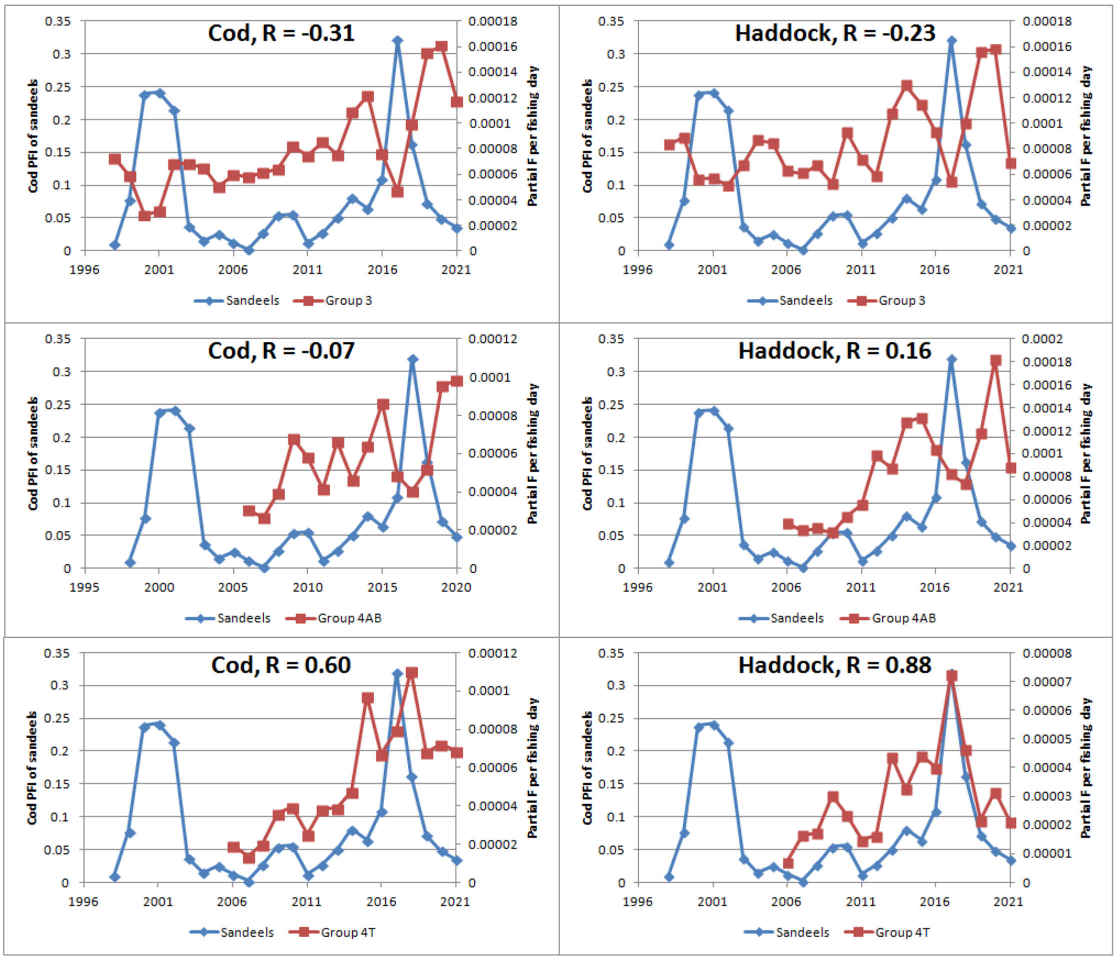


Figure 2.10. Partial F per fishing day of cod and haddock for large longliners (Group 3), medium-sized longliners (Group 4AB) and small single trawlers (Group 4T). A comparison with sandeel abundance is made.

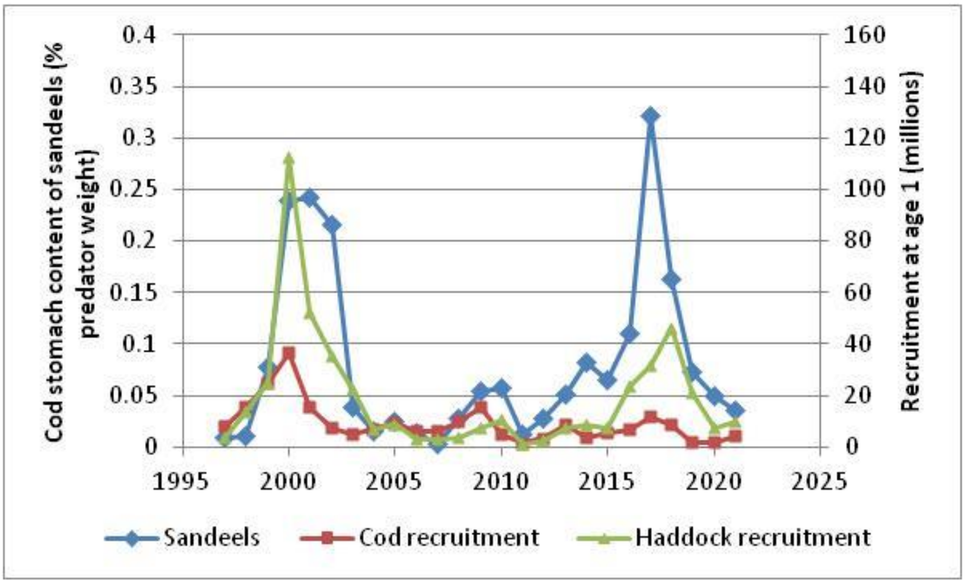


Figure 2.11. Sandeel abundance, as measured by cod stomach partial fullness index of sandeels, compared with the recruitment of cod and haddock.

3 Faroe Bank cod

This section was updated in November 2022.

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 61 in 2021. (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 and since 2008 is closed to fishery. 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. The index increased sharply in 2020 but it dropped again in 2021 and 2022. 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 since 2021. 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 from 2005 to 2020 but it has increased continuously in 2021 and 2022.

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).

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 slightly in 2011 and 2016 due to the increase in catches.

3.1 Comparison with previous assessment and forecast

The spring index suggests the stock biomass increased substantially in 2020 which it was however not confirmed by the summer index. In both 2021 and 2022 both indexes are in disagreement. There are no indications of incoming recruitment. In 2022 a category 3 (rb rule) was formulated for Faroe Bank cod. The rb rule is defined as:

$$C_{y+1} = A_y \times r \times b \times m$$

where

C_{y+1} : Catch Advice for next year

r: biomass ratio (survey trend)

b = 1 (biomass safeguard)

m = 0.5 (multiplier; tuning parameter)

The Von Bertalanfy growth equation ($L\infty$ = 109, k = 0.33, t_0 = -0.53) was applied to summer survey data (figure below). The rb rule is a simpler version of the rfb rule and is meant to cover those cases where length data are not available or insufficient.

3.2 Management plans and evaluations

None.

3.3 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.

In 2022, the advice was based on category 3 (rb rule) type (See 3.2 for more details). ICES advises that when rb approach is applied, catches in 2023 should be no more than 78 tonnes.

3.4 Regulations and their effects

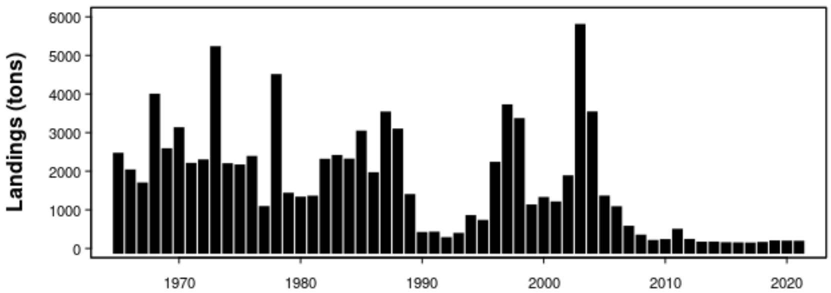
In 1990, the decreasing trends in cod landings from Faroe Bank lead ACFM to advise the Faroese authorities to close the bank to all fishing. This advice was followed for depths shallower than

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 2002–2021 as officially reported to ICES. From 1992 the catches by Faroe Islands and Norway are used in the assessment.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Faroe Islands	3607	1270	1005	471	231	81	111	393	115	40	40	26	19	14	33	74	55	63 *
Norway	18	37	10	7	1	4	1		0		1	0	1	1			13	2
France													3					
Greenland	-	-	-	-	-	-	5		1									
UK (E/W/NI)	15 3	24 3	0 3															
UK (Scotland)	244 3	1129 3	0	53	32	38	54				45	16	60	17 3	55	4		
Total	3884	2460	1015	531	264	123	171	393	116	40	86	42	83	32	88	78	68	65
Correction of Faroese catches in Vb2	-214	-75	-60	-28	-14	-5	-7	-23	-7	-2	-2	-2	-1	-1	-2	-4	-3	-4
Used in assessment	3411	1232	955	450	218	80	105	370	108	38	39	24	19	14	31	70	65	61



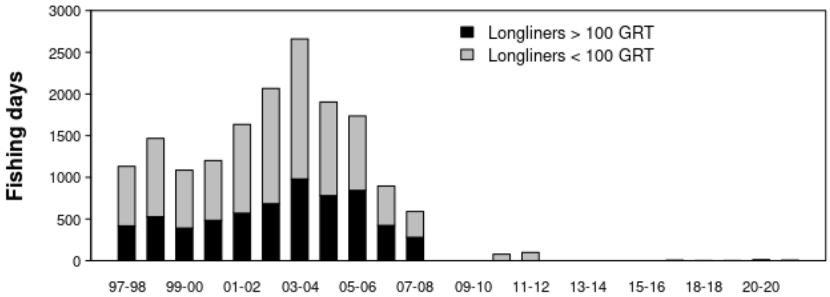


Figure 3.1. Faroe Bank (subdivision Vb2) cod. Reported landings 1965–2021. Since 1992 only catches from Faroese and Norwegian vessels are considered to be taken on Faroe Bank. Lower plot: fishing days (fishing year) 1997–2021 for long-line gear type in the Faroe Bank.

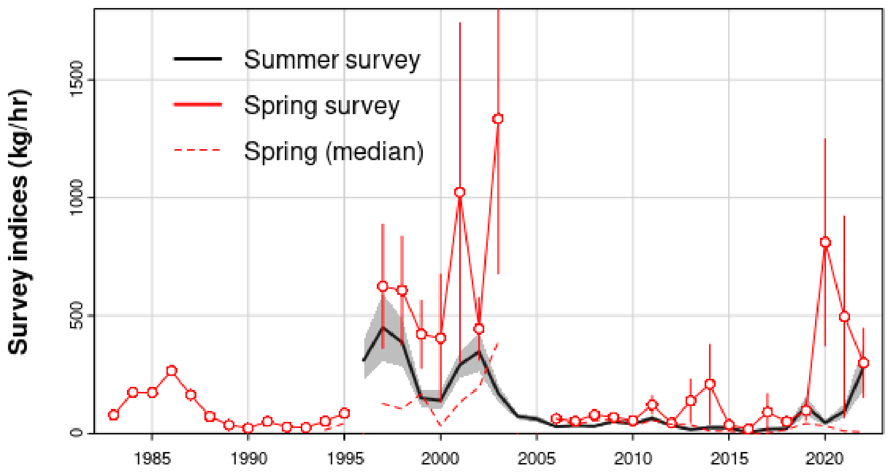


Figure 3.2. Faroe Bank (subdivision Vb2) cod. Catch per unit of effort in spring groundfish survey (1983–2022) (red line) and summer survey (1996–2022) (black line). Vertical bars and shaded areas show the standard error in the estimation of indices.

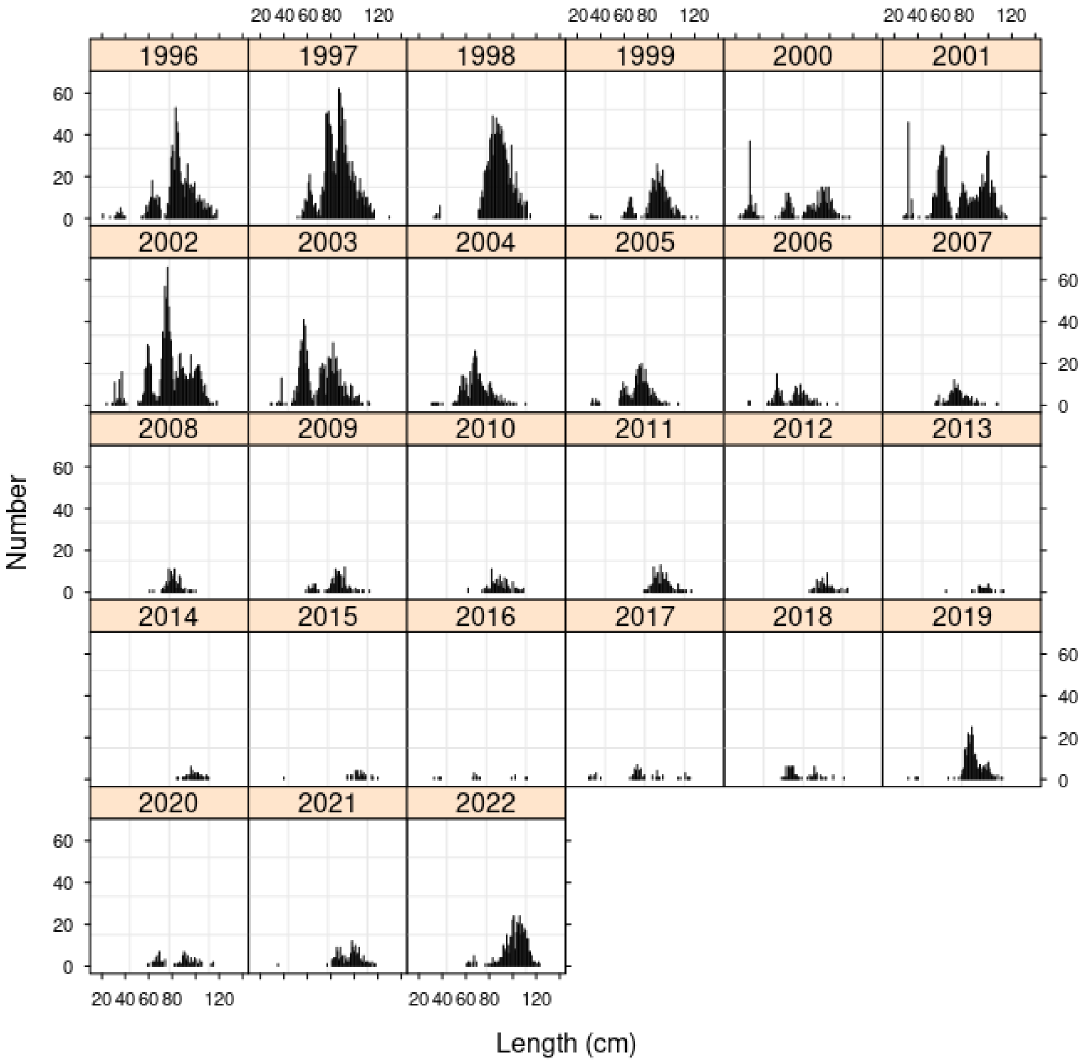


Figure 3.3. Faroe Bank (subdivision Vb2) cod. Length distributions in summer survey (1996–2022).

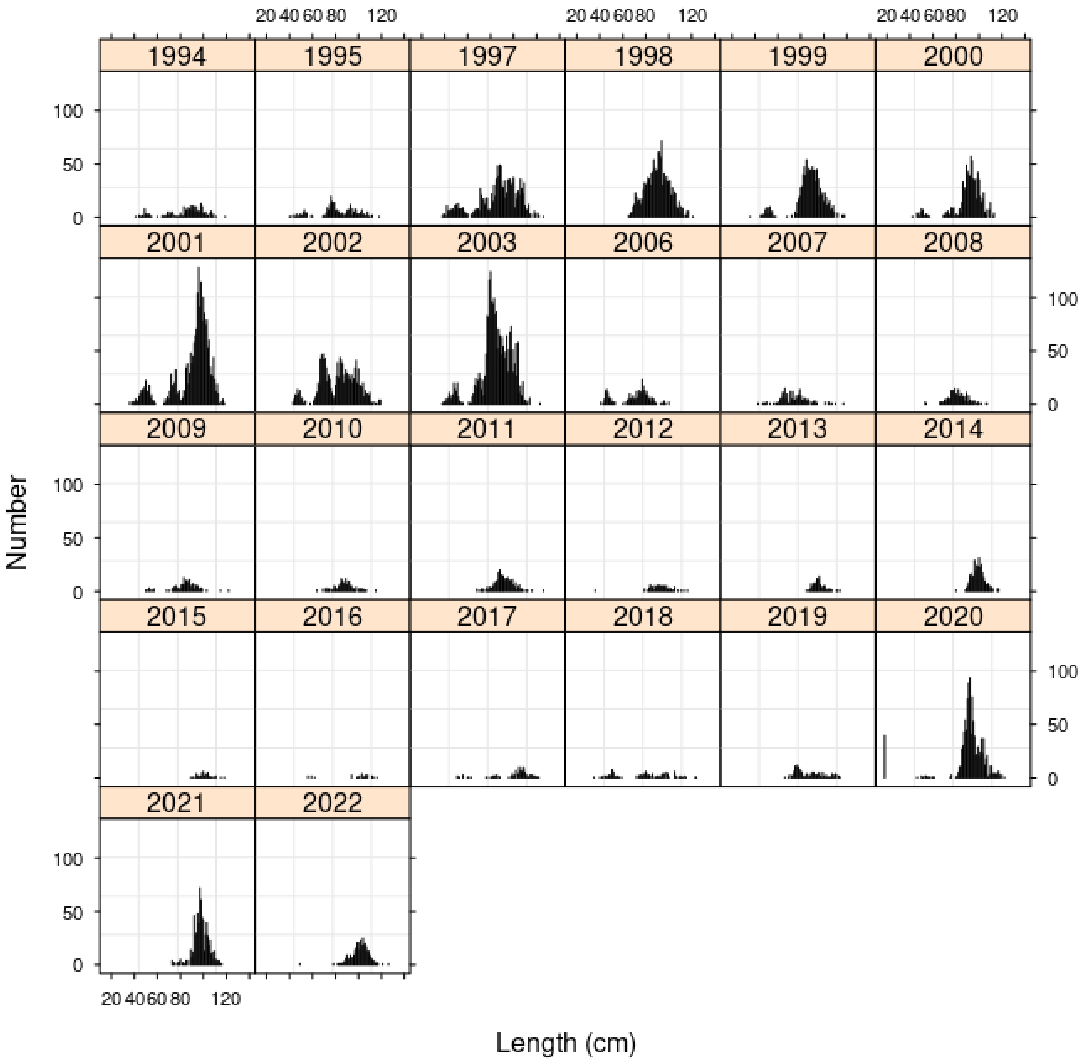


Figure 3.4. Faroe Bank (subdivision Vb2) cod. Length distributions in spring survey (1994–2022). No surveys were conducted in 1996, 2004 and 2005.

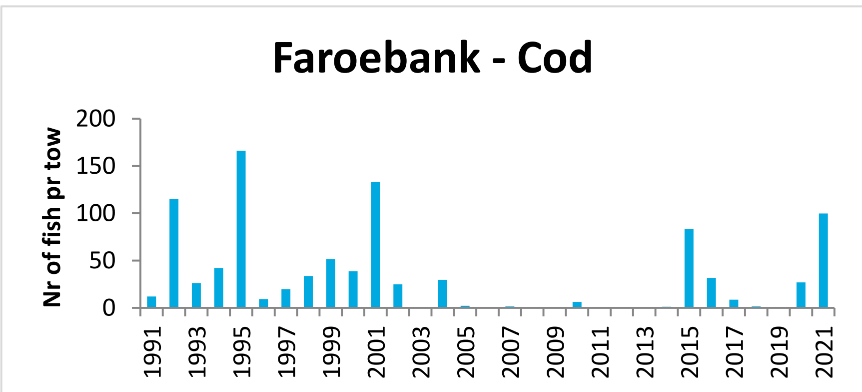


Figure 3.5. Faroe Bank (subdivision Vb2) cod. Ichtoplankton survey (1991–2021). No surveys were conducted in 2009, 2011 and 2013.

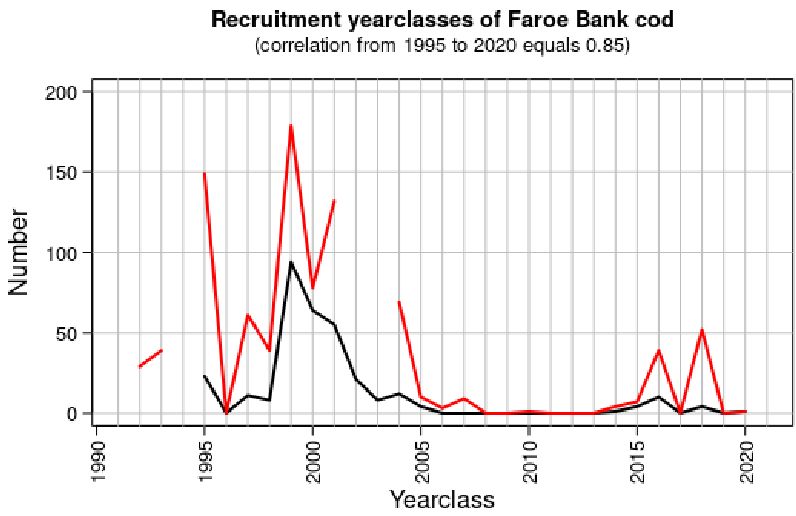


Figure 3.6. Faroe Bank (subdivision Vb2) cod. Correlation between recruitment year classes in both survey indices.

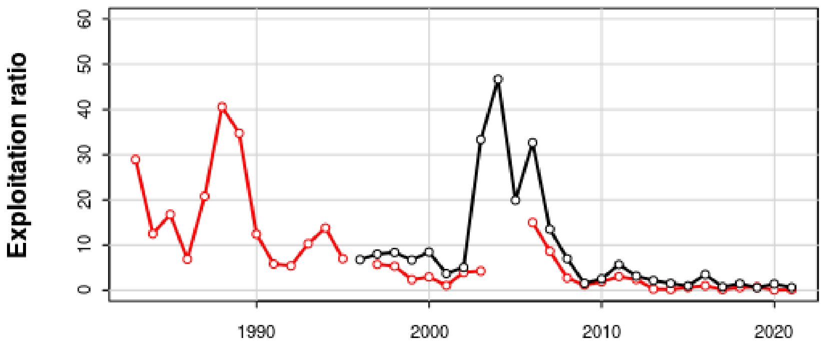


Figure 3.7. Faroe Bank (subdivision Vb2) cod. Exploitation ratios, ratio of spring index to landings (red line) and ratio of summer index to landings (black line).

4 Faroe Plateau cod

This section was updated in November 2022.

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 2021 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 2021 showed a discrepancy of 0 %. The weights have increased in recent years, but since decreased (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 and Jákup Sverri (since 2022) 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 attained the lowest value in 2022.

The other tuning series used is the Summer Groundfish Survey. The new research vessel, Jákup Sverri, conducted the august survey for the first time in 2021. The stratified mean catch of cod per unit effort has also decreased in recent years to record 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 2020–2022 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 4.2.9), 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).

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). The interbenchmark in September 2022 (IBPFAR) included the catch-at-age in the interim years into the assessment. The catch in tons was estimated from the January-September landings and scaled to the whole year by a regression analysis. The age composition in the catch was based on the January-June samples. Hence, the assessment was based on the newest information that was available.

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). After the interbenchmark in September 2022, where the effect of including a catch at age for the interim year was studied, new reference points were calculated and finalized at the NWWG meeting in October 2022.

Selection of B_{lim}

The stock recruit plot (Figure 4.5.1) had few observations between 20-40kt. As a result, there was no very clear indication of a decline in recruitment at any point above 20 kt. Below 20 kt there was a somewhat lower recruitment, coming from poor year classes in 2012-2021 with low SSB.

With the bulk of the points above 40kt associated with a wide range of recruitment values, a segmented regression fitted to these points had a breakpoint at the ~50kt (just before the bulk of points). However, this breakpoint was not strongly defined. Hence the breakpoint in the segreg was not used for B_{lim}.

The previous basis for B_{lim} was the lowest SSB from which the stock has recovered. Using the same basis with the most recent assessment the SSB in 1992 (17803t; Figure 4.5.2) was considered the appropriate value. The biomass was lower later in the period (2012-2017) but the stock had not recovered from this level at the time of the assessment and reference point calculations.

Calculation of B_{pa} and MSY $B_{trigger}$

The final year uncertainty on SSB and F from the SAM assessment (SSB: 0.14, F: 0.12) was considered an underestimate given the retrospective issues with the assessment. So uncertainty values of 0.2 were used in the simulations instead (Table 4.5.1).

Bpa = Blim*exp(1.645*sigma) where sigma=0.20 = 24739 t

F was high in 2019-2020 (above Fmsy) so MSY Btrigger was set at Bpa.

F_{MSY}

F_{MSY}(0.37) was well below F_{pa} = F_{p05} (0.69). This was well above the previous F_{MSY} for the stock (0.23). A possible part of the explanation is the change in selectivity compared to the previous assessment (Figure 4.5.3). The more dome-shaped selectivity was considered to favour a higher F_{MSY} since older fish that contribute to SSB experienced lower Fs even with a higher F_{MSY}. Also, F_{MSY} was still on the lower end of observed F over the whole time series (Figure 4.5.2). The stock had previously grown with F levels greater than 0.42 and the declines in 2015-22 came from Fs being between 0.5 and 0.8 from the mid-1990s to the 2010s. Old and new reference points are shown in Table 4.5.2.

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 process error (joint residuals) (Figure 4.6.2).

The results from the SAM-run show that fishing mortality (F3–7) has decreased in recent years from very high values (Table 4.6.2, Table 4.6.4, Figure 4.6.3). The population numbers, total biomass and spawning stock biomass were 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 between F_{pa} and F_{MSY} (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 11 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 spawning stock biomass is expected to be 10 thousand tonnes in 2023 and will not attain B_{lim} in 2024 even if F = 0. This is markedly lower than expected in the last years' forecast and sets the scene for a zero advice.

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 0.39 (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 393%, -35% and 46% for recruitment, F, and the spawning stock biomass, respectively. The downscaling of the recruitment is commented on later in this report (4.10). The interbenchmark process (IBPFAR, 2022) investigated the retrospective pattern and found that setting M = 0.4 from 2017 and onwards reduced the retrospective pattern, e.g. for SSB where it dropped from 20% to 6%. Applying this setting in the current assessment (with one additional year in the tuning series and two extra years in catch-at-age) reduced the rho for SSB from 46% to 21%. Setting M = 0.4 since 2013 reduced it to 24%. Setting M = 0.4 since 2009 reduced it to 31%. Hence, the rho-value became larger the longer back in time the M = 0.4 setting was moved. The setting of M = 0.4 since 2017 was supported by tagging results, but the NWWG suggested that this needed further scrutinization. The NWWG decided to keep the old setting of M = 0.2 for all years even though the rho-values were higher.

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). The importance of food is demonstrated in NWWG 2021, 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.

In the interbenchmark process (IBPFAR 2022) some biological considerations were presented (IBPFAR 2022, WD 1). Briefly, it was noted that very large numbers of small fish (0-2 year old cod and haddock) were observed in 2016-2018. This was probably a result of the high primary production in 2017 and low competition/predation of adult cod/haddock due to their low biomasses. Preliminary calculations showed that these small fish could consume as much as 80% of the total food consumption of the cod/haddock stocks. Since age 3-4 cod/haddock eat partially the same food as age 0-2 fish (Crustacea, Polychaeta, sandeels) it was proposed that the low condition factor of adult cod/haddock in 2019 probably was caused by the superabundant small cod/haddock. As already mentioned, the survival of small cod/haddock from age 1 to age 3 is low when the condition factor of adult cod/haddock is low (NWWG 2021, WD 30). According to this reasoning the actual problem for the cod/haddock stocks could be the low biomass of adult cod/haddock that is unable to keep down the abundance of small cod/haddock. Conversely, a large biomass of adult cod/haddock could probably prevent the occurrence of superabundant small fish and subsequent food shortage and lead to larger and more stable recruitment.

Such biological conditions could confuse any assessment model. Large numbers of age 1 fish used in the tuning tell the model that large year classes will enter the fishery in the near future. However, the same numbers might be signalling just the opposite, that the downscaling will be large and that small year classes will enter the fishery. Preliminary investigations at the NWWG meeting showed that the retrospective pattern was improved if the age 1 was excluded from the tuning in the cod assessment. There are indications that the downscaling of recruitment and SSB is levelling off since the two latest peels are close to each other (Figure 4.9.1).

4.10 Comparison with previous assessment and forecast

The assessment settings were according to the Stock Annex, with the change of using a catch-at-age for the interim year. The assessment this year showed 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.

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. In September 2022 cod lost the MSC-certification because the spawning stock biomass was below B_{lim}. The management plan is not yet sent to ICES for evaluation.

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. This could be relevant since the cod stock currently is very low and will likely stay low the next years. Cod and haddock are caught in a mixed fishery and managed by an effort management system. It might be a challenge for the fleets to avoid fishing cod while still fishing haddock.

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.

4.17 Category 3 assessment

A Category 3 assessment was performed for this stock in case the retrospective pattern was considered to be too large for a Category 1 assessment. The two survey indices were converted into one index after a standardization to their own mean and the average taken of both standardized indices. The advice for 2023 was 423 tons (Table 4.17.1). If the stock recovers in the future to the 1996-2003 level the advised catch only increases up to 600-700 tons and decreases afterwards (Figure 4.17.1) due to characteristics of the rfbm rule. This is to be compared with an average catch of 29048 tons for 1996-2003, i.e. the advised catch is a factor of 50–100 lower. Hence, the stock will likely be greatly underfished in the future if it recovers and the Category 3 approach is followed.

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		22282	1			0	219			0	233	22735
2020		10614	2			0	163			0	690	11470
2021		5879*	3				65				0	5947

*** 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.

		Faroese catches				Reported as 5.b.2			Foreign catches				
	Officially reported	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 ***	Used in the assessment
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

	Faroese catches					Reported as 5.b.2			Foreign catches				
	Officially reported	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 ***	Used in the assessment
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	22735		-1326	-804									20609
2020	11470		-630	-402									10438
2021	5947*		-348	-182									5417

*** 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
2021	533.1	3098.8	43.1	1159.7	519.3	5354	10.0	57.9	0.8	21.7	9.7

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	0.2	0	0.2			
2	6.3	32.9	2.1	41.3	15	80	5
3	281.5	88.5	15.5	385.5	73	23	4
4	531.4	129.4	93.4	754.1	70	17	12
5	164.8	60.7	88.7	314.2	52	19	28
6	68.4	30.3	19.2	117.9	58	26	16
7	30.1	17.9	6.6	54.7	55	33	12
8	8.5	9.1	2	19.6	43	46	10
9	0	6.5	0.2	6.7	0	97	3
10+	0	0.6	0.2	0.8	0	75	25
Sum	1091	376.1	227.9	1695	64	22	13

Table 4.2.5. Faroe Plateau cod (Subdivision 5.b.1). Number of samples, lengths, otoliths, and individual weights in year before the interim 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	0		48	0		0	0		47	0
Longliners < 100 GRT	2	0		245	0		0	0		120	0
Jiggers	0	0		0	0		0	0		0	0
Single trawlers < 400 HP	2	1		0	0		331	200		120	60
Single trawlers > 400 HP	0	0		0	0		0	0		0	0
Pair trawlers < 1000 HP	9	3		0	0		1415	305		538	178
Pair trawlers > 1000 HP	12	7		0	0		1423	911		717	417
Longliners > 100 GRT	5	6		0	0		879	1042		300	359
Sum	31	17		293	0		4048	2458		1842	1014

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

Year\age	1	2	3	4	5	6	7	8	9	10+
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
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

Year\age	1	2	3	4	5	6	7	8	9	10+
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	574	2163	1403	1238	925	238	36	23	9
2020	0	27	1634	1220	478	324	184	44	9	1
2021	0	41	386	754	314	118	55	20	7	1
2022	0	55	158	276	369	136	37	20	8	4

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

Year\age	2	3	4	5	6	7	8	9	10+
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
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	1.016	1.880	2.993	4.183	4.977	6.007	6.458	9.447	10.151
2022	1.087	1.784	2.769	4.208	5.919	7.672	8.988	11.224	11.852

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
2022	0.00	0.03	0.68	0.97	0.98	0.99	1.00	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 disregarded by the assessment model.

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
2022	200	33.9	279.5	198.9	181.7	186.1	47.8	21.3	17.3	4.1

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

Year	Effort (hours)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
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
2022	100	2.0	66.3	85.6	223.6	188.6	49.8	14.9	8.1	3.5

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	1353	1848	2011	1558	1046	810	335	219
1990	135	3308	2382	966	538	485	231	0
1991	10	193	1831	1135	431	294	85	121
1992	120	695	993	1762	1084	504	184	89
1993	66	1400	2840	967	1376	515	87	138
1994	1671	2709	1853	2809	887	1579	586	67
1995	689	4350	6180	5012	3305	648	644	127
1996	461	20234	31822	15231	8412	370	0	1380
1997	36	874	7830	12157	3129	1224	146	0
1998	85	775	1912	6294	5195	848	303	0
1999	505	2369	2200	3423	5844	2526	248	5
2000	5779	6575	2886	1588	1666	2815	634	0
2001	3447	6825	3065	565	423	812	878	26
2002	618	6938	5433	1337	468	433	45	247

Year	Age							
	2	3	4	5	6	7	8	9
2003	106	2264	7512	6129	1469	456	257	246
2004	44	0	522	4746	5302	3246	513	345
2005	71	686	1125	3033	3729	1476	255	120
2006	143	207	1074	1160	2428	941	1209	109
2007	60	852	1643	1294	745	610	192	43
2008	49	264	374	512	345	407	435	162
2009	18	1203	1313	1240	735	406	241	171
2010	3310	6122	3751	1140	1264	399	0	170
2011	44	2948	8082	3899	1232	873	189	49
2012	0	183	2967	3466	1841	431	78	206
2013	73	214	1590	3308	1401	216	119	76
2014	423	2363	1457	2447	2625	690	136	146
2015	51	1152	2316	1214	1419	1294	382	115
2016	159	594	2726	1863	1108	845	443	216
2017	553	1374	2996	5174	1965	967	756	497
2018	2167	4214	6745	6739	5127	2199	616	257
2019	3997	9468	4132	2223	624	159	15	10
2020	65	2021	3827	1550	599	323	152	46
2021	180	957	3702	2661	461	193	21	0

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

Year	Age							
	1	2	3	4	5	6	7	8
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	356	5698	5857	2203	1782	978	460
2021	23	1195	3509	4806	1942	981	600	275

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.

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

Year	Age							
	1	2	3	4	5	6	7	8
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
2020	0.0	3.1	49.8	51.2	19.3	15.6	8.6	4.0
2021	0.2	8.8	25.8	35.3	14.3	7.2	4.4	2.0

Table 4.5.1. Faroe Plateau cod (Subdivision 5.b.1). EQSIM settings for calculations of reference points at NWWG 2022.

Setting	Value
stockName	Cod.27.5b1
SAOAssessment	Cod_27_5b1
sigmaF	0.2
sigmaSSB	0.2
noSims	1001
SRused	Segreg_Ricker_Bevholt
SRyears_min	1959
SRyears_max	2021
acfRecLag1 (autocorrelation in recruitment)	0.56
rhoRec (simulate autocorrelation for recruitment)	FALSE
numAvgYrsB (biology years)	5
numAvgYrsS (selectivity years)	10
cvF (advice uncertainty)	0.212
phiF (advice uncertainty autocorrelation)	0.423

Table 4.5.2. Faroe Plateau cod (Subdivision 5.b.1). Results of reference point calculations from the NWWG 2022 assessment compared with the previous values.

Framework	Reference point	OLD Value	NEW Value	Technical basis
MSY approach	MSY $B_{trigger}$	29226 t	24739 t	B_{lim}*exp(1.645*sigma) where sigma = 0.20
	F_{MSY}	0.23	0.37	Stochastic simulations assuming segmented regression, Ricker and Beverton and Holt stock recruitment relationships.
Precautionary approach	B_{lim}	21000 t	17803 t	B_{loss} in 1992 from the 2022 assessment.
	B_{pa}	29226 t	24739 t	B_{lim}*exp(1.645*sigma) where sigma=0.20
	F_{lim}	0.90	1.47	F that gives a 50% probability of SSB > B_{lim}, from Stochastic simulations
	F_{pa}	0.41	0.69	F that gives a 95% probability of SSB > B_{lim}, from Stochastic simulations

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:

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-8.975	0.210	0.000	0.000	0.000
logFpar_1	-7.693	0.113	0.000	0.000	0.001
logFpar_2	-6.634	0.110	0.001	0.001	0.002
logFpar_3	-6.144	0.109	0.002	0.002	0.003
logFpar_4	-5.953	0.108	0.003	0.002	0.003
logFpar_5	-5.903	0.108	0.003	0.002	0.003
logFpar_6	-5.900	0.109	0.003	0.002	0.003
logFpar_7	-5.868	0.109	0.003	0.002	0.004
logFpar_8	-12.220	0.393	0.000	0.000	0.000
logFpar_9	-8.310	0.130	0.000	0.000	0.000
logFpar_10	-6.642	0.127	0.001	0.001	0.002
logFpar_11	-5.738	0.125	0.003	0.003	0.004
logFpar_12	-5.459	0.125	0.004	0.003	0.005
logFpar_13	-5.442	0.125	0.004	0.003	0.006
logFpar_14	-5.581	0.125	0.004	0.003	0.005
logFpar_15	-5.854	0.097	0.003	0.002	0.003
logSdLogFsta_0	-1.207	0.087	0.299	0.251	0.356
logSdLogFsta_1	-0.530	0.115	0.589	0.468	0.741
logSdLogN_0	-0.388	0.111	0.678	0.543	0.847
logSdLogN_1	-1.762	0.116	0.172	0.136	0.216
logSdLogObs_0	-1.868	0.104	0.154	0.125	0.190
logSdLogObs_1	0.035	0.140	1.036	0.783	1.370
logSdLogObs_2	-0.644	0.074	0.525	0.453	0.609
logSdLogObs_3	0.593	0.154	1.810	1.330	2.462
logSdLogObs_4	-0.431	0.050	0.650	0.588	0.718
logSdLogObs_5	-0.187	0.117	0.829	0.656	1.048

Model	log(L)	#par	AIC
Current	-836.38	28	1728.75
base	-836.38	28	1728.75

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		0.208	0.47	0.479	0.526	0.459	0.513	0.513	0.513	0.323
1960		0.431	0.642	0.643	0.714	0.709	0.841	0.841	0.841	0.494
1961		0.318	0.521	0.541	0.635	0.648	0.761	0.761	0.761	0.454
1962		0.279	0.472	0.521	0.616	0.591	0.602	0.602	0.602	0.371
1963		0.237	0.412	0.481	0.55	0.536	0.526	0.526	0.526	0.33
1964		0.14	0.322	0.43	0.533	0.579	0.612	0.612	0.612	0.376
1965		0.124	0.3	0.418	0.541	0.608	0.665	0.665	0.665	0.404
1966		0.086	0.237	0.339	0.477	0.627	0.85	0.85	0.85	0.499
1967		0.085	0.235	0.327	0.446	0.579	0.769	0.769	0.769	0.458
1968		0.097	0.256	0.37	0.463	0.532	0.613	0.613	0.613	0.377
1969		0.107	0.274	0.399	0.488	0.604	0.746	0.746	0.746	0.446
1970		0.061	0.209	0.309	0.375	0.488	0.588	0.588	0.588	0.364
1971		0.039	0.169	0.267	0.362	0.537	0.652	0.652	0.652	0.399
1972		0.047	0.173	0.254	0.319	0.438	0.467	0.467	0.467	0.301
1973		0.067	0.206	0.284	0.322	0.384	0.439	0.439	0.439	0.288
1974		0.068	0.192	0.268	0.327	0.401	0.472	0.472	0.472	0.304
1975		0.096	0.256	0.379	0.444	0.482	0.547	0.547	0.547	0.337
1976		0.077	0.241	0.398	0.526	0.594	0.754	0.754	0.754	0.426
1977		0.063	0.264	0.49	0.669	0.747	0.944	0.944	0.944	0.478
1978		0.052	0.231	0.398	0.492	0.534	0.641	0.641	0.641	0.336
1979		0.051	0.247	0.411	0.49	0.534	0.612	0.612	0.612	0.315
1980		0.055	0.256	0.388	0.451	0.501	0.581	0.581	0.581	0.293
1981		0.056	0.268	0.394	0.466	0.534	0.652	0.652	0.652	0.326
1982		0.054	0.262	0.38	0.441	0.506	0.661	0.661	0.661	0.33
1983		0.104	0.403	0.593	0.692	0.789	0.985	0.985	0.985	0.457
1984		0.095	0.378	0.543	0.578	0.582	0.646	0.646	0.646	0.315
1985		0.062	0.351	0.586	0.707	0.889	1.098	1.098	1.098	0.491
1986		0.034	0.294	0.543	0.637	0.757	0.802	0.802	0.802	0.368
1987		0.031	0.25	0.45	0.492	0.587	0.643	0.643	0.643	0.297
1988		0.066	0.33	0.581	0.616	0.747	0.834	0.834	0.834	0.359

Year Age	1	2	3	4	5	6	7	8	9	10
1989		0.145	0.434	0.761	0.814	0.948	1.047	1.047	1.047	0.423
1990		0.079	0.318	0.621	0.708	0.812	0.917	0.917	0.917	0.379
1991		0.042	0.216	0.462	0.545	0.619	0.674	0.674	0.674	0.293
1992		0.024	0.152	0.343	0.431	0.505	0.564	0.564	0.564	0.252
1993		0.016	0.114	0.238	0.288	0.321	0.373	0.373	0.373	0.175
1994		0.026	0.127	0.245	0.274	0.286	0.322	0.322	0.322	0.151
1995		0.06	0.189	0.358	0.384	0.405	0.453	0.453	0.453	0.199
1996		0.046	0.203	0.459	0.677	0.894	1.159	1.159	1.159	0.426
1997		0.048	0.211	0.449	0.739	1.098	1.532	1.532	1.532	0.513
1998		0.075	0.238	0.417	0.604	0.876	1.209	1.209	1.209	0.381
1999		0.107	0.271	0.405	0.497	0.699	1.049	1.049	1.049	0.3
2000		0.12	0.291	0.371	0.375	0.46	0.653	0.653	0.653	0.178
2001		0.134	0.321	0.409	0.407	0.492	0.691	0.691	0.691	0.176
2002		0.194	0.429	0.621	0.746	0.907	1.166	1.166	1.166	0.259
2003		0.13	0.368	0.577	0.78	0.95	1.07	1.07	1.07	0.229
2004		0.037	0.215	0.374	0.611	0.893	1.108	1.108	1.108	0.226
2005		0.092	0.295	0.423	0.589	0.805	0.943	0.943	0.943	0.186
2006		0.153	0.364	0.461	0.598	0.77	0.823	0.823	0.823	0.153
2007		0.116	0.331	0.408	0.479	0.587	0.629	0.629	0.629	0.117
2008		0.071	0.291	0.381	0.451	0.591	0.718	0.718	0.718	0.129
2009		0.141	0.438	0.518	0.535	0.604	0.616	0.616	0.616	0.108
2010		0.183	0.48	0.611	0.688	0.821	0.807	0.807	0.807	0.129
2011		0.097	0.362	0.509	0.595	0.696	0.672	0.672	0.672	0.099
2012		0.054	0.271	0.437	0.604	0.806	0.823	0.823	0.823	0.112
2013		0.026	0.174	0.273	0.374	0.464	0.464	0.464	0.464	0.063
2014		0.058	0.243	0.361	0.447	0.488	0.427	0.427	0.427	0.054
2015		0.064	0.248	0.382	0.485	0.643	0.691	0.691	0.691	0.077
2016		0.044	0.19	0.284	0.372	0.555	0.625	0.625	0.625	0.067
2017		0.023	0.139	0.208	0.289	0.456	0.507	0.507	0.507	0.054
2018		0.089	0.312	0.416	0.519	0.775	0.816	0.816	0.816	0.076
2019		0.099	0.518	0.837	1.07	1.403	1.276	1.276	1.276	0.106
2020		0.03	0.4	0.76	1.009	1.34	1.253	1.253	1.253	0.097
2021		0.03	0.347	0.587	0.716	0.881	0.765	0.765	0.765	0.063
2022		0.018	0.251	0.476	0.622	0.818	0.733	0.733	0.733	0.061

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	17348	12328	12091	2422	4303	628	523	162	27	0
1960	15799	14288	8706	6012	1201	1902	347	233	98	14
1961	23801	12525	7328	3680	2560	527	710	141	69	41
1962	24729	19956	7267	3489	1843	1144	245	231	54	48
1963	20838	20520	12671	3608	1726	759	516	133	90	51
1964	10801	17600	12742	6930	1739	839	345	231	81	73
1965	21172	8121	13329	7789	3546	838	379	130	123	77
1966	25759	17872	5476	8324	4046	1538	358	175	59	94
1967	21610	21598	13767	3649	5304	2099	675	113	58	67
1968	11776	18188	16462	8844	2443	3116	979	281	33	57
1969	9510	9401	13842	10824	4578	1212	1594	392	158	46
1970	12612	7542	6603	8534	6052	2238	557	722	126	86
1971	23410	10106	5658	4047	4782	3573	1163	238	374	107
1972	16456	20396	8414	4069	2493	2635	1653	513	85	225
1973	39148	12461	16444	6386	2775	1531	1079	765	319	187
1974	37056	34001	9029	9799	3835	1735	1058	508	406	285
1975	24976	31006	25349	6731	6583	2326	916	512	282	377
1976	11013	21012	23610	14063	3645	3596	1207	522	241	339
1977	14088	8422	15216	17629	7695	1679	1761	449	221	248
1978	16695	11591	6833	8909	9152	2918	642	499	148	195
1979	26421	13418	8586	4993	4616	4804	1361	286	210	175
1980	17387	22882	10793	5152	2741	2235	2280	703	114	193
1981	27800	13449	18238	6896	2799	1473	1066	1168	301	174
1982	30849	23300	10107	10935	4000	1416	690	415	538	238
1983	54416	24518	17974	6780	6047	2249	765	275	178	367
1984	22727	48859	18103	9087	3290	2472	823	215	81	247
1985	10078	18536	35748	10073	3986	1431	1262	409	99	183
1986	11530	7765	14324	20677	4988	1688	460	333	101	119
1987	11267	9536	6714	7983	9103	2079	602	159	140	103
1988	17823	8944	7911	4637	3861	4474	957	292	65	118
1989	4981	16306	6766	4600	2191	1770	1688	349	103	88
1990	6385	3699	11222	3588	1800	820	562	479	96	79
1991	11139	5125	2647	6208	1598	714	316	194	135	78
1992	11593	9426	3964	1730	2882	755	308	139	79	108

Year	1	2	3	4	5	6	7	8	9	10
1993	27829	8997	7818	3146	975	1400	342	127	72	109
1994	45807	23342	7473	5584	2308	579	820	179	70	118
1995	11958	42589	17999	6177	3817	1585	381	598	121	128
1996	6205	9394	32062	13146	3321	2535	951	218	421	147
1997	7815	5082	7402	21776	7128	1132	891	258	54	179
1998	15504	6691	3937	5183	11987	2749	288	159	48	91
1999	24940	12999	5140	2762	3238	5243	809	87	34	57
2000	36745	20876	10488	2925	1593	2033	2151	214	21	41
2001	15220	33917	14710	6556	1452	1066	1386	952	81	37
2002	7339	13028	23239	8271	3426	849	686	636	424	57
2003	4608	5963	8013	11640	3685	1197	297	175	179	143
2004	6993	3590	4064	4488	4793	1281	348	97	59	143
2005	9214	6004	2693	2778	2861	1837	396	81	30	108
2006	5910	8015	3973	1526	1530	1444	631	130	24	79
2007	6156	4870	4827	2284	870	702	565	217	49	64
2008	10021	4881	3651	2697	1343	476	324	262	112	71
2009	15337	7552	5251	2261	1617	743	226	132	104	99
2010	5060	13037	5915	2323	1061	844	342	110	64	118
2011	1386	4000	8238	3149	928	437	303	117	42	102
2012	3253	1058	2590	4323	1399	374	184	129	45	93
2013	8339	2524	1183	1619	2113	569	122	68	46	81
2014	3318	7181	2441	958	1236	1028	258	59	32	80
2015	5228	2714	5241	1666	601	669	464	115	40	78
2016	6741	4251	2445	3151	832	349	309	164	43	73
2017	11754	5481	2949	2028	1878	443	195	129	64	74
2018	8294	9971	4304	2497	1600	1036	207	104	69	83
2019	1953	6747	5911	2623	1673	1072	363	65	37	82
2020	1847	1338	4686	2452	843	471	227	76	14	63
2021	4010	1441	1248	2107	744	235	103	45	17	49
2022	2724	3388	933	762	885	267	77	42	16	45

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=0 fishing mortality.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	Catch	TSB	Low	High
1959	17348	11287	26663	48367	41946	55770	0.489	0.414	0.579	22415	66535	57810	76577
1960	15799	10346	24127	53273	47037	60336	0.71	0.61	0.825	32255	74408	65751	84204
1961	23801	15521	36499	45526	40157	51612	0.621	0.53	0.728	21598	64819	56962	73758
1962	24729	15999	38223	42476	37397	48244	0.56	0.475	0.661	20967	66814	57930	77059
1963	20838	13278	32702	48482	42306	55559	0.501	0.425	0.592	22215	76962	66056	89669
1964	10801	6828	17086	54574	47207	63091	0.495	0.42	0.584	21078	80272	68772	93694
1965	21172	13341	33598	54203	47011	62495	0.506	0.43	0.596	24212	70645	61059	81736
1966	25759	16237	40865	55313	47774	64043	0.506	0.429	0.597	20418	76960	65932	89832
1967	21610	13638	34242	67274	58294	77637	0.471	0.397	0.559	23562	96548	82590	112864
1968	11776	7400	18739	76878	66614	88724	0.447	0.377	0.53	29930	104449	89813	121471
1969	9510	5921	15274	79339	68540	91839	0.502	0.423	0.597	32371	101730	87549	118208
1970	12612	7816	20349	77417	66600	89990	0.394	0.328	0.473	24183	93057	80094	108119
1971	23410	14577	37595	59294	51014	68919	0.398	0.328	0.482	23010	72310	62271	83966
1972	16456	10288	26324	53714	46188	62466	0.33	0.271	0.402	18727	71628	61279	83724
1973	39148	24578	62357	74725	64032	87204	0.327	0.271	0.394	22228	101457	86226	119379
1974	37056	23399	58684	90084	77658	104499	0.332	0.277	0.398	24581	132898	112814	156557
1975	24976	15747	39612	104755	91174	120358	0.422	0.357	0.498	36775	145408	125240	168823
1976	11013	6902	17572	113498	98935	130205	0.503	0.429	0.589	39799	150480	130341	173730
1977	14088	8840	22452	108766	94611	125039	0.623	0.53	0.731	34927	131994	114756	151820
1978	16695	10478	26599	75310	65167	87031	0.459	0.387	0.545	26585	93392	81074	107581
1979	26421	16594	42067	64170	56013	73516	0.459	0.386	0.544	23112	81638	71213	93589

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	Catch	TSB	Low	High
1980	17387	10939	27637	56472	49660	64219	0.435	0.368	0.515	20513	81565	70296	94640
1981	27800	17575	43974	60128	52531	68823	0.463	0.393	0.545	22963	84245	72628	97719
1982	30849	19656	48415	62475	54730	71316	0.45	0.384	0.527	21489	94894	81227	110860
1983	54416	34408	86059	97371	85149	111346	0.692	0.598	0.802	38133	121941	105246	141284
1984	22727	14351	35991	114644	99331	132317	0.545	0.468	0.635	36979	151947	127848	180589
1985	10078	6301	16118	83333	72299	96050	0.726	0.629	0.838	39484	131343	112133	153843
1986	11530	7243	18356	74051	63307	86619	0.607	0.519	0.709	34595	98917	85256	114767
1987	11267	7148	17759	62112	53862	71625	0.484	0.413	0.568	21391	77651	67737	89016
1988	17823	11311	28083	53751	47693	60580	0.622	0.537	0.72	23182	65830	58232	74421
1989	4981	3114	7967	38187	34151	42700	0.801	0.696	0.921	22068	59361	51880	67922
1990	6385	3957	10302	29684	25947	33961	0.675	0.578	0.789	13692	38579	33404	44555
1991	11139	6862	18080	21823	18727	25432	0.503	0.421	0.602	8750	27241	23412	31696
1992	11593	7180	18718	17803	15182	20876	0.399	0.327	0.486	6396	31026	25890	37181
1993	27829	17551	44125	30273	25524	35906	0.267	0.217	0.327	6107	43666	36249	52602
1994	45807	28983	72399	64544	54302	76717	0.251	0.208	0.303	9046	74320	61797	89381
1995	11958	7732	18493	63136	55180	72238	0.358	0.305	0.42	23045	135103	113162	161297
1996	6205	4023	9570	83921	73731	95518	0.679	0.593	0.776	40422	134571	116400	155577
1997	7815	5112	11946	77661	67426	89449	0.806	0.709	0.916	34304	90294	78648	103665
1998	15504	10225	23508	52059	45268	59870	0.669	0.582	0.767	24005	62200	54603	70853
1999	24940	16495	37708	41221	36232	46898	0.584	0.503	0.678	19245	60203	53061	68306
2000	36745	24315	55529	41993	37272	47312	0.43	0.367	0.503	21833	88302	76348	102127
2001	15220	10135	22855	57540	51084	64813	0.464	0.4	0.538	28577	113590	97853	131858

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(3-7)	Low	High	Catch	TSB	Low	High
2002	7339	4846	11113	57342	50967	64514	0.774	0.679	0.882	38834	102212	89487	116746
2003	4608	2994	7092	42930	37626	48982	0.749	0.654	0.858	25167	62338	54885	70803
2004	6993	4614	10598	27117	23903	30763	0.64	0.555	0.738	12840	36490	32343	41169
2005	9214	6097	13926	22768	20240	25611	0.611	0.528	0.707	10119	30880	27460	34725
2006	5910	3908	8938	19241	17126	21617	0.603	0.519	0.701	9844	28512	25263	32180
2007	6156	4039	9382	16451	14605	18529	0.487	0.417	0.569	7511	25737	22716	29158
2008	10021	6657	15086	19519	17300	22023	0.486	0.418	0.567	7315	26982	23713	30702
2009	15337	10145	23184	19716	17557	22142	0.542	0.468	0.628	9979	29537	26133	33384
2010	5060	3325	7700	21423	19103	24025	0.682	0.589	0.789	12762	39372	34159	45381
2011	1386	884	2173	19341	16996	22010	0.567	0.483	0.664	9692	30966	26975	35549
2012	3253	2108	5020	17570	15339	20124	0.588	0.499	0.693	7205	21577	18869	24674
2013	8339	5423	12824	17777	15436	20474	0.35	0.293	0.418	4473	20381	17763	23385
2014	3318	2141	5143	18621	16448	21082	0.393	0.333	0.464	5711	25756	22352	29679
2015	5228	3402	8035	18325	16243	20673	0.49	0.417	0.575	7329	26971	23580	30849
2016	6741	4405	10316	22227	19337	25549	0.405	0.343	0.478	5876	28202	24391	32609
2017	11754	7662	18031	24456	21292	28092	0.32	0.271	0.378	5360	32839	28486	37858
2018	8294	5386	12773	29720	26484	33352	0.568	0.492	0.655	12214	47215	41289	53992
2019	1953	1233	3093	28922	25812	32406	1.021	0.901	1.157	20609	41933	37073	47430
2020	1847	1112	3066	16065	14202	18173	0.952	0.816	1.111	10438	22554	19763	25739
2021	4010	2044	7866	11245	9428	13412	0.659	0.522	0.833	5417	14291	11927	17123
2022	2724	814	9118	10190	7752	13394	0.58	0.4	0.841		14448	10656	19590

F=0 projection. Catch at age in 2022 of 4064 tonnes													
Year	**R(age 1)**	**Low**	**High**	**SSB**	**Low**	**High**	**Fbar(3-7)**	**Low**	**High**	**Catch**	**TSB**	**Low**	**High**
2022	2724	814	9118	10190	7752	13394	0.58	0.4	0.841	4064	14448	10656	19590
2023	4010	1386	11754	9682	6335	14855	0	0	0	0	14494	8926	24981
2024	4010	1386	11754	15161	9382	25754	0	0	0	0	22197	13271	37108
2025	4010	1386	11754	22985	13648	40193	0	0	0	0	31272	18104	51176

Table 4.17.1. Category 3 assessment for Faroe Plateau cod.

YEAR	August survey	March survey	Mean of standardized CPUE	Catch (tonnes)
1994		71.37		9046
1995		195.68		23045
1996	163.82	321.99	2.95	40422
1997	104.71	236.16	1.98	34304
1998	87.38	205.48	1.68	24005
1999	57.75	155.33	1.17	19245
2000	67.57	133.90	1.22	21833
2001	100.03	173.22	1.73	28577
2002	110.71	274.44	2.17	38834
2003	44.15	169.24	1.04	25167
2004	48.18	70.38	0.80	12840
2005	51.99	95.53	0.92	10119
2006	26.26	32.08	0.41	9844
2007	17.16	29.40	0.30	7511
2008	18.11	50.49	0.37	7315
2009	47.61	93.56	0.86	9979
2010	49.99	91.02	0.88	12762
2011	43.47	121.05	0.89	9692
2012	28.43	44.86	0.48	7205
2013	34.70	107.15	0.74	4473
2014	32.93	50.15	0.55	5711
2015	61.16	49.76	0.89	7329
2016	58.09	40.78	0.83	5876
2017	83.79	86.31	1.27	5360
2018	50.08	149.40	1.06	12214
2019	43.21	105.78	0.84	20609
2020	24.31	54.17	0.46	10438
2021	16.40	36.89	0.31	5417
2022	11.51	18.72	0.20	
		I_y-1		
		I_loss		

Parameters			
Biomass average 2018-2020 (kg pr. Hour)			0.79
Biomass average 2021-2022 (kg pr. Hour)			0.25
I 2021 (kg pr. Hour)			0.20
I_loss (kg pr. Hour)			0.20
mean length (cm)			73.09
Lf=m			83.25
Calculations			
r	The rate of change in biomass		0.32
f	mean lenght/L f=m	Status of the stock	0.88
b	I y-1 / 1.4*I_loss:	Biomass safeguard	0.71
m		Multiplier	0.95
rfbm			0.19
Advice 2023: rfbm x advice 2022 (tonnes)			423
Percentage change on last years advice			-80.8%
Apply buffer (+20% / -30%, and always first year in use)			No
Advice 2022 with buffer when applicable (tonnes)			423

ICES advice for 2022 *was*	2206

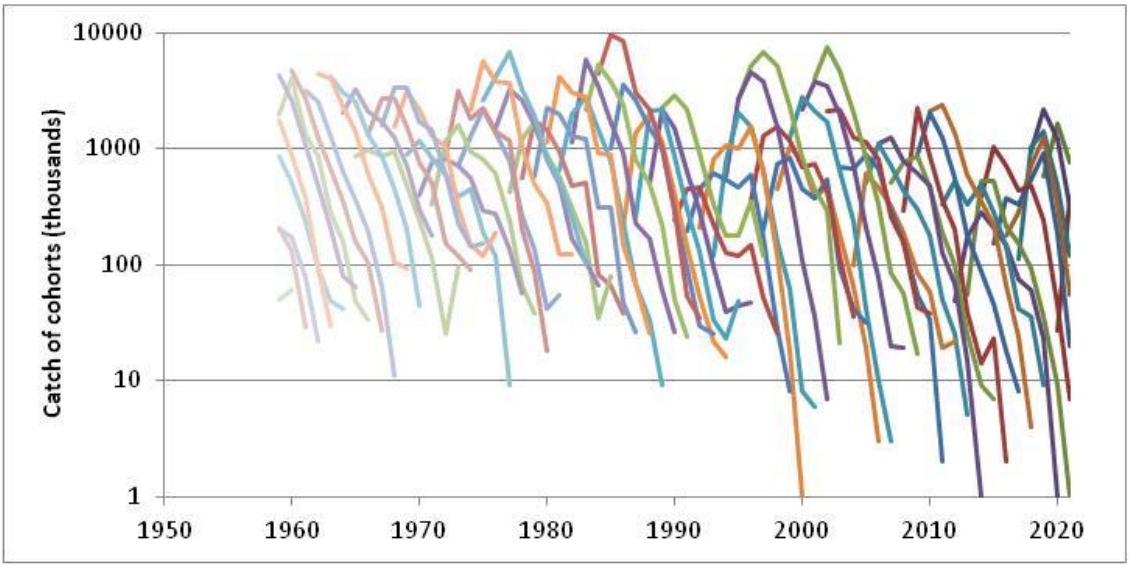


Figure 4.2.1. Faroe Plateau cod (Subdivision 5.b.1). Catch in numbers at age shown as catch curves.

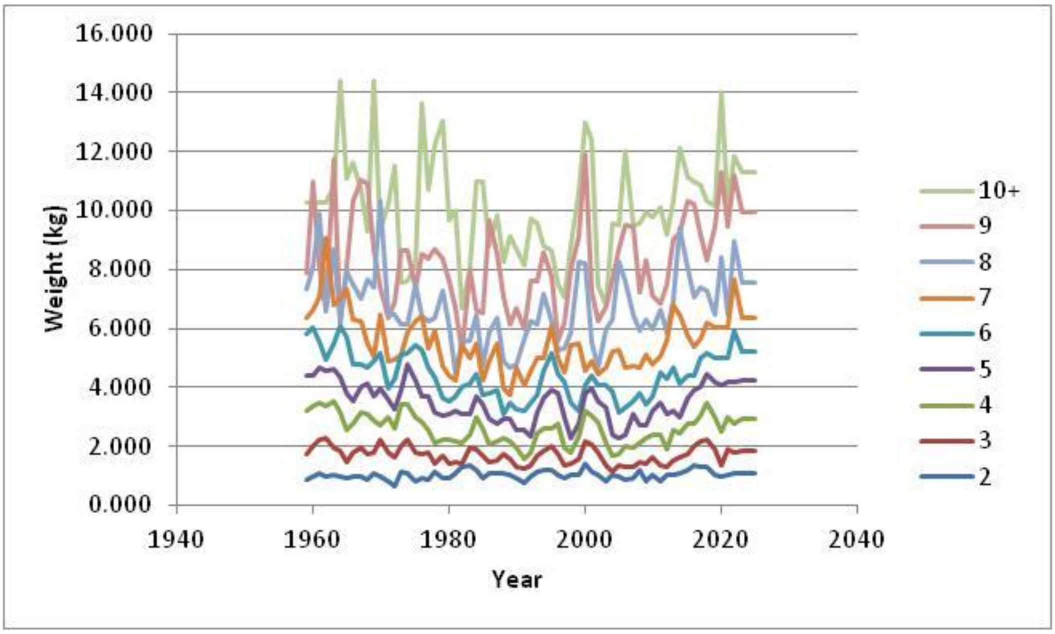


Figure 4.2.2. Faroe Plateau cod (Subdivision 5.b.1). Mean weight at age in the catches. The last three years are based on a previous 5 year average.

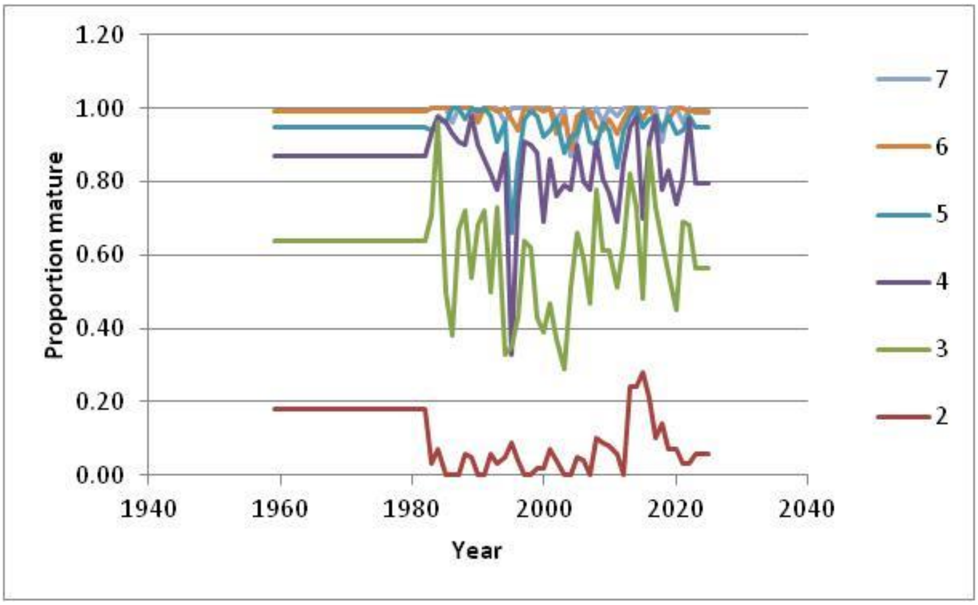


Figure 4.2.3. Faroe Plateau cod (Subdivision 5.b.1). Proportion mature at age as observed in the spring groundfish survey. The last three years are based on a previous 5 year average.

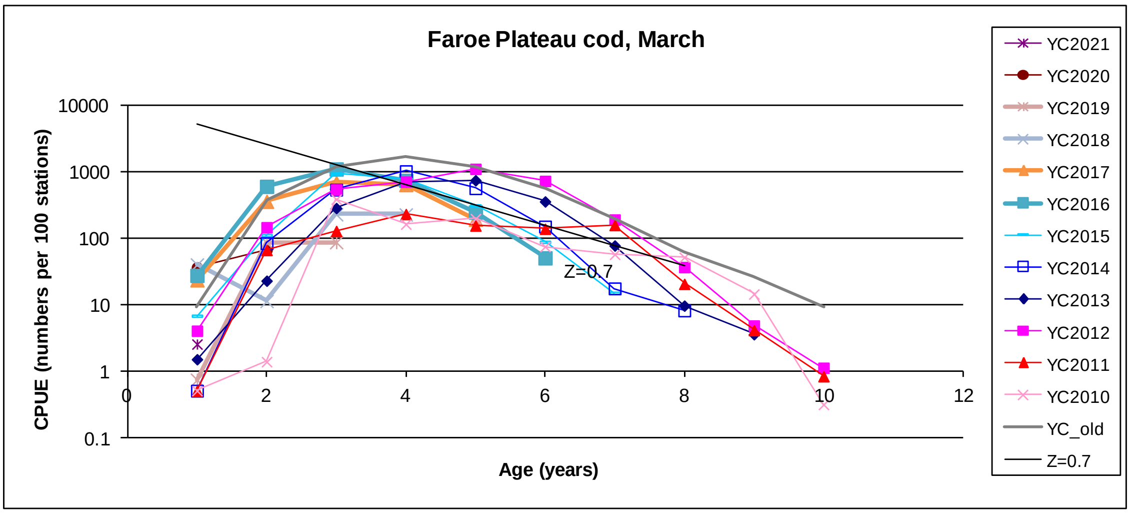


Figure 4.2.4. Faroe Plateau cod (Subdivision 5.b.1). Catch curves from the spring groundfish survey.

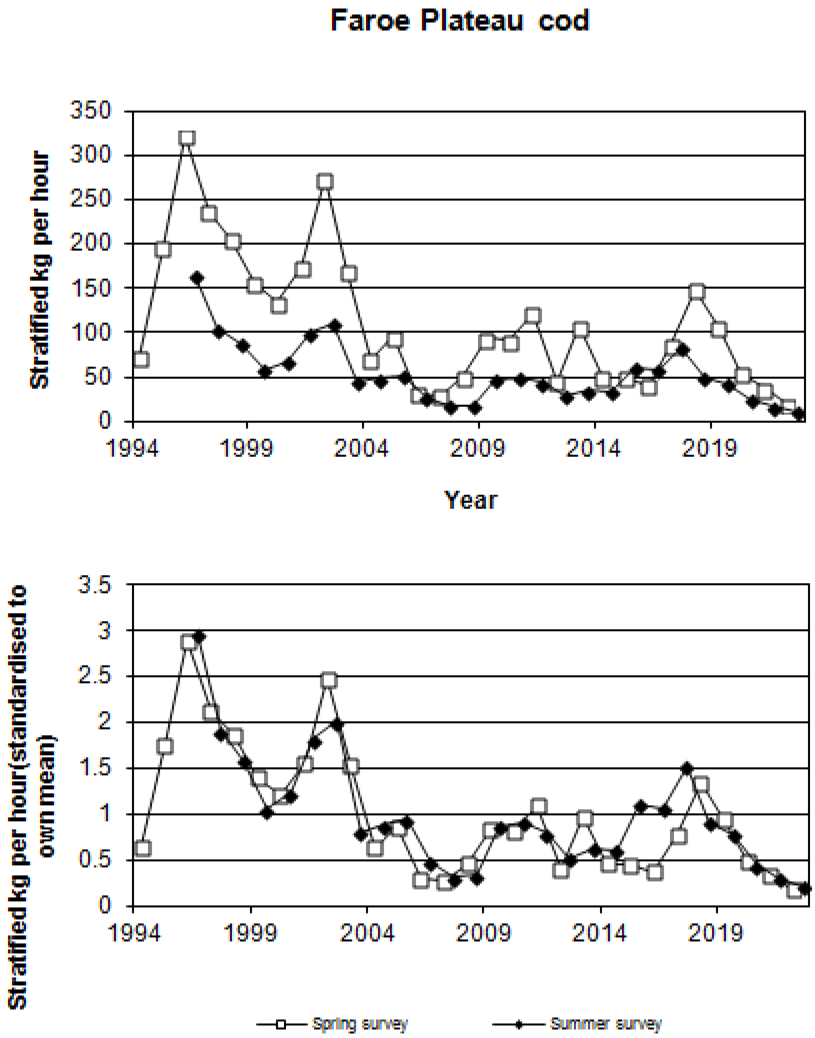


Figure 4.2.5. Faroe Plateau cod (Subdivision 5.b.1). Stratified kg/hour in the spring and summer surveys.

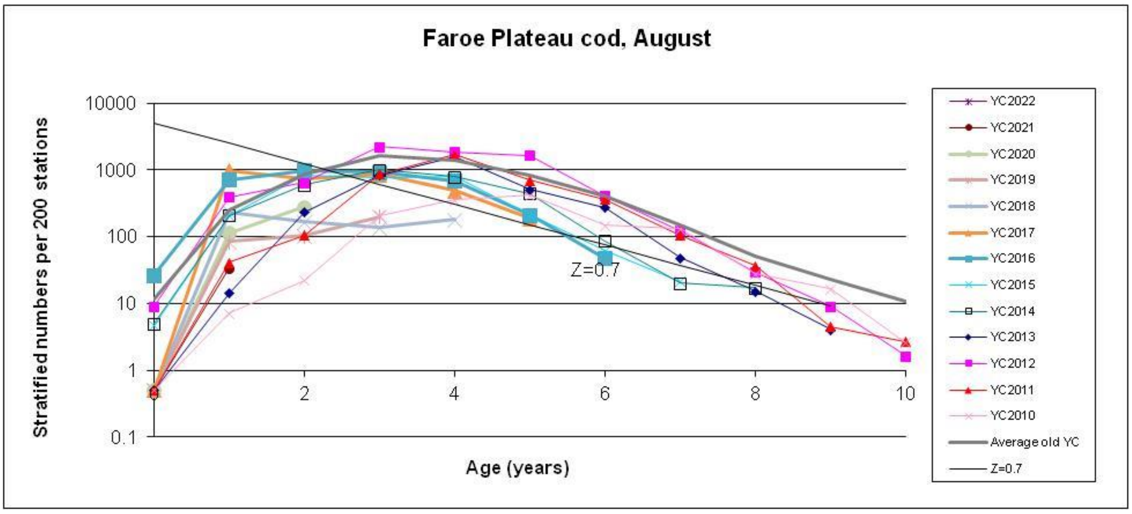


Figure 4.2.6. Faroe Plateau cod (Subdivision 5.b.1). Catch curves from the summer groundfish survey.

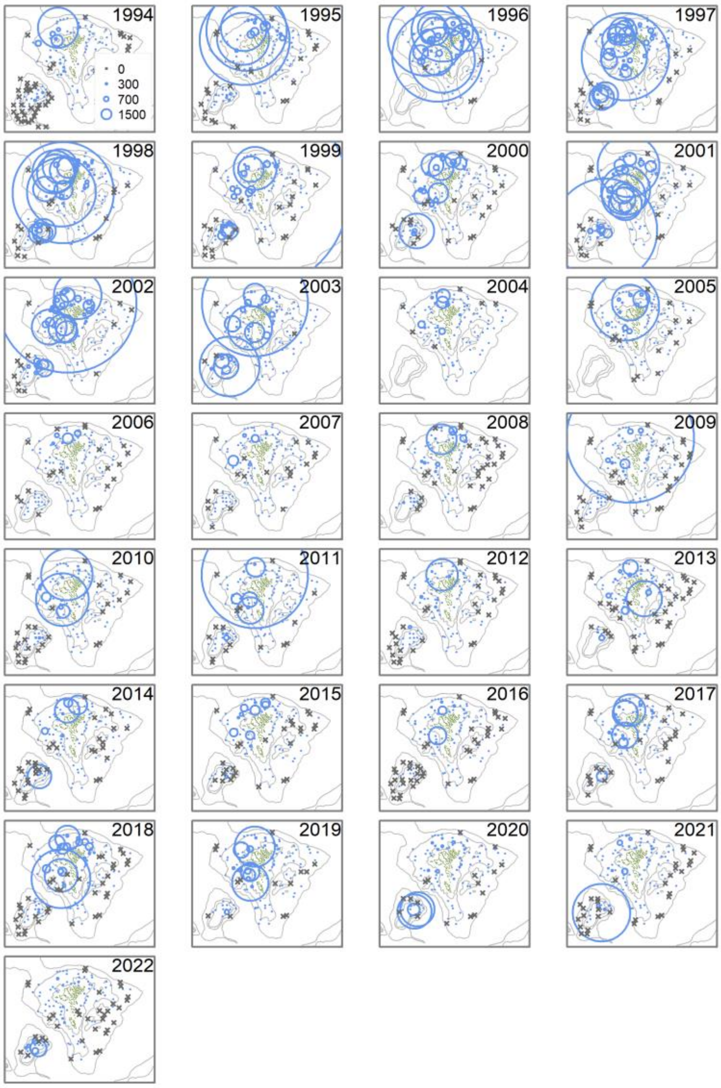


Figure 4.2.7. Faroe Plateau cod (Subdivision 5.b.1). Catch per tow in the spring groundfish survey.

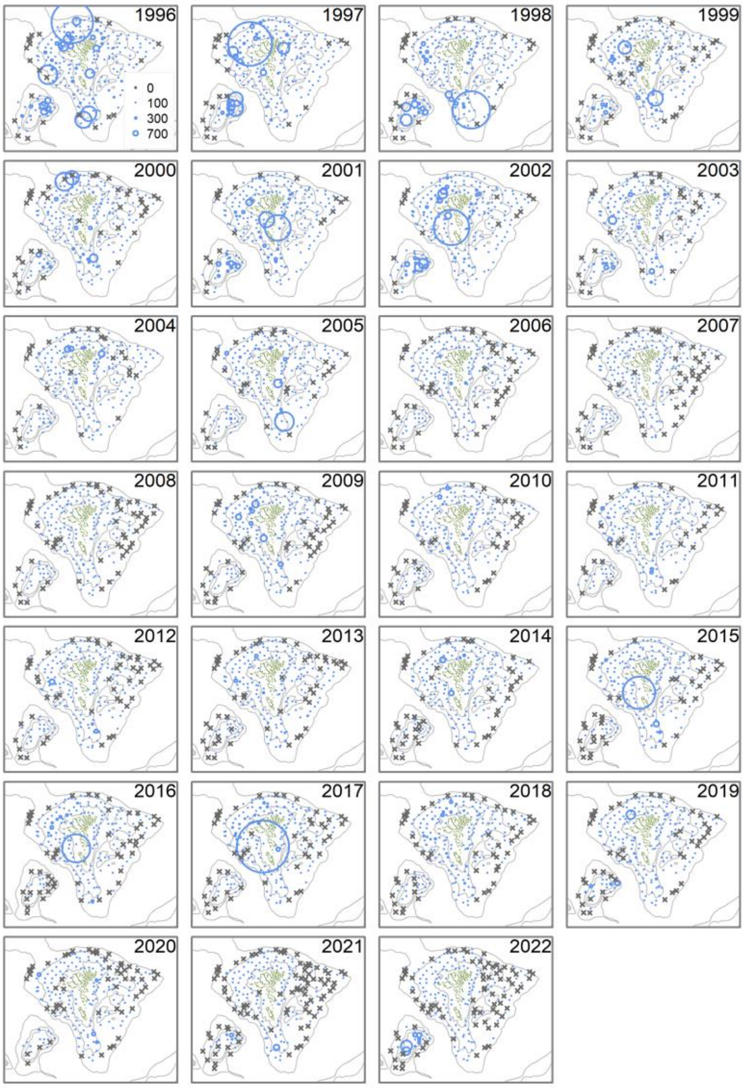


Figure 4.2.8. Faroe Plateau cod (Subdivision 5.b.1). Catch per tow in the summer groundfish survey.

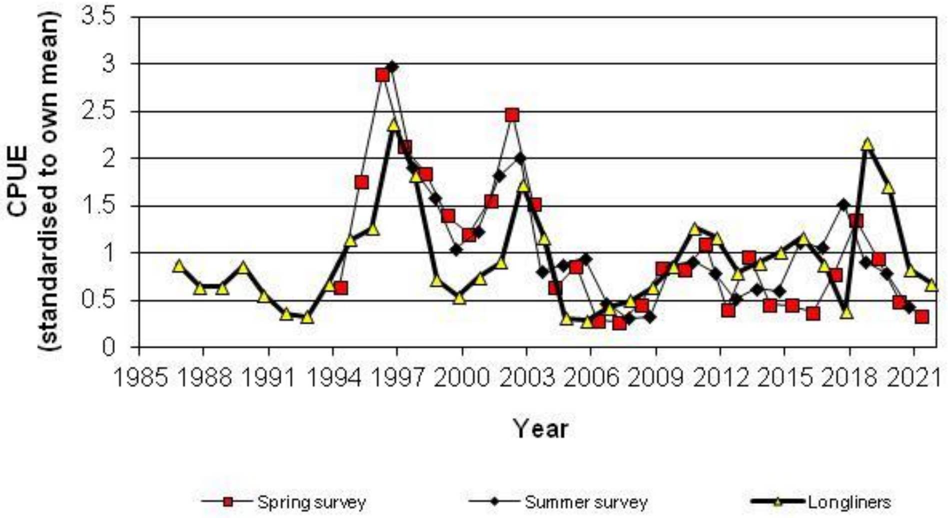


Figure 4.2.9. Faroe Plateau cod (Subdivision 5.b.1). Standardised catch per unit effort for pair trawlers and longliners. The two surveys are shown as well.

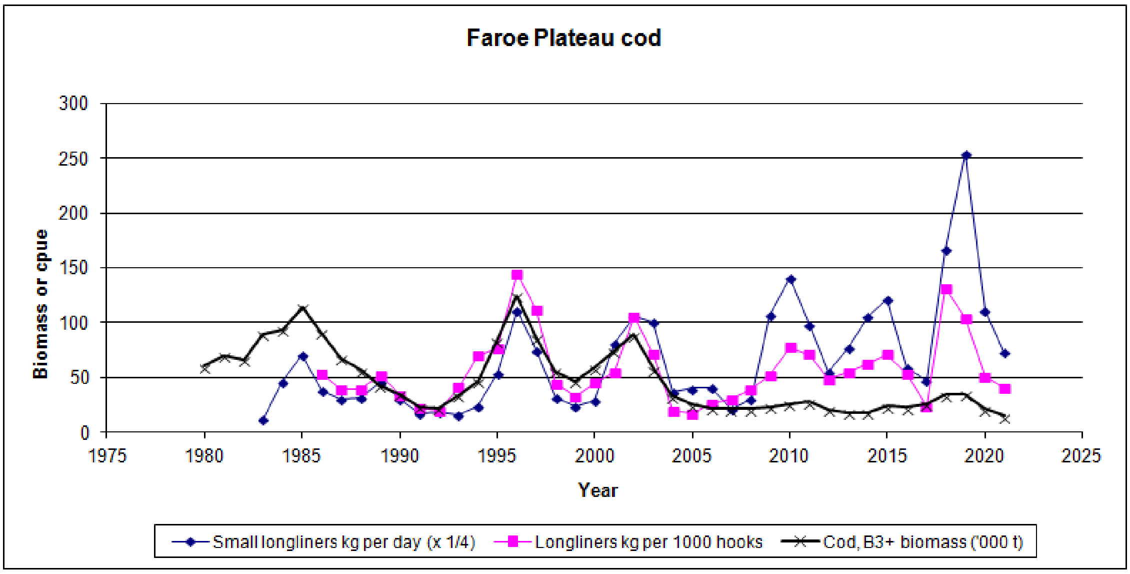


Figure 4.2.10. Faroe Plateau cod (Subdivision 5.b.1). Catch per unit effort for small and large longliners compared with the fishable (age 3+) biomass.

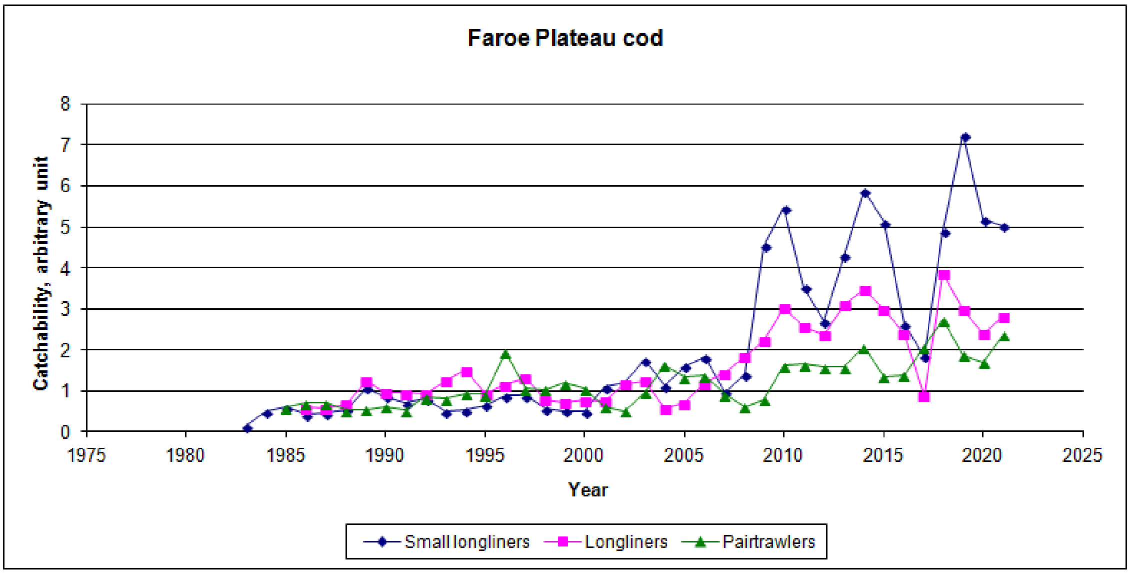


Figure 4.2.11. Faroe Plateau cod (Subdivision 5.b.1). Catchability (cpue divided by age 3+ biomass) for small and large longliners and pair trawlers.

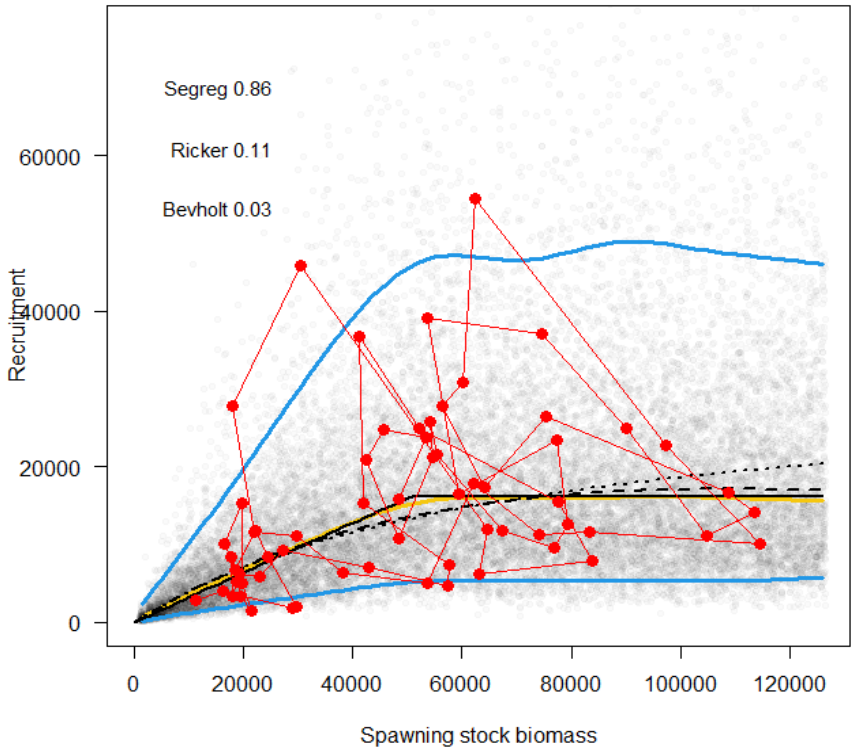


Figure 4.5.1. Faroe plateau cod stock-recruit relationships from the NWWG 2022 assessment.

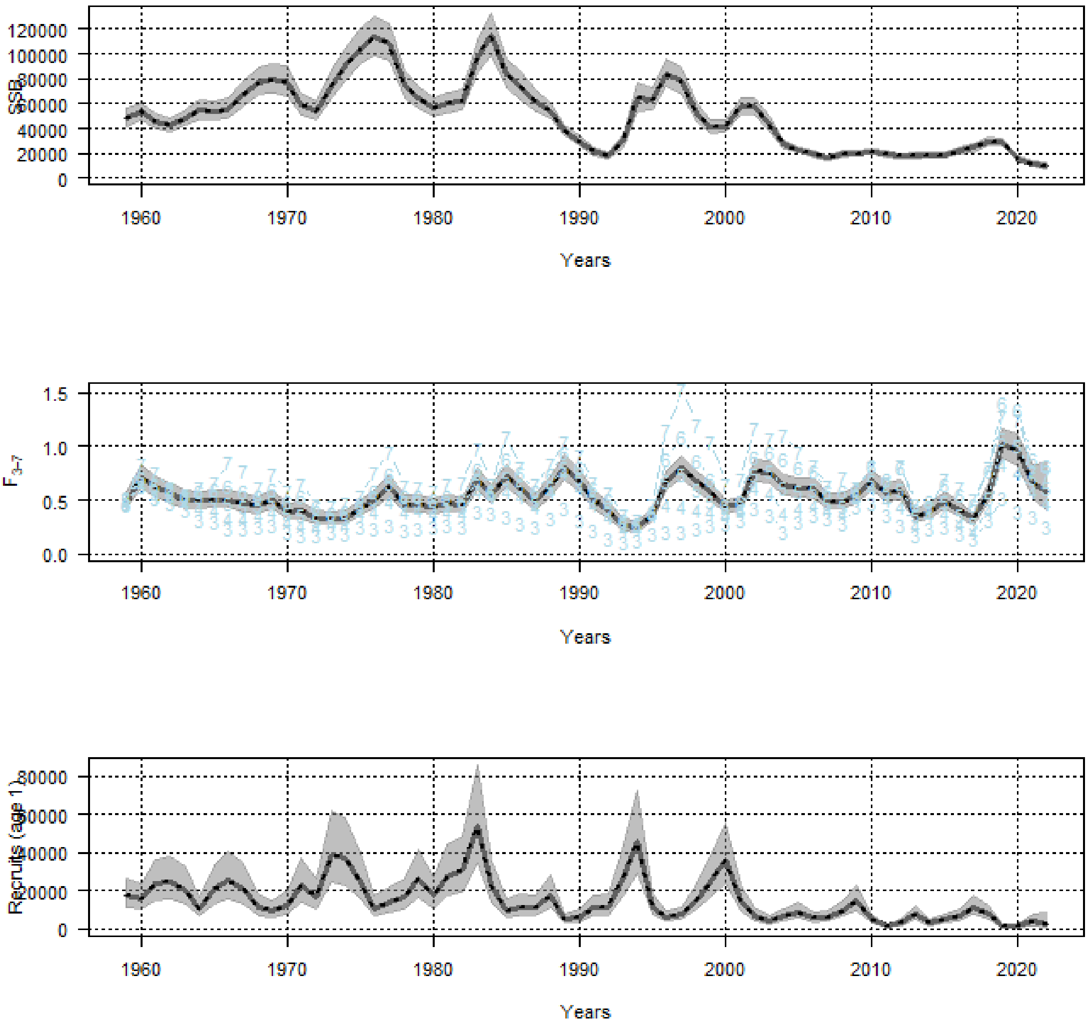


Figure 4.5.2. Faroe plateau cod SSB (top) and F (middle) and recruitment (bottom) from the NWWG 2022 assessment.

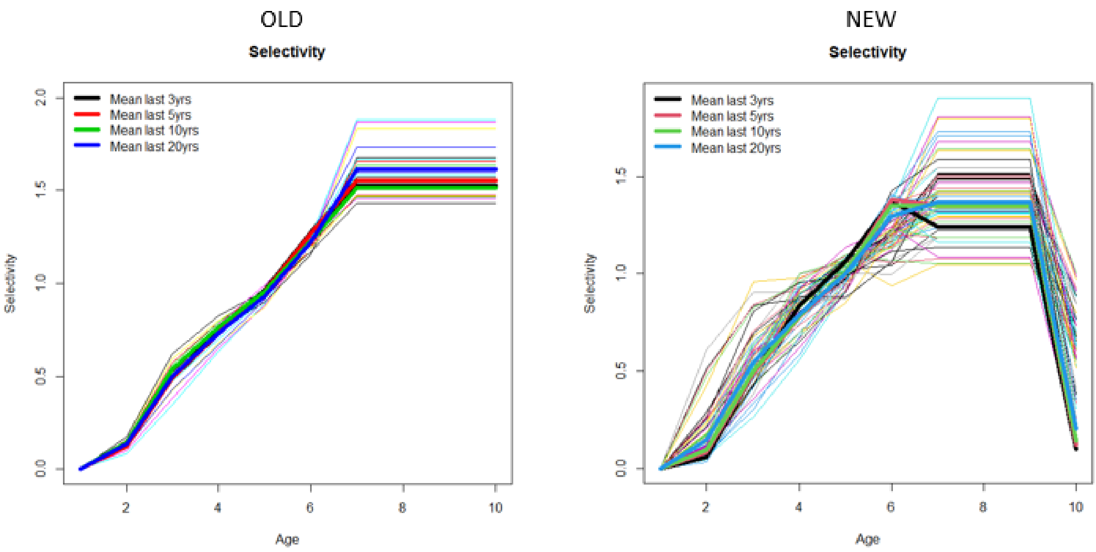


Figure 4.5.3. Faroe plateau cod selectivity from the NWWG 2022 assessment compared to the previous assessment.

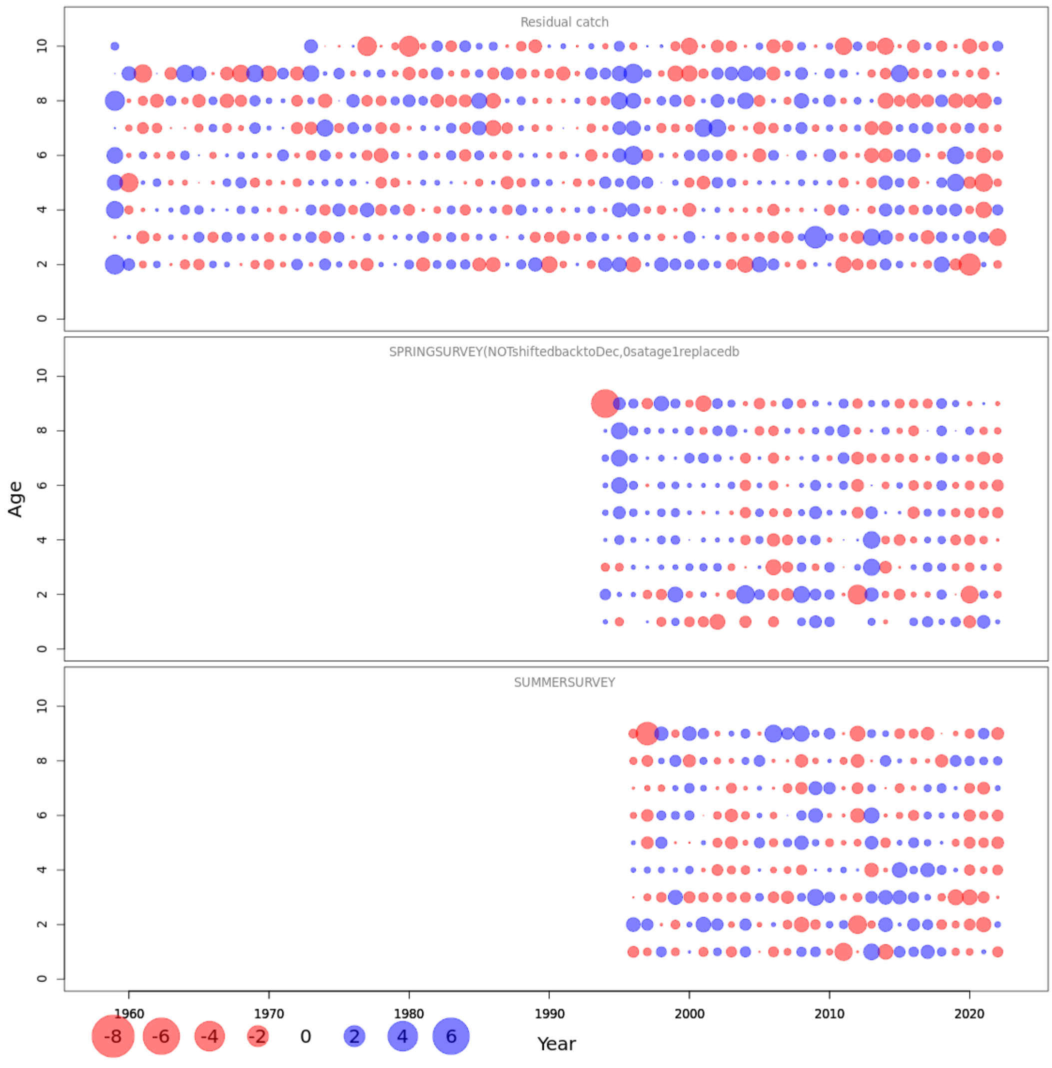


Figure 4.6.1. Faroe Plateau cod (Subdivision 5.b.1). Observation residuals for the catch, spring survey and the summer survey as estimated by the SAM model.

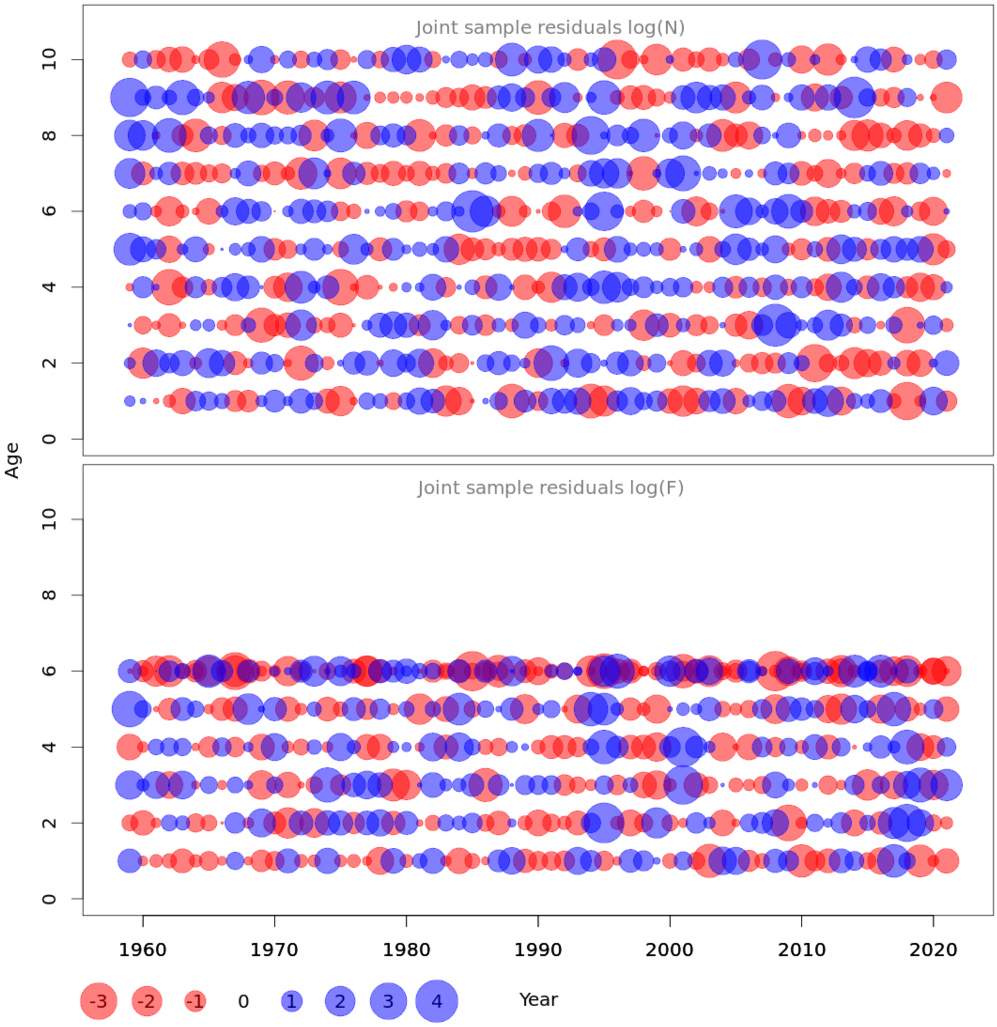


Figure 4.6.2. Faroe Plateau cod (Subdivision 5.b.1). Joint sample residuals for the population numbers and fishing mortality as estimated by the SAM model.

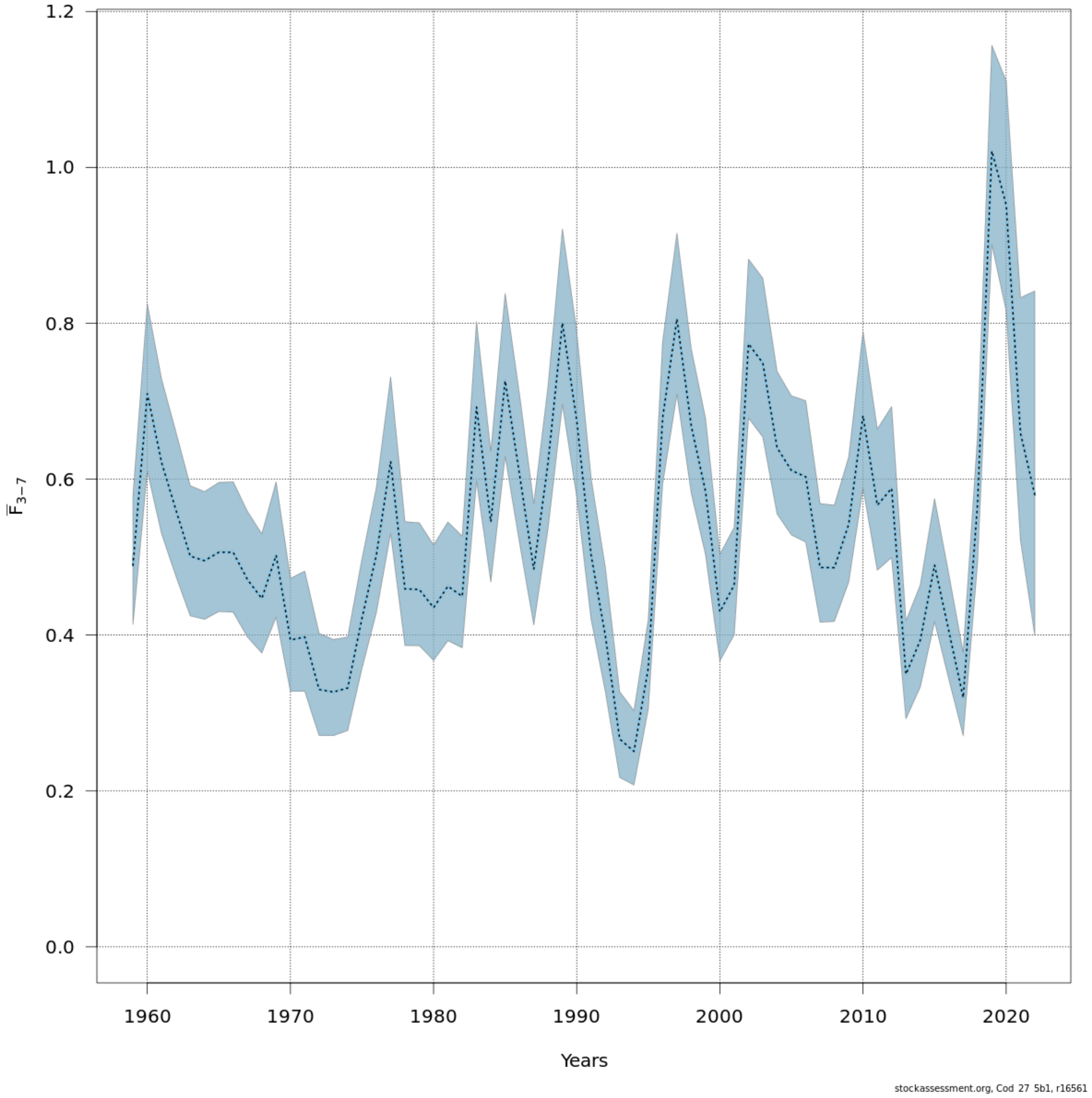


Figure 4.6.3. Faroe Plateau cod (Subdivision 5.b.1). Development of fishing mortality over time.

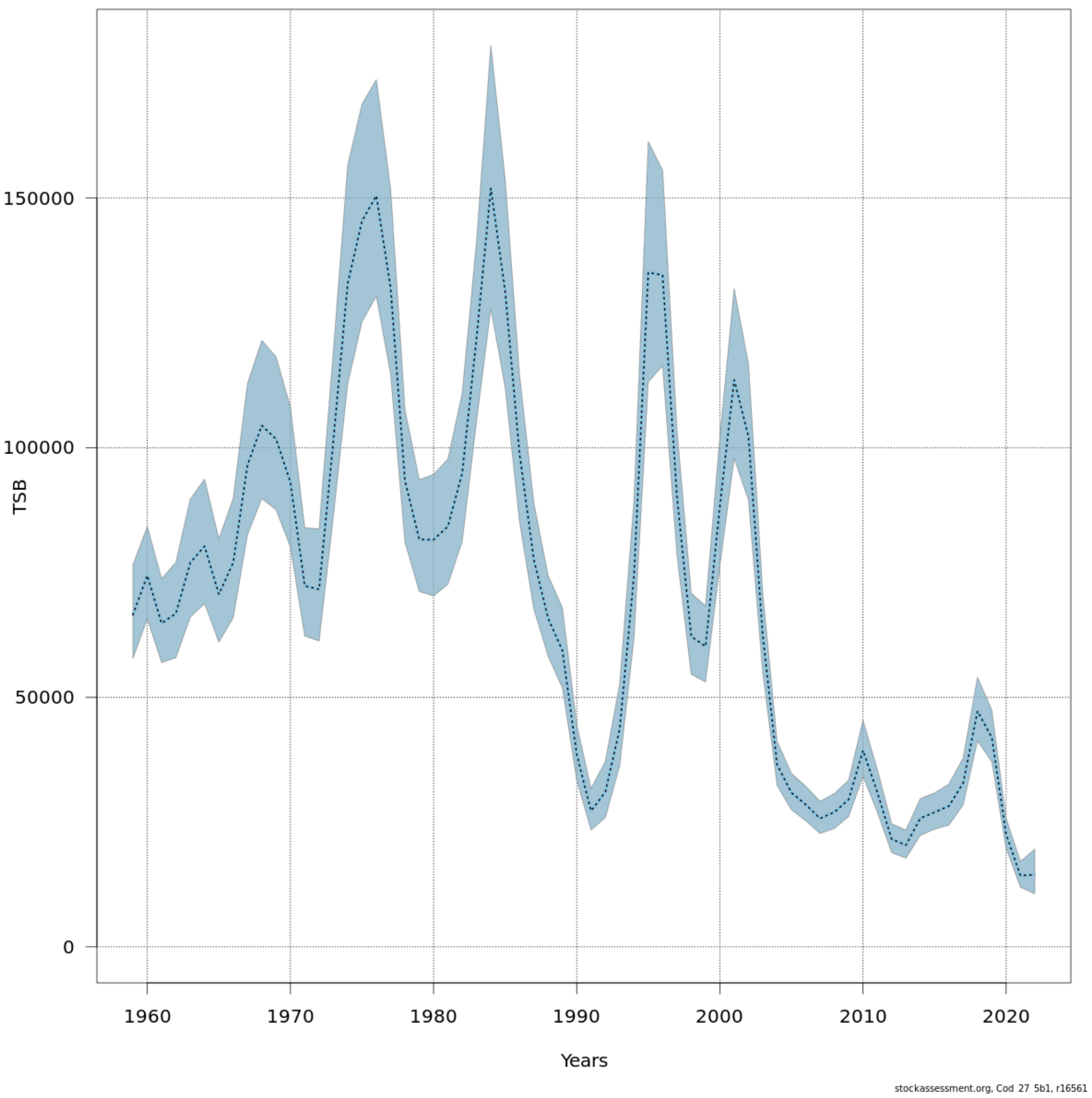


Figure 4.6.4. Faroe Plateau cod (Subdivision 5.b.1). Development of the total stock over time.

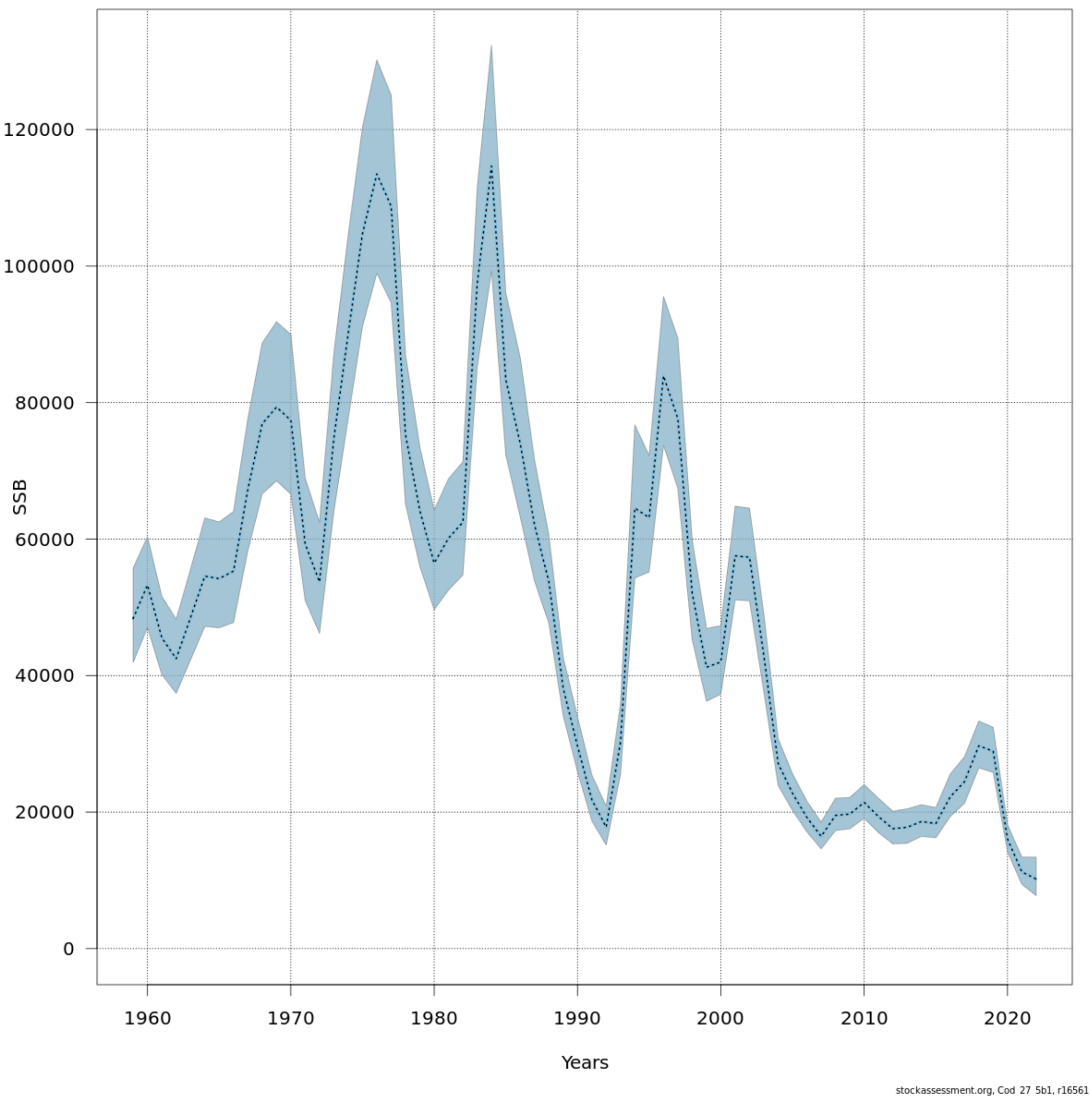


Figure 4.6.5. Faroe Plateau cod (Subdivision 5.b.1). Development of the spawning stock biomass over time.

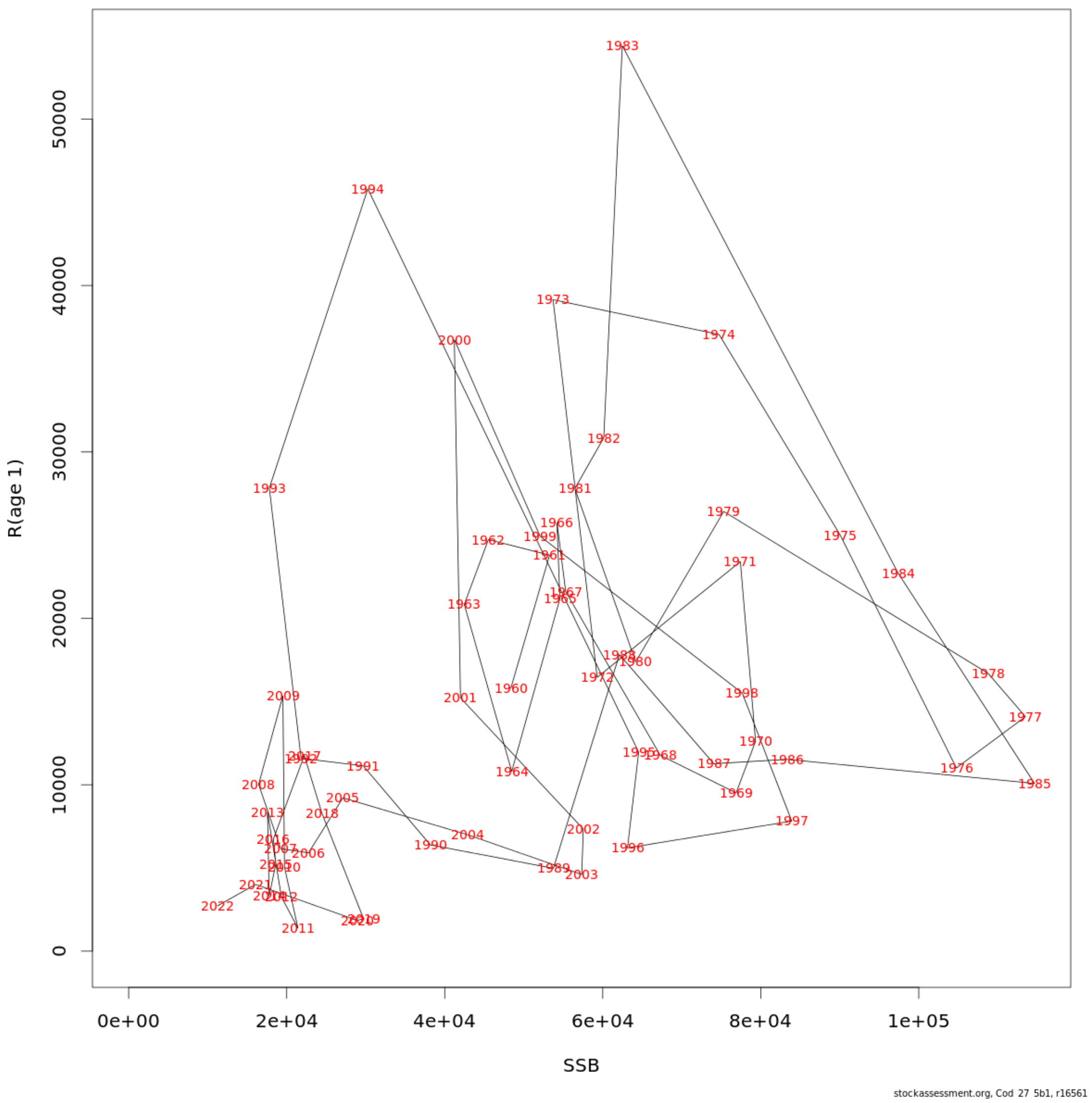


Figure 4.6.6. Faroe Plateau cod (Subdivision 5.b.1). Spawning stock (tons) – recruitment (thousands) relationship. Years are shown at each data point.

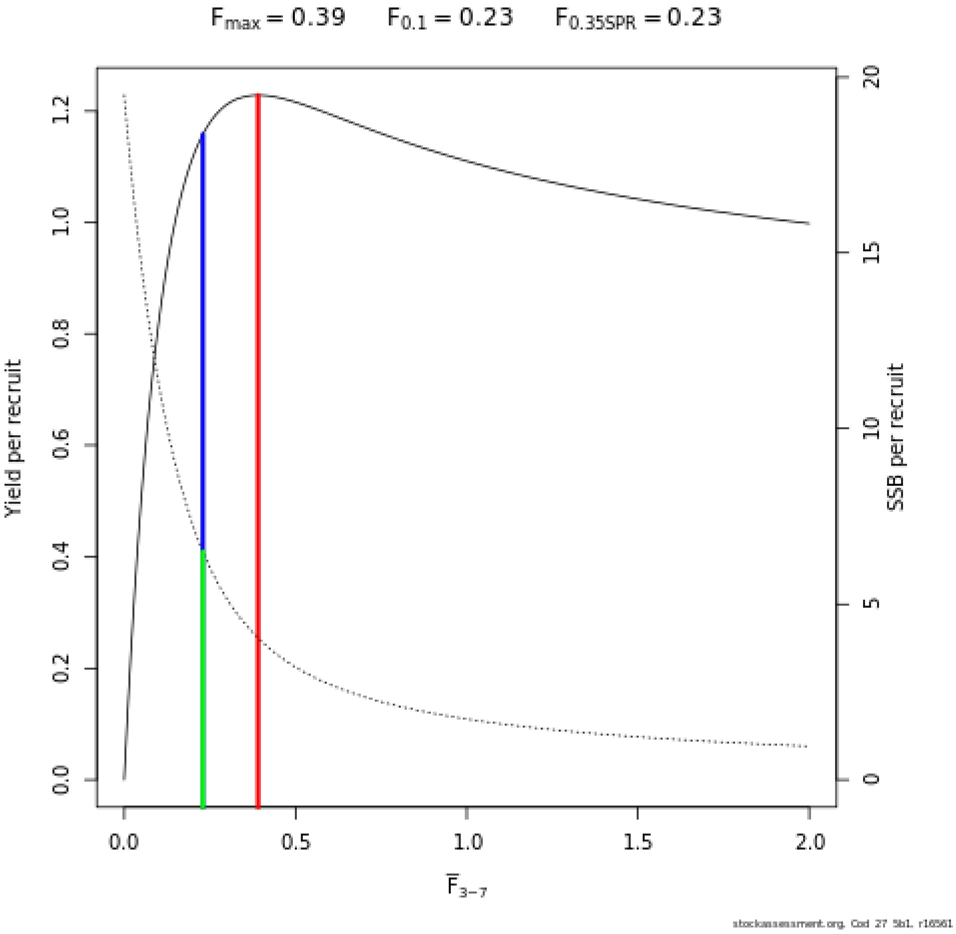


Figure 4.8.1. Faroe Plateau cod (Subdivision 5.b.1). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality.

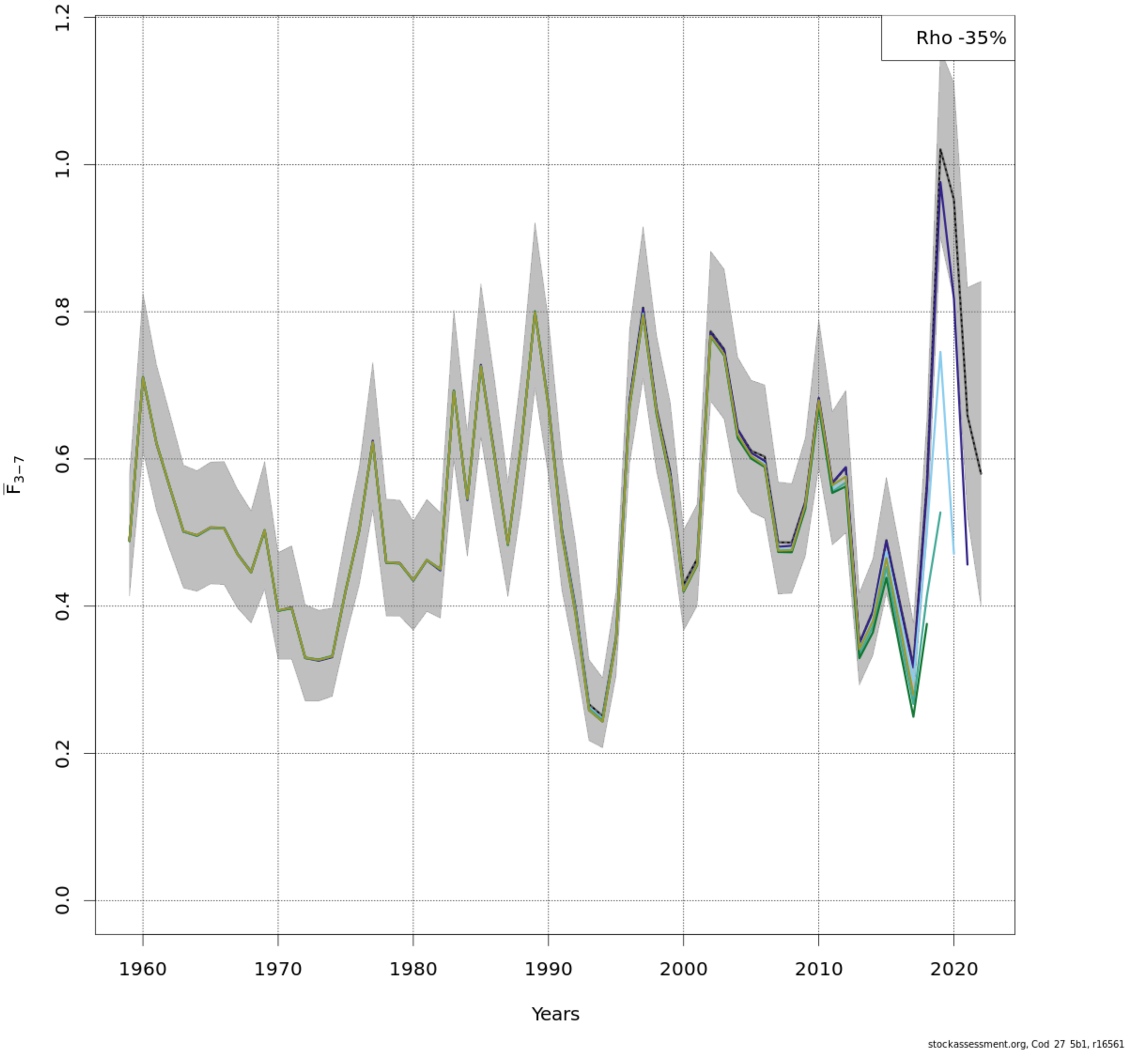


Figure 4.9.1. Faroe Plateau cod (Subdivision 5.b.1). Results from the SAM retrospective analysis of fishing mortality (ages 3–7).

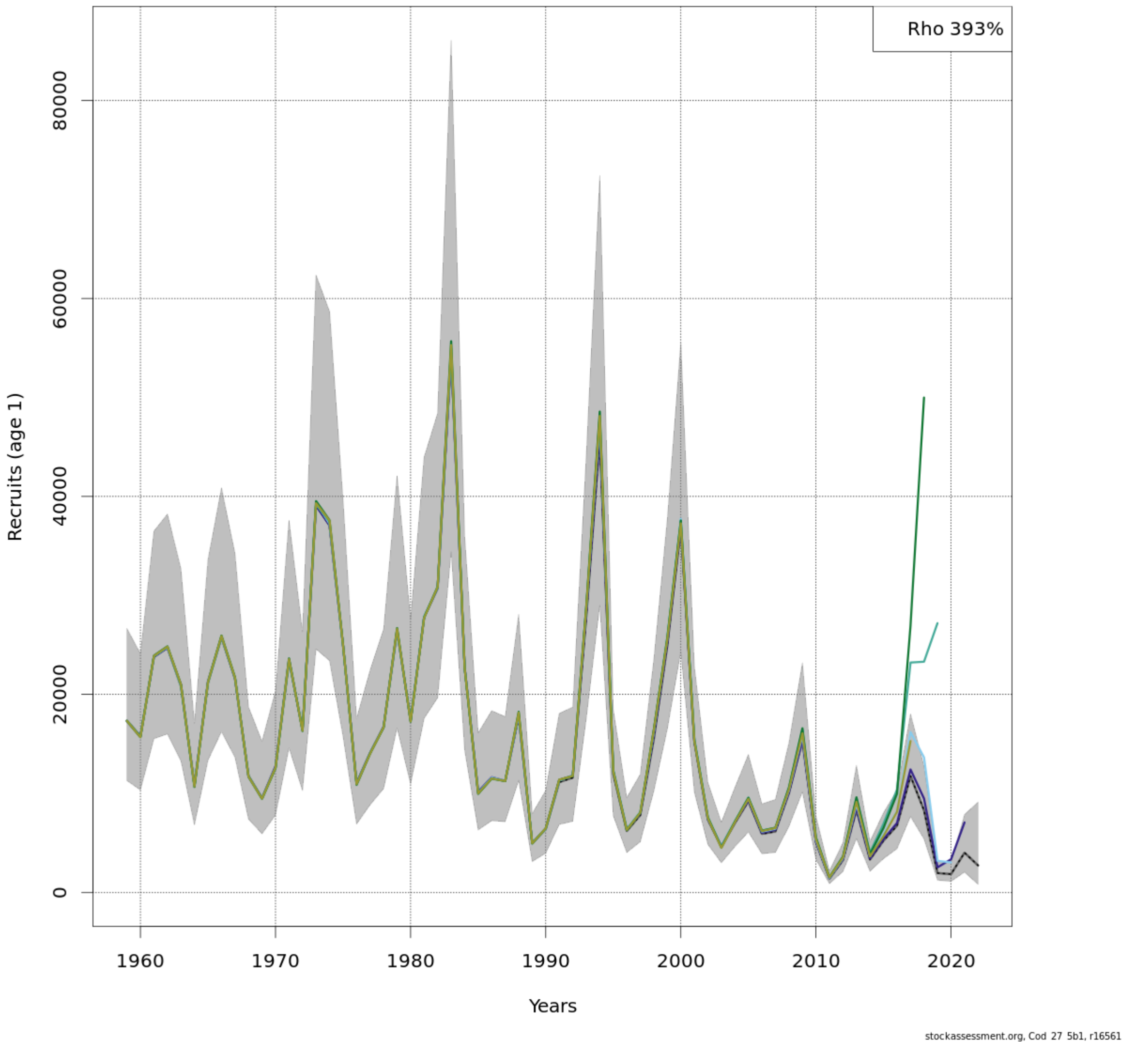


Figure 4.9.1. Faroe Plateau cod (Subdivision 5.b.1). Results from the SAM retrospective analysis (continued). Recruitment at age 1.

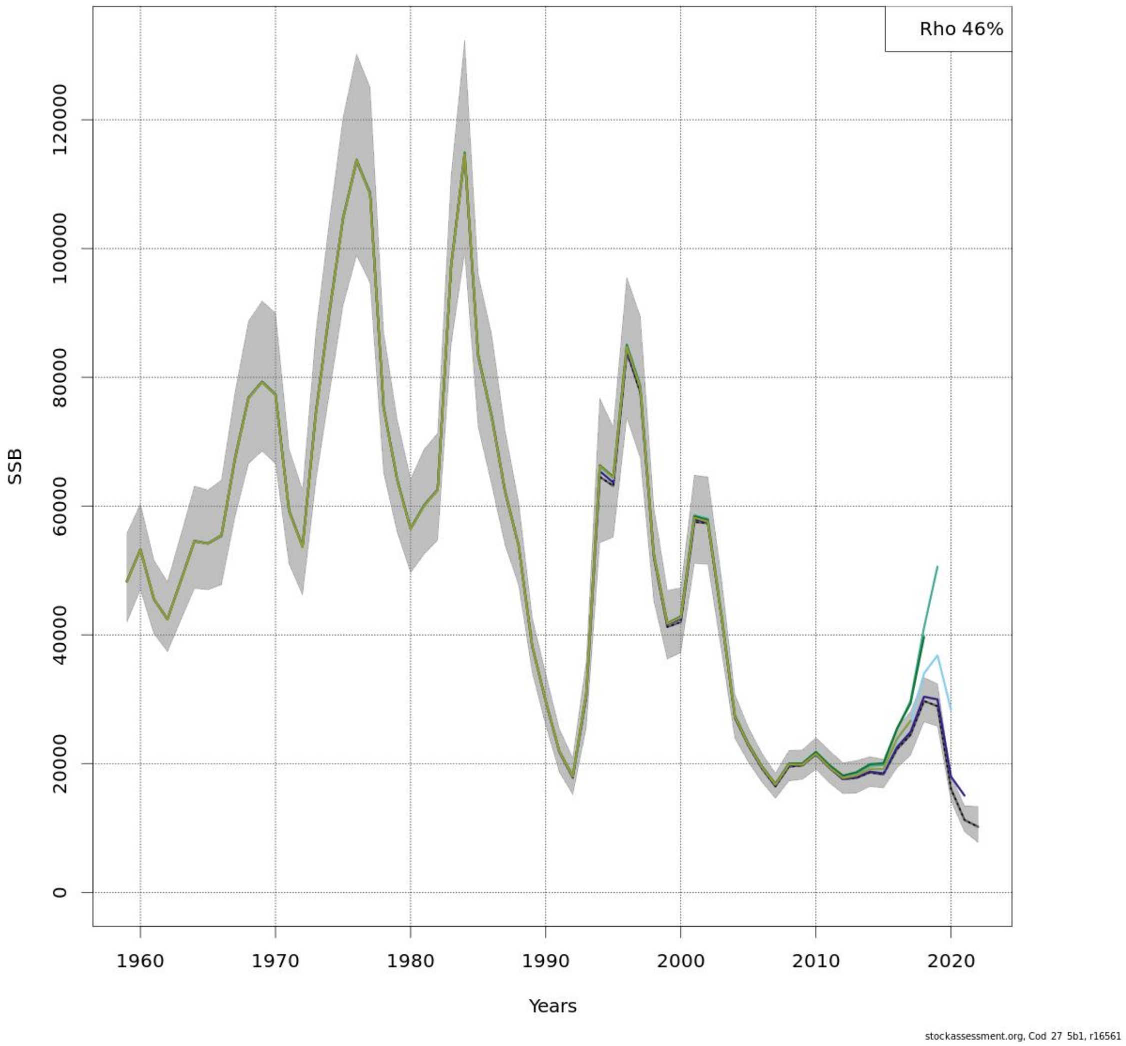


Figure 4.9.1. Faroe Plateau cod (Subdivision 5.b.1). Results from the SAM retrospective analysis (continued). Spawning stock biomass.

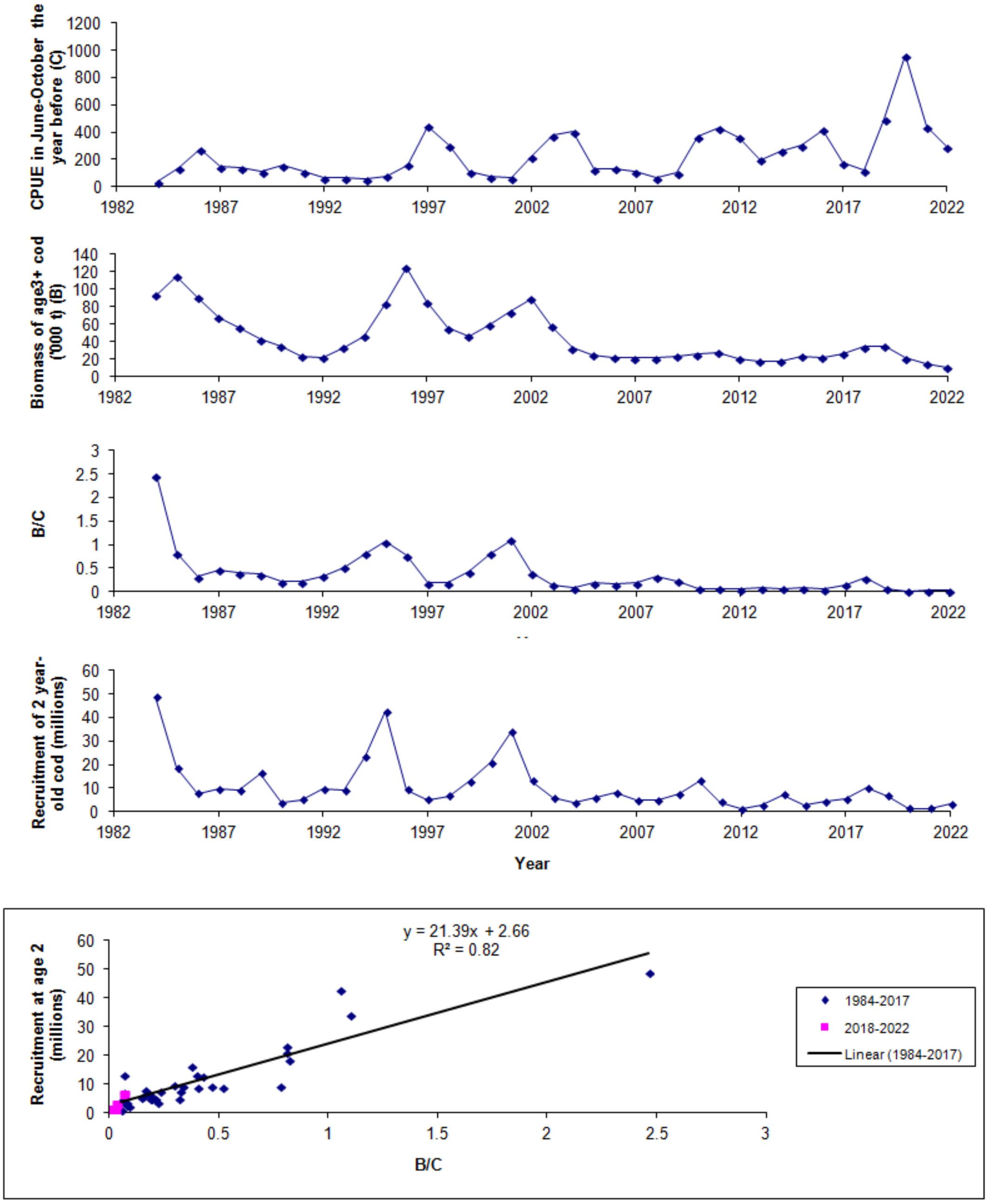


Figure 4.9.2. Faroe Plateau cod (Subdivision 5.b.1). Modelling cod recruitment in three steps. First, the catch-per-unit-effort of cod (C) for small boats operating close to land, as being indicative of the amount of cannibalistic cod. Second, the amount of cod (older than the recruiting cod) (B), as 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.

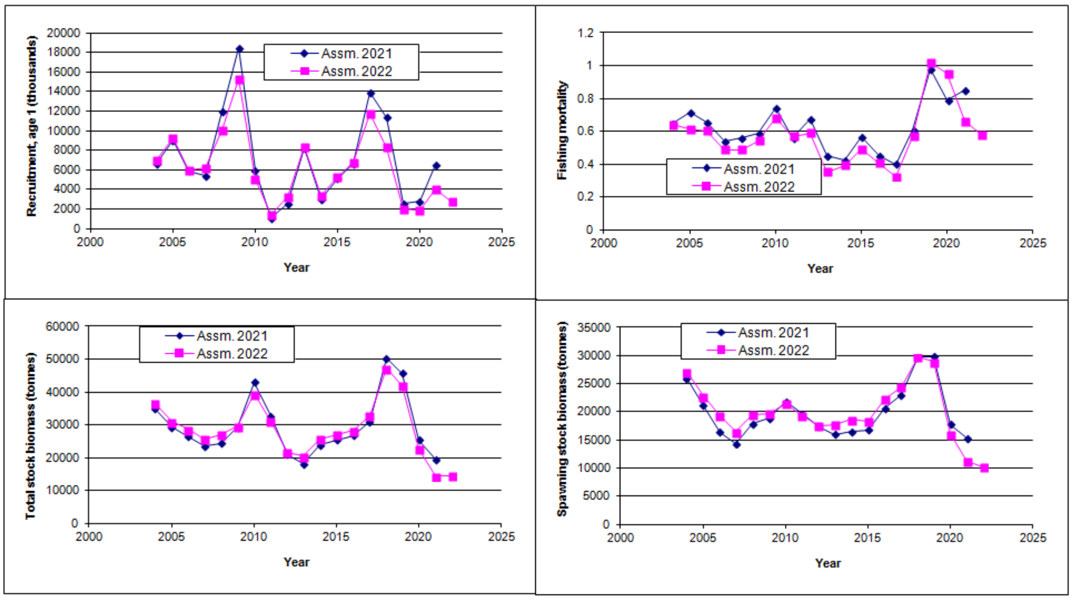


Figure 4.10.1. Faroe Plateau cod (Subdivision 5.b.1). Comparison between the results from the current autumn assessment compared with last year's assessment.

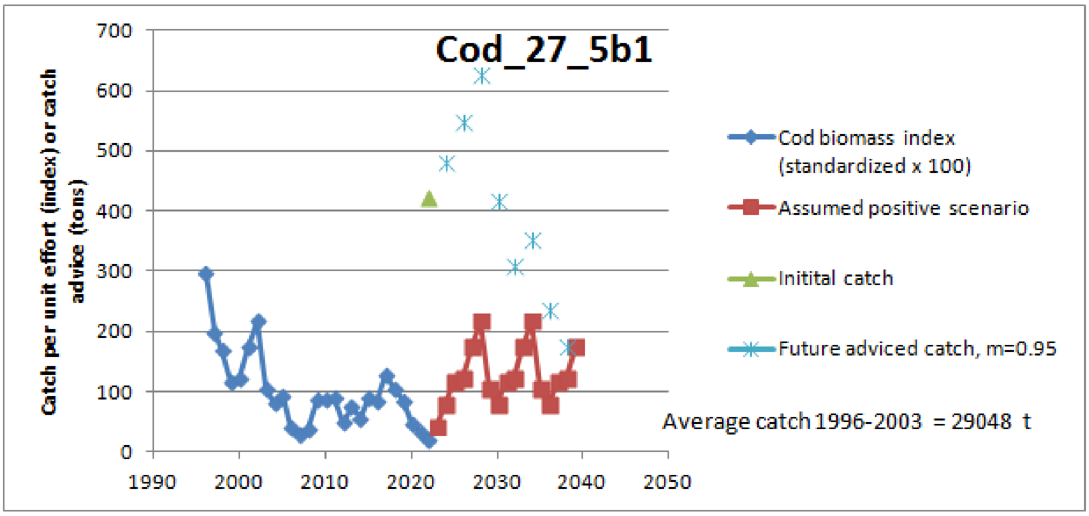


Figure 4.17.1. Faroe Plateau cod (Subdivision 5.b.1). Performance of a Category 3 approach in case of a recovery of the stock. Note that the advised catch for the future is a factor of 50 to 100 lower than the average catch when the stock was in good shape.

Faroe haddock

This section was updated in November 2022.

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 2021 the nominal catch was 6850 t. Most of the landings are taken from the Faroe Plateau; the 2021 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 819 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 2021 the share of longliners was 56% and share of trawlers was 17%. Small open boats and jiggers, which mainly fish near shore, caught 27% of the total catch of 2021 (Figure 5.2).

5.2.2 Catch-at-age

Landings-at-age for 2021 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 have mainly decreased for age 2–6 since 2018. 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. The interbenchmark in September 2022 (IBPFAR) included the catch-at-age in the interim years into the assessment. The catch in tons was estimated from the January-September landings and scaled to the whole year by a regression analysis. The age composition in the catch was based on the January-June samples. Hence, the assessment was based on the newest information that was available. Furthermore, it was decided to impose higher variance on interim year CAA data than full years catch data, as these are partial year observations, including use of linear regression to raise partial year to full year estimates, and only 6 month weight data to convert from catch weights to numbers at ages.

The 2022 assessment was done in October at an online NWWG-meeting. Comparison between the 2022 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.

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, replaced Magnus Heinason from 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, between 2019-2021, 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. In 2022 both surveys CPUE has increased and they are showing a similar trend again.

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). After the interbenchmark in September 2022, where the effect of including a catch at age for the interim year was studied, new reference points were calculated and finalized at the NWWG meeting in October 2022.

Since haddock is a spasmodic spawner (Figure 2), B_{lim} was chosen following the approach for Type 1 SRRs: B_{lim} = lowest SSB with large recruitment. If ~40mil is 'large' recruitment, then 1994 SSB (16 458 t) is a candidate for B_{lim}. This is also B_{loss} excluding the recent low period and compares to a segreg breakpoint of ~40kt.

In the previous evaluation of reference points for this stock the years prior to 1978 were excluded. Experts felt that since this time there has been a change in recruitment observed - a reduction in the mean recruits/spawner and more variability since 1978 can be seen. At the tie the **reviewer commented: "***Based on the SRR figure, the inclusion of only recent years appears to cause somewhat of a "shifting baseline" similar to what's seen for the cod Blim selection. Granted that haddock stocks seem to have characteristically sporadic recruitment, this consideration should call for close monitoring and whether the current AR is sufficiently allowing for stock rebuilding.***"** In the absence of any dedicated analyses confirming this change, it was decided to rather use the full time series of recruitment. A sensitivity analysis was run using the truncated time series and showed limited change in reference points (F_{MSY} and the biomass ref points were the same, F_{lim} and F_{pa} a bit lower).

Calculation of B_{pa} and MSY $B_{trigger}$

The final year uncertainty on SSB and F from the SAM assessment (SSB: 0.204, F: 0.227) were used in the simulations (Table 3).

$B_{pa} = B_{lim}*exp(1.645*sigma)$ where sigma=0.204 = 23 030 t

F has been high in recent years (above F_{msy}) so MSY $B_{trigger}$ was set at B_{pa}.

F_{MSY}

F_{MSY} (0.27) for this stock is well below $F_{pa} = F_{p05}$ (0.54). This is well above the previous F_{MSY} for the stock (0.165). A possible part of the explanation is the change in selectivity compared to the previous assessment (Figure 6). The selectivity is slightly lower on age 3-4 fish, which would favour a higher F_{MSY} since recruits entering into the SSB experience lower Fs even with a higher F_{MSY}. Selectivity seems to be changing over the recent years. A 10yr period was used in the simulations, but this differs from the most recent three years and may not be appropriate in future if selectivity changes continue to be observed.

The 0.27 for haddock is around the average F we have seen since the 1970s, and there are no clear signs that this has reduced recruitment potential (though the recruitment patterns for this species mean it will likely continue to have ups and downs fishing at 0.27)

Old and new reference points are shown in Table 5.15.

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 since 2018, and is above both F_{MSY} but beneath F_{pa} in 2021. (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 2021 (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 spawning stock biomass is expected to be 51 000 tonnes in 2023, 50 000 tonnes in 2024 and 2025, if the F_{MSY} is applied. This is 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 0.63, 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 59% for SSB, 29% for recruitment and -53% for F(ages 3–7).

The interbenchmark process (IBPFAR, 2022) investigated the retrospective pattern and concluded that despite that the inclusion of the preliminary catch-at-age did not improve the retrospective patters, it was considered beneficial to include it because the SAM relied on more data than before. The inter benchmark proceeded to investigate potential causes for SSB and Fbar deviating in the last year(s) (which implied larger than accepted rho values). Like previously described the two surveys included in the model were showing opposite trends in the last years (**Error! Reference source not found.**). This was unexpected, because from 2004 and up to 2018 these two surveys have had almost identical trends. The inter benchmark was unable to explain this sudden conflict between these two surveys. The stock experts considered the spring survey possibly to be more reliable of the two surveys, because it covered spawning areas and seems to follow the trend in the commercial fisheries. To verify that the retrospective pattern was caused by the two divergent surveys model runs were prepared where the last part of each of the two surveys were excluded. These runs showed that down-weighting (essentially omitted) the last two years of observations from the autumn survey produced a consistent assessment without a problematic retrospective pattern (SSB: rho=6%, Fbar: rho=-10%). Doing the reverse (down-weighting the last of the spring survey) did not resolve the retrospective pattern (SSB: rho=39%, Fbar: rho=-42%). However, the NWWG working group rejected this setting, because the IBPFAR was not fully capable to explain why it was beneficial to down-weight the survey from 2020 and not 2019, which is the year the surveys started to diverge. Furthermore, did the assessment result in quite unrealistic scene, and the advice for 2023 was 32 000 t, which is more than the highest recorded catch of haddock in the Faroe Islands.

One alternative approach that was also explored during IBPFAR which did improve the retrospective pattern was to increase the natural mortality in the last years (the model otherwise assumes M=0.2 for all ages in all years). Increasing the natural mortality for all ages in the last 5 years was explored by profiling the likelihood, which had an optimum around M=0.6 (Fig. 12 in haddock report), which the inter benchmark considered to be a very high. The resulting assessment had a borderline acceptable retrospective pattern (SSB: rho=0%, Fbar: rho=-15%). The high mortality assessment run was not fully explored, because it was only presented when the meeting was essentially closed and, unlike for cod, there were no biological evidence supporting such a drastic change in M, although cod and haddock historically have very had synchronized population trends.

In the interbenchmark process (IBPFAR 2022) some biological considerations were presented (IBPFAR 2022, WD 1). Briefly, it was noted that very large numbers of small fish (0-2 year old cod and haddock) were observed in 2016-2018. This was probably a result of the high primary production in 2017 and low competition/predation of adult cod/haddock due to their low biomasses. Preliminary calculations showed that these small fish could consume as much as 80% of the total food consumption of the cod/haddock stocks. Since age 3-4 cod/haddock eat partially the same food as age 0-2 fish (Crustacea, Polychaeta, sandeels) it was proposed that the low condition factor of adult cod/haddock in 2019 probably was caused by the superabundant small cod/haddock. As already mentioned, the survival of small cod/haddock from age 1 to age 3 is low when the condition factor of adult cod/haddock is low (NWWG 2021, WD 30). According to this reasoning the actual problem for the cod/haddock stocks could be the low biomass of adult cod/haddock that is unable to keep down the abundance of small cod/haddock. Conversely, a large biomass of adult cod/haddock could probably prevent the occurrence of superabundant small fish and subsequent food shortage and lead to larger and more stable recruitment.

Such biological conditions could confuse any assessment model. Large numbers of age 1 fish used in the tuning tell the model that large year classes will enter the fishery in the near future. However, the same numbers might be signalling just the opposite, that the downscaling will be large and that small year classes will enter the fishery. Preliminary investigations at the NWWG meeting showed that the retrospective pattern was improved if the age 1 was excluded from the tuning in the cod assessment. There are indications that the downscaling of recruitment and SSB is levelling off since the two latest peels are close to each other (Figure 4.9.1).

In an attempt to utilize all data, the NWWG recommended that the Category 1 assessment was accepted. The possibility that the retrospective pattern might improve over time as the problematic peels in 2017-2020 will disappear and peels with less deviation will appear when the period with poor environmental conditions hopefully is over. The 2022 assessment indicate that the extent of the downscaling of SSB has been reduced, i.e. the last two peels were closer to each other than the previous 3 peels while the retrospective pattern in F was still apparent. It is recommended that a full benchmark will be conducted in the near future that can evaluate the problems in the robustness and quality of the assessment and look more into the associated biological conditions. Comparison with previous assessment and forecast

The assessment settings were according to the Stock Annex. The assessment this year showed again 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). Possible reason for this downscaling is discussed in previous chapter (5.8). 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 sent to ICES for evaluation.

5.9 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).

5.10 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.

5.11 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 long-liners 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 long-liners and jiggers still exploit the shallow areas.

5.12 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.

5.13 Category 3 assessment

A Category 3 assessment was performed for this stock in case the retrospective pattern was considered to be too large for a Category 1 assessment. The two survey indices were converted into one index after standardization to their own mean and the average taken of both standardized indices. The advice for 2023 was 6111 tons (Table 5.16), based on rfb rule, method 2.1.

Table 5.1. Faroe Plateau (Sub-division 5b1) HADDOCK. Nominal catches (tonnes) by countries 2010-2021 and Working group estimates in 5b.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Faroe Islands	4932	3350	2490	2877	2756	2919	3090	2575	5192	8679	6688	6007
France	1	2	1	+	+	1	+	1	+	+	1	4
Germany												
Greenland												
Iceland			2									
Ireland						+						
Norway	6				+	5	11	1	21	41	49	19
Russia												
Spain												
UK (Engl. And Wales)												
UK (Scotland)	40											
United Kingdom				+	350	428	237	72	121	167	183	
Total (tonnes)	4979	3352	2493	2877	3105	3352	3339	2649	5334	8887	6921	6030

Table 5.2 Faroe Bank (Sub-division 5b2) HADDOCK. Nominal catches (tonnes) by countries, 2000–2021.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Faroe Islands	178	194	141	47	71	48	111	196	192	330	407	819
France							5					
Greenland	12											
Norway	1				2	1+		5	1	1	1	1
UK (Scotland)	33											
United Kingdom					74	21	15	14	22			
Total (tonnes)	224	194	141	47	147	69	131	214	215	332	408	820
Total catch in 5b (5b1+5b2)	**5203**	**3546**	**2634**	**2924**	**3252**	**3421**	**3470**	**2863**	**5549**	**9218**	**7329**	**6850**

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

	2021			
Fleet	**Samples**	**Lengths**	**Otoliths**	**Weights**
Open boats, **trawlboats** and longliners	7	1444	420	1444
Trawlers	26	5138	1560	5138
Total	33	6582	1980	6582

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

Age	Longliners, open boats, jiggers	Trawlers
0	0	0
1	0	0
2	0	3
3	2,320	155
4	2,890	401
5	422	85
6	114	13
7	12	2
8	31	2
9	12	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
Total no.	5,720	661
Catch, t.	5482	626

Numbers in 1000'

Catch, gutted weight in tonnes

Table 5.4. Faroe haddock. Catch in numbers at age 1957–2021.

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
1996	0	1	326	5234	1019	179	163	161	270	234	394

Year \ age	0	1	2	3	4	5	6	7	8	9	10
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
2021	0	0	3	2492	3232	510	127	15	33	12	0
2022*	0	0	1	533	2874	1647	310	40	17	6	0
*Preliminary											

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

Year \ age	1	2	3	4	5	6	7	8	9	10
1968	0.25	0.47	0.73	1.13	1.55	1.97	2.41	2.76	3.07	3.55
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	1.000	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
2021	0	0.556	0.785	0.915	1.587	2.217	2.355	2.452	2.249	2.796
2022*	0	0.394	0.748	0.964	1.374	2.289	2.916	4.074	3.983	2.796

*Preliminary

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

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
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
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

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
2021	0	0.01	0.25	0.85	0.97	1	1	1	1	1	1
2022*	0	0.02	0.16	0.92	0.99	1	1	1	1	1	1
*Preliminary											

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
2022	8038	12293	4646	26717	6384	268	68

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8
1996	47759	42901	64257	1278	214	299	248	425
1997	7738	14052	25104	49758	977	183	87	176
1998	20209	2763	2502	14017	19433	321	99	82
1999	24141	9549	6383	1620	8473	10331	235	6
2000	169563	19483	7956	390	1300	4696	6007	105
2001	96784	98147	13072	4632	181	647	2714	3429
2002	95407	53532	62498	6158	1974	170	412	1336
2003	45045	38177	21476	37994	4370	667	110	466
2004	7951	33766	10718	15151	17822	1003	207	27
2005	14510	7191	12563	16713	12085	12958	592	43
2006	2504	8700	1790	8009	8237	6980	3494	129
2007	3986	6587	1744	1565	4322	5364	2731	630
2008	4798	1877	1135	2505	1001	3183	3287	1513
2009	10597	1337	411	1303	1273	948	2300	1304
2010	24891	3636	1457	1072	576	828	776	1329
2011	670	12059	2108	530	486	294	319	424
2012	2454	357	5617	1176	223	149	161	105
2013	9447	212	1330	5021	1129	224	114	176
2014	13910	3989	891	1034	2944	428	94	84
2015	7676	9320	4086	873	1449	1094	129	74
2016	36511	3303	3101	1989	284	567	378	46
2017	144745	16698	1813	2529	1115	293	302	134
2018	135364	54716	12800	4557	3435	1106	528	598
2019	38266	6902	13595	9889	2665	1322	510	356
2020	13005	3652	11020	12442	1024	463	126	36
2021	34543	4883	5470	21531	2699	343	87	26
2022	40064	17742	3788	26061	6837	207	35	30

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	-4.624	0.173	0.01	0.007	0.014
logFpar_1	-5.358	0.162	0.005	0.003	0.007
logFpar_2	-5.491	0.117	0.004	0.003	0.005
logFpar_3	-5.205	0.113	0.005	0.004	0.007
logFpar_4	-5.273	0.111	0.005	0.004	0.006
logFpar_5	-5.254	0.109	0.005	0.004	0.007
logFpar_6	-5.156	0.095	0.006	0.005	0.007
logFpar_7	-5.442	0.212	0.004	0.003	0.007
logFpar_8	-4.891	0.147	0.008	0.006	0.01
logFpar_9	-5.422	0.137	0.004	0.003	0.006
logFpar_10	-5.325	0.132	0.005	0.004	0.006
logFpar_11	-5.522	0.127	0.004	0.003	0.005
logFpar_12	-5.616	0.119	0.004	0.003	0.005
logSdLogFsta_0	-0.856	0.098	0.425	0.349	0.517
logSdLogN_0	-0.077	0.111	0.926	0.742	1.156
logSdLogN_1	-1.242	0.089	0.289	0.242	0.345
logSdLogObs_0	-1.071	0.086	0.343	0.289	0.407
logSdLogObs_1	-0.371	0.125	0.69	0.538	0.886
logSdLogObs_2	-0.804	0.082	0.448	0.38	0.528
logSdLogObs_3	-0.017	0.163	0.983	0.709	1.363
logSdLogObs_4	-0.452	0.086	0.636	0.536	0.755
transfIRARdist_0	0.574	0.272	1.775	1.03	3.058
transfIRARdist_1	-0.443	0.232	0.642	0.403	1.022
itrans_rho_0	1.131	0.115	3.099	2.46	3.904

Model	log(L)	#par	AIC
Current	-1080.03	24	2208.06
base	-1019.03	24	2086.05

Year	sd(log(R))	sd(log(SSB))	sd(log(Fbar))
2021	0.377	0.167	0.227
2022	0.528	0.204	0.318

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	0.348	0.506	0.397	0.486	0.745	0.743	0.835	0.835
1958	0.005	0.173	0.445	0.608	0.498	0.641	1.027	1.074	1.292	1.292
1959	0.007	0.189	0.442	0.567	0.469	0.628	1.035	1.125	1.416	1.416
1960	0.010	0.230	0.527	0.664	0.541	0.717	1.200	1.294	1.603	1.603
1961	0.010	0.219	0.472	0.572	0.462	0.607	1.003	1.120	1.301	1.301
1962	0.010	0.243	0.537	0.646	0.511	0.658	1.087	1.336	1.548	1.548
1963	0.008	0.224	0.534	0.693	0.563	0.697	1.166	1.654	2.036	2.036
1964	0.004	0.109	0.311	0.475	0.427	0.548	0.854	1.378	1.622	1.622
1965	0.003	0.090	0.275	0.447	0.431	0.629	1.114	1.797	1.797	1.797
1966	0.003	0.087	0.276	0.446	0.419	0.592	1.001	1.345	1.491	1.491
1967	0.002	0.071	0.229	0.362	0.338	0.492	0.850	1.072	1.318	1.318
1968	0.002	0.090	0.278	0.410	0.360	0.503	0.849	0.975	1.236	1.236
1969	0.003	0.096	0.321	0.479	0.423	0.583	0.985	1.025	1.300	1.300
1970	0.003	0.081	0.300	0.444	0.405	0.520	0.821	0.687	0.727	0.727
1971	0.002	0.070	0.300	0.445	0.438	0.520	0.813	0.726	0.887	0.887
1972	0.002	0.070	0.330	0.435	0.415	0.415	0.611	0.562	0.761	0.761
1973	0.004	0.119	0.438	0.480	0.395	0.334	0.372	0.310	0.330	0.330
1974	0.003	0.082	0.299	0.364	0.302	0.276	0.300	0.306	0.371	0.371
1975	0.002	0.061	0.232	0.295	0.257	0.236	0.244	0.298	0.415	0.415
1976	0.001	0.044	0.207	0.315	0.324	0.343	0.350	0.439	0.569	0.569
1977	0.001	0.017	0.121	0.266	0.399	0.528	0.602	0.828	1.157	1.157
1978	0.000	0.006	0.067	0.179	0.298	0.417	0.562	0.849	1.201	1.201
1979	0.000	0.005	0.058	0.149	0.221	0.267	0.335	0.500	0.694	0.694
1980	0.000	0.014	0.118	0.259	0.315	0.313	0.335	0.445	0.577	0.577
1981	0.001	0.018	0.141	0.274	0.299	0.266	0.237	0.263	0.326	0.326
1982	0.001	0.034	0.248	0.437	0.459	0.394	0.329	0.378	0.464	0.464
1983	0.001	0.030	0.200	0.365	0.388	0.377	0.324	0.415	0.497	0.497
1984	0.001	0.029	0.172	0.320	0.331	0.353	0.280	0.401	0.486	0.486
1985	0.001	0.028	0.164	0.314	0.359	0.415	0.322	0.482	0.591	0.591
1986	0.000	0.021	0.122	0.249	0.317	0.400	0.361	0.602	0.731	0.731
1987	0.001	0.025	0.131	0.254	0.337	0.457	0.486	0.730	0.806	0.806
1988	0.000	0.021	0.109	0.210	0.280	0.363	0.395	0.535	0.635	0.635
1989	0.000	0.016	0.102	0.204	0.298	0.415	0.521	0.691	0.841	0.841
1990	0.000	0.022	0.141	0.256	0.327	0.445	0.572	0.722	0.976	0.976
1991	0.000	0.030	0.174	0.290	0.316	0.383	0.437	0.453	0.539	0.539
1992	0.000	0.027	0.144	0.252	0.277	0.314	0.347	0.349	0.423	0.423
1993	0.001	0.041	0.200	0.311	0.291	0.285	0.285	0.271	0.309	0.309
1994	0.000	0.019	0.126	0.250	0.267	0.287	0.303	0.298	0.331	0.331
1995	0.000	0.017	0.129	0.284	0.322	0.338	0.356	0.344	0.357	0.357

Year Age	1	2	3	4	5	6	7	8	9	10
1996	0.000	0.013	0.123	0.312	0.399	0.455	0.500	0.470	0.443	0.443
1997	0.000	0.014	0.134	0.297	0.422	0.539	0.668	0.648	0.582	0.582
1998	0.000	0.026	0.234	0.398	0.520	0.737	1.058	1.186	0.912	0.912
1999	0.000	0.031	0.302	0.442	0.515	0.677	0.959	1.445	0.974	0.974
2000	0.001	0.044	0.325	0.444	0.460	0.511	0.561	0.744	0.572	0.572
2001	0.001	0.036	0.259	0.409	0.444	0.458	0.426	0.484	0.426	0.426
2002	0.000	0.027	0.206	0.377	0.466	0.523	0.487	0.540	0.554	0.554
2003	0.000	0.014	0.125	0.296	0.487	0.722	0.784	0.836	0.912	0.912
2004	0.000	0.015	0.122	0.273	0.462	0.765	1.006	1.147	1.333	1.333
2005	0.001	0.019	0.137	0.276	0.435	0.677	0.954	1.138	1.417	1.417
2006	0.001	0.026	0.167	0.292	0.412	0.617	0.905	1.078	1.611	1.611
2007	0.001	0.031	0.195	0.311	0.390	0.532	0.771	0.977	1.259	1.259
2008	0.001	0.031	0.189	0.300	0.333	0.438	0.649	0.904	1.310	1.310
2009	0.001	0.025	0.194	0.312	0.323	0.388	0.509	0.635	0.894	0.894
2010	0.001	0.039	0.299	0.456	0.443	0.504	0.618	0.723	1.035	1.035
2011	0.001	0.026	0.233	0.400	0.424	0.494	0.642	0.747	1.099	1.099
2012	0.000	0.019	0.171	0.304	0.358	0.428	0.540	0.641	0.951	0.951
2013	0.000	0.034	0.264	0.359	0.401	0.470	0.593	0.733	1.116	1.116
2014	0.000	0.040	0.299	0.393	0.436	0.457	0.507	0.577	0.944	0.944
2015	0.000	0.042	0.314	0.403	0.438	0.475	0.480	0.561	1.023	1.023
2016	0.000	0.032	0.280	0.387	0.444	0.504	0.477	0.610	1.178	1.178
2017	0.000	0.011	0.147	0.253	0.314	0.380	0.384	0.595	1.300	1.300
2018	0.000	0.011	0.203	0.350	0.419	0.476	0.421	0.705	1.910	1.910
2019	0.000	0.006	0.231	0.547	0.780	0.909	0.682	1.044	2.663	2.663
2020	0.000	0.002	0.143	0.445	0.889	1.312	1.087	1.856	3.840	3.840
2021	0.000	0.001	0.091	0.233	0.417	0.628	0.462	0.956	2.053	2.053
2022	0.000	0.000	0.063	0.165	0.300	0.512	0.374	0.694	1.478	1.478

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	28124	36812	25363	20804	5394	2605	1226	470	202	119
1958	32746	31409	25267	14174	9486	2966	1334	480	183	129
1959	58409	29412	23549	12845	6286	4379	1268	388	134	68
1960	75153	39036	24401	13515	6263	3307	1792	378	104	39
1961	75562	53429	23832	12940	5778	3054	1353	411	90	22
1962	75162	49874	35163	12361	6584	3040	1369	399	108	27
1963	39758	59562	26396	16300	5500	3612	1271	370	85	25
1964	18624	28685	32613	11328	6506	2595	1738	306	60	11
1965	18166	17135	20979	17123	5168	3081	1148	843	63	11
1966	33389	15464	14195	13637	8387	2711	1268	300	95	11
1967	47727	25301	12768	9364	7106	4125	1208	359	68	19
1968	28912	48786	19142	9063	5658	4242	1923	418	102	19
1969	32607	26471	33475	12044	5323	3482	2154	670	132	28
1970	20382	26106	20901	19637	5830	3239	1651	683	202	29
1971	24384	14157	20219	13620	10015	3232	1617	514	282	125
1972	27205	19416	10509	13340	7375	5110	1514	584	188	143
1973	113707	23974	20065	4755	7841	3650	3307	606	322	85
1974	105009	77165	15142	11941	2274	4219	1998	2054	324	350
1975	67969	88781	47657	9247	6745	1476	2467	1141	1286	461
1976	27468	67065	52205	27596	5775	4282	1126	1873	713	949
1977	10854	20595	44109	28939	14702	3905	2409	775	1036	957
1978	1083	10154	17316	29363	17124	6672	1652	1086	308	484
1979	6196	598	14685	13861	18823	9756	3240	629	355	179
1980	6229	6372	673	14862	10167	11686	6232	1815	267	207
1981	17748	4606	4280	759	10767	6175	7292	3801	847	183
1982	21209	15805	3411	2752	636	7386	3855	4553	3029	624
1983	45166	16402	12416	1606	1440	351	4625	2279	2678	2067
1984	40205	40225	12424	8492	752	792	222	2670	1196	2609
1985	20210	34299	31833	8985	4630	442	424	173	1360	2092
1986	13732	16058	26129	21418	5655	2470	205	262	109	1553
1987	24753	10219	15331	19051	12913	3345	1270	131	108	668
1988	9785	23478	6354	13084	12962	7790	1728	532	48	294
1989	7198	7538	16528	4487	9699	8280	4609	1005	260	153
1990	3214	6184	8353	10397	3174	5702	4636	2101	387	155
1991	2681	2475	5769	6874	6050	2056	3049	2168	849	126
1992	3813	2083	1652	3951	4483	3768	1185	1518	1169	483
1993	24940	2690	1844	1190	2559	2709	2293	680	879	854
1994	25636	10639	1650	1392	755	1664	1779	1530	456	1133
1995	42676	39429	4851	1055	886	501	1108	1128	963	1016
1996	10288	34509	52924	2935	561	482	379	729	702	1231

Year Age	1	2	3	4	5	6	7	8	9	10
1997	3703	7945	29093	47073	1741	327	222	241	446	1183
1998	13750	3062	6005	20585	30899	947	125	121	129	851
1999	25007	12521	2245	3631	13366	16297	401	26	32	355
2000	112269	22436	12762	815	2069	7105	7806	146	4	139
2001	52124	101224	16935	7207	422	1224	3698	4307	57	64
2002	35281	42947	86554	9421	3567	304	737	2247	2636	73
2003	22413	23870	32557	53702	5463	1663	204	547	1291	1480
2004	6836	20750	21126	22733	34217	2427	597	99	214	1026
2005	8858	5382	16602	17788	17857	18287	871	185	32	272
2006	2784	8479	3579	11856	12446	11565	6265	295	59	69
2007	2871	2497	5709	2415	8063	8155	5498	1737	115	18
2008	3409	2470	1792	3750	1736	4888	4167	2134	480	40
2009	7357	2110	1754	1371	2259	1431	3020	1778	635	103
2010	10475	6404	1789	1252	860	1270	1121	1577	761	256
2011	957	9904	3963	961	650	529	590	641	601	296
2012	2204	834	8742	1955	502	323	328	230	277	231
2013	7408	1892	1464	5694	996	279	185	158	105	174
2014	8677	6179	1656	1622	3144	419	150	88	43	77
2015	7269	7276	5263	1049	1558	1161	166	78	39	36
2016	23612	6057	5417	2698	621	1012	406	65	37	21
2017	31563	15432	4021	3569	1422	393	481	162	26	15
2018	46133	30349	11257	3127	2283	808	284	237	49	10
2019	21117	32613	18389	6362	2020	1143	372	197	65	6
2020	7488	16236	22837	8805	1681	653	283	139	54	4
2021	9992	6325	17311	19527	2347	387	100	58	16	1
2022	12211	7759	5328	20500	10763	803	133	51	15	2

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

Year	Recruitment			SSB			Total Catch	F		
	Age 1	97.5 percentile	2.5 percentile	SSB	97.5 percen-tile	2.5 percentile		Mean F (ages 3–7)	97.5 percentile	2.5 percentile
	thousands			tonnes				tonnes		
1957	28124	54545	14501	50104	66217	37913	20995	0.50	0.68	0.36
1958	32746	60562	17705	50421	64542	39389	23871	0.64	0.85	0.49
1959	58409	106341	32081	45443	57609	35846	20239	0.63	0.83	0.48
1960	75153	136759	41299	45591	57401	36210	25727	0.73	0.95	0.56
1961	75562	138298	41285	42884	54203	33929	20831	0.62	0.82	0.47
1962	75162	137963	40948	47460	59874	37620	27151	0.69	0.90	0.53
1963	39758	73538	21495	47762	60796	37523	27571	0.73	0.96	0.56
1964	18624	34748	9982	44336	57112	34418	19490	0.52	0.70	0.39
1965	18166	33962	9717	44844	58247	34525	18479	0.58	0.77	0.44
1966	33389	62338	17884	41986	54750	32198	18766	0.55	0.73	0.41
1967	47727	89128	25557	38137	49231	29543	13381	0.45	0.61	0.34
1968	28912	53867	15518	40696	51481	32171	17852	0.48	0.64	0.36
1969	32607	60681	17521	47515	60304	37439	23272	0.56	0.74	0.42
1970	20382	38026	10925	50257	65415	38611	21361	0.50	0.68	0.37
1971	24384	45428	13089	50004	64890	38533	19393	0.50	0.69	0.37
1972	27205	50773	14577	45791	59871	35023	16485	0.44	0.62	0.32
1973	113707	217903	59335	42873	55747	32972	18035	0.40	0.57	0.29
1974	105009	202262	54517	44318	57261	34301	14773	0.31	0.44	0.22
1975	67969	132506	34865	56754	73640	43741	20715	0.25	0.36	0.178
1976	27468	54438	13859	79385	105011	60012	26211	0.31	0.43	0.22
1977	10854	24412	4825	81624	109441	60877	25555	0.38	0.55	0.27
1978	1083	2479	473	79901	109942	58069	19200	0.31	0.45	0.21

Year	Recruitment			SSB			Total Catch	F		
	Age 1	97.5 percentile	2.5 percentile	SSB	97.5 percentile	2.5 percentile		Mean F (ages 3–7)	97.5 percentile	2.5 percentile
	thousands			tonnes			tonnes			
1979	6196	12429	3089	63178	86888	45937	12424	0.21	0.31	0.138
1980	6229	13332	2910	58398	78799	43278	15016	0.27	0.39	0.185
1981	17748	37996	8290	52808	71668	38911	12233	0.24	0.35	0.171
1982	21209	45488	9889	40945	53759	31185	11937	0.37	0.53	0.27
1983	45166	97415	20941	37961	49995	28824	12894	0.33	0.47	0.23
1984	40205	80794	20007	41177	53481	31704	12378	0.29	0.42	0.20
1985	20210	43739	9338	49262	65574	37008	15143	0.32	0.45	0.22
1986	13732	29843	6318	54209	73646	39902	14477	0.29	0.41	0.20
1987	24753	54188	11307	54264	73294	40174	14882	0.33	0.47	0.24
1988	9785	21328	4489	49256	66119	36693	12178	0.27	0.38	0.192
1989	7198	15550	3332	42221	55476	32133	14325	0.31	0.44	0.22
1990	3214	6911	1495	35147	45766	26992	11726	0.35	0.50	0.24
1991	2681	5740	1252	27207	35795	20680	8429	0.32	0.46	0.22
1992	3813	8177	1778	20275	27084	15177	5476	0.27	0.39	0.184
1993	24940	49701	12515	17455	23400	13020	4026	0.27	0.39	0.193
1994	25636	48277	13613	16458	21686	12491	4252	0.25	0.35	0.175
1995	42676	83207	21888	17292	22084	13540	4948	0.29	0.40	0.21
1996	10288	17859	5927	35915	46873	27518	9642	0.36	0.48	0.27
1997	3703	6827	2009	65518	87060	49306	17924	0.41	0.55	0.31
1998	13750	24764	7635	64550	83931	49644	22210	0.59	0.78	0.45
1999	25007	42570	14690	46208	59474	35901	18482	0.58	0.75	0.44
2000	112269	191899	65682	35589	44677	28349	15799	0.46	0.61	0.35
2001	52124	89389	30394	44977	54639	37024	15891	0.40	0.53	0.30

Year	Recruitment			SSB			Total Catch	F		
	Age 1	97.5 percentile	2.5 percentile	SSB	97.5 percentile	2.5 percentile		Mean F (ages 3–7)	97.5 percentile	2.5 percentile
	thousands			tonnes			tonnes			
2002	35281	64293	19361	72382	91805	57068	24929	0.41	0.55	0.31
2003	22413	40663	12354	83971	109245	64544	26942	0.48	0.64	0.36
2004	6836	11839	3947	72226	92752	56243	23100	0.53	0.70	0.40
2005	8858	15976	4911	60152	75265	48074	21944	0.50	0.65	0.38
2006	2784	5030	1541	43143	53223	34972	17154	0.48	0.63	0.36
2007	2871	5173	1593	30069	36826	24552	12631	0.44	0.58	0.33
2008	3409	5965	1949	19620	23773	16192	7393	0.38	0.51	0.29
2009	7357	13217	4095	14618	17629	12121	5197	0.35	0.46	0.26
2010	10475	19033	5766	11280	13399	9497	5203	0.46	0.61	0.35
2011	957	1799	509	8901	10645	7442	3546	0.44	0.59	0.33
2012	2204	4017	1209	10637	13555	8347	2634	0.36	0.49	0.27
2013	7408	13325	4119	10801	13903	8391	2924	0.42	0.56	0.31
2014	8677	15580	4832	9333	11708	7441	3252	0.42	0.56	0.31
2015	7269	13171	4011	11659	14463	9398	3421	0.42	0.57	0.31
2016	23612	41401	13466	12190	15208	9772	3470	0.42	0.56	0.31
2017	31563	56708	17567	13675	17114	10927	2863	0.30	0.40	0.22
2018	46133	86162	24701	23260	29821	18142	5549	0.37	0.51	0.27
2019	21117	39166	11386	29837	38368	23203	9218	0.63	0.86	0.46
2020	7488	14526	3860	28322	37076	21635	7329	0.78	1.09	0.55
2021	9992	21257	4696	34760	48521	24902	6850*	0.37	0.58	0.23
2022	12211	35133	4244	41005	61694	27254		0.28	0.53	0.150

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

Forecast table 1. 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
2022	0.291	0.162	0.541	12513	4247	37318	41721	28321	61487	7413	4829	11607	45070	30643	65827
2023	0.291	0.162	0.541	8858	957	112269	51002	29619	89506	12597	7249	22983	57812	33695	98970
2024	0.291	0.162	0.541	8677	957	112269	49070	25021	96861	12660	6631	26449	58699	28646	115403
2025	0.291	0.162	0.541	8858	957	112269	48109	21259	103826	11473	5678	22598	57177	24876	128781

Forecast table 2. SQ then zero F.

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
2022	0.291	0.162	0.541	12513	4247	37318	41721	28321	61487	7413	4829	11607	45070	30643	65827
2023	0.000	0.000	0.000	8858	957	112269	51002	29619	89506	0	0	0	57812	33695	98970
2024	0.000	0.000	0.000	8677	957	112269	64625	36152	118413	0	0	0	74266	39960	137262
2025	0.000	0.000	0.000	8858	957	112269	79033	41274	152981	0	0	0	88178	45675	171008

Forecast table 3. SQ then Fpa.

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
2022	0.291	0.162	0.541	12513	4247	37318	41721	28321	61487	7413	4829	11607	45070	30643	65827
2023	0.540	0.300	1.005	8858	957	112269	51002	29619	89506	20115	11953	34860	57812	33695	98970
2024	0.540	0.300	1.005	8677	957	112269	40027	19288	84307	15446	8003	31771	49454	22692	100345
2025	0.540	0.300	1.005	8858	957	112269	35054	14195	86631	11939	5356	23967	43905	17387	117558

Forecast table 4. SQ then Flim.

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
2022	0.291	0.162	0.541	12513	4247	37318	41721	28321	61487	7413	4829	11607	45070	30643	65827
2023	1.430	0.795	2.661	8858	957	112269	51002	29619	89506	34596	20956	59537	57812	33695	98970
2024	1.430	0.795	2.661	8677	957	112269	23654	9928	54938	12757	5562	29163	31659	12711	78286
2025	1.430	0.795	2.661	8858	957	112269	19305	6450	64307	8991	3371	25649	27155	8943	95662

Forecast table 5. SQ then Fmsy.

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
2022	0.291	0.162	0.541	12513	4247	37318	41721	28321	61487	7413	4829	11607	45070	30643	65827
2023	0.270	0.150	0.502	8858	957	112269	51002	29619	89506	11853	6801	21674	57812	33695	98970
2024	0.270	0.150	0.502	8677	957	112269	49960	25634	98285	12170	6320	25410	59577	29320	116945
2025	0.270	0.150	0.502	8858	957	112269	49689	21885	105836	11282	5630	22141	58618	25771	131168

Table 5.15 Faroe haddock reference points from the NWWG 2022 assessment compared with the previous values.

Framework	Reference point	OLD Value	NEW Value	Technical basis
MSY approach	MSY $B_{trigger}$	22843 t	23030 t	B_{lim}*exp(1.645*sigma) where sigma = 0.204
	F_{MSY}	0.165	0.27	Stochastic simulations assuming segmented regression stock recruitment relationships.
Precautionary approach	B_{lim}	16780 t	16458 t	B_{loss} in 1992 from the 2022 assessment.
	B_{pa}	22843 t	23030 t	B_{lim}*exp(1.645*sigma) where sigma = 0.204
	F_{lim}	0.54	1.43	F that gives a 50% probability of SSB > B_{lim} from Stochastic simulations
	F_{pa}	0.19	0.54	F that gives a 95% probability of SSB > B_{lim} from Stochastic simulations

Table 5.16 Faroe haddock reference points from the NWWG 2022 assessment compared with the previous values.

			Mean of standardized CPUE
Parameters			
Biomass average 2018-2020 (kg pr. Hour)			**1.43**
Biomass average 2021-2022 (kg pr. Hour)			**1.12**
I 2021 (kg pr. Hour)			**1.34**
I_loss (kg pr. Hour)			**0.20**
mean length (cm)			**48.27**
Lf=m			**47.14**
Calculations			
r	The rate of change in biomass		**0.79**
f	mean lenght/L f=m	Status of the stock	**1.00**
b	I y-1 / 1.4*I_loss:	Biomass safeguard	**1.00**
m		Multiplier	**0.90**
rfbm			**0.71**
Advice 2023: rfbm x advice 2022 (tonnes)			**6111**
Percentage change on last years advice			**-29.3%**
Apply buffer (+20% / -30%)			**No**
Advice 2022 with buffer when applicable (tonnes)			**6111**

ICES advice for 2022 *was 8639 t.*

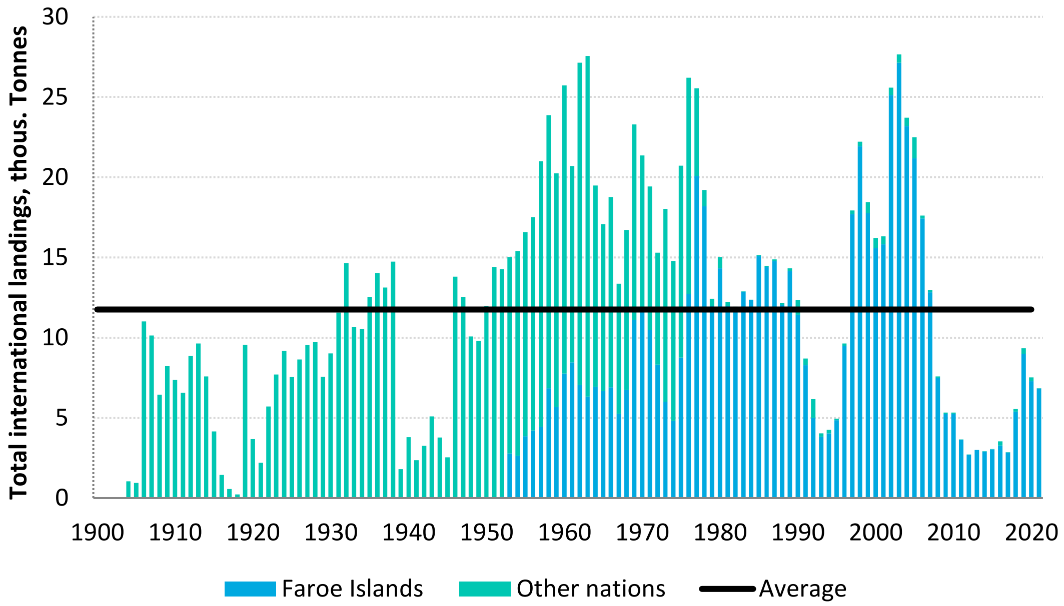


Figure 5.1. Haddock in ICES Division 5.b. Landings by all nations 1904–2020.

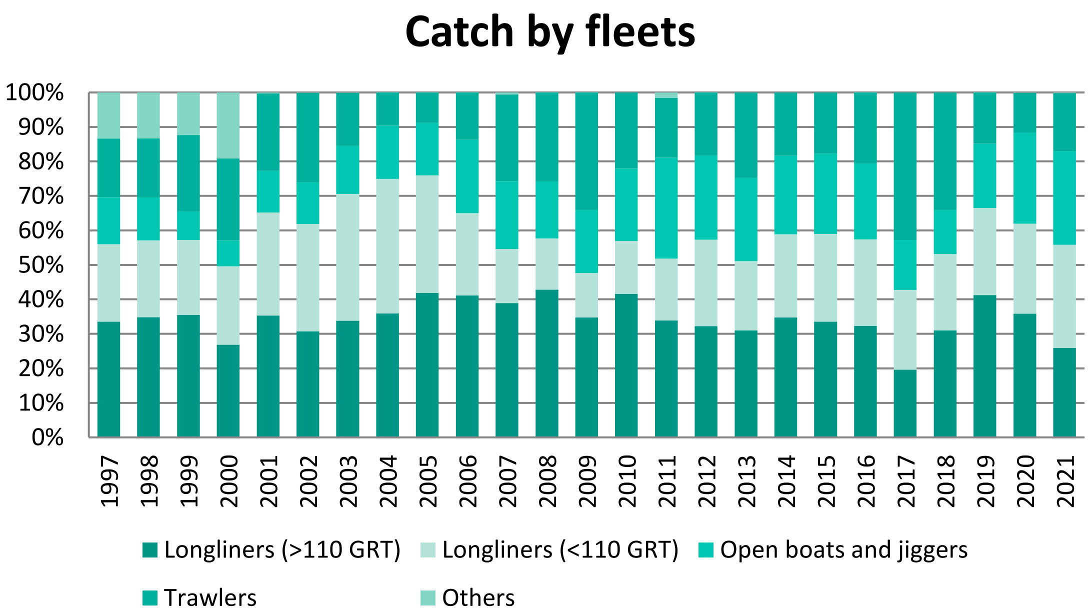


Figure 5.2. Faroe haddock. Catch distribution (%) between main fleets of the total Faroese landings 1997–2020.

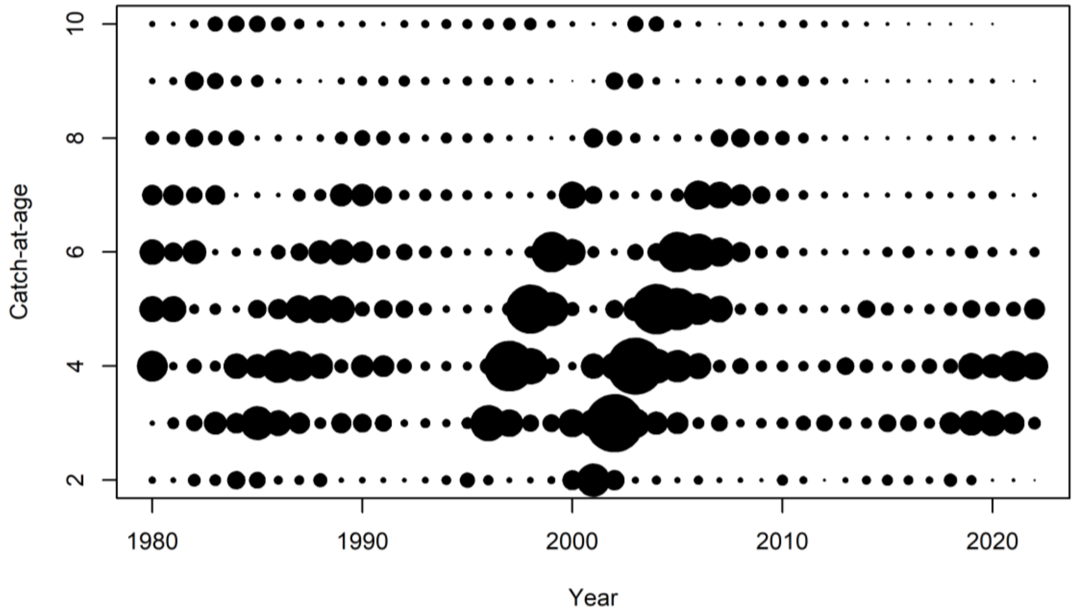


Figure 5.3. Faroe Haddock. Cath-at-age numbers in the commercial catches (ages 2–10) (1980–2021).

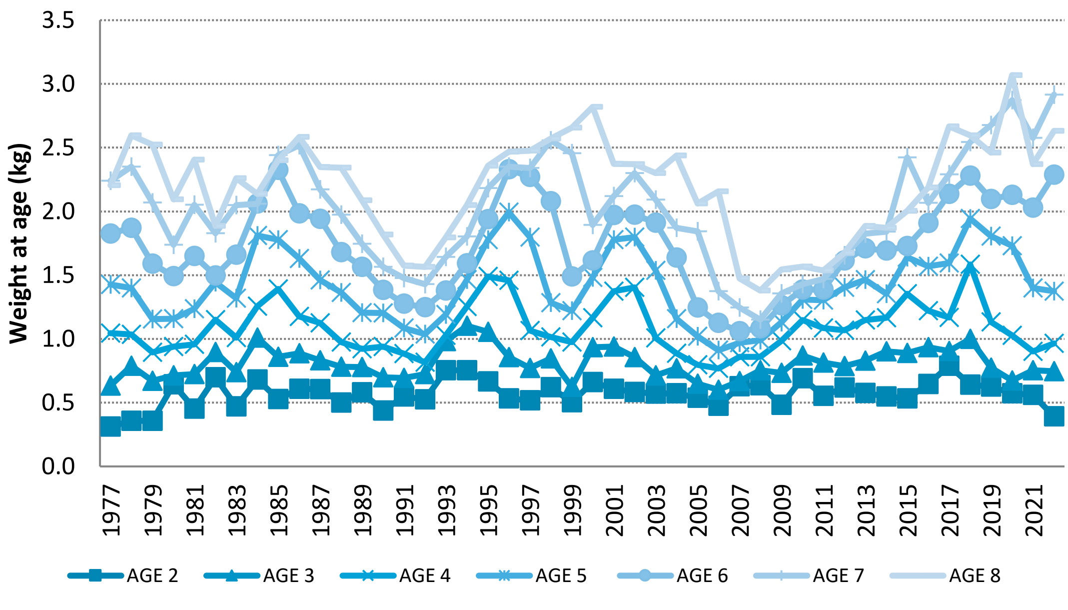


Figure 5.4. Faroe haddock. Mean weight (kg) at age (2–8).

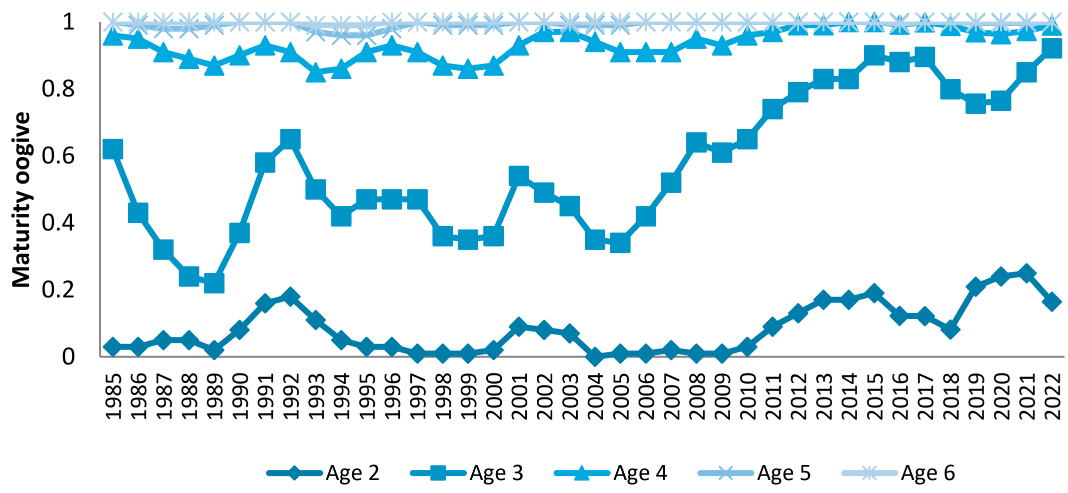


Figure 5.5. Faroe haddock. Maturity at age since 1985. Running 3-years average of spring survey observations for ages 2–6.

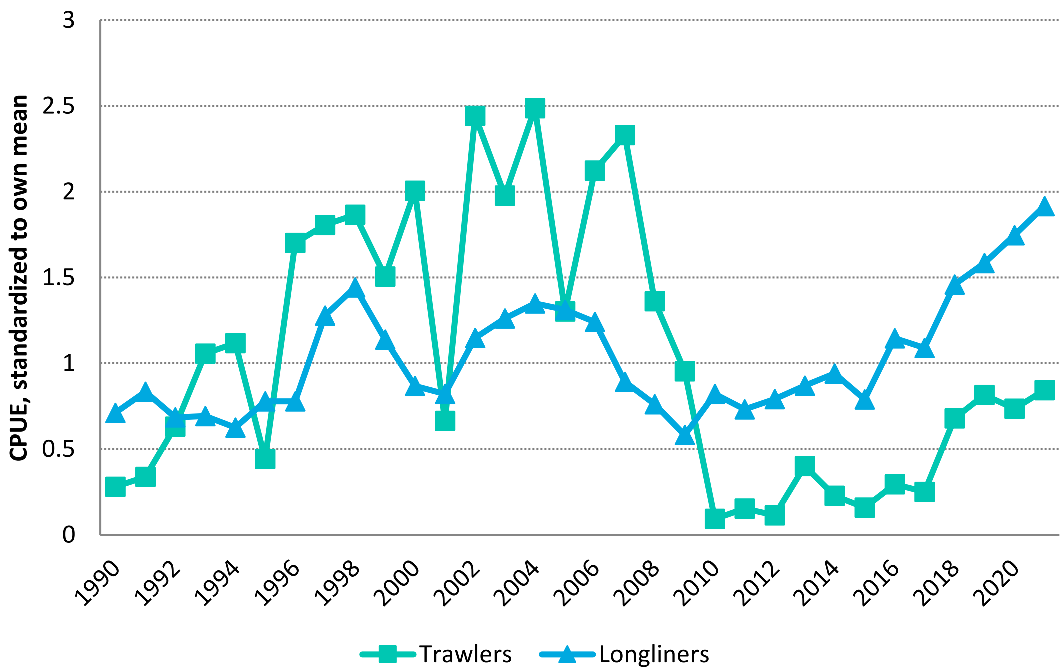


Figure 5.6. Commercial CPUEs of Faroe haddock for trawlers and longliners.

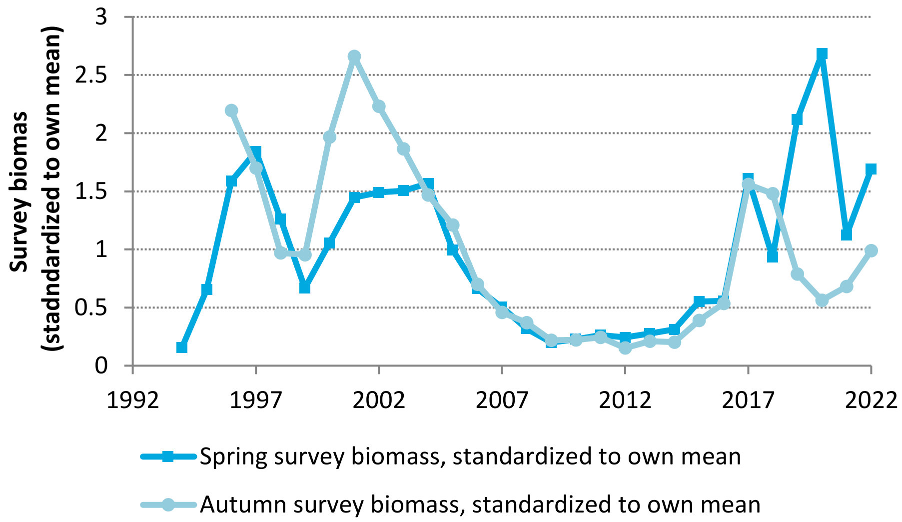


Figure 5.7. Tuning series biomass for spring surveys (1994–2021) and summer surveys (1996–2021). Surveys biomass is standardised to series mean biomass.

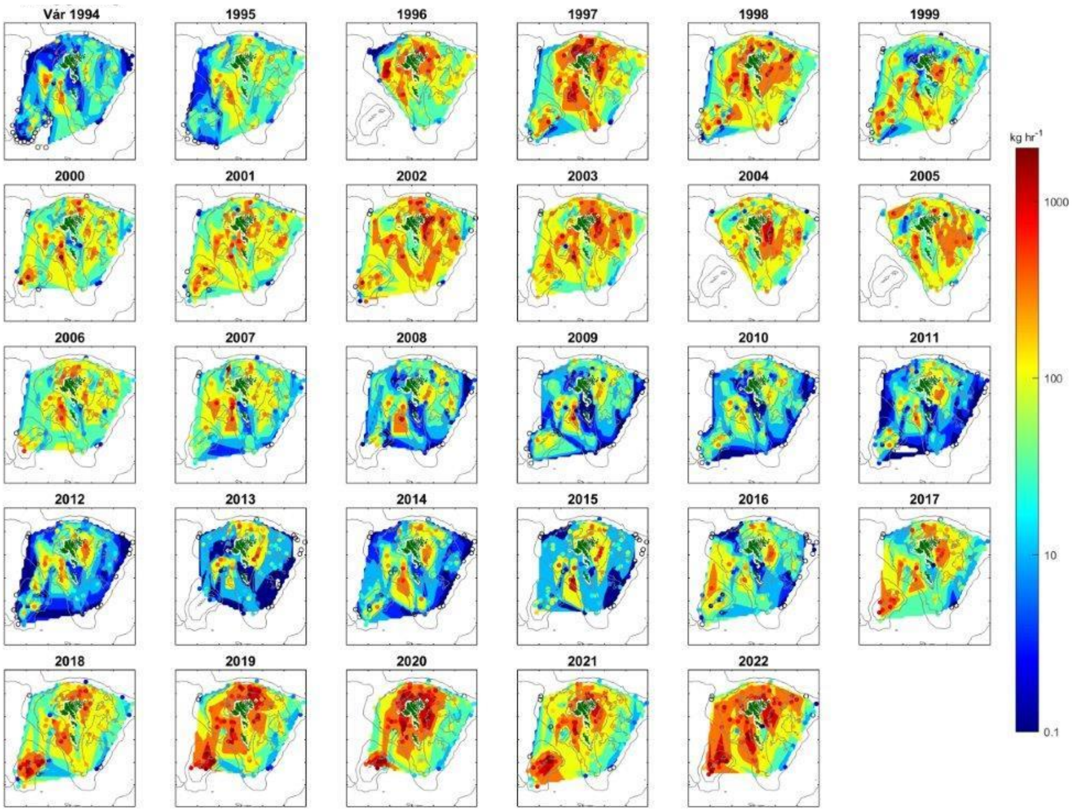


Figure 5.8a. Distribution of Faroe haddock catches in the spring survey.

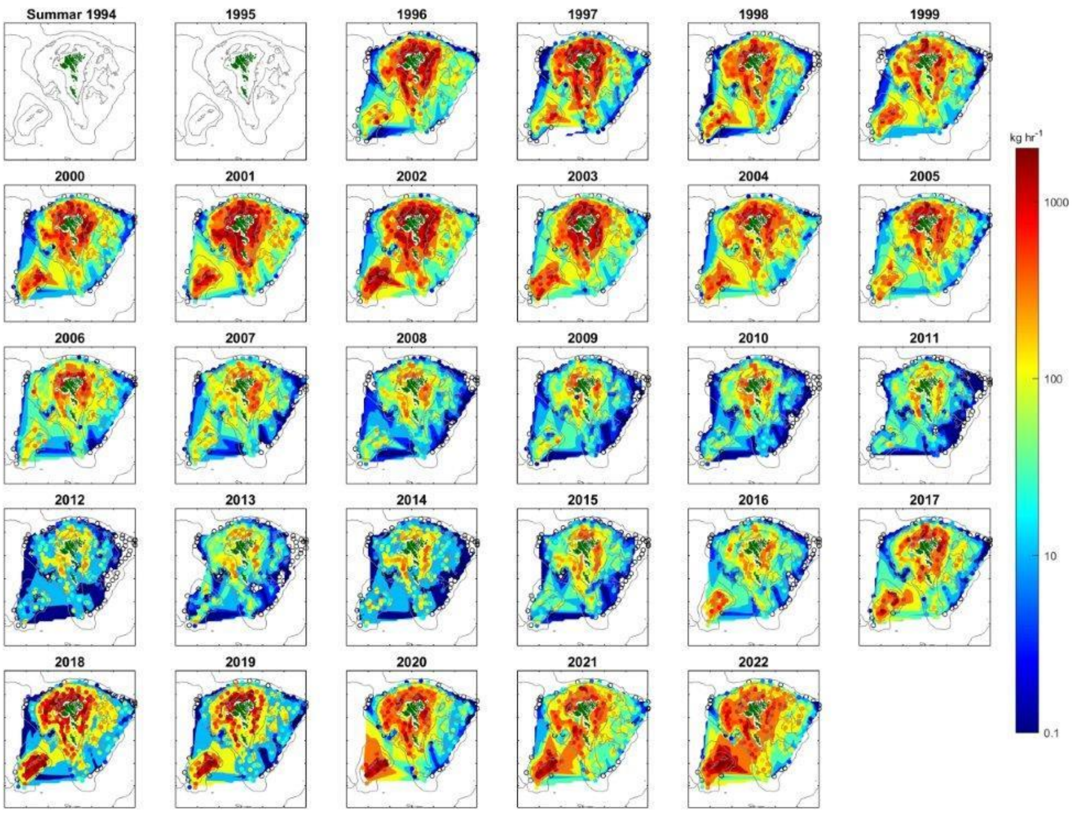


Figure 5.8b. Distribution of Faroe haddock catches in the summer survey.

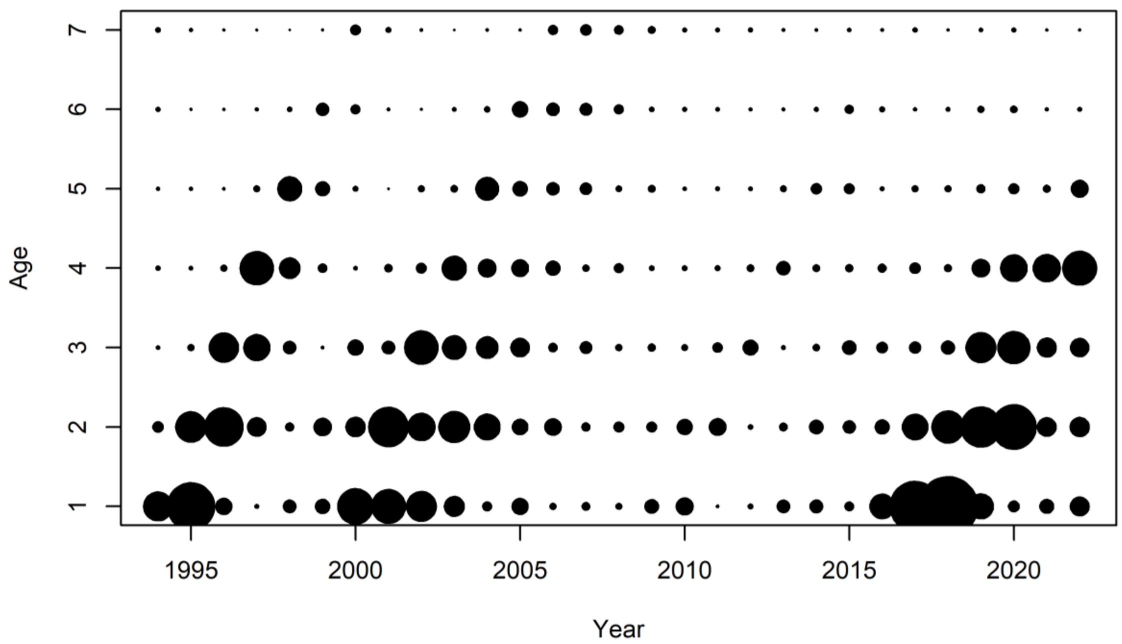


Figure 5.9. Faroe haddock. LN (catch at age in numbers) in the spring survey 1994–2020.

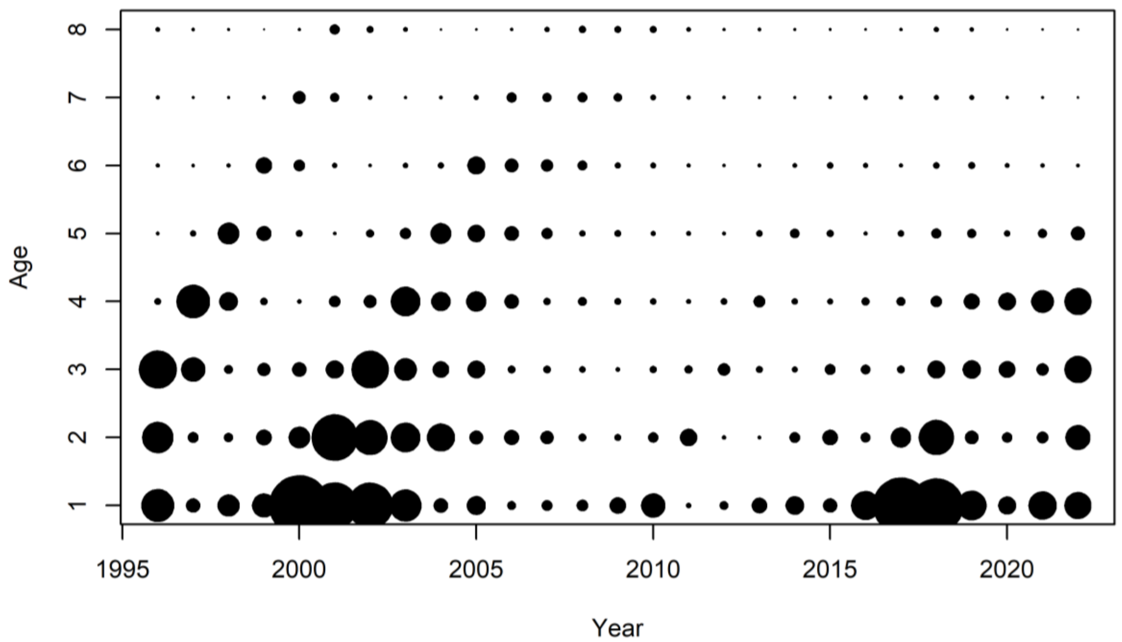


Figure 5.10. Faroe haddock. LN (catch at age in numbers) in the summer survey 1996–2021.

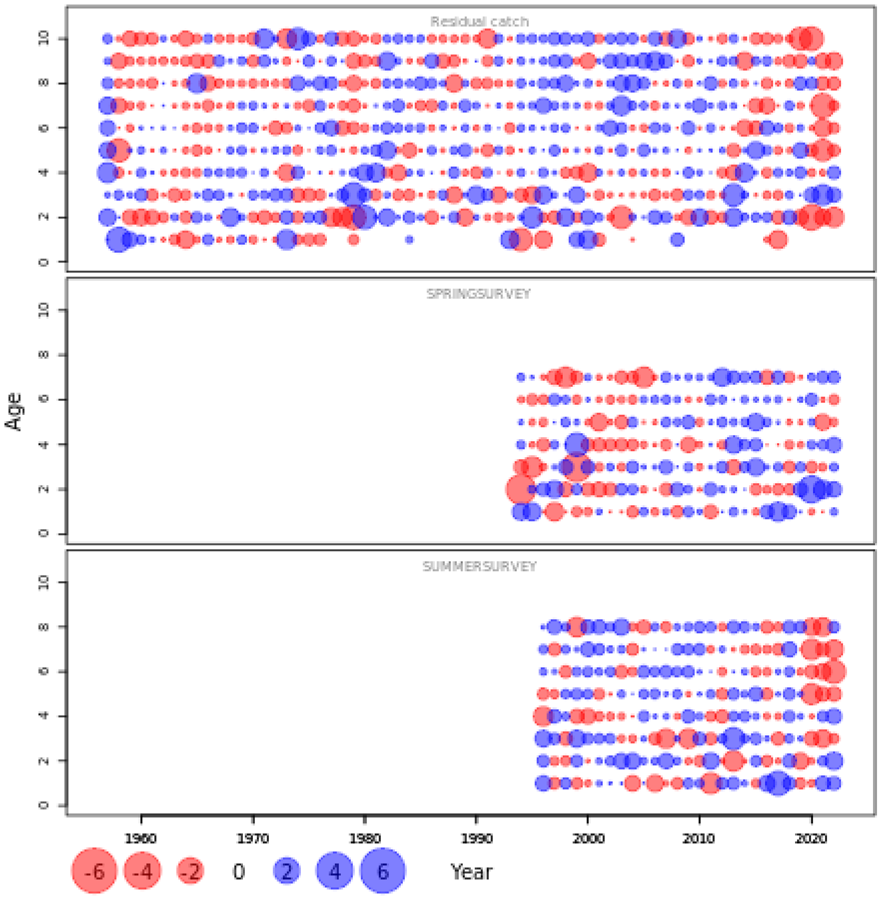


Figure 5.11. Faroe haddock (Division 5.b). Observation residuals for the catch spring survey and the summer survey as estimated by the SAM model.

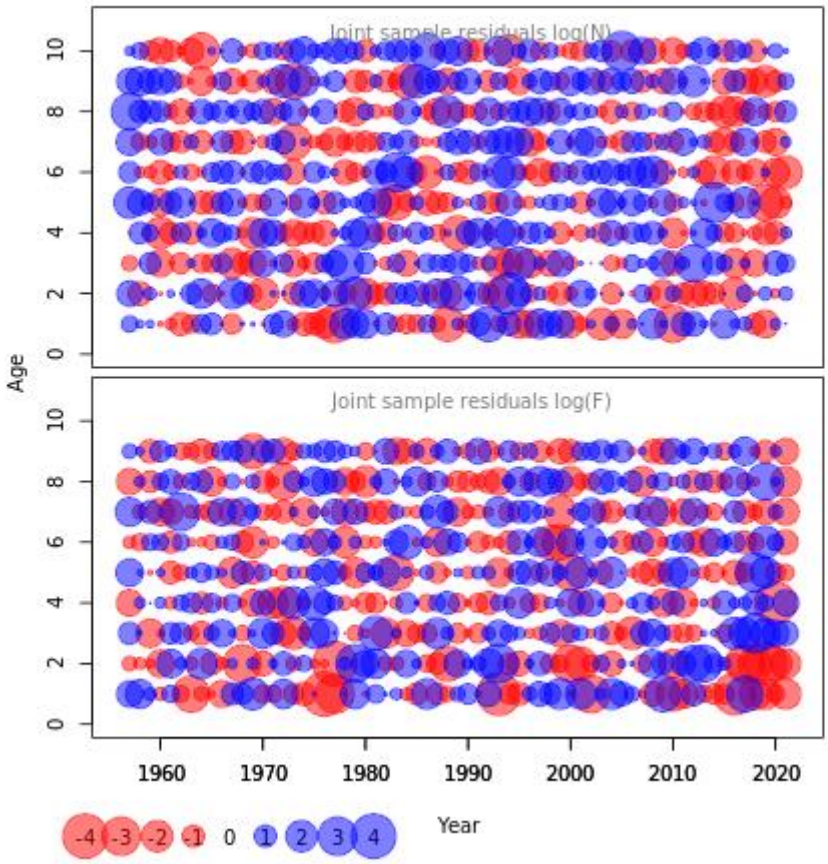


Figure 5.12. Faroe haddock (Division 5.b). Joint sample residuals for the population numbers and fishing mortality as estimated by the SAM model.

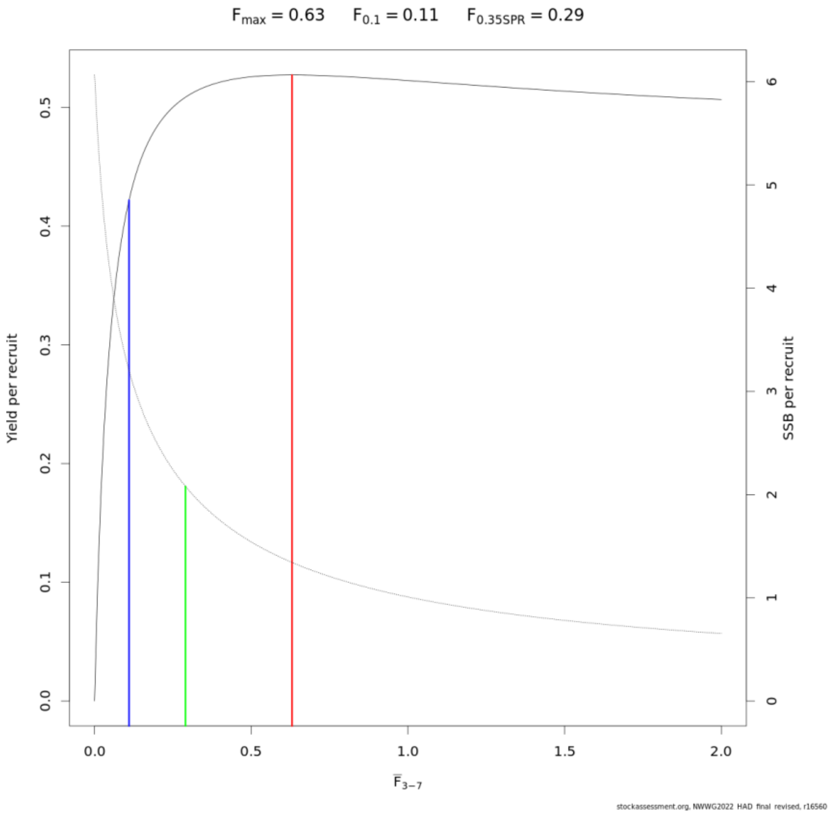


Figure 5.13. Faroe haddock (Division 5.b). Yield per recruit and spawning stock biomass (SSB) per recruit versus fishing mortality.

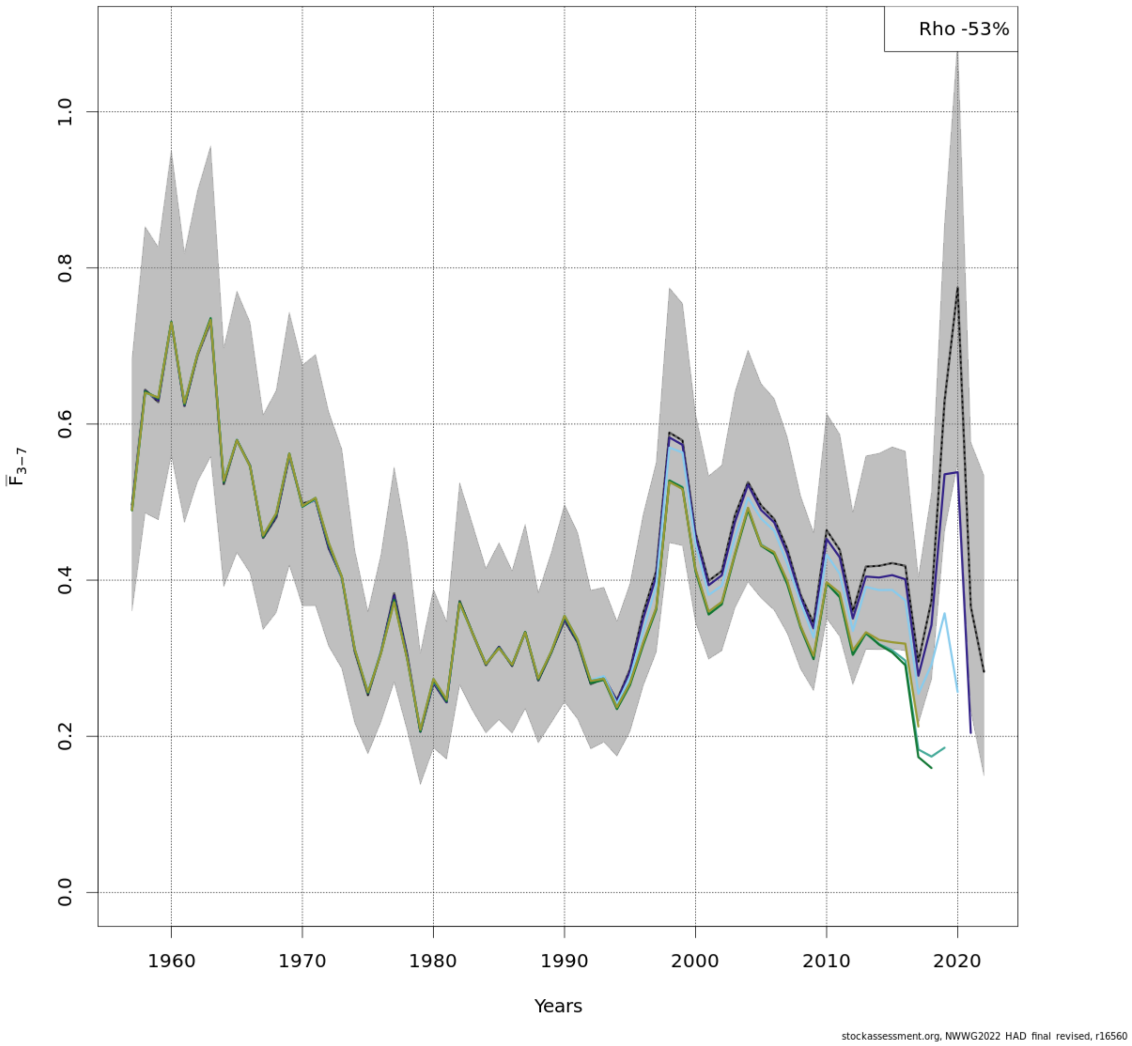


Figure 5.14. Faroe haddock (Division 5.b). Results from the SAM retrospective analysis of fishing mortality (ages 3–7).

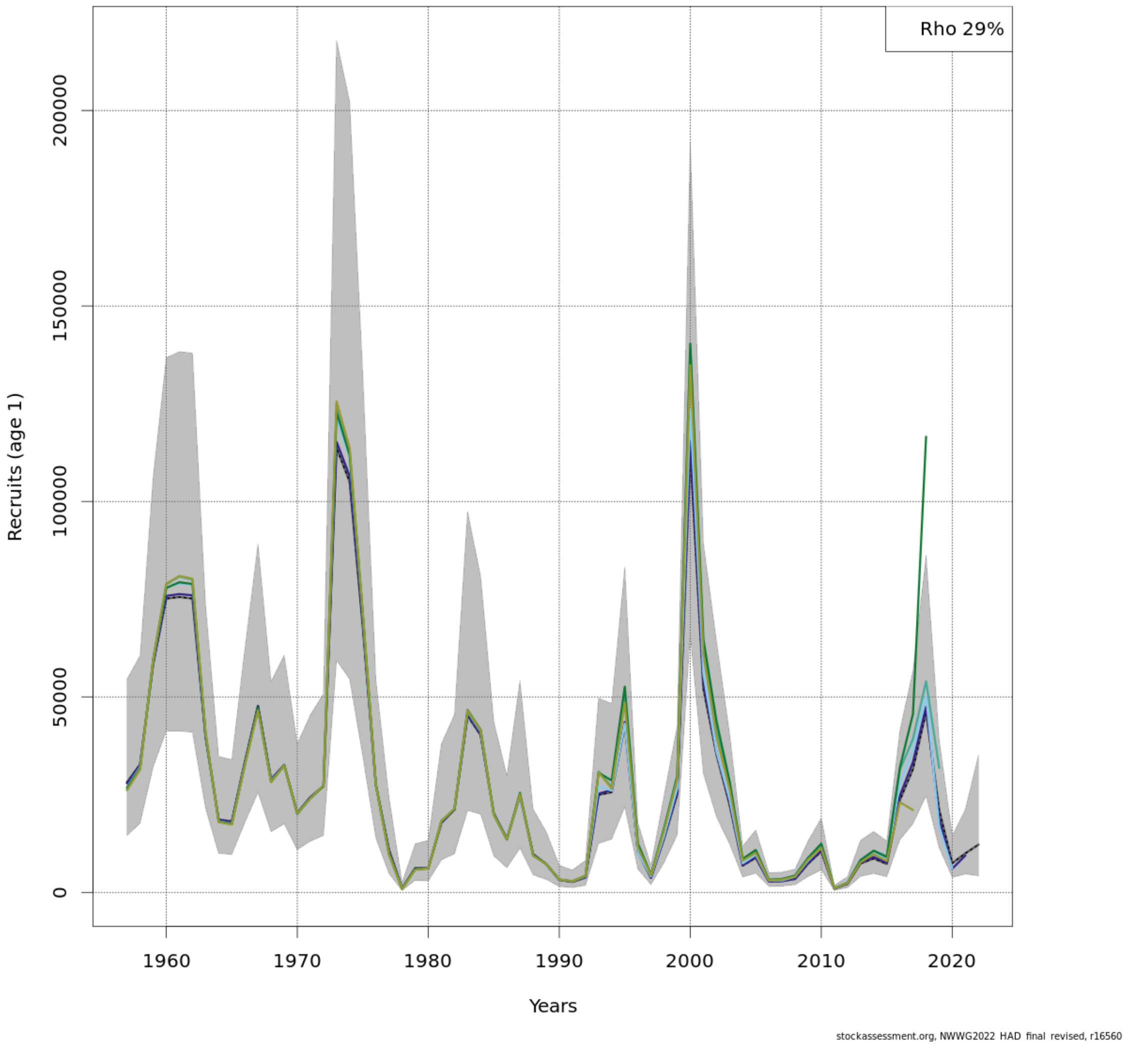


Figure 5.15. Faroe haddock (Division 5.b). Results from the SAM retrospective analysis. Recruitment at age 1.

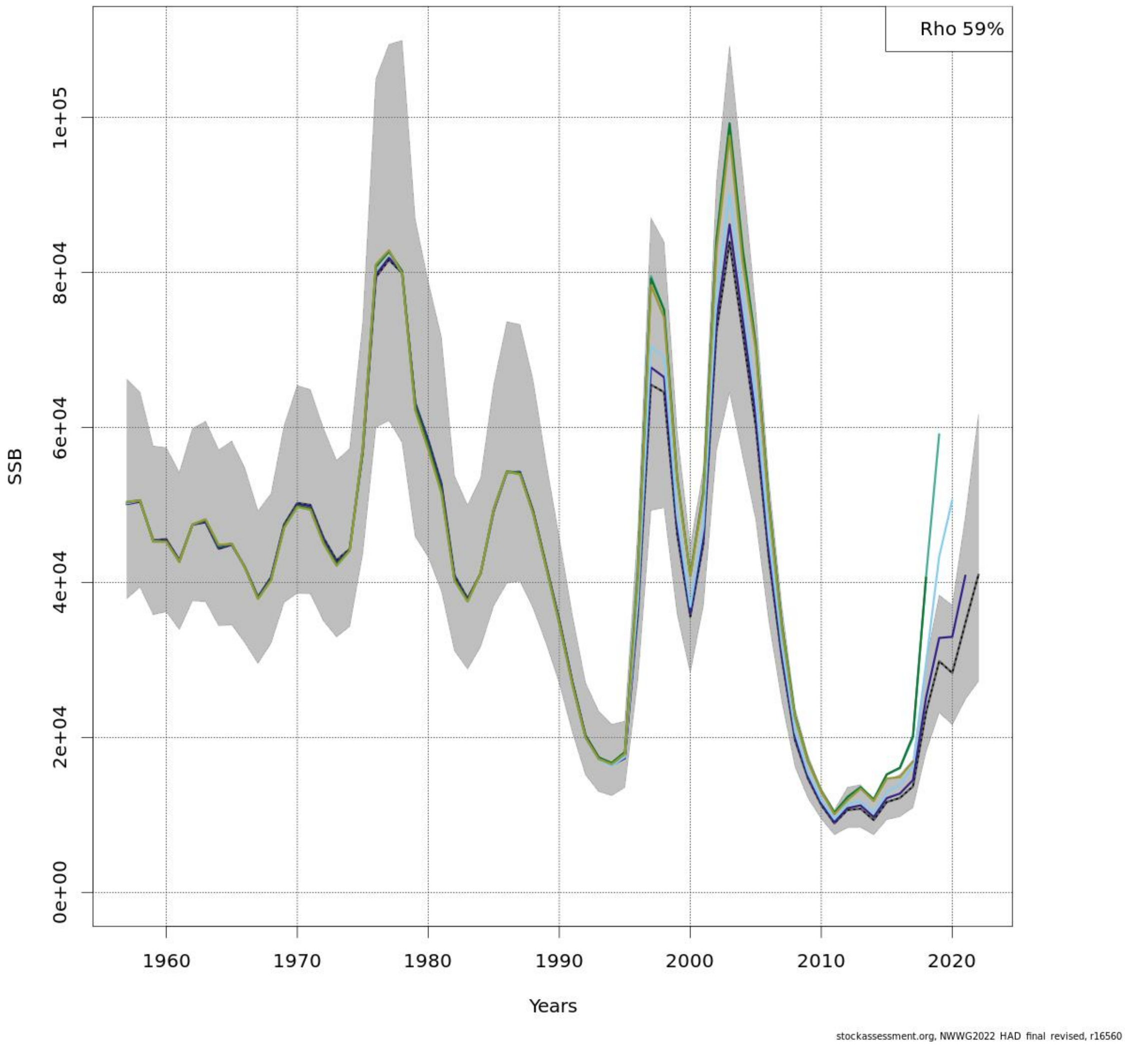


Figure 5.16. Faroe haddock (Division 5.b). Results from the SAM retrospective analysis (continued). Spawning stock biomass.

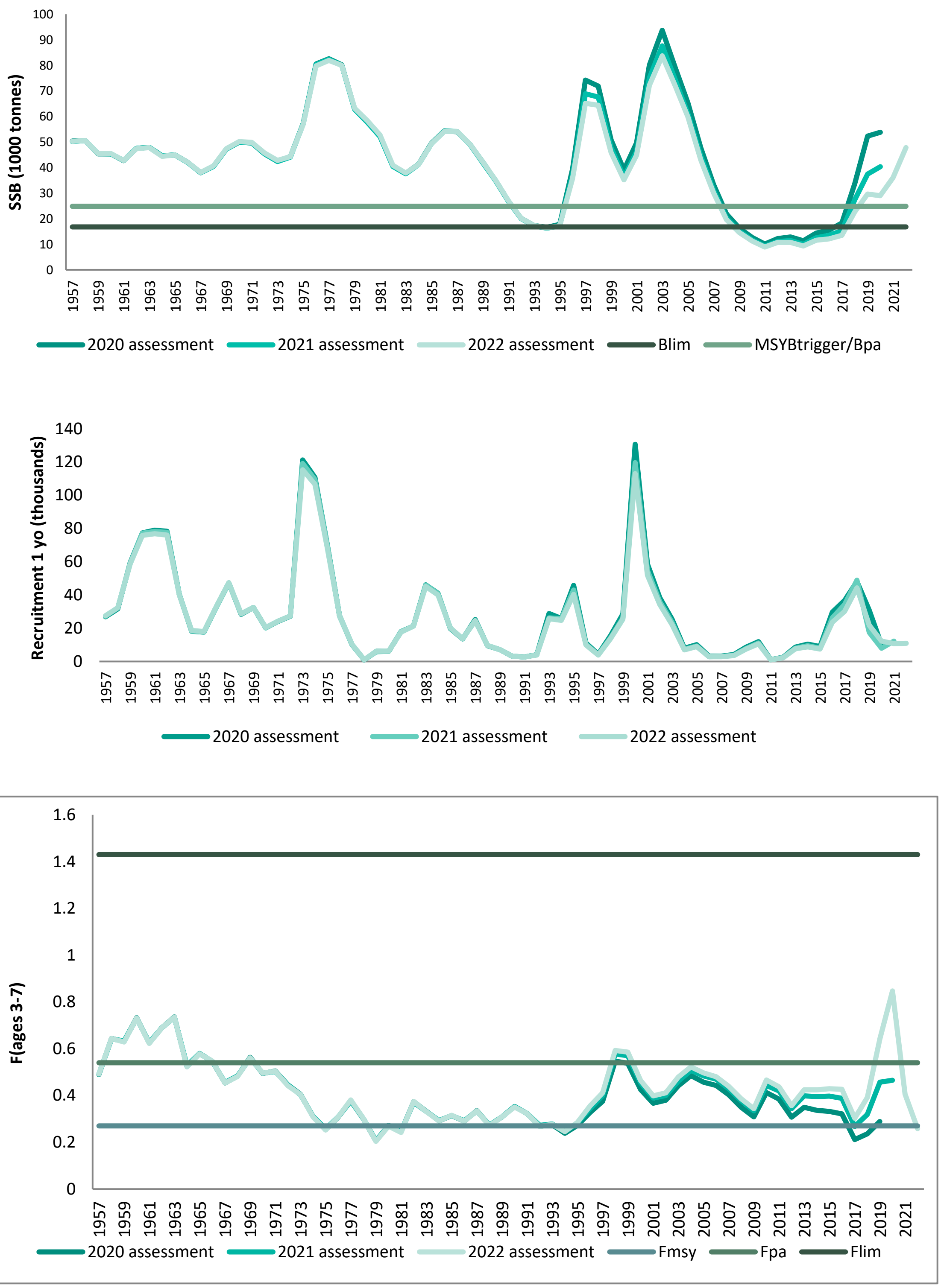


Figure 5.19. Faroe haddock (Division 5.b). Comparison between the November 2020 assessment (blue line) with the assessment (red) in the terminal year.

6 Faroe saithe

This section was updated in November 2022.

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 30 852 tonnes in 2017 to 17 038 tonnes in 2021.

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 since 2011 is among the poorest in the time-series. The progression of landings from January to August of 2022 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 all age groups but age 5 are lower in 2021 compared to 2020. Partial catch-at-age numbers for 2022 is compiled using sampling from January to June. These values are scaled up to estimated landings to the end of the year. Almost all age classes have decreased from 2021 to 2022.

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. Weight-at-age data are predicted with a Gaussian Markov Random Field (GMRF) with cohort and within year correlations in the SAM model. Weight-at-age in the forecast are predicted according to GMRF. 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 and at low levels. 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 a drop in stock size from 2021 to 2022. 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 intercessional 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://doi.org/10.17895/ices.pub.18623114.v1) 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 were not revised. In 2022 an inter-benchmark workshop (IBPFAR 2022) was conducted to investigate the inclusion of interim catch-at-age (ICAA) in the assessment year. Disaggregated catch numbers were raised to estimated landings to the end of the year according to a lineal regression of seasonal (January to September) to final annual catches. In addition, to account for the larger uncertainty of the last year's catches the observation variance of those observations were doubled, which corresponds to around 41% increased standard deviation. Weight-at-age data were predicted using a Gaussian Markov Random Field (GMRF) with cohort and within year correlations in the SAM model. The inclusion of the ICAA in the final year did overall improve the retrospective pattern (SSB: rho=24%, Fbar: rho=-11%). In the retrospective pattern of the SSB no individual peels are outside the confidence intervals of the model. The inter benchmark did not explore additional assessment runs. The assessment results are available on www.stockassessment.org under the following name; fsaithe-NWWG-2022

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).

At the IBPFAR, MSY and PA reference points for the stock were recalculated with EqSim following the Guidelines for ICES fisheries management reference points for category 1 and 2 stocks (ICES, 2021a). The Saithe stock was taken as conforming to "Type 1", a spasmodic stock showing occasional large year classes. B_{lim} is based on the lowest SSB, where large recruitment is observed (B_{loss} = 36 412 tonnes). The settings for the simulations are the following:

Parameter	Value
sigmaF	0.215
sigmaSSB	0.229
noSims	1001
SRused	Segreg_Bevholt_Ricker
SRyears_min	1961
SRyears_max	2020
acfRecLag1	0.49
rhoRec	FALSE
numAvgYrsB	5
numAvgYrsS	10
cvF	0.212
phiF	0.423
cvSSB	0
phiSSB	0

The revised reference points are shown in the table below.

	MSY Reference points		PA Reference points				
	MSY $B_{trigger}$ (tonnes)	F_{MSY}	B_{lim} (tonnes)	F_{lim}	B_{pa} (tonnes)	F_{pa}	F_{p05}
WKFAROE	41 400	0.30	29 571	0.70	41 400	0.30	0.30
IBPFAR	36 412	0.38	24 990	0.98	36 412	0.62	0.62

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 80 million from 1961 to 2022 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 from 2005 to 2015. Since 2019 recruitment estimates have declined to the historical lowest level in 2022. 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 162 kt to 83 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. F increased from F_{bar} = 0.42 in 2005 to F_{bar} = 0.62 in 2010 resulting in the largest landings of the whole time period (above 60 kt). 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. The saithe fishery is characterised with significant changes in the selection pattern (Figure 6.5.1.a). 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. SSB increased substantially from 1997 to 2005 due to the maturation of the strongest observed 1998 year class (age 3 in 2001). SSB has never been below MSY $B_{trigger}$ (36 412 tonnes). Since 2019 SSB is stable at around 50 000 t.

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 17 038 tonnes in 2021. Effort (number of fishing days) has decreased in recent years with around 20% to 30% of deactivated fishing days. 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 (excluding last estimated recruitment) and therefore the uncertainty in the recruitment pattern is captured in the forecast. The exploitation pattern is estimated internally in the SAM model and therefore not restrained by the use of arbitrary historical averages.

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.

According to the F_{MSY} advice (F_{MSY} = 0.38) catches are projected to 17 843 t in 2023 resulting in a SSB of 54 411 t. assuming a recruitment estimate of 11 mill. . In these conditions, SSB will go down to 53 319 t in 2024. The difference in the F_{msy} advice given in 2021 and this years' advice is -52%.

Landings in 2023 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 23%, -11% and 90% for the spawning stock biomass, F and recruitment, respectively. The difference between the 2021 assessment and the new adopted assessment model at the IBPFAR in 2022 is illustrated in the table below.

rho	NWWG 2021	IBPFAR 2022
R(age 3)	0.98	0.90
SSB	0.33	0.23
Fbar(4–8)	-0.13	-0.11

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).

At the IBPFAR (ICES, 2022) the assessment, MSY and PA reference points for the stock were

revised. Partial catch-at-age data for the intermediate year were compiled and associated with larger uncertainty in the observation variance. Weights in the catch-at-age were predicted with a GMRF model with cohort and within year correlations in the SAM model. EqSim simulations were run following the Guidelines for ICES fisheries management reference points for category 1 and 2 stocks (ICES, 2021a). The Saithe stock was taken as conforming to “Type 1”, a spasmodic stock showing occasional large year classes. B_{lim} is based on the lowest SSB, where large recruitment is observed (B_{loss} = 36 412 tonnes).

The updated assessment suggests a downwards revision in SSB with respect to the 2021 assessment (Figure 6.9.1). The 2021 assessment estimated $F_{4\text{–}8}$ = 0.35 in 2021 while the 2022 assessment suggests that fishing mortality was lower ($F_{4\text{–}8}$ = 0.29). Recruitment is revised downwards with respect to the 2021 assessment.

Predictions of landings in the 2021 assessment were very closed to estimates in the 2022 assessment (9%) but larger for F_{bar} (31%) and SSB (42%) (See table below).

Forecast comparison	Forecast NWWG2021	NWWG2022	Relative Difference
Fages 4–8 (2021)	0.20	0.29	31%
Landings (2021)	15663	17038	9%
SSB2022	89084	51258	42%

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 was finalized 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.

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

Gaard. E., Hansen, B., Olsen, B and Reinert, J. 2001. Ecological features and recent trends in physical environment, plankton, fish stocks and seabirds in the Faroe plateau ecosystem. In: K- Sherman and H-R Skjoldal (eds). Changing states of the Large Marine Ecosystems of the North Atlantic.

í Homrum, E., Ofstad, L.H. and Steingrund, P. 2009. Diet of Saithe on the Faroe Plateau. WD, NWWG 2009.

Hátún, H., Sandø, A. B., Drange, H., Hansen, B., and Valdimarsson, H. 2005: Influence of the Atlantic subpolar gyre on the thermohaline circulation. Science, 309, 1841-1844

Hátún, H., Payne, M., Beaugrand, G., Reid, P. C., Sandø, A. B., Drange, H., Hansen, B., Jacobsen, J. A., and Bloch, D. 2009. Large bio-geographical shifts in the north-eastern Atlantic Ocean: From the subpolar gyre, via plankton, to blue whiting and pilot whales. Progress in Oceanography, 80: 149-162

ICES. 2017. Report of the North Western Working Group (NWWG). ICES CM 2017/ACOM:08.

ICES. 2018. Report of the Benchmark Workshop on Faroese Stocks (WKFAROE 2017), 13–17 February 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:33. 239 pp.

ICES. 2020. Annex 7: Faroe saithe – adjustments of the SAM model configuration. *In* North Western Working Group (NWWG). ICES Scientific Reports. 2:51. 670 pp. https://doi.org/10.17895/ices.pub.6051

Steingrund, P. April 2003. Correction of the maturity stages from Faroese spring groundfish survey. WD 14, NWWG 2003.

Steingrund, P., and Gaard, E. 2005. Relationship between phytoplankton production and cod production on the Faroe Shelf. ICES Journal of Marine Science, 62: 163–176.

Steingrund, P., and Hátún, H. 2008. Relationship between the North Atlantic Subpolar Gyre and fluctuations of the saithe stock in Faroese waters. NWWG 2008 Working Document 20.

Steingrund, P., Mouritsen, R., Reinert, J., Gaard, E., and Hátún, H. 2010. Total stock size and cannibalism regulate recruitment in cod (Gadus morhua) on the Faroe Plateau. ICES Journal of Marine Science, 67: 111–124.

Table 6.2.1.1. Faroe saithe (Division 5.b). Nominal catches (tonnes round weight) by countries 1988–2021 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	2021 [1]
Denmark	-	-	-	-	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
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	22,764	24,334	18,405
France	607	370	147	123	315	108	97	68	46	135	40	31	28	122	336	40	27	5	20	-
Germany	422	281	186	1	49	3	3	0	-	-		-	-	-	-	-	-	-	-	-
Greenland	125	-			73	239	0	1			1	-	-	-	-	-	1	-	-	-
Irland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	-	148	-	-	-	-	-	-	-	-	-	0		3
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	40	38	10
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	0	1	340	304	601	291	214	71	352	
Total	57,004	49,377	49,546	76,266	73,878	67,326	64,000	64,308	49,062	32,510	38,319	28,688	26,027	27,961	31,986	33,325	25,973	22,887	24,745	18,418
Working Group estimate [4,5,6,7]	53,546	46,555	46,355	67,967	68,465	62,352	59,243	59,557	45,441	30,083	35,448	26,539	24,103	25,899	29,672	30,852	24,046	21,179	22,920	17,038

Table 6.2.1.2.a. Faroe saithe (Division 5.b). Contribution (%) by each fleet category to total national landings(1985–2020).

	Open boats	LL <100	LL >100	Gill-net	Jig-ger	ST <400	ST 400-1000	ST >1000	PT <1000	PT >1000	IT	Other	To-tal(%)
1985	0.2	0.1	0.1	0	2.6	0.1	6.6	33.7	28.2	28.2	0.2	0.2	100
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	100
1987	0.7	0.1	0.1	0.4	5.6	0.3	4.1	20.4	22.8	44.3	1.1	0	100
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	100
1989	0.9	0.1	0.1	0.2	9.3	0.3	5.4	17.7	23.5	41.1	1.3	0	100
1990	0.6	0.2	0.2	0.2	7.4	0.2	3.9	19.6	24	42.8	0.9	0	100
1991	0.6	0.1	0.1	0.6	9.8	0.1	1.3	13.9	26.5	46.2	0.8	0	100
1992	0.4	0.4	0.1	0	10.5	0	0.5	7.1	24.4	55.6	1	0	100
1993	0.6	0.2	0.1	0	9.3	0.1	0.6	6.5	21.4	60.6	0.7	0	100
1994	0.4	0.4	0.2	0	12.6	0.1	1.1	6.8	18.5	59.1	0.7	0	100
1995	0.2	0.1	0.3	0	9.6	0.4	0.9	9.9	17.7	60.9	0	0	100
1996	0	0	0.2	0	9.2	0.1	1.2	6.8	23.7	58.6	0	0	100
1997	0	0.1	0.4	0	8.9	0.1	2.5	10.7	17.8	58.9	0.4	0	100
1998	0.1	0.4	0.3	0	7.5	0.1	2.6	19.3	15.4	53.9	0.4	0	100
1999	0	0.1	0.2	0	5.7	0.1	1.2	12.6	18.5	60	1.6	0	100
2000	0.1	0.1	0.1	0	3.7	0.2	0.3	15	17.5	62.3	0.7	0	100
2001	0.1	0.1	0.2	0	2.8	0.1	0.3	20.2	16.5	58.8	0.8	0.1	100
2002	0.1	0.2	0.1	0	1.6	0.1	0.1	26.5	10.5	60.8	0	0	100
2003	0	0	0.1	0	0.9	1.9	0.4	17.4	14.7	64.7	0	0	100
2004	0.1	0.2	0.2	0	1.9	3.7	0.4	15.1	14.4	63.8	0	0	100
2005	0.2	0.1	0.2	0	2.4	4.4	0.2	12.7	20.6	59.2	0	0	100

	Open boats	LL <100	LL >100	Gill-net	Jig-ger	ST <400	ST 400-1000	ST >1000	PT <1000	PT >1000	IT	Other	To-tal(%)
2006	0.2	0.4	0.6	0	3.9	0.3	0.1	19.8	20.6	54.1	0	0	100
2007	0.2	0.2	0.3	0	2	0.2	0.1	30.4	16	50.6	0	0	100
2008	0.2	0.3	0.5	0	3.2	1.5	0.2	20.4	16	57.7	0	0	100
2009	0.4	0.2	0.2	0	4.3	3.3	0.1	9.6	15.1	66.8	0	0	100
2010	0.1	0.1	0.6	0	3.9	1.2	2.4	8.3	15.1	68.3	0	0	100
2011	0.1	0.1	0.5	0	3.6	0.5	1.3	2.6	14.1	77.1	0	0	100
2012	0.2	0.1	1	0	2.4	1.9	0.1	2.2	18.6	73.5	0	0	100
2013	0.1	0.3	0.5	0	3.2	1	0.2	0.6	24.9	69	0	0.1	100
2014	0.2	0.3	0.3	0	1.9	0.5	0.2	0.2	15.6	80.7	0	0.1	100
2015	0.2	0.4	0.3	0	2.3	1.1	0	2	18	75.5	0	0	100
2016	0.1	0.1	0.3	0	1.6	1.7	0.2	0.2	21.7	73.8	0	0.4	100
2017	0.1	0	0.1	0.1	0.7	0.7	0.3	0.2	20.6	76.9	0	0.1	100
2018	0.2	0	0.1	0	0.8	0.9	0.2	0.8	20.5	76.3	0	0	100
2019	0.1	0.1	0.3	0	0.3	0.4	0.4	1.3	18.4	78.6	0	0	100
2020	0.1	0.2	0.4	0	1.9	0.9	0.3	1.1	19.1	75.7	0	0	100

Table 6.2.1.2.b. Faroe saithe (Division 5.b). Contribution (%) by each fleet category to total national landings (2021).

	LL	Gillnet	Jigger	ST	PT	Other	To-tal(%)
2021	0	0	2	6	91	1	100%

Table 6.2.2.1. Faroe saithe (Division 5.b). Catch number-at-age by fleet categories in 2021. (From gutted weights)

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	3273	832	1182	2152	1320	180	117	47	6	4	3	0	0
2020	405	6668	500	900	970	352	75	49	1	0	4	0	0
2021	729	1319	2910	289	369	343	114	61	3	8	3	0	3
2022	26	1767	576	1049	285	314	270	96	42	28	1	2	2

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	Oth-ers	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

Year		Jiggers	Single trawlers >1000 HP	Pair trawlers <1000 HP	Pair trawlers >1000 HP	Oth-ers	Total
	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
2021	Lengths	0	195	4787	4940	0	9922
	Otoliths	0	60	1499	1428	0	2987
	Weights	0	195	4787	4940	0	9922

Table 6.2.3.1. Faroe saithe (Division 5.b). Catch weights at age (kg) (equal to stock-weights) from the commercial fleet (1961–2021). Catch weights in 2022 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 (1983–2022). 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
2021	0.07	0.29	0.54	0.75	0.9	0.98	0.99	1
2022	0.11	0.28	0.58	0.78	0.91	0.99	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	256	700	1673	1655	113	80	30	36
2019	200	4343	813	874	1113	622	107	59 41	
2020	200	403	1620	224	446	400	125	59	88
2021	200 3370	677	1379	191	250	320	142	128	
2022	200 398	2499	314	375	139	127	119	71	

					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	167	483	1251	855	65	36	40	20
2019	100	13608	1772	828	771	442	90	74 46	
2020	100	137	1458	178	266	331	229	66	92
2021	100 1901	1018	2061	298	433	473	139 142		
2022	100 242	945	194	205	32	94	130	91	

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	-7.532	0.212	0.001	0.000	0.001
logFpar_1	-6.971	0.166	0.001	0.001	0.001
logFpar_2	-6.689	0.162	0.001	0.001	0.002
logFpar_3	-6.784	0.112	0.001	0.001	0.001
logFpar_4	-6.941	0.115	0.001	0.001	0.001
logFpar_5	-7.041	0.118	0.001	0.001	0.001
logFpar_6	-7.087	0.138	0.001	0.001	0.001
logFpar_7	-8.285	0.247	0.000	0.000	0.000
logFpar_8	-7.419	0.197	0.001	0.000	0.001
logFpar_9	-7.166	0.130	0.001	0.001	0.001
logFpar_10	-7.073	0.096	0.001	0.001	0.001
logFpar_11	-7.244	0.101	0.001	0.001	0.001
logFpar_12	-7.121	0.105	0.001	0.001	0.001
logFpar_13	-7.075	0.116	0.001	0.001	0.001
logSdLogFsta_0	-1.354	0.107	0.258	0.209	0.320
logSdLogN_0	-0.508	0.133	0.602	0.461	0.785
logSdLogN_1	-1.404	0.102	0.246	0.200	0.301
logSdLogObs_0	-0.891	0.043	0.410	0.376	0.447
logSdLogObs_1	-0.038	0.140	0.963	0.727	1.274
logSdLogObs_2	-0.330	0.143	0.719	0.540	0.957
logSdLogObs_3	-0.359	0.140	0.698	0.528	0.923
logSdLogObs_4	-0.900	0.155	0.407	0.298	0.555
logSdLogObs_5	-0.885	0.146	0.413	0.308	0.552
logSdLogObs_6	-0.942	0.154	0.390	0.286	0.530
logSdLogObs_7	-0.780	0.162	0.458	0.331	0.634
logSdLogObs_8	-0.425	0.187	0.654	0.449	0.950
logSdLogObs_9	0.224	0.131	1.251	0.962	1.626
logSdLogObs_10	-0.009	0.124	0.991	0.773	1.269
logSdLogObs_11	-0.490	0.127	0.613	0.475	0.790
logSdLogObs_12	-0.920	0.132	0.399	0.306	0.519
logSdLogObs_13	-0.838	0.128	0.433	0.335	0.558
logSdLogObs_14	-0.812	0.141	0.444	0.335	0.589
logSdLogObs_15	-0.703	0.167	0.495	0.354	0.692
logSdLogObs_16	-0.038	0.143	0.963	0.723	1.283
transfIRARdist_0	-1.226	0.252	0.293	0.177	0.485

transfIRARdist_1	-0.722	0.211	0.486	0.319	0.740	
itrans_rho_0	1.333	0.144	3.792	2.842	5.058	
logPhiSW_0	5.311	1.095	202.460	22.669	1808.218	
logPhiSW_1	5.245	1.088	189.555	21.534	1668.538	
logSdProcLogSW_0		0.850	0.535	2.341	0.802	6.827
meanLogSW_0	0.269	0.087	1.308	1.099	1.557	
meanLogSW_1	0.565	0.085	1.760	1.485	2.085	
meanLogSW_2	0.823	0.083	2.278	1.929	2.691	
meanLogSW_3	1.075	0.082	2.931	2.488	3.454	
meanLogSW_4	1.325	0.081	3.762	3.198	4.425	
meanLogSW_5	1.543	0.081	4.680	3.982	5.500	
meanLogSW_6	1.707	0.081	5.515	4.693	6.480	
meanLogSW_7	1.840	0.081	6.295	5.354	7.401	
meanLogSW_8	1.959	0.082	7.089	6.022	8.347	
meanLogSW_9	2.043	0.083	7.712	6.537	9.099	
meanLogSW_10	2.098	0.084	8.150	6.889	9.643	
meanLogSW_11	2.192	0.086	8.953	7.540	10.632	
meanLogSW_12	2.306	0.088	10.031	8.409	11.965	
logSdLogSW_0	-3.107	0.173	0.045	0.032	0.063	
logPhiCW_0	5.311	1.095	202.460	22.669	1808.218	
logPhiCW_1	5.245	1.088	189.555	21.534	1668.538	
logSdProcLogCW_0		0.850	0.535	2.341	0.802	6.827
meanLogCW_0	0.269	0.087	1.308	1.099	1.557	
meanLogCW_1	0.565	0.085	1.760	1.485	2.085	
meanLogCW_2	0.823	0.083	2.278	1.929	2.691	
meanLogCW_3	1.075	0.082	2.931	2.488	3.454	
meanLogCW_4	1.325	0.081	3.762	3.198	4.425	
meanLogCW_5	1.543	0.081	4.680	3.982	5.500	
meanLogCW_6	1.707	0.081	5.515	4.693	6.480	
meanLogCW_7	1.840	0.081	6.295	5.354	7.401	
meanLogCW_8	1.959	0.082	7.089	6.022	8.347	
meanLogCW_9	2.043	0.083	7.712	6.537	9.099	
meanLogCW_10	2.098	0.084	8.150	6.889	9.643	
meanLogCW_11	2.192	0.086	8.953	7.540	10.632	
meanLogCW_12	2.306	0.088	10.031	8.409	11.965	
logSdLogCW_0	-3.107	0.173	0.045	0.032	0.063	

Table 6.5.1. Faroe saithe (Division 5.b). Estimated fishing mortality-at-age (1961–2022) 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	0.119	0.132	0.159	0.198	0.198	0.198	0.198	0.198
1962	0.034	0.072	0.112	0.133	0.145	0.139	0.156	0.191	0.239	0.239	0.239	0.239	0.239
1963	0.033	0.071	0.113	0.138	0.159	0.162	0.186	0.233	0.296	0.296	0.296	0.296	0.296
1964	0.042	0.094	0.149	0.178	0.202	0.202	0.221	0.264	0.318	0.318	0.318	0.318	0.318
1965	0.044	0.102	0.163	0.199	0.233	0.244	0.274	0.330	0.400	0.400	0.400	0.400	0.400
1966	0.042	0.103	0.165	0.200	0.236	0.253	0.283	0.337	0.394	0.394	0.394	0.394	0.394
1967	0.038	0.093	0.144	0.170	0.197	0.211	0.232	0.267	0.297	0.297	0.297	0.297	0.297
1968	0.041	0.103	0.152	0.172	0.193	0.209	0.233	0.271	0.302	0.302	0.302	0.302	0.302
1969	0.052	0.132	0.190	0.204	0.218	0.232	0.253	0.287	0.306	0.306	0.306	0.306	0.306
1970	0.061	0.149	0.202	0.201	0.200	0.201	0.209	0.228	0.233	0.233	0.233	0.233	0.233
1971	0.069	0.161	0.211	0.197	0.184	0.175	0.173	0.180	0.175	0.175	0.175	0.175	0.175
1972	0.085	0.201	0.272	0.265	0.251	0.241	0.239	0.242	0.225	0.225	0.225	0.225	0.225
1973	0.108	0.263	0.340	0.308	0.265	0.237	0.219	0.210	0.190	0.190	0.190	0.190	0.190
1974	0.119	0.290	0.357	0.310	0.252	0.219	0.198	0.189	0.177	0.177	0.177	0.177	0.177
1975	0.116	0.290	0.348	0.293	0.232	0.199	0.175	0.165	0.158	0.158	0.158	0.158	0.158
1976	0.109	0.283	0.335	0.286	0.227	0.197	0.171	0.155	0.148	0.148	0.148	0.148	0.148
1977	0.096	0.271	0.335	0.303	0.253	0.228	0.199	0.177	0.165	0.165	0.165	0.165	0.165
1978	0.072	0.219	0.284	0.277	0.254	0.250	0.232	0.210	0.198	0.198	0.198	0.198	0.198
1979	0.057	0.193	0.269	0.290	0.285	0.293	0.281	0.252	0.238	0.238	0.238	0.238	0.238
1980	0.050	0.181	0.261	0.303	0.309	0.325	0.317	0.279	0.270	0.270	0.270	0.270	0.270
1981	0.045	0.186	0.294	0.379	0.406	0.440	0.434	0.368	0.369	0.369	0.369	0.369	0.369
1982	0.041	0.185	0.305	0.403	0.427	0.462	0.457	0.376	0.399	0.399	0.399	0.399	0.399
1983	0.044	0.210	0.369	0.491	0.517	0.552	0.551	0.448	0.502	0.502	0.502	0.502	0.502
1984	0.041	0.213	0.390	0.515	0.524	0.534	0.522	0.428	0.490	0.490	0.490	0.490	0.490
1985	0.039	0.207	0.395	0.517	0.516	0.519	0.508	0.435	0.525	0.525	0.525	0.525	0.525
1986	0.037	0.205	0.429	0.599	0.604	0.628	0.628	0.551	0.653	0.653	0.653	0.653	0.653
1987	0.034	0.193	0.416	0.585	0.579	0.581	0.568	0.492	0.553	0.553	0.553	0.553	0.553
1988	0.029	0.169	0.376	0.534	0.521	0.498	0.456	0.377	0.393	0.393	0.393	0.393	0.393
1989	0.027	0.165	0.366	0.508	0.484	0.445	0.400	0.343	0.383	0.383	0.383	0.383	0.383
1990	0.032	0.203	0.460	0.629	0.590	0.519	0.467	0.434	0.535	0.535	0.535	0.535	0.535
1991	0.042	0.272	0.613	0.825	0.785	0.705	0.670	0.656	0.829	0.829	0.829	0.829	0.829
1992	0.039	0.241	0.536	0.715	0.700	0.647	0.645	0.672	0.877	0.877	0.877	0.877	0.877
1993	0.037	0.214	0.459	0.600	0.597	0.549	0.536	0.544	0.664	0.664	0.664	0.664	0.664
1994	0.033	0.186	0.399	0.535	0.563	0.528	0.505	0.494	0.550	0.550	0.550	0.550	0.550
1995	0.027	0.153	0.355	0.512	0.596	0.599	0.597	0.602	0.679	0.679	0.679	0.679	0.679
1996	0.019	0.106	0.252	0.386	0.479	0.500	0.494	0.490	0.533	0.533	0.533	0.533	0.533
1997	0.016	0.092	0.223	0.358	0.467	0.515	0.532	0.552	0.618	0.618	0.618	0.618	0.618
1998	0.014	0.085	0.211	0.345	0.469	0.546	0.585	0.616	0.699	0.699	0.699	0.699	0.699
1999	0.014	0.084	0.214	0.355	0.484	0.579	0.631	0.682	0.788	0.788	0.788	0.788	0.788

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
2000	0.014	0.088	0.229	0.375	0.493	0.564	0.586	0.611	0.679	0.679	0.679	0.679	0.679
2001	0.015	0.102	0.288	0.504	0.692	0.812	0.880	0.956	1.141	1.141	1.141	1.141	1.141
2002	0.012	0.088	0.258	0.453	0.617	0.718	0.755	0.803	0.970	0.970	0.970	0.970	0.970
2003	0.011	0.075	0.225	0.404	0.567	0.674	0.739	0.768	0.961	0.961	0.961	0.961	0.961
2004	0.011	0.077	0.225	0.402	0.579	0.723	0.846	0.886	1.175	1.175	1.175	1.175	1.175
2005	0.017	0.109	0.284	0.445	0.577	0.658	0.727	0.696	0.907	0.907	0.907	0.907	0.907
2006	0.028	0.168	0.385	0.543	0.650	0.717	0.796	0.771	0.992	0.992	0.992	0.992	0.992
2007	0.037	0.218	0.445	0.564	0.621	0.674	0.773	0.765	1.033	1.033	1.033	1.033	1.033
2008	0.052	0.293	0.550	0.628	0.626	0.631	0.718	0.716	0.976	0.976	0.976	0.976	0.976
2009	0.058	0.339	0.610	0.672	0.643	0.615	0.680	0.670	0.885	0.885	0.885	0.885	0.885
2010	0.066	0.382	0.666	0.734	0.681	0.644	0.690	0.684	0.890	0.890	0.890	0.890	0.890
2011	0.056	0.321	0.554	0.631	0.593	0.569	0.613	0.646	0.884	0.884	0.884	0.884	0.884
2012	0.057	0.335	0.563	0.654	0.640	0.623	0.674	0.744	1.076	1.076	1.076	1.076	1.076
2013	0.055	0.319	0.530	0.603	0.591	0.579	0.600	0.656	0.953	0.953	0.953	0.953	0.953
2014	0.054	0.305	0.508	0.594	0.579	0.567	0.536	0.529	0.652	0.652	0.652	0.652	0.652
2015	0.060	0.346	0.588	0.716	0.706	0.720	0.671	0.619	0.651	0.651	0.651	0.651	0.651
2016	0.056	0.321	0.541	0.641	0.611	0.593	0.524	0.428	0.340	0.340	0.340	0.340	0.340
2017	0.052	0.287	0.466	0.526	0.481	0.441	0.362	0.263	0.172	0.172	0.172	0.172	0.172
2018	0.054	0.296	0.453	0.496	0.454	0.411	0.346	0.254	0.152	0.152	0.152	0.152	0.152
2019	0.058	0.309	0.435	0.449	0.399	0.343	0.273	0.192	0.099	0.099	0.099	0.099	0.099
2020	0.050	0.279	0.379	0.366	0.311	0.261	0.195	0.131	0.062	0.062	0.062	0.062	0.062
2021	0.043	0.252	0.356	0.338	0.280	0.237	0.178	0.120	0.056	0.056	0.056	0.056	0.056
2022	0.034	0.207	0.314	0.321	0.275	0.242	0.186	0.127	0.059	0.059	0.059	0.059	0.059

Table 6.5.2. Faroe saithe (Division 5.b). Stock number-at-age (start of year) (Thousands) (1961–2022).

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1961	8713	7304	5761	3493	1939	1357	1023	684	317	119	60	6	289
1962	13775	6947	5749	4298	2420	1384	1012	732	497	224	71	48	197
1963	20537	9873	4923	4145	3076	1653	1054	735	498	372	176	41	143
1964	16905	17869	8437	3786	3082	2154	1152	748	472	330	207	113	95
1965	20820	12015	13271	5886	2638	2067	1361	798	501	295	212	116	130
1966	15869	16401	8690	9402	3908	1726	1329	792	498	289	152	111	133
1967	20186	12301	11936	5899	6232	2435	1080	827	434	287	162	75	120
1968	20780	17333	9808	8528	4063	3910	1492	673	509	251	175	100	137
1969	33665	16367	13485	7696	6168	2904	2444	929	423	337	145	107	126
1970	30435	31708	11248	9346	5551	4234	1944	1384	524	245	206	83	130
1971	33483	23681	22667	7694	6509	4044	2915	1357	823	328	151	128	125
1972	33815	22902	16461	13424	5721	4921	3279	2264	1054	550	209	120	164
1973	26475	25752	18020	11493	7635	3645	3146	2105	1363	646	317	142	211
1974	23427	18926	15592	10688	7139	4326	2363	2074	1339	864	408	243	275
1975	19343	15009	11486	8785	6371	4748	2748	1620	1386	882	560	290	395
1976	21361	13095	8173	6097	5367	4312	3436	2021	1213	939	577	391	494
1977	14742	14372	7260	4586	3568	3661	3120	2601	1612	948	692	408	576
1978	9153	10130	8389	3718	2504	2115	2458	2276	2049	1186	732	535	679
1979	7949	6453	6243	4980	2330	1607	1205	1640	1536	1472	819	510	973
1980	14695	6113	4176	3658	3044	1396	954	687	945	931	1140	573	1069
1981	18182	10476	4226	2707	2272	1836	869	575	376	542	599	836	1199
1982	14340	18785	6267	2846	1462	1154	902	451	310	198	300	343	1339
1983	38299	10271	14898	3860	1568	809	541	439	267	165	103	201	877
1984	20856	32671	7361	9191	1987	772	384	211	248	138	66	56	521

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
1985	26092	18508	18560	4274	4576	932	383	180	102	150	68	29	305
1986	41356	17767	12780	8755	2424	2180	478	218	107	52	80	27	152
1987	41650	37211	11852	6832	3330	1285	882	206	110	45	20	31	73
1988	37932	30921	28895	6311	3120	1441	690	385	98	55	33	8	30
1989	24351	33341	23081	17728	2827	1458	632	357	179	53	23	24	30
1990	18121	20826	23298	15175	9190	1443	700	309	217	81	34	15	39
1991	24074	15932	14426	11067	6760	3941	740	417	174	122	38	16	24
1992	19110	19674	9563	6153	3689	2547	1569	304	188	58	48	13	14
1993	25097	15117	12910	4393	2435	1505	1190	690	129	80	18	14	7
1994	15613	19012	10095	6629	1951	1145	759	624	345	56	43	6	7
1995	17910	10353	10178	6559	3102	870	586	396	294	164	25	25	7
1996	15480	16549	6601	4641	2989	1215	414	244	192	126	69	8	15
1997	22413	12346	14432	4522	3152	1661	526	194	103	104	63	33	13
1998	13910	19820	11239	13378	3250	1565	837	224	89	45	50	28	18
1999	30259	9978	17658	8759	11514	1812	764	353	87	39	16	22	19
2000	38981	33675	7146	14832	6213	7008	774	359	132	35	14	6	11
2001	80739	28262	33067	5043	8246	3197	2706	415	152	50	15	8	7
2002	48695	77202	21397	24571	2327	2859	1292	779	121	38	13	3	4
2003	46349	51090	56130	12319	10829	1106	882	590	247	45	10	4	2
2004	21098	42435	55187	39200	6149	3812	389	405	222	78	15	3	2
2005	40197	25782	32442	45605	17442	2481	1279	148	133	55	16	4	1
2006	32538	41003	24664	19953	23379	8021	971	502	63	38	18	6	2
2007	24911	18824	37079	15240	9813	8565	3019	551	142	21	12	5	2
2008	41837	17252	9750	22454	8007	5571	3954	1106	239	31	7	4	2
2009	16167	22462	11435	4376	9796	4389	3257	1763	461	79	8	2	2
2010	25235	10874	12679	2995	2379	4147	2463	1379	807	152	28	3	1

Year Age	3	4	5	6	7	8	9	10	11	12	13	14	15
2011	40021	16474	5338	4252	1344	1058	1830	1064	573	309	58	9	1
2012	23359	27980	11710	2564	1631	724	615	803	438	171	127	22	3
2013	14100	19630	12463	6728	1167	749	332	298	294	123	38	40	7
2014	16493	11461	10767	4844	2547	564	379	214	151	92	37	8	15
2015	41595	9978	7931	4905	2118	858	322	218	127	75	34	15	10
2016	22574	41230	4823	3819	1610	852	279	133	140	62	37	10	8
2017	11232	19853	23814	2272	1529	914	359	144	42	85	50	20	9
2018	7051	7985	13198	11397	1115	736	362	213	102	32	65	35	21
2019	26764	4499	4975	6811	4178	743	456	193	112	68	25	45	39
2020	8594	19639	2318	3291	3799	1568	512	354	85	81	54	18	60
2021	17110	5208	9135	1419	1996	2305	893	507	201	74	60	40	58
2022	4111	15099	2923	3500	967	1278	1363	705	415	188	48	45	68

Table 6.5.3. Faroe saithe (Division 5.b). Summary table (1961–2022).

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4-8)	Low	High	TSB	Low	High
1961	8713	4724	16072	63990	48596	84260	0.105	0.070	0.157	100369	75744	133001
1962	13775	7806	24308	69108	53106	89932	0.120	0.083	0.174	109630	83753	143501
1963	20537	11726	35968	76995	60002	98800	0.129	0.090	0.184	129938	99665	169407
1964	16905	9722	29397	88074	69062	112321	0.165	0.117	0.232	150935	115510	197224
1965	20820	11978	36187	98171	76433	126093	0.188	0.134	0.265	163333	125233	213024
1966	15869	9105	27655	102756	79088	133506	0.191	0.135	0.270	166483	127249	217815
1967	20186	11634	35025	99328	75788	130181	0.163	0.115	0.231	159765	121865	209453
1968	20780	12063	35796	101242	77500	132257	0.166	0.117	0.235	164764	126201	215111
1969	33665	19671	57614	107803	82737	140462	0.195	0.138	0.275	185915	142583	242416
1970	30435	17944	51622	113934	87417	148496	0.191	0.135	0.268	201489	154741	262361
1971	33483	19897	56347	126476	97321	164365	0.186	0.133	0.260	210775	163717	271359
1972	33815	20219	56555	145450	113066	187109	0.246	0.177	0.341	229156	180670	290655
1973	26475	15878	44144	161788	126263	207309	0.283	0.205	0.390	251922	200043	317254
1974	23427	13987	39241	156288	122135	199992	0.286	0.207	0.394	240735	191884	302022
1975	19343	11537	32429	155835	121932	199164	0.272	0.197	0.376	222775	178232	278450
1976	21361	12685	35971	138908	109534	176160	0.266	0.192	0.367	197347	158921	245064
1977	14742	8757	24817	129160	103156	161719	0.278	0.201	0.384	178296	144776	219578
1978	9153	5433	15419	115851	93762	143143	0.257	0.187	0.352	159609	130259	195571
1979	7949	4704	13433	104303	84954	128059	0.266	0.196	0.362	134614	110884	163423
1980	14695	8730	24733	98236	80616	119707	0.276	0.205	0.371	135365	112011	163590
1981	18182	10765	30710	82449	68251	99600	0.341	0.256	0.454	130073	106709	158553
1982	14340	8486	24232	75953	62983	91594	0.356	0.270	0.471	131195	105800	162685
1983	38299	22556	65030	78120	63399	96259	0.428	0.327	0.560	161841	126583	206920
1984	20856	12390	35106	87378	69513	109834	0.435	0.333	0.568	177392	137403	229018
1985	26092	15566	43735	94829	75342	119356	0.431	0.331	0.562	184786	145101	235325
1986	41356	24550	69665	88190	70661	110068	0.493	0.379	0.642	197464	152151	256271
1987	41650	24754	70079	85704	68709	106903	0.471	0.361	0.614	214012	162309	282186
1988	37932	22520	63889	94929	74729	120590	0.420	0.318	0.553	218996	167379	286530
1989	24351	14506	40876	103850	81332	132604	0.394	0.299	0.518	201833	157052	259381
1990	18121	10826	30330	100512	79620	126887	0.480	0.371	0.622	173012	137761	217283
1991	24074	14472	40045	82922	66906	102773	0.640	0.498	0.823	148213	119532	183777
1992	19110	11510	31727	65057	53230	79511	0.568	0.441	0.731	126190	101219	157321
1993	25097	15106	41695	62873	51424	76870	0.484	0.374	0.626	134389	106364	169799
1994	15613	9503	25651	61035	50325	74025	0.442	0.341	0.574	127970	101692	161038
1995	17910	10835	29603	59498	48865	72444	0.443	0.339	0.579	117110	93400	146840
1996	15480	9494	25238	49774	40804	60715	0.345	0.262	0.453	108497	84751	138897
1997	22413	13822	36344	55408	45079	68103	0.331	0.254	0.431	123336	95987	158477
1998	13910	8567	22583	64602	52653	79264	0.331	0.255	0.430	132804	105559	167079

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4-8)	Low	High	TSB	Low	High
1999	30259	18360	49868	78384	63868	96201	0.343	0.265	0.445	161572	128536	203097
2000	38981	24137	62952	90280	74350	109623	0.350	0.269	0.455	210745	166444	266839
2001	80739	50047	130253	95889	78778	116717	0.480	0.370	0.621	275678	211863	358715
2002	48695	29657	79956	99324	80948	121872	0.427	0.327	0.557	282293	217980	365582
2003	46349	28562	75213	107388	86049	134020	0.389	0.296	0.512	275077	213846	353841
2004	21098	12642	35211	116685	93729	145262	0.401	0.308	0.523	265308	210062	335084
2005	40197	25089	64404	112834	91369	139343	0.415	0.319	0.539	257249	207426	319039
2006	32538	20485	51684	105229	86337	128254	0.493	0.385	0.631	234553	191262	287643
2007	24911	15834	39194	91449	75701	110474	0.504	0.397	0.641	192950	158511	234871
2008	41837	25866	67671	82974	68982	99805	0.546	0.430	0.692	182158	148679	223176
2009	16167	10252	25497	74783	62404	89617	0.576	0.452	0.733	142758	118138	172510
2010	25235	16132	39476	59259	49600	70799	0.621	0.486	0.795	130137	106289	159336
2011	40021	25300	63306	45243	38226	53549	0.534	0.417	0.683	124013	98266	156506
2012	23359	14894	36637	40470	33966	48221	0.563	0.443	0.717	110623	87991	139076
2013	14100	8986	22126	37628	31076	45563	0.524	0.407	0.674	97404	77941	121728
2014	16493	10471	25977	41940	34424	51097	0.511	0.393	0.664	95393	76499	118954
2015	41595	26302	65782	40799	33469	49735	0.615	0.473	0.801	106151	83198	135435
2016	22574	14311	35609	41789	33554	52045	0.541	0.411	0.713	113113	86689	147591
2017	11232	7050	17896	51343	40100	65737	0.440	0.327	0.592	111148	85995	143659
2018	7051	4341	11453	52319	40762	67153	0.422	0.309	0.576	94872	74171	121349
2019	26764	15732	45532	48713	37322	63581	0.387	0.277	0.541	98652	73627	132184
2020	8594	4785	15434	49934	37021	67351	0.319	0.218	0.468	93401	67976	128335
2021	17110	8270	35397	52421	36958	74353	0.292	0.184	0.464	92011	62361	135759
2022	4111	1515	11150	51258	33064	79463	0.272	0.152	0.486	81837	49727	134680

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
2022	0.278	0.156	0.463	4107	1636	11355	52997	36387	80869	14173	9905	19895	83461	55675	137859
2023	0.380	0.212	0.632	11232	7051	26764	54411	32955	96536	17843	11578	29311	88325	54503	154444
2024	0.380	0.212	0.632	11232	7051	26764	53319	28085	104557	17230	10978	29885	89888	53647	160029
2025	0.380	0.212	0.632	11232	7051	26764	52665	27369	108627	17890	10734	32954	95143	56643	171991

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

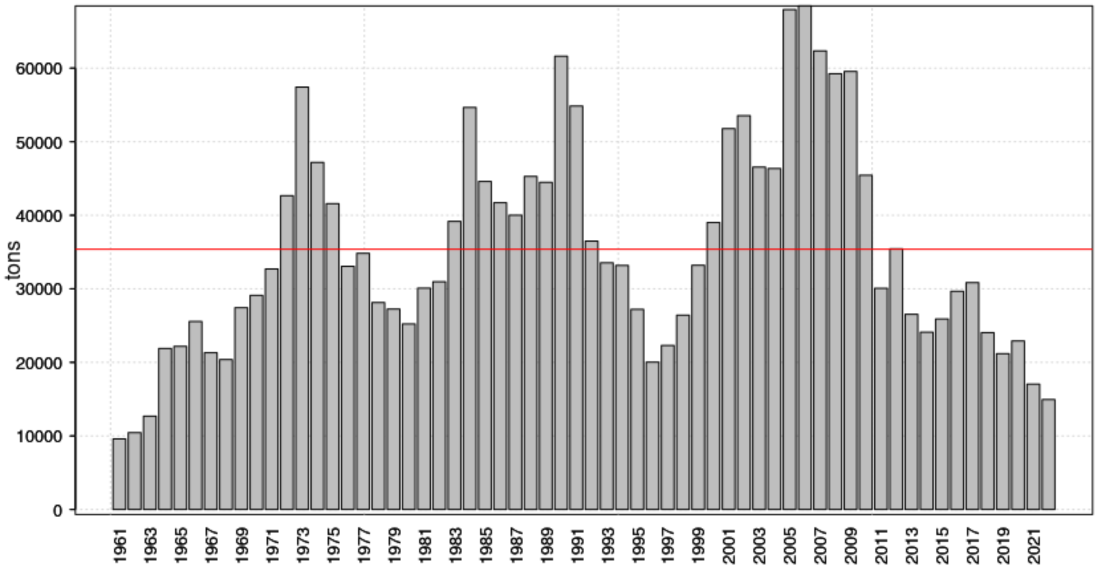


Figure 6.2.1.1. Faroe saithe (Division 5.b). Landings (tonnes) (1961–2022). Horizontal red line represents average landings. Landings in 2022 are estimated from January to September and extrapolated to total at the end of the year

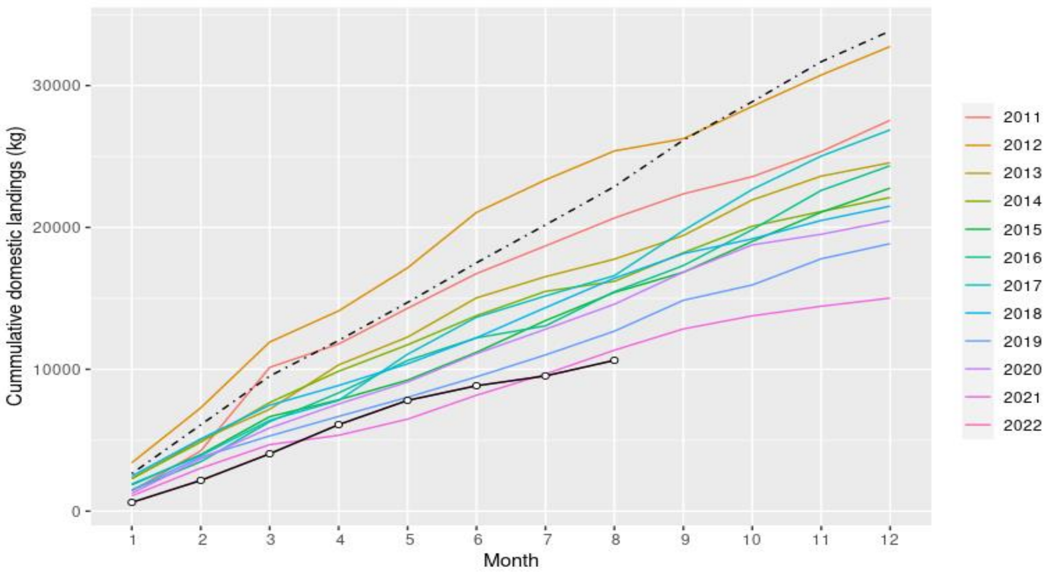


Figure 6.2.1.2. Saithe in the Faroes (Division 5.b). Cumulative domestic landings (2011–2021). Black line shows the first eight months of 2022.

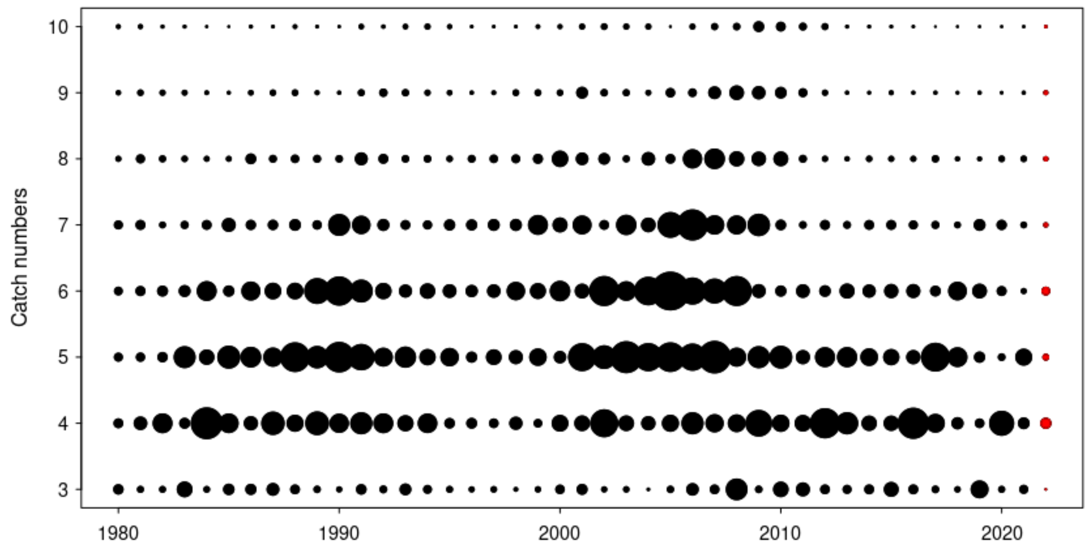


Figure 6.2.2.2. Faroe saithe (Division 5.b). Cath-at-age numbers in the commercial catches (ages 3–10) (1961–2022). Catch-at-age for 2022 are interim data.

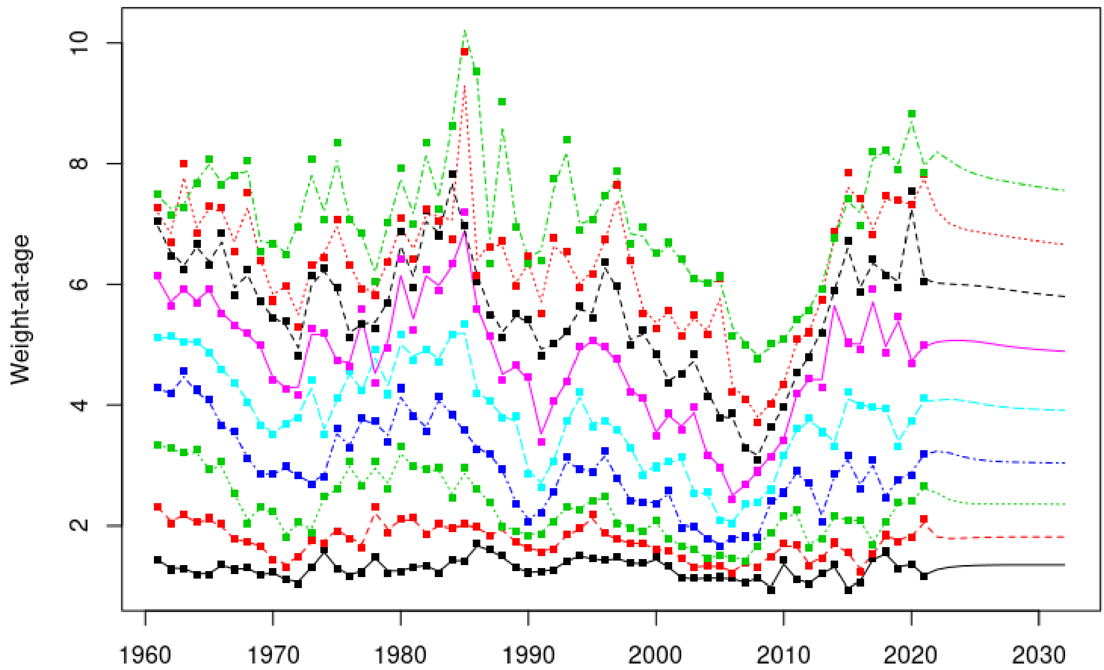


Figure 6.2.3.1.a Faroe saithe (Division 5.b). Observed (points) and predicted (line) mean weight at age (kg) in commercial catches (ages 3–11) (1961–2021). Values for 2022 and onwards are estimates.

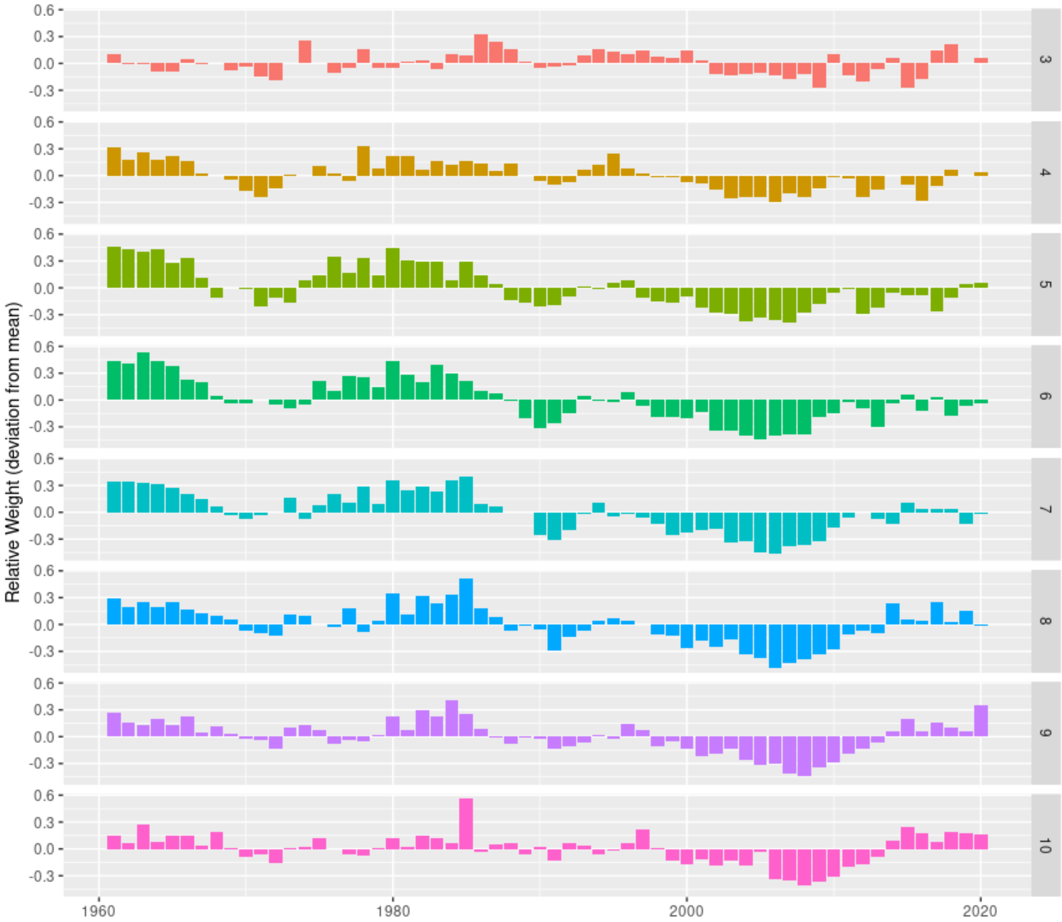


Figure 6.2.3.1.b Faroe saithe (Division 5.b). Deviations of mean weight at age (kg) from historical average in commercial catches (ages 3–10) (1961–2021). Weights in 2021 are estimated.

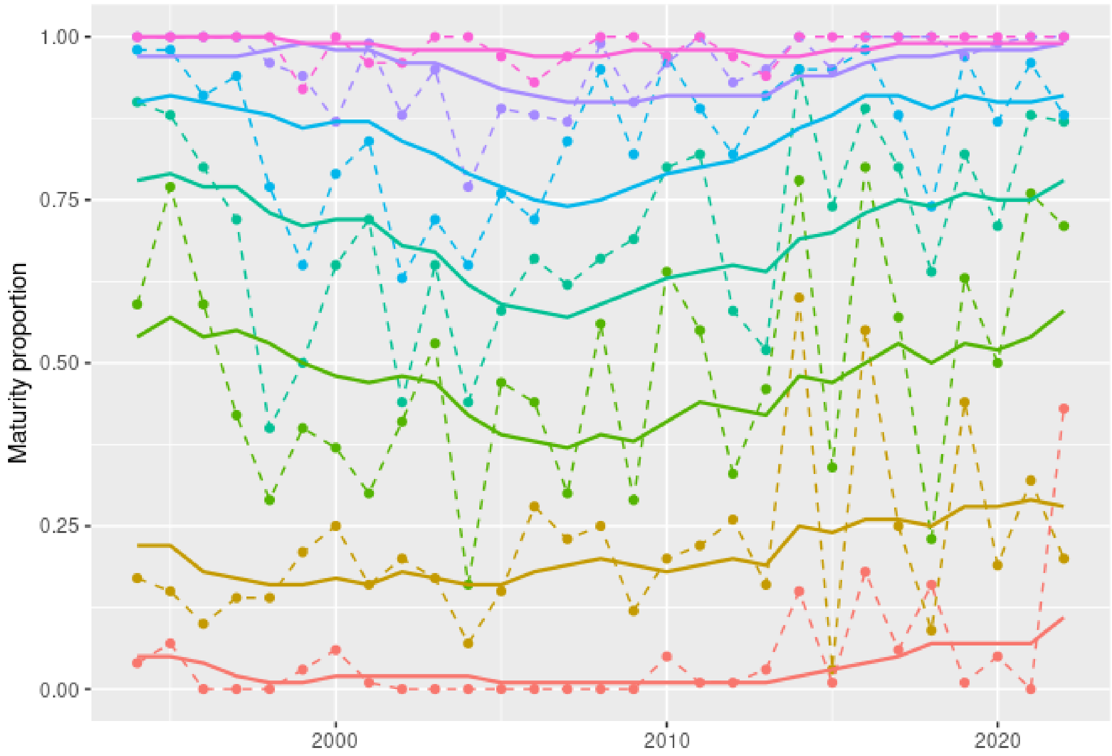


Figure 6.2.4.1. Faroe saithe (Division 5.b). Observed and smoothed maturity ogives (ages 3–9) (1994–2022) from FGFS1 (spring survey).

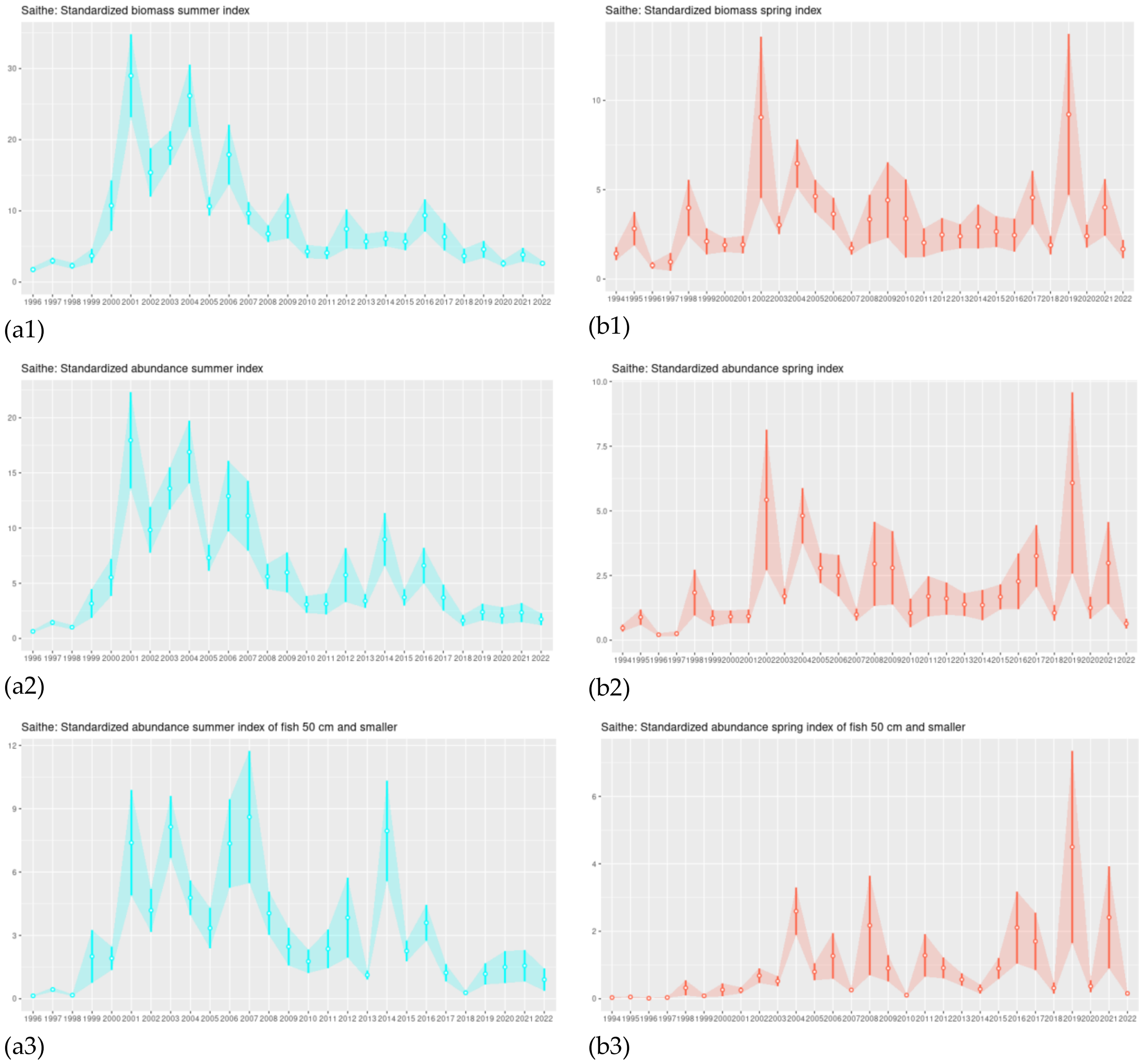


Figure 6.2.5.1.1. Faroe saithe (Division 5.b). Standardised biomass (a1) (b1) and abundance (a2)(b2) indices from the Faroese bottom-trawl summer FGFS1 (1996–2022) and spring surveys FGFS2 (1994–2022). Abundance indices of fish 50 cm and smaller are proxies for recruitment strength (a3) (b3). Shade areas show standard errors in the estimation of indices.

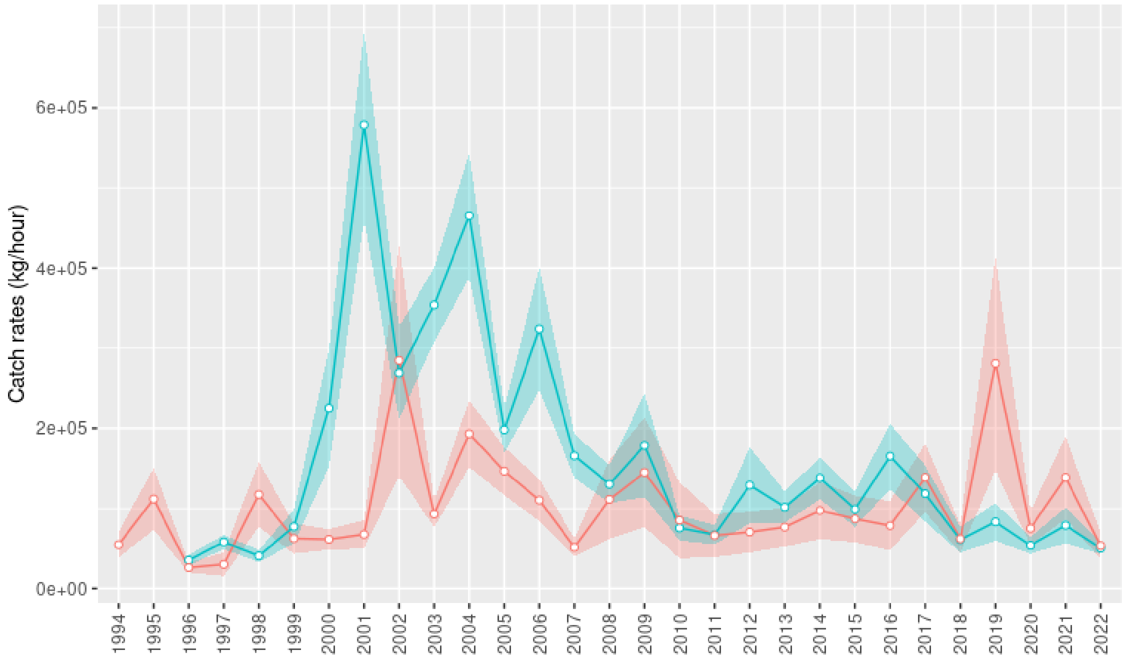


Figure 6.2.5.1.2. Faroe saithe (Division 5.b). Catch rates (kg/hour) from the Faroese bottom-trawl spring FGFS1 (1994–2022) (red line) and summer survey FGFS2 (1996–2022) (cyan line). Shade areas show standard errors in the estimation of indices.

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.

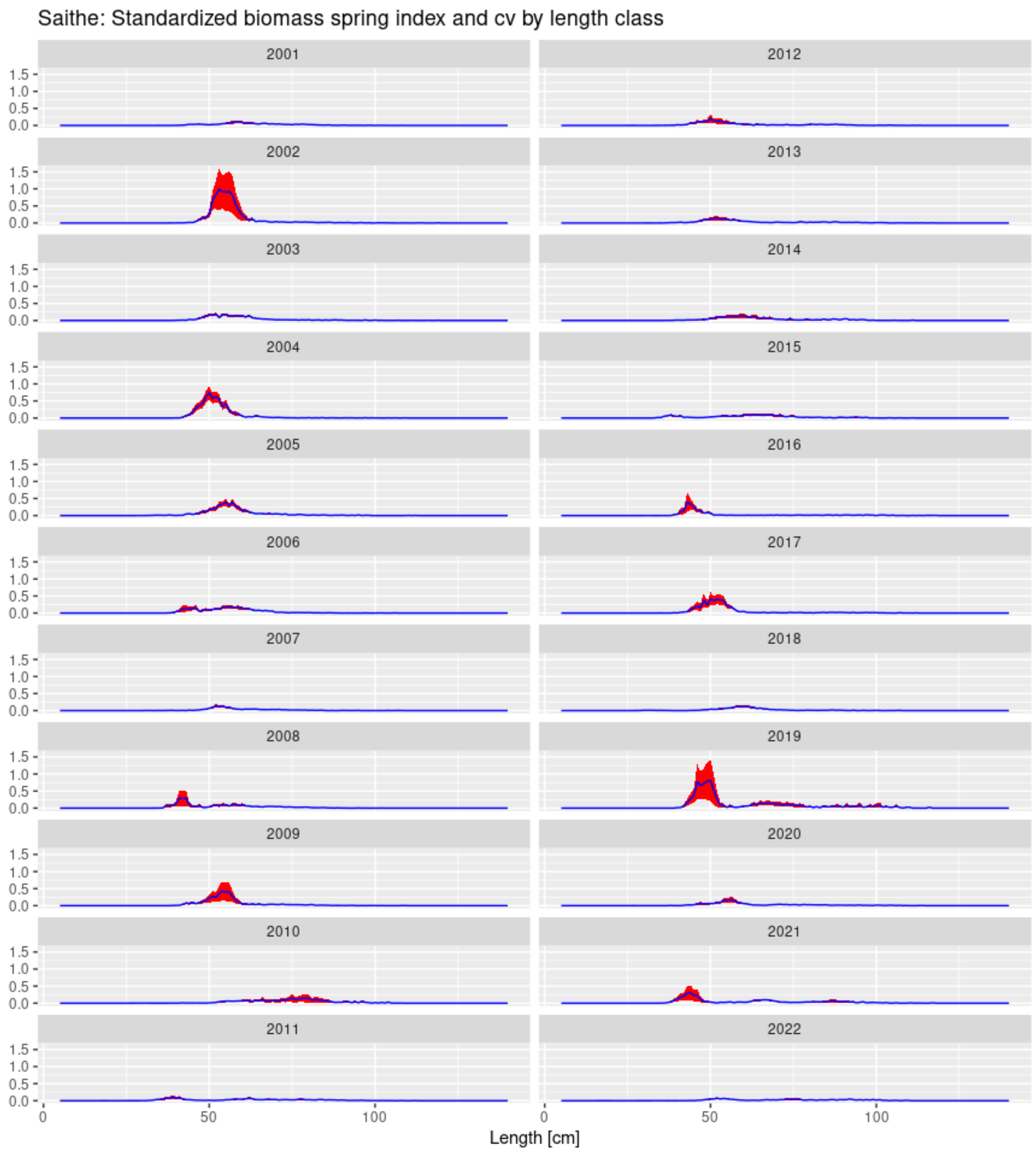


Figure 6.2.5.1.4. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl spring survey FGFS1 (2001–2022).

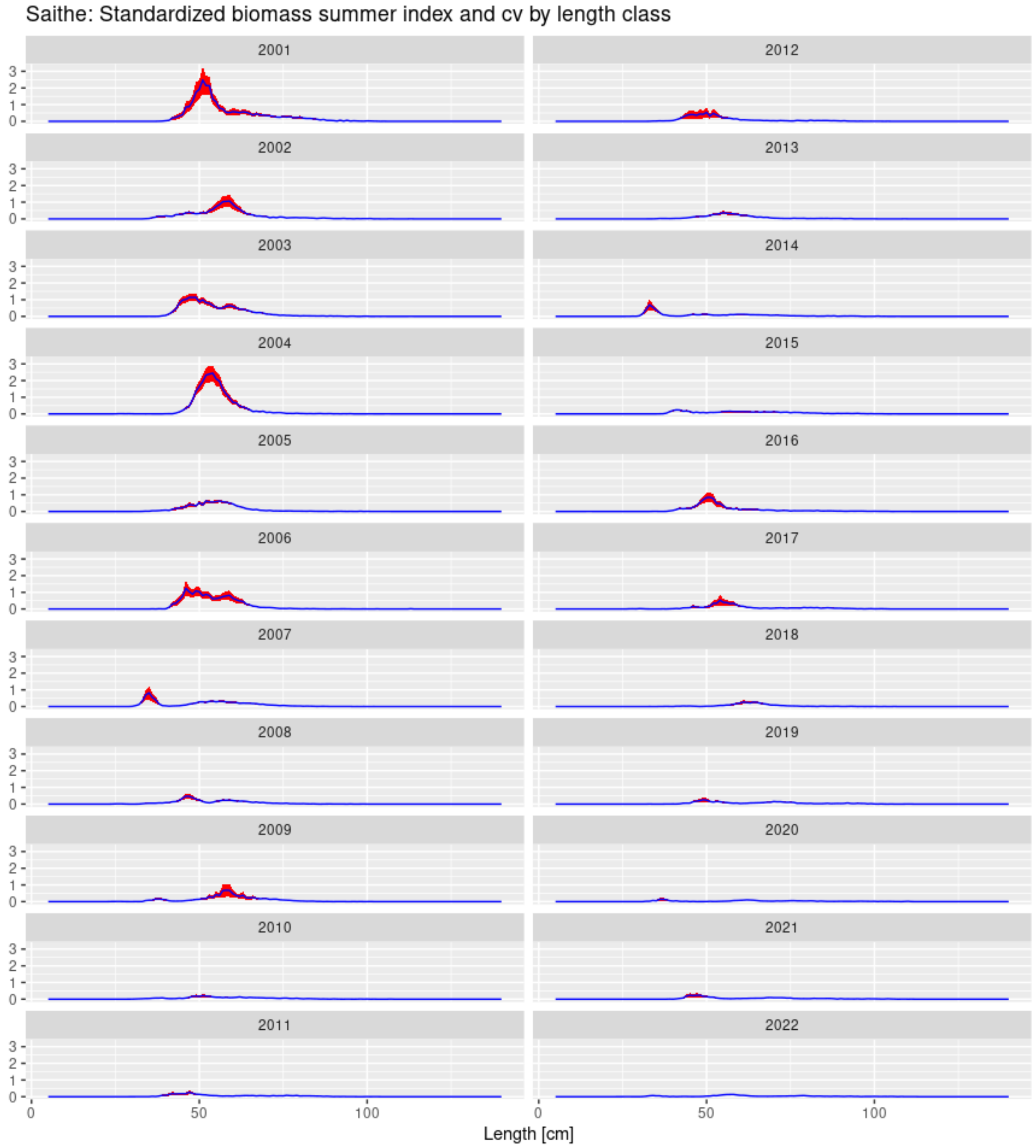


Figure 6.2.5.1.5. Faroe saithe (Division 5.b). Length composition from the Faroese bottom-trawl summer survey FGFS2 (2000–2022).

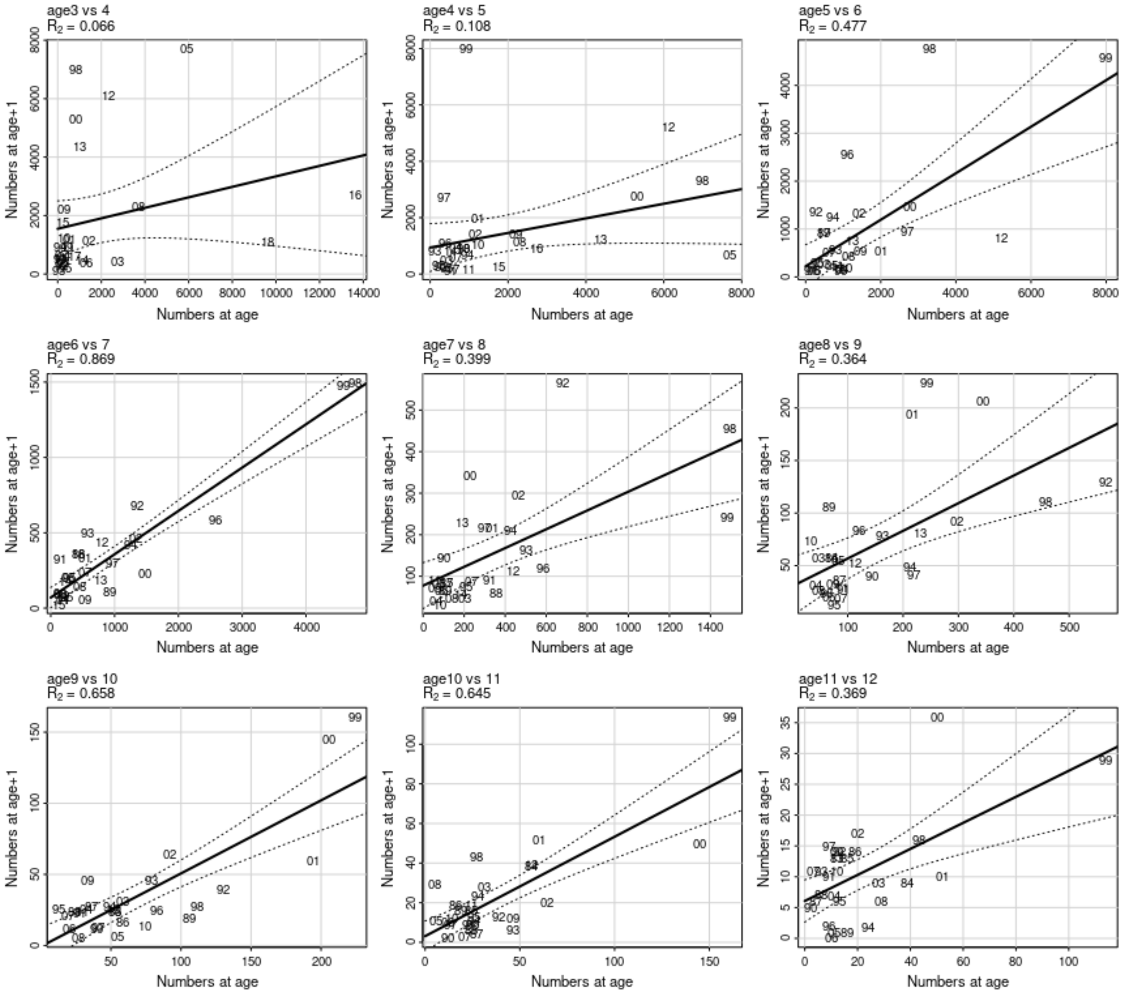


Figure 6.2.5.1.6. Faroe saithe (Division 5.b). Numbers from spring survey (FGFS1) plotted against numbers of the same year class one year later. Letters in the figures represent year classes. Horizontal and vertical lines crossing is the most recent pair.

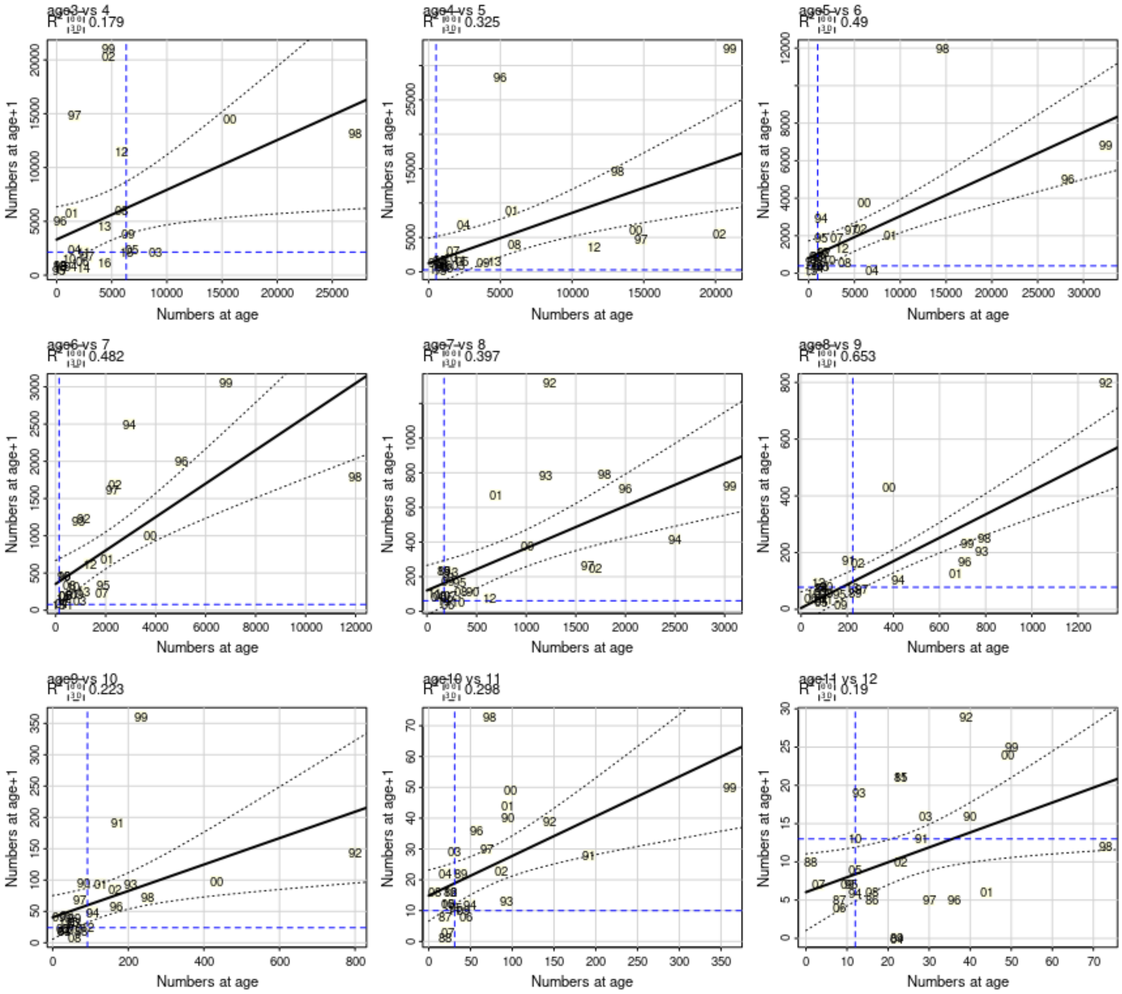


Figure 6.2.5.1.7. Faroe saithe (Division 5.b). Numbers from summer survey (FGFS2) plotted against numbers of the same year class one year later. Letters in the figures represent year classes. Horizontal and vertical lines crossing is the most recent pair.

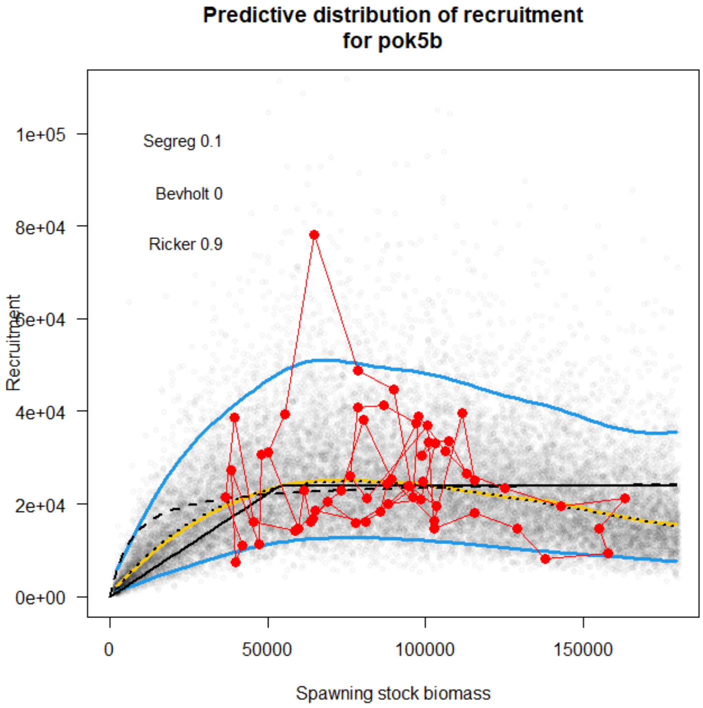


Figure 6.4.1.1. Faroe saithe (Division 5.b). EqSim simulations. Stock–recruitment functions used in the simulations (Ricker, Beverton-Holt and Segmented).

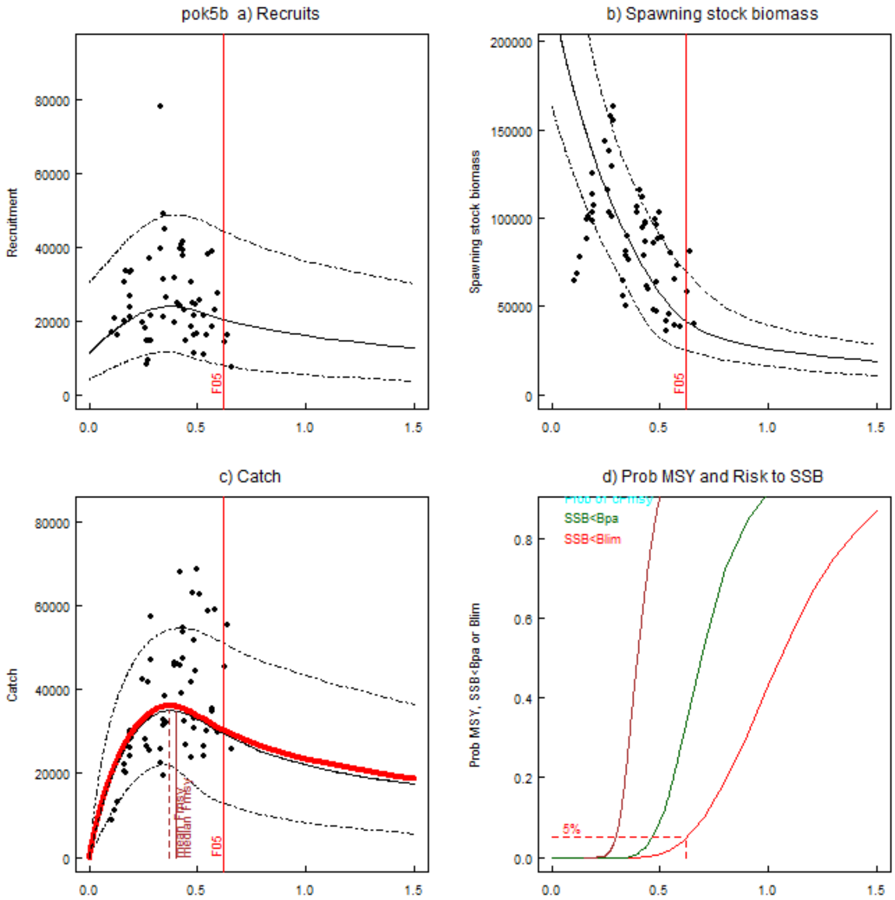


Figure 6.4.1.2. Faroe saithe (Division 5.b). EqSim simulation results. F_{MSY} = 0.38 is the vertical red line in the bottom-left graph.

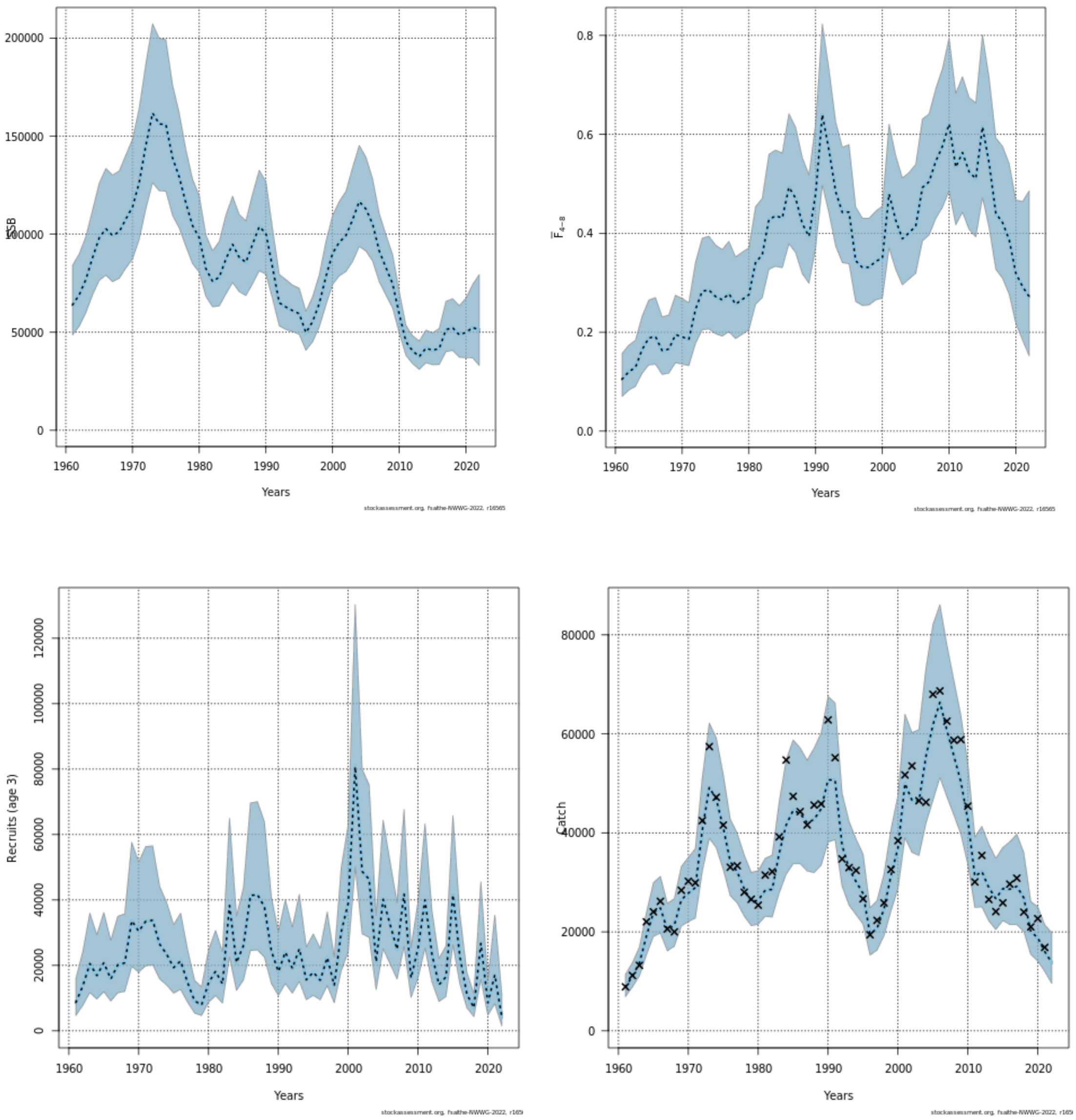


Figure 6.5.1. Faroe saithe (Division 5.b). Spawning-stock biomass (tonnes) (top-left), recruitment (age 3) in millions (bottom-left), F_{bar} (ages 4 to 8) (top-right) and landings (tonnes) (bottom-right) from the SAM assessment. Reference points ($B_{trigger} = B_{pa}$ = 36 412 t and F_{MSY} = 0.38 respectively).

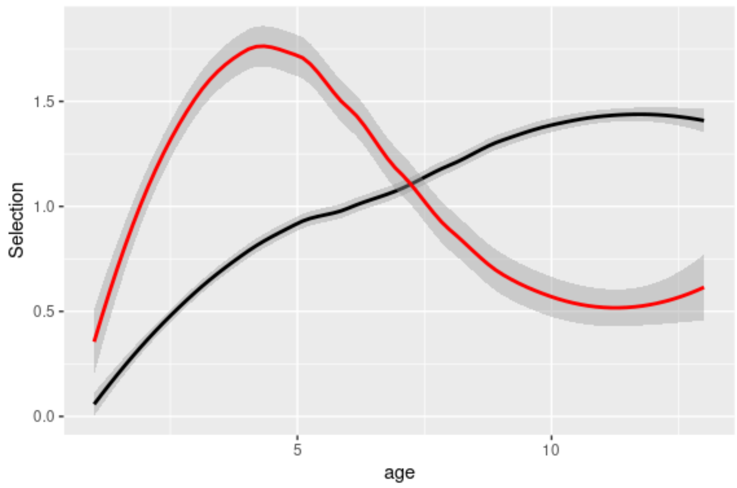


Figure 6.5.1.a Faroe saithe (Division 5.b). Selection pattern by periods in the fishery. Average selection from 2000 to 2014 (black line) and from 2015 to 2022 (red line).

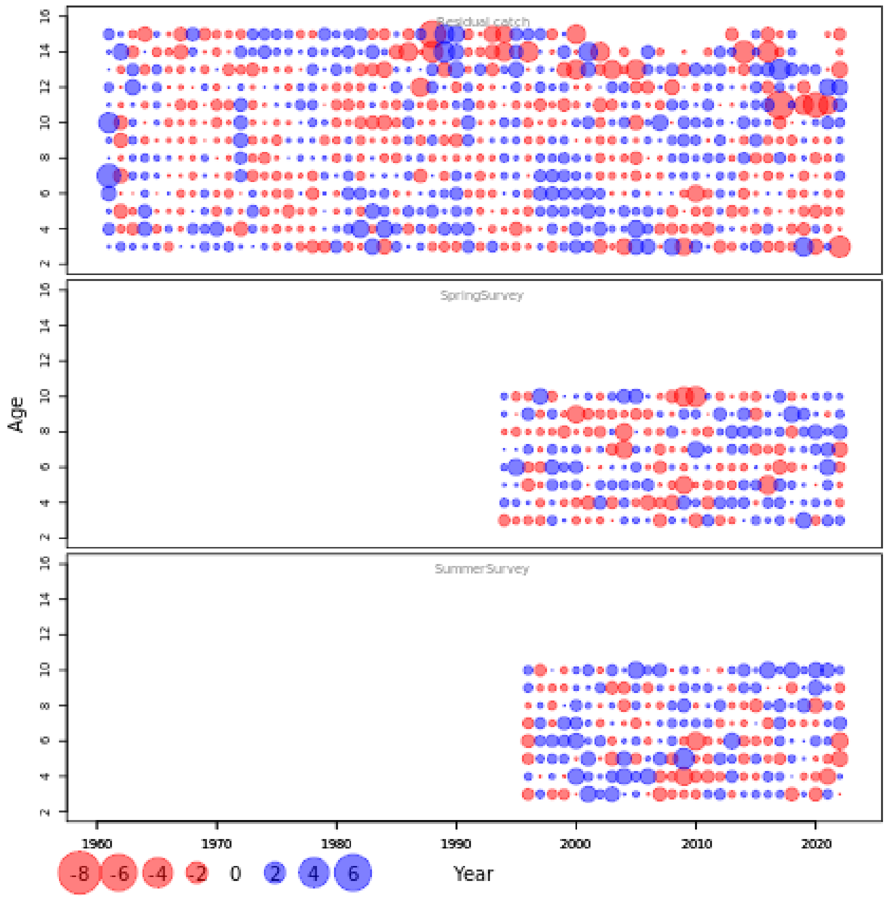


Figure 6.5.2. Faroe saithe (Division 5.b). Residuals of the SAM assessment calibrated with both survey indices. Blue and red bubbles represent positive and negative residuals respectively.

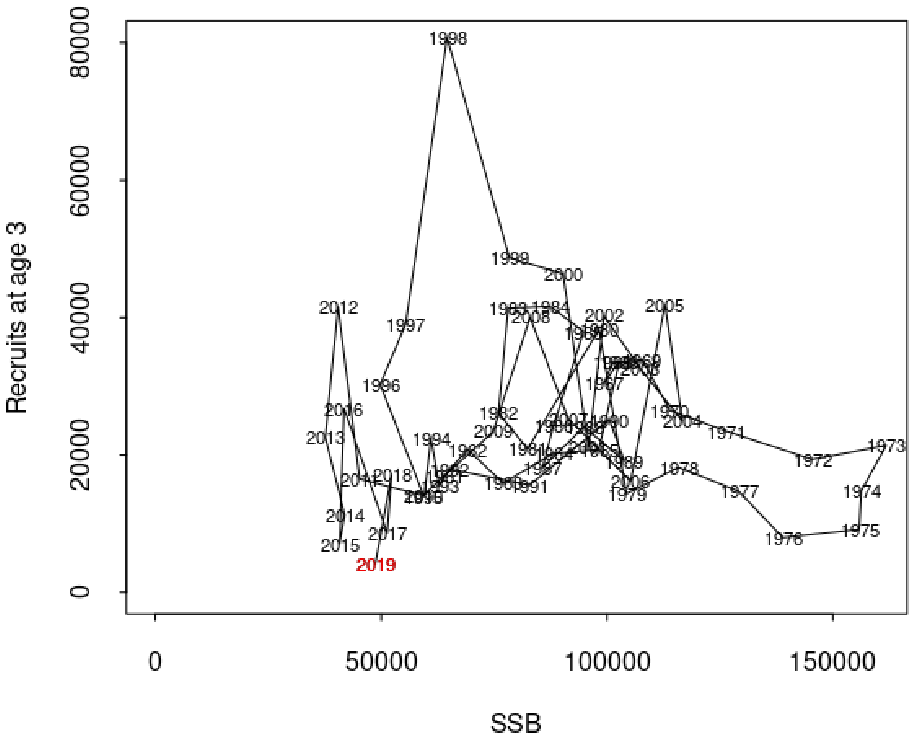


Figure 6.5.3. Faroe saithe (Division 5.b). Relation between SSB and recruitment (age 3). Numbers represent year-classes. The most recent year-class (2019) is highlighted in red.

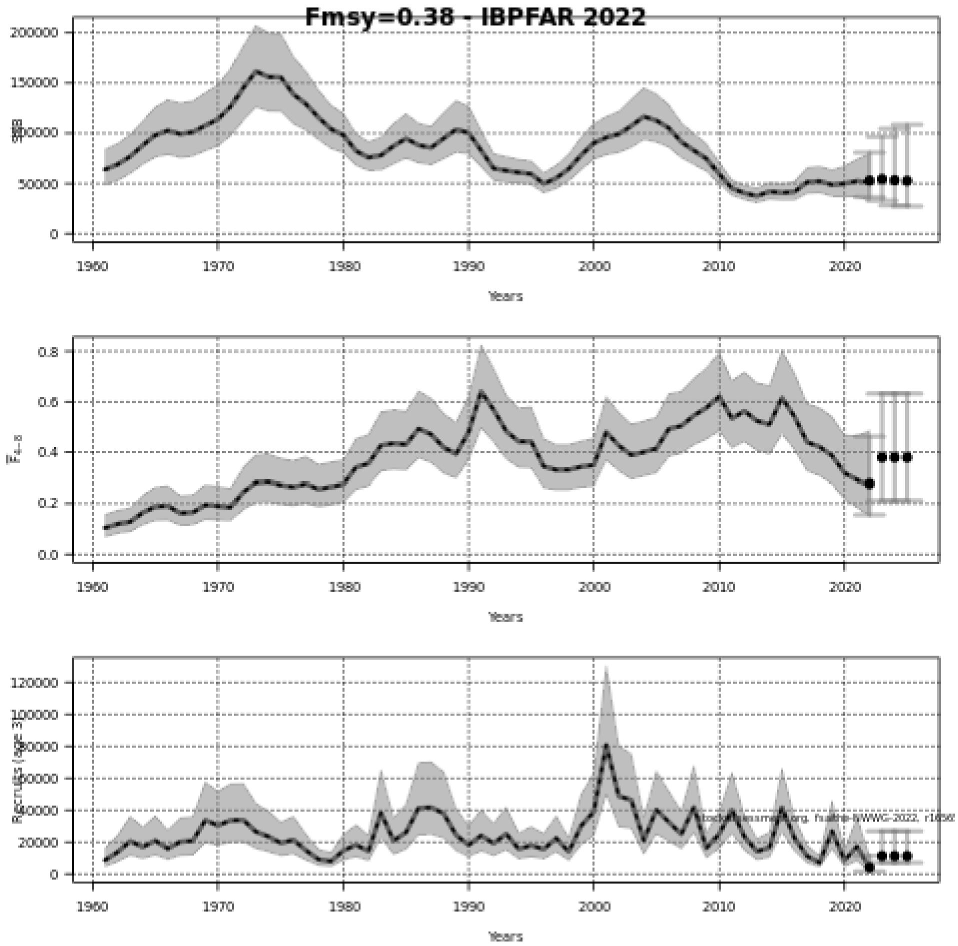


Figure 6.6.2.1. Faroe saithe (Division 5.b). Short-term forecast based on the F_{MSY} advice including historical assessment. Spawning stock biomass (top, red line represents $B_{trigger}$), average fishing mortality (F_{4-8}) (middle) and recruitment (numbers age 3, bottom).

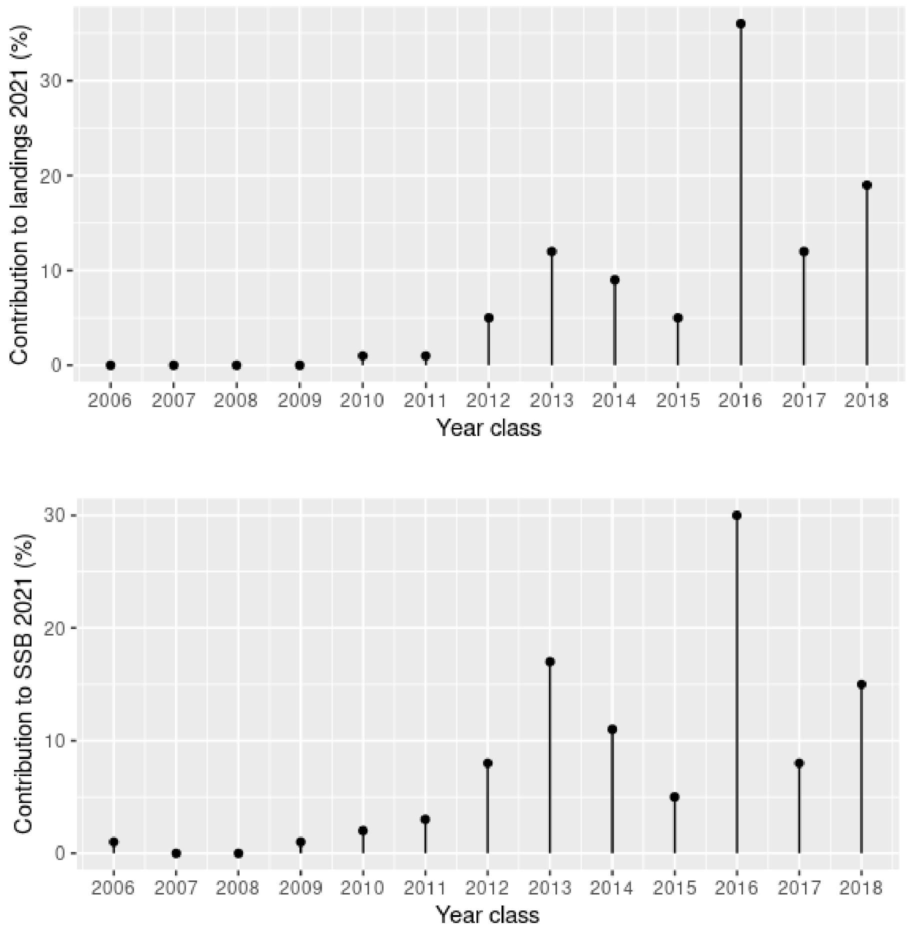


Figure 6.6.2.2. Faroe saithe (Division 5.b). Contribution of year classes to landings (top) and spawning stock biomass (bottom) in 2021.

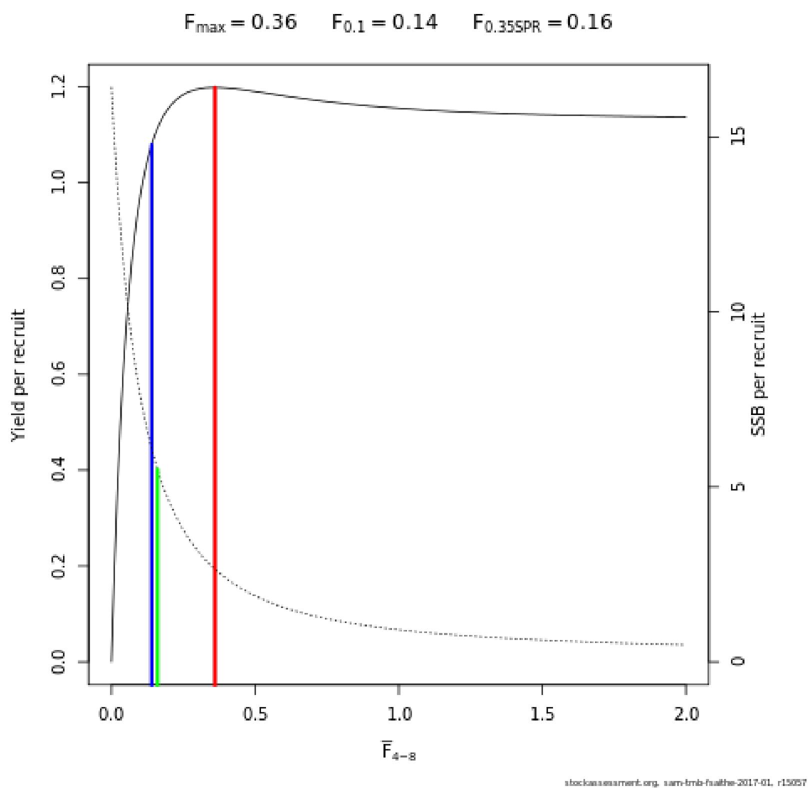


Figure 6.7.1. Faroe saithe (Division 5.b). Yield-per-recruit analysis.

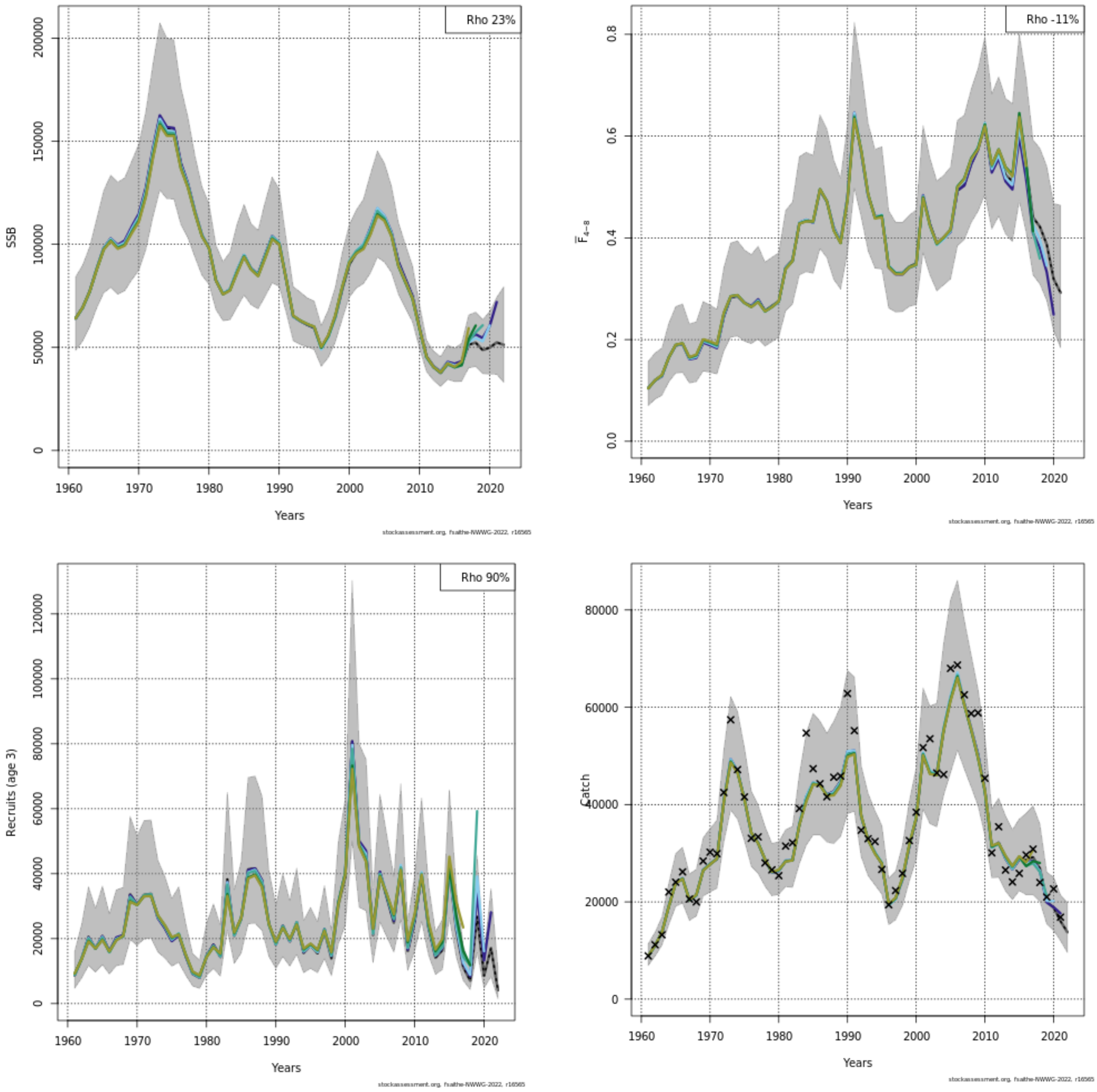


Figure 6.8.1. Faroe saithe (Division 5.b). Retrospective analysis of spawning-stock biomass (tonnes)(top-left), average fishing mortality over age groups 4–8 (top-right), recruitment-at-age 3 ('000) (bottom-left) and total landings (tons)(bottom-right) from the SAM assessment.

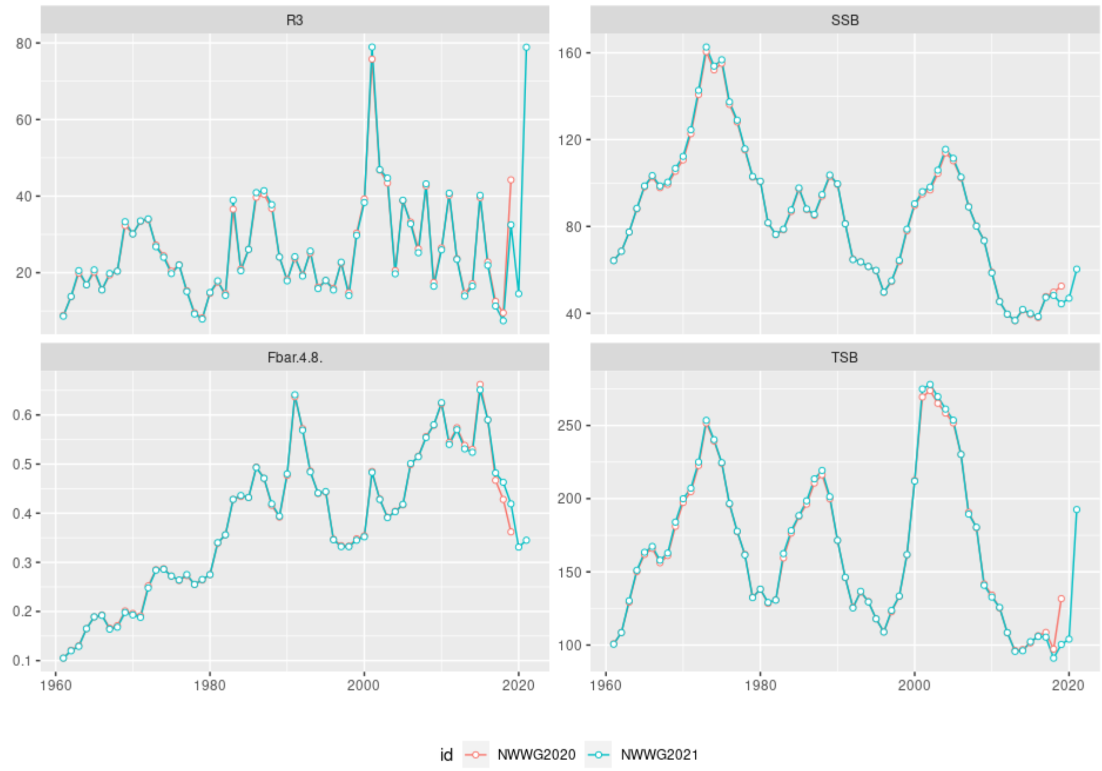


Figure 6.9.1. Faroe saithe (Division 5.b). Comparison with previous assessment. Recruitment-at-age 3 ('000) (top-left), spawning-stock biomass (tonnes)(top-right), average fishing mortality over age groups 4–8 (bottom-left) and total biomass (tonnes) (bottom-right) from the 2020 (red) and 2021 (cyan)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

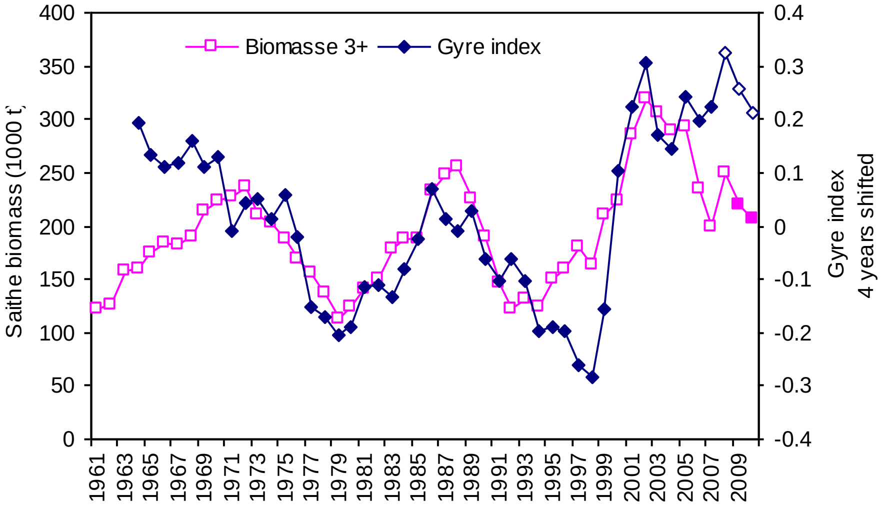


Figure 6.15.1. Faroe saithe (Division 5.b). Relationship between the Gyre index (4 years shifted) and saithe biomass (age 3+) in Faroese waters.

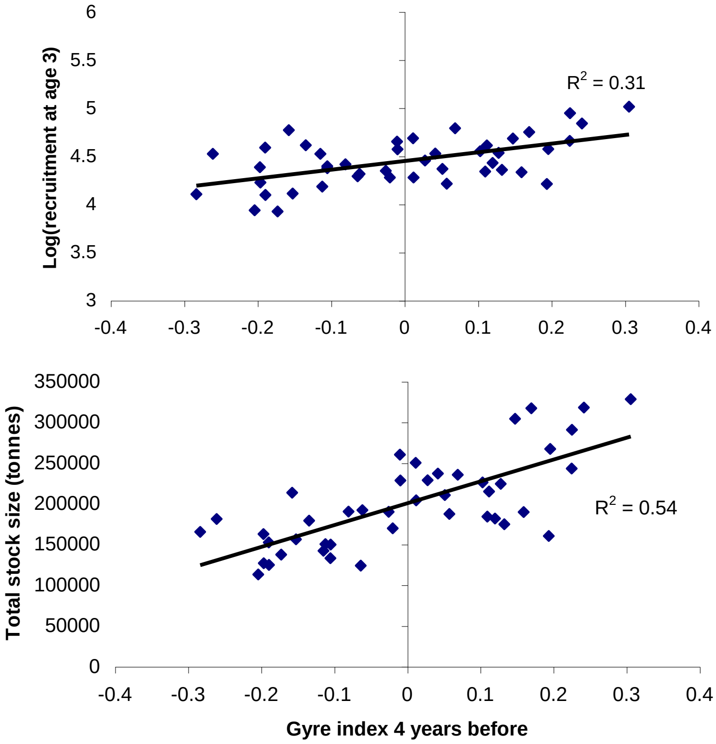


Figure 6.15.2. Relationship between the gyre index and both recruitment (top figure) and total stock biomass estimates (bottom figure.) Note that a large gyre index indicates a small subpolar gyre, and, consequently, a large influx of plankton-rich warmer-than-average water to the outer areas (bottom 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 publication:

- ICES. 2021. Icelandic Waters ecoregion –Ecosystem overview. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 11.1, https://doi.org/10.17895/ices.advice.9440

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

- ICES. 2021. Icelandic Waters ecoregion – Fisheries overview. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021. https://doi.org/10.17895/ices.advice.9167

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 2021 are estimated to have been 59 774 t (Table 8.1 and Figure 8.1). This is 20% increase from last year, still lower than 2018 and 2020 and as in most recent years well below the allocated TAC that has been around 80 thousand tonnes (Figure 8.4)

Of the landings, 53 248 t were caught by trawl, 2967 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 2018–2021, 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 1998–2021 (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 longliners that supply fish evenly through the year. Increase in the haddock stock in the early 2000s and progress in automatic baiting were also an important factor. This trend might be changing as the effort by longliners decreased by 20% between 2014–2016 and 2020–2021.

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 increased gradually from 0.8% before 2000 to 2.2% in 2013–2016 but reduced again to 1.5% in 2020 and 0.8% in 2021.

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 larger proportion of the catch of saithe and redfish compared to cod and haddock (Figure 8.6). 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). The trend in recent years has been reduction in catch of all species by the freezing trawlers.

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 between 2012 and 2021 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). The average numbers of hours trawled might be the best measure of the stock size. Shorter hauls means larger stock.

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 2020/2021 is estimated to have been 56 thous. tonnes, while the set TAC was 80 thous. 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 overestimation 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 157 tonnes are included in the landings above. They are mostly caught by longlines (68 tonnes) and handlines (88 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 addition, 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 samples when compiling catch in number for the year 2021 leads to more of 6 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, larger fish in 2018–2020 but smaller again in 2021 (Figure 8.10). In 2020 the +110 cm group was unusually abundant.

Numbers sampled in 2019–2021 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 (Figure 8.3). On the other hand, 25% of the aged otoliths come from sea samples. These numbers were different in 2020 when no aged fish and 50% of length measured fish came 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 all age groups have been below average in recent years, the older age groups though closer to average (Table 8.5 and Figures 8.12–8.14). The large 2012 year class had the lowest mean weight of all year classes at age 4 and 5, 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. The long-term trend since 1980 has been decline for younger age groups but increase for older age groups (Figure 8-14).

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 below the 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 (ice-smb) data are used to calibrate the assessment. Compared to the autumn survey (ice-smh) 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 8.18) 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 8.18). Most of the increase was caused by year class 2012 that was strong in the surveys 2015–2018 (Figure 8.20). The biomass index from the March survey reduced much from 2018–2019 but has fluctuated since. The 2022 value is 2/3rd of the 2021 value that was relatively high. The 2022 value is only 35% of the 2018 value that is the highest value in the series (the 1986 value is considered an outlier) Similar reduction in survey biomass has been seen before. Usually, the highest CV is estimated for the high survey value, the exception is 2018 where CV is around average. The 2022 index has similar CV as the 2009 index that is the lowest CV in the series.

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 more 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, the age group that is “best fitted” in the survey. The 2018 index had medium CV.

The autumn survey shows similar trend as the spring survey and the index was 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 8.5) in an area where large schools of saithe are sometimes found. Excluding these stations leads to lower but more stable index.

Catch curves 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 and 2022 values are lower. (Figure 8.13). The gillnet survey is mostly targeting large saithe (mean weight in 2022 was 7.5 kg).

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

The high index in March 1986 (Figure 8.18) was 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 cannot 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 re-evaluated 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 re-evaluated at WKICEMSE 2019 (See table below and ICES, 2019a). B_{lim}, B_{pa}, MSY $B_{trigger}$, HR_{MSY} and HR_{Mgt} were unchanged, MGMT $B_{trigger}$ 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}	MSY $B_{trigger}$	MGT $B_{trigger}$	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 136 to 415 kt (in 1999 and 1988), but this range has been narrower since 2003, between 230 and 343 kt. The current estimated stock size of $B4+_{2022}$ = 325 kt is among the highest values in the time series. Spawning biomass is estimated as 167 kt, also among highest in the timeseries.

The harvest rate peaked around 29% in the mid 1990s but has since 2016 been below HR_{Mgt} target of 20%. The explanations for lower than intended harvest rate since 2016 are that the allocated TAC has not been fished and the stabilizer was reducing the TAC when the stock was increasing. Overestimation of the stock in last years would have lead to HR > HR_{Mgt} if the TAC was caught. 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 compared to the time before that.

Recruitment has been relatively stable since year class 2006, above average. Year class 2012 is estimated to be strong and year class 2015 poor but the remaining year classes from 2006–2018 close to 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 2021 (Figure 8.28) are negative for age 9 and older except for age 10. The residuals for the same age groups in 2020 have opposite sign. 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 2019–2022 residuals are mostly positive for the years 2019 and 2021 but negative for the years 2020 and 2022, as seen in comparison of observed and predicted survey biomass (Figure 8.26).

Assumptions about catch in the assessment year deviate from the stock annex that specifies the catch in the calendar year 2022 as the remaining TAC from the fishing year 2021/2022 at 1 January 2022 plus 1/3 of the catch in the fishing year 2022/2023. 60 thousand tonnes of the catch for the fishing year 2021/2022 were remaining 1 January and the total catch for the year 2021 will be 84 thousand. tonnes following this procedure. Development of landings indicate that the catch for 2021 will be around 68 thousand tonnes so the parameter "remaining TAC" in the model is set to 44 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 2022 assessment of Icelandic saithe is substantial downward revision of the stock compared to the 2021 assessment. The change is caused by 2022 survey but the survey biomass in 2022 is 33% lower than in survey 2021

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 2018–2022 Mohns rho is 0.25 for the reference biomass, -0.16 for the Harvest rate, 0.29 for SSB and 0.05 for recruitment (Table 8.11 called Stdsettings). The retrospective pattern in last 5 years is caused by the very high 2018 survey index and then again relatively high 2021 index. If the last estimated year is 2021 instead of 2022 rho for SSB changes to 0.24 and for B4+ to 0.21. Higher Mohns rho for the SSB than for B4+ is not unexpected as old/large saithe are due to pelagic behaviour, difficult to catch by demersal gear. Model settings using ages 3–14 from the survey has lower Mohns rho, compared to the adopted model but the difference is not large (0.19 vs 0.25 and 0.23 vs 0.29). Over the range of assessment years 2002–2022 that model would though have performed little worse than the adopted model if Mohns rho in 5 years just before the assessment year is a measure of performance.

Looking at metrics from (nearly) 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 (2001–2017) that are not used when compiling results for Table 8.11 (2018–2022). The results shown in Table 8.11 are in line with the assumptions used in the HCR evaluations in 2022 (CV = 0.22, bias = 0 and first order autocorrelation = 0.5.

Using peels of 5 years for stock with low fishing mortality is rather questionable, the assessments used in the evaluations have not converged. Retrospective pattern of Mohns rho illustrates this problem well (Figure 8.33). The value of Mohns rho cannot be obtained from the HCR simulations where only current estimate and "correct value" are available, the first value is the basis for advice and the second value basis for development of the stock. Intermediate values do not affect, neither the advice nor the stock.

Alternative settings of the Muppet model and one SAM run were tested (Figure 8.30) compared to the results. The result show low estimated biomass when the survey data are downweighted, the same result is obtained with the leaveout run in SAM, both showing that catch in numbers indicate smaller stock compared to survey indices. Winchorised survey indices lead to less noise in the and therefore 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 is 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 reweighted" model show lower biomass but it does also converge to lower biomass as the selection pattern of the oldest fish is different. Compared to last year the difference between the estimate of B4+ from different models is smaller.

All the models except the model with less weight on survey show similar retrospective pattern in recent years, ≈17% reduction in estimate of B4+ between assessment years 2021 and 2022 and ≈30% between assessment years 2018 and 2022.

The table below show B4+$_{2022}$, the number that matters for the advice. The values are in thousand tonnes.

Std settings 2022	Winchorised survey	Adapt	LessWeight on survey	Reweighed survey CV	Ages 3–14 in survey.	Survey CV	Std settings 2021	SAM
325	424	288	222	275	344	270	375	323

If all the models would be taken as equally plausible configurations (which they are not) the average B4+2022 is 301 and CV 0.17.

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). In spite of overestimation of the stock, the assessment models do not indicate high fishing mortality nor harvest rate in last 5 years (Figure 8.24), mostly because the TAC has not been fished. The selection pattern observed since 2004 (Figure 8.23) 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 large saithe has shown 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 and decline in gillnet survey support that the stock has been overestimated and the TAC therefore too high.

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.

The assessment of Icelandic cod was benchmarked in 2021 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 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 be able to detect such 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. Four 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 questionable.

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 4 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. ChangedCVpattern. ϵ = 0.1 for all age groups. Age 2 not included and pattern of CV by age in the survey re-estimated.
3. surveyCV. Model uses estimated $CV_{y,a}$in survey as described above.
4. Ages3to14. ϵ = 0.1 for all age groups. Survey indices age 3–14. Pattern of CV by age in the survey estimated.

Model 1 is tuned with ages 2–10, 2 and 3 with ages 3–10 and 4 with 3–14. Models 1–3 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 for last 5 years. Looking at difference between contemporary and converged assessment in the years 2001–2017 model 1 performs best but the metrics for models 1 and 3 are similar. The Mohns rho indicates that recruitment estimates are good in last 5 years but historically recruitment of saithe is not well estimated, this is just coincidence for this short period. Mohns rho from the SAM model is around 0.3 (for SSB), similar to the other models.

Comparing models 1 and 2 B4+2022 is 325 vs 275 thousand tonnes, and the objective function -774.5 vs -756. Model 1 fits the data better and indicates larger stock. Retrospective performance of model 1 is also better. Model 3 has an objective function of -853 but with 8 more parameters than model 1, might indicate that the approach used was promising. Model 4 uses more data than the other models and the objective function is therefore not comparable.

An interesting factor to look at in the models is estimated q from the surveys (Figure 8.32). Model 4 uses ages 3–14 for tuning but the other models 2–10 or 3–10. q is constrained to be identical for ages 9 and older in model 4 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 4 leads to larger stock.

Estimated selection (since 2004) in the model is also somewhat different (Figure 8.33). Models 1 and 3 have different selection pattern for older fish and do therefore not converge to exactly the same biomass in the period after 2003. The Adapt model (shown in Figure 30) might be considered as some kind of truth in this respect although is not completely insensitive to the number in the oldest age group that it gets from a separable model.

In summary, no obvious choice can be pointed at if a new model was adopted today. What works best for last 5 years according to Mohns rho does not work best when comparing contemporary and converged assessment 2001–2017.

8.10 References

Armannsson, H. and S.T. Jonsson. 2012. Vertical migrations of saithe (*Pollachius virens*) in Icelandic waters as observed with data storage tags. ICES J. Mar. Sci. 69:1372-1381.

Armannsson, H., S.T. Jonsson, J.D. Neilson, and G. Marteinsdottir. 2007. Distribution and migration of saithe (*Pollachius virens*) around Iceland inferred from mark-recapture studies. ICES J. Mar. Sci. 64:1006-1016.

Björnsson, Höskuldur, Einar Hjörleifsson and Bjarki Þór Elvarsson, 2019. Muppet: Program for Simulating Harvest Control Rules. Reykjavík: Marinc and Fresh water Institute. http://www.github.com/hoski/Muppet-HCR.

Gudmundsson, G. 2013. Fish stock assessment by time series analysis. ICES NWWG WD29.

i Homrum, E., B. Hansen, S.T. Jonsson, K. Michalsen, J. Burgos, D. Righton, P. Steingrund, T. Jakobsen, R. Mouritsen, H. Hatun, H. Armannsson, and J.S. Joensen. 2013. Migration of saithe (*Pollachius virens*) in the Northeast Atlantic. ICES J. Mar. Sci. 70:782-792.

ICES. 2008. Report of the North-Western Working Group (NWWG). ICES CM 2008/ACOM:03.

ICES. 2010. Report of the Benchmark Workshop on Roundfish (WKROUND). ICES CM 2010/ACOM:36.

ICES. 2013. Report of the evaluation of the Icelandic saithe management plan. ICES CM 2013/ACOM:60.

ICES. 2019. North Western Working Group (NWWG). ICES Scientific Reports. 1:14. 826 pp. http://doi.org/10.17895/ices.pub.5298

ICES. 2019a. Workshop on the benchmark assessment and management plan evaluation for Icelandic haddock and saithe (WKICEMSE). ICES Scientific Reports. 1:10. 107 pp. http://doi.org/10.17895/ices.pub.5091

ICES. 2019b. Saithe (*Pollachius virens*) in Division 5.a (Iceland grounds). *In* Report of the ICES Advisory Committee, 2019, pok.27.5a, https://doi.org/10.17895/ices.advice.4731

ICES. 2021. Workshop on the re-evaluation of management plan for the Icelandic cod stock (WKICECOD). ICES Scientific Reports. 3:30. 85 pp. https://doi.org/10.17895/ices.pub.7987

Magnusson, A. 2012. Icelandic saithe: New model to predict current weight at age. ICES NWWG WD30.

Magnusson, A. 2013. Mathematical properties of the Icelandic saithe HCR. ICES NWWG WD 31.

Ministry of Industries and Innovation. 2013. Adoption of management plan for Icelandic saithe. Letter to ICES, dated 22 Apr 2013.

Palsson, O.K., G. Karlsson, A. Arason, G.R. Gislason, G. Johannesson, and S. Adalsteinsson. 2003. Discards in demersal Icelandic fisheries 2002. Mar. Res. Inst. Rep. 94.

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		231			64 295	6				64 532
2020		188			50 058	6				50 253
2021		156			59 618	1				59 774

Table 8.2. Saithe in Division 5.a. Sampling from catches 2019–2021

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
2019	Long lines	966	0	0	5	19	5
2019	Gillnets	1405	0	0	0	0	0
2019	Jiggers	1843	4	100	8	468	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	29684	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	8182	26
2020	Other gear	319	0	0	0	0	0
2020	Total	50253	41	1012	79	9595	34
2021	Long lines	457	0	0	0	0	0
2021	Gillnets	2968	2	50	2	234	0
2021	Jiggers	1651	2	50	2	195	0
2021	Danish seine	1184	8	200	8	932	0
2021	Bottom trawl	53255	57	1550	159	29057	115
2021	Other gear	261	0	0	0	0	0
2021	Total	59775	69	1850	171	30418	115

Table 8.3. Saithe in Division 5.a. Sampling from catches 2021. No age samples were taken at sea.

Gear	Length sea-samples	Length shore-samples	Age sea-samples	Age shore-samples
Bottom trawl	115	44	13	44
Demersal seine	0	8	0	8
Gillnets	0	2	0	2
Handlines	0	2	0	2

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
2021	1832	6777	4160	1305	2380	1082	1303	471	197	190

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

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

Year	3	4	5	6	7	8	9	10	11	12+
2013	1056	1675	2219	3244	4529	5628	6397	7055	7378	8342
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	1336	1719	2515	3227	4379	5296	6265	7152	8045	9062
2022	1369	1855	2411	3412	4373	5489	6498	7309	8298	9341
2023	1369	1855	2411	3412	4373	5489	6498	7309	8298	9341

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

Year	3	4	5	6	7	8	9	10	11	12
1980	0	0.083	0.189	0.374	0.604	0.796	0.909	1	1	1
1981	0	0.083	0.189	0.374	0.604	0.796	0.909	1	1	1
1982	0	0.083	0.189	0.374	0.604	0.796	0.909	1	1	1
1983	0	0.083	0.189	0.374	0.604	0.796	0.909	1	1	1
1984	0	0.083	0.189	0.374	0.604	0.796	0.909	1	1	1
1985	0	0.083	0.189	0.374	0.604	0.796	0.909	1	1	1
1986	0	0.075	0.173	0.349	0.578	0.778	0.9	1	1	1
1987	0	0.069	0.159	0.326	0.553	0.76	0.89	1	1	1
1988	0	0.063	0.147	0.306	0.53	0.743	0.881	1	1	1
1989	0	0.058	0.137	0.29	0.511	0.728	0.873	1	1	1
1990	0	0.055	0.131	0.278	0.496	0.716	0.866	1	1	1
1991	0	0.054	0.127	0.271	0.488	0.71	0.862	1	1	1
1992	0	0.054	0.127	0.271	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	0.292	0.514	0.73	0.874	1	1	1
1995	0	0.066	0.153	0.317	0.543	0.753	0.886	1	1	1
1996	0	0.077	0.176	0.353	0.583	0.782	0.902	1	1	1
1997	0	0.092	0.205	0.398	0.629	0.813	0.918	1	1	1
1998	0	0.11	0.24	0.448	0.675	0.842	0.932	1	1	1
1999	0	0.13	0.277	0.495	0.715	0.865	0.943	1	1	1
2000	0	0.149	0.31	0.535	0.746	0.883	0.951	1	1	1
2001	0	0.163	0.333	0.561	0.766	0.893	0.955	1	1	1
2002	0	0.168	0.341	0.57	0.773	0.897	0.957	1	1	1
2003	0	0.166	0.338	0.566	0.77	0.896	0.956	1	1	1
2004	0	0.159	0.326	0.554	0.761	0.891	0.954	1	1	1
2005	0	0.15	0.311	0.536	0.747	0.883	0.951	1	1	1

Year	3	4	5	6	7	8	9	10	11	12
2006	0	0.141	0.296	0.518	0.734	0.876	0.948	1	1	1
2007	0	0.134	0.284	0.505	0.723	0.87	0.945	1	1	1
2008	0	0.129	0.276	0.494	0.714	0.865	0.943	1	1	1
2009	0	0.126	0.269	0.485	0.707	0.861	0.941	1	1	1
2010	0	0.122	0.263	0.478	0.701	0.857	0.939	1	1	1
2011	0	0.119	0.257	0.469	0.694	0.853	0.937	1	1	1
2012	0	0.115	0.249	0.459	0.685	0.848	0.934	1	1	1
2013	0	0.109	0.239	0.446	0.674	0.841	0.931	1	1	1
2014	0	0.104	0.229	0.432	0.661	0.833	0.927	1	1	1
2015	0	0.098	0.219	0.417	0.647	0.825	0.923	1	1	1
2016	0	0.094	0.209	0.404	0.634	0.816	0.919	1	1	1
2017	0	0.09	0.201	0.392	0.623	0.809	0.916	1	1	1
2018	0	0.087	0.196	0.384	0.615	0.804	0.913	1	1	1
2019	0	0.085	0.192	0.378	0.609	0.8	0.911	1	1	1
2020	0	0.084	0.19	0.375	0.605	0.797	0.91	1	1	1
2021	0	0.083	0.188	0.372	0.603	0.795	0.909	1	1	1
2022	0	0.082	0.187	0.37	0.601	0.794	0.908	1	1	1
2023	0	0.082	0.187	0.37	0.601	0.794	0.908	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

Year	2	3	4	5	6	7	8	9	10
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
2022	1.2	2.43	4.39	3	1.11	0.24	0.69	0.25	0.53

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

Year	Recruitment (Age 3) in thousands	Stock size		Harvest rate B_{4+}	Total catch
		SSB	Reference biomass ages 4+		
1980	28194	113844	313210	0.184	57659
1981	20200	120803	305796	0.211	57548
1982	21587	137948	295536	0.204	67865
1983	32176	137885	270934	0.218	56504
1984	41845	140591	288126	0.194	60405
1985	35340	138908	300230	0.205	53728
1986	67101	137191	319223	0.236	65230
1987	90981	128893	335997	0.233	80237
1988	50576	125932	415344	0.194	77244
1989	32086	129370	397933	0.232	82339
1990	20854	136640	377550	0.267	97537
1991	29494	146412	337083	0.258	102201
1992	14916	137968	288848	0.257	79568
1993	19972	114293	231610	0.286	71539
1994	17862	94886	188599	0.283	63559

Year	Recruitment (Age 3) in thousands	Stock size		Harvest rate B_{4+}	Total catch
		SSB	Reference biomass ages 4+		
1995	30190	71030	154737	0.274	48296
1996	26067	62499	151431	0.248	39352
1997	17231	63747	159365	0.205	36671
1998	8955	70538	157812	0.195	30657
1999	31354	75485	136435	0.236	30898
2000	32322	77980	148364	0.215	32751
2001	55573	85582	169929	0.227	31570
2002	64990	103865	229739	0.213	41969
2003	73114	128421	292820	0.207	52306
2004	25973	148710	334806	0.202	64668
2005	72850	159450	300772	0.244	69054
2006	41946	167787	326328	0.208	75462
2007	18583	163771	297054	0.228	64261
2008	26069	162159	265710	0.238	69426
2009	38008	150028	238651	0.235	60266
2010	36151	138308	235635	0.22	53853
2011	42905	128618	236694	0.216	50769
2012	39235	123151	238935	0.232	51252
2013	39735	121399	241432	0.205	57522
2014	28627	117718	234649	0.202	45538
2015	83965	120310	231664	0.211	48476
2016	38622	127521	287821	0.171	49223
2017	51816	142285	312092	0.193	49054
2018	14939	160004	342972	0.187	65583
2019	33070	171929	316665	0.172	63130
2020	47444	167026	295506	0.192	50245
2021	48299	172309	312448	0.208	59762
2022	38727	167743	325190		

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	62.4	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	51.1	32.2	17.4	12.2	11.8	14.9	7.5	2	1.4	0.6	0.2	0.1	0.1
1984	100.1	43.2	41.8	26	13.3	8.6	7.5	9.1	4.3	1.1	0.8	0.4	0.1	0.1
1985	135.7	82	35.3	33.8	19.9	9.4	5.6	4.6	5.3	2.6	0.7	0.5	0.2	0.1
1986	75.4	111.1	67.1	28.5	25.8	14	6	3.4	2.6	3.1	1.5	0.4	0.3	0.1
1987	47.9	61.8	91	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	40	14.3	10.2	4.6	1.7	0.9	0.7	0.9	0.5	0.1
1989	44	25.5	32.1	40.7	54.5	26.9	8.4	5.6	2.3	0.9	0.5	0.4	0.5	0.3
1990	22.3	36	20.9	25.8	30.5	37	16.2	4.7	2.9	1.3	0.5	0.3	0.2	0.3
1991	29.8	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	24.4	14.9	23.7	12.3	12.5	11.4	16.2	4.1	1.1	0.7	0.3	0.1	0.1
1993	45	21.8	20	12	17.4	8.1	7.1	5.9	7.7	2	0.5	0.4	0.2	0.1
1994	38.9	36.9	17.9	16	8.7	11.2	4.4	3.6	2.7	3.7	0.9	0.3	0.2	0.1
1995	25.7	31.8	30.2	14.3	11.5	5.5	5.9	2.1	1.5	1.2	1.5	0.4	0.1	0.1
1996	13.4	21	26.1	24.1	10.2	7.2	2.8	2.7	0.9	0.7	0.5	0.8	0.2	0.1
1997	46.8	10.9	17.2	20.9	17.6	6.6	3.9	1.4	1.2	0.4	0.3	0.3	0.4	0.1
1998	48.2	38.3	9	13.6	14.8	11.5	4	2.1	0.7	0.6	0.2	0.1	0.1	0.2
1999	82.9	39.5	31.4	7.1	9.9	10.1	7.3	2.3	1.2	0.4	0.3	0.1	0.1	0.1
2000	97	67.9	32.3	24.9	5.2	6.7	6.4	4.3	1.3	0.6	0.2	0.2	0.1	0
2001	109.1	79.4	55.6	25.7	18	3.5	4.2	3.7	2.2	0.6	0.3	0.1	0.1	0
2002	38.7	89.3	65	44.3	18.9	12.5	2.3	2.6	2.1	1.2	0.4	0.2	0.1	0.1
2003	108.7	31.7	73.1	51.7	32.4	12.9	8	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	62.6	89	26	58.3	37.9	22.2	8.3	4.8	0.7	0.8	0.6	0.4	0.1	0.1
2005	27.7	51.2	72.8	20.5	39.7	23.8	13.8	5.3	3.1	0.5	0.5	0.4	0.2	0.1
2006	38.9	22.7	41.9	57.2	13.7	24.4	14.4	8.5	3.4	1.9	0.3	0.3	0.2	0.1
2007	56.7	31.8	18.6	32.8	37.7	8.2	14.3	8.7	5.3	2	1.2	0.2	0.2	0.1
2008	53.9	46.4	26.1	14.6	22	23.1	5	8.9	5.5	3.3	1.3	0.7	0.1	0.1
2009	64	44.2	38	20.3	9.4	12.8	13.2	2.9	5.4	3.3	1.9	0.7	0.4	0.1
2010	58.5	52.4	36.2	29.7	13.3	5.6	7.5	7.9	1.8	3.3	2	1.1	0.4	0.2
2011	59.3	47.9	42.9	28.3	19.8	8.1	3.4	4.6	5	1.1	2	1.2	0.7	0.3
2012	42.7	48.5	39.2	33.7	19.1	12.2	4.9	2.1	2.9	3.1	0.7	1.2	0.7	0.4
2013	125.3	35	39.7	30.8	22.7	11.8	7.5	3.1	1.3	1.8	2	0.4	0.8	0.5
2014	57.6	102.6	28.6	31.1	20.2	13.5	6.9	4.5	1.9	0.8	1.1	1.2	0.3	0.5
2015	77.3	47.2	84	22.6	21.4	12.9	8.5	4.4	2.9	1.2	0.5	0.7	0.7	0.2
2016	22.3	63.3	38.6	66.3	15.6	13.7	8.2	5.5	2.9	1.9	0.8	0.3	0.5	0.5
2017	49.3	18.2	51.8	30.6	46.2	10.1	8.8	5.3	3.7	1.9	1.2	0.5	0.2	0.3
2018	70.8	40.4	14.9	41.3	21.9	31.2	6.8	6	3.7	2.5	1.3	0.8	0.3	0.1
2019	72.1	57.9	33.1	11.8	28.5	14	19.7	4.4	3.9	2.4	1.6	0.8	0.5	0.2
2020	57.8	59	47.4	26.1	8.1	18.2	8.9	12.7	2.9	2.5	1.5	1	0.5	0.3
2021	54.9	47.3	48.3	37.7	18.5	5.4	11.9	5.9	8.6	1.9	1.7	1	0.7	0.4
2022	52	45	38.7	38.1	25.8	11.7	3.4	7.6	3.9	5.6	1.2	1.1	0.6	0.4
2023	51.7	42.6	36.8	30.5	25.8	16	7.2	2.1	4.9	2.4	3.5	0.8	0.7	0.4
2024	51.7	42.4	34.9	28.9	20.4	15.8	9.7	4.4	1.3	3	1.5	2.1	0.5	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	0.147	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	0.246	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	0.343	0.343	0.343
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	0.392	0.392	0.392
1989	0.017	0.089	0.185	0.307	0.379	0.455	0.422	0.455	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	0.513	0.554	0.429	0.453	0.453	0.453
1992	0.02	0.106	0.221	0.366	0.451	0.542	0.502	0.542	0.42	0.444	0.444	0.444
1993	0.022	0.115	0.239	0.396	0.488	0.586	0.543	0.586	0.454	0.48	0.48	0.48
1994	0.025	0.13	0.271	0.448	0.552	0.663	0.615	0.663	0.514	0.543	0.543	0.543
1995	0.025	0.132	0.275	0.456	0.562	0.675	0.626	0.675	0.523	0.552	0.552	0.552
1996	0.022	0.115	0.239	0.397	0.489	0.587	0.544	0.587	0.455	0.48	0.48	0.48
1997	0.035	0.143	0.228	0.307	0.407	0.506	0.537	0.504	0.505	0.458	0.458	0.458
1998	0.028	0.116	0.184	0.247	0.328	0.408	0.433	0.407	0.407	0.37	0.37	0.37
1999	0.029	0.12	0.191	0.257	0.34	0.423	0.449	0.422	0.422	0.383	0.383	0.383
2000	0.031	0.126	0.2	0.269	0.356	0.443	0.47	0.442	0.442	0.402	0.402	0.402
2001	0.026	0.105	0.167	0.224	0.297	0.37	0.392	0.369	0.369	0.335	0.335	0.335
2002	0.028	0.114	0.181	0.243	0.322	0.401	0.426	0.4	0.4	0.363	0.363	0.363
2003	0.027	0.111	0.177	0.238	0.315	0.392	0.415	0.39	0.391	0.355	0.355	0.355
2004	0.038	0.182	0.264	0.277	0.256	0.232	0.248	0.256	0.267	0.263	0.263	0.263

Year	3	4	5	6	7	8	9	10	11	12	13	14
2005	0.042	0.2	0.289	0.303	0.28	0.253	0.272	0.28	0.293	0.288	0.288	0.288
2006	0.046	0.217	0.314	0.33	0.305	0.275	0.295	0.304	0.318	0.313	0.313	0.313
2007	0.042	0.201	0.291	0.305	0.282	0.255	0.274	0.282	0.295	0.29	0.29	0.29
2008	0.049	0.234	0.339	0.356	0.329	0.297	0.319	0.328	0.343	0.338	0.338	0.338
2009	0.047	0.224	0.324	0.34	0.314	0.284	0.305	0.314	0.328	0.322	0.322	0.322
2010	0.043	0.205	0.297	0.312	0.288	0.261	0.28	0.288	0.301	0.296	0.296	0.296
2011	0.041	0.194	0.281	0.295	0.272	0.246	0.264	0.272	0.284	0.279	0.279	0.279
2012	0.041	0.194	0.281	0.295	0.273	0.246	0.264	0.272	0.284	0.28	0.28	0.28
2013	0.046	0.221	0.32	0.336	0.31	0.28	0.301	0.309	0.324	0.318	0.318	0.318
2014	0.036	0.172	0.25	0.262	0.242	0.219	0.235	0.242	0.253	0.248	0.248	0.248
2015	0.036	0.171	0.247	0.26	0.24	0.217	0.233	0.239	0.25	0.246	0.246	0.246
2016	0.034	0.161	0.233	0.245	0.227	0.205	0.22	0.226	0.236	0.232	0.232	0.232
2017	0.028	0.133	0.193	0.203	0.187	0.169	0.182	0.187	0.195	0.192	0.192	0.192
2018	0.036	0.17	0.246	0.258	0.239	0.216	0.231	0.238	0.249	0.245	0.245	0.245
2019	0.036	0.171	0.248	0.26	0.24	0.217	0.233	0.24	0.251	0.246	0.246	0.246
2020	0.031	0.146	0.212	0.222	0.205	0.186	0.199	0.205	0.214	0.211	0.211	0.211
2021	0.037	0.178	0.257	0.27	0.249	0.225	0.242	0.249	0.26	0.256	0.256	0.256
2022	0.04	0.191	0.276	0.29	0.268	0.242	0.26	0.267	0.28	0.275	0.275	0.275
2023	0.042	0.202	0.292	0.307	0.283	0.256	0.275	0.283	0.296	0.291	0.291	0.291

Table 8.11. Mohns rho for the 5 models compared as candidate assessment model. The value is based on assessment years 2018–2022. Stdsettings is the adopted model today. The lower table applies if year < Assessment year but the upper table if year <= Assessment year.

model	B4+	ssb	N3	hr	f4-9
Stdsettings	0.2518	0.2887	0.0468	-0.1675	-0.2099
ChangedCVpattern	0.2189	0.2837	0.0154	-0.152	-0.1945
SurveyCV	0.2532	0.3071	0.0073	-0.1672	-0.2117
Ages3to14	0.1924	0.2288	-0.0452	-0.1356	-0.1738

model	B4+	ssb	N3	hr	f4-9
Stdsettings	0.2115	0.2384	0.2025	-0.1675	-0.2099
ChangedCVpattern	0.1882	0.2475	0.1687	-0.152	-0.1945
SurveyCV	0.2095	0.2615	0.2478	-0.1672	-0.2117
Ages3to14	0.1652	0.1913	0.1467	-0.1356	-0.1738

Table 8.12. Bias, CV and Mohns rho for the 4 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 2022 assessment.

Parameter	Model	Bias	CV	Mohns rho
B4+	Stdsettings	-0.063	0.212	-0.042
B4+	ChangedCVpattern	-0.037	0.266	-0.004
B4+	SurveyCV	0.136	0.268	0.185
B4+	Ages3to14	-0.156	0.246	-0.121
F4-9	Stdsettings	0.032	0.25	0.064
F4-9	ChangedCVpattern	-0.004	0.303	0.04
F4-9	SurveyCV	-0.153	0.288	-0.107
F4-9	Ages3to14	0.119	0.287	0.172
hr	Stdsettings	0.029	0.206	0.05
hr	ChangedCVpattern	-0.006	0.248	0.023
hr	SurveyCV	-0.134	0.245	-0.1
hr	Ages3to14	0.095	0.231	0.128
N3	Stdsettings	-0.272	0.362	-0.192
N3	ChangedCVpattern	-0.301	0.318	-0.224
N3	SurveyCV	-0.174	0.271	-0.132
N3	Ages3to14	-0.37	0.313	-0.277
ssb	Stdsettings	-0.091	0.269	-0.057
ssb	ChangedCVpattern	-0.043	0.343	0.011
ssb	SurveyCV	0.135	0.328	0.201
ssb	Ages3to14	-0.189	0.322	-0.133

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

2022			
B4+	SSB	Fbar	Landings
325	168	0.255	67.7

2023				2024		
B4+	SSB	F_{bar}	Landings	B4+	SSB	Rationale
312	157	0.269	69.8	294	148	20% HCR

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

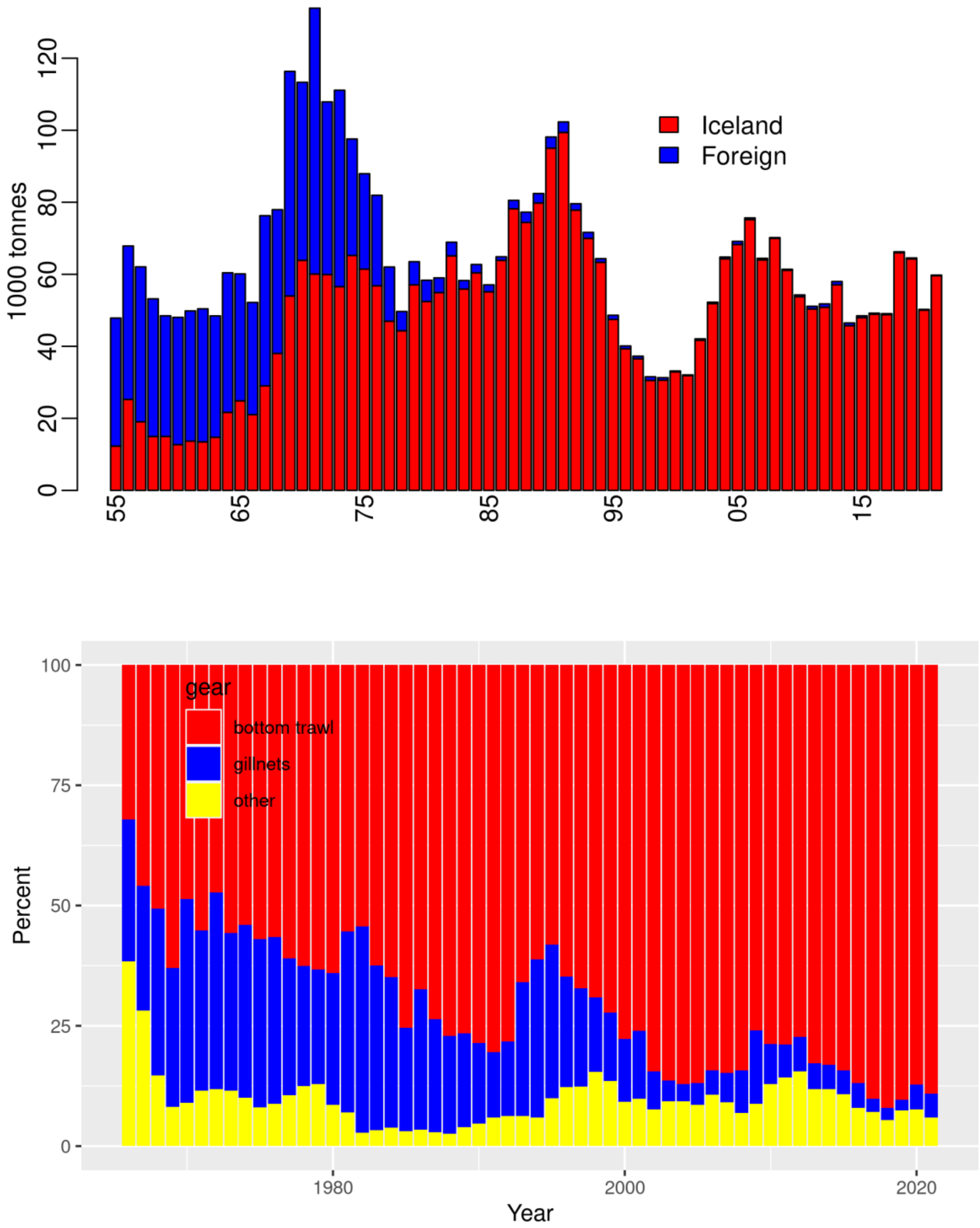


Figure 8.1 Saithe in Division 5.a. Total landings and percent by gear.

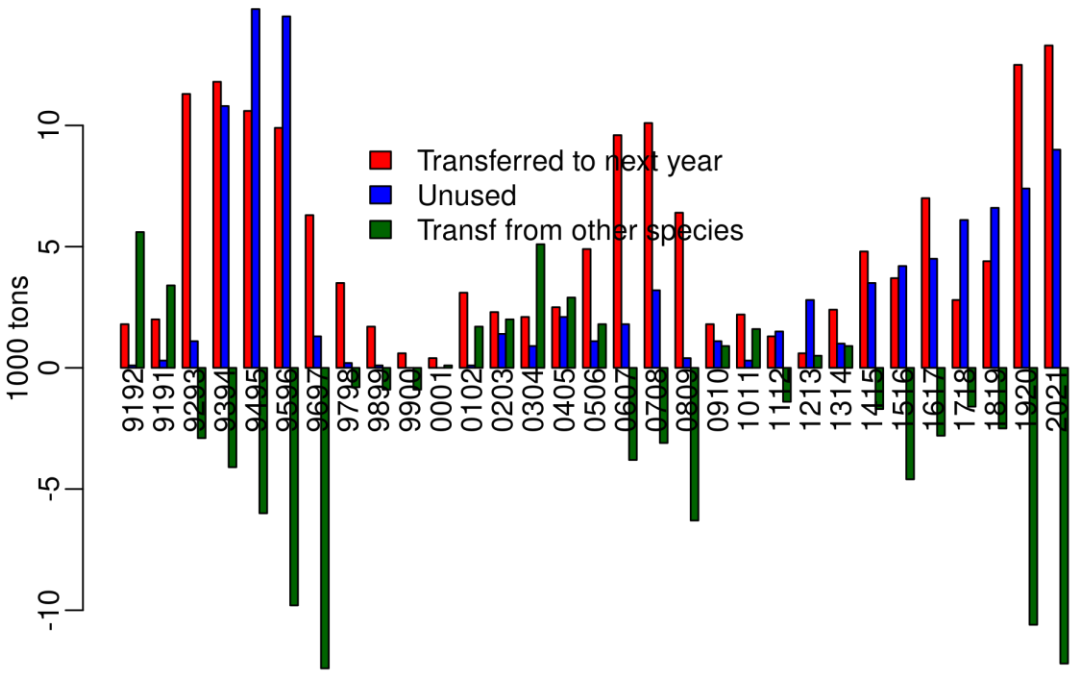


Figure 8.2 Saithe in Division 5.a. Upper figure. Cumulative landings in the current fishing year (left) and calendar year (right). The vertical (green line) in the left figure shows the quota for the current fishing year. Lower figure. Transfer of quota to next fishing year, unused quota and transfer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

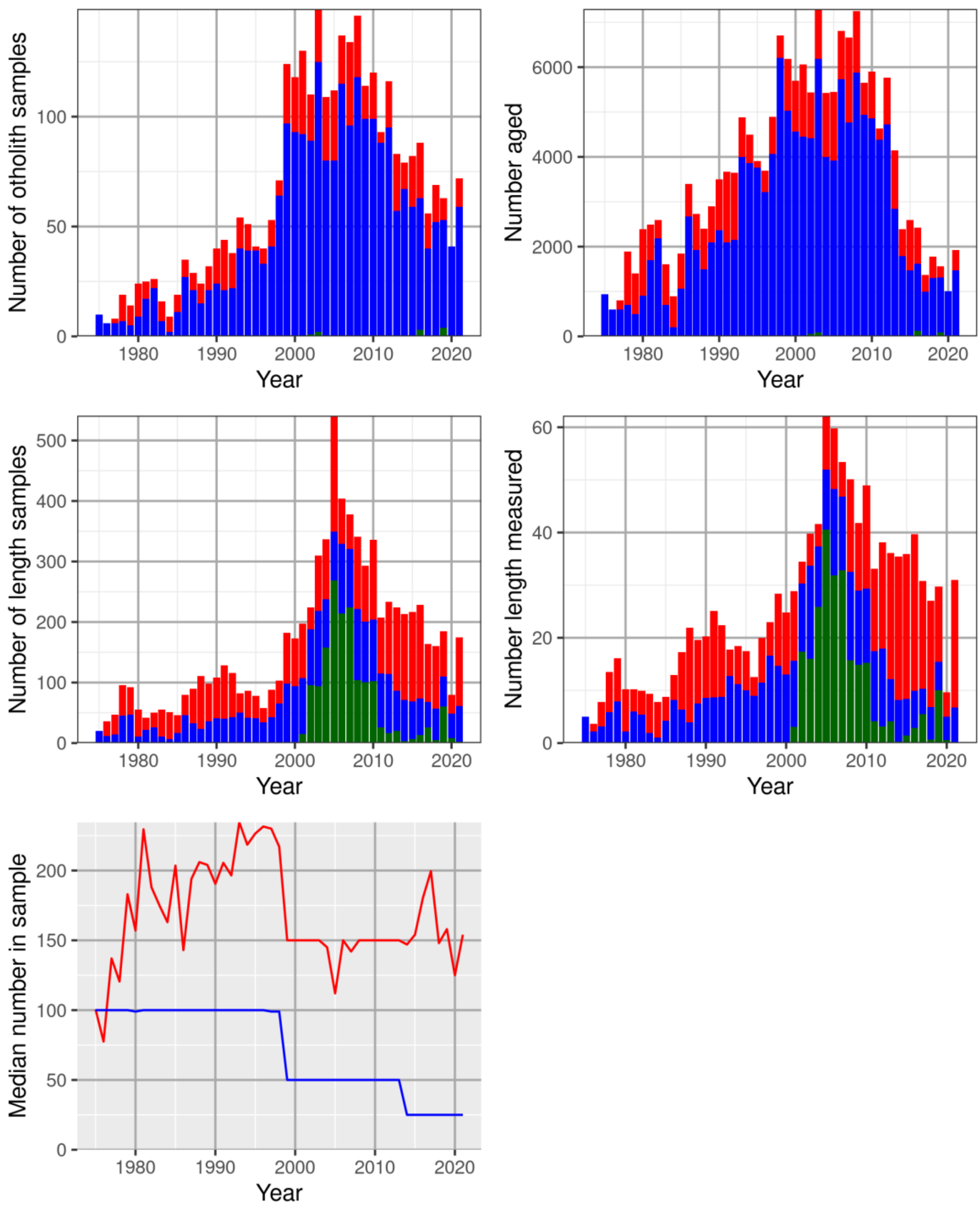


Figure 8.3 Saithe in Division 5.a. Development of sampling intensity from catches. Red is sea samples from the Fisheries Directorate, blue harbour samples from the MFRI and green from a discard project, combination of sea and shore samples.

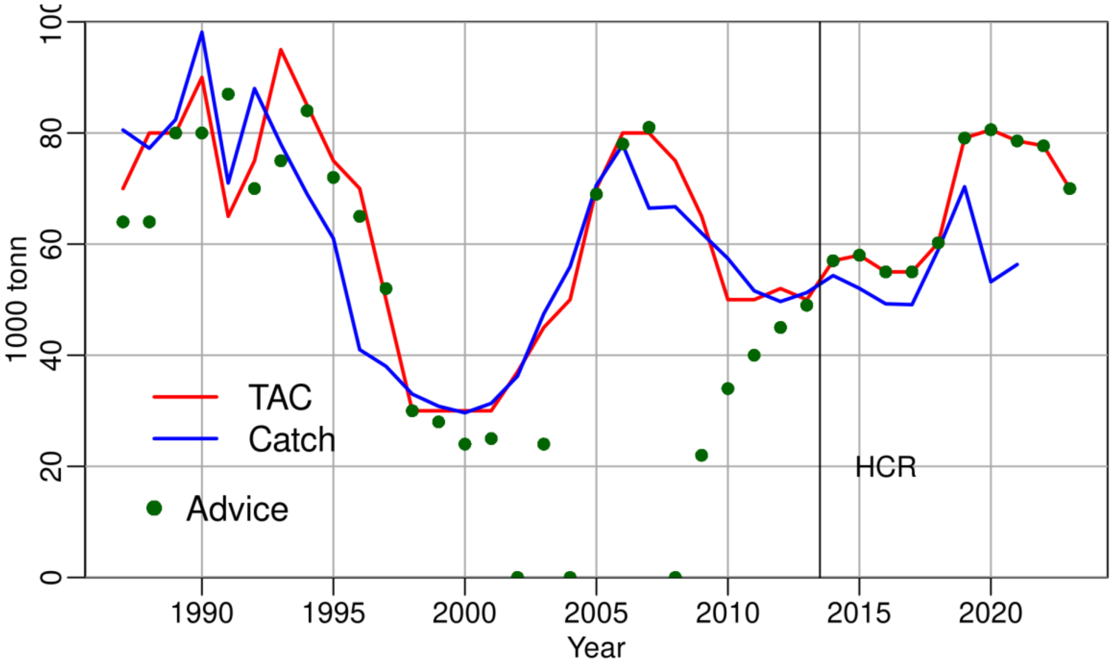


Figure 8.4. Advice, TAC and catch of saithe since 1987.

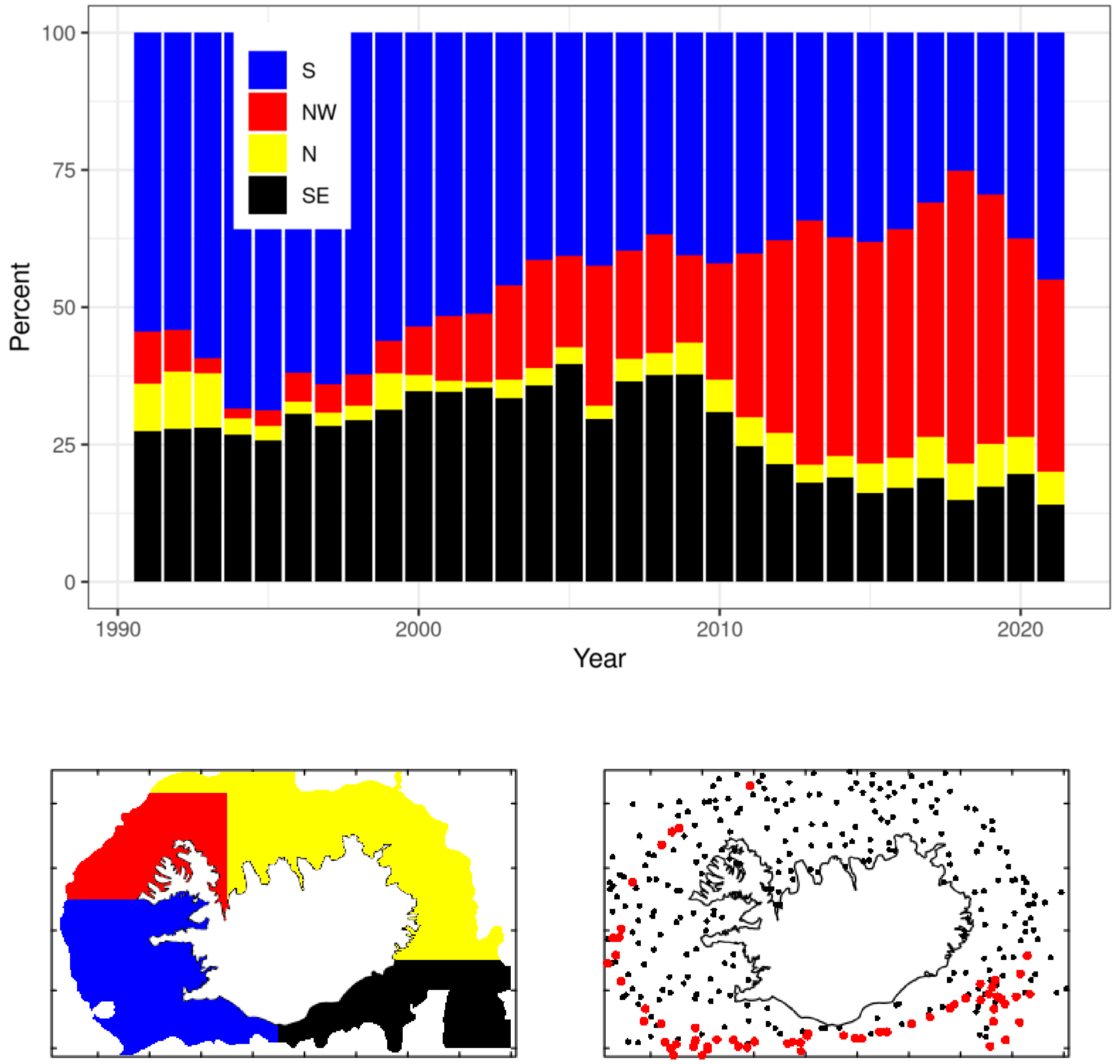


Figure 8.5. Saithe in Division 5.a. Upper figure percent of landings by regions defined in the lower figure to the left. Lower right, stations added in the autumn survey in 2000 (red dots).

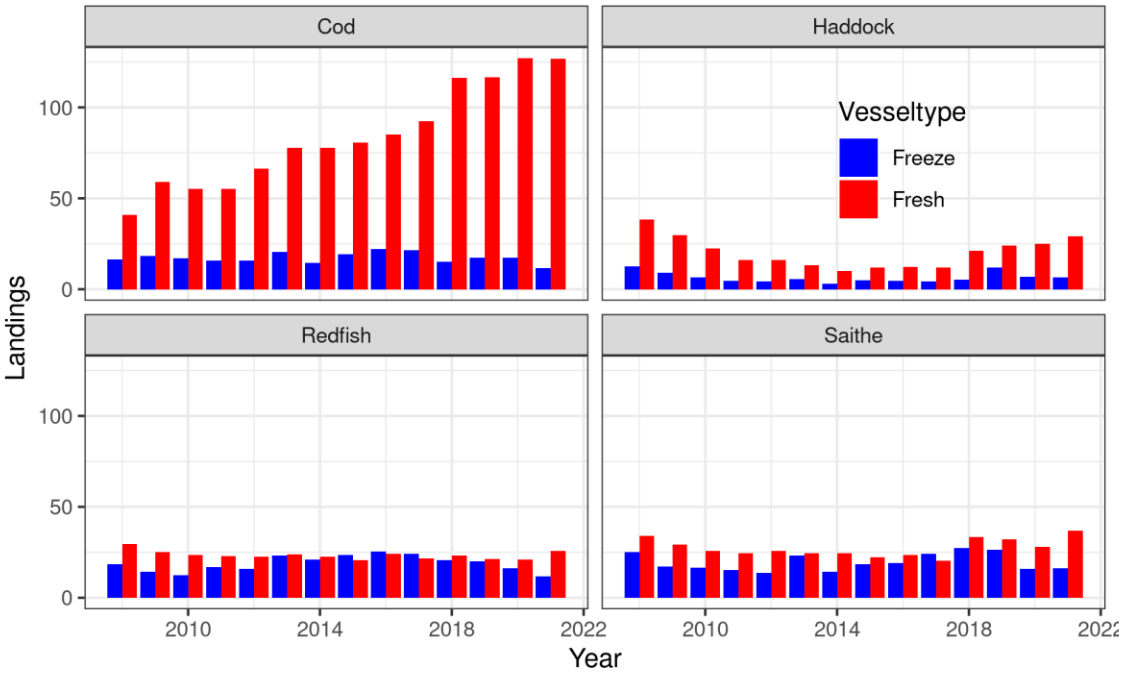


Figure 8.6 Saithe in Division 5.a. Catch by trawlers divided between those that freeze the catch and those that do not. Number of trawlers landing more than 500 tonnes has been reducing gradually from 42 in 2008 to 33 in 2020. Freezing trawlers landing > 500 tonnes were 26 in 2008 but 9 in 2020.

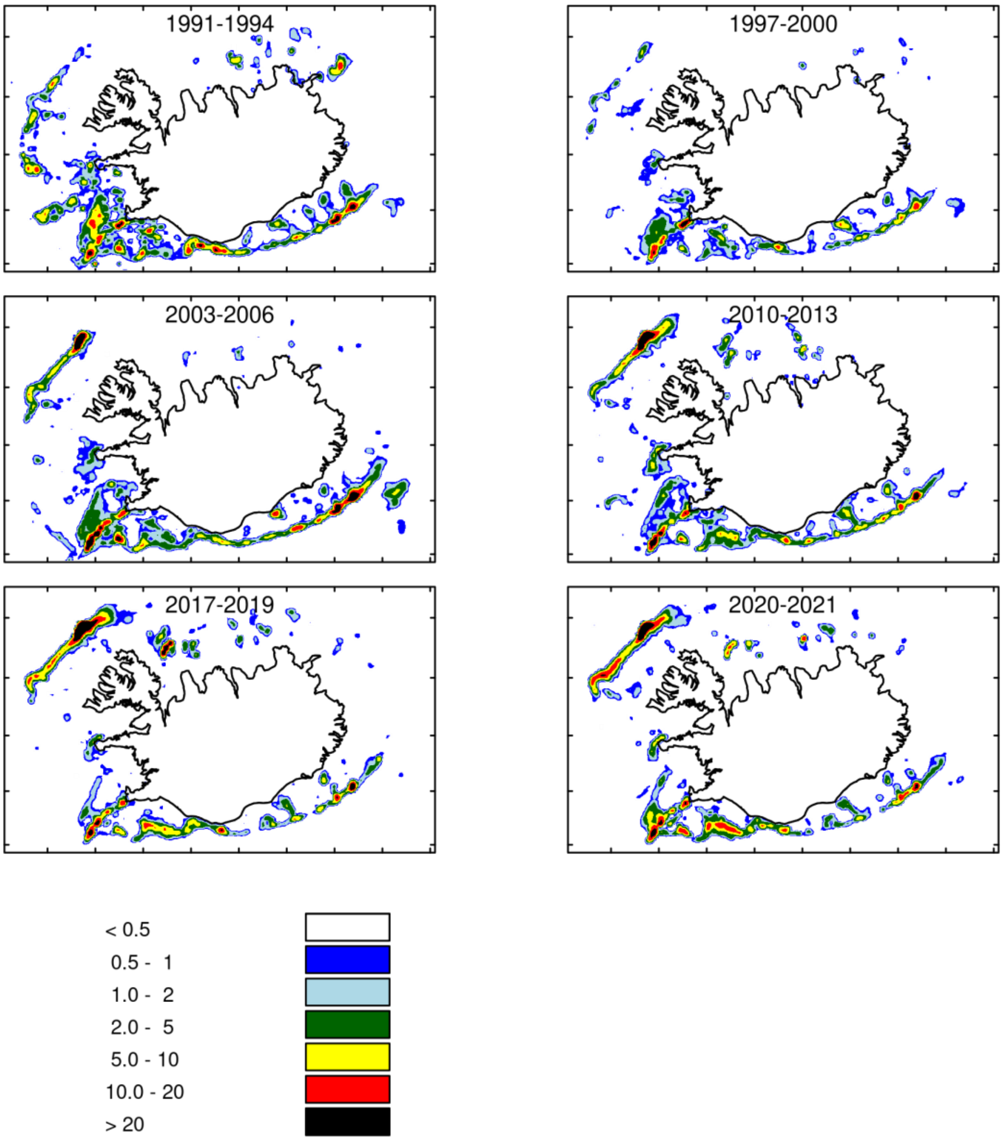


Figure 8.7. Spatial distribution of saithe catch as tonnes per square nautical mile per year.

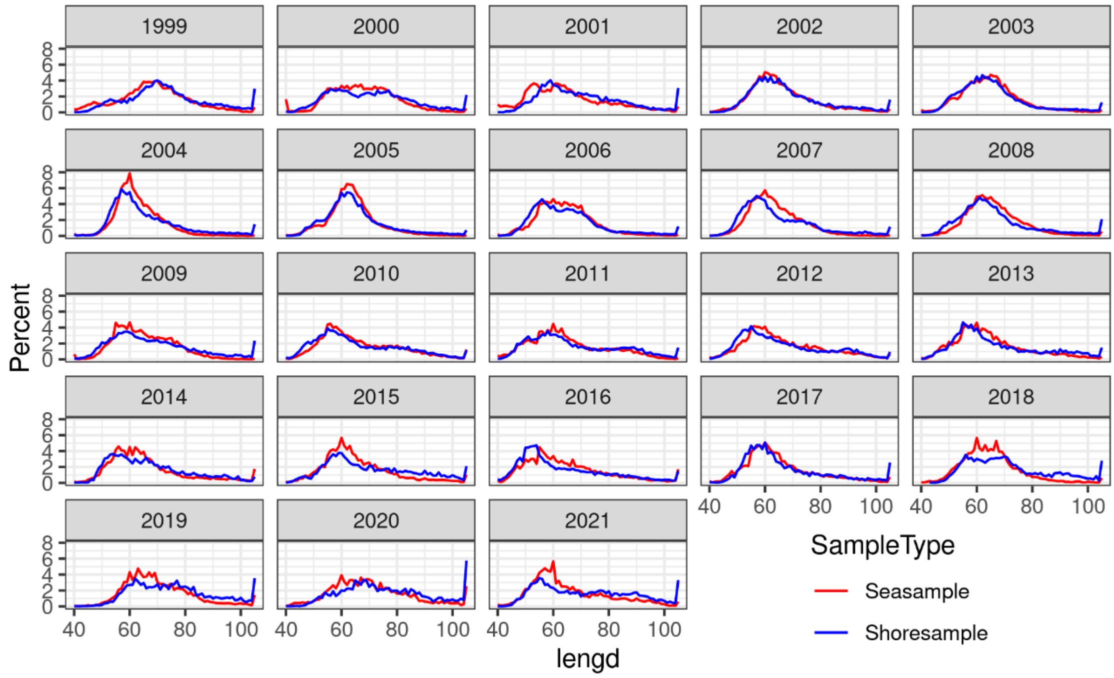


Figure 8.8. Length distributions from sea and shore samples.

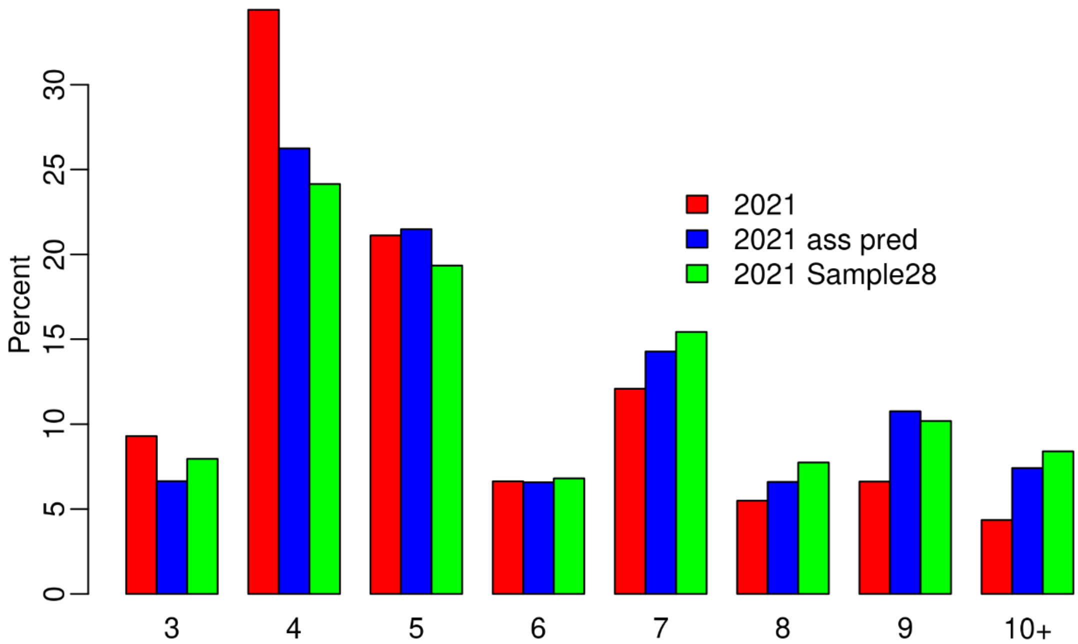


Figure 8.9. Catch in numbers 2020 compared to last year's prediction. The green bars show catch in numbers only based on shore samples.

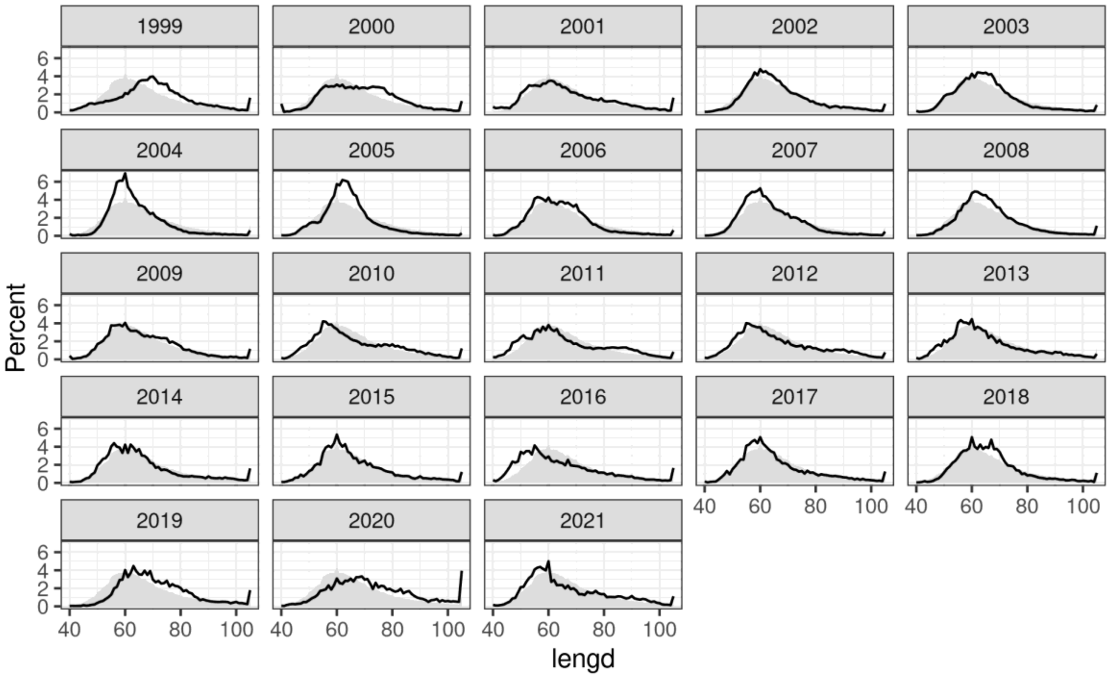


Figure 8.10. Length distributions from bottom trawl catches (lines) compared to average (grey shading).

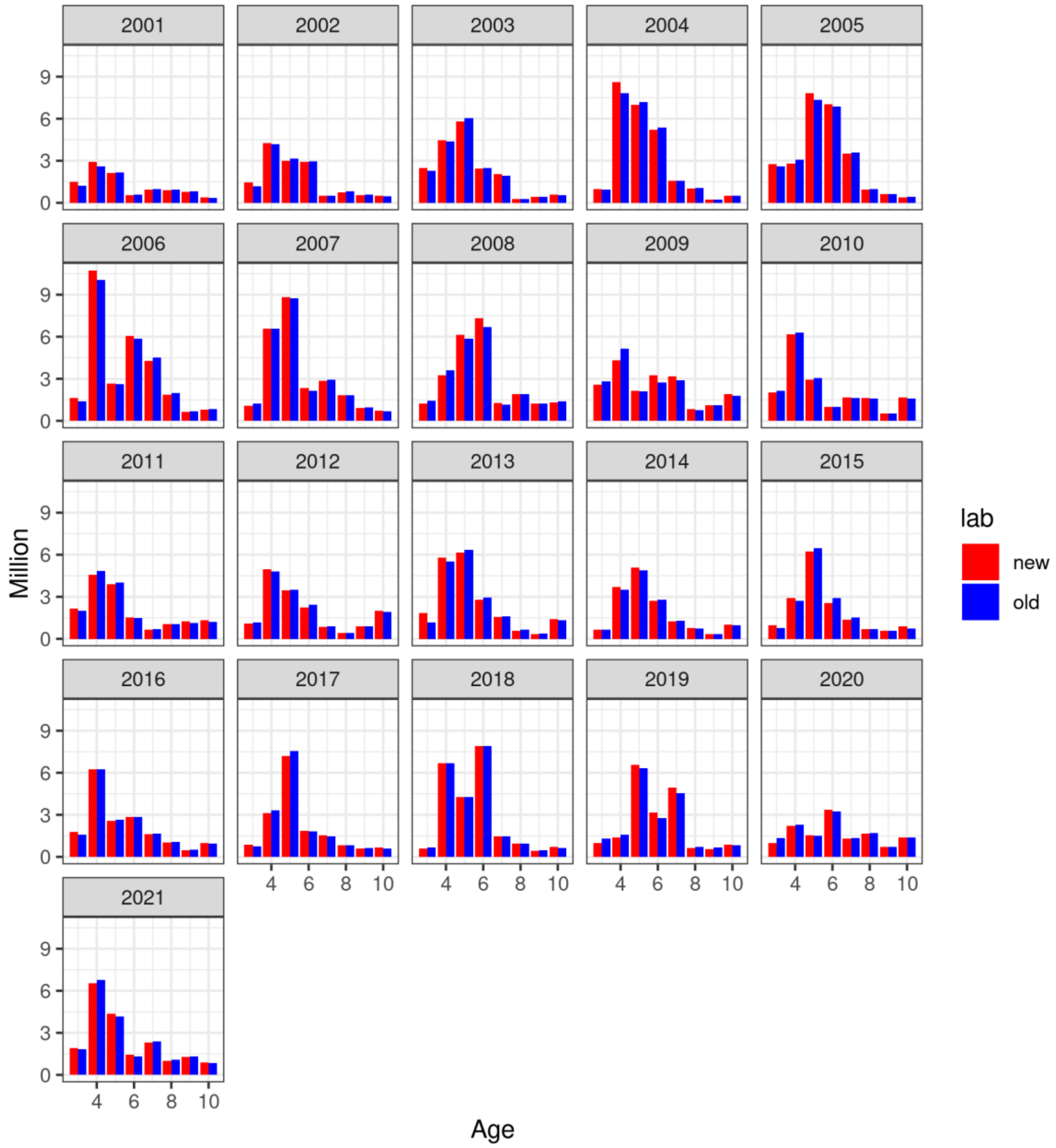


Figure 8.11. Catch in numbers 2000–2021 compiled by 1 region and 1 time interval (old) compared to catch in numbers compiled by 2 regions and 2 time interval (new). The regions are shown in Figure 8.6, north red and yellow and south blue and black.

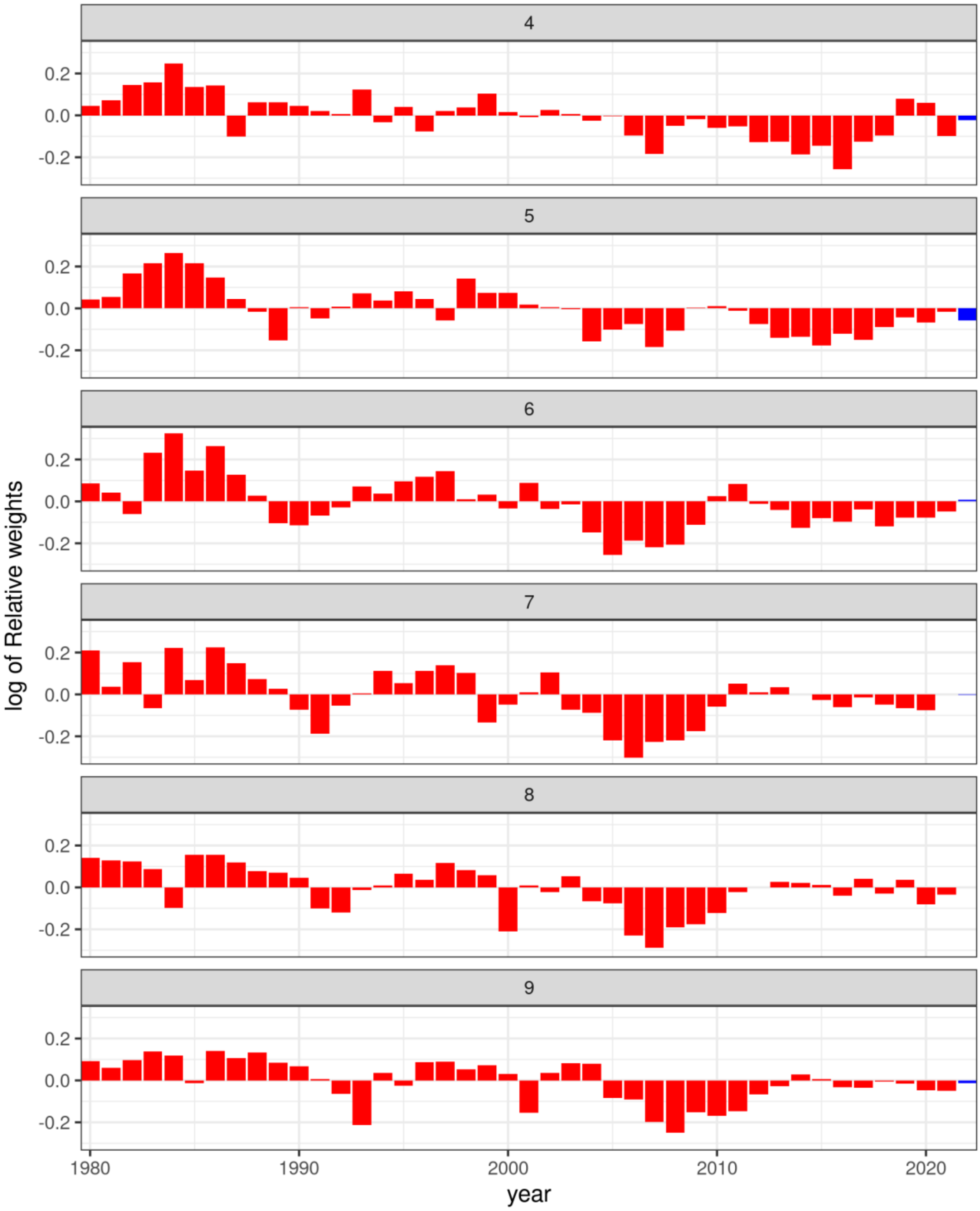


Figure 8.12. Saithe in Division 5.a. Weight at age in the catches, as relative deviations from the mean. Blue bars show prediction.

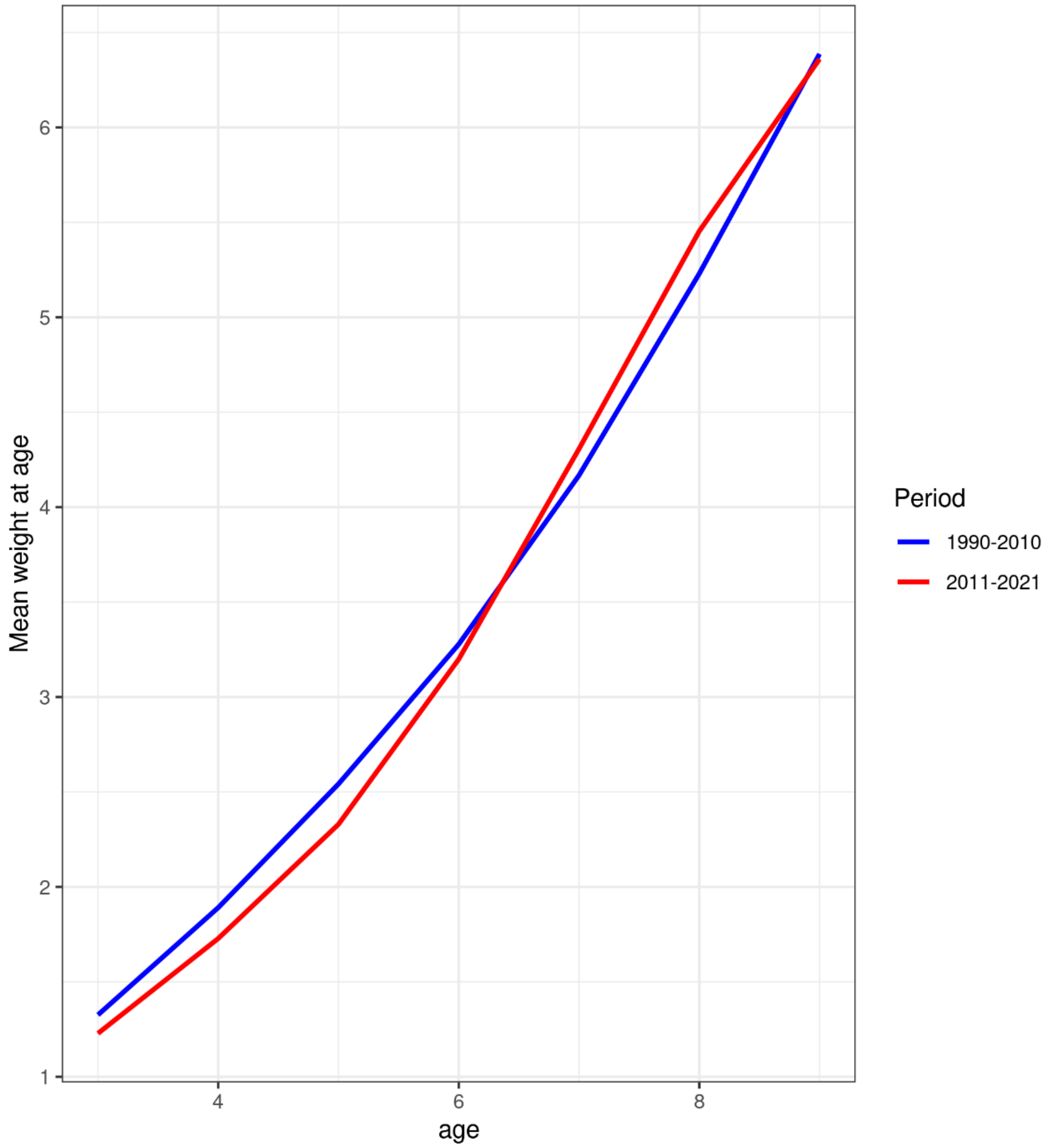


Figure 8.13. Saithe in Division 5.a. Weight at age in the catches shown as average for 2 periods.

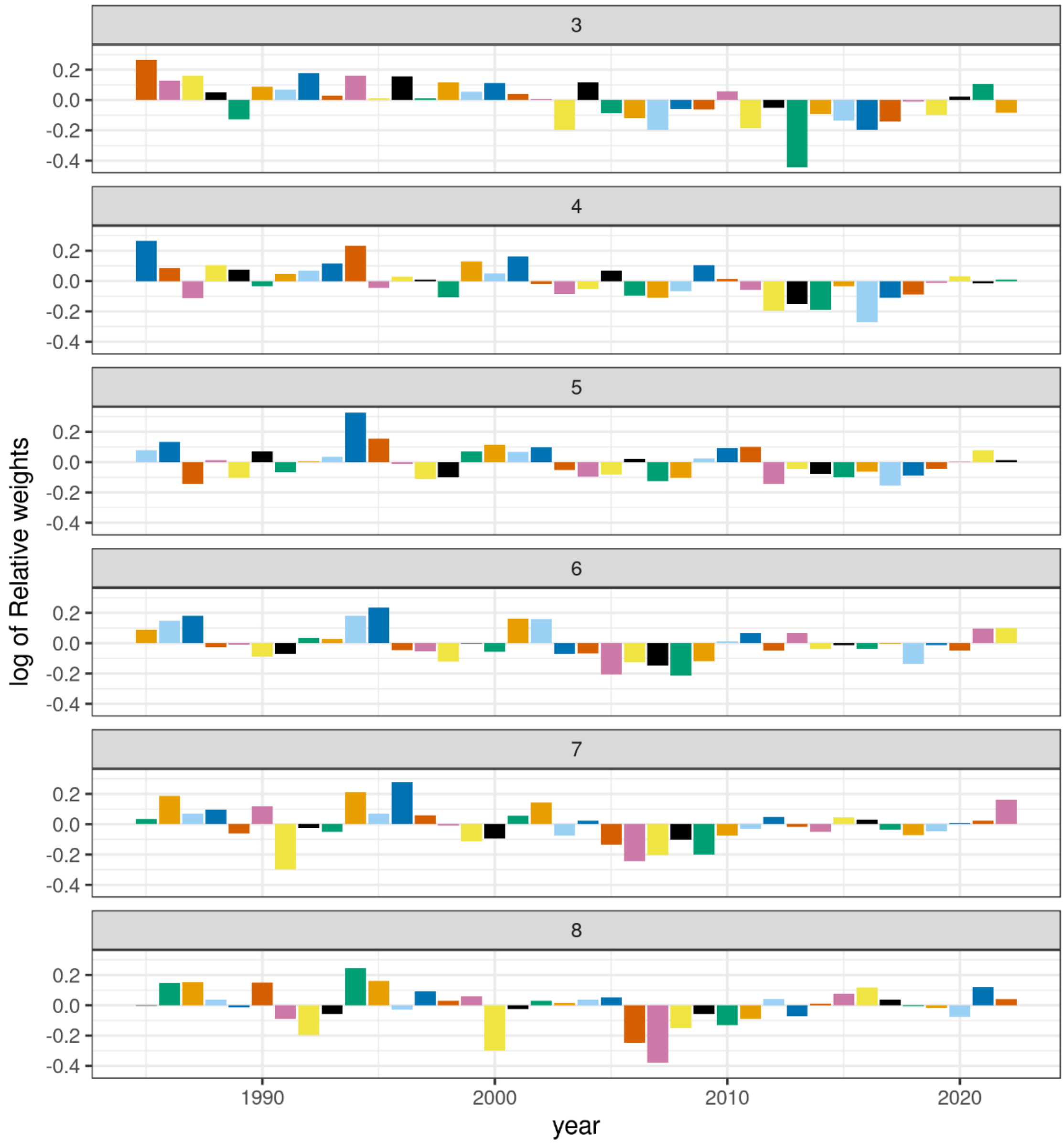


Figure 8.14 Saithe in Division 5.a. Weight at age in the survey, as relative deviations from the mean. Colours can be used to follow year classes.

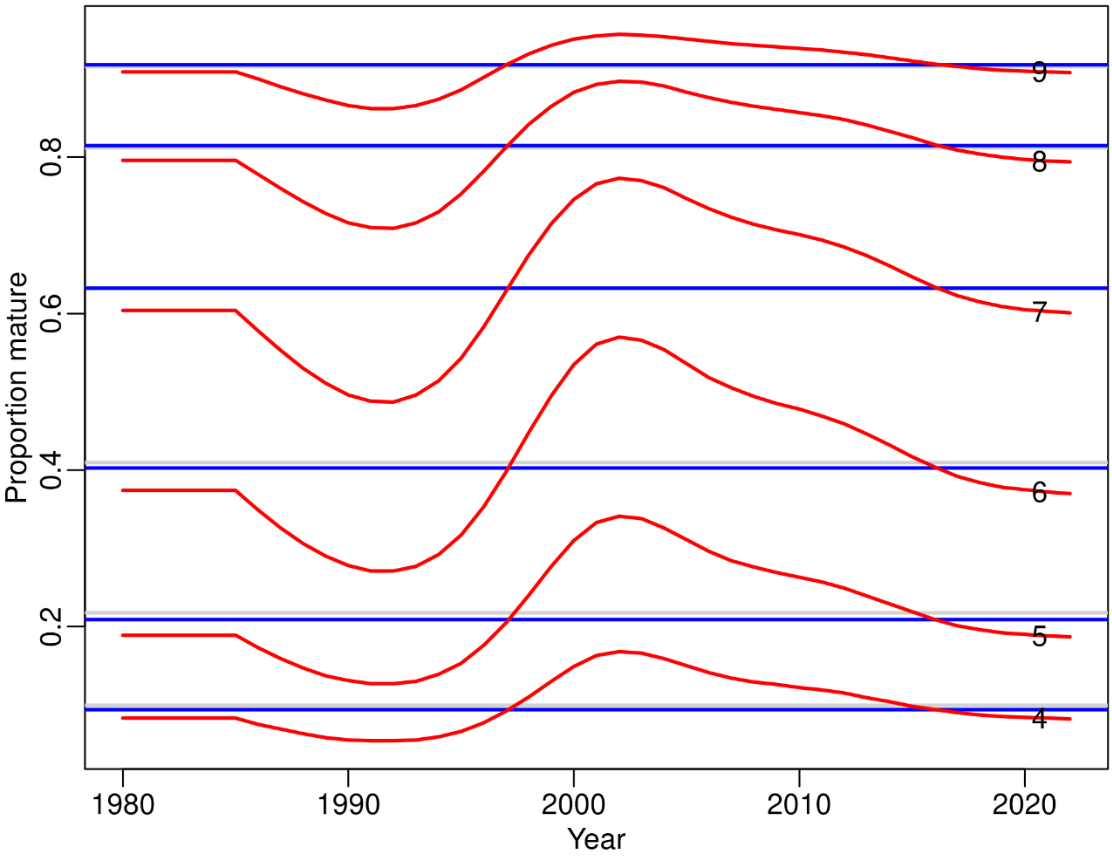


Figure 8.15. Saithe in Division 5.a. Maturity at age used for calculating the SSB. The horizonal lines show the average of last 10 years (blue one) and the average since 1985.

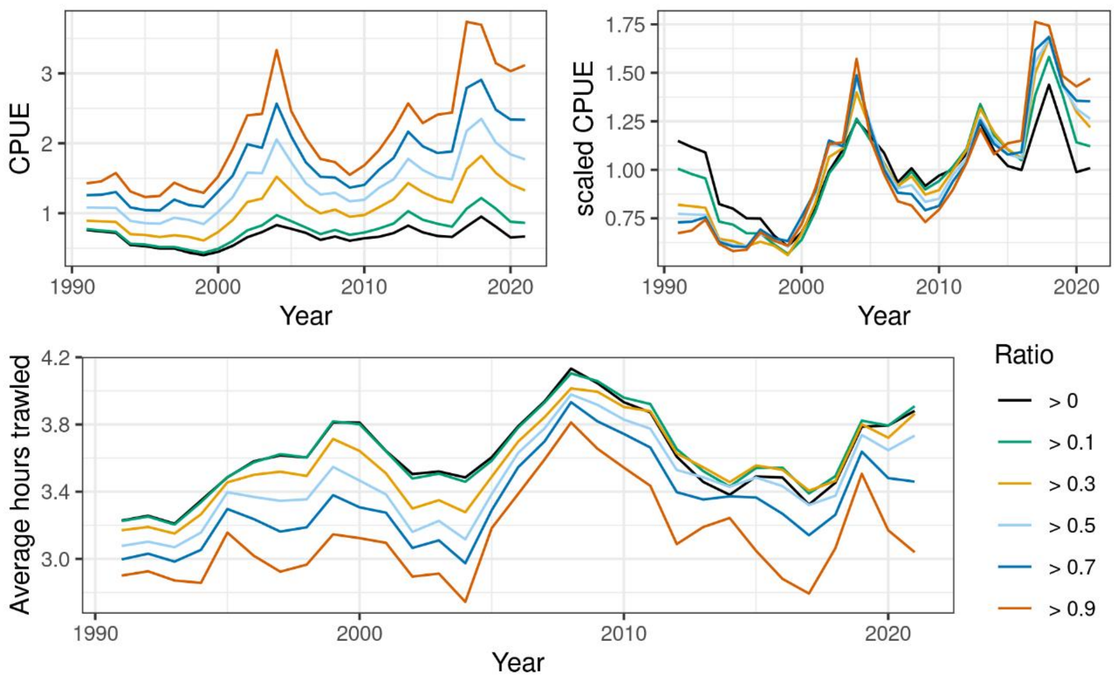


Figure 8.16. CPUE, CPUE scaled to an average of 1 and average numbers of hour trawled. Different colours indicate selection of tows where proportion of saithe of the total catch exceeds certain specified value.

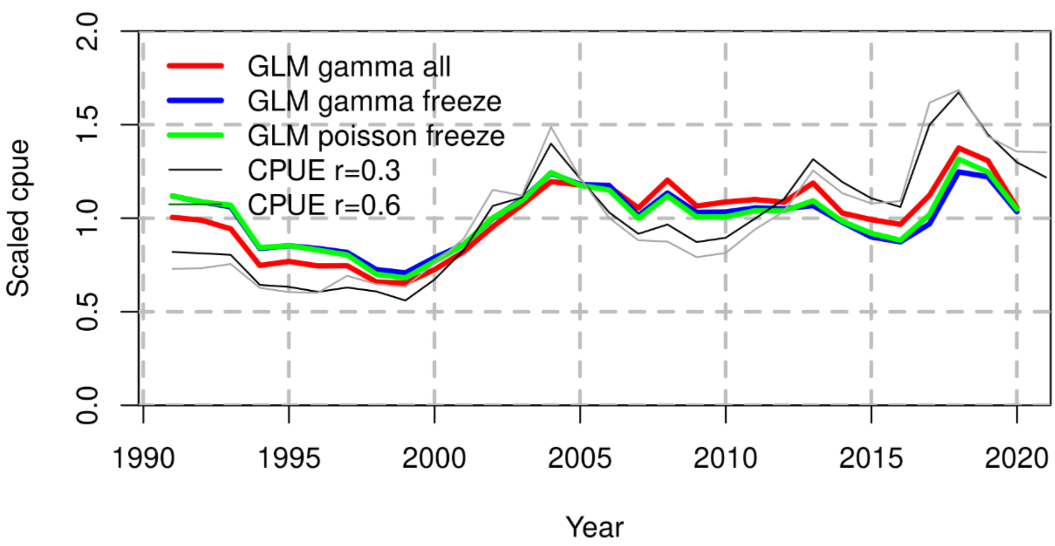


Figure 8.17. CPUE compiled from 3 different models compared to CPUE compiled in similar way as shown in figure 8.16. All curves scaled to an average of 1.

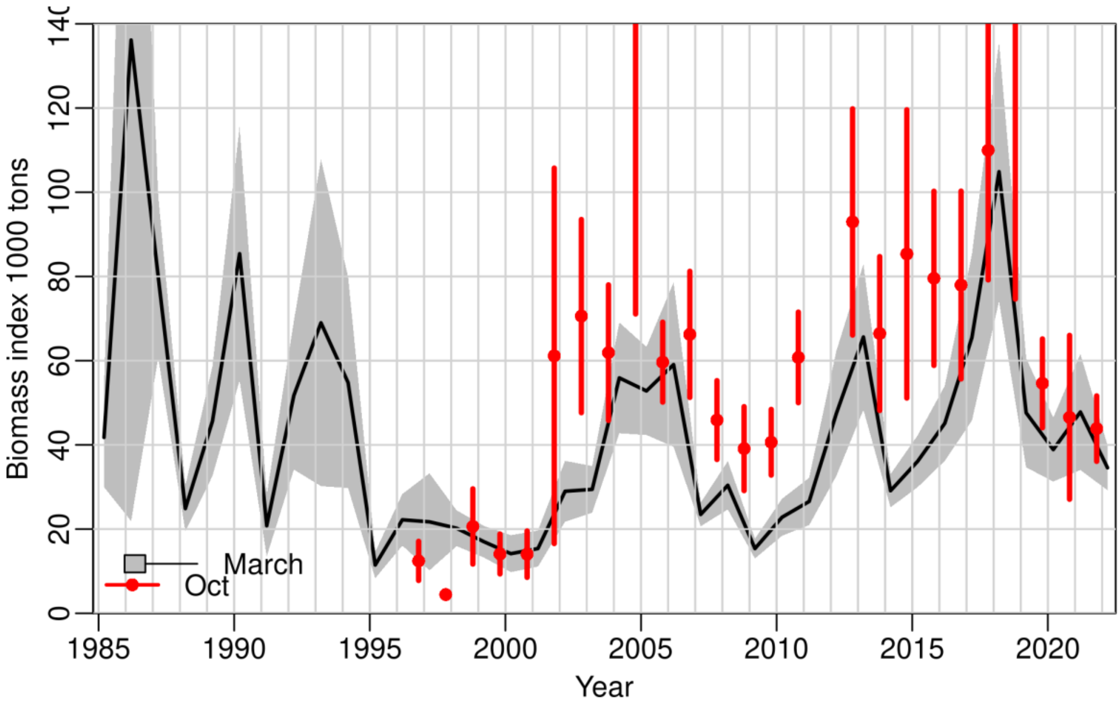


Figure 8.18. Saithe in Division 5.a. Biomass index from the groundfish surveys in March and October.

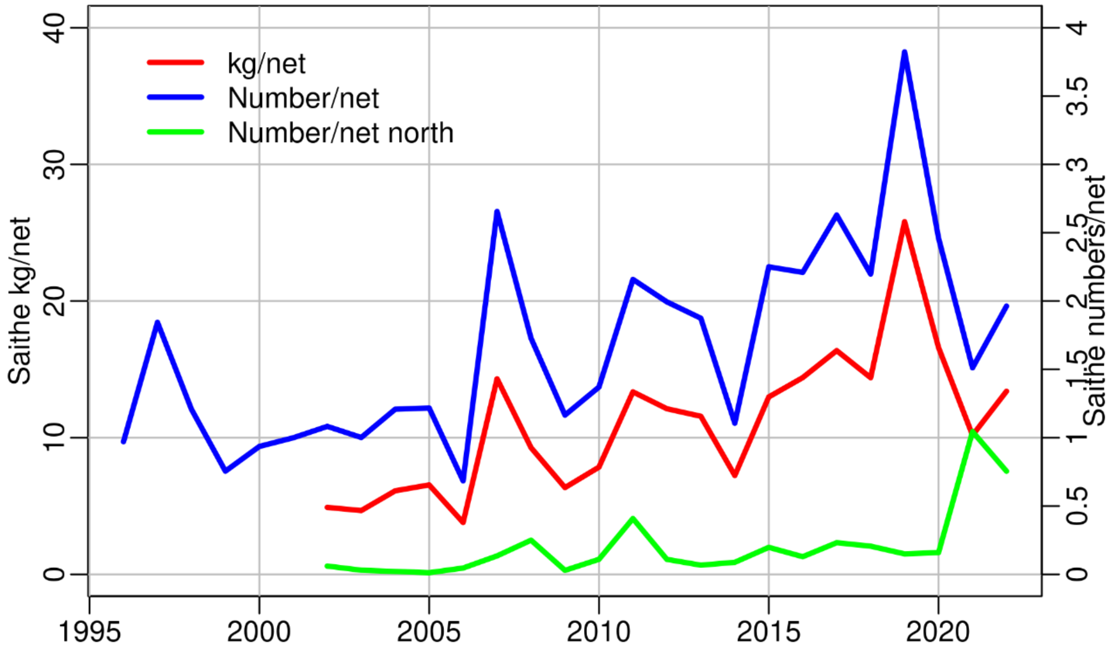


Figure 8.19. Saithe in Division 5.a. Indices from the gillnet survey in April 1996–2022. Saithe was not length measured in the survey before 2002 so catch in kg cannot be compiled.

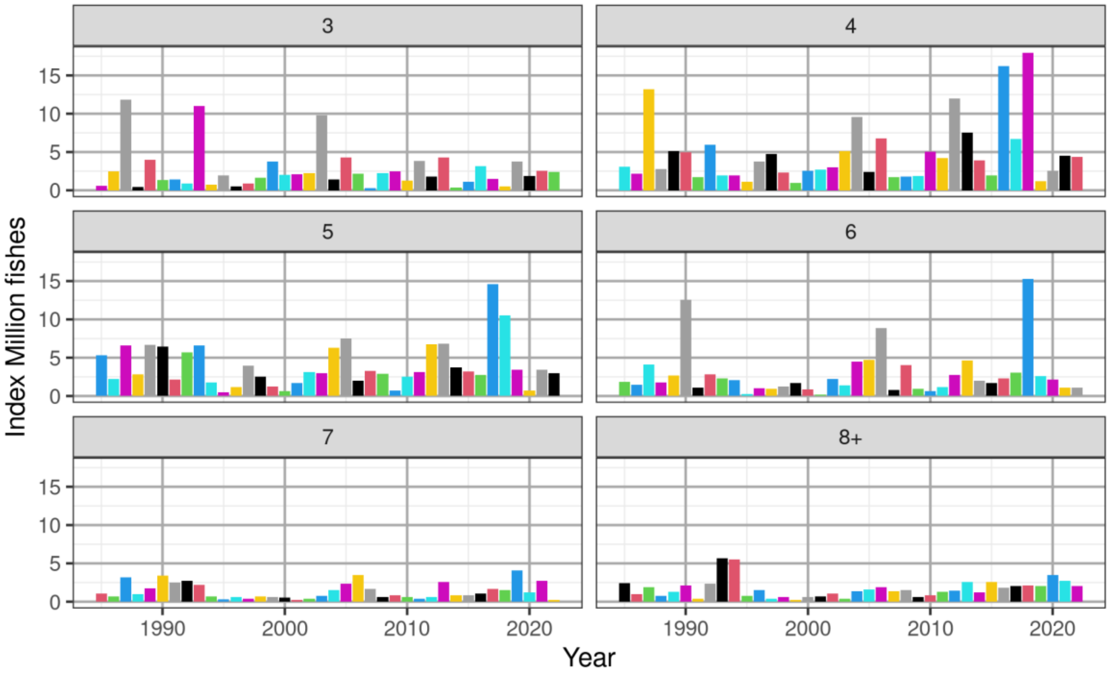


Figure 8.20. Saithe in Division 5.a. Survey indices by age from the spring survey. The colours follows year classes except of course for age 8+.

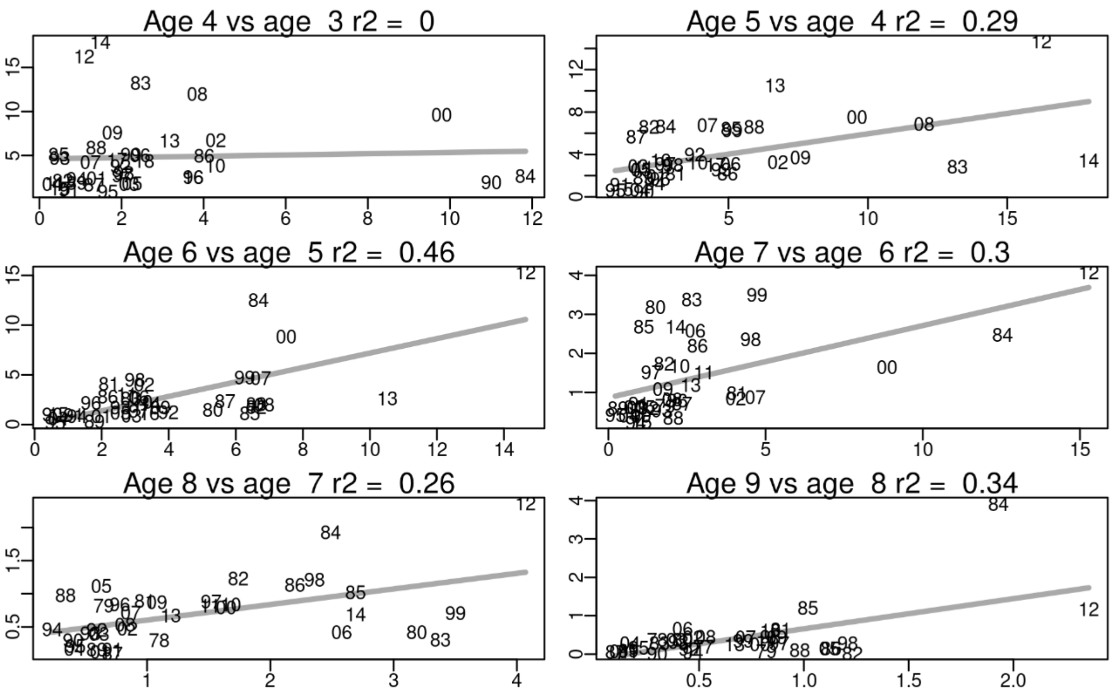


Figure 8.21. Saithe in Division 5.a. Survey indices by age from the spring survey plotted against indices of the same cohort one year earlier.

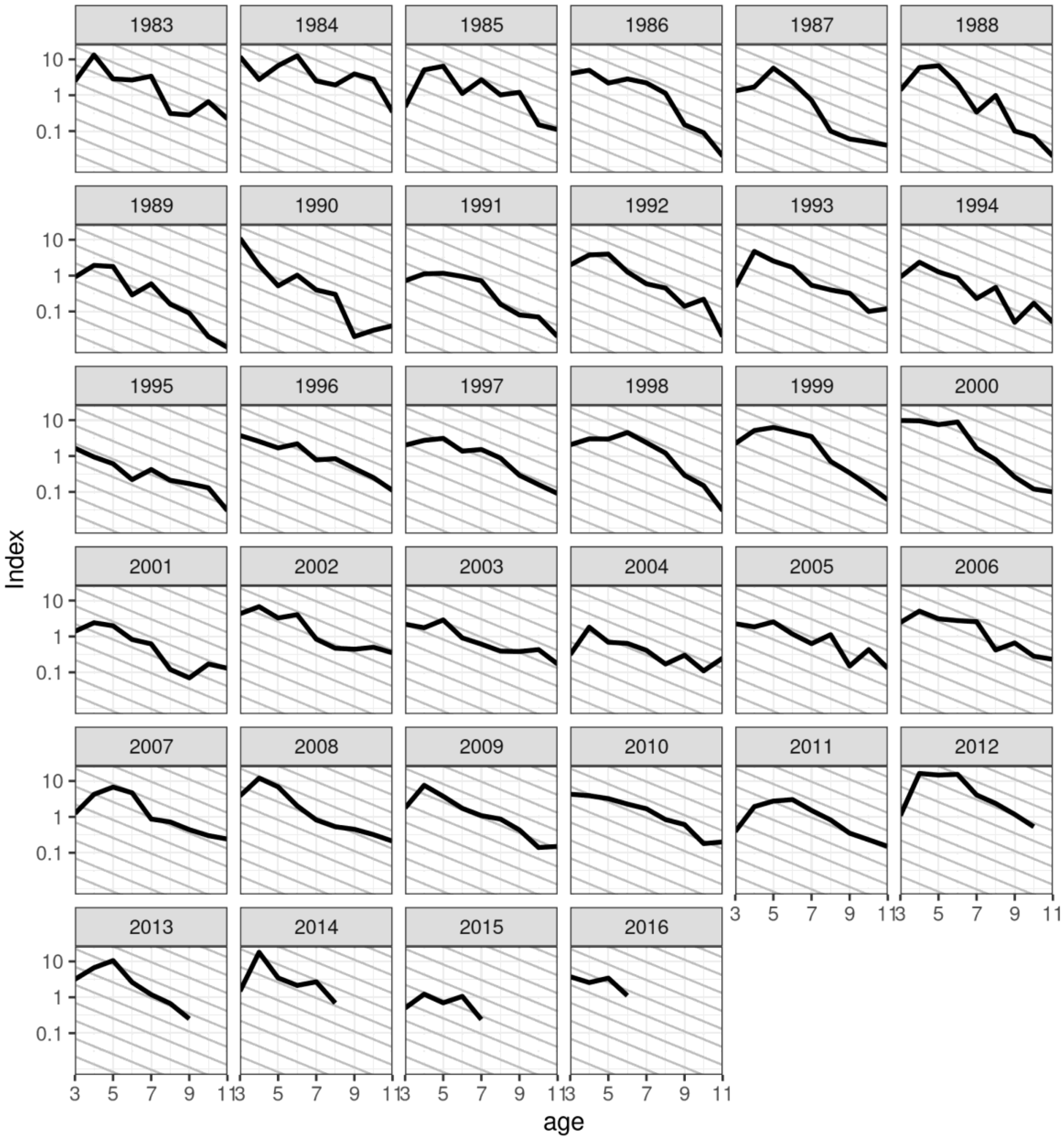
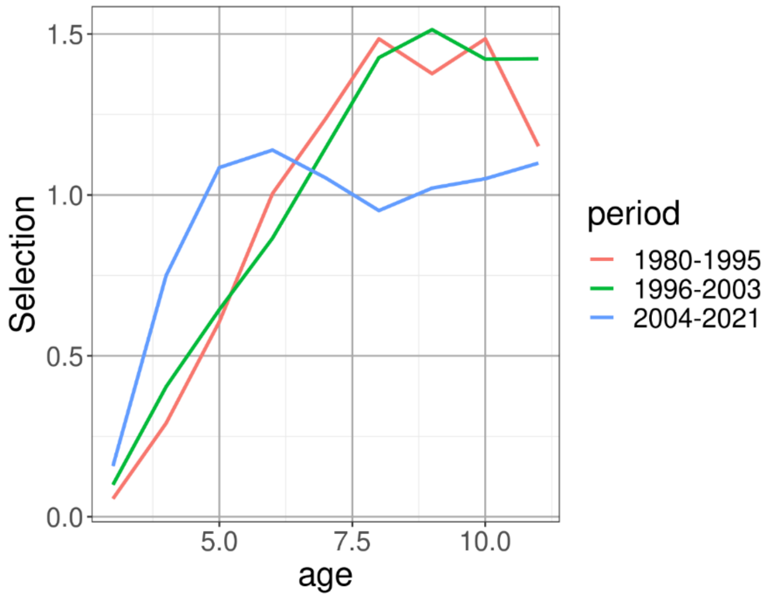


Figure 8.22. Saithe in Division 5.a. Survey indices by age from the spring survey plotted as catch curves for each year class. The grey lines correspond to Z = 0.5.



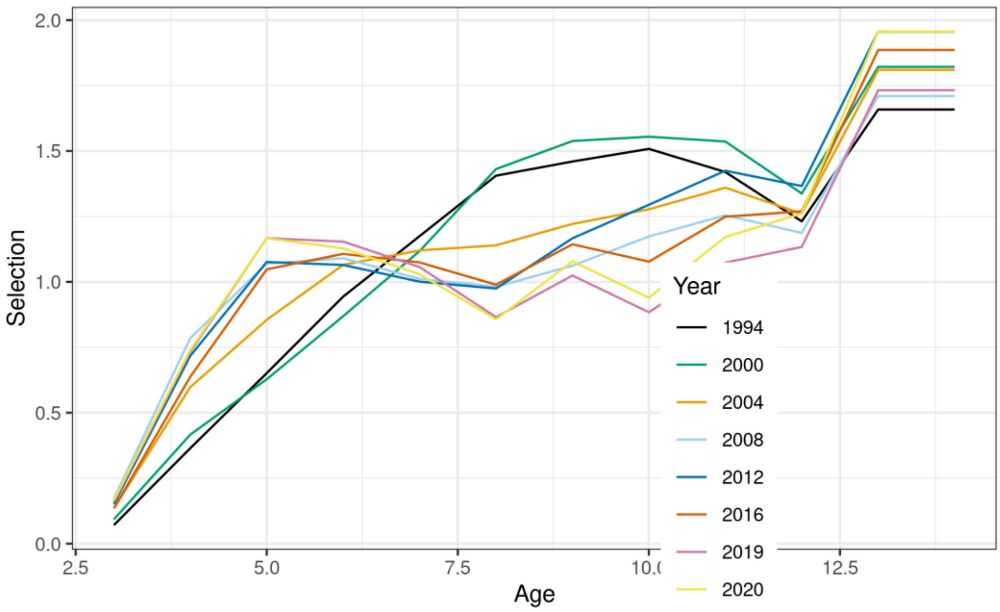


Figure 8.23. Upper figure. Estimated selectivity patterns for the 3 periods, 1980–1996, 1997–2003 and 2004–2020. Lower figure estimated selection from the SAM model. The timing of selection change around 2004 is also evident in the SAM model results.

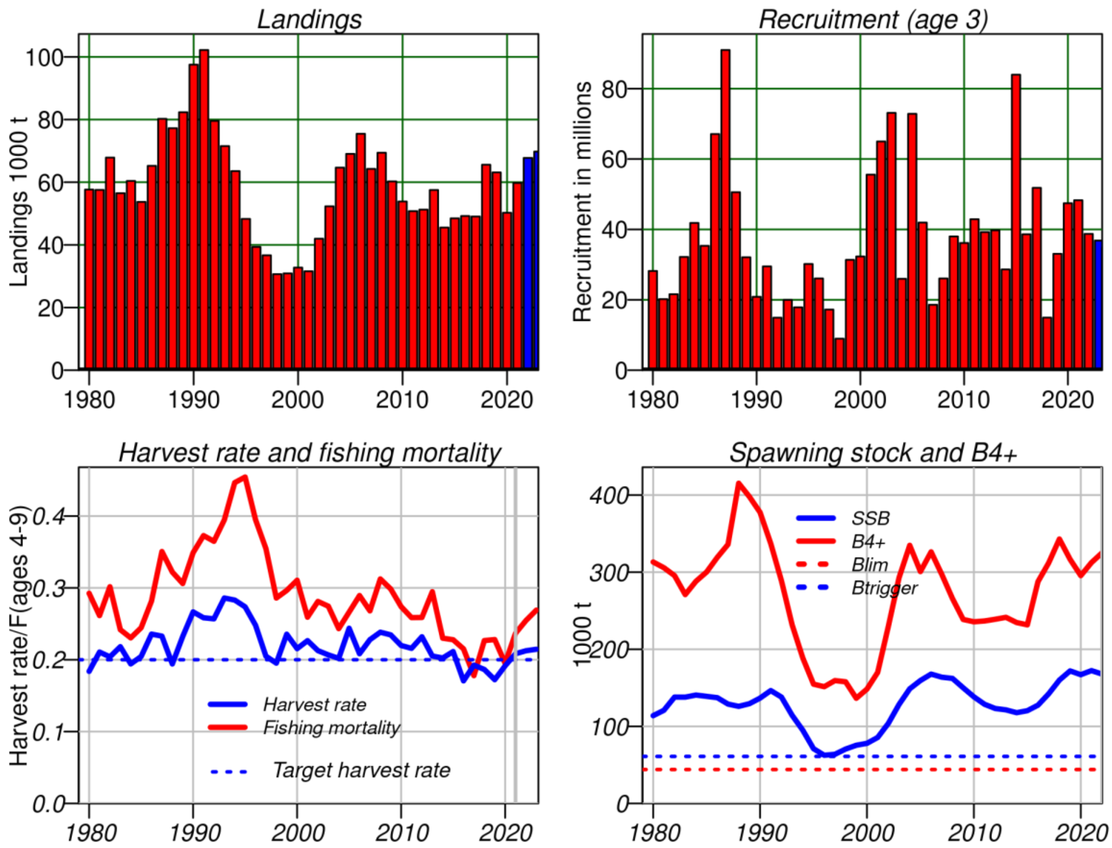


Figure 8.24. Saithe in Division 5.a. Results from the adopted benchmark (SPALY) model and short-term forecast.

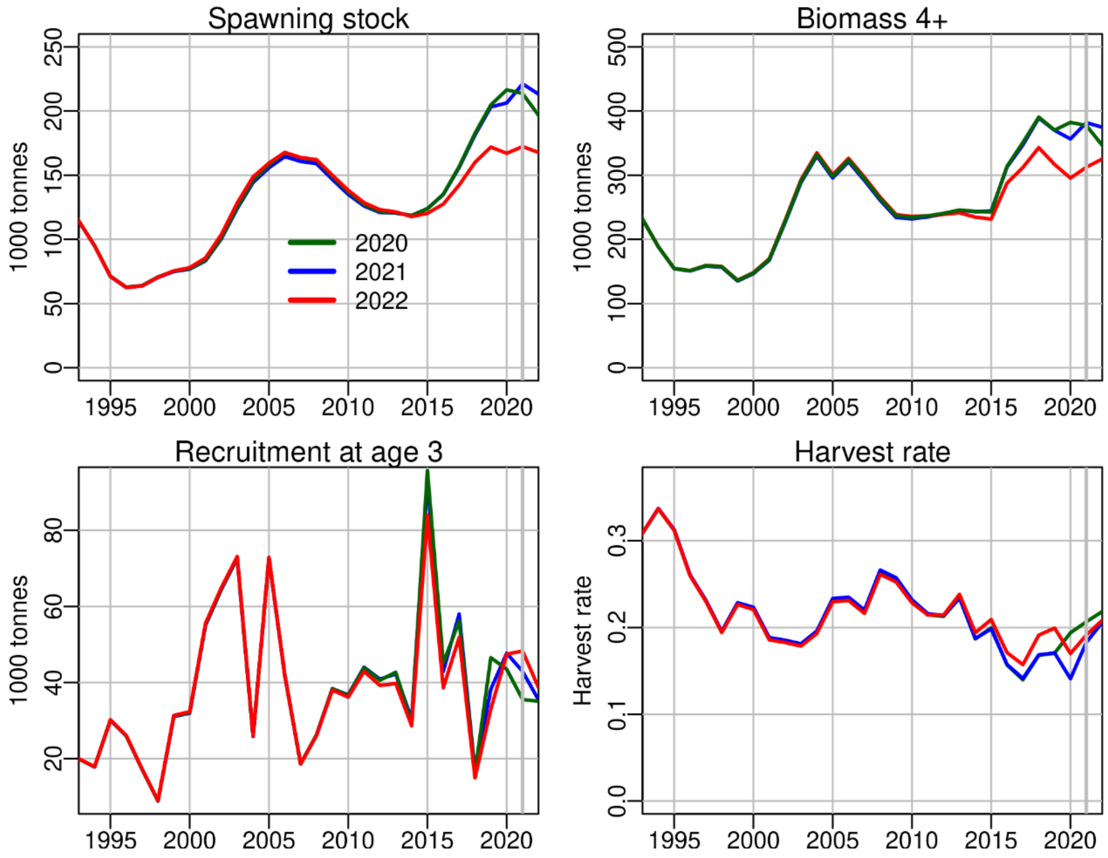


Figure 8.25. Saithe in Division 5.a. Comparison of this year's assessment and short term forecast with results from two earlier years.

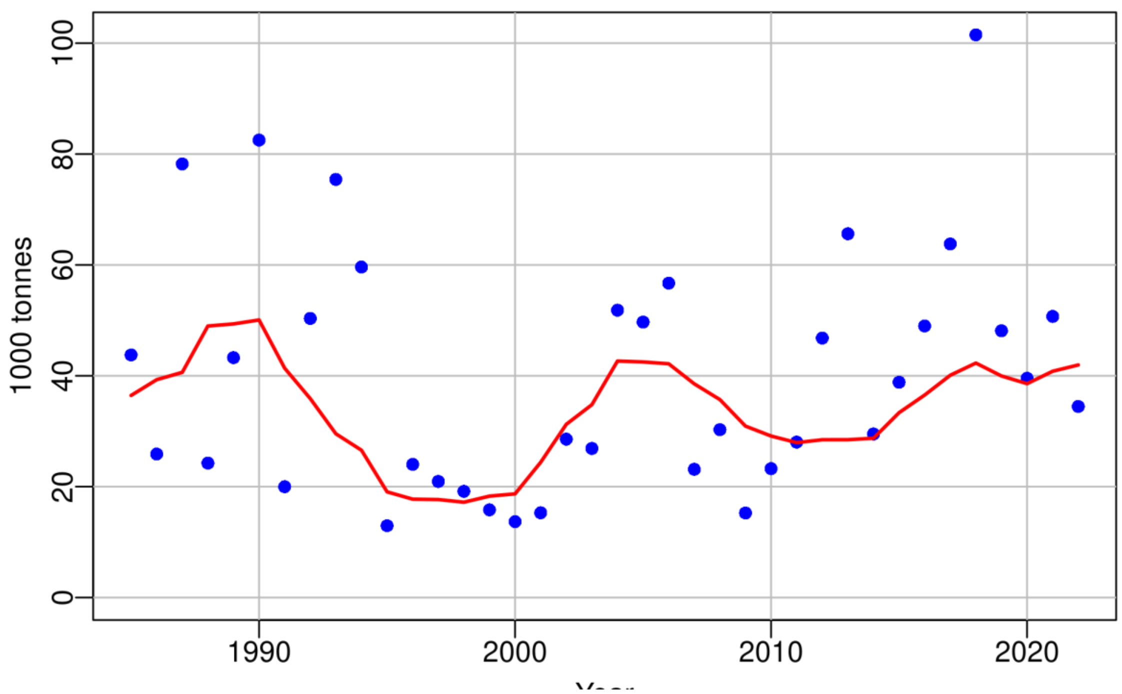


Figure 8.26. Saithe in Division 5.a. Observed and predicted survey biomass from the "SPALY model".

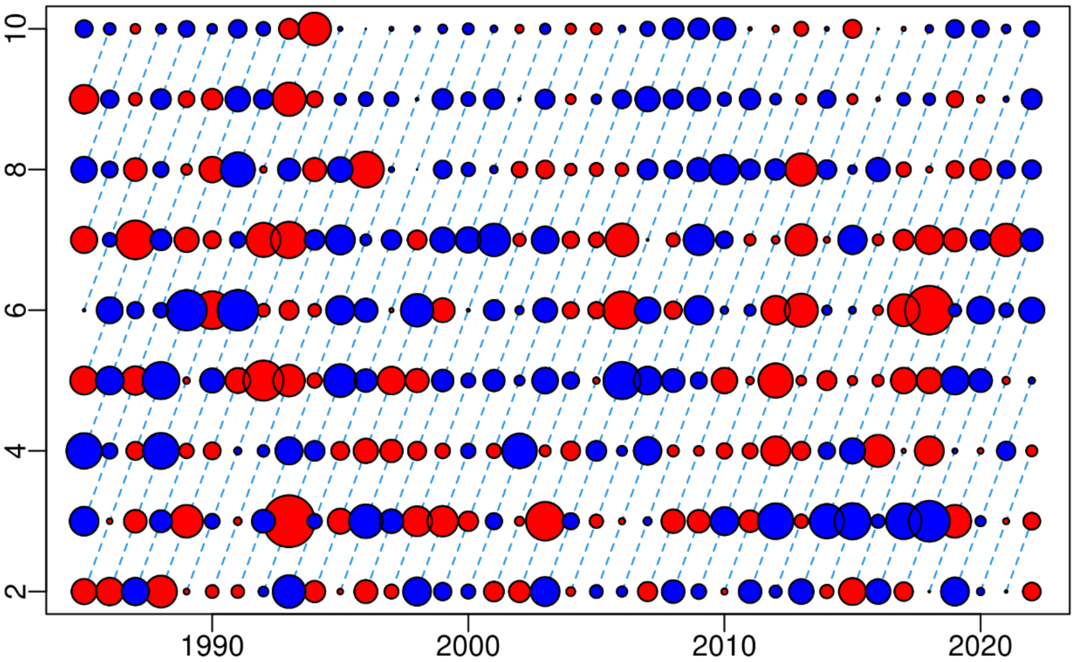


Figure 8.27. Saithe in Division 5.a. Survey residuals from the “Adopted model”. The residuals are standardised.

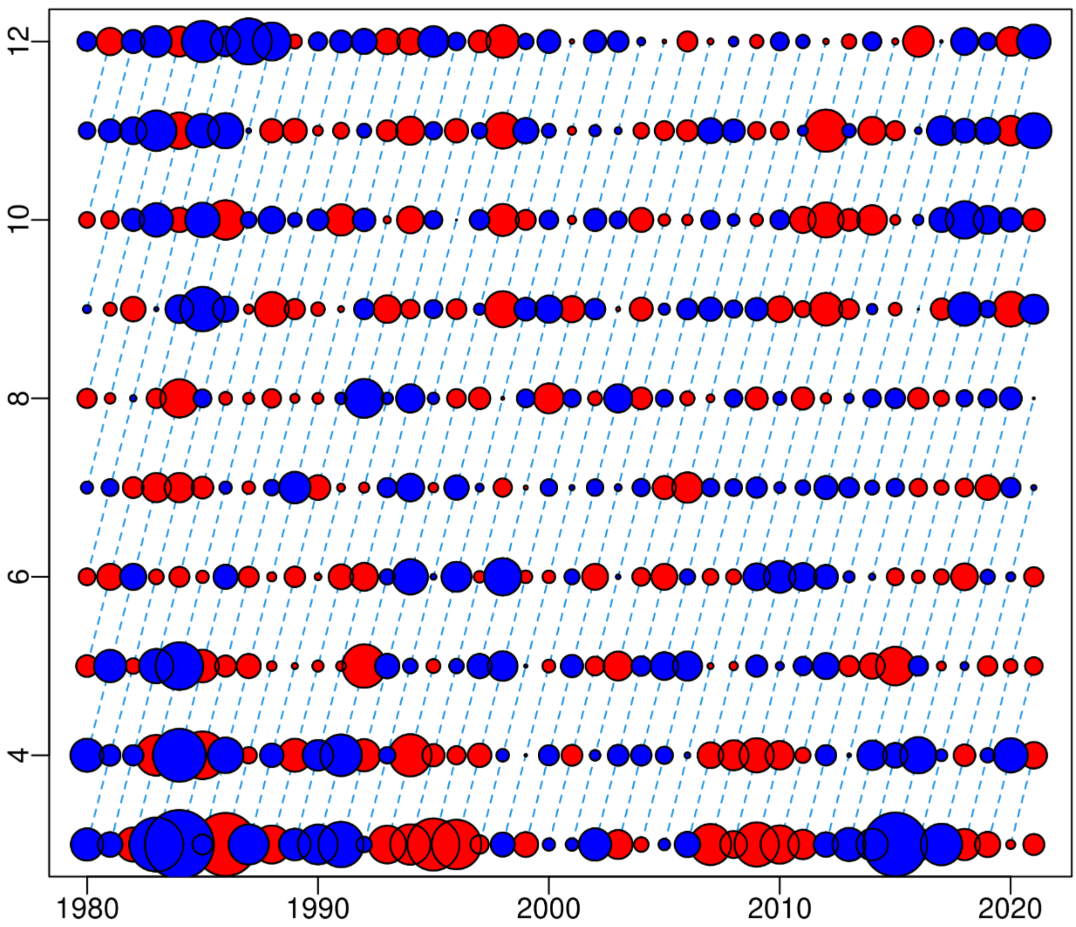


Figure 8.28. Saithe in Division 5.a. Catch residuals from the "Adopted model".

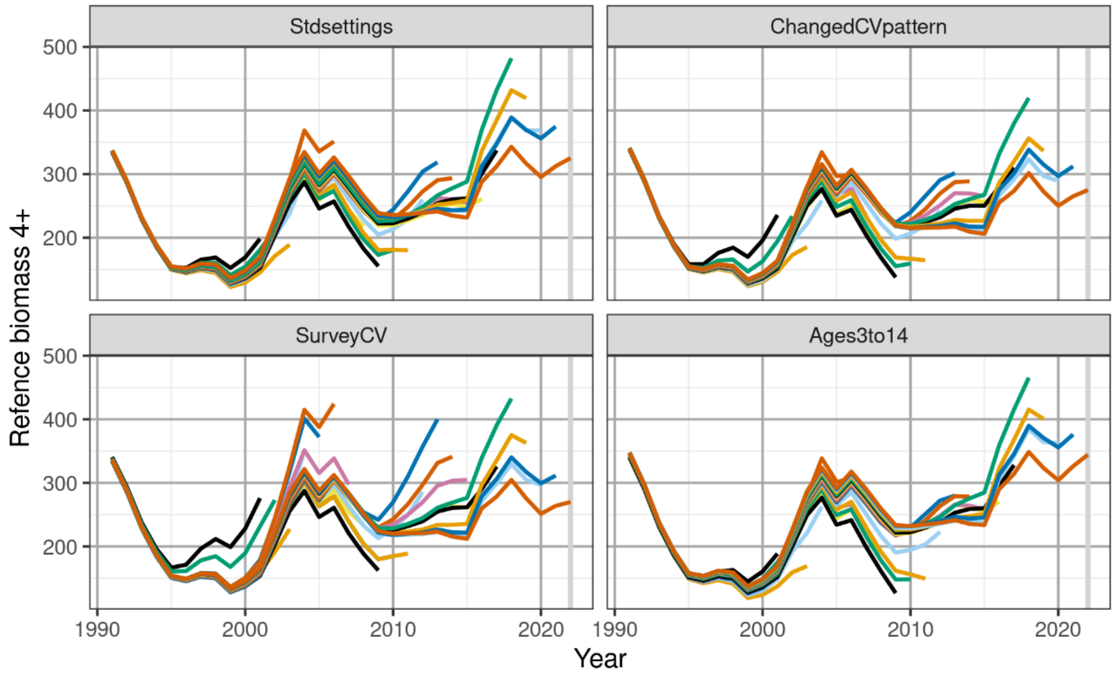


Figure 8.29. Saithe in Division 5.a. Retrospective pattern for the adopted assessment model (Oldsettings) and alternative configurations of the model. The figure shows estimate of B4+, the metric affecting advised catch. The grey vertical lines show the year 2021.

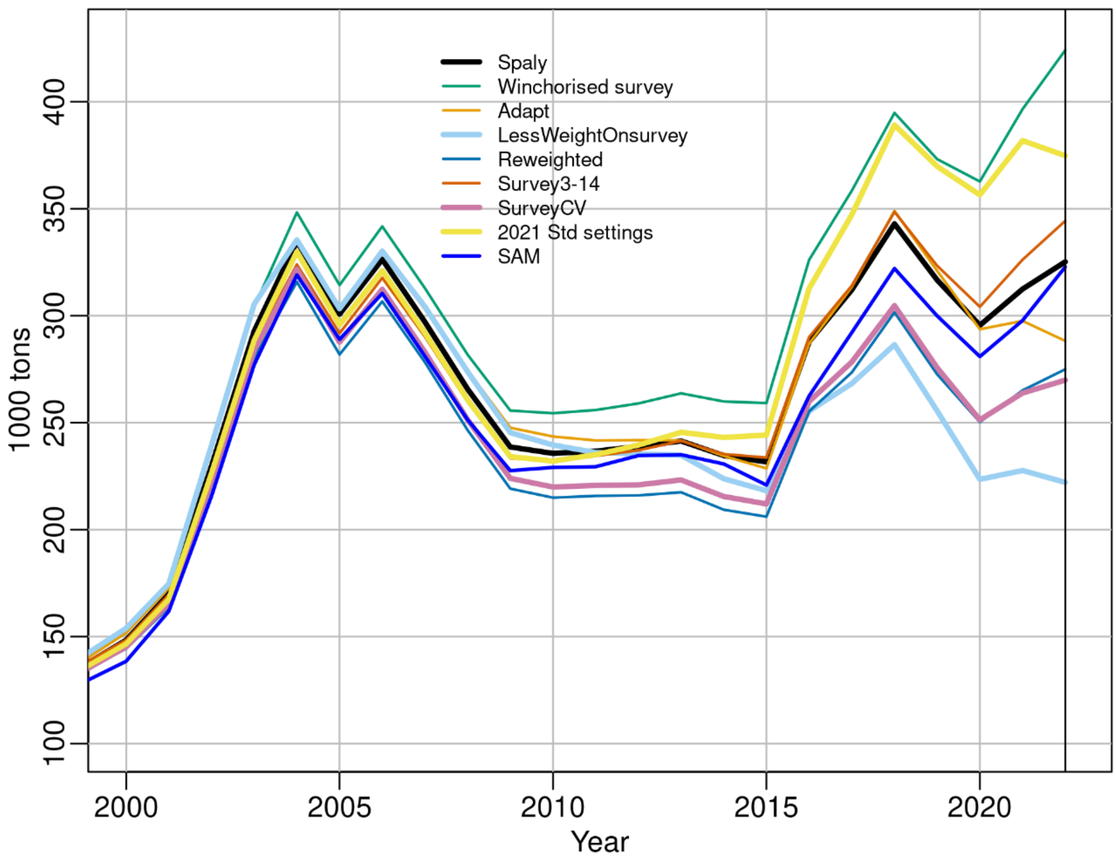


Figure 8.30. Saithe in Division 5.a. Comparison between the default separable model (Muppet) and alternative assessment models and model settings.

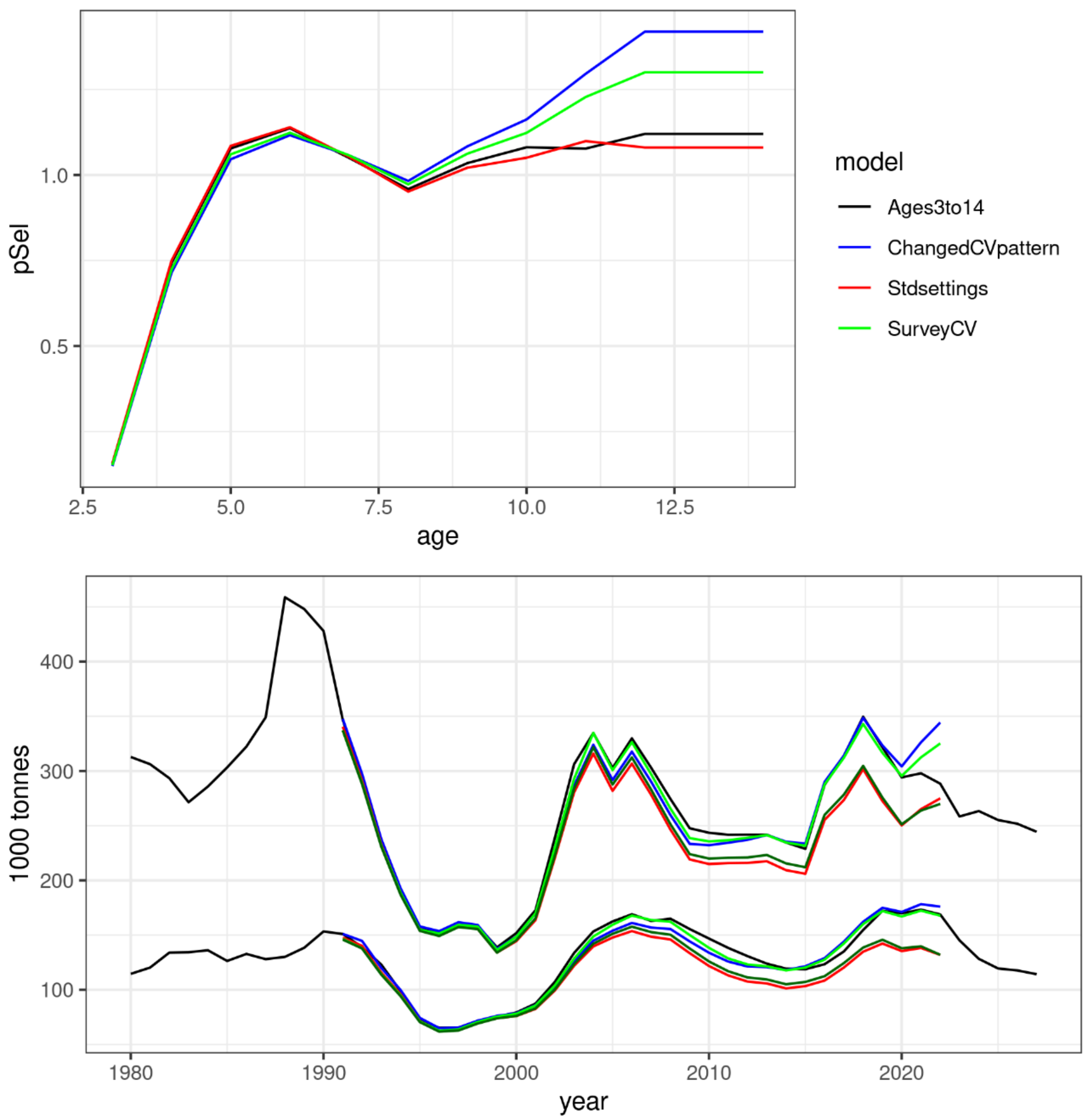


Figure 8.31. Saithe in Division 5a. Comparison between 2022 assessment results of the models shown in Figure 8.29. The Adapt model is added to the list shown there to see the “converged biomass”. The lower figure shows B4+ and SSB.

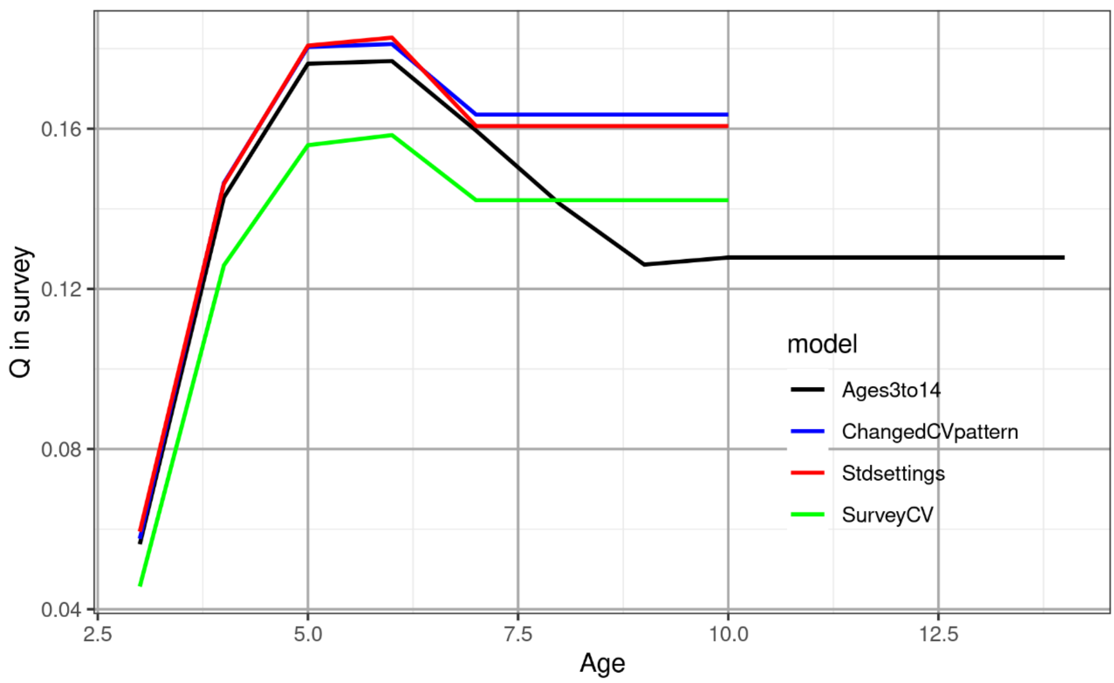


Figure 8.32. Saithe in Division 5a. Q by age in the March survey for the different models.

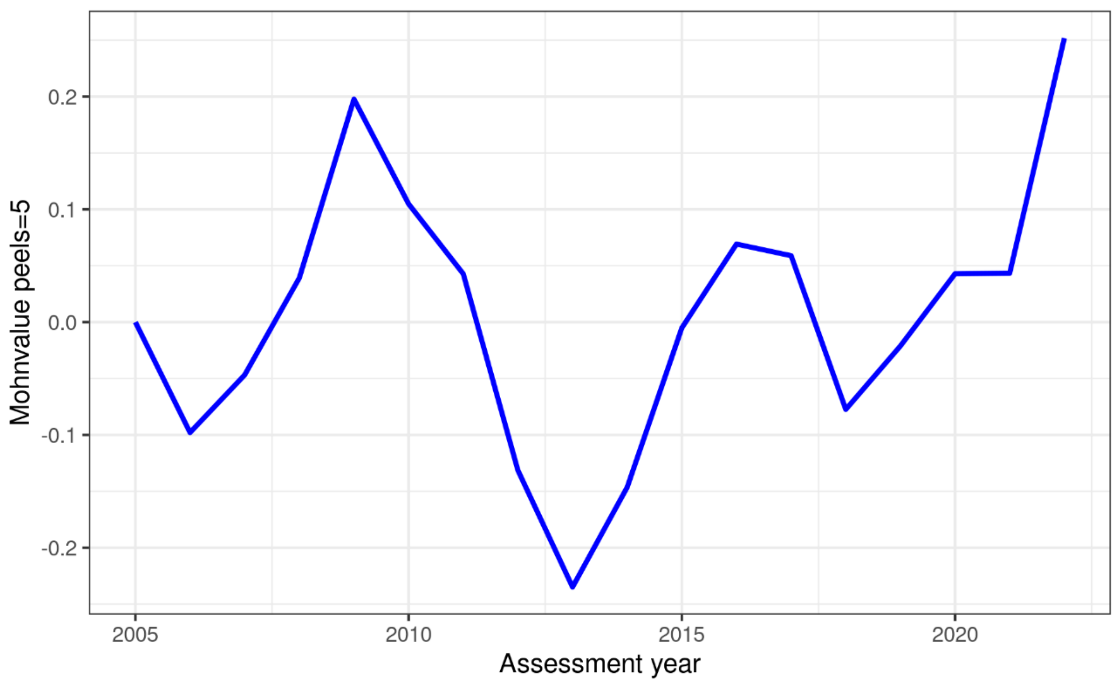


Figure 8.33. Saithe in Division 5a. Retrospective pattern of Mohns rho for B4+.

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:

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

The TAC for the current fishing year (2021/2022) based on last year's assessment was 222.737 kt.

The results of this year's assessment show that the spawning stock in 2022 is estimated to be 356.697 kt. The values estimated in recent years are higher than have been observed during the last five decades. The reference biomass B_{4+} in 2022 is estimated to be 976.59 kt. Fishing mortality is 0.42 in 2021 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 35% 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 (2022/2023) is 209.028 kt based on the following:

$$TAC_{2021/2022} = \left(0.20 * 976.590_{2022} + 222.373_{2021/2022}\right)/2 = 208.846$$

Following the benchmark 2021 the reference biomass upon which the advice is based was approximately 20% lower in recent (non-converged) years than based on setting prior to the benchmark. This in part is reflected in somewhat higher recent 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 1955–2021 (age 3 to 14) and ages 1 to 14 (from the 1985–2022 spring (often referred to as SMB in this report) and ages 3 to 13 from the 1996–2021 fall groundfish surveys (often referred to as SMH in this report).

The advisory outputs are:

Table 1.1: Advice table 1

Variable	Value	Notes
HR_2022	0.22	Catch constraint, tonnes.
SSB_2023	370488	Tonnes.
B4+_2023	1074370	Tonnes.
R3_2022	179427	From the assessment; thousands.
R3_2023	147870	From the assessment; thousands.
R3_2024	127681	From the assessment; thousands.
Catch_2022	215624	Estimated catch until the end of the fishing year (31 August 2022) and estimated catch in the first four months of the next fishing year (1 September–31 December 2022); tonnes.

Table 1.2: Advice table 2

Catch 2022/2023	HR 2023	SSB 2024	B4+ 2024	% SSB change	% TAC change
209028	0.2	393257	1124180	6%	-6%

The reference biomass (B_{4+}) upon which the TAC in the fishing year is set is the sumproduct of the population numbers in the beginning of the assessment year and catch weights in that year. The catch weights are not known and hence need to be predicted. An alternative model to the spaly catch weight prediction model was explored and the WG concluded that it was an improvement. However, under current ICES protocol a working group is not allowed to deviated from the benchmark protocol unless an interbenchmark process is called for, a system that is now already in overload. The WG thus proceeded reluctantly with the spaly model and will patiently wait for passing the alternative model through next benchmark, that for this stock will most likely occur in 2026 or 2027.

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 2021 are estimated to have been 265.729 kt, the bulk taken by the Icelandic fleet.

The share of the catch by different gears in 2021 is according to the following in-text table:

Gear	p
Longline	0.27
Gillnet	0.07
Jiggers	0.06
Scottish seine	0.07
Bottom trawl	0.53

The estimates of landings for the current calendar year of 216 kt is based on the remainder of the quota from the current fishing year (2020/21, 223 kt) on 1 January 2021 (143 kt), the catch that is expected to be taken from 1 September to 31 December 2021 (70 kt, 1/3rd of the advised TAC of 209 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 3.1) 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 2021 at or above the average 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 surveys (Table 3.3 and Figure 3.2).

Prediction of catch weights in 2022: The reference biomass (B_{4+}) upon which the TAC in the fishing year is set is derived from population numbers in the beginning of the assessment year and catch weights. The catch weights are though not known. 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 ($y-1$} (for ages 10 and older the weights from the previous year are used). The same approach was used this year for predicting weight at age in the catches for 2022 (Figure 3.3). I.e. the α and β were estimated from:

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

and the catch weights for 2022 then from:

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

Based on this the mean weights at age in the catches in 2022 are predicted to be quite high for ages 3 and 4 (Figure 3.1) and Table 3.2), even though the weights in the spring survey in those age groups are below or at the long term mean (Figure 3.2). The reason for this is that predication for those age groups are also based on the observations in the older age groups.

An alternative model based using all data from 1990 onwards to estimate α and β **within each age group 3 to 9** (Figure 3.4) was explored:

$$cW_a = \alpha + \beta * sW_a$$

The catch weight in the assessment year would then be predicted using "each age" α and β and the observed stock weights in the assessment year. This alternative model gave a much more plausible estimates of catch weights in 2022 although the reference biomass in the terminal year (2022) was very similar (spaly B_{4+} = 977 kt vs alternative 959 kt). A retrospective analysis, using the current estimates of the parameters α and β, indicated that the overall predictive power of the reference biomass was better (cv of 0.035 vs 0.050, bias -0.0020 vs -0.0049) using the alternative model (Figures 3.5 and 3.6). The alternative model was discussed within the NWWG 2022 and there was a conclusion among the more than dozen scientists that the model was an improvement over the spaly weight prediction model. Under current ICES protocol a working group is not allowed to deviated from the benchmark protocol unless an interbenchmark process is called for, a system that is now already in overload. The WG thus proceeded reluctantly with the spaly model and will patiently wait for passing the alternative model through next benchmark, that for this stock will most likely occur in 2026 or 2027.

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

Biomass indices: The total spring (SMB) and fall survey (SMH) measurements decreased significantly from the highest value observed in 2017 to the 2020 measurement (Figure 3.7). While the 2021 and 2022 spring survey measurement were on par with that observed in 2018 and 2019 the fall survey measurement in 2021 continued to decline, it being the lowest observed since 2004. In general, the two surveys have shown similar trends through time (Figure 3.8) but the contrast through the increase and decline since the late 2000s being greater in the fall survey. The discrepancy between the last two pairs of the spring (2021 and 2022) vs the fall biomass measurements (2000 and 2021) are the highest observed in the time series.

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 3.9). 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 and 2022 spring survey these year classes are however more on par with the 2019 measurement. In the fall survey measurements in the last two years there is a clear indication that most age groups are lower relative to the mean than that observed in the spring survey. It is also clear that the increase in the older age groups in recent years is not as pronounced in the fall survey compared to that observed in the spring survey as well as that observed in the catches.

9.2.2 The 2022 assessment

The framework: A separable statistical catch at age model (sometimes refer 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. This framework was benchmarked in 2021.

Diagnostics: The diagnostic (see Tables 3.8, 3.9 and 3.9 and Figure 3.10) 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. The fall survey residuals in the last 2–3 terminal years are all negative, being most pronounced in the median age groups. A summarised diagnostic of the observed vs predicted survey biomass (Figure 3.11) 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 3.12. The reference biomass is estimated to be 976.59 kt in 2022 and the fishing mortality 0.42 in 2021. The 2016 year class that is now entering the reference biomass is below recent (1985 onwards) average recruitment (20% lower). The reference biomass has decreased somewhat in recent years, in part driven by incoming recruitment being somewhat lower and in part driven by increase in fishing pressure. The first estimates of the 2021 year class indicates that it is somewhat below average, but this year class will not enter the reference biomass until 2025.

Mohn's rho: One of the ToR for this year was to evaluate the retrospective pattern of the assessment (Figure 3.13) and calculate the Mohn's rho values. The default 5-year peels resulted in the following values:

variable	value
fbar	0.043
bio	0.015
ssb	-0.024
rec	0.059

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	0.036
bio	0.012
ssb	-0.004
rec	0.035

Alternative runs: Tuning with each survey alone (Figure 3.15 shows that the spring survey gives somewhat higher biomass than when both surveys are used while the fall survey gives a 10% lower biomass estimates. It is of interest to note that the three runs do not converge and actually show a "crossover" with time. This is in part driven by difference in the estimated selection patterns. The most likely cause is that in an assessment where two surveys are included the catches get less influence than if only one survey is used. It would be of interest to investigate this issue in future stock assessments.

9.2.2.1 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 benchmark 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 being 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.

9.2.2.2 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 than normally because the advice is not for a calendar year but fishing year. It was decided to use the following metric in the summary (Table 3.13) as well as the table in the advice sheet:

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

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 1955–2021.

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
2021	4.071	8.397	9.783	17.340	11.149	4.337	3.344	2.217	1.589	1.180	0.593	0.352

Table 3.2: Icelandic cod in Division 5.a. Estimated mean weight at age in the catch (kg) in period the 1955–2021. The weights for age groups 3 to 9 in 2022 are based on predictions from the 2022 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

year	3	4	5	6	7	8	9	10	11	12	13	14
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
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

year	3	4	5	6	7	8	9	10	11	12	13	14
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	1.273	1.915	3.012	3.656	4.570	5.877	6.974	7.889	8.748	9.307	9.836	10.331
2022	1.501	2.062	2.601	3.875	4.604	5.514	7.126	7.889	8.748	9.307	9.836	10.331

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

year	1	2	3	4	5	6	7	8	9
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
2022	0.014	0.090	0.391	1.118	1.816	3.468	4.412	5.592	7.682

Table 3.4: Icelandic cod in Division 5.a. Estimated weight at age in the spawning stock (kg) in period the 1955–2022. 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

year	3	4	5	6	7	8	9	10	11	12	13	14
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
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

year	3	4	5	6	7	8	9	10	11	12	13	14
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	1.349	2.943	3.818	4.523	6.061	7.879	7.889	8.748	9.307	9.836	10.331
2022	0.965	1.620	2.530	4.285	4.590	5.781	7.753	7.889	8.748	9.307	9.836	10.331

Table 3.5: Icelandic cod in Division 5.a. Estimated maturity at age in period the 1955–2022.

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

year	3	4	5	6	7	8	9	10	11	12	13	14
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
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

year	3	4	5	6	7	8	9	10	11	12	13	14
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	0.985	1.000	1.000	1.000	1
2022	0.000	0.007	0.055	0.425	0.776	0.868	0.975	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	17.19	111.14	35.40	48.28	64.88	23.24	15.48	5.23	3.59	1.96	0.32	0.33	0.09	0.08
1986	15.61	61.09	96.44	22.58	21.75	27.74	7.37	2.86	0.97	0.86	0.32	0.08	0.06	0.04
1987	3.66	28.17	104.43	82.68	21.47	12.84	13.02	2.81	0.99	0.42	0.45	0.23	0.13	0.13
1988	3.45	7.08	73.13	103.75	69.61	8.50	6.59	7.33	0.71	0.29	0.13	0.27	0.06	0.05
1989	4.02	16.39	21.27	75.09	71.48	38.47	4.83	1.71	1.42	0.27	0.19	0.06	0.01	0.01
1990	5.47	11.74	26.44	14.30	27.98	35.30	16.80	1.76	0.58	0.48	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	16.97	33.52	18.79	16.45	6.80	6.33	5.75	1.48	0.23	0.04	0.04	0.04	NA
1993	3.55	4.66	30.75	36.68	13.49	10.59	2.42	2.02	1.39	0.41	0.13	0.03	0.03	0.01
1994	14.23	14.72	9.02	26.93	22.46	6.08	3.95	0.79	0.53	0.50	0.18	0.02	0.03	0.01
1995	1.08	29.27	24.78	9.07	24.56	18.47	4.04	1.92	0.39	0.20	0.24	0.14	0.03	NA
1996	3.71	5.42	42.51	29.69	13.26	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	33.16	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	27.70	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	40.60	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	36.91	29.22	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	42.24	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	25.03	33.76	18.16	36.43	40.35	23.63	22.55	11.86	5.15	2.09	0.88	0.54	0.09

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2018	11.48	14.52	29.97	36.89	16.12	28.83	26.68	15.33	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	19.13	40.24	26.89	34.19	18.07	33.55	21.40	6.79	6.01	5.30	3.19	2.48	1.17	0.38
2022	6.88	18.00	45.36	35.74	40.29	16.81	30.15	10.47	2.92	2.45	1.68	1.16	0.56	0.06

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	11.57	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	5.54	4.87	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	4.01	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	17.96	18.82	5.90	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	6.02	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	2.47	1.68	0.74	0.26	0.16
2020	15.00	8.78	12.79	11.51	4.01	4.04	2.34	1.49	0.90	0.36	0.17
2021	10.07	12.03	6.31	10.32	5.61	1.68	2.17	1.20	0.54	0.38	0.25

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	-0.06
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	0.16	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	-0.32	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	0.04	0.07	-0.03	0.02
1977	-0.55	-0.06	0.04	-0.16	0.19	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	-0.09	-0.02	0.03
1979	0.13	0.25	-0.16	0.01	0.06	0.09	-0.25	-0.03	-0.02	-0.07	-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	0.14	-0.02	0.06
1982	-0.50	-0.04	0.07	-0.08	-0.26	0.18	0.22	0.03	-0.10	-0.23	-0.02	-0.04
1983	-0.85	-0.56	0.12	0.19	0.09	0.09	0.00	-0.08	-0.05	0.06	-0.07	0.03
1984	0.26	0.05	-0.01	0.01	-0.04	0.06	0.02	-0.18	-0.36	-0.08	0.03	-0.01
1985	0.12	0.18	-0.02	0.11	-0.10	-0.03	-0.19	-0.01	-0.08	-0.31	-0.03	0.01
1986	0.31	-0.16	0.05	0.01	0.10	-0.07	0.03	-0.21	-0.02	-0.05	-0.22	-0.02
1987	-0.17	0.13	0.09	-0.13	0.04	0.04	0.01	0.06	-0.08	-0.03	-0.01	-0.04
1988	-0.30	-0.15	0.04	0.15	-0.21	0.07	0.13	0.05	0.18	0.04	0.08	0.01
1989	-0.41	0.04	0.28	0.06	-0.06	-0.20	-0.24	-0.04	0.02	0.06	0.00	-0.02
1990	-0.01	-0.20	-0.03	0.12	0.09	-0.03	-0.16	-0.11	0.05	0.02	0.00	0.01
1991	0.33	0.05	-0.13	-0.03	0.09	-0.09	-0.03	-0.06	-0.03	0.04	-0.01	0.01
1992	0.19	-0.03	0.06	-0.05	-0.06	-0.01	0.00	-0.02	-0.07	-0.05	-0.01	0.00
1993	1.00	0.00	-0.29	-0.09	-0.29	-0.15	0.26	0.56	0.20	0.01	-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	0.03	0.01
1995	0.81	0.21	0.12	-0.08	-0.09	-0.13	-0.16	-0.10	0.01	0.26	0.07	0.02
1996	0.09	0.16	-0.32	0.01	0.08	-0.02	0.02	0.09	-0.03	0.03	0.13	0.01
1997	-0.46	0.14	-0.09	-0.29	-0.09	0.24	0.07	0.20	0.15	-0.02	0.05	0.05
1998	-0.50	-0.25	0.03	0.06	-0.12	-0.20	0.17	0.00	0.07	0.07	0.05	0.01
1999	-0.25	0.01	-0.05	0.10	0.05	-0.17	-0.29	-0.18	-0.08	-0.02	0.00	0.00
2000	0.36	-0.34	0.09	-0.06	-0.03	0.12	-0.06	-0.10	0.05	0.05	0.02	0.01
2001	0.75	0.33	-0.25	0.10	-0.01	-0.15	0.17	0.19	0.03	0.13	0.00	0.06
2002	0.12	0.20	0.10	-0.08	0.07	0.09	0.05	0.27	0.12	0.03	0.06	0.00
2003	-0.05	0.09	0.08	-0.06	0.02	0.15	0.18	-0.06	0.07	0.03	0.03	0.07
2004	-0.48	0.02	0.06	0.00	-0.12	0.15	0.02	0.13	-0.10	0.05	0.02	0.00
2005	0.04	-0.45	0.08	-0.05	-0.19	-0.07	0.20	0.07	0.16	0.06	0.04	0.00
2006	-0.18	-0.05	-0.27	0.14	0.00	-0.04	-0.02	0.13	-0.02	-0.01	-0.02	0.01
2007	-0.31	0.04	-0.15	-0.07	-0.14	0.12	0.08	0.22	0.38	0.00	0.15	-0.01
2008	-0.24	-0.35	0.06	-0.10	0.09	-0.05	0.14	0.19	0.04	0.07	0.04	-0.01
2009	-0.11	-0.25	-0.02	0.20	0.08	0.16	-0.13	-0.24	-0.07	-0.18	0.00	-0.01
2010	-0.03	-0.02	-0.12	-0.02	0.21	0.02	0.10	-0.21	-0.22	-0.10	0.01	0.03
2011	-0.11	-0.03	0.12	0.00	0.06	0.09	-0.09	-0.06	-0.23	-0.28	-0.13	-0.04
2012	-0.18	0.02	0.03	-0.06	0.09	0.16	0.03	-0.25	-0.17	-0.28	-0.12	-0.05
2013	0.39	-0.03	0.02	-0.05	-0.05	-0.04	0.06	-0.02	-0.21	-0.11	-0.10	-0.08
2014	0.03	0.02	0.03	-0.07	0.06	-0.01	-0.02	0.12	0.06	-0.17	0.03	0.06
2015	0.34	0.25	0.02	-0.07	-0.09	0.04	-0.06	-0.02	0.29	-0.19	-0.23	-0.05
2016	0.07	0.21	-0.13	-0.01	0.10	-0.03	0.06	0.02	-0.04	0.14	-0.18	-0.16
2017	0.27	0.29	0.16	-0.07	-0.09	-0.09	-0.05	0.11	-0.08	-0.09	0.07	0.01
2018	0.10	0.23	0.02	0.06	-0.03	0.11	-0.07	-0.19	-0.13	-0.10	-0.23	-0.01
2019	-0.13	-0.30	-0.04	-0.04	-0.16	-0.12	0.13	0.29	0.29	0.05	0.08	0.06
2020	-0.38	0.17	0.11	0.15	0.00	-0.22	-0.10	0.12	-0.04	-0.03	0.16	0.22
2021	-0.07	-0.29	-0.09	0.10	0.05	-0.05	-0.07	-0.08	0.38	0.22	0.26	0.39

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	0.00	0.25	0.48	0.08	0.34	0.47	0.22	0.20	0.42	-0.03	-0.31	-0.10	0.09
1986	0.35	-0.17	-0.45	-0.22	-0.06	-0.11	-0.11	-0.26	-0.25	-0.12	-0.15	-0.12	-0.33	-0.04
1987	0.62	-0.11	0.04	-0.52	0.05	-0.02	-0.02	-0.02	-0.06	-0.04	0.15	0.12	0.16	0.09
1988	-0.24	-0.10	0.47	0.10	-0.11	-0.29	0.17	0.54	-0.06	-0.08	-0.02	0.26	0.01	0.08
1989	0.29	0.03	0.54	0.51	0.23	0.12	-0.03	-0.10	0.19	0.01	0.15	0.02	-0.07	-0.02
1990	-0.56	0.03	0.10	0.08	-0.15	-0.36	0.03	-0.13	-0.08	0.07	0.07	-0.10	0.05	0.06
1991	-0.01	-0.59	0.04	0.21	0.33	0.04	-0.01	-0.13	0.23	0.09	0.13	-0.09	0.14	0.16
1992	-0.28	0.15	-0.23	0.07	-0.04	0.00	-0.13	-0.10	0.04	0.02	-0.08	-0.02	0.07	-0.01
1993	-0.50	-0.12	0.34	-0.09	0.09	0.15	-0.06	-0.02	-0.01	0.03	0.14	0.01	0.04	0.02
1994	0.53	-0.31	0.06	0.17	-0.18	-0.21	0.03	-0.11	-0.03	0.09	0.12	0.00	0.05	0.01
1995	-0.33	0.14	-0.20	-0.08	0.22	0.02	-0.08	0.02	0.01	-0.08	0.13	0.19	0.05	-0.01
1996	-0.71	-0.29	0.12	-0.12	0.19	-0.01	0.28	0.49	0.23	0.04	-0.05	0.30	0.18	0.11
1997	0.22	-0.10	0.15	0.32	-0.06	0.01	-0.06	0.21	-0.38	-0.20	0.22	0.01	0.26	0.21
1998	-0.06	0.16	-0.19	0.18	0.54	0.30	0.11	0.13	0.32	0.28	0.09	-0.07	0.02	-0.02
1999	0.08	0.23	-0.05	0.09	0.01	0.09	0.01	-0.06	-0.13	0.02	0.07	0.05	-0.02	-0.01
2000	0.86	0.23	0.36	-0.17	-0.02	-0.07	-0.21	0.03	-0.31	-0.23	-0.26	-0.03	0.06	0.02
2001	0.14	-0.02	0.12	-0.05	-0.49	-0.18	-0.27	-0.58	-0.31	0.05	-0.06	0.06	0.09	0.04
2002	-0.27	0.22	0.15	0.15	0.09	0.04	-0.11	-0.21	-0.42	-0.18	-0.05	-0.09	-0.05	-0.01
2003	-0.14	-0.40	0.03	-0.05	-0.08	-0.26	-0.07	-0.01	0.16	-0.45	-0.09	-0.06	0.16	-0.02
2004	-0.15	0.23	-0.20	0.32	0.17	0.34	0.23	0.30	0.55	0.21	0.16	-0.12	-0.03	0.01
2005	-0.26	0.11	0.25	-0.16	0.11	0.08	-0.05	0.03	0.05	0.24	0.23	0.30	0.02	-0.01
2006	0.13	-0.09	0.04	0.13	-0.06	0.15	-0.17	-0.35	-0.33	-0.16	-0.17	-0.06	-0.06	-0.02
2007	-0.03	0.23	-0.33	-0.17	-0.09	-0.07	-0.39	-0.10	0.00	-0.09	0.24	0.06	-0.02	-0.02
2008	-0.12	0.04	0.01	-0.40	-0.19	-0.07	0.21	-0.09	0.02	-0.24	0.04	0.06	0.02	-0.02
2009	0.20	-0.13	-0.10	-0.13	-0.07	-0.04	-0.10	-0.01	-0.26	-0.21	-0.32	-0.16	0.10	0.03
2010	-0.17	-0.26	-0.15	-0.14	-0.07	-0.10	-0.08	-0.09	0.25	-0.05	-0.15	0.00	-0.08	0.02
2011	-0.79	-0.35	-0.40	-0.23	0.01	0.12	0.15	0.08	-0.07	-0.21	-0.05	-0.25	-0.10	-0.05
2012	0.09	-0.33	-0.19	0.20	0.42	0.38	0.39	0.25	0.12	0.12	0.20	-0.09	0.26	0.15
2013	-0.04	0.16	-0.25	-0.17	0.04	0.07	0.01	0.18	0.47	0.08	0.10	0.36	-0.18	0.29
2014	0.00	0.21	-0.08	-0.12	-0.06	0.06	-0.06	-0.22	-0.28	0.00	-0.50	-0.23	-0.10	-0.01
2015	0.49	0.35	-0.05	-0.11	-0.30	0.04	0.02	0.32	-0.07	0.03	0.15	-0.25	-0.30	0.03
2016	0.77	0.38	0.24	0.11	0.15	0.09	0.17	0.05	0.09	-0.20	-0.24	0.17	-0.24	-0.12
2017	-0.23	0.05	0.05	0.24	0.04	0.06	0.11	0.12	0.27	0.40	0.22	-0.02	0.26	-0.23
2018	0.05	0.32	-0.16	0.02	-0.03	-0.03	-0.12	0.13	-0.21	-0.17	-0.29	-0.23	-0.26	-0.11
2019	-0.03	0.14	-0.09	-0.24	-0.15	-0.13	-0.13	-0.03	0.35	0.24	0.08	0.03	-0.02	-0.32
2020	0.28	-0.15	-0.39	-0.59	-0.72	-0.63	-0.48	-0.26	-0.09	0.26	0.38	0.47	0.09	-0.31
2021	0.42	0.20	0.14	0.07	-0.08	0.13	0.02	-0.07	0.02	0.36	0.65	0.67	0.59	0.32
2022	-0.14	-0.15	-0.06	0.30	0.23	-0.06	0.32	-0.14	-0.16	-0.11	-0.03	0.35	0.11	-0.27

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	-0.15	-0.31	-0.11	-0.09	0.22	0.28	-0.10	0.01	-0.04	0.06	0.01
1997	-0.15	0.21	0.06	-0.06	-0.19	-0.13	-0.23	-0.03	-0.04	0.03	0.08
1998	-0.35	-0.05	-0.03	0.41	0.54	0.10	0.25	0.04	-0.01	0.03	0.01
1999	0.10	0.11	0.13	-0.01	-0.09	-0.41	-0.32	0.13	-0.04	-0.04	0.14
2000	-0.40	-0.20	-0.16	-0.25	-0.39	-0.27	0.01	0.16	0.07	0.01	0.02
2001	-0.02	-0.03	-0.27	-0.24	-0.24	-0.52	-0.47	-0.17	0.10	-0.01	-0.01
2002	-0.31	0.16	0.01	0.25	0.09	0.10	0.02	-0.22	0.26	0.00	0.07
2003	-0.03	-0.23	-0.12	-0.22	-0.15	0.20	-0.03	-0.23	0.04	0.01	0.02
2004	0.01	0.12	0.18	0.12	0.29	0.49	0.58	0.14	0.06	0.11	-0.01
2005	0.01	-0.02	0.31	0.00	-0.27	-0.22	-0.12	0.04	-0.05	0.07	0.04
2006	0.05	0.12	0.12	0.08	0.07	-0.15	0.03	0.01	0.02	-0.05	0.01
2007	-0.51	-0.26	0.01	0.03	-0.14	0.09	-0.20	0.14	-0.05	0.09	-0.02
2008	0.05	-0.11	0.19	0.33	0.34	0.32	-0.03	0.21	0.13	0.14	0.00
2009	0.16	0.15	0.27	0.17	0.24	0.31	0.27	0.17	0.08	0.15	0.00
2010	0.15	0.23	0.20	0.05	0.21	0.30	0.48	0.15	0.21	-0.10	0.14
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	-0.14	-0.24	-0.17	-0.09	0.07	0.28	0.04	0.02	0.23	-0.17	0.05
2013	-0.05	-0.17	-0.09	-0.06	-0.01	0.11	0.31	0.16	0.21	0.41	0.16
2014	0.17	-0.03	-0.07	0.04	-0.05	0.13	0.19	0.50	0.37	0.36	0.39
2015	0.63	0.42	0.16	0.26	0.24	-0.05	0.08	-0.27	-0.04	0.06	0.02
2016	0.07	-0.13	-0.09	-0.27	-0.14	-0.16	-0.16	0.02	-0.08	0.19	-0.06
2017	0.48	0.62	0.49	0.46	0.21	0.11	-0.02	-0.07	0.13	0.04	0.30
2018	0.01	-0.03	-0.16	-0.18	0.00	0.20	0.05	0.04	-0.03	0.00	-0.11
2019	0.60	0.13	-0.06	-0.05	-0.15	-0.33	-0.21	-0.24	-0.29	-0.20	-0.04
2020	-0.16	-0.21	-0.41	-0.27	-0.36	-0.30	-0.40	0.03	-0.12	-0.15	-0.01
2021	-0.36	-0.43	-0.53	-0.39	-0.46	-0.57	-0.21	-0.26	-0.15	-0.10	0.08

Table 3.11: Icelandic cod in Division 5.a. Estimates of fishing mortality 1955–2021 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	0.96	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	0.52	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	0.86	0.84	0.80	0.67	0.71	0.71	0.71
1977	0.04	0.19	0.33	0.48	0.60	0.70	0.68	0.65	0.54	0.57	0.57	0.57
1978	0.03	0.15	0.27	0.38	0.49	0.57	0.55	0.53	0.44	0.46	0.46	0.46
1979	0.03	0.15	0.25	0.36	0.46	0.54	0.52	0.50	0.41	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	0.48	0.48	0.48
1981	0.04	0.20	0.36	0.51	0.65	0.75	0.73	0.70	0.58	0.62	0.62	0.62
1982	0.05	0.23	0.41	0.58	0.74	0.86	0.84	0.80	0.66	0.70	0.70	0.70
1983	0.04	0.22	0.38	0.55	0.69	0.80	0.78	0.74	0.62	0.66	0.66	0.66
1984	0.04	0.20	0.36	0.51	0.64	0.75	0.73	0.69	0.58	0.61	0.61	0.61
1985	0.05	0.23	0.40	0.57	0.72	0.84	0.82	0.78	0.65	0.69	0.69	0.69
1986	0.06	0.28	0.48	0.69	0.88	1.02	1.00	0.95	0.79	0.84	0.84	0.84
1987	0.06	0.29	0.51	0.73	0.93	1.08	1.06	1.00	0.83	0.89	0.89	0.89
1988	0.06	0.30	0.52	0.75	0.95	1.10	1.08	1.02	0.85	0.90	0.90	0.90
1989	0.05	0.25	0.43	0.62	0.78	0.91	0.89	0.84	0.70	0.74	0.74	0.74
1990	0.05	0.25	0.44	0.63	0.79	0.92	0.90	0.86	0.71	0.75	0.75	0.75
1991	0.06	0.30	0.52	0.75	0.94	1.10	1.07	1.02	0.85	0.90	0.90	0.90
1992	0.07	0.33	0.58	0.83	1.05	1.22	1.19	1.13	0.94	1.00	1.00	1.00
1993	0.07	0.32	0.57	0.81	1.03	1.20	1.17	1.11	0.92	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	0.81	0.79	0.75	0.63	0.66	0.66	0.66
1995	0.04	0.14	0.30	0.45	0.58	0.66	0.73	0.77	0.79	0.77	0.77	0.77
1996	0.03	0.13	0.28	0.43	0.55	0.63	0.69	0.73	0.75	0.74	0.74	0.74
1997	0.03	0.13	0.29	0.44	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	0.77	0.85	0.91	0.93	0.91	0.91	0.91
1999	0.05	0.19	0.41	0.62	0.80	0.91	1.00	1.06	1.09	1.07	1.07	1.07
2000	0.05	0.19	0.42	0.63	0.81	0.92	1.02	1.08	1.11	1.09	1.09	1.09
2001	0.05	0.18	0.39	0.58	0.75	0.85	0.94	1.00	1.02	1.00	1.00	1.00
2002	0.04	0.15	0.32	0.48	0.62	0.70	0.78	0.82	0.84	0.83	0.83	0.83
2003	0.04	0.14	0.31	0.47	0.60	0.69	0.76	0.80	0.82	0.81	0.81	0.81
2004	0.04	0.15	0.33	0.50	0.64	0.73	0.81	0.86	0.88	0.86	0.86	0.86
2005	0.04	0.14	0.32	0.48	0.61	0.70	0.77	0.82	0.84	0.83	0.83	0.83
2006	0.04	0.14	0.30	0.45	0.58	0.66	0.73	0.78	0.80	0.78	0.78	0.78
2007	0.03	0.13	0.28	0.42	0.54	0.61	0.67	0.71	0.73	0.72	0.72	0.72
2008	0.04	0.11	0.20	0.32	0.39	0.48	0.47	0.49	0.49	0.62	0.62	0.62
2009	0.04	0.12	0.21	0.34	0.41	0.51	0.50	0.53	0.53	0.67	0.67	0.67
2010	0.03	0.10	0.18	0.29	0.35	0.43	0.43	0.45	0.45	0.57	0.57	0.57
2011	0.03	0.09	0.17	0.27	0.33	0.41	0.40	0.42	0.42	0.53	0.53	0.53
2012	0.03	0.10	0.17	0.27	0.33	0.41	0.41	0.43	0.42	0.54	0.54	0.54
2013	0.03	0.10	0.18	0.29	0.36	0.44	0.44	0.46	0.46	0.58	0.58	0.58
2014	0.03	0.09	0.16	0.26	0.32	0.40	0.39	0.41	0.41	0.52	0.52	0.52
2015	0.03	0.09	0.16	0.25	0.31	0.38	0.38	0.40	0.39	0.50	0.50	0.50
2016	0.03	0.09	0.16	0.26	0.32	0.39	0.39	0.41	0.40	0.51	0.51	0.51
2017	0.03	0.09	0.16	0.26	0.32	0.39	0.39	0.41	0.40	0.51	0.51	0.51
2018	0.03	0.10	0.17	0.28	0.34	0.43	0.42	0.44	0.44	0.55	0.55	0.55
2019	0.03	0.11	0.19	0.31	0.38	0.47	0.46	0.48	0.48	0.61	0.61	0.61
2020	0.04	0.12	0.22	0.35	0.43	0.53	0.52	0.55	0.54	0.69	0.69	0.69
2021	0.04	0.12	0.21	0.34	0.42	0.51	0.51	0.53	0.53	0.67	0.67	0.67

Table 3.12: Icelandic cod in Division 5.a. Estimates of numbers at age in the stock 1955–2022 (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	161.467	143.755	151.014	211.538	199.652	110.948	31.896	20.440	9.573	77.118	6.371	4.707	5.492	1.820
1956	215.102	161.468	143.756	116.170	145.110	128.590	70.710	19.158	11.538	5.182	38.312	2.976	2.277	2.656
1957	304.142	215.102	161.468	110.617	79.752	93.561	82.045	42.528	10.832	6.257	2.580	17.940	1.443	1.104
1958	153.654	304.142	215.102	123.338	74.376	49.990	57.962	47.580	34.750	5.595	2.938	1.131	8.175	0.657
1959	195.928	153.654	304.142	162.879	80.900	45.079	29.902	32.186	39.724	16.939	2.449	1.190	0.479	3.461
1960	125.151	195.928	153.654	232.451	109.690	50.819	27.990	17.389	17.478	31.621	7.988	1.079	0.545	0.219
1961	173.213	125.151	195.928	116.498	153.022	66.810	30.554	15.642	9.002	8.592	13.984	3.274	0.462	0.233
1962	197.572	173.214	125.151	149.270	77.752	94.957	40.957	17.490	25.151	4.570	3.950	5.987	1.460	0.206
1963	219.611	197.573	173.214	95.319	99.538	48.192	58.141	23.410	9.303	12.742	2.096	1.687	2.662	0.649
1964	233.049	219.611	197.572	130.592	61.755	59.329	28.327	31.596	11.719	4.408	5.387	0.817	0.688	1.086
1965	320.333	233.049	219.611	147.336	82.021	35.291	33.374	14.579	14.818	5.161	1.707	1.902	0.304	0.256
1966	171.147	320.333	233.049	162.540	90.577	45.530	19.259	16.544	6.536	6.207	1.882	0.563	0.664	0.106
1967	239.615	171.147	320.333	173.838	102.164	51.815	25.639	9.925	7.771	2.884	2.409	0.666	0.210	0.248
1968	179.502	239.615	171.147	240.500	111.294	59.919	29.948	13.646	4.846	3.579	1.179	0.904	0.262	0.083
1969	193.003	179.502	239.615	126.627	147.706	61.698	32.654	44.935	6.105	2.025	1.301	0.388	0.315	0.091
1970	141.890	193.003	179.502	180.724	82.130	88.172	36.323	31.391	22.548	2.899	0.859	0.509	0.159	0.129
1971	277.773	141.890	193.003	132.806	110.990	45.528	48.048	17.974	14.044	9.423	1.054	0.282	0.177	0.055
1972	187.011	277.773	141.890	140.008	77.123	57.030	22.920	21.558	23.526	5.149	2.925	0.290	0.083	0.052
1973	259.286	187.010	277.773	102.996	81.455	39.727	28.785	10.316	8.607	8.663	1.607	0.810	0.086	0.025
1974	370.746	259.287	187.011	200.365	58.859	40.951	19.550	12.556	3.967	3.039	2.570	0.420	0.228	0.024
1975	144.057	370.747	259.287	134.366	113.229	29.146	19.836	8.363	4.716	1.365	0.874	0.649	0.114	0.062
1976	225.138	144.056	370.746	186.520	76.192	56.330	14.186	8.536	3.164	1.636	0.396	0.223	0.178	0.031
1977	239.412	225.138	144.057	289.546	120.835	41.380	25.635	5.524	2.943	1.114	0.600	0.166	0.090	0.072
1978	141.344	239.412	225.138	113.517	196.093	70.938	21.050	11.493	2.244	1.216	0.476	0.286	0.077	0.041

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1979	145.812	141.344	239.412	178.722	79.741	122.738	39.550	10.598	5.343	1.058	0.589	0.252	0.147	0.040
1980	139.361	145.812	141.344	190.362	126.561	50.622	75.313	20.430	5.076	2.593	0.527	0.319	0.133	0.078
1981	230.373	139.361	145.812	112.043	132.773	78.235	27.724	45.492	9.252	2.332	1.226	0.273	0.161	0.067
1982	140.407	230.373	139.361	114.574	74.818	76.044	38.415	11.886	17.541	3.633	0.950	0.561	0.121	0.071
1983	139.253	140.407	230.373	108.878	74.359	40.763	34.763	15.045	4.125	6.216	1.342	0.401	0.228	0.049
1984	304.350	139.253	140.407	180.529	71.732	41.594	19.350	14.280	5.519	1.543	2.417	0.591	0.170	0.097
1985	252.412	304.350	139.253	110.353	120.694	41.169	20.484	8.327	5.530	2.177	0.631	1.110	0.262	0.075
1986	175.919	252.412	304.350	108.901	71.973	66.326	19.054	8.149	2.943	1.995	0.817	0.270	0.457	0.108
1987	96.453	175.919	252.412	235.676	67.632	36.298	27.149	6.489	2.403	0.890	0.633	0.304	0.096	0.162
1988	131.054	96.453	175.919	194.813	143.987	33.144	14.260	8.777	1.801	0.685	0.267	0.225	0.103	0.032
1989	113.339	131.053	96.453	135.614	118.322	69.836	12.829	4.525	2.384	0.503	0.202	0.093	0.075	0.034
1990	170.454	113.339	131.054	75.147	86.813	92.728	30.843	4.810	1.492	0.804	0.177	0.082	0.036	0.029
1991	126.162	170.454	113.339	102.032	47.937	45.890	40.596	11.437	1.566	0.497	0.280	0.071	0.031	0.014
1992	81.361	126.162	170.454	87.395	62.051	23.304	17.821	12.934	3.121	0.439	0.147	0.098	0.024	0.010
1993	145.447	81.362	126.162	130.556	51.408	28.453	8.324	5.108	3.121	0.776	0.116	0.047	0.030	0.007
1994	160.310	145.447	81.362	96.756	77.290	23.839	10.329	2.435	1.262	0.794	0.209	0.038	0.014	0.009
1995	93.942	160.311	145.447	63.726	63.588	43.045	11.246	4.209	0.885	0.468	0.306	0.091	0.016	0.006
1996	158.668	93.942	160.310	114.910	45.560	38.618	22.527	5.174	1.786	0.351	0.178	0.114	0.035	0.006
1997	76.441	158.668	93.942	126.870	82.690	28.070	20.650	10.655	2.266	0.733	0.138	0.069	0.045	0.014
1998	162.550	76.440	158.668	74.289	91.033	50.622	14.867	9.647	4.602	0.916	0.284	0.053	0.026	0.017
1999	150.427	162.550	76.440	124.561	51.845	52.422	24.462	6.172	3.642	1.603	0.303	0.092	0.017	0.009
2000	156.840	150.427	162.550	59.571	84.539	28.076	23.105	9.020	2.035	1.093	0.453	0.083	0.026	0.005
2001	174.457	156.840	150.427	126.584	40.319	45.505	12.262	8.421	2.935	0.602	0.304	0.123	0.023	0.007
2002	88.400	174.457	156.840	117.600	86.952	22.421	20.869	4.759	2.944	0.939	0.182	0.090	0.037	0.007
2003	149.958	88.400	174.457	123.602	83.282	51.714	11.372	9.221	1.929	1.109	0.338	0.064	0.032	0.013
2004	130.877	149.958	88.400	137.599	87.810	49.878	26.504	5.092	3.795	0.739	0.406	0.121	0.023	0.012

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	97.867	130.877	149.958	69.554	96.850	51.524	24.790	11.409	2.004	1.383	0.257	0.138	0.042	0.008
2006	127.615	97.868	130.876	118.192	49.278	57.656	26.170	10.974	4.634	0.756	0.499	0.091	0.049	0.015
2007	115.215	127.615	97.868	103.359	84.376	29.831	30.028	11.965	4.624	1.822	0.285	0.184	0.034	0.019
2008	125.928	115.215	127.615	77.513	74.600	52.327	16.109	14.384	5.317	1.928	0.730	0.112	0.073	0.014
2009	167.612	125.928	115.215	100.852	56.842	55.785	31.235	8.972	7.309	2.721	0.964	0.366	0.049	0.032
2010	179.149	167.612	125.928	90.817	73.362	37.726	32.537	16.912	4.403	3.615	1.312	0.466	0.154	0.021
2011	129.313	179.149	167.612	99.833	67.254	50.260	23.161	18.753	8.967	2.350	1.888	0.687	0.217	0.072
2012	169.171	129.314	179.149	133.168	74.433	46.633	31.462	13.670	10.239	4.926	1.265	1.019	0.332	0.105
2013	143.418	169.170	129.313	142.260	99.126	51.463	29.056	18.464	7.411	5.586	2.632	0.678	0.488	0.159
2014	94.980	143.418	169.171	102.438	105.099	67.625	31.380	16.608	9.689	3.915	2.886	1.364	0.311	0.224
2015	149.155	94.981	143.418	134.467	76.483	73.057	42.503	18.612	9.123	5.354	2.121	1.567	0.664	0.152
2016	155.717	149.155	94.981	114.138	100.783	53.529	46.426	25.550	10.395	5.125	2.951	1.172	0.780	0.331
2017	108.847	155.718	149.155	75.539	85.367	70.275	33.813	27.704	14.141	5.788	2.798	1.615	0.576	0.384
2018	141.828	108.846	155.717	118.610	56.477	59.487	44.344	20.152	15.309	7.861	3.155	1.529	0.793	0.283
2019	129.060	141.829	108.846	123.527	88.009	38.828	36.728	25.735	10.776	8.239	4.142	1.666	0.719	0.373
2020	179.427	129.061	141.829	86.074	90.763	59.463	23.309	20.597	13.190	5.562	4.154	2.094	0.742	0.320
2021	147.869	179.426	129.060	111.652	62.363	59.816	34.288	12.446	9.935	6.413	2.634	1.973	0.861	0.305
2022	127.681	147.869	179.427	101.716	81.181	41.358	34.843	18.536	6.095	4.903	3.085	1.271	0.828	0.362

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	151.014	726.287	545.250	0.35	2090.380	0.24
1956	143.756	583.865	486.909	0.35	1818.210	0.26
1957	161.468	574.634	455.182	0.39	1639.830	0.30
1958	215.102	690.021	517.359	0.44	1650.440	0.29
1959	304.142	639.289	459.081	0.38	1580.370	0.30
1960	153.654	583.577	470.121	0.43	1657.820	0.25
1961	195.928	399.325	377.291	0.40	1430.540	0.27
1962	125.151	505.488	388.985	0.40	1464.290	0.27
1963	173.214	460.458	408.800	0.46	1298.690	0.33
1964	197.572	420.077	437.012	0.52	1210.680	0.33
1965	219.611	322.929	387.106	0.56	1052.730	0.35
1966	233.049	295.716	353.357	0.52	1063.300	0.32
1967	320.333	280.608	335.721	0.48	1139.650	0.32
1968	171.147	248.437	381.770	0.56	1242.780	0.32
1969	239.615	354.205	403.205	0.46	1335.700	0.34
1970	179.502	354.810	475.077	0.56	1332.680	0.34
1971	193.003	253.013	444.248	0.67	1083.460	0.38
1972	141.890	225.481	395.166	0.67	978.391	0.39
1973	277.773	244.958	369.205	0.71	830.101	0.44
1974	187.011	188.447	368.133	0.73	908.431	0.40
1975	259.287	174.471	364.754	0.72	889.532	0.40
1976	370.746	145.135	346.253	0.71	946.192	0.36
1977	144.057	198.192	340.086	0.57	1297.730	0.26
1978	225.138	211.522	329.602	0.46	1307.230	0.27
1979	239.412	307.151	366.462	0.44	1410.180	0.29
1980	141.344	369.493	432.237	0.49	1513.860	0.30
1981	145.812	268.949	465.032	0.62	1246.070	0.33
1982	139.361	178.333	380.068	0.70	982.289	0.33
1983	230.373	140.074	298.049	0.66	795.748	0.36
1984	140.407	149.501	282.022	0.61	909.695	0.34
1985	139.253	165.679	323.428	0.69	931.199	0.38
1986	304.350	192.296	364.797	0.84	856.081	0.45
1987	252.412	145.121	389.915	0.89	992.122	0.38
1988	175.919	160.566	377.554	0.90	988.243	0.37
1989	96.453	162.074	363.125	0.74	952.690	0.36
1990	131.054	197.937	335.316	0.76	816.241	0.39

Year	Recruits	SSB	Yield	F5–10	Reference biomass	Harvest rate
1991	113.339	156.179	307.759	0.90	696.964	0.40
1992	170.454	142.297	264.834	1.00	563.496	0.45
1993	126.162	114.903	250.704	0.98	600.233	0.34
1994	81.362	152.802	178.138	0.67	572.888	0.30
1995	145.447	174.584	168.592	0.58	568.306	0.31
1996	160.310	158.421	180.701	0.55	686.994	0.28
1997	93.942	192.365	203.112	0.56	794.598	0.29
1998	158.668	201.138	243.987	0.68	735.256	0.35
1999	76.440	176.040	260.147	0.80	727.314	0.33
2000	162.550	161.451	235.092	0.81	587.904	0.40
2001	150.427	158.282	236.707	0.75	652.560	0.33
2002	156.840	190.365	209.535	0.62	697.062	0.30
2003	174.457	186.811	207.241	0.61	728.622	0.30
2004	88.400	193.412	228.330	0.65	794.511	0.28
2005	149.958	221.675	213.863	0.62	719.230	0.28
2006	130.876	212.724	197.200	0.59	677.717	0.27
2007	97.868	196.537	171.641	0.54	652.804	0.24
2008	127.615	246.662	147.663	0.39	661.153	0.26
2009	115.215	226.776	183.315	0.42	728.730	0.24
2010	125.928	255.878	170.018	0.35	775.171	0.22
2011	167.612	313.000	172.197	0.33	821.969	0.23
2012	179.149	346.497	196.188	0.34	944.292	0.23
2013	129.313	367.227	223.593	0.36	1071.480	0.21
2014	169.171	336.090	222.013	0.33	1082.680	0.21
2015	143.418	443.964	230.168	0.31	1157.530	0.21
2016	94.981	387.901	251.238	0.32	1201.250	0.21
2017	149.155	514.595	244.021	0.32	1122.360	0.23
2018	155.717	499.909	267.490	0.35	1157.120	0.23
2019	108.846	441.162	262.950	0.38	1092.400	0.24
2020	141.829	386.745	269.871	0.43	978.667	0.27
2021	129.060	364.187	265.729	0.42	1023.090	0.23
2022	179.427	356.697	215.624	0.36	976.590	0.22
2023	147.870	370.488	NA	0.33	1074.370	0.20
2024	127.681	393.257	NA	NA	1124.180	NA

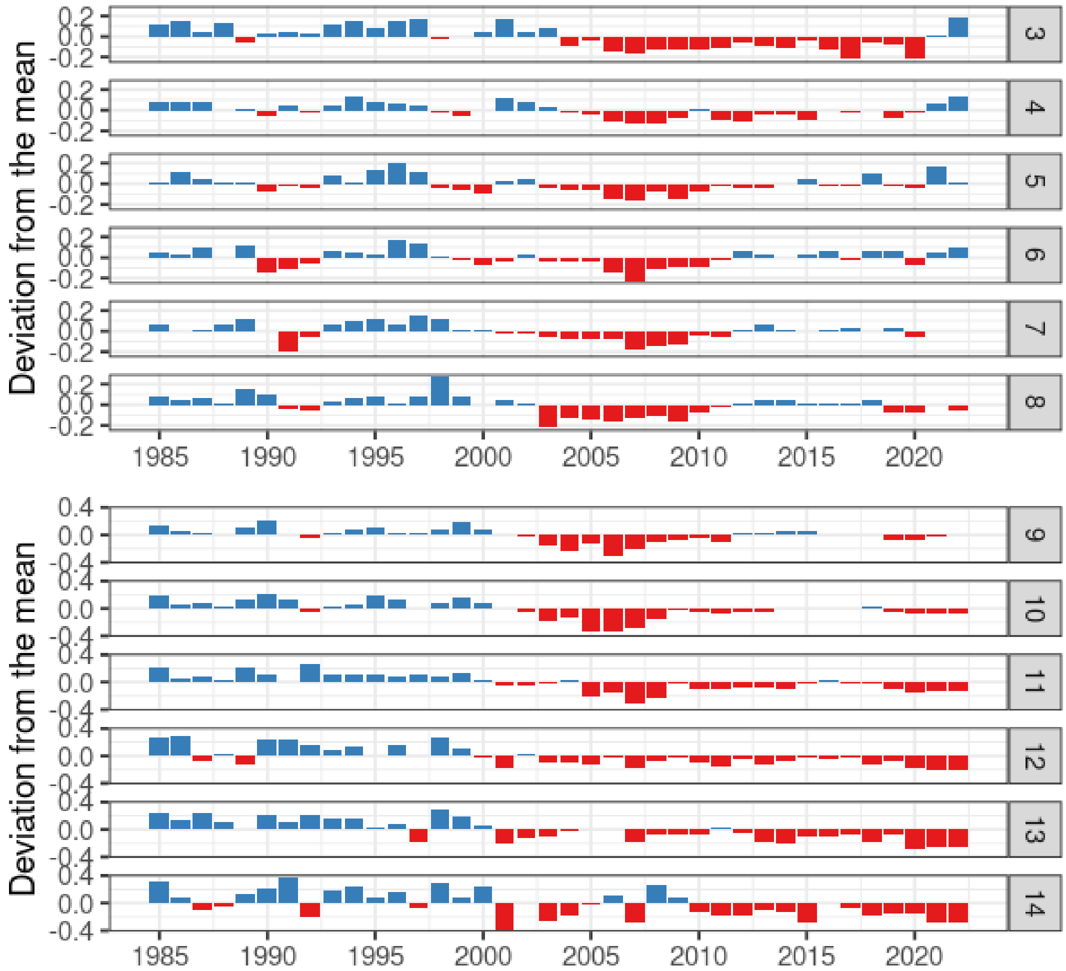


Figure 3.1: Icelandic cod Division 5.a. Weight at age (numbers in panel indicate age classes) in the catches expressed as deviations from the mean. Weight at age in the assessment year are based on predictions using the spring survey weights. Note that values that are equal to the mean are not visible in this type of a plot.

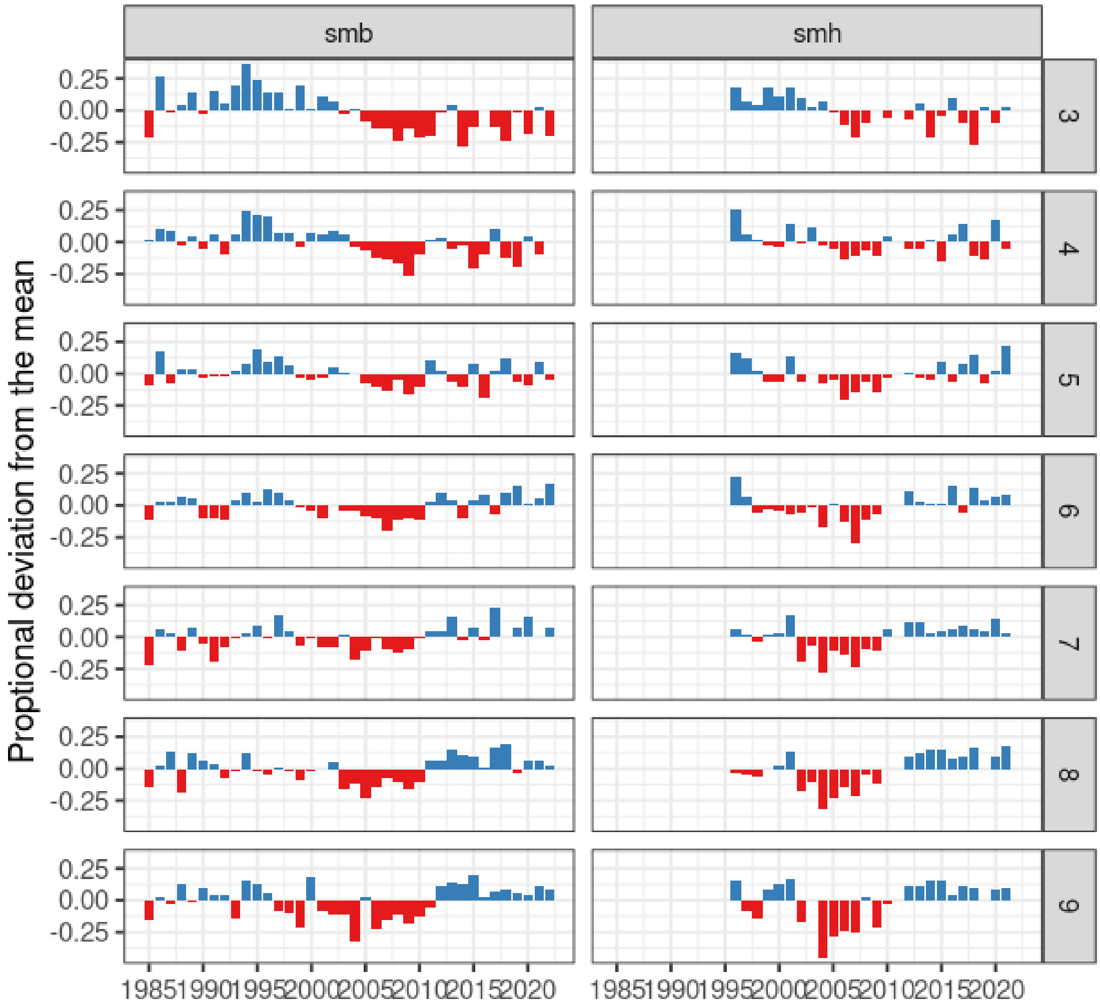


Figure 3.2: Icelandic cod Division 5.a. Weight at age (numbers in panel indicate age classes) in the spring survey (SMB) and fall survey (SMH) expressed as deviations from the mean. No fall survey was conducted in 2011. Note that values that are equal to the mean are not visible in this type of a plot.

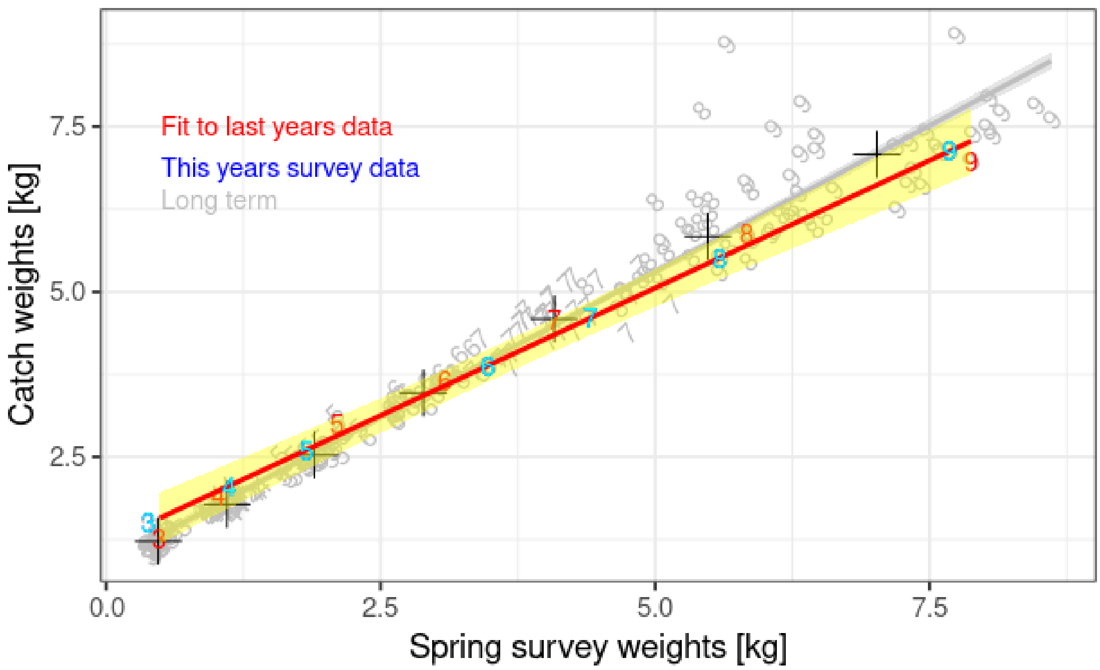


Figure 3.3: Icelandic cod Division 5.a. Prediction of catch weights age 3 to 9 in the assessment year. The 'crossed' points are the mean from 1990 to the present.

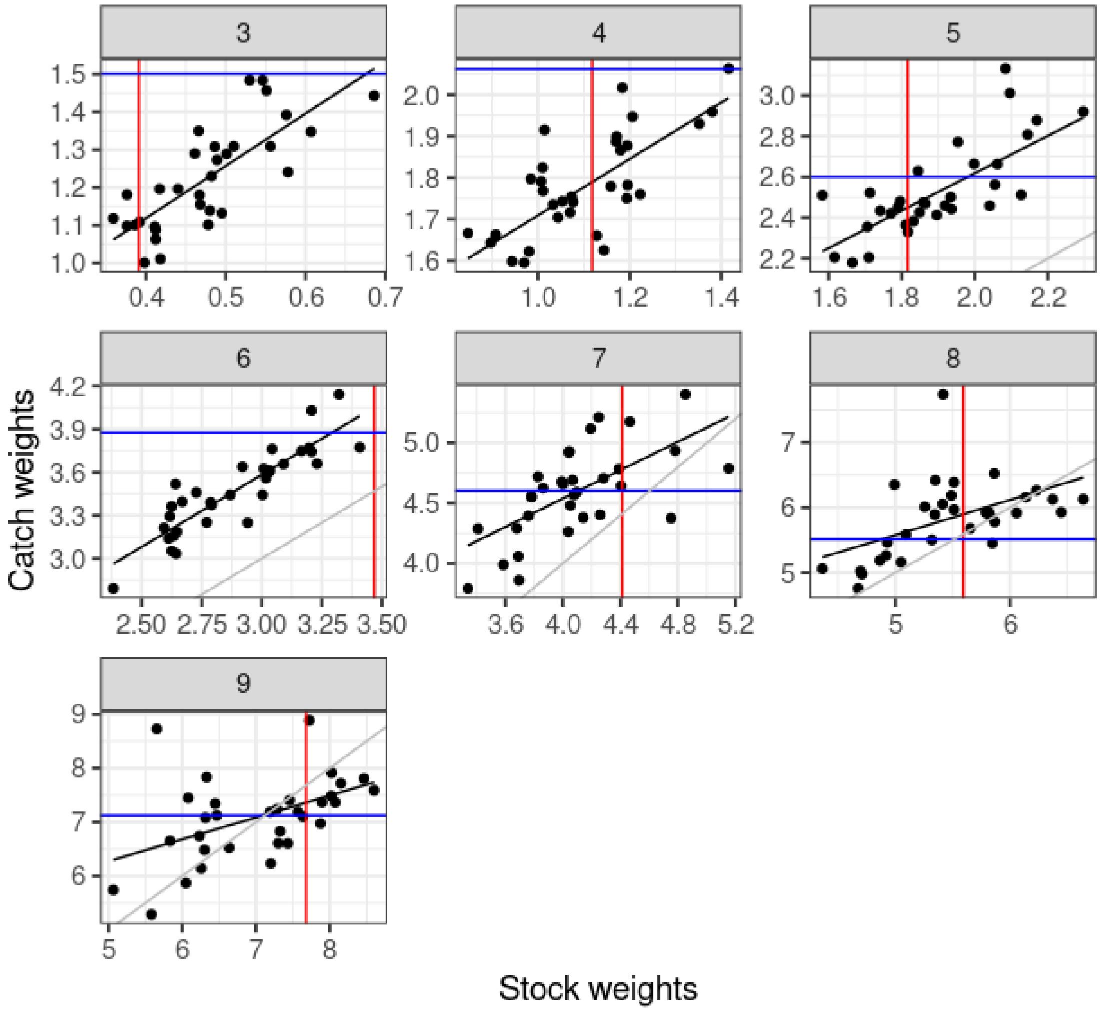


Figure 3.4: Icelandic cod Division 5.a. Alternative catch weight prediction model using a regression within each age groups based on data from 1990 onwards. The vertical red line shows the survey measurements in the current assessment year and the blue line the predicted weight using the spaly weight prediction model.

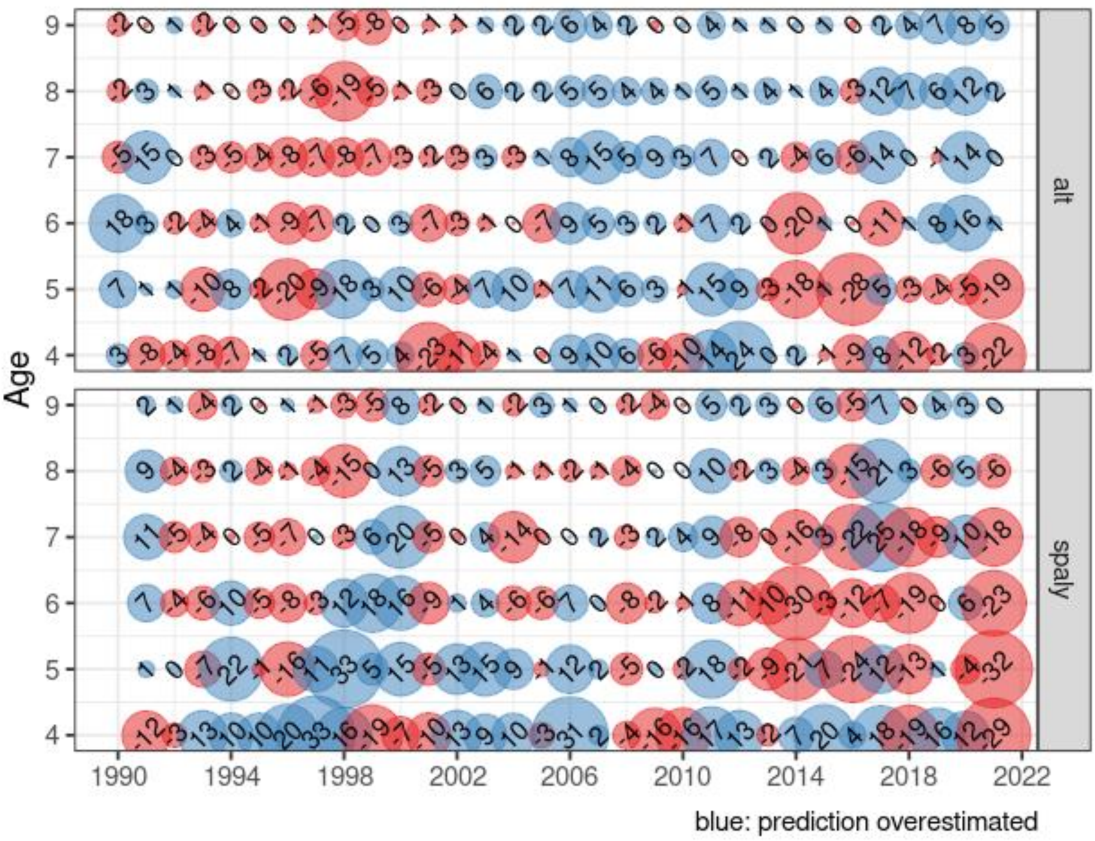


Figure 3.5: Icelandic cod Division 5.a. Residuals of the two catch prediction models. Numbers indicate the equivalence of biomass in kilotonnes.

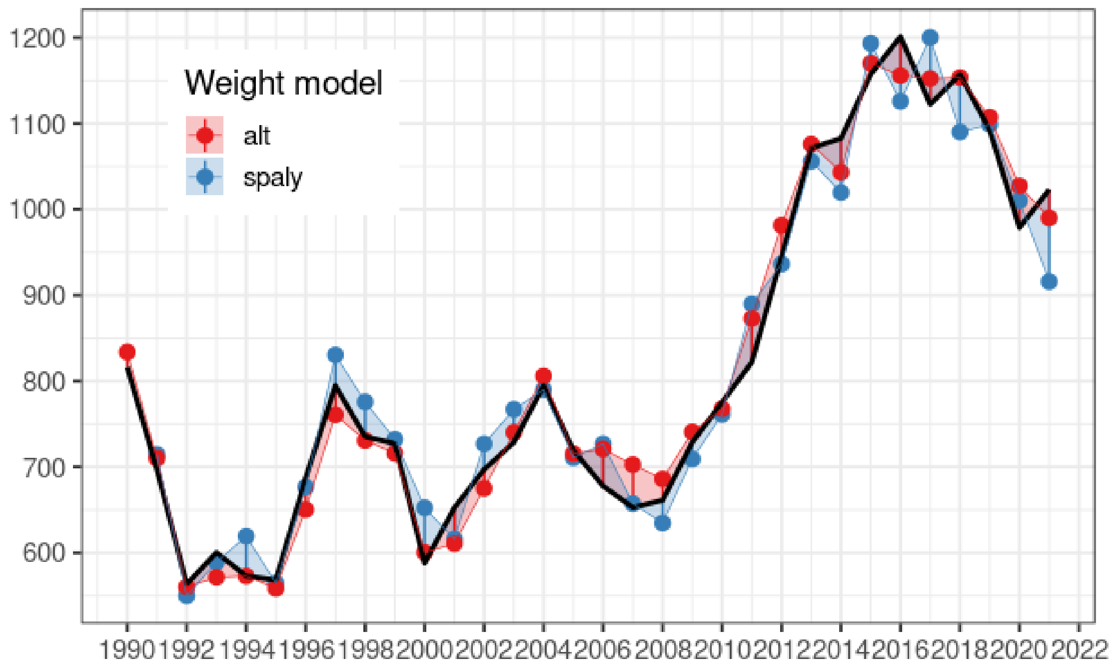


Figure 3.6: Icelandic cod Division 5.a. Comparison of the reference biomass using the two catch prediction models.

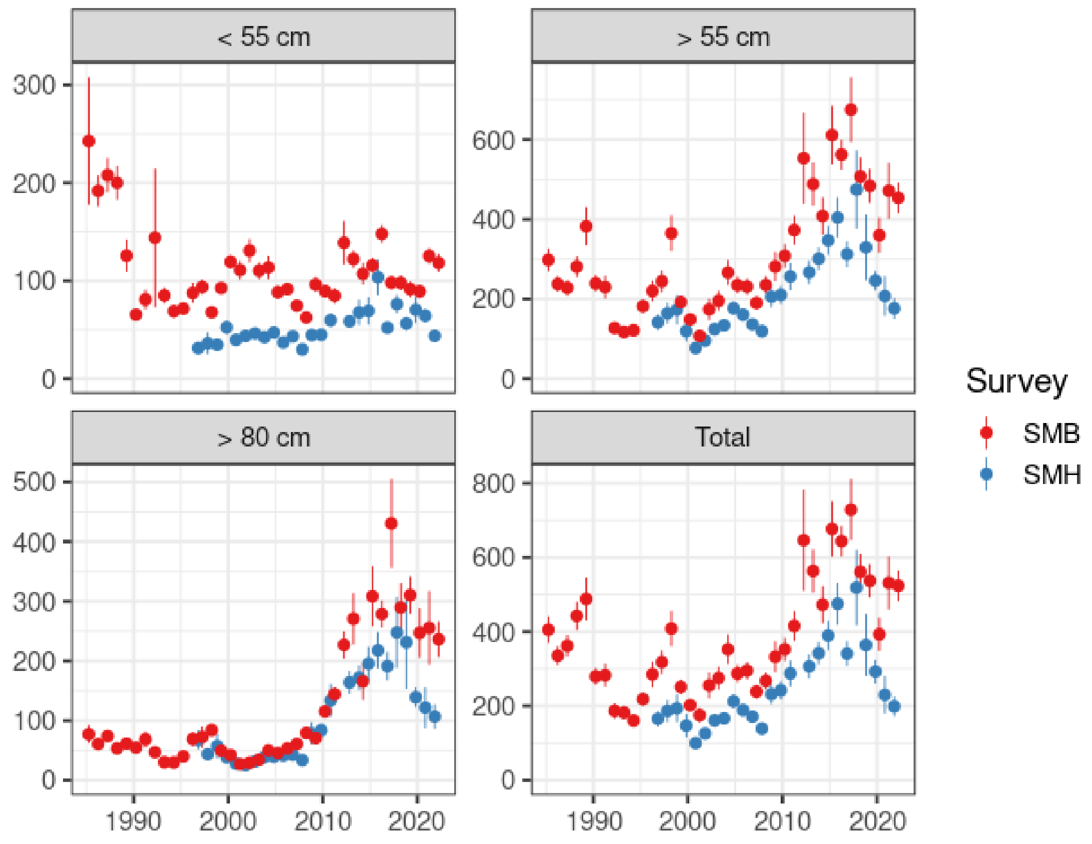


Figure 3.7: Icelandic cod Division 5.a. Indices of cod in the spring (SMB, red) and fall (SMH, blue) groundfish surveys. Abundance index of fish less than 55 cm, (< 55 cm, top left) and biomass indices of 55 cm and larger (>55 cm, top right), biomass index 80 cm and larger (bottom left) and total biomass (Total, bottom right). The vertical bar show 1 standard error of the estimate.

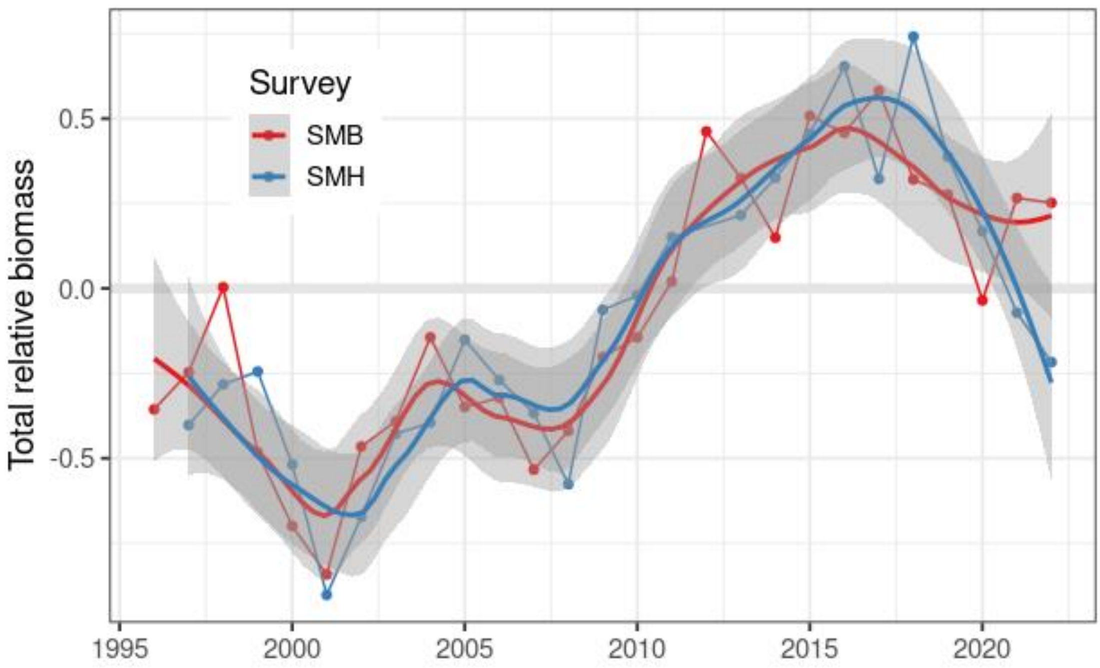


Figure 3.8: Icelandic cod Division 5.a. Relative total survey biomass if the spring (SMB, red) and the fall (SMH, blue) survey biomass. The survey measurements are shifted to the beginning/end of each year (hence the last data points are the fall 2021 and spring 2022 measurements.

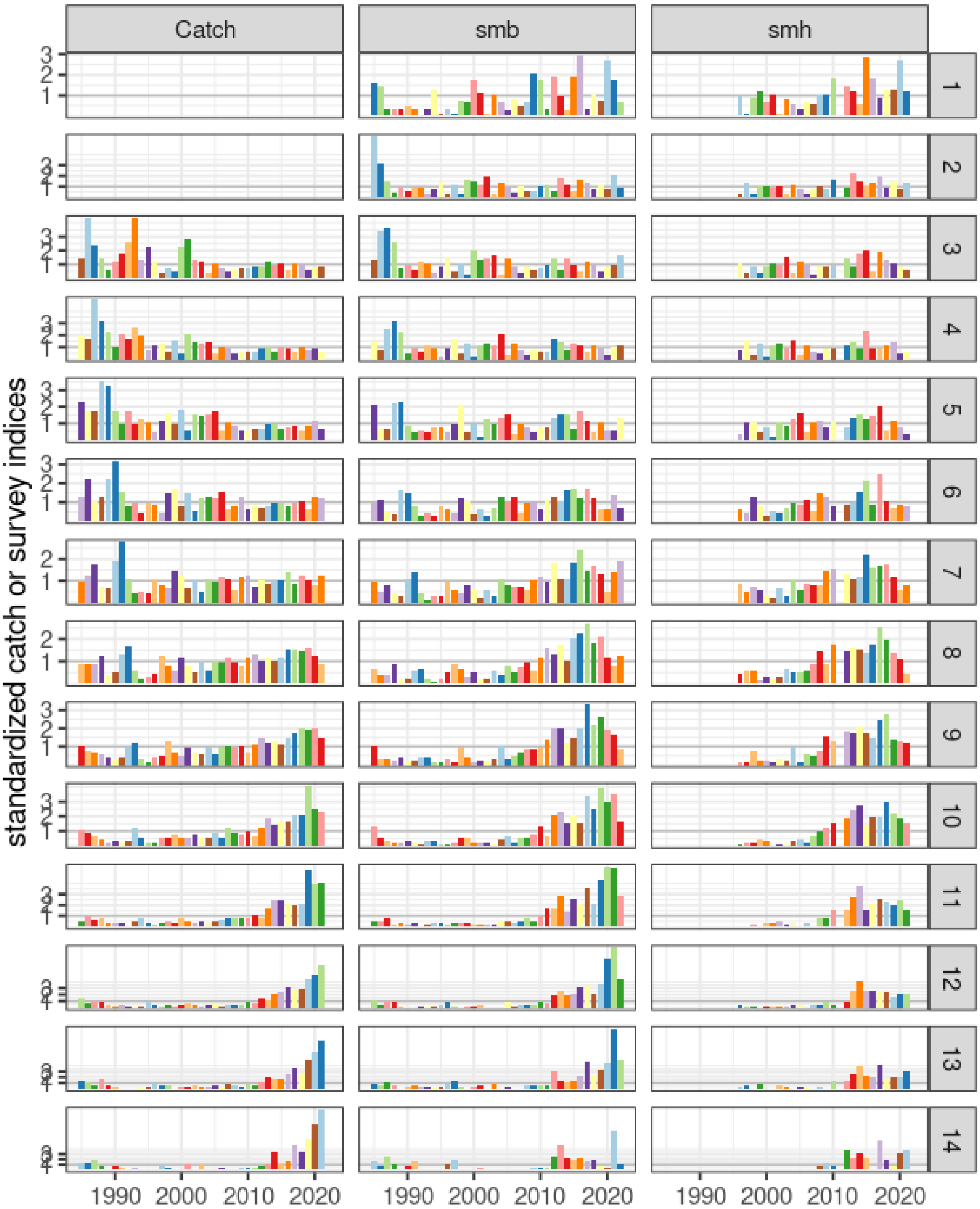


Figure 3.9: Icelandic cod Division 5.a. Age based catch and abundance indices of cod in the groundfish survey in spring (SMB) and fall (SMH). The values are standardized within each age group and within each survey in years 1996 to the present. Age 1, 2 and 14 indices from the fall survey are not used in the assessment.

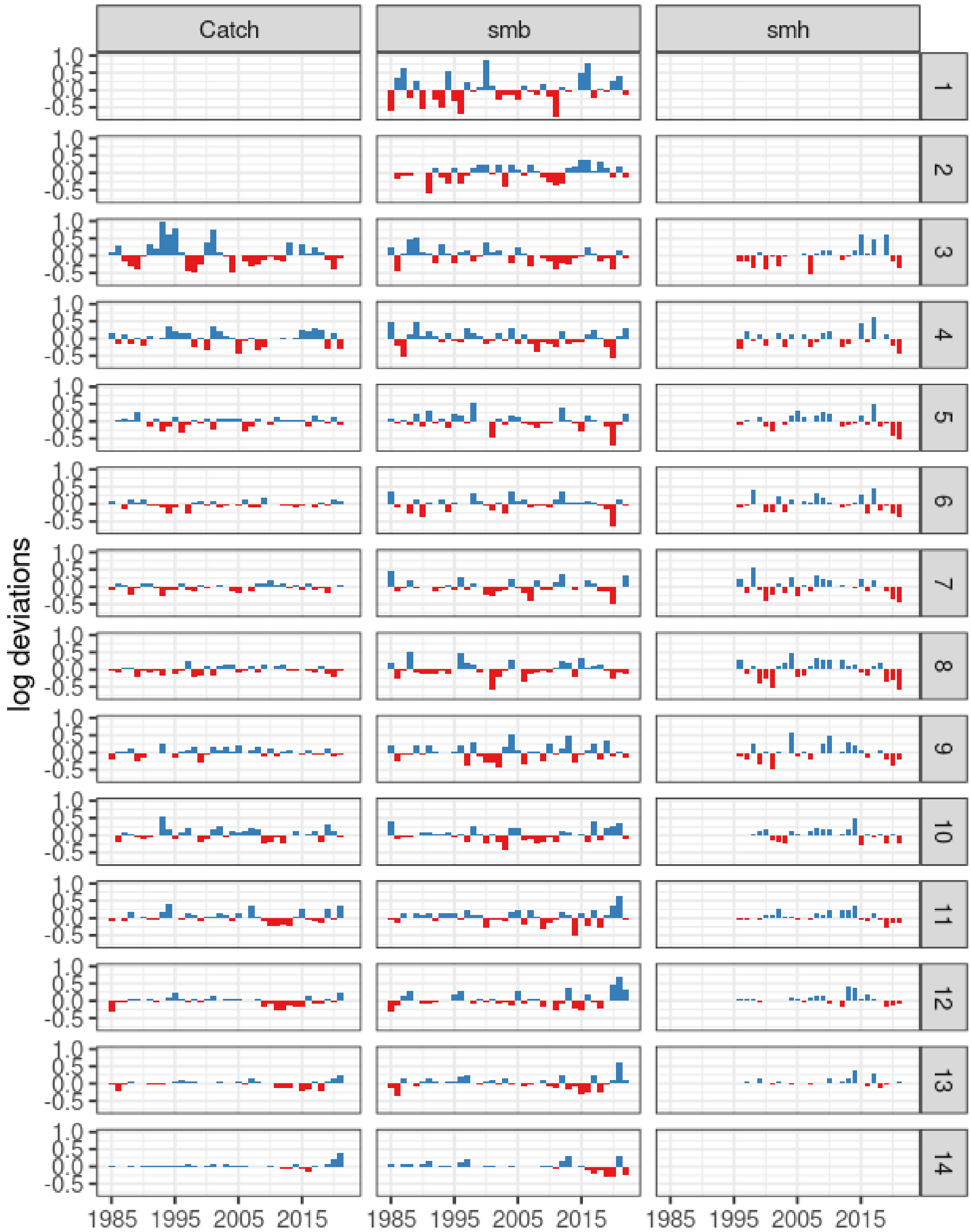


Figure 3.10: Icelandic cod Division 5.a. Catch residuals (left), spring survey residuals (SMB, middle) and fall survey residuals (SMH, right) by year and age. Note that values that are equal to zero are not visible in this type of a plot and that no survey was carried out in the fall 2011.

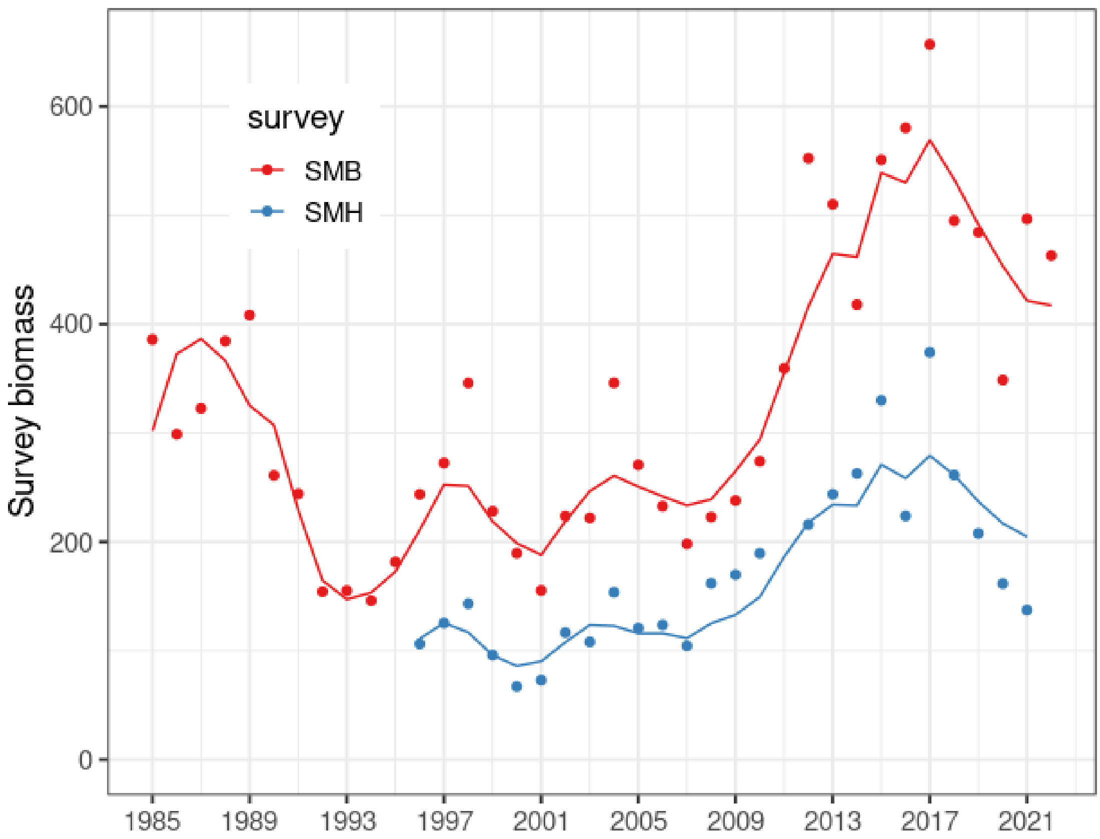


Figure 3.11: Icelandic cod Division 5.a. Summary plot of observed vs predicted survey biomass.

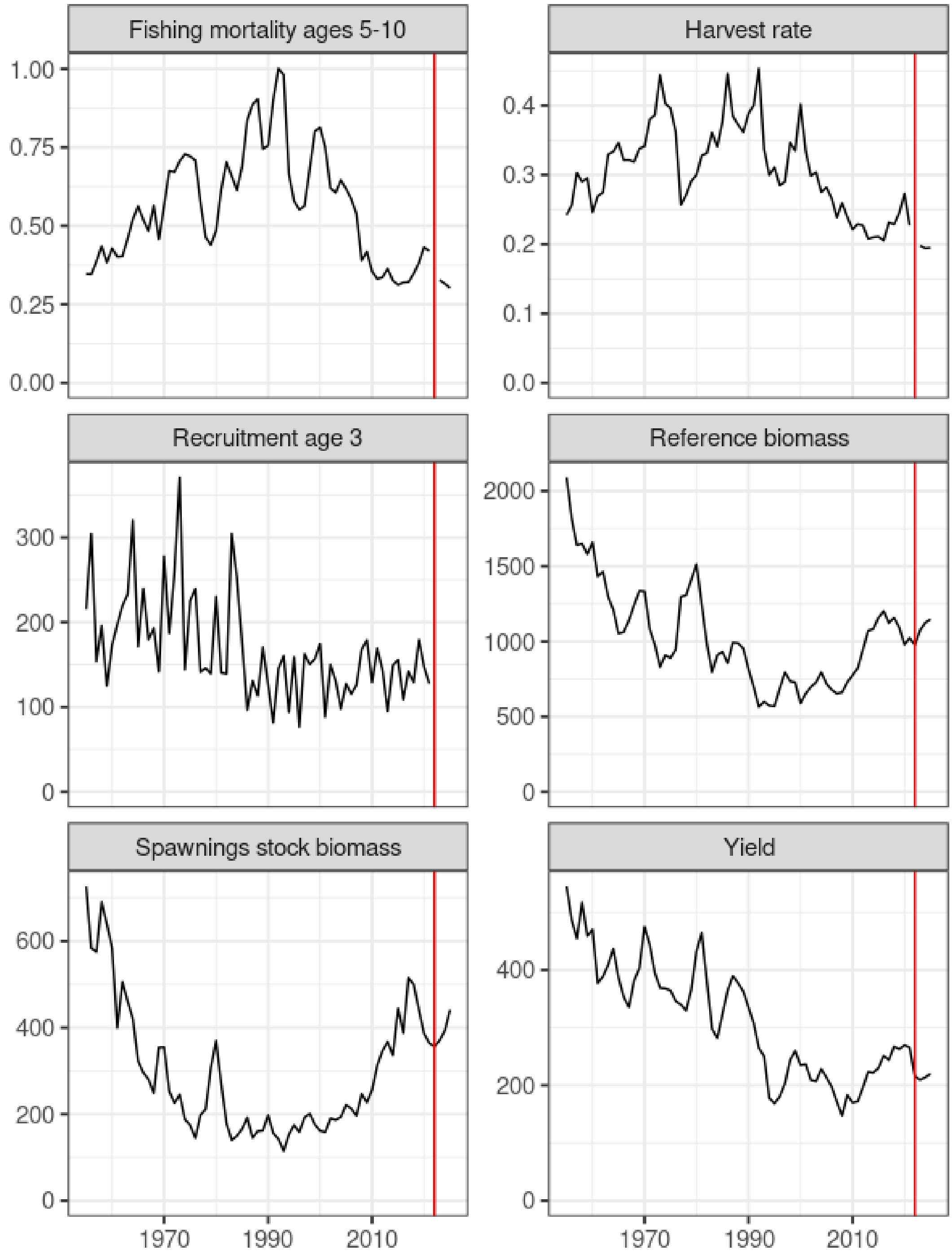


Figure 3.12: Icelandic cod in Division 5.a. Assessment summary. The x-axis for the recruitment refers to the year class

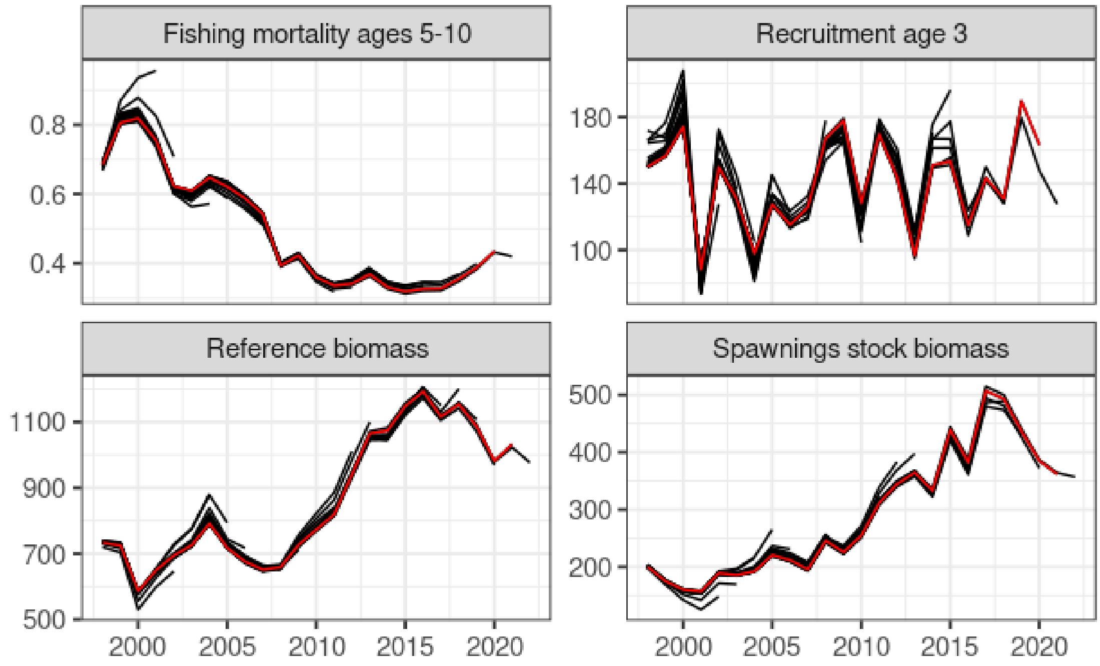


Figure 3.13: Icelandic cod in Division 5.a. Analytical retrospective pattern of key metrics in the last eight years and the current estimates.

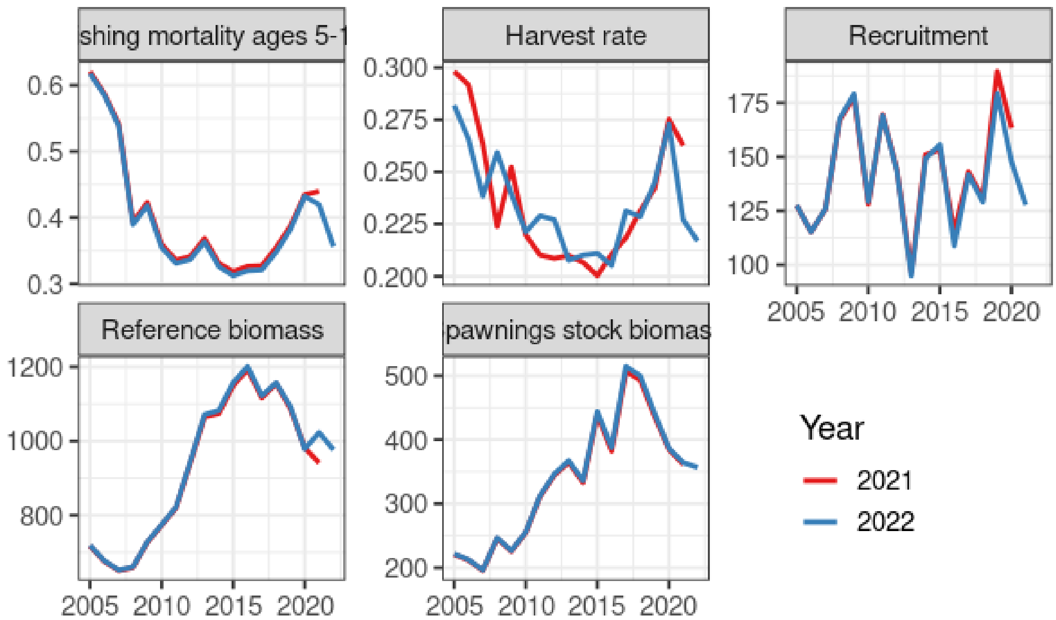


Figure 3.14: Icelandic cod in Division 5.a. Comparison with last year’s assessment.

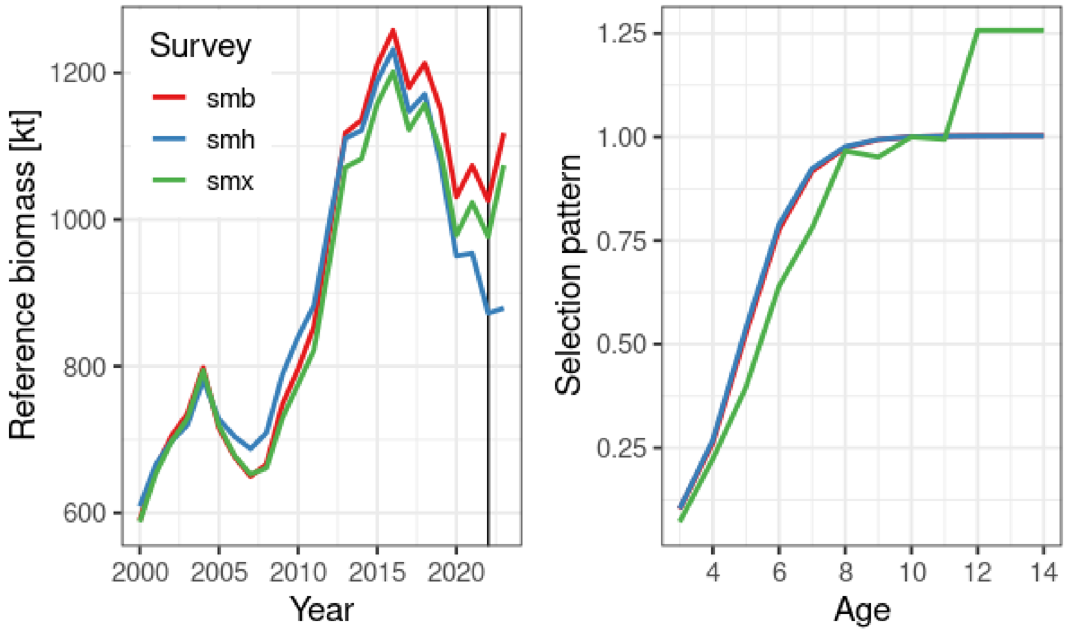


Figure 3.15: Icelandic cod in Division 5.a. Comparisons of alternative tunings.

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 (maximum of less than 10 tons in 2016). The nearest area to the Icelandic were haddock are found in reasonable abundance are in shallow Faroese waters, an area that constitutes as a separate stock. The two grounds are separated by a wide and relatively deep ridge, an area where reporting of haddock catches is non-existent, both commercially and scientifically. Tagging studies (Jónsson 1996) conducted between 1953 and 1965 showed no migrations of juvenile and mature fish outside of Icelandic waters, with most recaptures taking place in the area of tagging (or adjacent areas) and on the spawning grounds south of Iceland. Information about stock structure (metapopulation) of haddock in Icelandic waters is limited.

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

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). 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 is now around 60%. At the same time the proportion caught by longlines has increased from around 15% in 1995–2000 to 40% in 2011–2021. Catches in demersal seine have varied less and have been at around 15% of Icelandic catches of haddock in 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 10.2). Most of the haddock caught in 5.a by Icelandic vessels is caught at depths less than 200 m (Figure 10.3). 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 10.4) and Figure 10.5). 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.

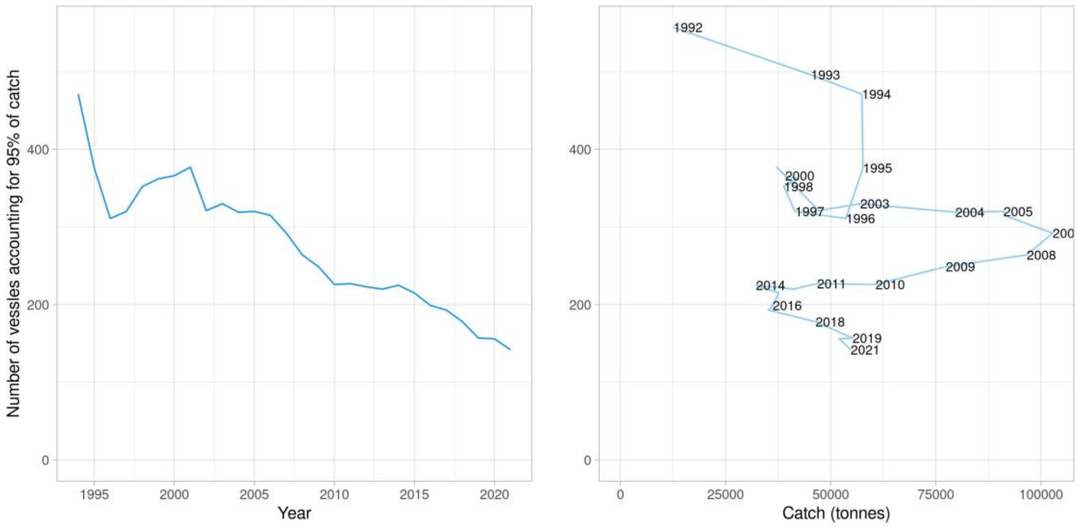


Figure 10.1: Haddock in 5.a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

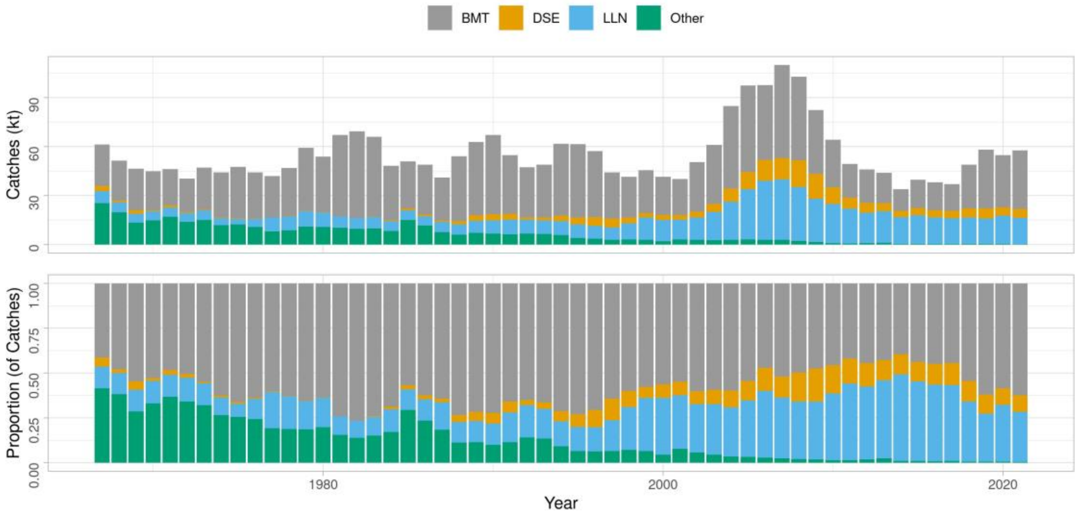


Figure 10.2: Haddock in 5.a. Landings in tons and percent of total by gear and year

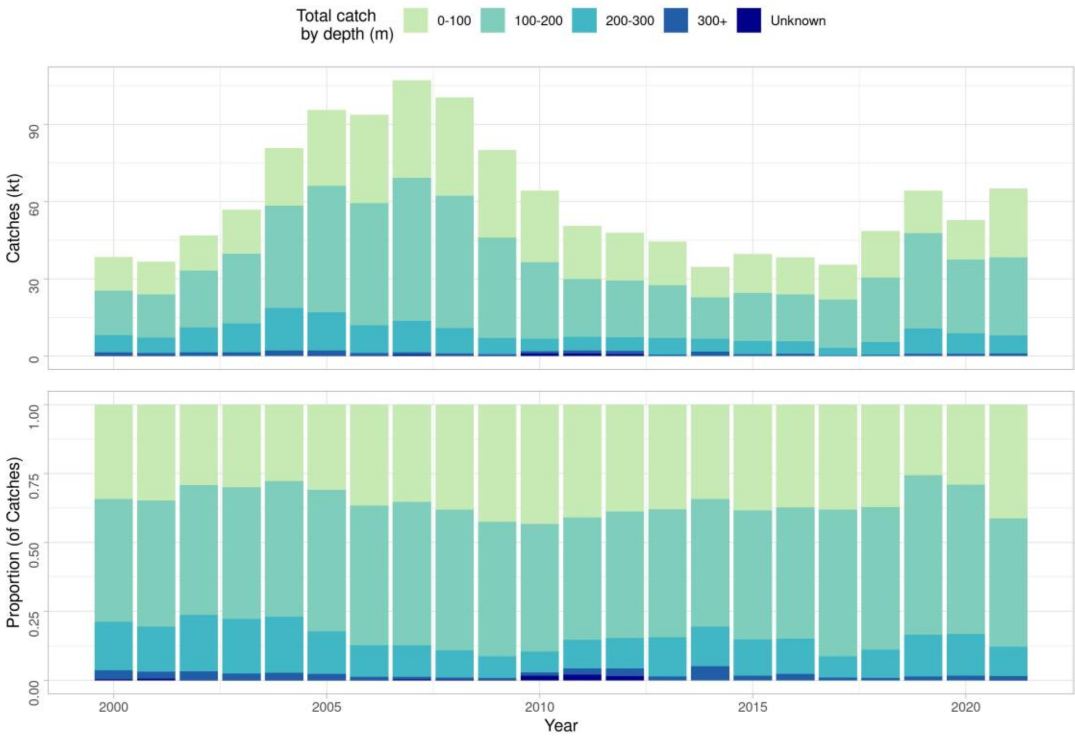


Figure 10.3: Haddock in 5.a. Depth distribution of haddock catches from bottom trawls, longlines, trawls and demersal seine from Icelandic logbooks.

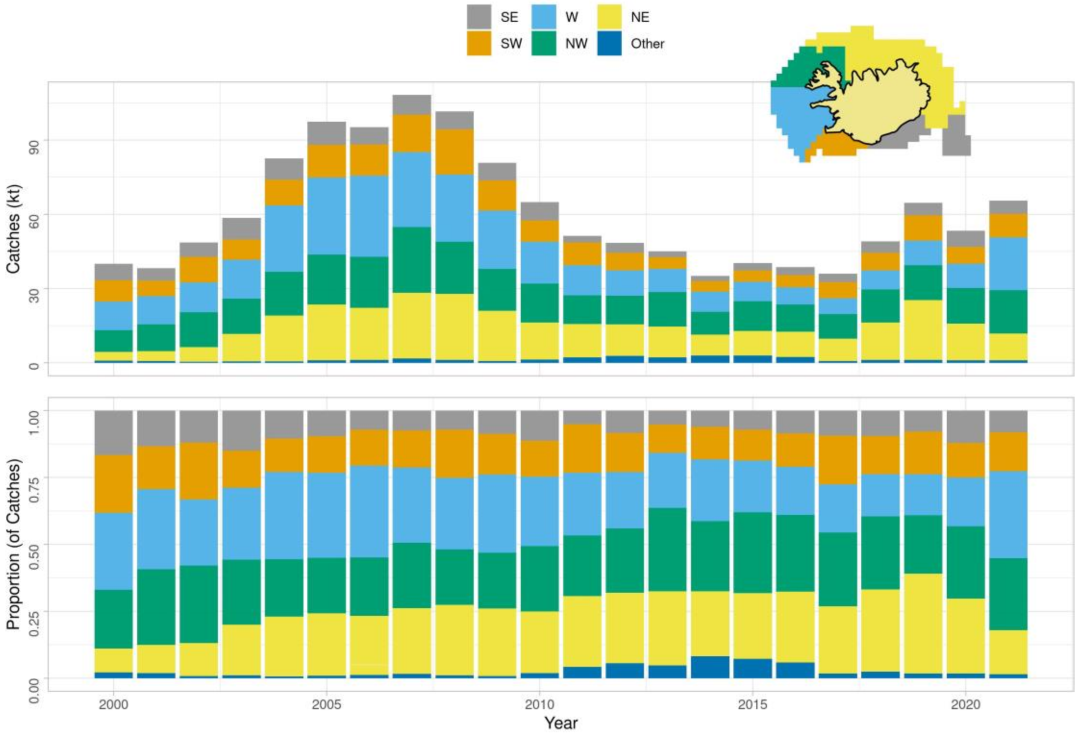


Figure 10.4: Haddock in 5.a. Changes in spatial distribution of haddock catches as recorded in Icelandic logbooks.

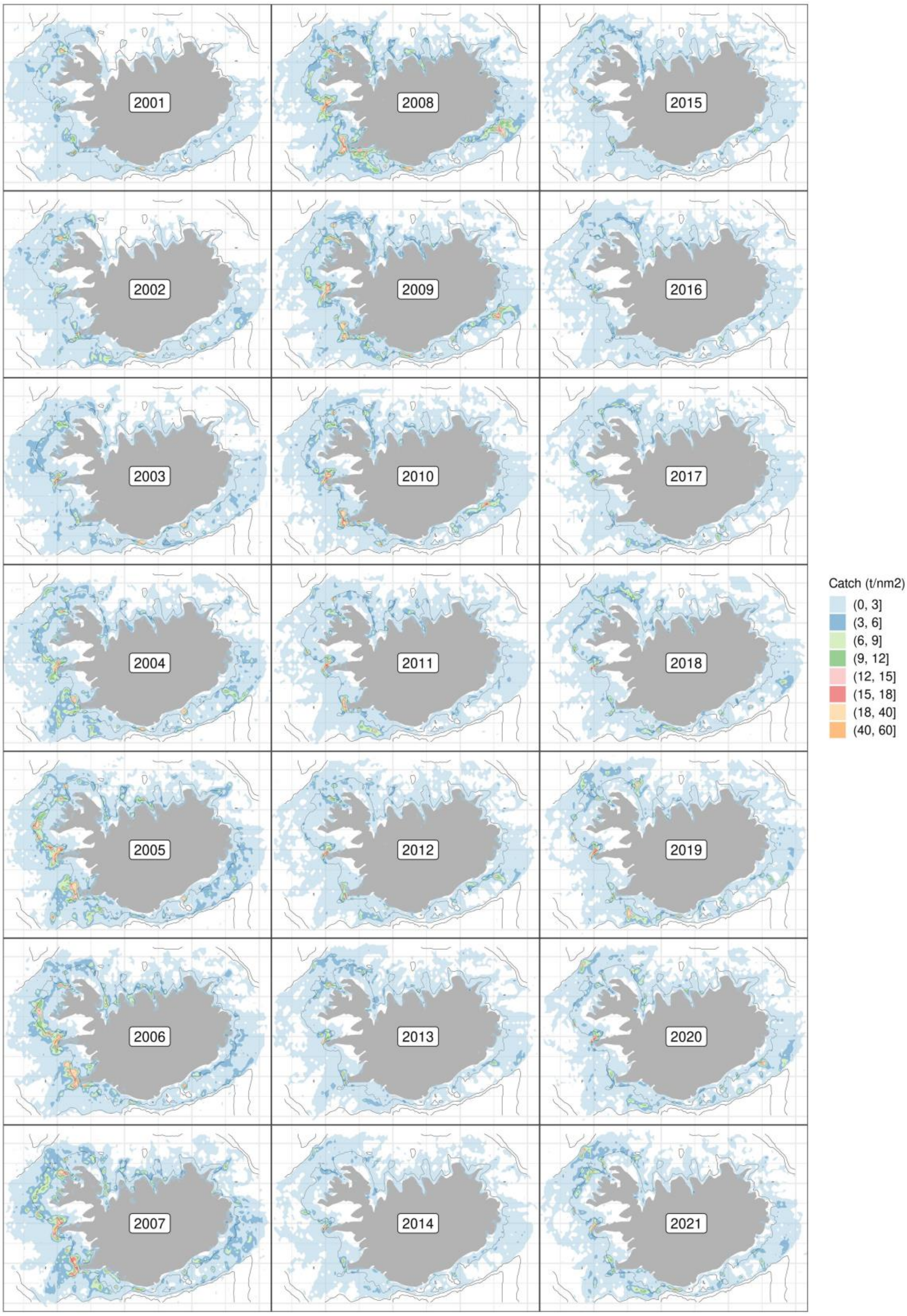


Figure 10.5: Haddock in 5.a. Spatial distribution of catches by all gears.

10.1.1 Landing trends

Landings of Icelandic haddock in 2021 are estimated to have been 57 599 tonnes, see Figure 10.6. 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 1960s, to the current level which is slightly lower than observed between 1975 to early 2000s.

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

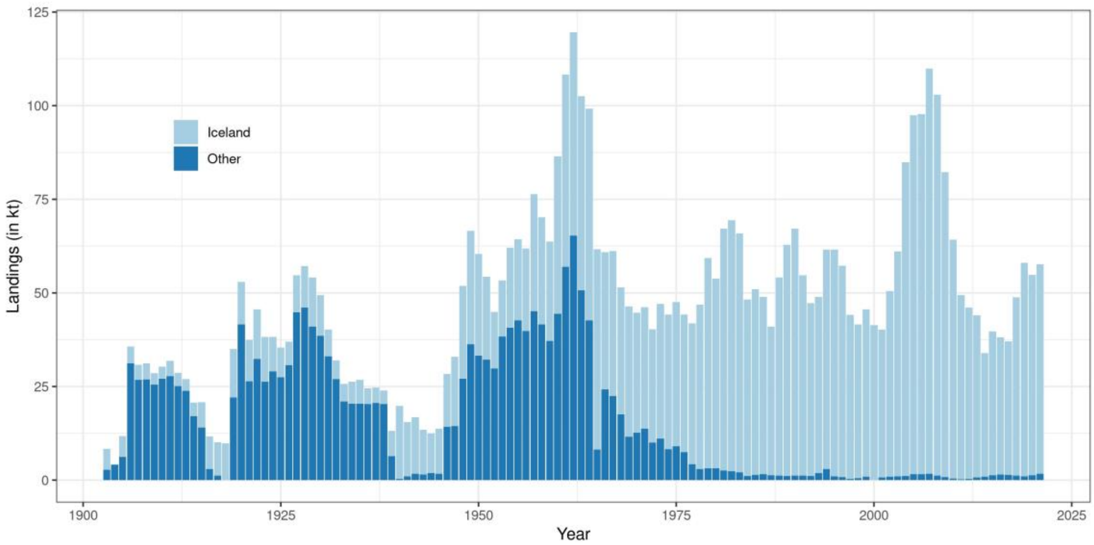


Figure 10.6: Haddock in 5.a. Recorded landings since 1905.

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 10.7and Figure 10.8. 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.

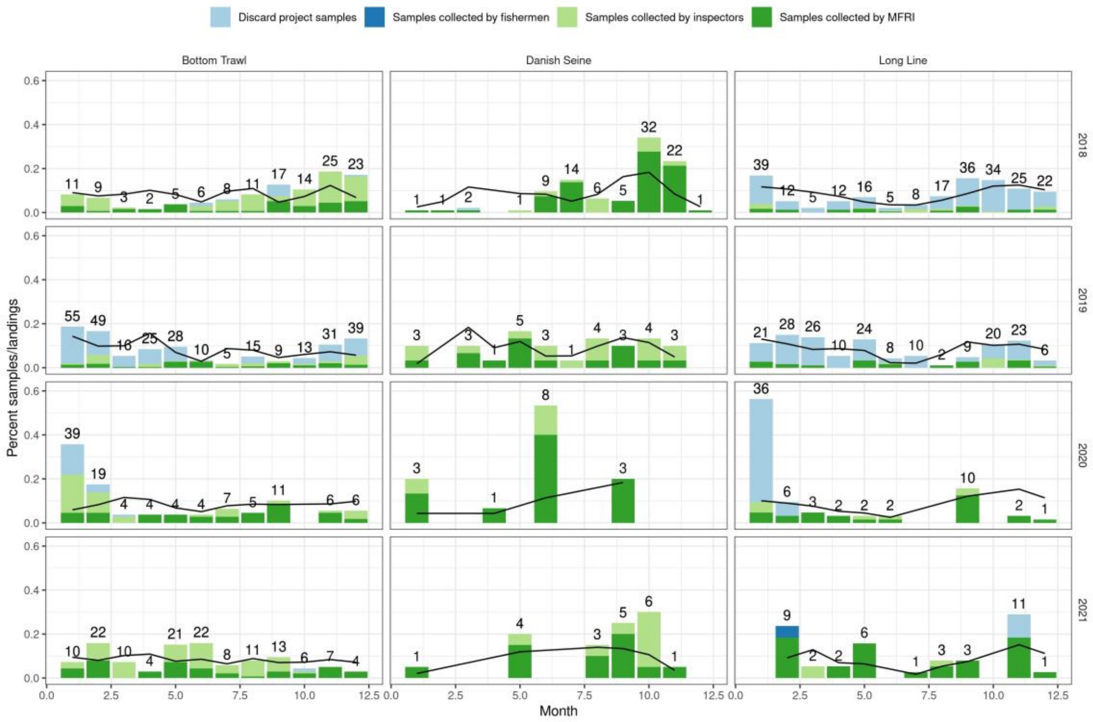


Figure 10.7: Haddock in 5.a. Ratio of samples by month (blue bars) compared with landings by month (solid black line) split by year and main gear types. Numbers of above the bars indicate number of samples by year, month and gear.

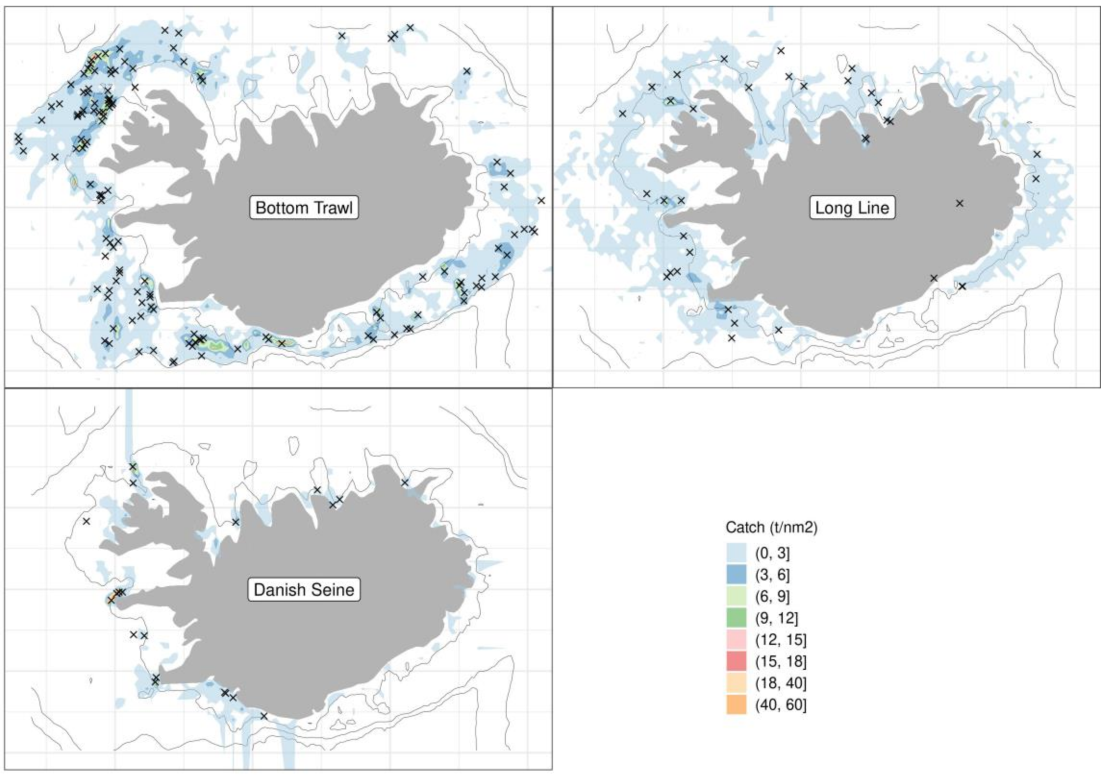


Figure 10.8: Haddock in 5.a. Fishing grounds in 2019 as reported in logbooks (contours) and positions of samples taken from landings (crosses) by main gear types.

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 due to highgrading are estimated very low in recent years (<3% in either numbers or weight, see MRI (2016) for further details) while historically discards may have been substantial in the early 1990s. Measures in the management system such as converting quota share from one species to another are used by the fleet to a large extent and this is thought to discourage discarding in mixed fisheries. In addition to prevent high grading and quota mismatch the fisheries are allowed to land fish that will not be accounted for in the allotted quota, provided that the proceedings when the landed catch is sold will go to the Fisheries Project Fund (Verkefnasjóður sjávarútvegsins). A more detailed description of the management system can be found on https://www.responsiblefisheries.is/seafood-industry/management-and-control-system/.

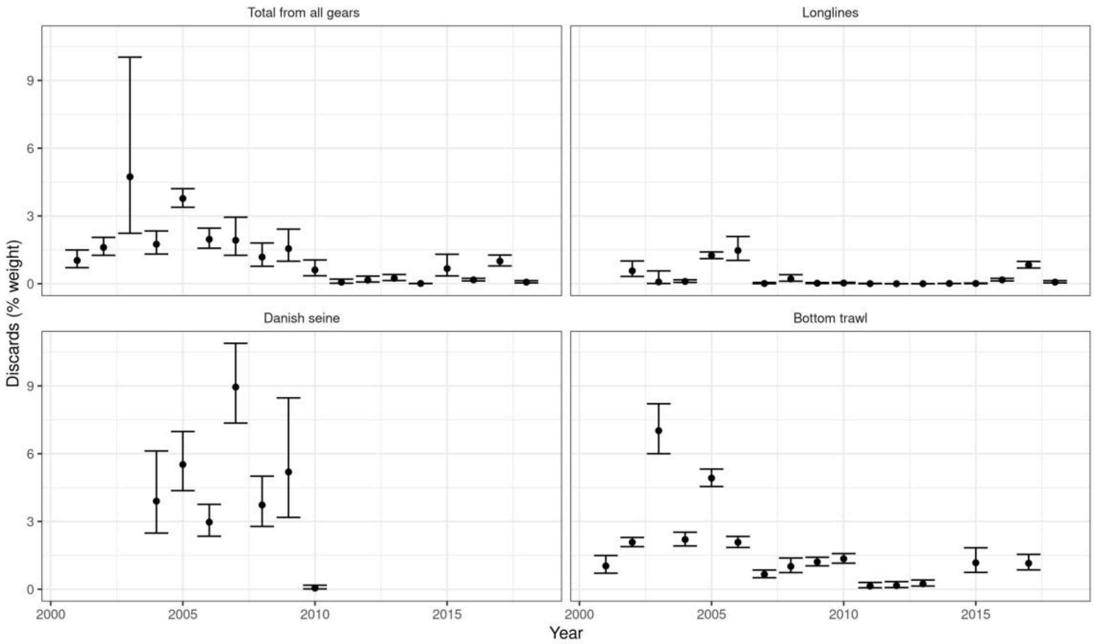


Figure 10.9: Haddock in 5.a. Estimates of annual discards by gear. Vertical lines indicate the 95% confidence interval while dots the point estimates. No estimates are available since 2018.

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 10.10. 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.

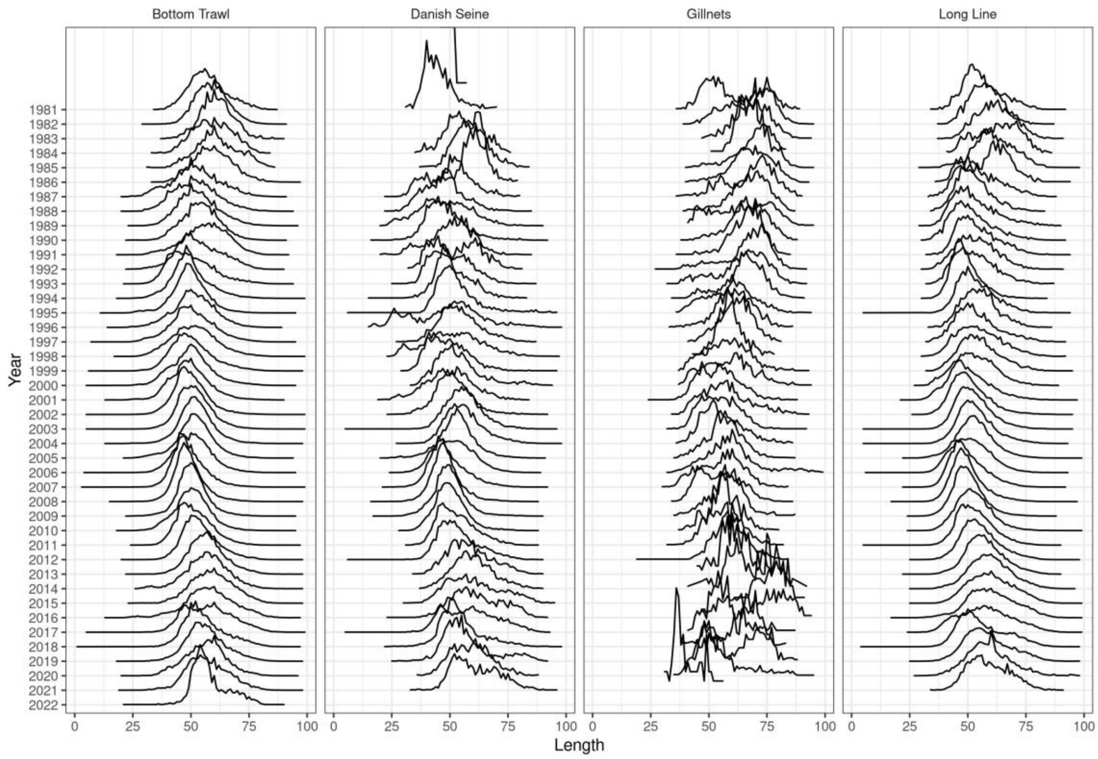


Figure 10.10: Haddock in 5.a. Commercial length distributions by gear and year.

10.2.3 Age compositions

Catch in numbers-at-age is shown in Figure 10.11. The catches in 2021 are mainly composed with the 2014 to 2017-year classes. The number of year classes contributing to the catches is unusually many; the result of low fishing mortality in recent years and the last year class contributing with more than 1% of total is 11 years old (Figure 10.12).

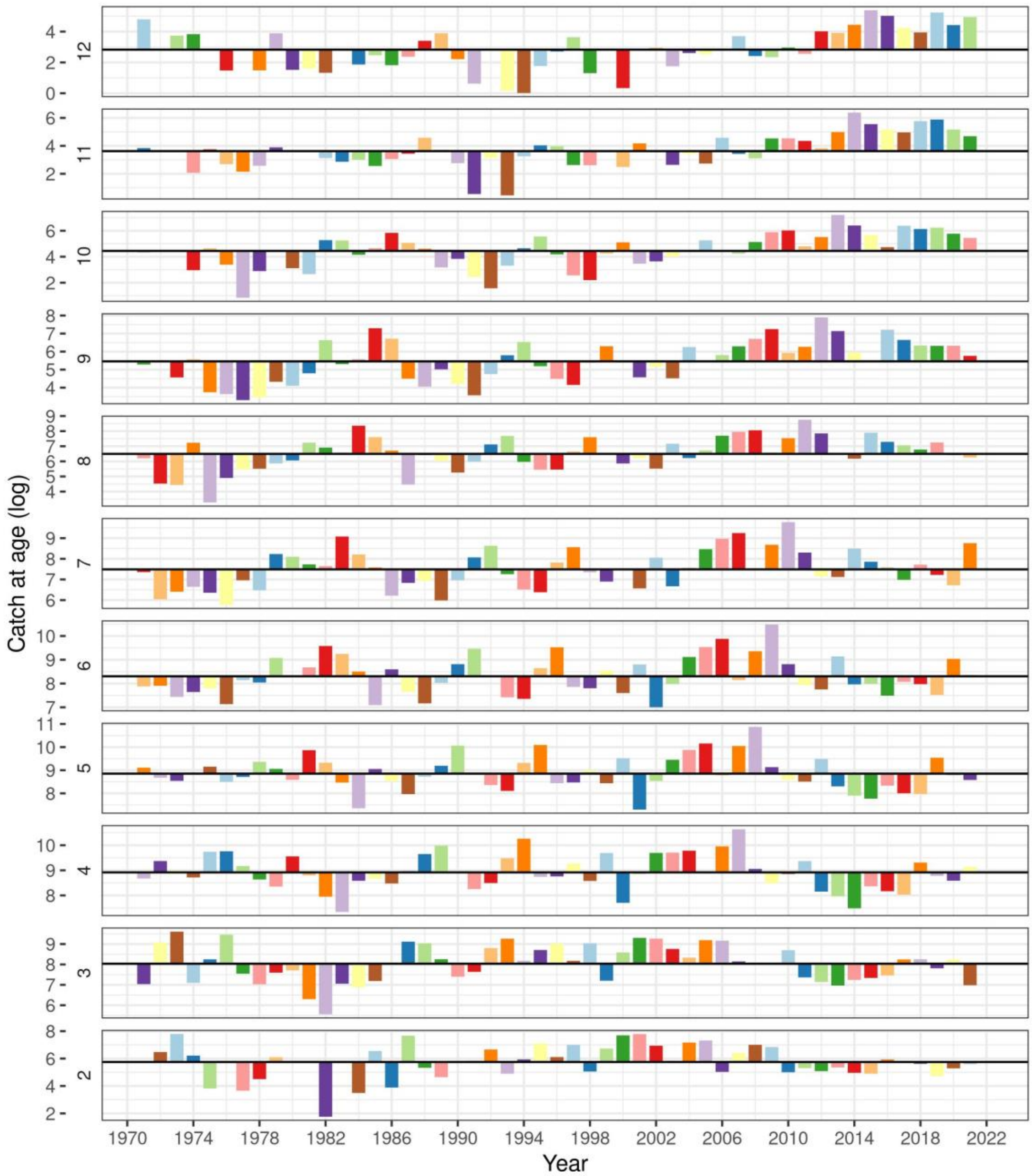


Figure 10.11: Haddock in 5.a. Catch at age from the commercial fishery in Iceland waters. Bar size is indicative of the catch in numbers and bars are coloured by cohort.

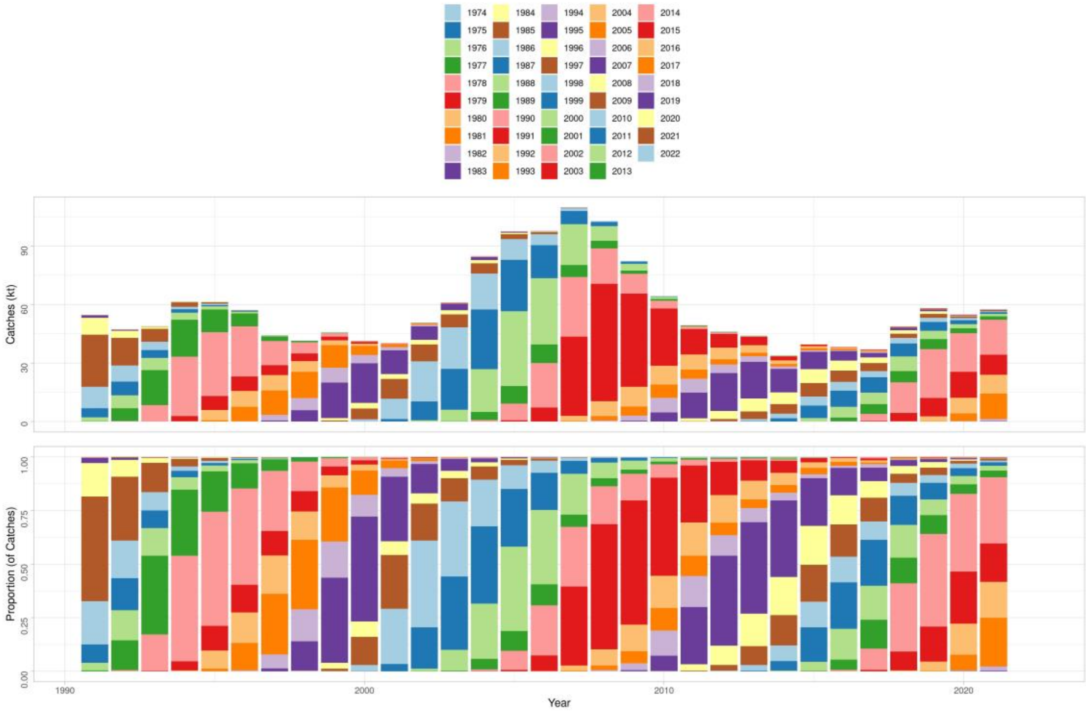


Figure 10.12: Haddock in 5.a. Catch at age from the commercial fishery in Iceland waters. Biomass caught by year and age, bars are coloured by cohort.

10.2.4 Weight at age in the catch

Mean weight at age in the catch is shown in Figure 10.13. Catch weights of the older year classes have been increasing in recent years, after being very low when the stock was large between 2005 and 2009. Higher mean weight at age is most apparent for the younger haddock from the small cohorts (2008–2013), which has resulted in a mean weight of the old fish above average. Mean weight of younger year classes in the catches has decreased but is still above average.

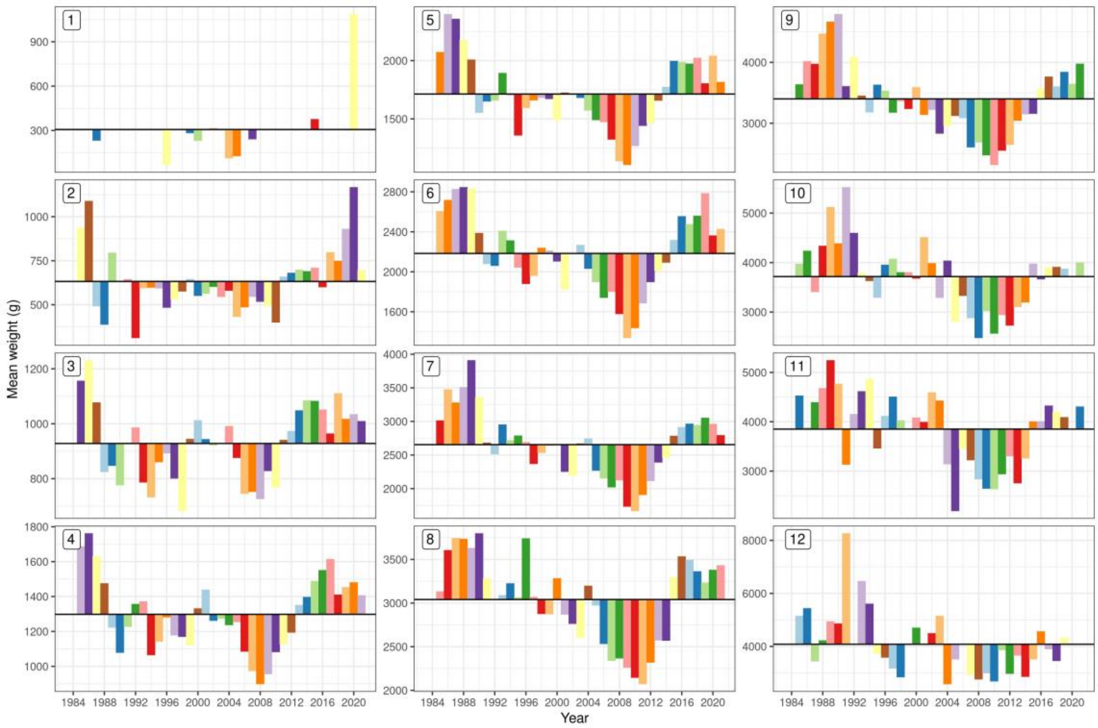


Figure 10.13: Haddock in 5.a. Catch weights from the commercial fishery in Icelandic waters. Bars are coloured by cohort.

10.2.5 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.

10.3 Catch, effort and research vessel data

10.3.1 Catch per unit of effort from commercial fisheries

Catch per unit of effort data (Figure 10.14 shows that for hauls where the catch is composed of more than 50% haddock the CPUE has been steadily increasing since 1990 for the main gear types. The CPUE from all catches from bottom trawls and demersal seine is amongst the highest recorded while for longlines it is fairly low. This is in-line with fishermen's perception that it is easy to catch haddock. This gives a different picture of the development of the stock than that which is observed in surveys and assessment, much less increase after 2000 and much less decrease in recent years. However, it is worth noting that there is also a considerable change in the size composition of the stock, where the biomass of 60 cm and above is at the highest observed in the time series, while the total biomass is close to it average value, suggesting that the CPUE may be more representative of larger fish.

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

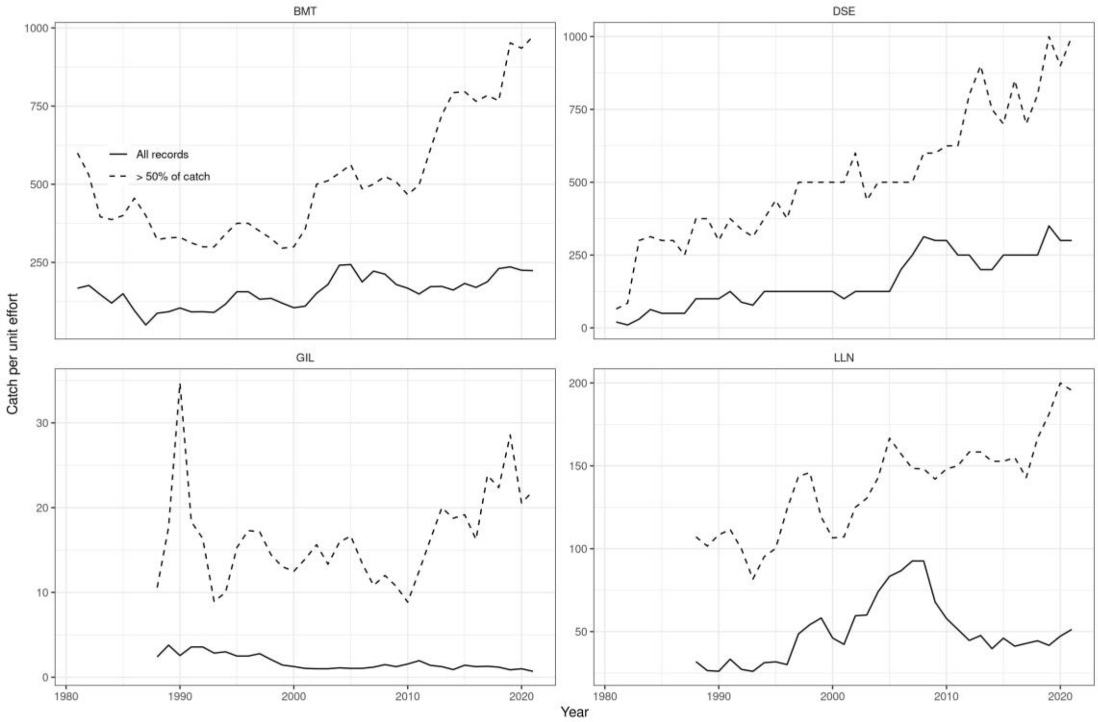


Figure 10.14: Haddock in 5.a. Catch per unit of effort in the most important gear types. The dashed lines are based on locations where more than 50% of the catch is haddock and solid lines on all records where haddock is caught. A change occurred in the longline fleet starting September 1999. Earlier only vessels larger than 10 BRT were required to return logbooks but later all vessels were required to return logbooks.

10.3.2 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 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 10.15 shows both a recruitment index and the trends in various biomass indices. Changes in spatial distribution observed in the spring survey are shown in Figure 10.16. The figure shows that a larger proportion of the observed biomass now resides in the north (areas NW and NE). Survey length distributions are shown in Figure 10.18 (abundance) and changes in spatial distribution in Figure 10.17.

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

Age disaggregated indices from the March survey are shown in Figure 10.19. 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.

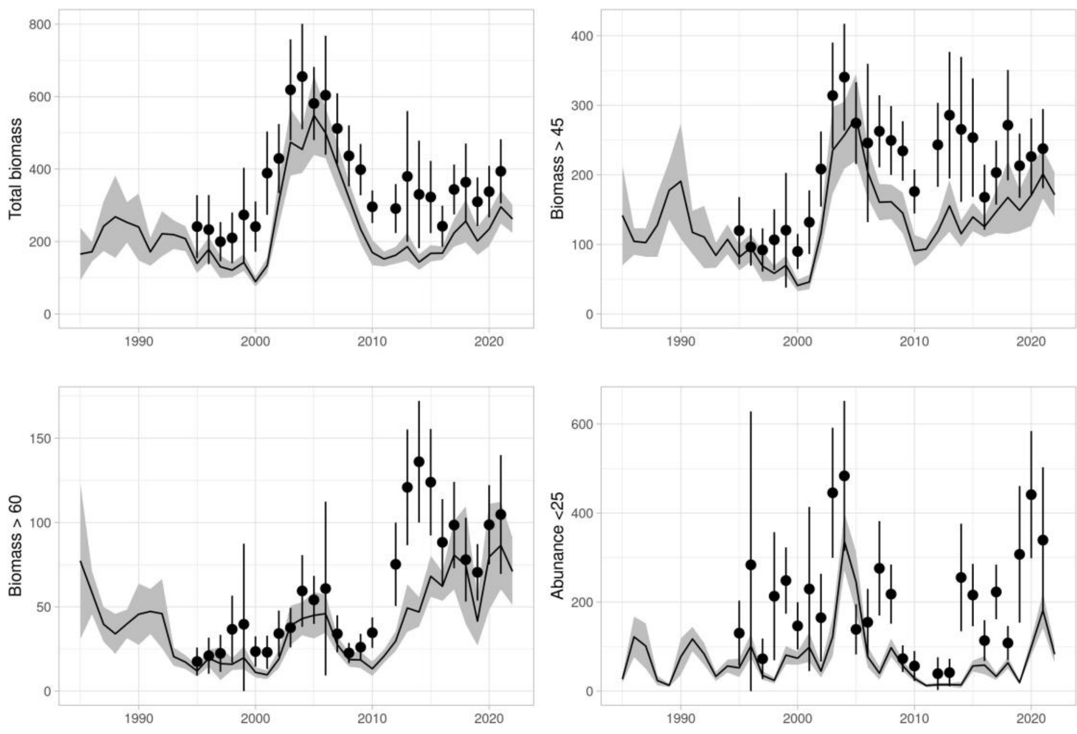


Figure 10.15: Haddock in 5.a. Indices in the Spring Survey (March) 1985 and onwards (line shaded area) and the autumn survey (point ranges).

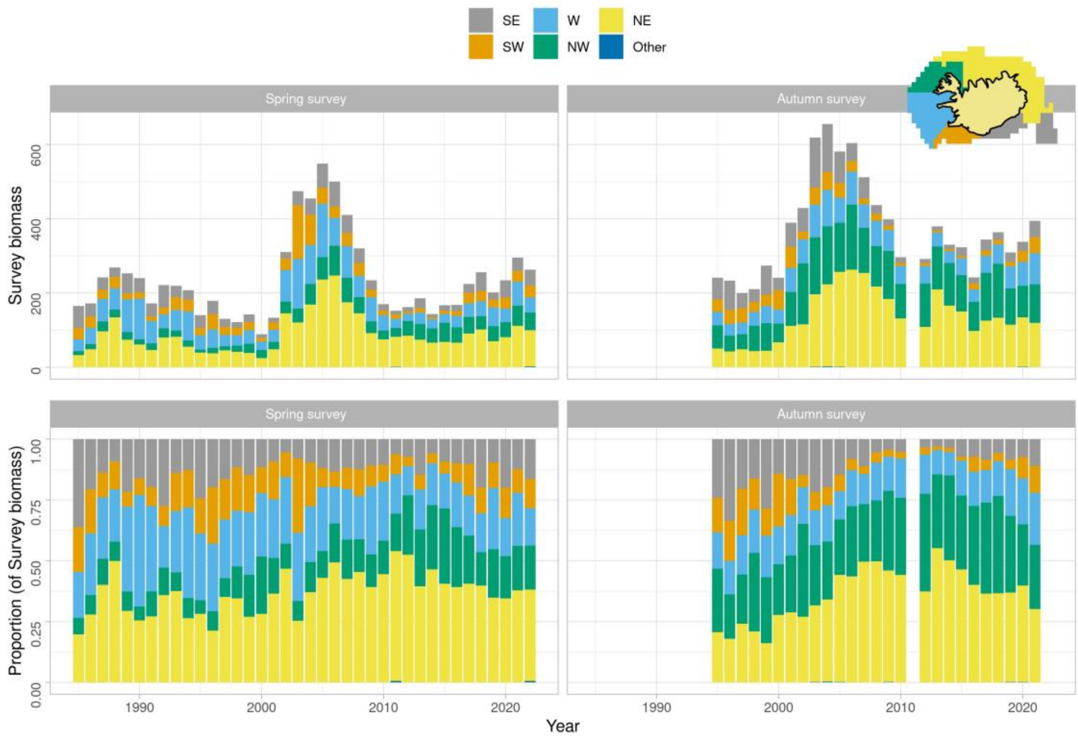


Figure 10.16: Haddock in 5.a. Changes in geographical distribution of the survey biomass.

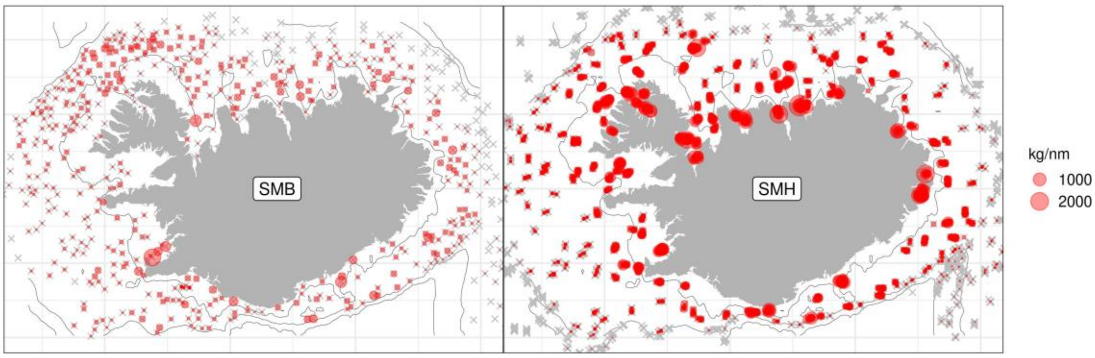


Figure 10.17: Haddock in 5.a. Location of haddock in the March 2022 (SMB) and the Autumn 2021 (SMH) survey, bubble sizes are relative to catch sizes.

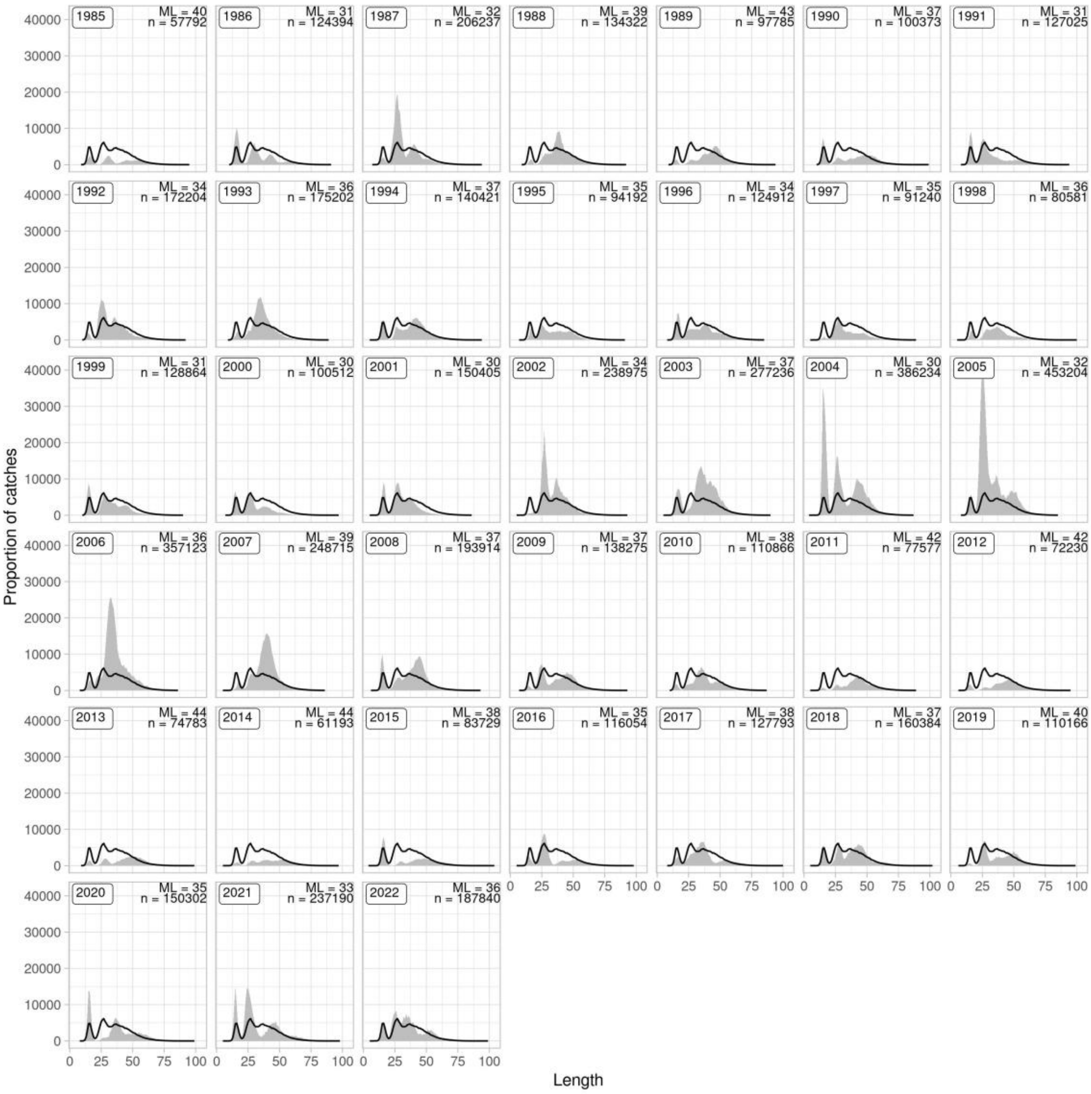


Figure 10.18: Haddock in 5.a. Length disaggregated abundance indices from the March survey 1985 and onwards.

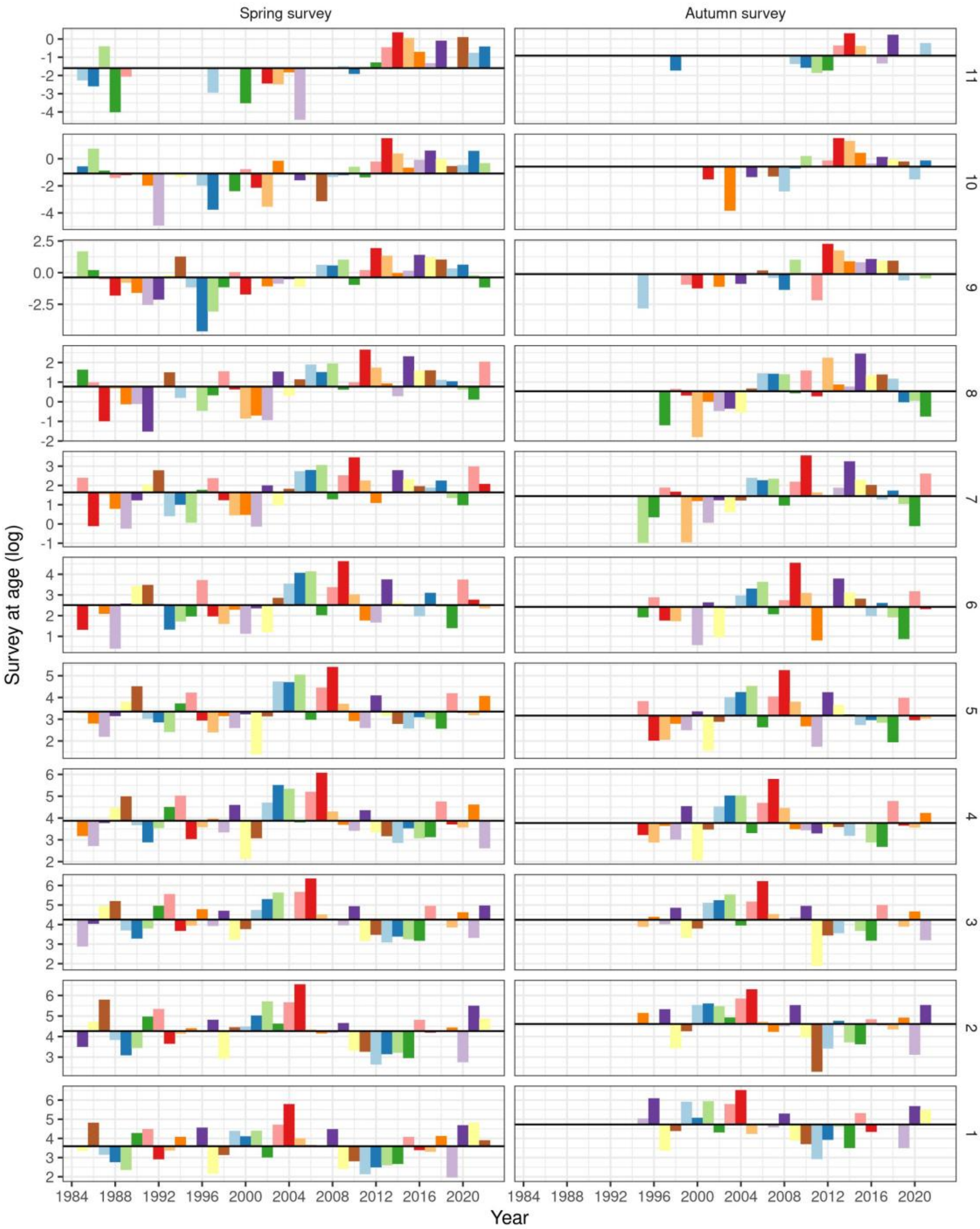


Figure 10.19: Haddock in 5.a. Age disaggregated indices in the Spring Survey (left) and the autumn survey (rights). Bars indicated the deviation from the log mean index, fill colors indicate cohorts. Note different scales on y-axes.

10.3.3 Stock weight at age

Mean weight at age in the catch is shown in Figure 10.13. Stock weights are obtained from the groundfish survey in March and are also used as mean weight at age in the spawning stock. Both stock and catch weights of the older year classes have been increasing in recent years, after being very low when the stock was large between 2005 and 2009. Higher mean weight at age is most apparent for the younger haddock from the small cohorts (2008–2013), which has resulted in a mean weight of the old fish above average. Mean weight of younger year classes has decreased but is still above average.

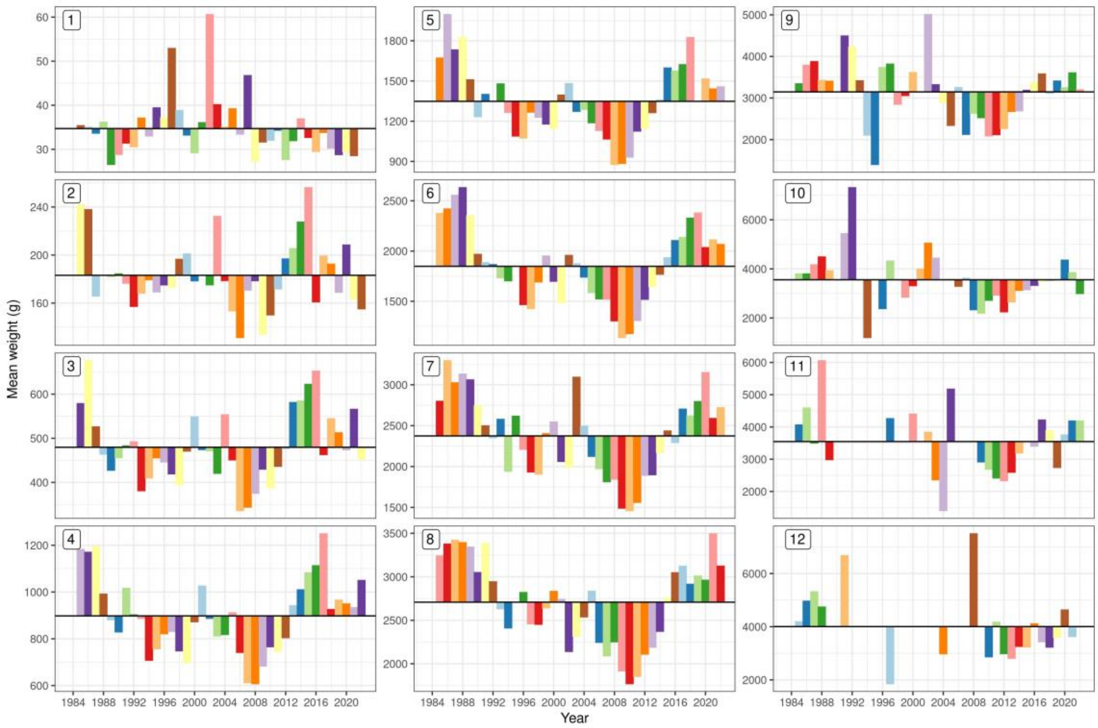


Figure 10.20: Haddock in 5.a. Stock weights from the March survey in Icelandic waters. Bars are coloured by cohort.

10.3.4 Stock maturity at age

Maturity-at-age data are shown Figure 10.21. Those data are obtained from the groundfish survey in March. Maturity-at-age of the youngest age groups has been decreasing in recent years which is likely to be related to the distributional shift towards the north. Maturity by size has been decreasing and the most likely explanation is large proportion of those age groups north of Iceland where proportion mature has always been low, as illustrated in Figure 10.22.

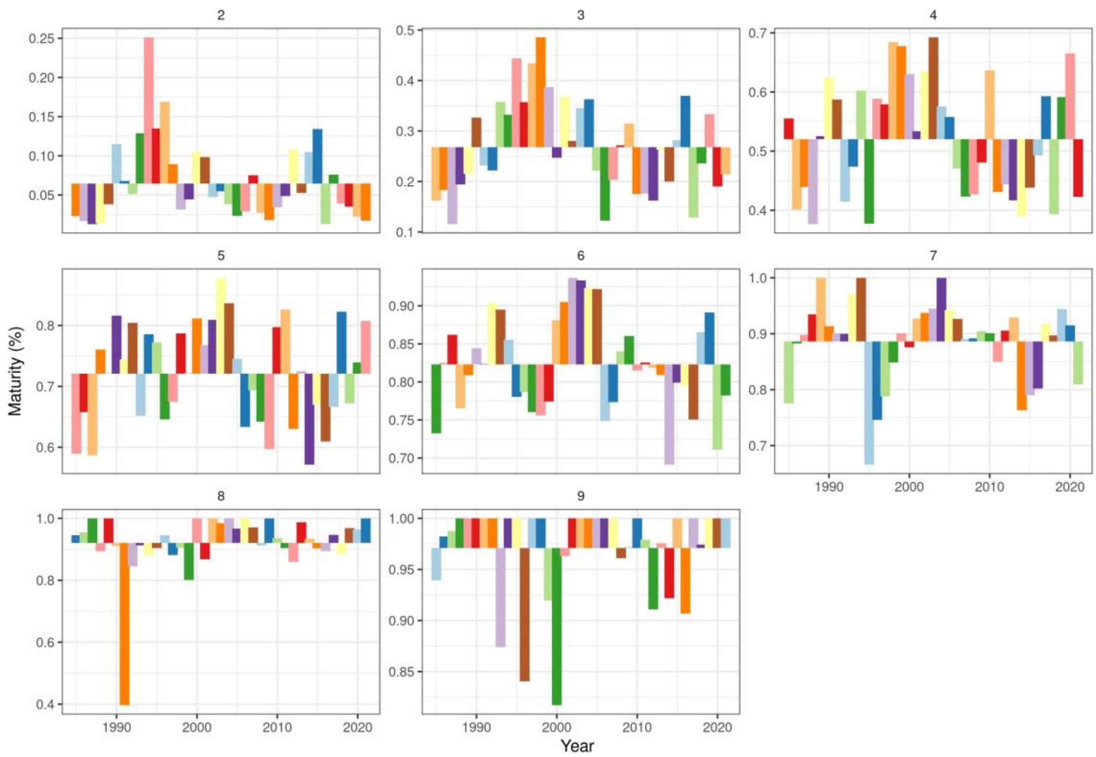


Figure 10.21: Haddock in Division 5.a. Maturity at age in the survey. Bars are coloured by cohort. The values are used to calculate the spawning stock.

Figure 10.22: Haddock in 5.a. Geographical differences in proportion mature by year and age (top), and stock weights (below).

10.4 Data analyses

10.4.1 Analytical assessment

This stock was last benchmarked in 2019 (WKICEMSE; ICES, 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:

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

The rationale for this choice, compared to a more traditional age-based selection, is to account for observed changes in growth between year classes. Larger year classes tend to have lower mean weight compared to smaller year classes, as observed in Figure 10.13. As fishery selection is mainly size based, the assessment model using a size-based selection only requires two parameters to estimate the selection pattern. In contrast an age-based selection pattern would require parameter based on multiple selection time periods.

The weights to the survey data are based on a common multiplier to the variance estimates of each age group and survey obtained from a backwards calculation model (described in Bjornsson, Hjorleifsson, and Elvarsson 2019), shown in Figure 10.23.

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.

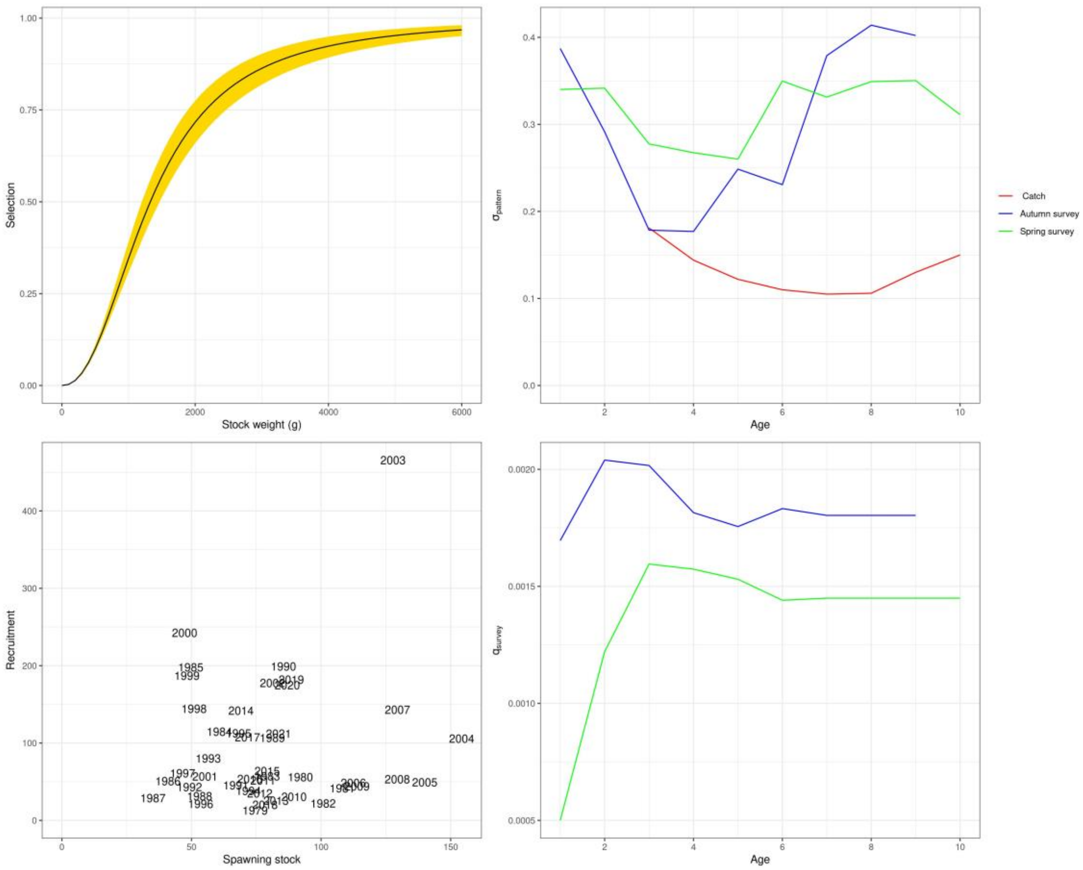


Figure 10.23: Haddock in 5.a. Estimated selection by weight, CV pattern, stock recruitment relationship and survey catchability.

10.4.2 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).

10.4.3 Diagnostics

The fit to data is illustrated in Figure 10.25 where no concerning residual patterns are observed. When looking at the combined fit (Figure 10.24) the figure shows the observed vs. predicted biomass from the surveys and it indicates that historically the autumn survey biomass has been closer to the prediction than corresponding values from the March survey, where the contrast in observed biomass is more than predicted from the assessment. The model accounts for this by estimating a stronger residual correlation for the spring survey (0.527) compared with the autumn survey (0.193). When contrasting the biomass levels before and after the mid 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, Figure 10.23 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.

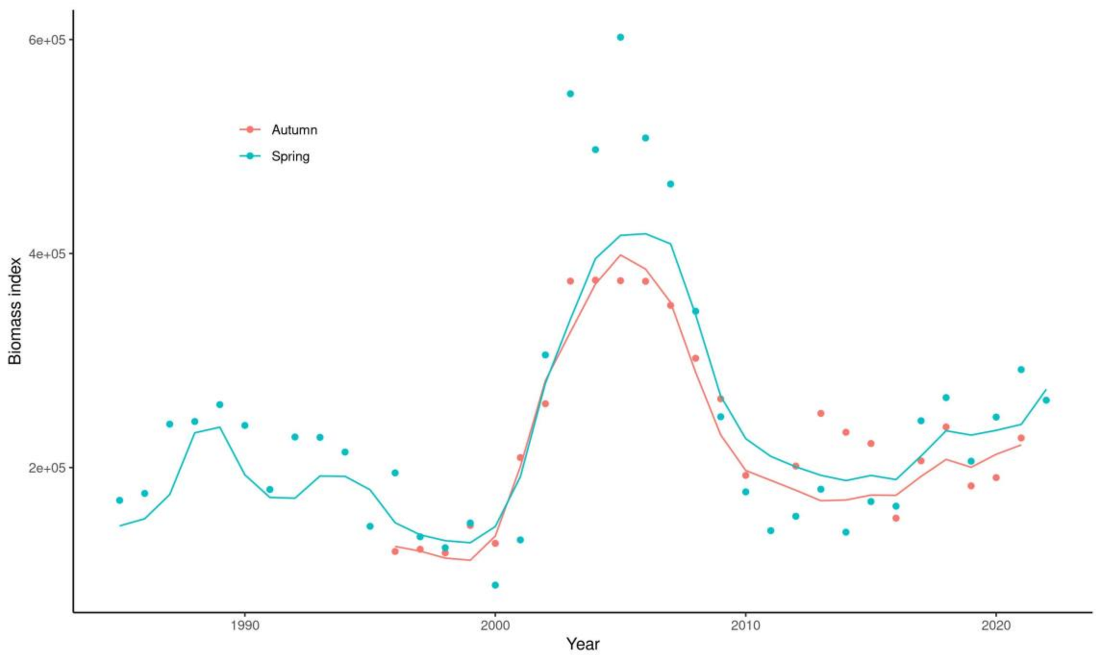


Figure 10.24: Haddock in Division 5.a. Aggregated model fit to the total biomass indices.

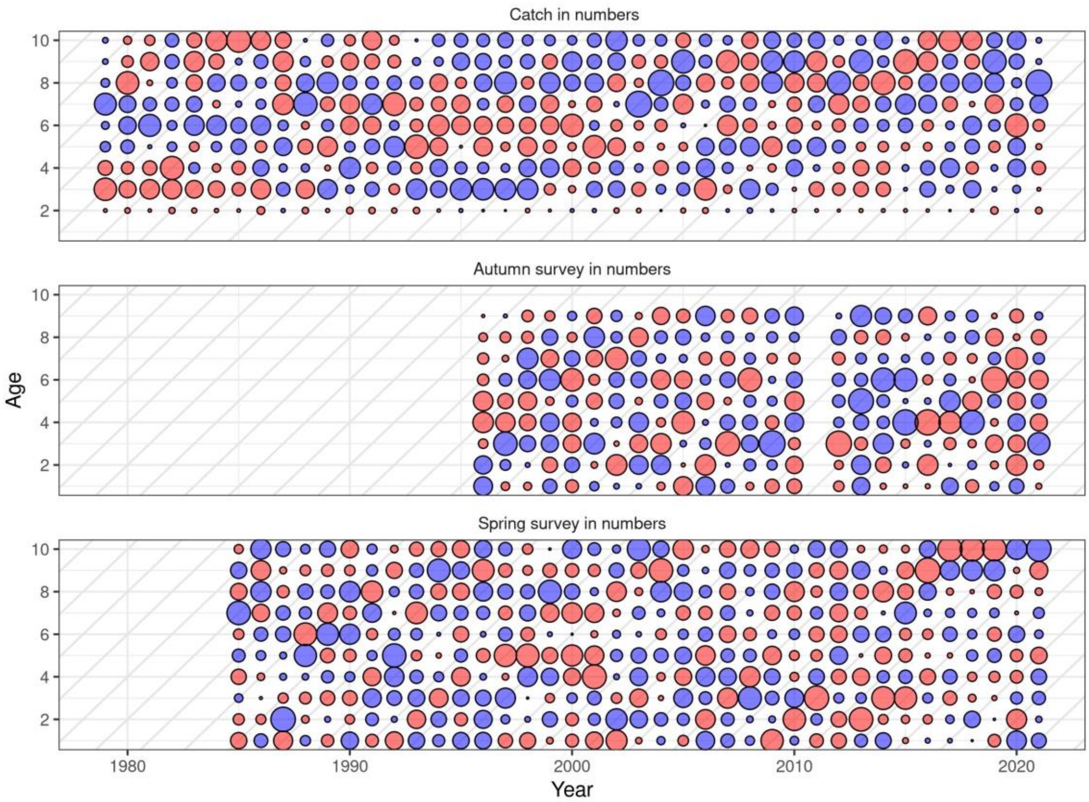


Figure 10.25: Haddock in Division 5.a. Residuals from the model fit to survey and catch data based on the both the surveys. Red circles indicate negative residuals (observed < modelled), while blue positive. Residuals are proportional to the area of the circles.

10.4.4 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 10.26). 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 10.28) 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 as illustrated in Figure 10.28.

Assessment in recent years has shown some difference between model runs where either or both of the two different tuning series, i.e. March and the October surveys, are omitted from the estimation, but currently this difference is mostly within the estimated uncertainty (Figure 10.27) but that has not always been the case. When the model is only fitted with catch data the reference biomass is estimated to be increasing a much faster rate than the baseline assessment suggest.

Estimated selection is illustrated in Figure 10.29, 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 10.32.

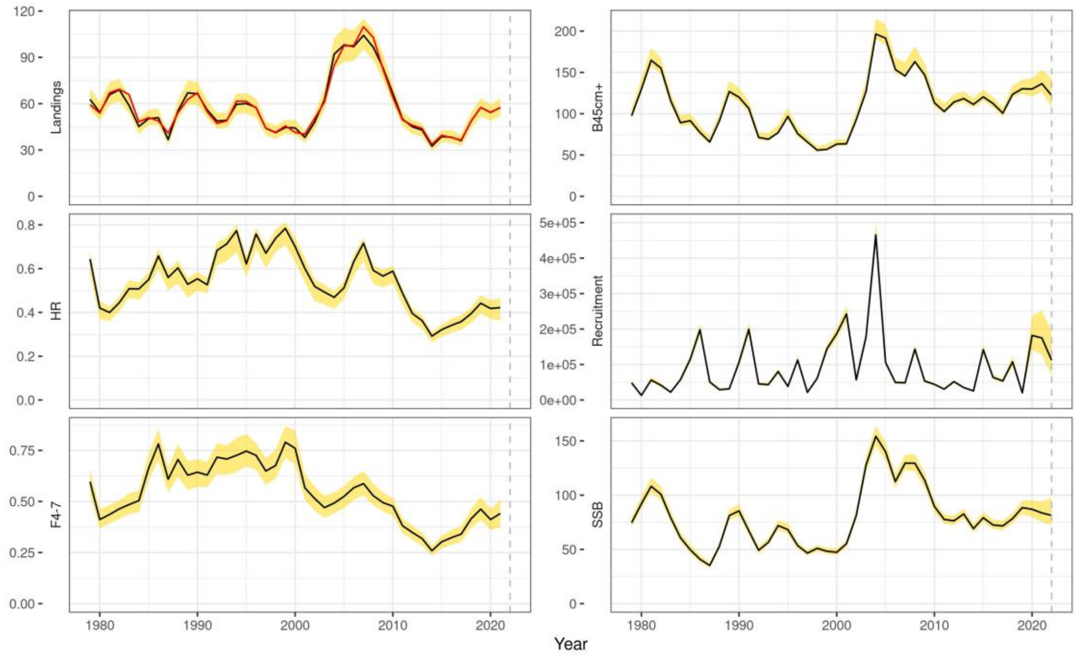


Figure 10.26: Haddock in Division 5.a. Summary from assessment. Dashed vertical line indicates the assessment year and yellow shaded region the uncertainty as estimated by the model.

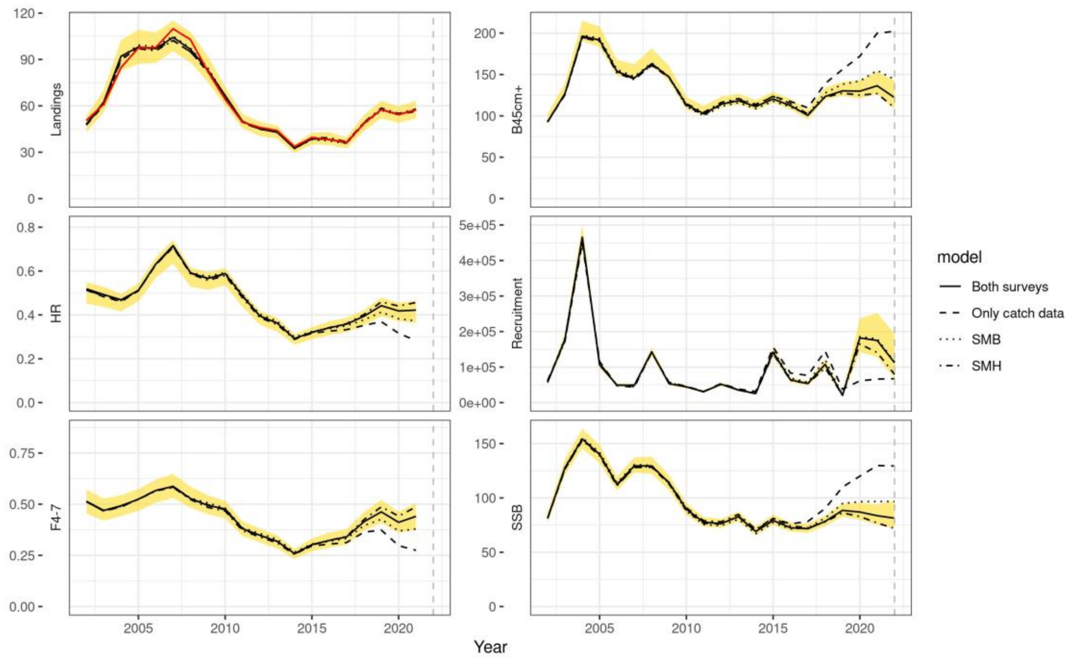


Figure 10.27: Haddock in 5.a. Comparison of assessment results where either the spring survey or the autumn survey is omitted from the estimation.

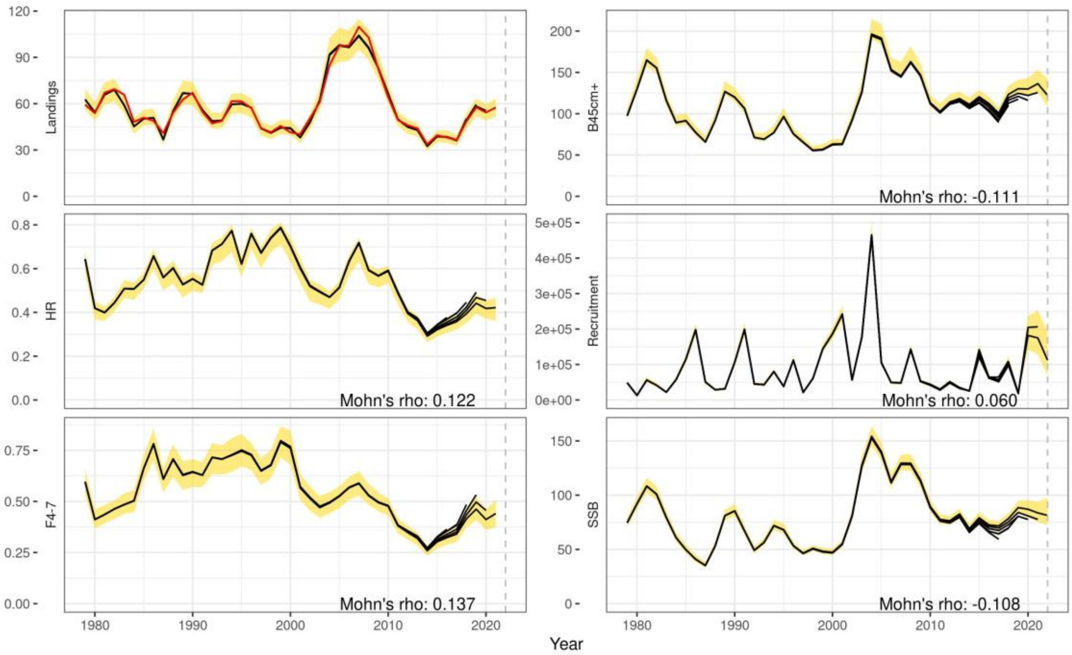


Figure 10.28: Haddock in Division 5.a. Analytical retrospective analysis of the assessment of haddock with a *5-year* peel.

Figure 10.29: Haddock in 5.a. Estimated selection at age.

10.4.5 Short term projections

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

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

where according to the stock annex the factor δ_y for the assessment year (Figure 10.32) is the average of the points estimates of the growth factor in the two preceding years. Growth has been high but somewhat variable in recent years but was much less in when the stock was larger. Maturity, selection, catch weights at age and proportion of the biomass above 45cm^+ are then predicted from stock weights in 2022. When those values have been estimated the prediction is done by the same model as used in the assessment. The model works iteratively as the estimated TAC for the fishing year 2022/2023 has some effect of the biomass at the beginning of 2023, which the TAC is based on. This procedure is described in the detail in the stock annex.

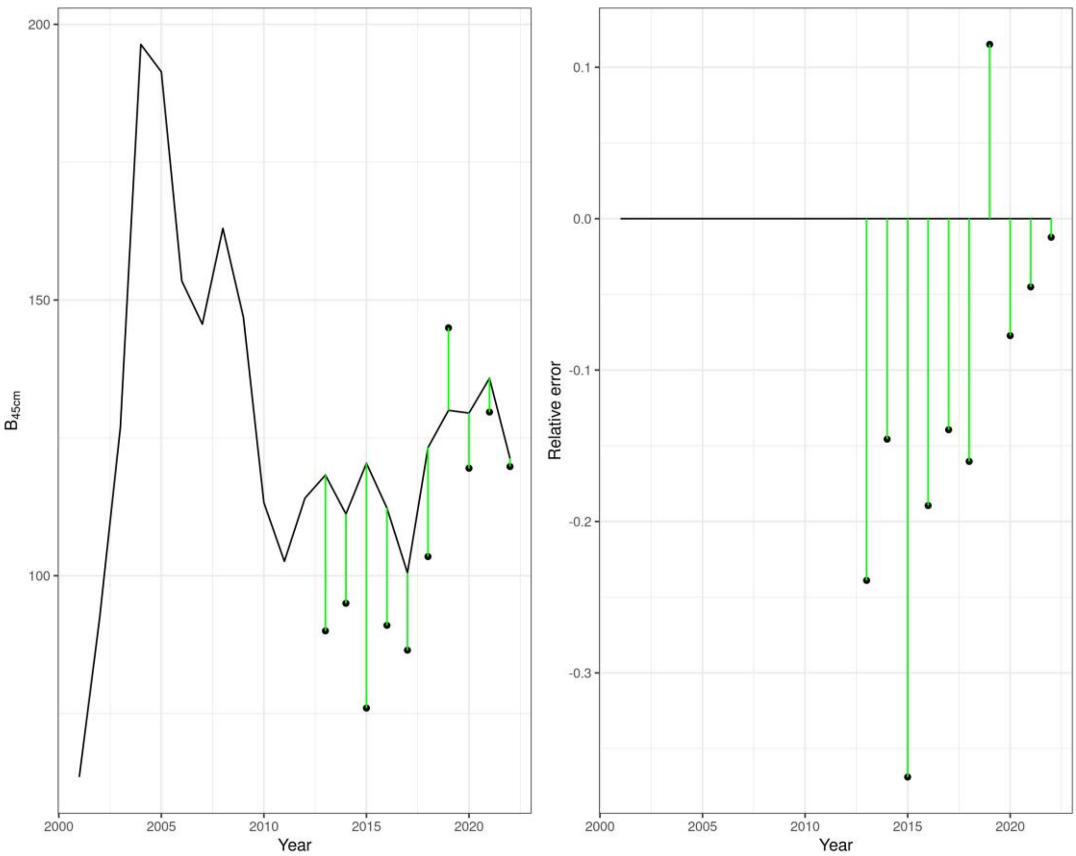


Figure 10.30: Haddock in 5.a. Comparison of the short-term prediction of reference biomass to the realised value a year later.

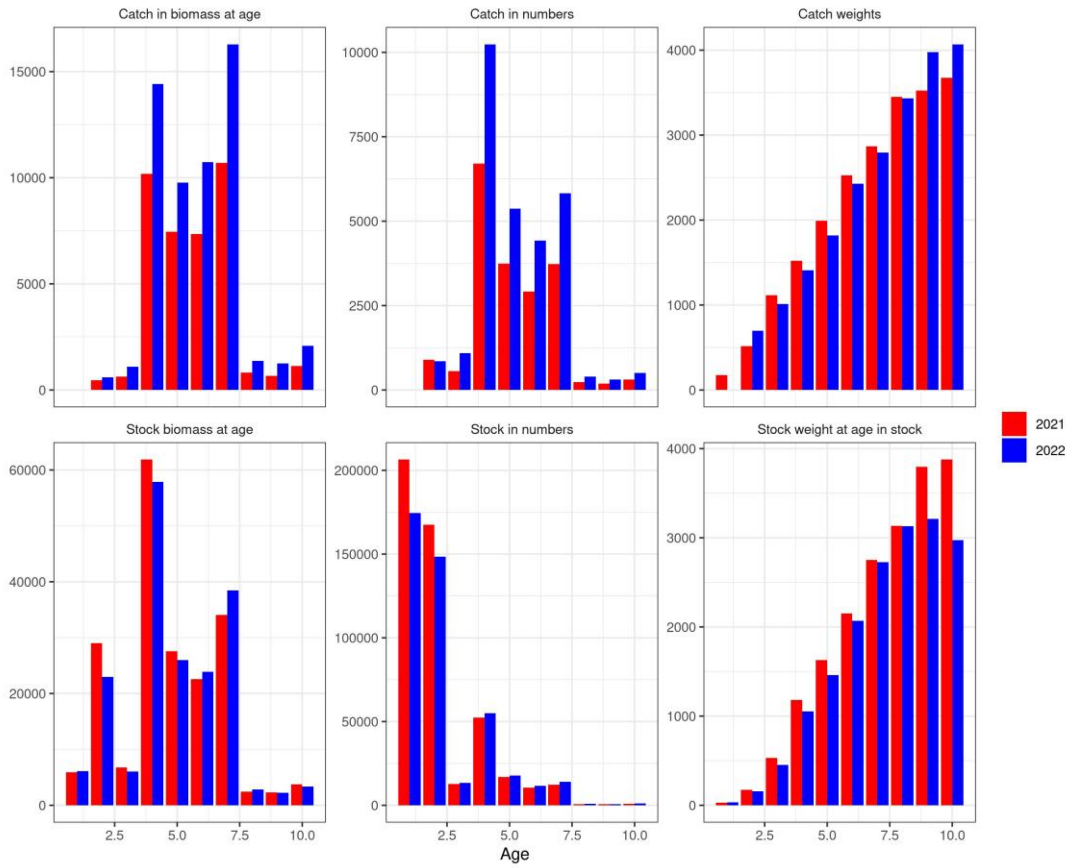


Figure 10.31: Haddock in 5.a. Comparison of some of the results of 2019 assessment based on different tuning data and 2017 assessment tuned with both the surveys.

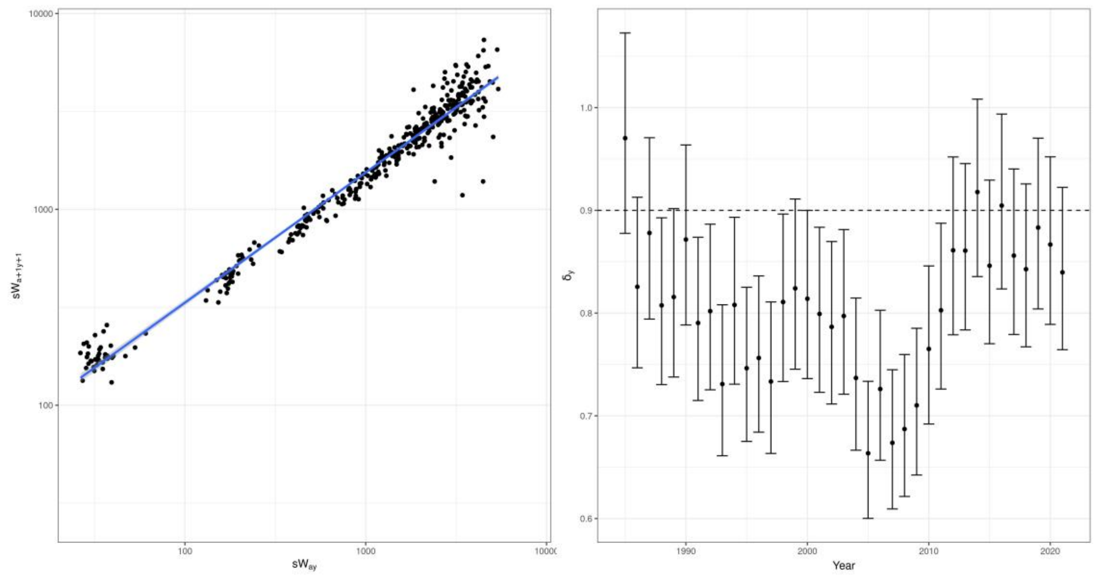


Figure 10.32: Haddock in 5.a. Input data to prediction model, where the exponent of the year factor (growth multiplier) is estimated to derive the reference biomass in the advisory year, as described in the text.

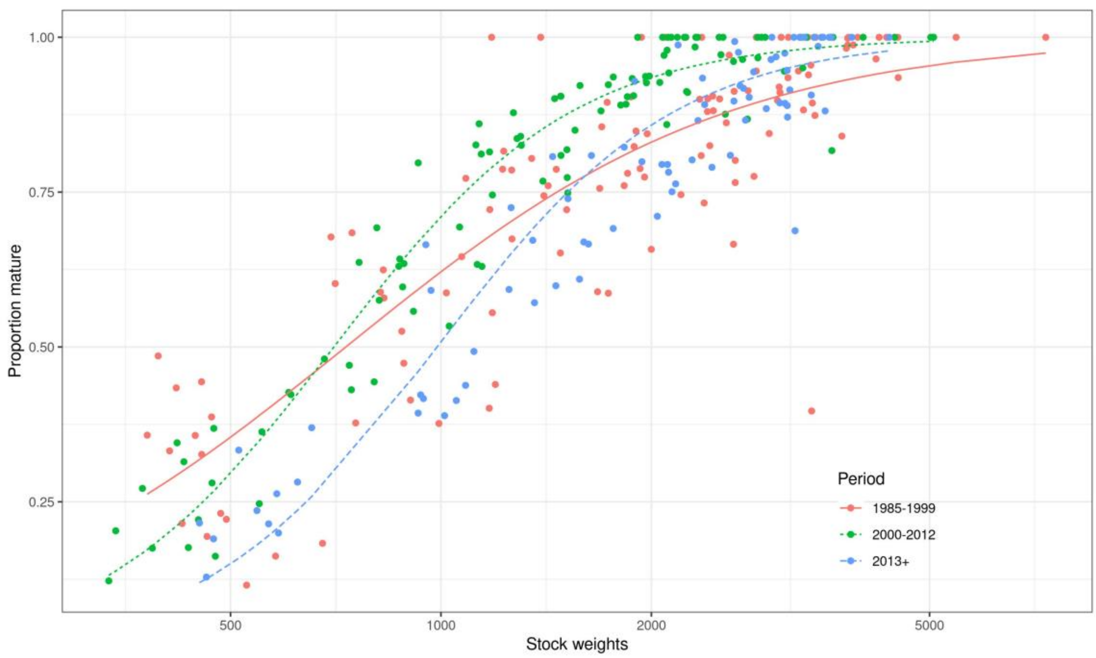


Figure 10.33: Haddock in 5.a. Maturity at weight as used in the projections.

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 MFRI and the set TAC in all fishing years (`r tables(display='cite,'"tachist) and Figure 10.34) . Since the 2001/2002 the catches have exceeded more that 5% the set TAC in seven fishing years. The largest overshoot in landings in relation to advice/TAC was observed in the fishing year 2007/2008 when the landings of haddock exceeded the advice by 11%. The reasons for the implementation errors are related to the management system that allow for transfers of quota share between fishing years and conversion of TAC from one species to another (species transformation).

The TAC system does not include catches taken by Norway and the Faroe Islands by bilateral agreement. The level of those catches is known in advance but has until recently not been taken into consideration by the Ministry when allocating TAC to Icelandic vessels. There is no minimum landing size for haddock in 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 t of demersal fish species in Icelandic waters which includes maximum 1200 tonnes of cod and 40 t of Atlantic halibut.

The effect of these species transformations and quota transfers is illustrated in Figure 10.35. The figure illustrates that when the biomass of haddock was high in the years between 2002 to 2007 the net transfers to haddock from other species increased. This may in part be explained by shifts in distribution of haddock, as illustrated in Figure 10.5, as the fisheries that traditionally target the northern area had lower amounts of haddock in their quota portfolio. However, looking over longer period quota transfer towards/from haddock has on the average been close to zero. With the establishment a management plan in 2013 the transfers between quota years have decreased substantially, while at the same time transfers from other species have increased. This is likely due to the fact that haddock is easy to catch, as demonstrated by high CPUE in recent years. The haddock quota may also be limiting in some mixed fisheries and that haddock may have been underestimated in last years could also contribute to transfer towards haddock. These effects were considered when the management plan was tested.

Figure 10.34 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 and 2020/2021 fishing years the government of Iceland increased TAC mid-season.

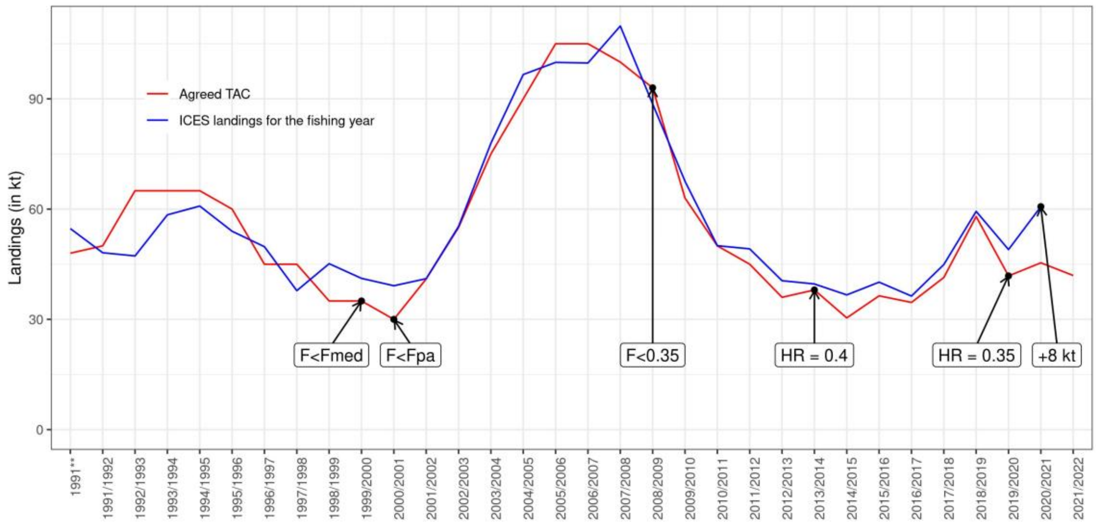


Figure 10.34: Haddock in 5.a. Comparison of the realised catches and the set TAC for the fishing operations in Icelandic waters. Note that in the 1999/2000 fishing year the government of Iceland increased TAC mid-season.

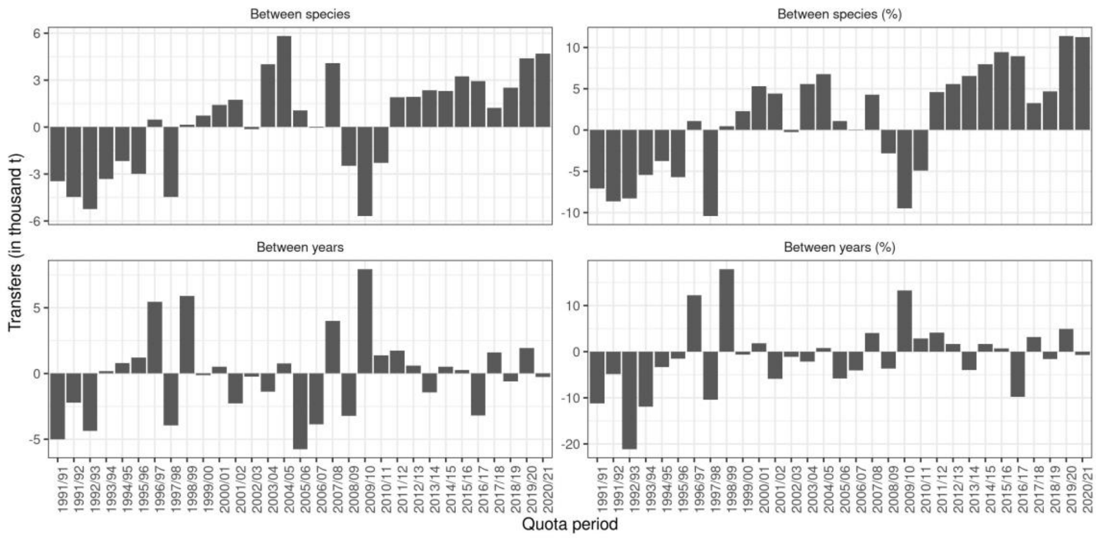


Figure 10.35: Haddock in 5.a. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

10.6 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 has remained at the current levels however it is projected to increase in coming years due to strong incoming recruitment from the 2019- and 2020-year classes.

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

10.7 References

Bjornsson, Höskuldur, Einar Hjorleifsson, and Bjarki Þór Elvarsson. 2019. "Muppet: Program for Simulating Harvest Control Rules." Reykjavik: Marine; Freshwater Researh Institute. http://www.github.com/hoski/Muppet-HCR.

ICES. 2019. "Stock Annex: Haddock (*Melanogrammus aeglefinus*) in Division 5.a (Iceland grounds)." International Council for the Exploration of the Seas; ICES publishing.

Jónsson, Jón. 1996. *Tagging of Cod (Gadus Morhua) in Icelandic Waters 1948-1986;: Tagging of Haddock (Gadus Aeglefinus) in Icelandic Waters 1953-1965*. Hafrannsóknastofnunin.

MRI. 2016. "Mælingar á brottkasti þorsks og ýsu (e. Measurments of discards of Cod and Haddock), 2014–2016, Reykjavik, Iceland." Vol. 3. Marine; Freshwater Research Institute, Iceland; Marine Research Institute, Iceland. https://www.hafogvatn.is/static/research/files/fjolrit-183pdf.

Table 10.1: Haddock in Division 5.a. Age disaggregated survey indices from the groundfish survey in March (SMB).

Year	1	2	3	4	5	6	7	8	9	10
1985	28.575	32.942	17.726	23.888	26.496	3.724	11.004	5.136	5.388	0.755
1986	124.260	112.224	56.704	15.099	16.485	12.434	0.892	2.685	1.221	2.275
1987	23.144	329.992	141.902	43.321	8.957	8.037	4.720	0.370	0.593	1.136
1988	15.732	46.130	182.259	86.779	23.148	1.495	2.189	1.954	0.163	0.603
1989	10.484	21.911	40.355	147.443	44.812	13.275	0.783	0.879	0.449	0.471
1990	72.401	31.170	26.620	39.264	91.654	31.171	3.399	0.891	0.202	0.014
1991	89.422	144.534	44.742	17.872	20.519	32.658	7.560	0.218	0.078	0.176
1992	18.338	209.604	142.976	34.360	17.333	13.307	16.221	2.270	0.119	0.007
1993	28.982	38.349	260.775	90.610	11.129	3.749	1.492	4.484	0.824	0.000
1994	59.314	62.235	39.417	151.828	41.570	5.554	2.717	1.213	3.573	0.261
1995	37.657	82.030	51.491	20.769	68.456	7.093	1.066	0.000	0.313	0.000
1996	96.043	71.077	119.894	35.767	18.907	41.364	5.871	0.628	0.010	0.267
1997	8.637	123.936	50.662	52.476	10.959	7.128	10.759	1.386	0.046	0.144
1998	22.943	18.632	110.949	28.160	23.220	4.932	3.430	4.736	0.315	0.000
1999	81.048	86.172	24.993	99.569	13.394	9.840	1.560	1.871	1.043	0.091
2000	61.023	88.972	43.210	8.310	25.115	3.076	1.597	0.425	0.178	0.494
2001	81.677	152.426	115.467	21.515	3.980	10.488	0.870	0.495	0.000	0.117
2002	20.178	303.588	201.158	110.796	22.887	3.300	7.419	0.392	0.338	0.116
2003	112.023	102.610	281.386	248.277	113.835	17.457	2.619	4.667	0.415	1.074
2004	327.761	290.418	70.478	208.872	110.711	34.864	6.216	1.353	0.598	0.262
2005	54.827	696.286	290.880	44.657	156.682	58.724	15.478	3.130	0.324	0.215
2006	38.729	77.757	577.128	182.402	19.575	62.962	16.475	6.668	0.722	0.286
2007	35.891	63.410	91.770	435.838	86.037	7.541	21.380	4.547	1.861	0.043
2008	88.825	65.201	73.828	73.634	222.247	29.253	3.599	7.010	1.762	0.267
2009	11.016	105.699	52.440	39.978	41.061	102.901	12.533	1.850	2.795	0.524
2010	16.492	27.417	140.054	30.317	18.515	20.723	31.743	2.701	0.383	0.779
2011	8.427	26.024	23.499	78.086	13.394	5.835	9.561	14.242	1.229	0.538
2012	12.009	13.983	32.281	28.317	60.113	5.282	2.967	5.703	6.979	1.309
2013	13.378	23.074	21.862	23.664	23.471	42.631	5.062	2.545	3.833	5.670
2014	14.328	24.730	29.546	17.388	16.230	14.422	16.325	1.327	0.965	3.194
2015	59.116	19.117	25.709	34.048	13.040	11.655	10.223	10.149	1.171	2.592
2016	29.504	123.420	23.794	21.484	21.940	7.179	7.120	4.886	4.077	2.772
2017	27.159	66.004	142.143	22.664	20.269	22.290	6.603	4.960	3.359	2.694
2018	61.837	72.756	72.695	116.651	13.002	11.346	9.518	3.065	2.819	2.666
2019	7.074	85.034	47.072	40.624	66.640	4.021	3.838	2.838	1.394	1.280
2020	109.055	15.592	102.591	35.257	27.056	42.384	2.640	1.841	1.881	2.867
2021	125.030	245.271	27.611	101.262	24.203	16.004	19.858	1.115	0.818	2.996

Table 10.2: Haddock in 5.a. Age disaggregated survey indices from the groundfish survey in October (SMH).

Year	1	2	3	4	5	6	7	9	8	10
1995	154.864	172.708	48.674	24.973	46.202	6.813	0.374	0.059	0.000	0.000
1996	444.043	95.984	81.458	17.765	7.492	17.992	1.412	0.000	0.000	0.000
1997	28.706	207.232	55.529	37.967	7.776	5.817	6.624	0.000	0.302	0.000
1998	80.045	30.852	129.177	20.260	16.282	5.638	5.342	0.000	1.926	0.177
1999	370.846	70.470	27.763	94.065	12.155	10.678	0.385	0.385	1.373	0.000
2000	160.181	254.381	44.552	7.877	28.856	1.778	3.282	0.288	0.165	0.583
2001	380.844	273.787	167.008	32.126	4.757	14.064	1.062	0.000	1.001	0.218
2002	74.302	239.702	190.160	93.061	17.865	2.588	3.413	0.327	0.624	0.000
2003	328.368	138.413	255.385	153.303	55.406	10.602	1.822	0.000	0.703	0.021
2004	681.123	347.882	52.084	153.426	70.075	19.583	3.374	0.413	0.575	0.000
2005	68.926	546.809	177.657	27.280	93.127	27.336	10.970	0.000	1.969	0.258
2006	115.089	113.726	504.347	109.392	13.868	37.863	9.671	1.190	4.267	0.000
2007	96.848	68.528	93.803	327.185	57.284	7.890	10.484	0.660	4.171	0.436
2008	199.775	90.485	67.844	86.833	191.883	15.575	2.598	0.256	4.065	0.089
2009	48.686	253.068	78.961	32.685	45.054	95.188	8.994	2.780	1.533	0.779
2010	40.375	52.221	142.049	30.998	14.517	22.205	35.128	0.875	4.917	1.431
2011	18.494	9.832	6.558	26.895	5.670	2.228	5.148	0.113	1.318	0.706
2012	50.528	30.510	31.275	35.669	69.741	11.124	4.070	9.744	9.448	1.778
2013	100.212	117.391	35.064	36.077	38.712	44.429	6.562	5.795	2.408	5.320
2014	32.906	41.101	65.795	24.072	25.116	22.714	25.851	2.452	2.170	5.575
2015	204.531	37.485	39.498	44.785	15.351	16.777	10.005	2.273	11.679	3.977
2016	76.474	126.869	23.911	17.796	19.247	7.199	7.568	2.942	3.882	2.746
2017	114.513	95.433	148.700	14.540	17.124	13.655	3.559	2.585	4.010	2.422
2018	116.330	77.363	71.032	118.870	6.954	6.816	5.665	2.570	3.248	2.762
2019	32.724	137.558	48.989	38.534	53.835	2.378	2.824	0.543	0.975	1.530
2020	294.574	22.447	107.108	35.272	19.230	24.054	0.893	0.827	1.049	1.421
2021	243.117	254.206	24.464	68.903	20.637	10.114	13.645	0.632	0.470	2.895

Table 10.3: Haddock in 5.a. Catch at age from the commercial fishery in Icelandic waters.

Year	1	2	3	4	5	6	7	8	9	10
1980	0.000	0.000	2221.874	14138.266	5355.917	4090.140	3286.567	429.641	60.333	27.111
1981	0.000	0.000	543.586	6598.800	19310.260	5869.602	2279.548	1387.274	120.786	19.257
1982	0.000	5.803	258.057	2830.554	11210.060	14438.292	2095.553	1002.869	761.265	223.358
1983	0.000	0.000	1159.392	1540.786	4752.128	10348.082	8781.591	718.420	201.248	209.561
1984	0.000	32.780	968.914	5342.904	1564.204	4923.345	3681.561	4281.210	262.851	90.093
1985	0.000	699.672	1321.939	5821.849	8536.695	1203.141	1954.735	2013.169	1474.208	129.323
1986	0.000	48.736	3147.191	4797.900	5075.571	5411.823	499.496	821.098	825.411	371.867
1987	20.798	2132.538	9130.410	7926.622	2881.908	2090.971	928.181	86.432	89.912	215.307
1988	0.000	205.740	8411.111	15521.575	6130.332	1293.851	1020.191	614.903	57.732	234.700
1989	0.000	103.972	3843.204	21726.203	9843.391	3060.735	396.987	419.211	150.418	137.092
1990	0.000	0.000	1634.584	7703.042	23502.597	6733.964	1052.278	191.805	67.187	84.219
1991	0.000	344.152	2074.261	3846.022	6678.415	12865.482	3189.809	396.451	35.715	21.968
1992	0.000	783.463	6651.669	4884.572	4273.294	4020.142	5601.953	1235.599	115.608	33.508
1993	0.000	133.592	10586.490	13101.384	3314.864	1672.311	1417.994	2165.992	329.360	45.715
1994	0.000	378.504	3563.435	28575.159	11121.534	1563.422	674.095	389.795	686.903	137.259
1995	0.000	1205.166	6068.412	6240.857	24121.217	5688.891	590.750	231.371	179.126	333.056
1996	4.239	450.082	8243.179	6350.035	4623.802	13698.612	2488.972	234.542	88.927	133.347
1997	0.000	1099.232	3560.281	10633.050	4769.054	2578.991	5230.422	778.831	63.478	72.514
1998	0.000	156.657	8410.930	5312.313	8009.675	2446.463	1555.858	1993.312	218.377	38.102
1999	28.062	838.643	1339.786	16168.284	4610.576	5178.171	989.398	655.445	542.582	72.769
2000	10.980	2192.932	5368.257	2221.052	13623.793	1997.687	1771.258	351.226	222.581	181.429
2001	0.000	2410.158	10971.731	7018.579	1476.688	6658.580	710.021	492.758	96.911	96.612
2002	48.668	1028.303	10563.234	16224.354	5103.822	1099.873	3152.381	250.174	173.346	96.267
2003	0.000	343.784	6377.242	16406.366	12713.737	2926.486	787.355	1294.895	91.940	80.883
2004	148.588	1297.681	4170.831	17725.087	19507.597	9091.762	1930.665	501.625	518.568	151.181

Year	1	2	3	4	5	6	7	8	9	10
2005	13.227	1505.182	9816.255	7200.101	25743.637	13846.241	4748.460	831.304	232.163	223.935
2006	0.000	152.423	9568.296	21031.033	6510.775	19511.355	7888.710	2206.788	332.323	188.039
2007	2.594	607.522	3458.200	41721.344	23126.995	3444.497	10389.848	2852.144	539.706	174.109
2008	0.000	1101.971	3087.078	8577.185	52881.654	11568.482	1839.906	3151.774	816.989	203.124
2009	0.000	939.482	3109.408	4842.328	9266.287	35700.432	5890.757	722.269	1403.324	463.969
2010	0.000	148.509	6009.741	6998.964	5295.788	6725.127	17658.364	1876.916	374.547	524.554
2011	0.000	201.009	1581.966	11728.962	4955.563	2781.487	4043.655	6338.837	525.455	217.067
2012	0.000	161.056	1260.847	3476.323	13223.730	2323.123	1269.345	2565.420	2691.292	369.902
2013	0.000	210.841	1060.127	2881.729	4030.712	9339.414	1237.613	683.129	1260.590	1585.576
2014	0.000	142.526	1398.118	1779.265	2706.454	2880.811	4919.265	482.547	381.528	1378.930
2015	14.282	133.635	1537.578	4281.608	2376.038	2937.280	2591.206	2676.264	229.600	833.304
2016	0.000	377.393	1738.299	3526.989	4162.824	1783.324	1971.885	1466.092	1355.079	482.511
2017	0.000	319.798	3808.866	3071.488	2991.626	3195.463	1077.711	1166.778	770.356	1007.459
2018	0.000	275.375	3851.346	11032.346	2900.917	2906.067	2247.882	882.748	564.579	959.497
2019	0.000	111.999	2466.497	6508.906	13896.604	1847.004	1367.499	1407.630	553.526	1189.208
2020	13.118	197.608	3813.351	5369.245	6536.633	8396.383	827.778	618.802	556.756	746.452
2021	0.000	268.788	1078.199	9297.478	5312.507	4241.979	6378.002	522.309	317.909	586.707

Table 10.4: Haddock in 5.a. Catch weights from the commercial fishery in Icelandic waters.

Year	1	2	3	4	5	6	7	8	9	10
1980	4000	4000	807	1293	2099	2616	3008	3593	4924	4687
1981	4000	4000	1050	1157	1718	2298	3106	3333	3810	4119
1982	4000	553	973	1465	1650	2295	2940	3329	3824	3998
1983	4000	4000	951	1501	1918	2358	2818	3391	4191	4307
1984	4000	1102	926	1426	1931	2391	3077	2852	3843	3629
1985	4000	938	1157	1688	2074	2608	3015	3134	3639	3976
1986	4000	1090	1232	1763	2399	2719	3478	3608	4020	4239
1987	231	491	1078	1631	2358	2829	3281	3746	3976	3402
1988	4000	387	824	1476	2179	2847	3511	3736	4471	4340
1989	4000	796	847	1222	2009	2833	3911	3632	4668	5123
1990	4000	4000	776	1077	1552	2389	3362	3800	4793	4390
1991	4000	645	931	1226	1649	2077	2686	3285	3610	5526
1992	4000	311	987	1358	1657	2059	2511	3036	4090	4601
1993	4000	594	786	1372	1894	2410	2956	3091	3454	3798
1994	4000	597	732	1064	1704	2314	2721	3227	3178	3626
1995	4000	592	860	1141	1357	2041	2791	3066	3633	3289
1996	66	483	892	1280	1593	1878	2694	3742	3533	3958
1997	4000	530	800	1177	1659	1959	2366	3072	3173	4076
1998	4000	575	682	1168	1680	2240	2531	2875	3361	3806
1999	281	646	945	1120	1670	2213	2639	2871	3234	3805
2000	229	550	1013	1333	1489	2103	2641	3285	3592	3676
2001	4000	562	944	1440	1726	1822	2249	2867	3136	4515
2002	315	601	921	1261	1708	2188	2189	2761	3219	3989
2003	4000	544	929	1273	1679	2269	2672	2604	2829	3287
2004	111	580	992	1236	1571	2029	2746	3199	2957	4040
2005	126	431	875	1253	1489	1896	2266	2971	3119	2808
2006	4000	485	744	1084	1472	1739	2150	2531	3083	3327
2007	240	545	752	972	1322	1800	2019	2337	2603	2876
2008	4000	517	726	897	1136	1577	2123	2365	2684	2474
2009	4000	493	828	955	1104	1336	1731	2259	2473	3019
2010	4000	399	767	1081	1267	1436	1664	2144	2314	2564
2011	4000	660	941	1126	1440	1683	1905	2070	2550	2939
2012	4000	682	974	1193	1463	1896	2112	2317	2645	2727
2013	4000	699	1049	1352	1656	2011	2388	2572	3042	3102
2014	4000	691	1085	1398	1775	2091	2462	2568	3145	3195
2015	377	711	1083	1489	1997	2319	2787	3297	3155	3978
2016	4000	599	1052	1552	1989	2556	2916	3536	3565	3661
2017	4000	799	965	1615	1975	2477	2967	3496	3767	3903
2018	4000	750	1111	1411	2024	2561	2946	3364	3605	3913

Year	1	2	3	4	5	6	7	8	9	10
2019	4000	931	1018	1454	1805	2787	3055	3234	3844	3877
2020	1088	1168	1035	1482	2042	2363	2964	3381	3649	3721
2021	4000	697	1010	1407	1817	2429	2796	3434	3978	4002

Table 10.5: Haddock in 5.a. Stock weights from the March survey in Icelandic waters.

Year	1	2	3	4	5	6	7	8	9	10
1980	37	185	481	910	1409	1968	2496	3077	3300	4000
1981	37	185	481	910	1409	1968	2496	3077	3300	4000
1982	37	185	481	910	1409	1968	2496	3077	3300	4000
1983	37	185	481	910	1409	1968	2496	3077	3300	4000
1984	37	185	481	910	1409	1968	2496	3077	3300	4000
1985	35	242	580	1184	1675	2380	2804	3246	3356	3818
1986	35	238	677	1172	1999	2424	3301	3382	3801	3818
1987	34	165	527	1196	1736	2560	3031	3427	3889	4191
1988	36	183	463	993	1828	2636	3137	3399	3436	4510
1989	26	182	426	879	1513	2357	3067	3347	3417	3945
1990	29	185	455	827	1230	1973	2751	3055	3141	4000
1991	31	176	484	1018	1404	1889	2504	3391	4505	5457
1992	30	157	493	905	1348	1871	2345	2949	4235	7332
1993	37	168	380	885	1482	1729	2584	2627	3428	4000
1994	33	179	409	706	1262	1698	1936	2406	2095	1182
1995	40	169	455	755	1085	1849	2621	4000	1389	4000
1996	37	175	445	819	1071	1462	2205	2825	3745	2361
1997	53	173	418	829	1264	1423	1927	2453	3829	4341
1998	39	197	394	746	1225	1687	1901	2447	2837	4000
1999	33	201	470	696	1175	1955	2409	2637	3047	2826
2000	29	178	550	870	1142	1694	2551	2839	3624	3293
2001	36	183	473	1028	1399	1483	2056	2744	4000	4018
2002	61	175	470	885	1485	1962	1987	2135	5020	5067
2003	40	233	419	810	1270	1878	3099	2310	3333	4458
2004	35	178	554	816	1285	1736	2500	2533	2875	4000
2005	39	153	450	913	1185	1581	2118	2840	2329	3608
2006	33	131	335	739	1127	1518	1968	2240	3264	3273
2007	47	170	343	610	1063	1516	1808	2085	2113	3638
2008	27	178	374	606	873	1300	1839	2246	2622	2315
2009	32	134	429	681	881	1134	1485	1912	2515	2179
2010	32	150	387	764	928	1174	1454	1764	2075	2701
2011	34	171	435	744	1122	1303	1555	1848	2106	2910
2012	28	197	476	803	1145	1514	1886	2104	2254	2230
2013	32	206	582	944	1260	1642	1893	2184	2665	2632

Year	1	2	3	4	5	6	7	8	9	10
2014	37	228	586	1012	1361	1764	2166	2367	2679	3106
2015	33	257	624	1085	1601	1939	2442	2760	3198	3132
2016	29	161	653	1115	1579	2109	2287	3053	3387	3310
2017	34	200	462	1251	1626	2141	2709	3128	3593	3464
2018	30	193	545	928	1829	2332	2625	2920	3103	3523
2019	29	169	514	968	1353	2384	2801	3016	3421	3545
2020	29	209	473	951	1520	2040	3155	2967	3260	4380
2021	28	163	567	935	1445	2116	2594	3501	3618	3871

Table 10.6: 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
1980	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000
1981	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000
1982	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000
1983	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000
1984	0.000	0.080	0.301	0.539	0.722	0.821	0.868	0.904	0.963	1.000
1985	0.000	0.023	0.162	0.555	0.589	0.732	0.775	0.945	0.939	0.987
1986	0.000	0.017	0.183	0.401	0.658	0.825	0.883	0.955	0.982	0.998
1987	0.000	0.013	0.115	0.439	0.587	0.862	0.898	1.000	0.988	0.965
1988	0.000	0.014	0.194	0.376	0.760	0.765	0.935	0.894	1.000	0.935
1989	0.000	0.038	0.215	0.525	0.722	0.809	1.000	1.000	1.000	1.000
1990	0.000	0.115	0.327	0.624	0.816	0.844	0.914	0.911	1.000	1.000
1991	0.000	0.068	0.231	0.587	0.744	0.824	0.901	0.397	1.000	1.000
1992	0.000	0.051	0.222	0.414	0.804	0.904	0.900	0.845	1.000	1.000
1993	0.000	0.129	0.358	0.474	0.652	0.895	0.971	0.913	0.874	1.000
1994	0.037	0.251	0.332	0.602	0.786	0.855	1.000	0.880	1.000	1.000
1995	0.000	0.135	0.444	0.377	0.772	0.780	0.666	0.904	1.000	1.000
1996	0.000	0.169	0.357	0.589	0.646	0.787	0.746	0.945	0.840	1.000
1997	0.132	0.089	0.434	0.579	0.674	0.760	0.788	0.881	1.000	1.000
1998	0.001	0.031	0.486	0.684	0.787	0.756	0.849	0.905	1.000	1.000
1999	0.000	0.044	0.387	0.678	0.722	0.774	0.901	0.801	0.920	1.000
2000	0.012	0.105	0.247	0.630	0.811	0.881	0.876	1.000	0.817	0.950
2001	0.003	0.098	0.369	0.534	0.768	0.905	0.927	0.868	0.963	1.000
2002	0.000	0.047	0.280	0.635	0.809	0.937	0.937	1.000	1.000	1.000
2003	0.063	0.055	0.345	0.692	0.878	0.933	0.945	0.984	1.000	1.000
2004	0.000	0.038	0.363	0.575	0.836	0.923	1.000	1.000	1.000	1.000
2005	0.000	0.023	0.221	0.558	0.745	0.922	0.942	0.967	1.000	1.000
2006	0.031	0.029	0.122	0.470	0.633	0.749	0.926	1.000	1.000	1.000
2007	0.000	0.075	0.203	0.423	0.694	0.774	0.891	0.971	1.000	1.000

year	1	2	3	4	5	6	7	8	9	10
2008	0.002	0.027	0.272	0.427	0.642	0.840	0.892	0.912	0.961	1.000
2009	0.001	0.018	0.315	0.481	0.597	0.860	0.905	1.000	0.972	1.000
2010	0.011	0.034	0.175	0.637	0.797	0.815	0.901	0.936	1.000	0.964
2011	0.001	0.049	0.176	0.431	0.826	0.825	0.850	0.904	0.979	1.000
2012	0.001	0.108	0.162	0.444	0.630	0.818	0.906	0.859	0.911	1.000
2013	0.001	0.053	0.263	0.417	0.725	0.809	0.929	0.988	0.976	0.993
2014	0.002	0.105	0.200	0.389	0.571	0.691	0.763	0.934	0.922	0.893
2015	0.000	0.134	0.282	0.438	0.669	0.799	0.790	0.903	1.000	0.871
2016	0.002	0.013	0.370	0.493	0.609	0.795	0.802	0.894	0.907	1.000
2017	0.001	0.076	0.129	0.593	0.666	0.751	0.918	0.947	1.000	0.985
2018	0.001	0.039	0.236	0.393	0.823	0.866	0.897	0.885	0.974	1.000
2019	0.011	0.035	0.333	0.591	0.672	0.891	0.944	0.968	1.000	0.881
2020	0.002	0.022	0.190	0.665	0.739	0.711	0.915	0.964	1.000	1.000
2021	0.003	0.017	0.214	0.423	0.807	0.782	0.809	1.000	1.000	1.000

Table 10.7: Haddock in Division 5.a. Landings by nation.

Year	Belgium	Faroe Islands	Iceland	Norway	UK	Germany	Russia	Greenland	Denmark	Lithuania
1979	1010	2161	56150	11	0	0	0	0	0	0
1980	1144	2029	50674	23	0	0	0	0	0	0
1981	673	1839	64599	15	0	0	0	0	0	0
1982	377	1982	66998	28	0	0	0	0	0	0
1983	268	1783	63815	3	0	0	0	0	0	0
1984	359	707	47167	3	0	0	0	0	0	0
1985	391	987	49573	0	2	0	0	0	0	0
1986	257	1289	47335	0	0	0	0	0	0	0
1987	238	1043	39751	1	0	0	0	0	0	0
1988	352	797	52999	0	0	0	0	0	0	0
1989	483	606	61715	0	0	0	0	0	0	0
1990	595	603	65919	0	0	0	0	0	0	0
1991	485	733	53497	0	0	0	0	0	0	0
1992	361	757	46119	0	0	0	0	0	0	0
1993	458	758	47075	0	0	6	606	0	0	0
1994	271	915	58697	13	173	1046	492	2	0	0
1995	0	968	60499	0	57	0	2	0	0	0
1996	0	764	56438	4	0	0	17	0	0	0
1997	0	340	43824	0	0	0	0	0	0	0
1998	0	513	41015	0	0	0	0	0	0	0
1999	0	885	44708	18	0	0	0	0	0	0
2000	0	5	41391	4	1	0	0	0	0	0

2001	0	690	39474	56	0	0	0	0	0	0
2002	0	847	49669	8	0	0	0	0	0	0
2003	0	968	60017	1	51	0	0	0	0	0
2004	0	1125	83809	1	0	0	0	0	0	0
2005	0	1515	95882	3	44	0	0	0	0	0
2006	0	1588	96133	4	0	0	0	0	0	0
2007	0	1686	108182	11	0	0	0	2	0	0
2008	0	1197	101680	11	0	0	0	0	0	0
2009	0	824	81439	5	0	0	0	0	0	0
2010	0	360	63869	8	0	0	0	0	0	0
2011	0	214	49232	3	0	0	0	0	0	0
2012	0	325	45711	13	0	0	0	0	0	0
2013	0	654	43370	23	0	0	0	0	0	0
2014	0	876	33048	11	0	0	0	0	0	0
2015	0	1257	38393	15	0	0	0	0	0	0
2016	0	1444	36648	8	0	0	0	0	0	0
2017	0	1355	35695	11	0	0	0	0	0	0
2018	0	1172	47677	15	0	0	0	0	0	0
2019	0	969	57075	1	0	0	0	0	0	0
2020	0	1248	53528	6	0	0	0	0	0	0
2021	0	1696	55882	20	0	0	0	0	0	0

Table 10.8: Haddock in 5.a. Number of Icelandic boats and catches by fleet segment participating in the haddock fishery in 5.a.

Year	Nr. Bottom Trawl	Nr. Danish Seine	Nr. Long Line	Bottom Trawl	Other	Danish Seine	Long Line	Total catch
1992	308	92	844	30705	5577	1379	8458	46119
1993	374	143	808	32008	5159	1787	8121	47075
1994	322	154	842	42299	4370	3431	8597	58697
1995	269	139	743	44839	3224	4321	8115	60499
1996	228	150	625	40380	2895	5563	7601	56439
1997	211	155	474	28342	2543	5343	7596	43824
1998	199	139	469	24928	2477	3692	9918	41015
1999	187	129	492	26294	2064	2780	13569	44707
2000	165	118	479	23315	1881	3105	13091	41392
2001	146	92	451	22065	2372	3049	11987	39473
2002	144	91	419	30385	2043	3602	13639	49669
2003	136	96	435	36240	1685	4806	17285	60016
2004	131	95	449	50722	1793	8096	23198	83809
2005	126	91	449	53046	1577	10493	30767	95883
2006	117	93	436	45969	1218	12709	36237	96133
2007	109	94	407	57033	1081	12869	37199	108182

Year	Nr. Bottom Trawl	Nr. Danish Seine	Nr. Long Line	Bottom Trawl	Other	Danish Seine	Long Line	Total catch
2008	102	91	362	51228	944	16457	33051	101680
2009	98	81	335	39078	608	15182	26571	81439
2010	94	67	279	29341	475	10138	23916	63870
2011	95	54	278	20718	473	6866	21175	49232
2012	98	56	289	20469	473	6048	18722	45712
2013	95	65	281	18829	398	4955	19188	43370
2014	84	47	282	13438	329	3776	15505	33048
2015	83	50	256	17337	360	4327	16369	38393
2016	82	53	236	17045	321	4456	14826	36648
2017	80	53	209	16456	343	4539	14358	35696
2018	72	58	193	26639	336	5585	15117	47677
2019	69	43	182	35947	302	6237	14588	57074
2020	73	42	148	32005	278	5079	16165	53527
2021	82	46	140	35957	264	5337	14323	55881

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). These surveys are conducted in the period of October–January and March-April. 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 2021/2022 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 2 (juvenile survey for age 1 was not conducted in the year 2021), 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 2022, and east and southeast of Iceland (Figure 11.1.2.1). The total acoustic estimate, according to these two surveys, came to 2.8 billion in numbers and the total biomass index was 528 kt (Table 11.1.1.1). The fishable part of the stock (≥ 27 cm) accounted for 63% in number and 83% of the biomass, or 437 kt.

The annual survey aiming for the abundance of herring juveniles east and southeast of Iceland took place in November 2021. Areas covered (Figure 11.1.2.1) were different from previous years, with the distribution more condensed in the east. The survey in the south and southeast is aimed for assessing the younger part of the stock, while the survey in the west assesses the older part.

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). Also, the separate model run in the assessment, Muppet, estimated the *Icthyophonus* multiplier and it was very close to 0.3 (the value used in the assessment). The prevalence of the *Ichthyophonus* infection in the stock in 2021/22 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 younger year classes (age 2-4) seems to be low, or <6.5% in the west and east combined (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 2022, like in previous years. Thus, in the stock prognosis (Section 11.6), the abundance estimates from the final year of the assessment (1 January 2022) 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. The M for 2021 (Table 11.3.2.1) should be used in the prognosis in 2022 and in the analytical assessment from 2022 and onwards, until better more reliable estimates become available.

11.2 Information from the commercial fishery

The total landings of ISS herring in 2021/2022 season was 70 084 t including the summer catches in 2021 with no discards reported (Table 11.2.1 and in Figure 11.2.1). 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 2021/2022 fishing season (1 September–31 August; ICES, 2018) and TAC (Regulation No. 672, 2 July 2020) was 72.2 kt (Table 11.2.1). Officially, according to the Directorate of Fisheries (www.fiskistofa.is/veidar/aflaupplysingar/heildaraflamarksstada/), 70.1 kt had been caught in April 2022, slightly below the TAC.

The direct fishery in offshore areas west of Iceland in October-December contributed 74% (52 kt) of the total catches (Figure 11.2.2). The remaining 25% (18 kt) of the catch was taken in September-October in the east and the final 1% (1 kt) as bycatch in the fishery also in the east in June-August (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 2021/2022 was taken in pelagic trawls (Figure 11.2.1), which reflects that both the targeting and bycatch fisheries. 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 change in this pattern, with less proportion in Breiðafjörður, and then in 2014/2015 almost all the overwintering west of Iceland took place offshore, which has continued since. 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 2021/22. 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 2021/2022:

The procedure for the catch-at-age estimations, as described in the Stock Annex, was followed for the 2021/22 fishing season. It involves calculations from catch data collected at the harbours by the research personnel (0%) or at sea by fishers (100%). This year, the calculations were accomplished by dividing the total catch into two 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. Based on difference in length-at-age, two 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 catch and sampling in 2021/2022 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 1989 to 2017 (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 inference from the catch curves for those recent years less meaningful.

Catch curves were also plotted using the age disaggregated survey indices for each year class from 1989–2017 (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 Assessment

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 another 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 1987/88–2021/22 (Table 11.2.2.1) and survey data from 1987/88–2021/22 (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 2017–2021 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 2022. The stock numbers at age 2 and 3 in 2022 were derived by using geometric mean for the period 1987-2019. 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). Compared to last year, estimated catchability and uncertainty in the survey are similar.

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 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 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 based on a Management Plan

In this update assessment, where the 2021/22 catch and survey data have been added to the input data, additional natural mortality was applied for 2022 because of the *Ichthyophonus* infection in the stock. The same approach was used as for 2009–2011 and 2017-2021 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 is slightly lower than in the previous year. Spawning stock biomass for 2023 is estimated 404 kt and the reference biomass of age 4+ (B_{Ref}) is 441.3 kt in the beginning of the year 2022. As the SSB will be above MGT $B_{trigger}$ = 200 kt, the advised TAC according to the Iceland Management Plan is $HR_{MGT} \times B_{Ref} = 0.15 \times 441\,299 = 66\,195$ 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. The 2017-year class was large, and indices from the last fishing season 2021/22 indicate that the 2018-year class will also be above average and will enter the fishable stock in autumn 2022 at age 4.

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, 2022, 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 2022 (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 2018–2021 (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).

In summary, the basis for the stock projection is as follows: SSB(2022) = 421.1 kt; Biomass age 4+ (1 January 2022) = 441.3 kt; Catch (2021/22) = 70.1 kt; WF_{5-10}(2021) = 0.288; HCR (2021) = 0.15.

11.6.2 Prognosis results

SSB in the beginning of the fishing season 2022/23 (approximately the same time as spawning in July 2022) is estimated to be 421 132 kt, which is above MGT $B_{trigger}$ of 200 kt. Consequently, advised TAC on basis of the Management rule is 0.15 × Biomass 4+ (441 299 kt) = 66 195 kt. This results in F_{W5-10} = 0.202 in 2022/23 and SSB = 403 999 kt in 2023 (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 2017-2021 ($M_{infected, age, year}$ 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 (2017–2021), 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.

11.8.2 Uncertainty in forecast

It is important to notice that the advice for 2022/2023 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 and size of the recruiting year classes, apply also for the forecast.

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 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.

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. Additional natural mortality was applied to because of the infection.

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 have taken place in the stock in the past 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 2017–2021, and this second outbreak might continue in the coming year.

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 the past decade. As pointed out above, a new infection since the summer 2022 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 2021/2022. 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 2021/2022 was different from the previous 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 no 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, 2021) that we could expect a good recruitment in the stock. It seems to be coming about with the 2017-year class and an encouraging measurement of the 2018-year class as well.

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 which entered the reference biomass in autumn 2021 and a above average 2018-year class as well, might cause an upward revision of the assessment in coming years, but time will tell.

There is compelling evidence for new infection by *Ichthyophonus* in the stock in the winter 2022/23, even if less intense 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

Astthorsson, O. S., Valdimarsson H., Gudmundsdottir, A., Óskarsson, G. J. 2012. Climate-related variations in the occurrence and distribution of mackerel (Scomber scombrus) in Icelandic waters. ICES Journal of Marine Science. 69: 1289–1297.

Björnsson, H. 2018. Icelandic herring. ICES North Western Working Group, 27 April - 4 May 2018, Working Document No. 20. 2 pp.

Debes, H., Homrum, E., Jacobsen, J. A., Hátún, H., and Danielsen, J. 2012. The feeding ecology of pelagic fish in the southwestern Norwegian Sea – Inter species food competition between herring (Clupea harengus) and mackerel (Scomber scombrus). ICES CM 2012/M:07. 19 pp.

ICES. 2011a. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks (WKBENCH 2011), 24–31 January 2011, Lisbon, Portugal. ICES CM 2011/ACOM:38. 418 pp.

ICES. 2011b. Report of the North Western Working Group (NWWG), 26 April - 3 May 2011, ICES Headquarters, Copenhagen. ICES CM 2011/ACOM:7. 975 pp

ICES. 2014. Report of the North Western Working Group (NWWG), 24 April-1 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:07. 902 pp.

ICES. 2016. Report of the North-Western Working Group (NWWG), 27 April–4 May, 2016, ICES Headquarters, Copenhagen. ICES CM 2016/ACOM:08.

ICES. 2017a. Icelandic Waters ecoregion – Ecosystem overview. http://ices.dk/sites/pub/Publication%20Reports/Advice/2017/2017/Ecosystem_overview-Icelandic_Waters_ecoregion.pdf

ICES. 2017b. Report of the Workshop on Evaluation of the Adopted Harvest Control Rules for Icelandic Summer Spawning Herring, Ling and Tusk (WKICEMSE), 21–25 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:45. 49 pp.

ICES. 2017c. Report of the North Western Working Group (NWWG), 27 April – 4 May 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:08. 642 pp.

ICES. 2018. Report of the North-Western Working Group (NWWG), 26 April–3 May, 2018, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:09. 733 pp.

Jones, S.R.M. and Dawe, S.C., 2002. Ichthyophonus hoferi Plehn & Mulsow in British Columbia stocks of Pacific herring, Clupea pallasi Valenciennes, and its infectivity to chinook salmon, Oncorhynchus tshawytscha (Walbaum). Journal of Fish Diseases 25, 415-421.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C. and Fernö, A. 2012. Overlap in distribution and diets of Atlantic mackerel (Scomber scombrus), Norwegian spring- spawning herring (Clupea harengus) and blue whiting (Micromesistius poutassou) in the Norwegian Sea during late summer. Marine biology research, 8: 442–460.

MRI 2016. Environmental conditions in Icelandic waters 2015. Marine and Freshwater Research Institute. HV 2016-001, ISSN 2298-9137 (https://www.hafogvatn.is/is/midlun/utgafa/haf-og-vatnarannsoknir/thaettir-ur-vistfraedi-sjavar-2015)

Nøttestad, L., Utne, K.R., Guðmundur J. Óskarsson, Sigurður Þ. Jónsson, Jacobsen, J.A., Tangen, Ø., Anthonypillai, V., Aanes, S., Vølstad, J.H., Bernasconi, M., Debes, H., Smith, L., Sveinn Sveinbjörnsson, Holst, J.C., Jansen, T. og Slotte, A. 2016. Quantifying changes in abundance, biomass and spatial distribution of Northeast Atlantic mackerel (Scomber scombrus) in the Nordic seas from 2007 to 2014. ICES Journal of Marine Science, 73: 359-373.

Óskarsson, G.J. 2008. Variation in body condition, fat content and growth rate of Icelandic summer-spawning herring (Clupea harengus L.). Journal of Fish Biology 72: 2655–2676.

Óskarsson, G.J. 2019. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2018/2019 fishing season and the development of Ichthyophonus sp. infection in the stock. ICES North Western Working Group, 25 April - 1 May 2019, Working Document No. 5. 15 pp.

Óskarsson, G.J. and C.T. Taggart 2010. Variation in reproductive potential and influence on Icelandic herring recruitment. Fisheries Oceanography. 19: 412–426.

Óskarsson, G.J. and Pálsson, J. 2017. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2016/2017 fishing season and the development of Ichthyophonus hoferi infection in the stock. ICES North Western Working Group, 27 April - 4 May 2017, Working Document No. 10. 15 pp.

Óskarsson, G.J. and Pálsson, J. 2018. Estimation on number-at-age of the catch of Icelandic summer-spawning herring in 2017/2018 fishing season and the development of Ichthyophonus sp. infection in the stock. ICES North Western Working Group, 27 April - 4 May 2018, Working Document No. 2. 15 pp.

Óskarsson, G.J., J. Pálsson, and Á. Guðmundsdóttir 2009. Estimation of infection by Ichthyophonus hoferi in the Icelandic summer-spawning herring during the winter 2008/09. ICES North Western Working Group, 29 April - 5 May 2009, Working Document 1. 10 p.

Óskarsson, G.J., P. Reynisson, and Á. Guðmundsdóttir 2010. Comparison of acoustic measurements of Icelandic summer-spawning herring the winter 2009/10 and selection of measurement for stock assessment. Marine Research Institute, Reykjavik, Iceland. An Internal Report. 14 pp.

Óskarsson, G.J., A. Gudmundsdottir, S. Sveinbjörnsson & Þ. Sigurðsson 2016. Feeding ecology of mackerel and dietary overlap with herring in Icelandic waters. Marine Biology Research, 12: 16-29.

Óskarsson, G.J., Ólafsdóttir, S.R., Sigurðsson, Þ., and Valdimarsson, H. 2018a. Observation and quantification of two incidents of mass fish kill of Icelandic summer spawning herring (Clupea harengus) in the winter 2012/2013. Fisheries Oceanography. DOI: 10.1111/fog.12253.

Óskarsson, G.J., Pálsson, J., and Gudmundsdottir, A. 2018b. An ichthyophoniasis epizootic in Atlantic herring in marine waters around Iceland. Can. J. Fish. Aquat. Sci. dx.doi.org/10.1139/cjfas-2017-0219.

Skagen, D. 2012. HCS program for simulating harvest control rules. Program description and instructions for users. Version HCS12_2. Available from the author.

11.18 Tables

Table 11.1.1.1. Icelandic summer-spawning herring. Acoustic estimates (in millions) in the winters 1973/74–2021/22 (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
2021/22	16.189	629.418	655.481	400.632	153.292	237.094	179.000	174.174	81.586	83.935	82.750	32.917	46.798	21.847	2795

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 1987/88–2021/22 (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+	To-tal	To-tal	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

	Number of scales															N of samples		
Year/age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	To-tal	To-tal	West	East
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
2021/22	39	89	588	258	254	113	138	87	78	49	34	24	19	8	1890	12	5	7

*** 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	70.1	70.1	72.2	72.2
1987	75	75	70	73	2022/2023			66.2	66.2
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

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Catch
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
2021	12.440	21.018	88.992	37.291	37.244	17.231	21.230	13.155	11.781	7.270	5.213	3.549	2.771	1.583	70.084

*** 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 Kolgrafarfjörður.**

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

Year\age	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2020	81	140	229	267	288	311	329	345	351	367	372	370	382	398
2021	90	154	212	253	272	296	314	325	337	356	352	361	372	364

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
1986–2022	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 (1987 refers to season 1987/1988 etc.). The estimate of, for example, M for age 4 in 2022 represents estimated infection rate of age 3 in 2021.

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	0.110	0.116	0.152	0.186	0.158	0.154	0.196	0.195	0.238	0.226	0.220	0.179	0.225	0.235
2021	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
2022**	0.100	0.111	0.120	0.115	0.149	0.177	0.159	0.176	0.163	0.198	0.218	0.236	0.172	0.218

*** Based on prevalence of infection estimates and acoustic measurements (Minfected multiplied by 0.3 and added to 0.1; Óskarsson *et al.*, 2018b).**

**** Based on prevalence of infection estimates in the winter 2021/22 (multiplied by 0.3 and added to 0.1) and should by applied in the prognosis in the 2022 assessment.**

Table 11.3.2.2. Model settings and results of model parameters from the final NFT-Adapt run in 2022 for Icelandic summer spawning herring.

VPA Version 3.3.0

Model ID: RUN1 2022

Date of Run: 10-APR-2022 Time of Run: 14:53

Levenburg-Marquardt Algorithm Completed 8 Iterations

Residual Sum of Squares = 65.4254

Number of Residuals = 272

Number of Parameters = 9

Degrees of Freedom = 263

Mean Squared Residual = 0.248766

Standard Deviation = 0.498764

Number of Years = 35

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 (2022)

Age	Stock Predicted	Std. Error	CV
4	671014.455	0.339944E+06	0.506613E+00
5	509204.179	0.195627E+06	0.384181E+00
6	157671.665	0.532277E+05	0.337586E+00
7	82271.990	0.281588E+05	0.342264E+00
8	32656.999	0.113016E+05	0.346068E+00
9	56923.876	0.175491E+05	0.308290E+00
10	29574.628	0.902573E+04	0.305185E+00
11	27000.180	0.784834E+04	0.290677E+00
12	29431.270	0.921902E+04	0.313239E+00

Catchability Values for Each Survey Used in Estimate

INDEX	Catchability	Std. Error	CV

1	0.976851E+00	0.996878E-01	0.102050E+00
2	0.122127E+01	0.107875E+00	0.883301E-01
3	0.131558E+01	0.745975E-01	0.567031E-01
4	0.148712E+01	0.913680E-01	0.614394E-01
5	0.163428E+01	0.126798E+00	0.775868E-01
6	0.180057E+01	0.150146E+00	0.833882E-01
7	0.191803E+01	0.200064E+00	0.104307E+00
8	0.182053E+01	0.187039E+00	0.102739E+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 2022
  = Geometric Mean of First Age Populations
    Year Range Applied = 1991 to 2014
- Survey Weight Factors Were Used

Stock Estimates

Age 4-12

Full F in Terminal Year = 0.3006

F in Oldest True Age in Terminal Year = 0.2916

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	0.075	0.0291	NO	Stock Estimate in T+1
4	0.800	0.386	0.1502	NO	Stock Estimate in T+1
5	1.000	0.515	0.2004	YES	Stock Estimate in T+1
6	1.000	0.895	0.3483	YES	Stock Estimate in T+1
7	1.000	1.000	0.3893	YES	Stock Estimate in T+1
8	1.000	0.755	0.2940	YES	Stock Estimate in T+1
9	1.000	0.866	0.3373	YES	Stock Estimate in T+1
10	1.000	0.866	0.3370	YES	Stock Estimate in T+1
11	1.000	0.508	0.1979	YES	Stock Estimate in T+1
12	**1.000**	**0.749**	**0.2916**		**F-Oldest**

Table 11.3.2.3. Icelandic summer spawners stock estimates (from NFT-Adapt in 2022) in numbers (millions) by age (years) at 1 January during 1987–2022.

Year\Age	3	4	5	6	7	8	9	10	11	12	13+	Total
1987	529.83	988.96	300.67	84.60	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	128.70	29.84	20.62	18.03	10.18	9.48	26.10	1999.74
1990	300.81	383.25	192.47	280.67	433.68	75.61	19.30	13.07	9.41	4.69	26.46	1739.42
1991	840.51	258.04	292.66	140.37	178.35	243.51	39.78	9.72	7.68	5.31	24.86	2040.79
1992	1033.06	676.29	186.91	183.01	94.01	109.04	116.17	26.44	4.86	4.36	24.19	2458.33
1993	635.38	844.63	495.54	132.70	110.06	58.60	62.27	54.88	12.95	2.76	23.67	2433.44
1994	691.67	526.31	595.56	360.42	100.33	72.50	40.39	37.75	35.19	7.69	22.92	2490.74
1995	202.67	498.10	368.74	403.36	243.40	67.15	46.35	21.12	19.31	17.94	23.14	1911.28
1996	181.36	163.45	320.58	251.25	261.49	147.48	40.52	27.52	11.03	8.38	27.53	1440.57
1997	772.44	148.93	109.66	208.35	161.99	156.39	95.83	22.70	16.92	4.46	22.16	1719.81
1998	320.39	661.64	106.15	74.27	153.65	114.59	112.06	65.58	12.46	12.10	10.02	1642.92
1999	552.38	246.80	432.23	74.52	59.02	100.25	79.07	71.02	45.44	9.26	13.40	1683.39
2000	391.05	446.32	171.35	257.57	52.16	40.59	60.89	52.73	43.38	29.16	11.66	1556.86
2001	468.22	299.45	274.68	108.31	160.44	36.24	28.86	39.57	38.34	28.51	25.23	1507.85
2002	1454.52	383.47	189.03	159.87	69.25	93.55	22.96	17.81	24.20	25.29	32.42	2472.37
2003	1074.13	1239.26	279.78	127.78	93.31	42.55	44.73	11.42	11.65	15.72	25.63	2965.96
2004	662.19	771.21	850.00	198.01	89.07	60.16	25.05	30.10	8.22	7.30	28.18	2729.47
2005	989.93	538.99	565.37	596.00	140.74	67.56	45.57	17.19	20.57	4.46	23.96	3010.34
2006	734.93	870.92	447.68	399.68	412.69	101.19	49.67	32.50	10.65	13.76	20.39	3094.06
2007	657.50	552.47	581.60	353.03	315.76	319.06	78.64	39.25	25.32	8.79	26.51	2957.93
2008	523.72	505.96	421.84	374.57	259.10	200.77	200.13	48.96	24.37	15.94	21.25	2596.61
2009	442.15	436.98	371.50	306.01	236.88	177.85	122.72	129.55	27.13	14.25	22.62	2287.64
2010	466.51	336.35	320.26	270.51	229.48	170.37	133.83	90.54	95.74	19.84	27.43	2160.86
2011	541.37	340.76	231.69	217.24	187.55	166.05	118.15	96.31	64.67	68.03	33.89	2065.71
2012	355.61	466.61	241.48	161.81	149.11	127.72	118.73	77.39	67.04	45.98	73.51	1884.98
2013	484.75	304.83	337.33	169.87	105.56	86.40	75.91	74.58	44.24	37.04	77.88	1798.38
2014	267.53	394.11	252.23	271.92	137.31	77.91	60.12	48.00	52.35	25.06	76.42	1662.94

Year\Age	3	4	5	6	7	8	9	10	11	12	13+	Total
2015	249.09	238.70	306.05	180.20	179.62	91.63	49.56	33.43	30.83	30.54	75.65	1465.29
2016	341.30	219.66	187.60	226.07	121.79	121.72	68.16	34.63	22.03	20.15	83.02	1446.14
2017	173.25	298.61	174.47	141.35	164.74	85.70	86.49	52.64	24.00	14.17	78.76	1294.17
2018	263.29	150.10	235.40	137.13	109.53	124.12	62.60	62.38	38.51	15.61	69.41	1268.08
2019	296.86	226.05	115.66	166.86	101.13	80.64	83.59	43.74	42.24	26.23	60.42	1243.42
2020	789.26	261.32	182.72	88.11	126.31	70.54	61.74	61.73	30.82	28.90	62.75	1764.18
2021	778.10	684.72	217.66	136.09	58.34	90.00	50.26	44.34	45.15	21.61	65.68	2191.95
2022	464.74	671.01	509.20	157.67	82.27	32.66	56.92	29.58	27.00	29.43	57.66	2118.15

Table 11.3.2.4. Estimated fishing mortality at age of Icelandic summer-spawning herring (from NFT-Adapt in 2022) by age (years) during 1987–2021 (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	0.480	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	1.043	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	0.292	0.439	0.387	0.638	0.599	0.324	0.332	0.473	0.948	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	0.211	0.255	0.241	0.176	0.178	0.276	0.281	0.510	0.311	0.288	0.245
2005	0.028	0.086	0.247	0.268	0.230	0.208	0.238	0.379	0.302	0.282	0.223	0.253
2006	0.185	0.304	0.138	0.136	0.157	0.152	0.135	0.150	0.093	0.132	0.167	0.144
2007	0.162	0.170	0.340	0.209	0.353	0.366	0.374	0.377	0.363	0.370	0.420	0.322
2008	0.081	0.209	0.221	0.358	0.276	0.392	0.335	0.490	0.437	0.414	0.385	0.311
2009	0.057	0.094	0.100	0.071	0.113	0.067	0.087	0.085	0.096	0.084	0.075	0.089
2010	0.022	0.081	0.111	0.107	0.074	0.122	0.088	0.099	0.110	0.105	0.100	0.101
2011	0.019	0.085	0.103	0.126	0.152	0.098	0.176	0.124	0.139	0.134	0.097	0.127
2012*	0.054	0.224	0.252	0.327	0.446	0.420	0.365	0.459	0.493	0.434	0.267	0.357
2013	0.107	0.089	0.116	0.113	0.204	0.263	0.358	0.254	0.468	0.336	0.295	0.175
2014	0.014	0.153	0.236	0.315	0.305	0.352	0.487	0.343	0.439	0.405	0.133	0.307
2015	0.026	0.141	0.203	0.292	0.289	0.196	0.258	0.317	0.325	0.274	0.099	0.247
2016	0.034	0.130	0.183	0.217	0.252	0.242	0.158	0.267	0.342	0.252	0.151	0.215
2017	0.032	0.120	0.117	0.082	0.108	0.139	0.120	0.126	0.174	0.140	0.078	0.112
2018	0.037	0.149	0.172	0.143	0.131	0.167	0.133	0.143	0.109	0.138	0.064	0.154
2019	0.017	0.078	0.128	0.110	0.144	0.098	0.132	0.167	0.135	0.133	0.133	0.125
2020	0.032	0.067	0.143	0.226	0.181	0.185	0.135	0.118	0.117	0.139	0.084	0.165
2021	0.029	0.150	0.200	0.348	0.389	0.294	0.337	0.337	0.198	0.292	0.148	0.288

*** Derived from both the landings (WF5–10 ~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 2022 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	$WF_{age\ 5-10}$	HR 4+
1987	530	504	415	384	75	0.197	0.347	0.182
1988	271	495	452	423	93	0.219	0.266	0.205
1989	447	459	401	386	101	0.262	0.322	0.252
1990	301	410	371	350	105	0.300	0.400	0.283
1991	841	424	310	310	109	0.354	0.436	0.353
1992	1033	502	349	343	109	0.316	0.415	0.310
1993	635	546	454	424	103	0.243	0.248	0.227
1994	692	553	461	441	134	0.304	0.312	0.291
1995	203	462	435	406	126	0.310	0.343	0.289
1996	181	347	322	307	96	0.312	0.361	0.298
1997	772	368	267	269	65	0.242	0.250	0.244
1998	320	366	323	298	87	0.292	0.280	0.270
1999	552	372	297	290	93	0.321	0.377	0.313
2000	391	386	324	306	100	0.328	0.335	0.310
2001	468	347	282	272	96	0.352	0.415	0.339
2002	1455	512	278	297	96	0.324	0.418	0.347
2003	1074	578	411	389	126	0.323	0.280	0.306
2004	662	614	516	486	114	0.235	0.245	0.222
2005	990	705	536	525	103	0.196	0.253	0.192
2006	735	784	645	611	135	0.221	0.144	0.210
2007	658	697	594	568	159	0.280	0.322	0.267
2008	524	682	591	563	152	0.270	0.311	0.257
2009	442	625	541	487	46	0.095	0.089	0.086
2010	467	600	504	449	44	0.097	0.101	0.086
2011	541	575	473	427	49	0.116	0.127	0.104
2012	356	530	457	432	72	0.167	0.357	0.158
2013	485	479	390	378	72	0.191	0.175	0.185
2014	268	480	426	401	95	0.237	0.307	0.223

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+
2015	249	414	363	347	70	0.201	0.247	0.192
2016	341	407	338	327	60	0.184	0.215	0.178
2017	173	377	344	312	35	0.112	0.112	0.102
2018	263	372	322	296	41	0.137	0.154	0.126
2019	297	339	287	265	30	0.113	0.125	0.105
2020	789	396	285	275	36	0.131	0.165	0.127
2021	778	482	362	412	70	0.170	0.288	0.194
2022	465	514	441	421				

*** 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 2022 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	-0.148	-0.193	0.086	-0.395	-0.789	-0.313	-0.232	-0.492
1989	-0.155	-0.720	-0.848	-0.015	-0.049	-0.004	-0.001	-0.001
1990	0.560	-0.270	-0.281	-0.084	0.374	-0.449	-0.001	-0.003
1991	-0.645	-0.324	-0.671	-0.328	0.257	0.102	0.007	-0.004
1992	0.463	0.440	0.284	-0.442	-0.253	0.206	-0.868	0.001
1993	0.007	0.187	-0.095	-0.224	-0.570	-0.152	-0.085	0.040
1994	-0.017	0.194	0.046	-0.801	-0.709	0.378	-0.393	-0.571
1995								
1996	-0.177	0.665	-0.173	-0.010	-0.309	0.297	-0.084	-0.213
1997	0.621	-0.002	0.536	0.114	0.242	0.231	0.759	0.589
1998	-0.071	-0.470	-0.533	0.228	-0.183	0.008	-0.174	0.447
1999	0.060	0.717	0.053	-0.528	-0.192	-0.703	-0.293	-0.428
2000	0.655	0.133	0.581	0.129	-0.425	0.413	-0.118	0.429
2001	1.196	1.367	0.293	0.704	-0.544	-1.195	-0.693	-1.584
2002	-0.266	-0.060	0.214	0.447	0.816	0.413	0.514	-0.137
2003	0.461	0.482	0.202	0.637	0.789	1.232	1.511	0.809
2004	0.644	0.684	0.239	-0.194	0.025	-0.153	-0.236	-0.008
2005	0.304	0.392	0.289	-0.200	-0.570	-0.616	-1.103	-0.447
2006	-0.651	-0.460	0.443	0.688	0.532	0.312	0.732	1.330
2007	0.120	0.400	-0.124	-0.101	0.285	-0.389	0.497	0.056
2008	-0.079	-0.577	0.094	-0.219	0.205	0.668	0.859	1.708
2009	-0.778	-0.085	-0.334	0.262	-0.085	0.021	-0.386	-0.501
2010	-0.039	0.227	0.444	-0.229	0.162	-0.480	-0.728	-0.105
2011	-0.171	-0.212	0.065	0.060	-0.671	0.348	-1.108	0.183
2012	0.763	0.388	0.388	0.205	0.137	-0.324	0.165	-0.367
2013	0.964	0.427	-0.294	-0.212	0.006	-0.216	-0.388	-0.081
2014	-0.201	-0.342	-0.036	-0.298	0.042	0.109	0.251	-0.062
2015	-0.949	-0.124	0.096	-0.031	0.227	0.227	0.357	-0.394

Year\Age	4	5	6	7	8	9	10	11
2016	-0.267	-0.272	0.049	0.221	0.079	-0.269	-0.057	0.630
2017	-0.279	-0.440	-0.202	0.069	-0.023	0.438	-0.500	0.246
2018	-1.855	-1.106	-0.050	0.215	0.456	0.618	0.758	0.078
2019	-0.474	-0.732	-0.086	-0.389	-0.173	0.106	0.669	-0.047
2020	-0.105	-0.341	-0.112	0.117	-0.154	-0.727	-0.688	-0.284
2021	0.511	0.468	-0.259	-0.057	-0.141	-0.308	0.190	0.007
2022	0.000	-0.440	-0.302	0.662	1.210	0.530	0.363	0.535
Max. Residuals	1.196	1.367	0.581	0.704	1.210	1.232	1.511	1.708

Table 11.6.1.1. The input data used for prognosis of the Icelandic summer-spawning herring in the 2022 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 (2019)	0.160	0.10	0.200	0.138	0.000	0.500	464.7
4 (2018)	0.210	0.11	0.850	0.686	0.000	0.500	671.0
5 (2017)	0.255	0.12	1.000	1.000	0.000	0.500	509.2
6 (2016)	0.287	0.12	1.000	1.000	0.000	0.500	157.7
7 (2015)	0.302	0.15	1.000	1.000	0.000	0.500	82.3
8 (2014)	0.320	0.18	1.000	1.000	0.000	0.500	32.7
9 (2013)	0.334	0.16	1.000	1.000	0.000	0.500	56.9
10 (2012)	0.343	0.18	1.000	1.000	0.000	0.500	29.6
11 (2011)	0.352	0.16	1.000	1.000	0.000	0.500	27.0
12 (2010)	0.367	0.20	1.000	1.000	0.000	0.500	29.4
13+ (2009+)	0.364	0.22	1.000	1.000	0.000	0.500	57.7

Table 11.6.2.1. Icelandic summer-spawning herring. Catch options table for the 2022/2023 season according to the Management plan where the basis is: SSB (1 July 2022) 384 kt (accounted for $M_{infection}$ in 2022); Biomass age 4+ (1 January 2022) is 441.3 kt; Catch (2021/22) 70.1 kt; HR (2021) 0.19, and WF_{5-10}(2021) 0.288.

Rationale	Catches (2022/2023)	Basis	F (2022/2023)	Biomass of age 4+ (2023)	SSB 2023	%SSB change *	% TAC change **
Management plan	66.2	HR = 0.15	0.202	423	404	-4	-8
MSY approach	72	F_{MSY}=0.22	0.220	417	399	-5	-1
Zero catch	0	F = 0	0	515	468	11	-100
F_{pa}	128	F_{pa} = 0.43	0.430	379	344	-18	78
F_{lim}	170	F_{lim} = 0.61	0.610	334	305	-28	135

***SSB 2023 relative to SSB 2022**

****TAC 2022/23 relative to landings 2021/22**

11.19 Figures

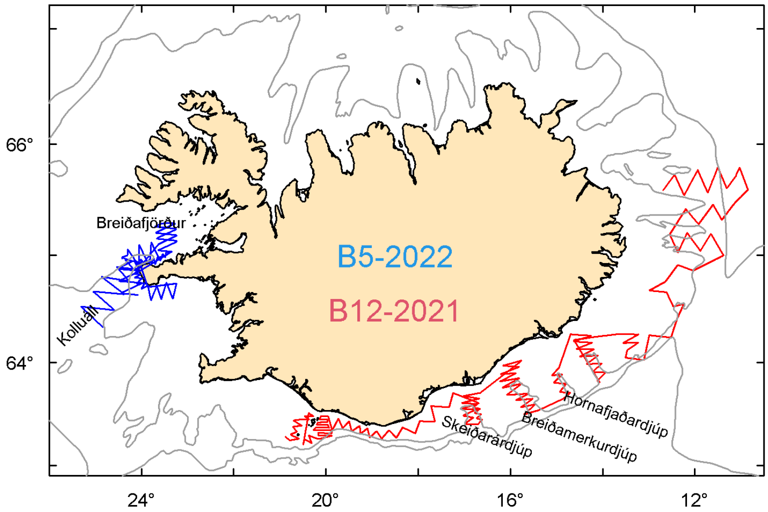


Figure 11.1.2.1. The survey tracks of two acoustic surveys on Icelandic summer-spawning herring in the south and south-east (B12-2021; younger part of the stock; red) and in the west (B5-2022; adults; blue) in 2021/22 and locations of the areas that are referred to in the text.

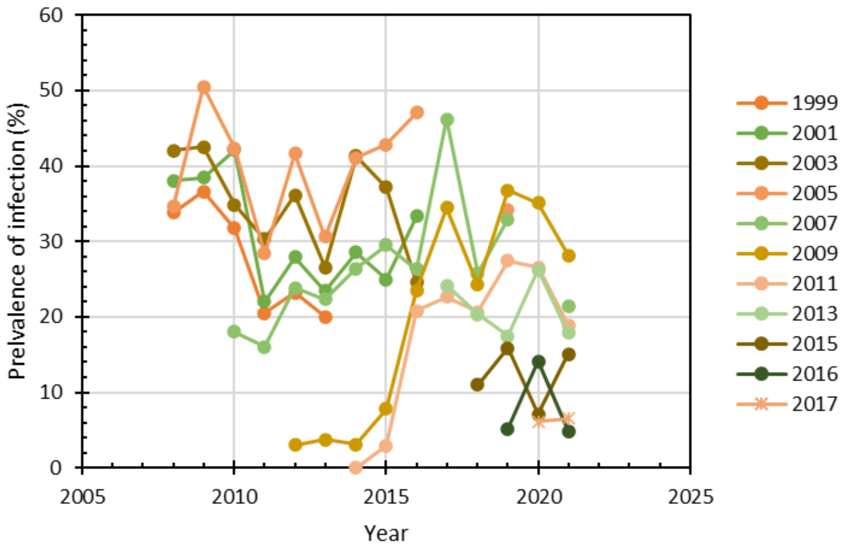


Figure 11.1.3.1. The prevalence of the Ichthyophonus infection followed for each yearclass (starting at age 3) from 1999-2017. Only every second yearclass shown (and last three). Estimated from catch samples west of Iceland in the autumn (Oct.–Dec.) and samples southeast of Iceland from the acoustic survey (Nov).

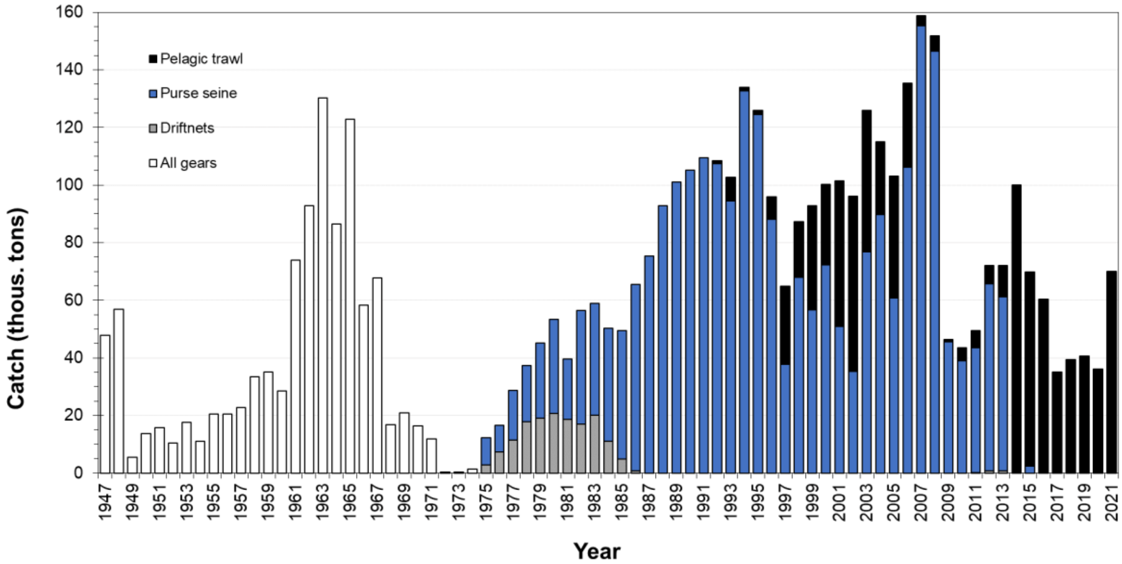


Figure 11.2.1. Icelandic summer spawning herring. Seasonal total landings (in thousand tonnes) during 1947–2021, referring to the autumns, by different fishing gears from 1975 onwards).

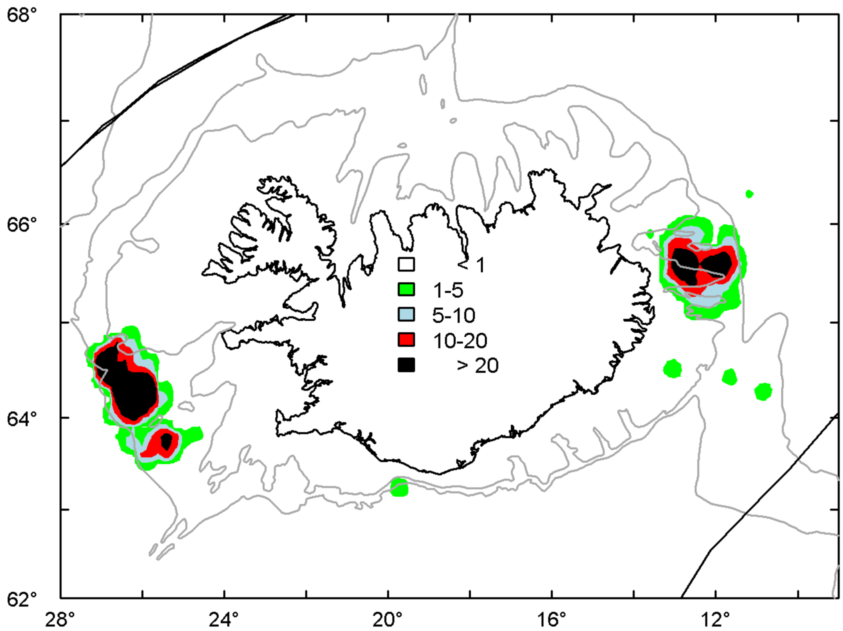


Figure 11.2.2. The distribution of the fishery (in tonnes) of Icelandic summer spawning herring during the fishing season 2021/22, including the bycatch (mackerel and Norwegian spring spawning herring fishery) in July–September 2021.

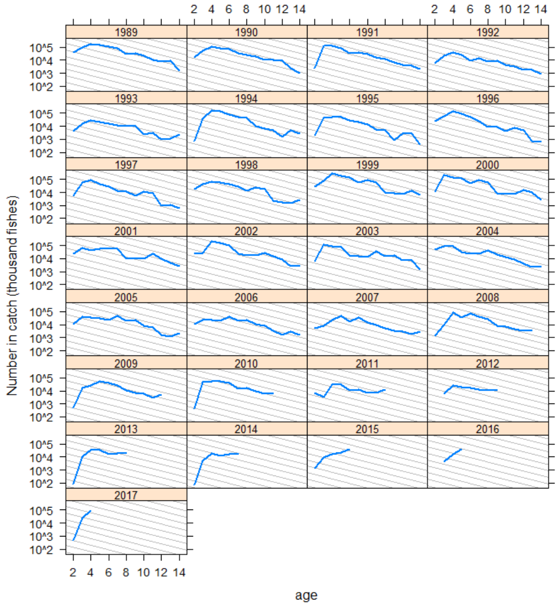


Figure 11.3.1.1. Icelandic summer-spawning herring. Catch curves ($\log_2$ of catches) by year classes 1989–2017. Grey lines correspond to Z = 0.4. Note that the mass mortality in Kolgrafafjörður is added to the catches in 2012.

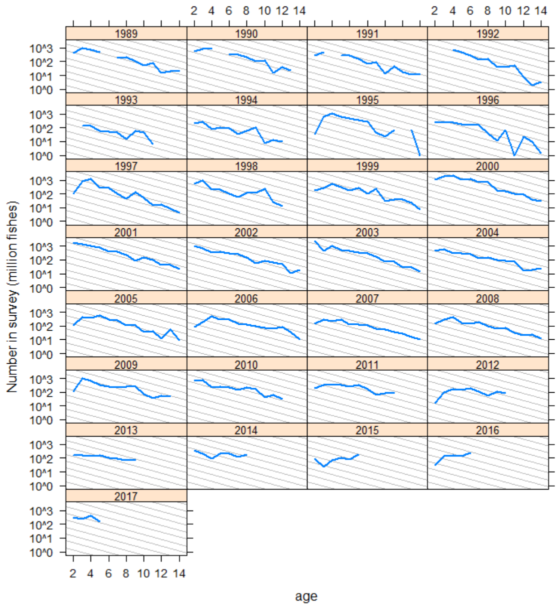


Figure 11.3.1.2. Icelandic summer spawning herring. Catch curves ($\log_2$ of indices) from survey data by year classes 1989–2017. Grey lines correspond to Z = 0.4.

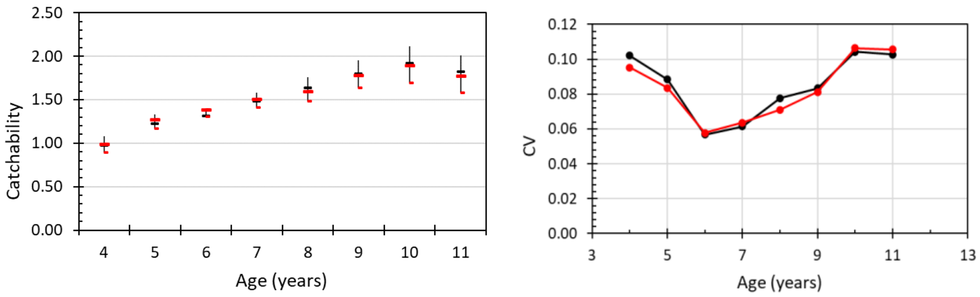


Figure 11.3.2.1. Icelandic summer-spawning herring. The catchability (± 2 SE; left graph) and its CV (right graph) for the acoustic surveys used in the final Adapt run in 2022 (1987–2021) compared to the assessment in 2021 (red lines).

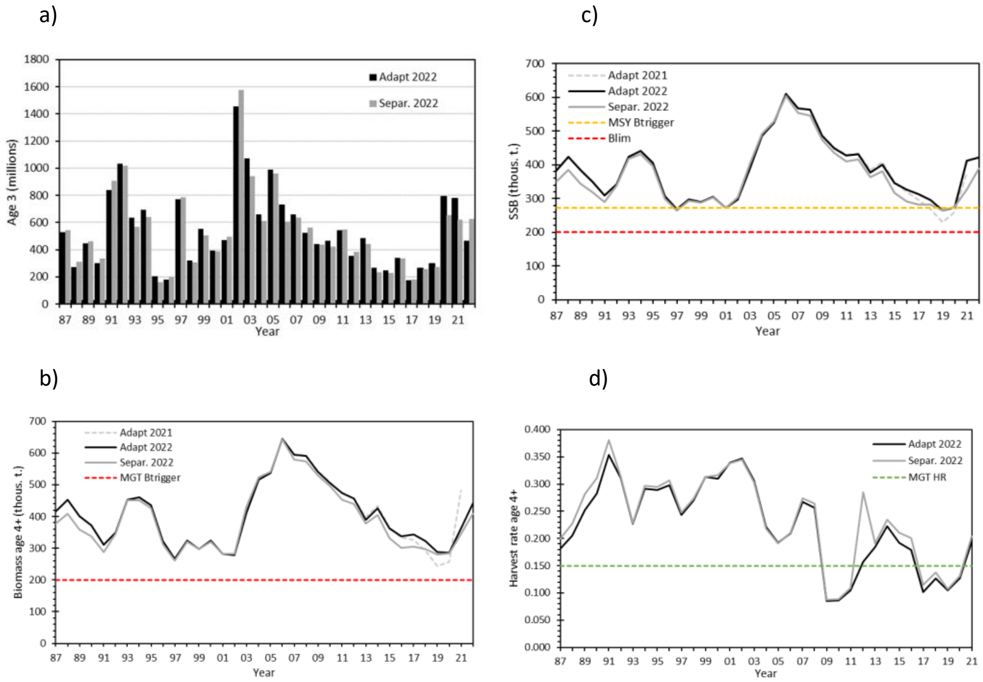


Figure 11.3.2.2. Icelandic summer-spawning herring. Comparisons of the final NFT-Adapt run in 2022, NFT-Adapt run in 2021 and a run from a separate model (Muppet) in 2022 concerning (a) number at age-3 (recruitment), (b) biomass of age 4+ (reference biomass), (c) SSB and (d) harvest rate of the reference biomass (HR_{MGT} shown). Some reference points are also shown (see Table 11.6.2.1). Note that the mass mortality in Kolgrafafjörður in the winter 2012/13 is included in harvest rate (d) for Muppet but not in Adapt run 2022.

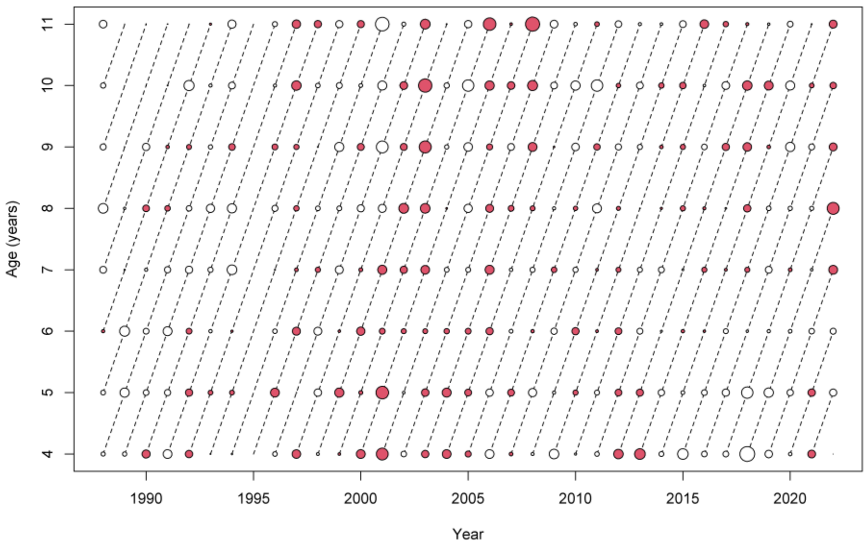


Figure 11.3.2.3. Icelandic summer spawning herring. Residuals of NFT-Adapt run in 2022 from survey observations (moved to 1 January). Filled bubbles are positive (i.e. survey estimates higher than the assessment) and open negative.

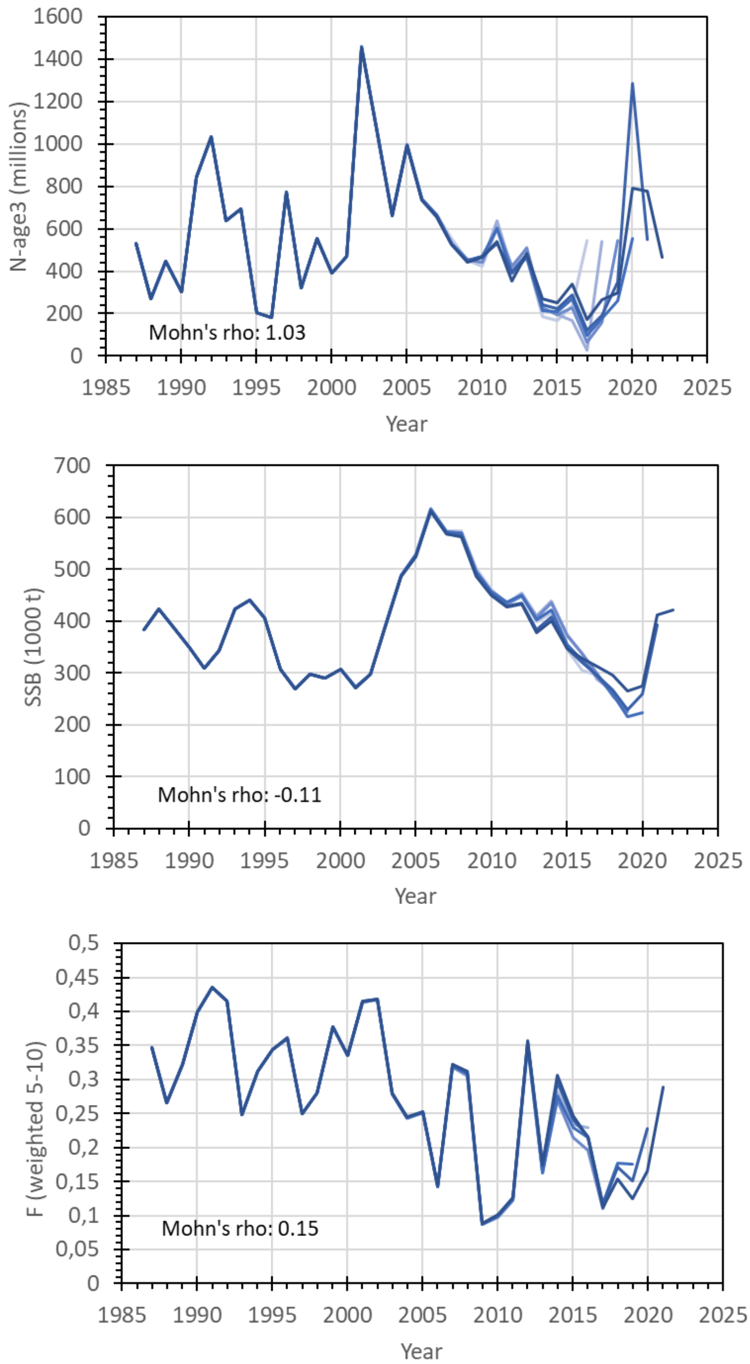
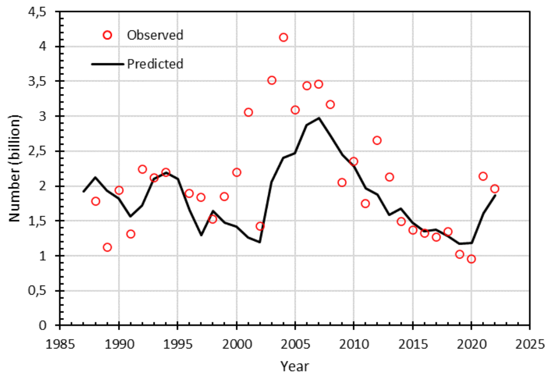


Figure 11.3.2.4. Icelandic summer spawning herring. Six years (2017–2021) retrospective pattern from NFT-Adapt in 2022 in recruitment as number at age 3 (the top panel), spawning stock biomass (middle panel) and N weighted F_{5-10} (lowest panel).



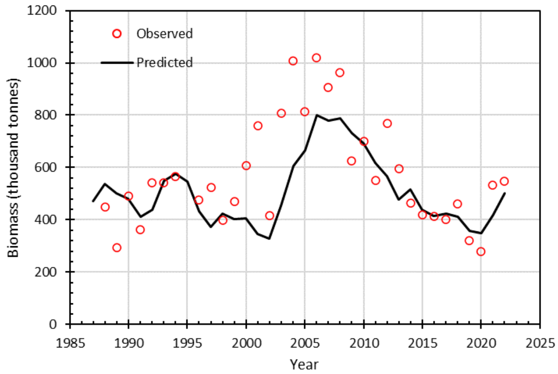


Figure 11.3.2.5. Icelandic summer-spawning herring. Observed versus predicted survey values from NFT-Adapt run in 2022 for ages 4–11 with respect to numbers (upper) and biomass (lower). Note that there was no survey in 1995.

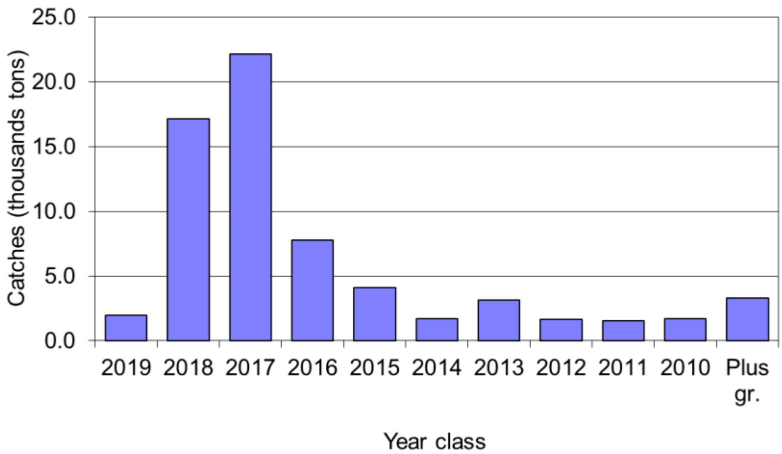


Figure 11.6.2.1. Icelandic summer spawning herring. The predicted biomass contribution of the different year classes to the catches in the fishing season 2022/2023 (total catch of 66 195 tonnes).

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 by the research vessels Bjarni Sæmundsson on behalf of MFRI and Árni Friðriksson, rented by GINR.

The survey area was on and along the shelf edge off East Greenland from about 64°30′N towards about 75°15′ N, also covering the Denmark Strait and the slope off northwest Iceland. The Iceland Sea, Kolbeinsey ridge and Greenland basin were only briefly scouted due to time constraints and for same reason hydrographic measurements and zooplankton sampling were limited compared to previous years (Bardarson et al., 2021). Both vessels departed from Hafnarfjörður harbour on 6 September and sailed towards their first parallel transects crossing the Denmark Strait. From there Bjarni continued covering the East-Greenland shelf areas to southwest while Arni covered to northeast along the East-Greenland shelf and shelf edges. Based on weather prospects, Bjarni skipped the 6 southern most environmental and zooplankton sampling stations along the Denmark Strait sampling transect (Transect B) to make possible additional two transect passage across the Denmark Strait before having to halt measurements due to weather. It was essential to wait in the southern Denmark Strait because wind and sea were predicted to calm much sooner in the south. The 12 September Bjarni reached the shelf edge by Isafjardardjup in heavy wind and seas and sought shelter in Isafjordur harbour for two days. Following this delay it was evident that Bjarni would not be able to finish the scheduled transects within the survey time but it was endeavored to stay as long as possible on the scheduled parallel transects while mixtures of mature and immature capelin were still observed in the Denmark Strait but eventually the region west of Kangerlussuaq Fjord had to be covered by following more widely spread diagonal transects to make it possible to reach the southwestern extent of the survey area within the survey time. During the survey an acoustic probe (Simrad WBT-Tube) was launched from Bjarni for at depth measurements of acoustic properties of capelin. Further, one humpback whale was tagged with a satellite tag and two biopsy samples were collected from finwhales. Bjarni finished exploring the Greenlandic shelf areas on the morning of 21 September and arrived to Hafnarfjörður harbour in the afternoon of 22 September after crossing the Irminger Sea. While covering the northeastern survey areas Arni did not have substantial delays due to weather although order of transects was adapted outside Scoresby and a few hours halt was made by Pendulum Islands. About 25 nmi east of Scoresby an oceanographic mooring was successfully retrieved for the Greenland Institute of Natural Resources (GINR). Arni finished the northern most transect east of Shannon Island in the evening of 19 September and sailed south following adapted (due to time constraints) coarse scouting zig-zag routes trough West Jan Mayen Ridge areas towards the Iceland Sea where high winds caused further delays and transects had to be adapted accordingly. Arni arrived in Hafnarfjordur harbour the 24 September. In general, drift ice did not limit the coverage of the survey vessels although icebergs and a lack of benthic mapping occasionally limited extension of transects towards the Greenlandic coast. Maturing capelin was mainly observed along the East Greenlandic continental shelf and shelf edges in Denmark Strait and the Scoresby Sund areas reaching north to 73°27 N. 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 nor along Icelandic shelf edges. Juveniles (0-group) of various species, including 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. In general the gonad development of maturing capelin was at unusually late stage making it more challenging to distinguish between mature and immature developmental stages. Macroscopic post survey analysis of frozen subsamples from the survey indicated that there might be an overestimate of the proportion of immatures. The distribution of capelin was westerly as in recent years. Figures 1 and 2 show the cruise tracks, distribution and relative density of the capelin during the survey. The total number of capelins amounted to 228 billions whereof the 1-group was about 85.8 billions. The total estimate of 2 group capelin was about 133.5 billions. The total biomass estimate was 2894 000 tonnes of which about 2447 000 tonnes were 2 years and older. About 1.1 % in numbers of the 1-group was estimated to be maturing to spawn, about 65.6% of the 2-year-old and 90.8 % of the 3-year-old capelin appeared to be maturing. This gives about 1834 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. Maturity proportions may be subject to revision based on examination of frozen samples, further analyses and results from additional surveys this winter. Tables 12.2.2 and 12.2.3 show the historic time series of abundance and mean weights by age and maturity in autumn. Based on the estimate of the maturing part of the stock the Marine and Freshwater Research Institute recommended intermediate TAC of 904 200 tonnes) for the fishing season 2021/2022 (MFRI, 2021). This recommendation was in accordance with existing HCR and management plan between Iceland, Norway and Greenland.

12.2.2 Surveys in winter 2021/2022

Winter surveys were conducted in January–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 the research vessels Arni Friðriksson and Bjarni Sæmundsson where each coverage was based on combined acoustic and trawl data from both 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 18–25 January 2022

The survey area was on and along the shelf edge from Norðfjarðardjúp east of Iceland to Strandagrunn northwest of Iceland (Figure 12.2.3). Árni Friðriksson started on the southernmost transects while Bjarni Sæmundsson started to the north near Héraðsdjúp. Both vessels progressed along the shelf north- northwest in a zig-zag coverage. Árni Friðriksson then moved to the west and started surveying again in the north, moving west along the shelf until ice coverage hindered further surveying of the Vestfirðir area. Due to bad weather both vessels had to stop surveying for approximately 24 hours during the survey. The vessels managed to cover the planned survey area except for considerably hindered coverage in the area west of Iceland, due to sea ice. A complete coverage of the survey area was obtained on 24 January and subsequently it was decided to get a second, denser coverage.

Mature capelin dominated in the northwest area where multiple fishing vessels were trawling in the schools. Mixtures of immatures and mature capelin were found in the Northern areas, west of Kolbeinsey-ridge.

Total SSB was estimated 404 000 tonnes but due to restricted coverage because of sea ice in the western area and sparge coverage over a large survey area, this was considered to be an underestimate.

12.2.2.2 Winter surveys 2. Coverage in 25January– 2 February 2022

The survey area was similar to coverage 1. only more focused on and along the shelf edge where capelin was located in the 1.st coverage, from Norðfjarðardjúp east of Iceland to Strandagrunn northwest of Iceland (Figure 12.2.4, blue and green track). Arni Fridriksson and Bjarni Sæmundsson started in the north where they finished the 1.st coverage and headed east in a zig-zag coverage. Once Arni Friðriksson reached the area where Bjarni Sæmundsson started, Arni Friðriksson leap-frogged west ahead of Bjarni Sæmundsson and continued surveying and Bjarni Sæmundsson did the same when approaching the area Arni Friðriksson had covered. Once both vessels had finished in the southeast of Iceland it was decided to survey the area on the shelf, close to Iceland as reports from fishing vessels indicated that capelin schools had gathered there. The vessels managed to cover the planned survey area except coverage near the Vestfjords was still 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 903 600 tonnes but due to restricted coverage because of sea ice near the Vestdjords, there was a risk of the total population not being covered. Also the SSB estimate from the previous autumn indicated that a portion of the stock would be arriving later to the spawning site due to underdeveloped gonads in autumn. Winter surveys 3. Coverage in 10– 15 February 2022

The acoustic measurements was conducted by the research vessel Arni Friðriksson.

Due to the area west of Iceland being unreachable during the first two coverages, it was decided to cover the are as soon as it cleared up of ice. The survey area was from Dohrnbanki in the west to Kolbeinsey-ridge (Figure 12.2.5). Ice did not hinder the survey coverage and the survey area was completed with no interuptions.

Immature capelin dominated the survey area and capelin with low maturity stage, although mature capelin was also found in the area. Total SSB was 105 000 tonnes and 109 000 tonnes of immature capelin. Part of the mature portion was considered to be an addition to the second coverage.

12.3 The fishery (fleet composition, behaviour and catch)

Initial catch quota for the 2021/2022 fishing season was 400 000 tonnes (ICES, 2020), but no summer fishery took place in 2021.

The intermediate TAC advice based on the autumn survey 2021 recommended TAC = 904 200 tonnes (MFRI, 2021) and this advice was updated to a final quota of 869 600 t in winter 2022 (MFRI, 2022). In total, 689 000 t were caught in the 2021/2022 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 2021) to advice the initial quota for the fishing season 2022/23. 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 for 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 1 833 630 in September-October 2021 and 938 700 tonnes in January - February 2022. The predation model (ICES, 2015), accounting for catches (in this case total catch of 689 000 t) and predation between surveys and spawning by cod, saithe and haddock, estimated that 699 000 tonnes were left for spawning in spring 2022 (Table 12.7.1). Given the uncertainty estimates, there was more than 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 130.2 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 2022/23 (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 0.15 in the 2021 autumn survey. The CV for the mature biomass was estimated to 0.19 in the 2021 autumn survey but in the winter survey (January-February) used for the assessment in 2022 it was 0.17.

There was a good spatial coverage of the main distributions of the mature component of the stock in the autumn survey 2021 as sea ice distribution was limited to close proximities of the Greenlandic coast and survey tracks reached far north of the observed capelin distribution. Although, due to weather delays the region west of Denmark Strait had to be covered by following more widely spread diagonal transects to make it possible to reach the southwestern extent of the survey area within the survey time, potentially affecting quality of measurements of the immature stock component (used for intermediate TAC advice 2022/2023). In general, the gonad development of maturing capelin was at unusually late stage making it more challenging to distinguish between mature and immature developmental stages, but maturation estimates affect proportions of immature and mature stock components in the autumn stock estimate.

The final estimate was based on combination of partial coverages within two surveys as measurements of the northwestern survey area, off Vestfirðir, had to be delayed due to sea ice and weather. Possible migration during the few days interval between the estimates could not be accounted for. 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 2021/2022 400 000 t initial quota was advised and intermediate TAC was set to 904 000 tonnes while final advice was 870 000 t. High juvenile index in autumn 2021 predicts large fishable stock in 2022/2023.

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 and autumn 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). In late November 2021 the western boundary of the allowed area for pelagic trawling was extended westwards, from 14°30W to 18°W, because the fishing fleet had problems to catch capelin with perse seines due to deep occurrences of the capelin schools in the area.

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 2021/22 (689 000 t, preliminary numbers) were taken by purse-seining (48%) and pelagic trawl (52%), 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 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

Marine and Freshwater Research Institute. 2021. State of Marine Stocks and Advice 2021, advice on capelin. https://www.hafogvatn.is/static/extras/images/lodnahaust20211278546.pdf ICES. 2020. Capelin (Mallotus villosus) in subareas 5 and 14 and Division 2.a west of 5°W (Iceland and Faroes grounds, East Greenland, Jan Mayen area). In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, cap.27.2a514. https://doi.org/10.17895/ices.advice.5890.

Bardarson, B., Jonsson, S.Th., Bjarnason, S, Heilman, L. and Jansen, T. 2021. Preliminary cruise report: Acoustic assessment of the Iceland-Greenland-Jan Mayen capelin stock in autumn 2021. ICES North Western Working Group, 2 - 7 May 2022, Working Document No. 14. 10 pp.

. Marine and Freshwater Research Institute. 2022. State of Marine Stocks and Advice 2022, advice on capelin. https://www.hafogvatn.is/static/extras/images/lodnavetur2022_final1303547.pdfEngilbertsson, V., Óskarsson, G.J. and Marteinsdóttir, G. (2012). Inter-annual Variation in Fat Content of the Icelandic Capelin. ICES CM 2013/N:26.

Gjøsæter, H., Bogstad, B., and Tjelmeland, S. 2002. Assessment methodology for Barents Sea capelin, Mallotus villosus (Müller). – ICES Journal of Marine Science, 59: 1086–1095.

Gudmundsdottir, A., and Vilhjalmsson, H. 2002. Predicting Total Allowable Catches for Icelandic capelin, 1978–2001. ICES Journal of Marine Science, 59: 1105–1115.

Gudmundsdottir, A., and Sigurdsson, Th. 2014. Growth of capelin in the Iceland-East Greenland-Jan Mayen area. NWWG 2014/WD:29.

ICES 2015. Report of the Benchmark Workshop on Icelandic Stocks (WKICE), 26-30 January, 2015. ICES Headquarters. ICES CM 2015/ACOM:31.

Jansen, T, Hansen, F.T., Bardason, B. 2021. Larval drift dynamics, thermal conditions and the shift in juvenile capelin distribution and recruitment success around Iceland and East Greenland. Fish. Res. 236.

Vilhjálmsson, H. 2002. Capelin (Mallotus villosus) in the Iceland–East Greenland–Jan Mayen ecosystem.

ICES Journal of Marine Science: Journal du Conseil, 59: 870–883.

Vilhjálmsson, H. 2007. Impact of changes in natural conditions on ocean resources. Law, science and ocean management 11, 225.

Vilhjalmsson, H. 1994. The Icelandic capelin stock. Capelin, Mallotus villosus (Müller), in the Iceland–Greenland–Jan Mayen area. Rit Fiskideildar, 13: 281 pp.

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 6. September – 24. October 2021.

Length (cm)	Numbers at Age (10^9)				Numbers (10^9)	Biomass (10^3t)	Mean weight (g)
	1	2	3	4			
9	278.4	0	0	0	278.40	680.20	2.44
9.5	1947.51	0	0	0	1947.51	5645.12	2.90
10	6402.2	0	0	0	6402.20	22127.16	3.46
10.5	14693.62	0	0	0	14693.62	59582.09	4.05
11	21904.01	0	0	0	21904.01	102991.99	4.70
11.5	20239.66	759.56	0	0	20999.21	116025.29	5.53
12	11421.02	1305.57	0	0	12726.59	81701.34	6.42
12.5	5861.66	3297.28	0	0	9158.94	67352.36	7.35
13	2658.49	6683.11	0	0	9341.60	82423.35	8.82
13.5	240.77	7953.21	0	0	8193.98	84927.87	10.36
14	148.15	12664.87	120.38	0	12933.40	153282.58	11.85
14.5	0	16566.1	139.2	0	16705.30	227177.83	13.60
15	0	21694.26	290.01	0	21984.27	337206.62	15.34
15.5	0	18171.02	691.2	0	18862.22	328679.22	17.43
16	0	16208.72	770.87	0	16979.60	338849.83	19.96
16.5	0	13113.31	996.95	0	14110.25	318246.40	22.55
17	0	8019.78	1871.11	0	9890.89	252825.00	25.56
17.5	0	4277.44	1681.98	16.41	5975.83	164899.73	27.59
18	0	2009	1323.91	16.41	3349.33	102753.49	30.68
18.5	0	612.85	319.76	0	932.61	29981.06	32.15
19	0	153.21	251.7	0	404.91	15451.63	38.16
19.5	0	0	16.41	0	16.41	788.87	48.06
9	278.4	0	0	0	278.40	680.20	2.44

Table 12.2.1 Icelandic Capelin. Summary of the capelin stock components from the acoustic survey in 6. September – 24. October 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	85.79548278	133.4892994	8.473480105	0.0328287	227.791091	
TSB	446.9879468	2232.442388	213.2121802	0.956518028	2893.599032	
MeanW	5.209924022	16.72375536	25.16229195	29.13664067	12.70286305	12.70286305
MeanL	11.22693038	15.14547899	16.95204428	17.75	13.73716943	13.73716943
TSNp	37.66410811	58.60163312	3.719847017	0.014411758	100	
SSN	0.963077581	87.57050864	7.691567575	0.0328287	96.2579825	
SSB	6.633598056	1629.795203	196.240818	0.95840105	1833.628021	
MeanW	6.887916596	18.61123372	25.51376116	29.19399968		19.0491009
MeanL	11.8125	15.56958551	16.99881594	17.75		15.6469426
SSNp	1.000517107	90.97480164	7.990576341	0.034104912	100	
ISN	84.8324052	45.91879079	0.781912529	0	131.5331085	
ISB	440.1131833	602.9315768	16.92625191	0	1059.971012	
MeanW	5.188031416	13.13038881	21.64724477	0		8.058587103
MeanL	11.22028258	14.3366767	16.49195774	0		12.3395676
ISNp	64.49509645	34.91044294	0.594460618	0	100	

Table 12.2.2. Icelandic Capelin. Abundance of age-classes in numbers (10^9) measured in acoustic surveys in autumn.

Year	Month	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									

Year	Month	Day	Age1 Imm.	Age1 Mat.	Age2 Imm.	Age2 Mat.	Age3 Imm.	Age3 Mat.	Age4 Mat.	Age5 Mat.
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		
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		
2021	9	6	84.8	1.0	45.9	87.6	0.8	7.7	0.03	

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 Imm.	Age1 Mat.	Age2 Imm.	Age2 Mat.	Age3 Imm.	Age3 Mat.	Age4 Mat.	Age5 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	

Year	Mon	Age1	Age1	Age2	Age2	Age3	Age3	Age4	Age5
		Imm.	Mat.	Imm.	Mat.	Imm.	Mat.	Mat.	Mat.
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	
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		
2021	9	5.2	6.9	13.1	18.6	21.7	25.5	29.1	

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

Year	Winter season					Summer and autumn season						Total
	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Norway	Faroes	Greenland	EU	Season total	
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
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

Year	Winter season					Summer and autumn season						Total
	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Norway	Faroes	Greenland	EU	Season total	
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
2012	576.2	46.2	29.7	22.3	674.4	9	-	-	1	-	10	684.4
2013	454	40	30	17	541	-	-	-	-	-	-	541

Year	Winter season					Summer and autumn season						Total
	Iceland	Norway	Faroes	Greenland	Season total	Iceland	Norway	Faroes	Greenland	EU	Season total	
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	75.8	-	-	1.3	-	77.1	206.5
2022*	433.8	122.3	29.5	26.6	612.1							

*** 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

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Total number	Total weight
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	-	-	-	-	-	-	-
2022	-	2.6	0.6	0.01	-	4.2	77.1

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

Year	age 1	age 2	age 3	age 4	age 5	Total number	Total weight
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
2022	-	0.2	22.6	1.5	0.01	24.3	612.1

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

Fishing season	Initial advice	Final TAC	Landings
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	170[5]	127	129
2021/22[6]	400[5]	870	689

The final TAC was set on basis of autumn surveys in the season.

Indices from April 2003 were projected back to October 2002.

The initial quota was set on a basis of an acoustic survey in June/July 2004

No fishery was allowed, 15 000 t was assigned to scouting vessels.

Initial advice based on low probability of exceeding final TAC.

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

Season (Summer/winter)	Recruitment	Landings	Spawning stock biomass
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*
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*
2021/22	130.7	689	699

*** Based on predation model in current HCR.**

12.19 Figures

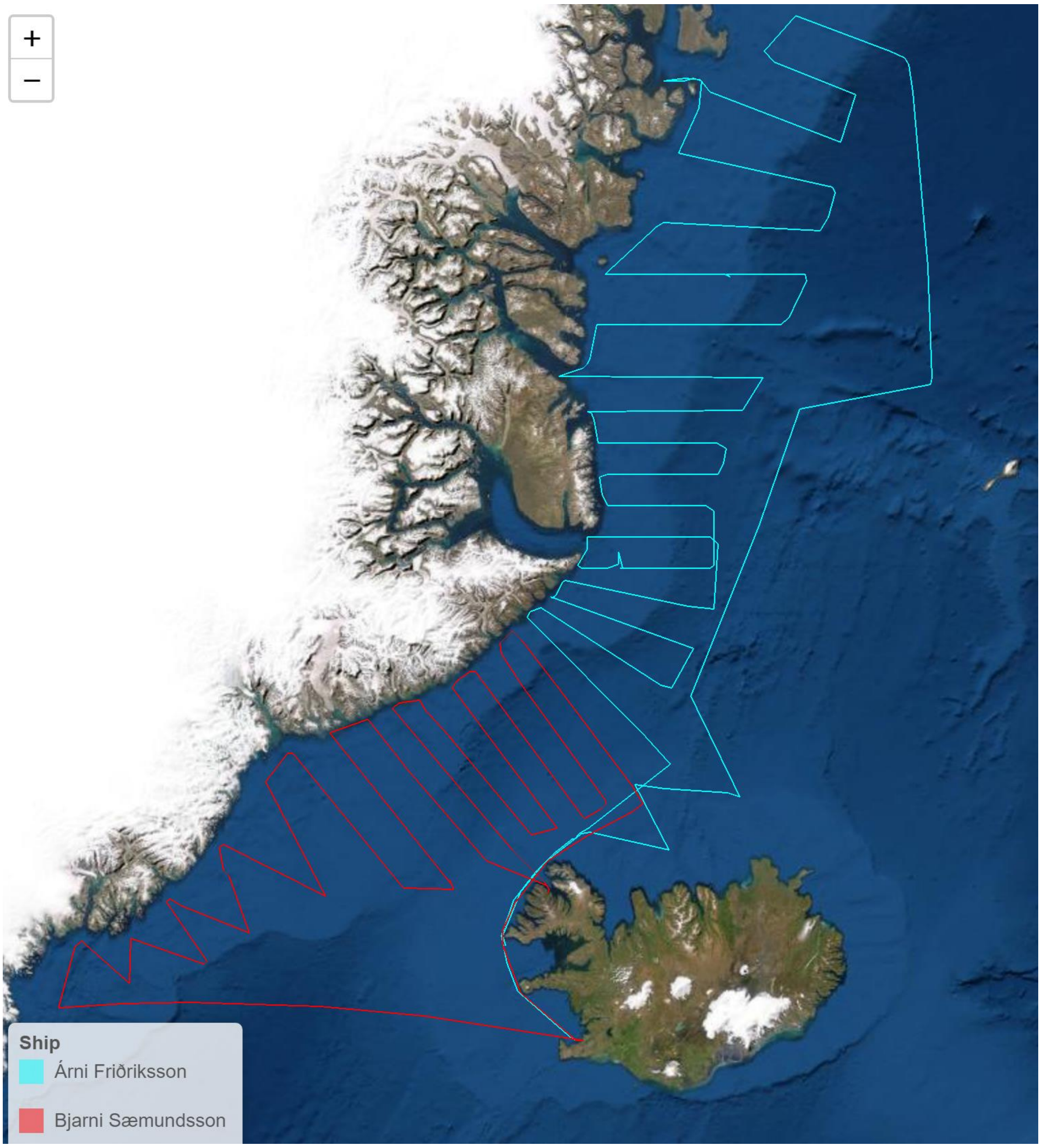


Figure 12.2.1. Icelandic capelin. Cruise tracks during an acoustic survey by r/v Arni Fridriksson (blue) and Bjarni Saemundsson (red) during 6 – 24 September 2021.

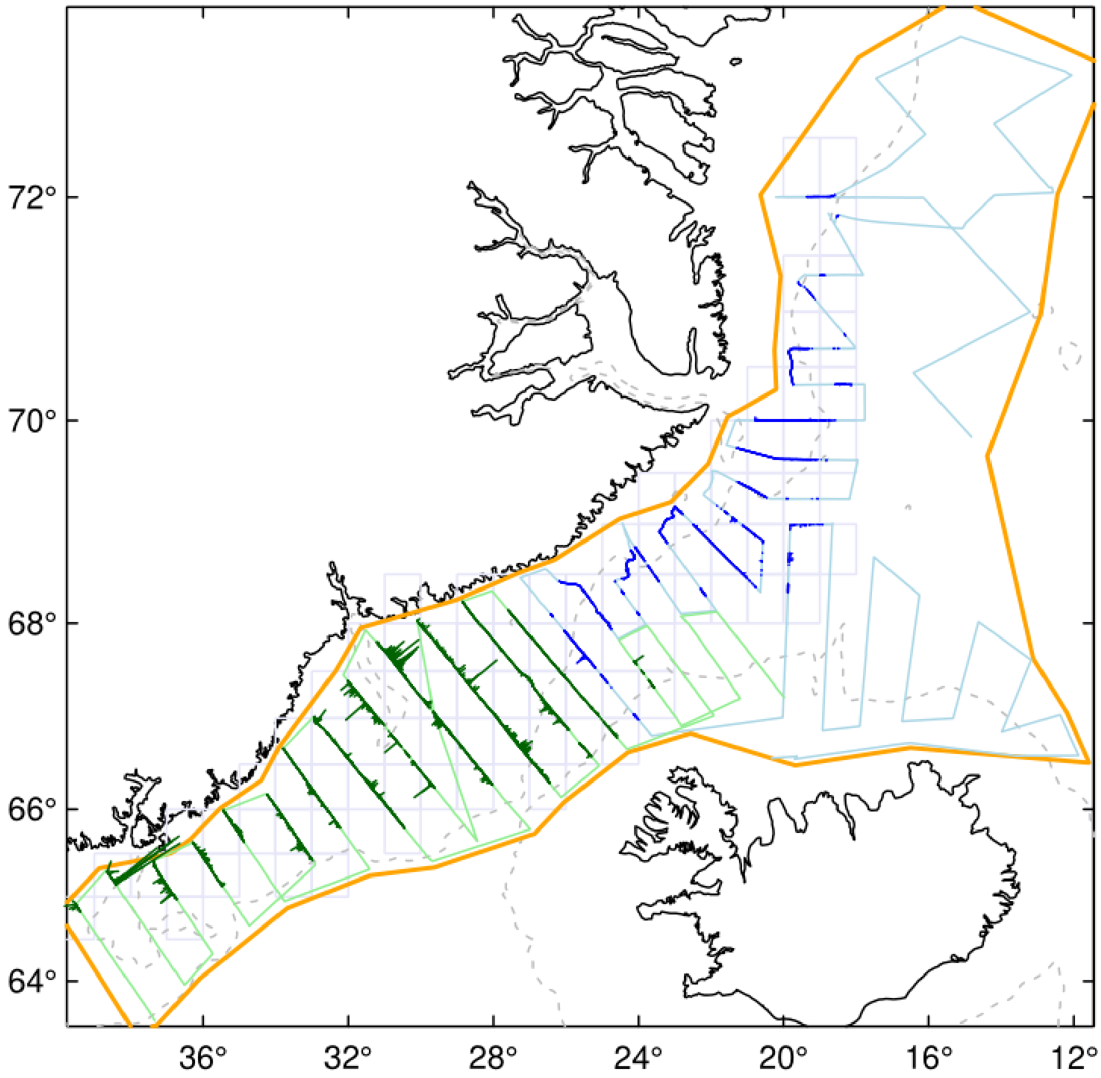


Figure 12.2.2. Icelandic capelin. Relative density and distribution of capelin shown as peri bars during an acoustic survey by r/v Arni Fridriksson and Bjarni Sæmundsson during 6 – 24 September 2021.

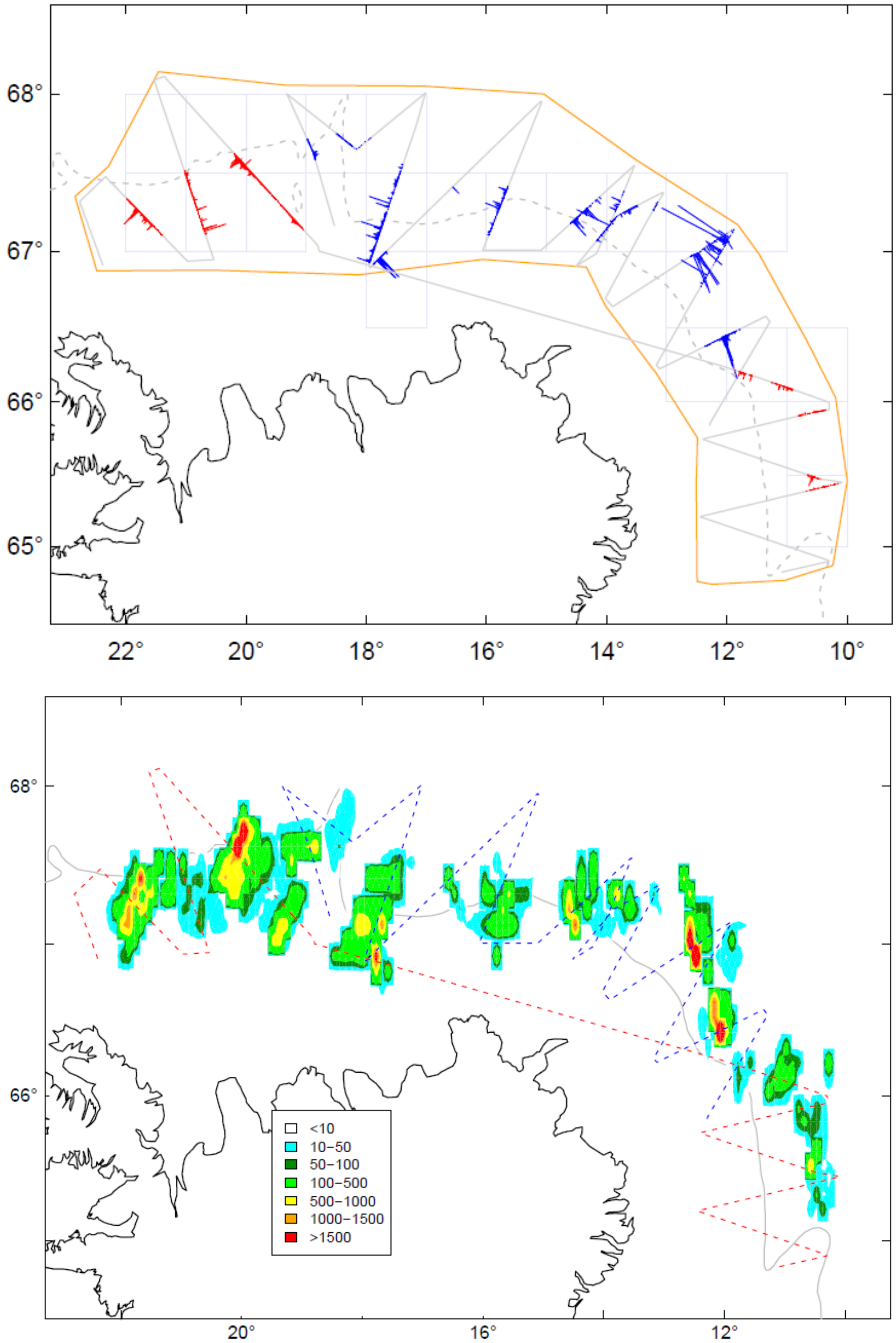


Figure 12.2.3. Icelandic capelin. Survey tracks (A) of the participating vessels during 18–25 January 2022 and distribution (B) of capelin.

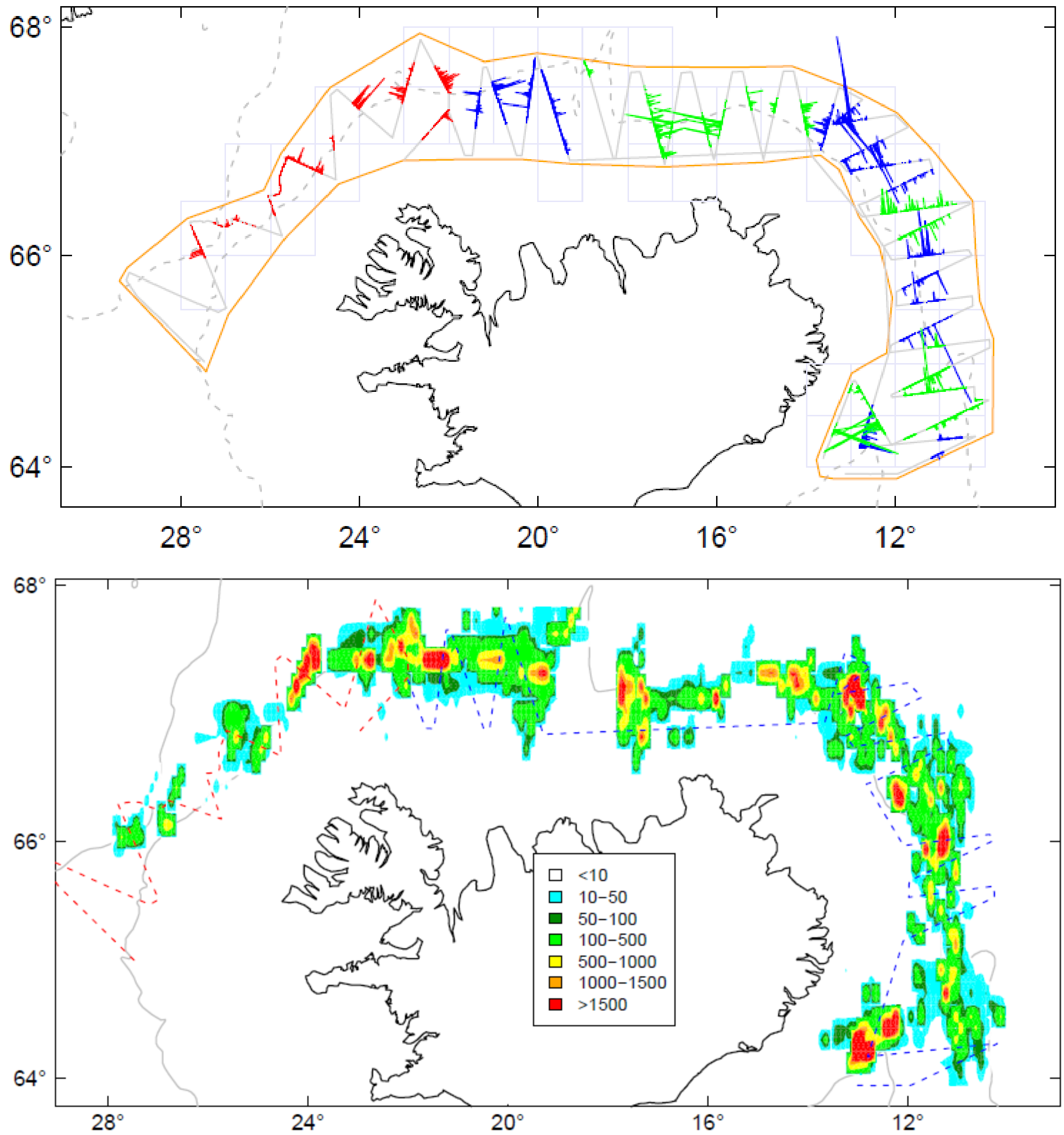


Figure 12.2.4. Icelandic capelin. Survey tracks (A) of participating vessels during 25 January–2 February 2021 and distribution (B) of capelin.

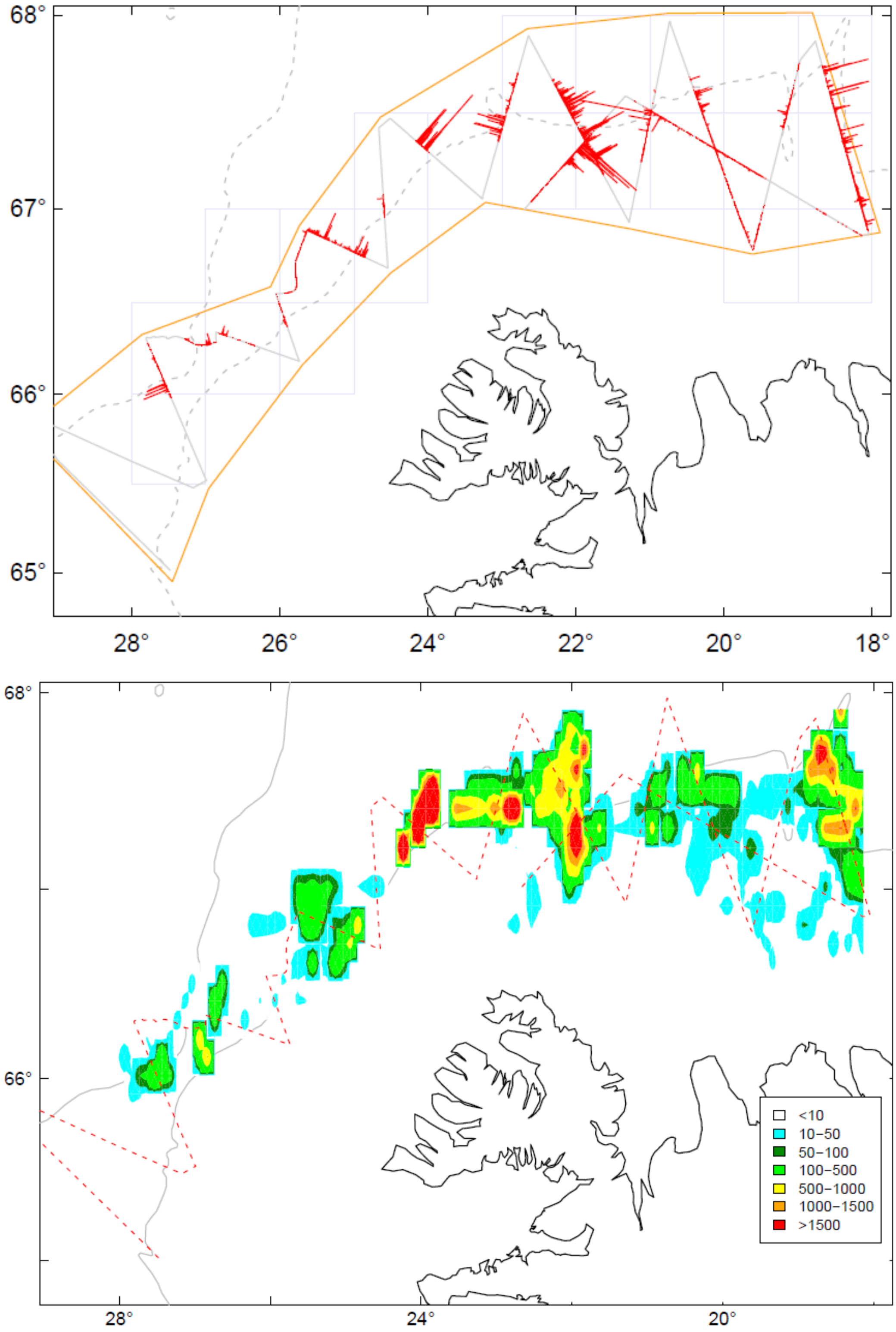


Figure 12.2.5. Icelandic capelin. Survey tracks (A) of participating vessels on 10–15 February 2022 and distribution (B) of capelin.

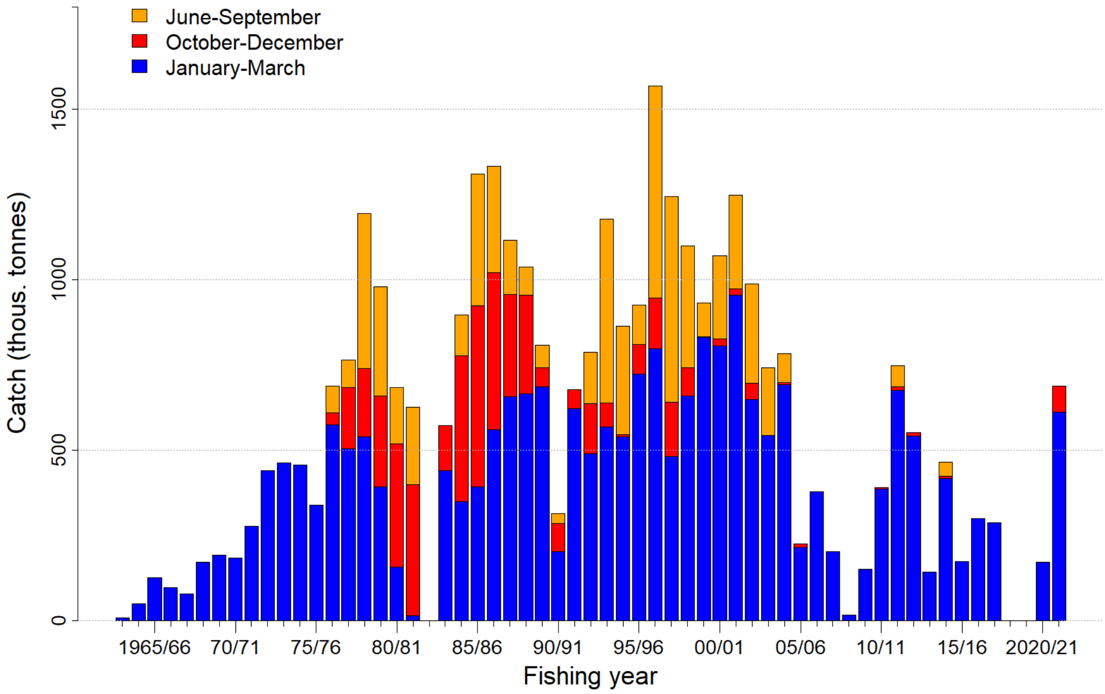


Figure 12.3.1. Icelandic capelin. The total catch (in thousand tonnes) of the Icelandic capelin since 1963/64 by season.

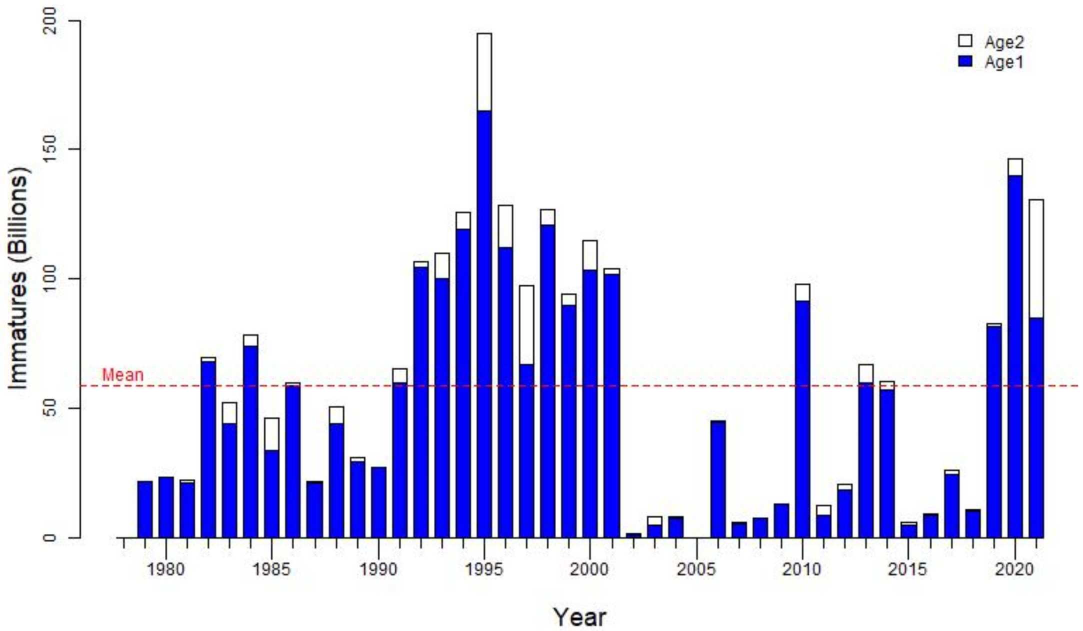


Figure 12.7.1. Icelandic capelin. Indices of immature 1 and immature 2 years old capelin from acoustic surveys in autumn since 1979.

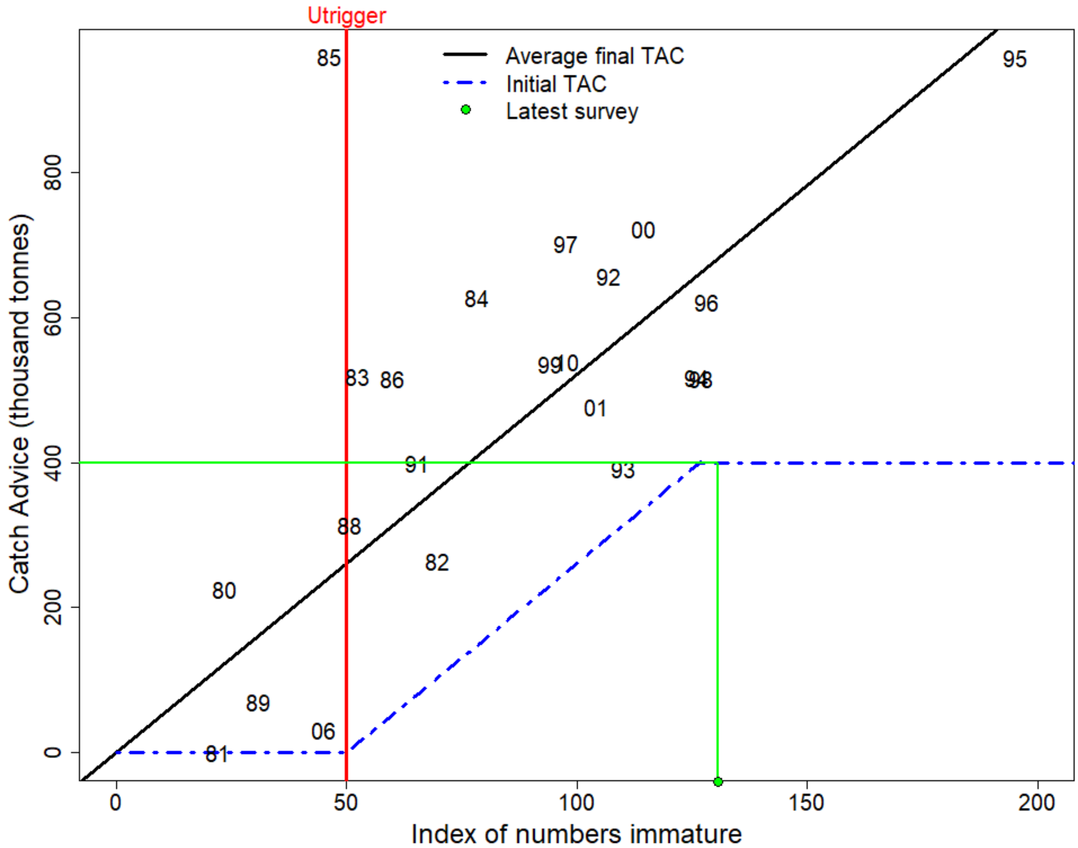


Figure 12.7.2 Icelandic Capelin. Catch advice according to the proposed stochastic HCR, based on the measured number of immature capelins about 15 months earlier. The figure shows the estimated final TAC (black unbroken line) and the initial (preliminary) TAC (blue dashed line). The latter is set using 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 2021, with the corresponding initial TAC for 2022/2023 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).

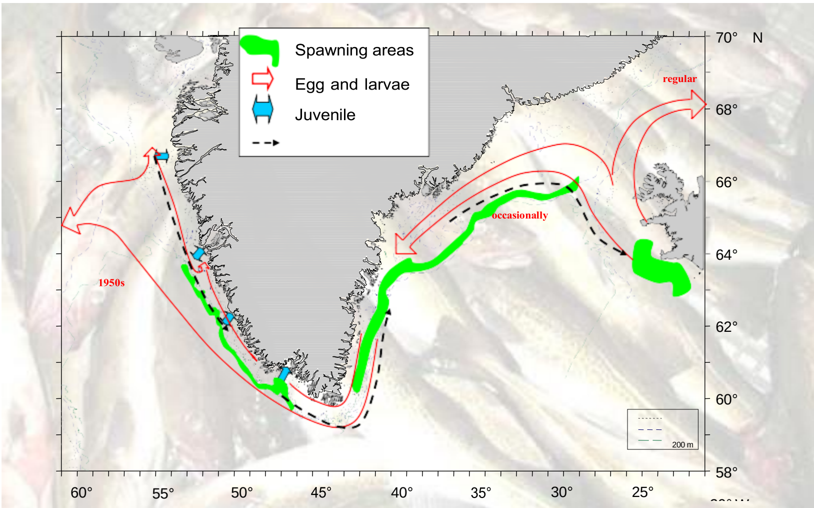


Figure 1. Spawning areas, egg and larval transport of Atlantic cod (*Gadus morhus*) in Greenlandic and Icelandic waters.

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).

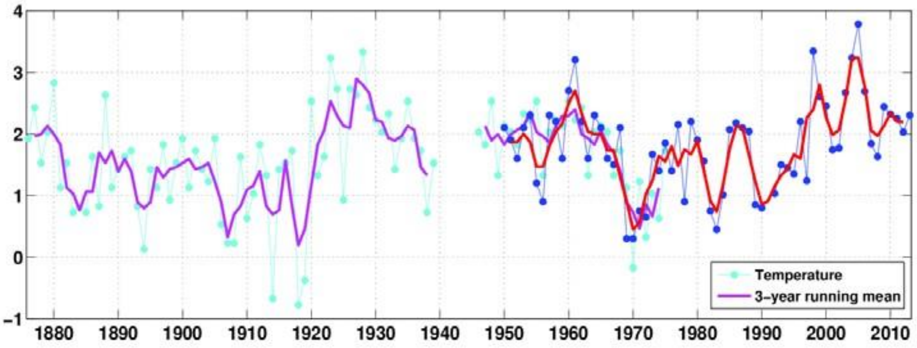


Figure 2. Mean temperature on top of Fylla Bank (located outside Nuuk Fjord, 0–40 m depth) in the middle of June for the period 1950–2013. The curves are 3 year running mean values. The magenta/purple line is extended back to 1876 using Smed-data for area A1. From Ribergaard (2014).

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.*

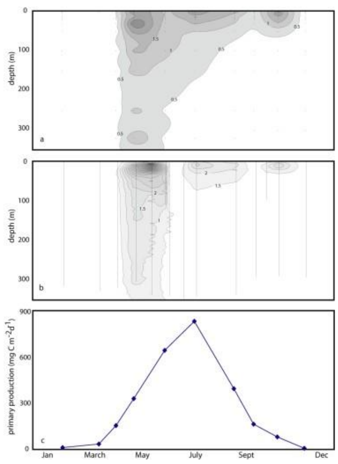


Figure 3. Annual variation in algal biomass and productivity at the inlet of Nuuk Fjord. a: chlorophyll (µg l-1), b: fluorescence, c: primary production (mg C m-2 d-1). Dots represent sampling points. From Mikkelsen *et al.* (2008).

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.

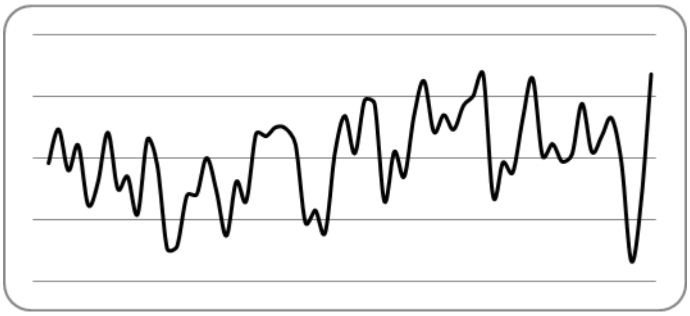


Figure 4. NAO Index (Dec–Feb) 1950–2012.

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).

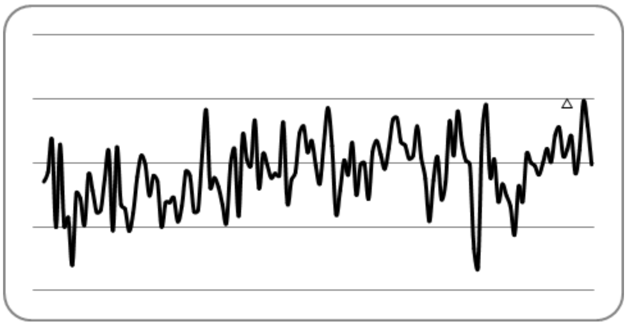


Figure 5. Time-series of annual mean winter (DEC–FEB) air temperature anomalies (K) at Nuuk (1876–2012, rel. 1961–1990)

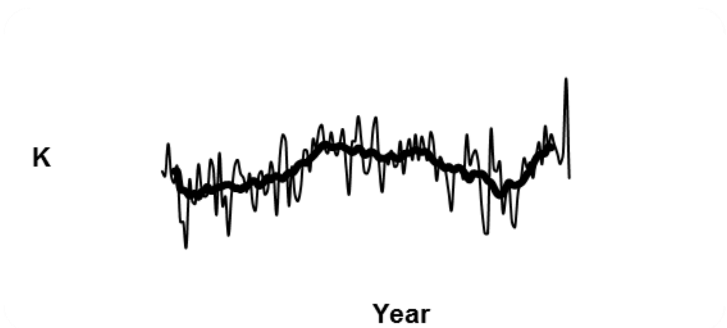


Figure 6. Time-series of annual mean air temperature anomalies (K) at Nuuk (1876–2011, rel. 1961–1990), and 13 year running mean.

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.

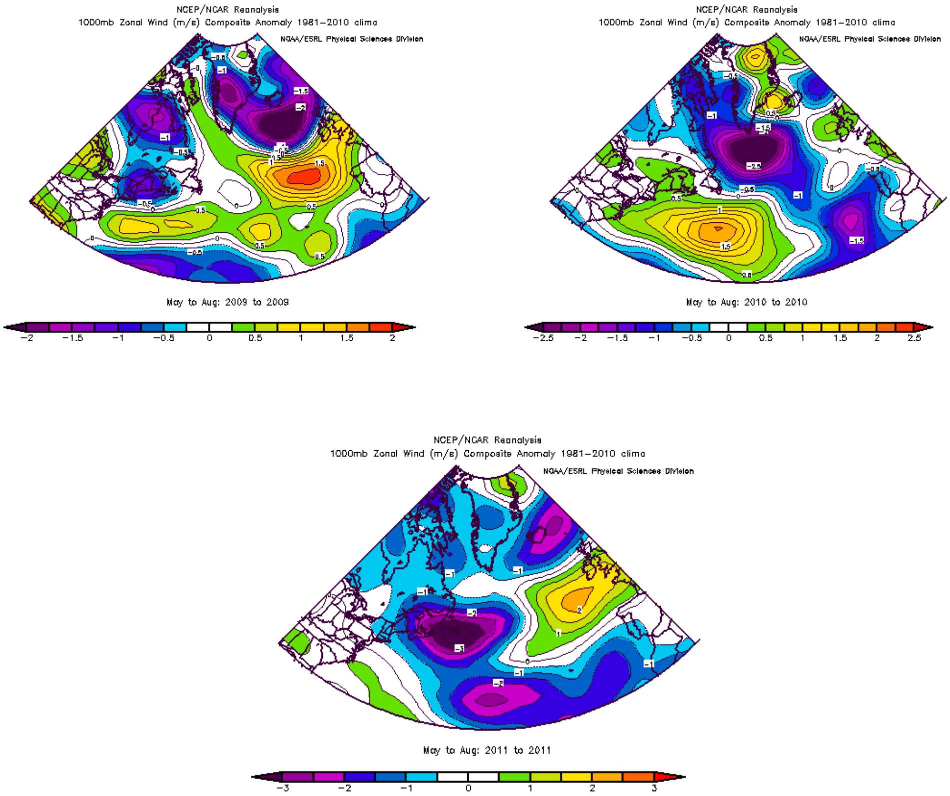


Figure 7. Zonal wind components for the North Atlantic (May–Aug), anomalies from 1981–2010.Top left: 2009; top right: 2010; bottom: 2011.

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).

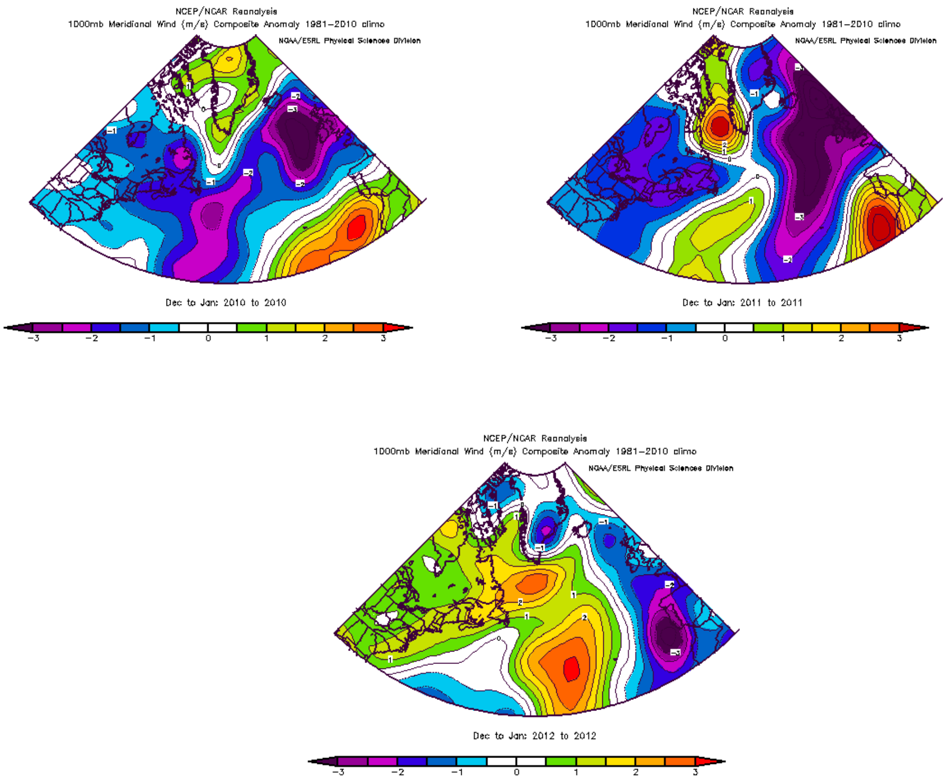


Figure 8. Meridional wind component (Dec–Jan), anomalies from 1981–2010. top left: 2009/2010; top right: 2010/2011; bottom: 2011/2012;

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.

13.3 References

Blicher, M. E., Rysgaard, S. and Sejr, M. K. 2007. Growth and production of sea urchin Strongylocentrotus droebachiensis in a high-Arctic fjord, and growth along a climatic gradient (64 to 77 degrees N) (vol. 341, pg 89, 2007). Marine Ecology-Progress Series, 346: 314–314.

Gordon, J.D.M., Bergstad, O.A., Figueiredo, I. And G. Menezes. 2003. Deep-water Fisheries of the Northeast Atlantic: I Description and current Trends. J. Northw. Atl. Fish. Sci. Vol: 31; 37–150.

Hovgård, H. and K. Wieland, 2008. Fishery and environmental aspects relevant for the emergence and decline of Atlantic cod (Gadus morhua) in West Greenland waters. In: Resiliency of Gadid stocks to fishing and climate change, p 89–110 (Ed.: G.H. Kruse, K Drinkwater , J.N. Ianelle, J.S. Link, D.L. Stram, V. Wepestad and D.Woodby). Anchorage, Alaska, 2008.

Hvingel, C., Kingsley, M.C.S. 2006. A framework to model shrimp (Pandalus borealis) stock dynamics and quantity risk associated with alternative management options, using Bayesian methods, ICES J. Mar. Sci. 63; 68–82.

ICES. 2013a. Report of the Ad hoc Group on the Distribution and Migration of Northeast Atlantic Mackerel (AGDMM). ICES CM 2013/ACOM:58. 215 pp.

ICES. 2013c. ICES Report on Ocean Climate 2012 Prepared by the Working Group on Oceanic Hydrography. No. 321 Special Issue. 74 pp.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C., and A. Fernø. 2012. Overlap in distribution and diets of Atlantic mackerel (Scomber scombrus), Norwegian spring-spawning herring (Clupea harengus) and blue whiting (Micromesistius poutassou) in the Norwegian Sea during late summer. Marine Biology Research 8: 442–460

Mikkelsen, D.M., Rysgaard, S., Mortensen, J., Retzel, A., Nygaard, R., Juul-Pedersen, T., Sejr, M., Blicher, M., Krause-Jensen, D., Christensen, P.B., Labansen, A., Egevang, C., Witting, L., Boye, T. K., Simon, M. 2008. Nuuk Basic: The Marine Basic programme 2007. GN Report 2008.

Møller, P. R., J.G. Nielsen, S. W. Knudsen, J. Y. Poulsen, K. Sünksen, O. A. Jørgensen. 2010. A checklist of the fish fauna of Greenland waters. Zootax 2378:1–84.

Ribergaard, M.H. 2014. Oceanographic Investigations off West Greenland 2013. Danish Meteorological Institute Centre for Ocean and Ice.

Rudels, B., Korhonen, M., Budéus, G., Beszczynska-Möller, A., Schauer, U., Nummelin, A., Quadfasel, D., and Valdimarsson, H. 2012. The East Greenland Current and its impacts on the Nordic Seas: observed trends in the past decade. – ICES Journal of Marine Science, 69:

Stein, M. 2004. Climatic Overview of NAFO Subarea 1, 1991-2000. J.Northw.Atl.Fish.Sci., 34: 29–41.

Stein, M. and V.A. Borovkov. 2004. Greenland cod (Gadus morhua): modelling recruitment variation during the second half of the 20th century. Fish. Oceanogr. 13(2): 111–120.

Sünksen, K., Stenberg, C., and Grønkjær, P. Temperature effects on growth of juvenile Greenland halibut (Reinhardtius hippoglossoides Walbaum) in West Greenland waters. Journal of Sea Research 64(1):125-132.

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 5000 tonnes was introduced as an experimental fishery. In 2019 the start TAC was 0 tonne, but during the year 2000 tonnes 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 2021

In 2021 TAC was 0 tonnes, however 96 tonnes 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 in September and October. 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 and 2021. 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, 2022.

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. Hoever 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

No survey was performed in 2021.

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 tonnes (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 year classes, 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 WestGreenland 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 year classes.

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 year classes between NAFO divisions reveals a pattern of West Greenland offshore component dominating the year classes 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 years) are found off East Greenland primarily north of 63°N, b) Cod at ages 4-6 years are found primarily in Southwest Greenland and c) Young cod (<3 years) 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 year class 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 (2021).

14.3.2 Results of the German groundfish survey

No survey was performed in 2021.

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 were 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 26 596 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 years 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 2022

No fishery is allowed in 2022 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 2023

The stock is proposed to go through a benchmark in 2023.

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 *et al*., 2022; Buch *et al*., 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*., 2022). 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

Buch, T.B., Retzel, A., Riget, F., Jansen, T., Boje, J., Berg, C. 2022. DNA split of Atlantic cod (*Gadus morhua*) stocks in Greenland waters. An Overview of data. ICES North Western Working Group (NWWG) May 2-7, 2022, WD 13.

Burmeister, A, Riget, F.F. 2018. The West Greenland trawl survey for *Pandalus borealis* 2018, with reference to earlier results. NAFO SCR Doc. 018/055.

Burmeister, A, Riget, F.F. 2019. The West Greenland trawl survey for *Pandalus borealis* 2019, with reference to earlier results. NAFO SCR Doc. 019/043.

Burmeister, A, Riget, F.F. 2020. The West Greenland trawl survey for *Pandalus borealis* 2020, with reference to earlier results. NAFO SCR Doc. 20/53.

Christensen, H.T., Rigét, F., Retzel, A., Nielsen, E.H., Nielsen, E.E., Hedeholm, R.B. 2022. Year-round genetic monitoring of mixed stocks in an Atlantic cod (*Gadus morhua*) fishery; implications for management. ICES Journal of Marine Science. 0, 1-15. DOI: 10.1093/icesjms/fsac076

ICES. 2017. Report of the North Western Working Group (NWWG). ICES CM 2017/ACOM:08.

Hedeholm, R.B. 2017. Length Based indicators and SPiCT in relation to reference points for the West Greenland offshore Atlantic cod stock (cod-wegr). ICES North Western Working Group (NWWG) April 27May 4, 2017, WD 09.

Horsted, S.A. 2000. A review of the cod fisheries at Greenland, 1910-1995. J.Northw.Atl.Fish.Sci. 28: 1-112.

Retzel, A. 2015. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2014.

ICES North Western Working Group (NWWG) April 28May 5, 2015, WD 20.

Retzel, A. 2018. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2017. ICES North Western Working Group (NWWG) April 26May 3, 2018, WD 07.

Retzel, A. 2020. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) and results from survey on spawning cod in NAFO subarea 1C in 2020. ICES North Western Working Group (NWWG) April 23-28, 2020, WD 05.

Retzel, A. 2022. Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2021. ICES North Western Working Group (NWWG) May 2-7, 2022, WD 07.

Retzel, A. 2021. Greenland Shrimp and Fish survey results for Atlantic cod in NAFO subareas 1A-1E (West Greenland) 2021. ICES North Western Working Group (NWWG) April 22-29, 2021, WD 08.

Therkildsen, N.O.,Hemmer-Hansen, J., Hedeholm, R.B., Wisz, M.S., Pampoulie, C., Meldrup, D., Bonanomi, S., Retzel, A., Olsen, S.M., Nielsen, E.E. 2013. Spatiotemporal SNP analysis reveal pronounced biocomplexity at the northern renge margin of Atlantic cod *Gadus morhua*. Evoltutionary Applications. DOI 10.1111/eva. 12055

Werner, K., Fock, H., 2021. Update of Groundfish Survey Results for the Atlantic Cod Greenland offshore component. ICES North Western Working Group (NWWG) April 22-29, 2021, WD 18.

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
2021	0	0	96	0	0	192	0	96

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	To-tal	%
1C									61	31	4		**96**	100%

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									61	31	4		**96**

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, 2020 and 2021.

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								
2021								
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								
2021								

Table 14.3.1.1. Number of hauls in the Greenland Shrimp and Fish survey in West Greenland by year and NAFO subdivisions. No survey in 2021.

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. No survey in 2021.

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. No survey in 2021.

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). No survey in 2021.

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. No survey in 2021.

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											
Div. 1B											
Div. 1C											
Div. 1D											
Div. 1E											

Table 14.3.1.6 Mean weight of cod from the Greenland Shrimp and Fish survey in West Greenland (NAFO 1A–1E). No survey in 2021.

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, 2018 and 2021. 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, 2018 and 2021. 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, 2018 and 2021. 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, 2018 and 2021. 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, 2018 and 2021. 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
2021	131			1084

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)	562	3	29	8
Bank (West) NAFO 1C, Tovqussaq		1		4
Bank (West) NAFO 1D+1E, Dana		2	69	
East Greenland			36	124
Iceland	3		47	197

14.14 Figures

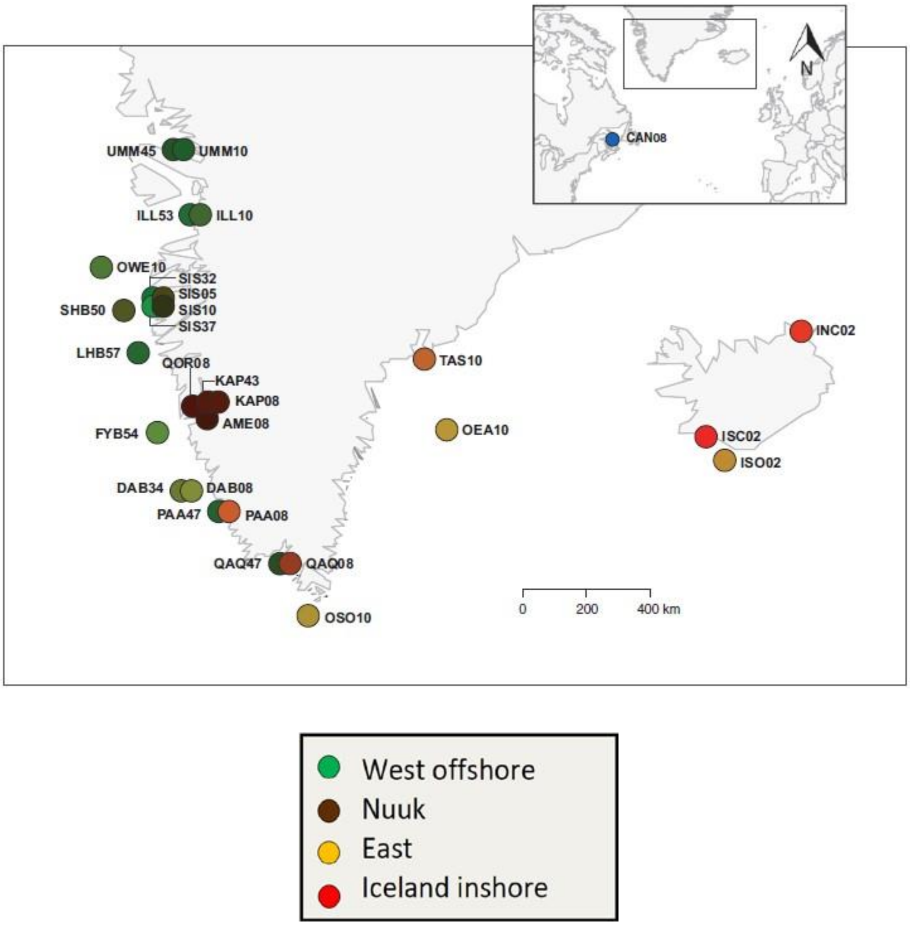


Figure. 14.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red, respectively. After Therkildsen *et al*. (2013).

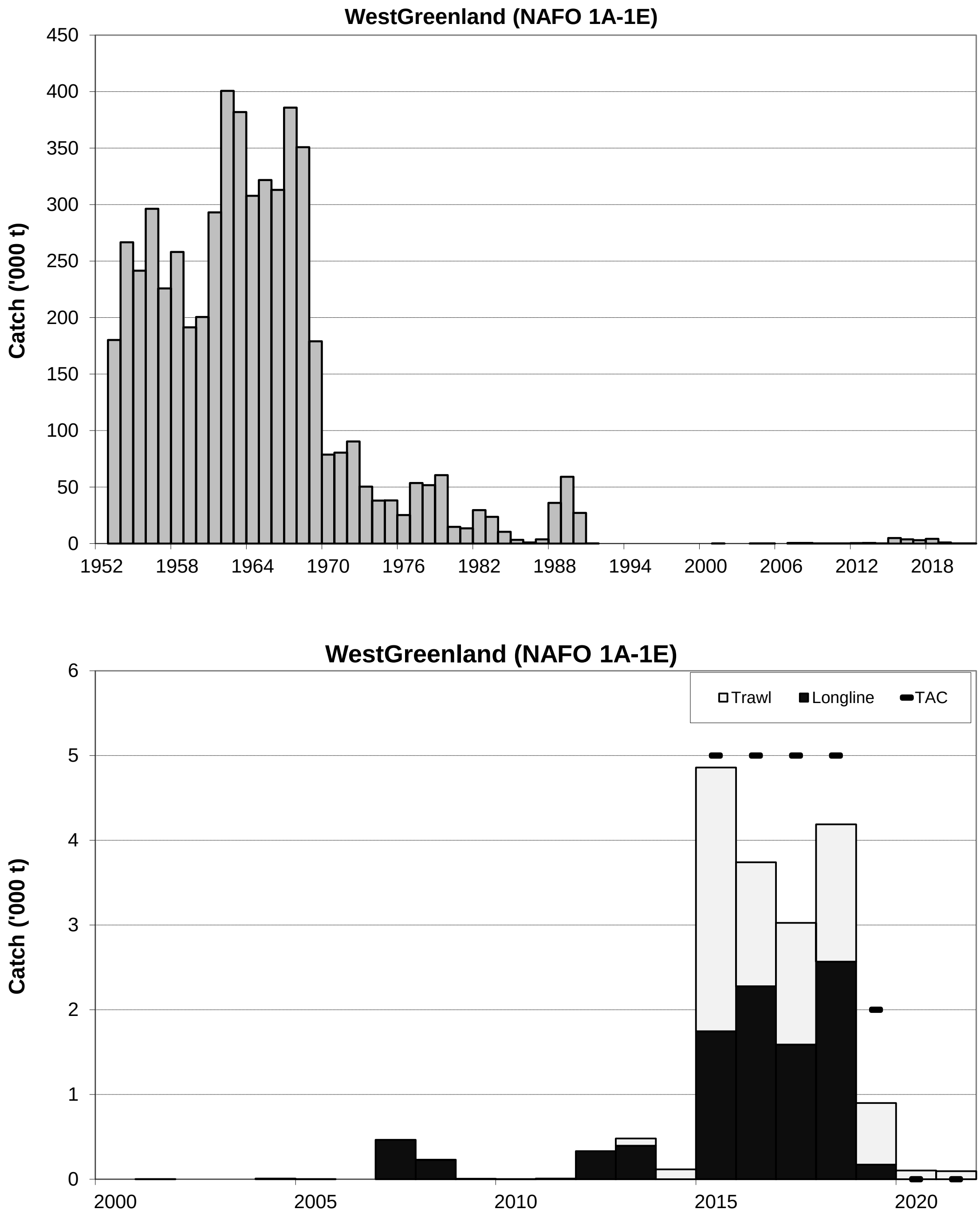


Figure 14.2.1. Annual catch of cod in offshore West Greenland (NAFO subdivisions 1A–1E) used by the Working Group. Top: from 1952, bottom from 2000.

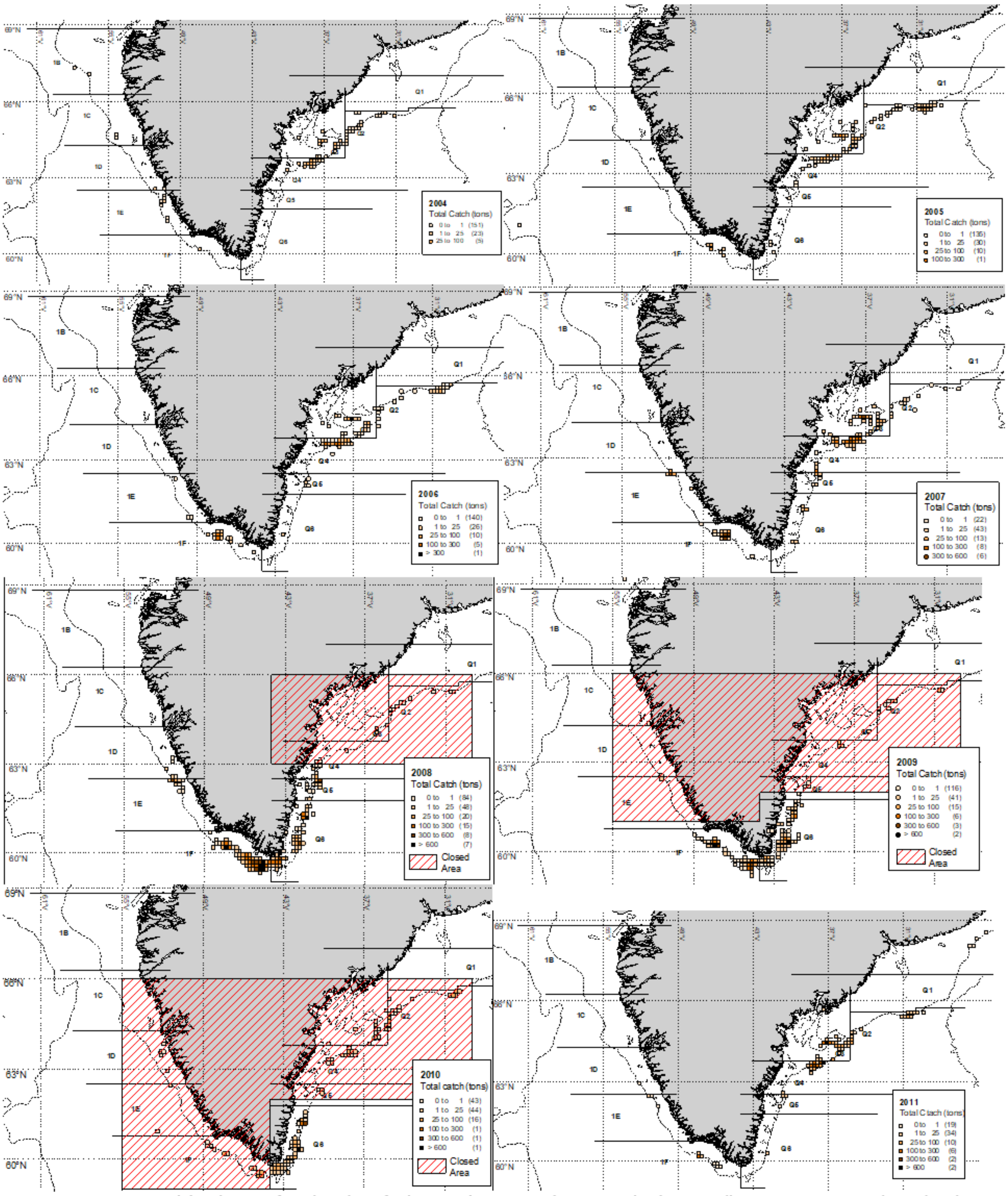


Figure 14.2.2.1: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

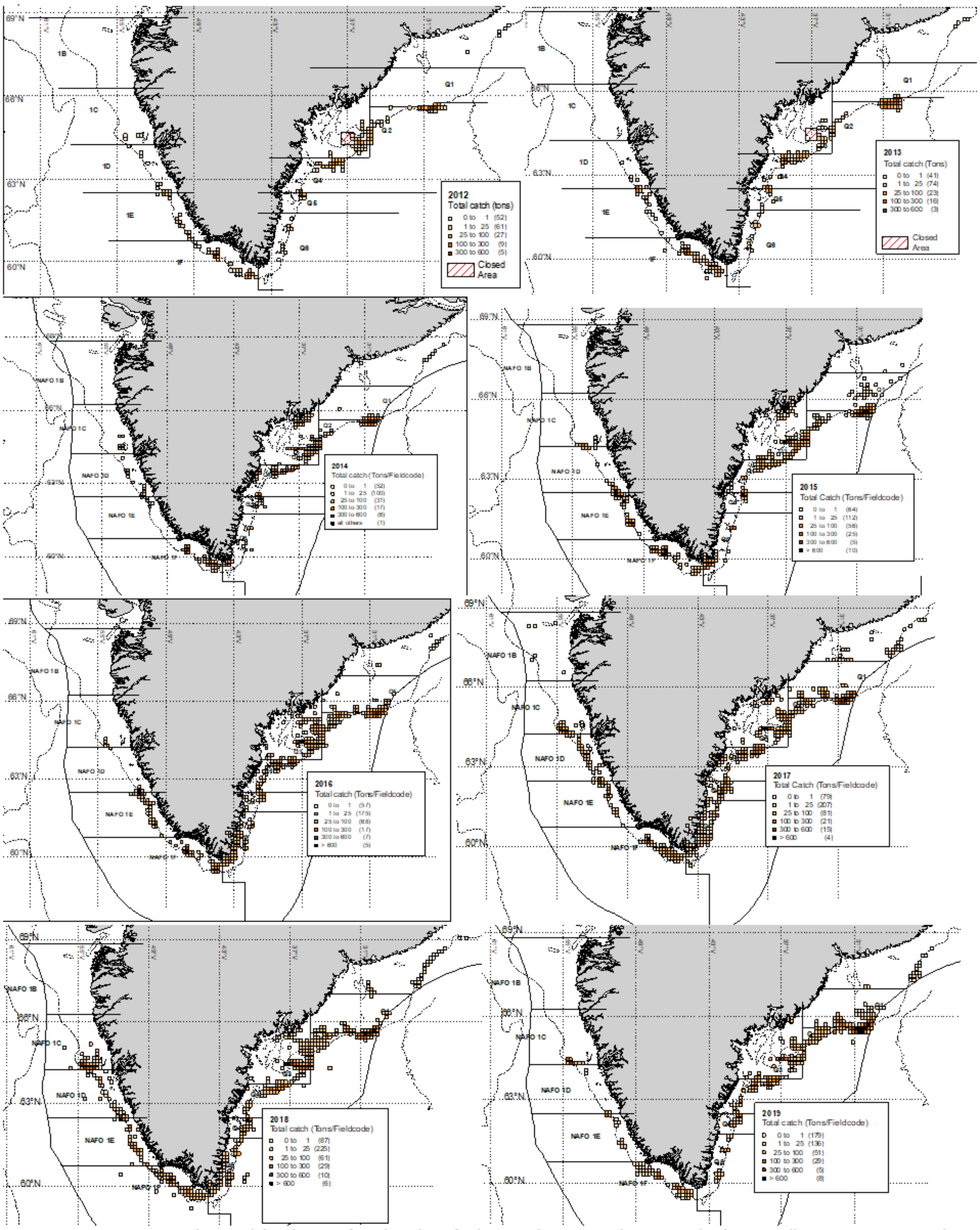


Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

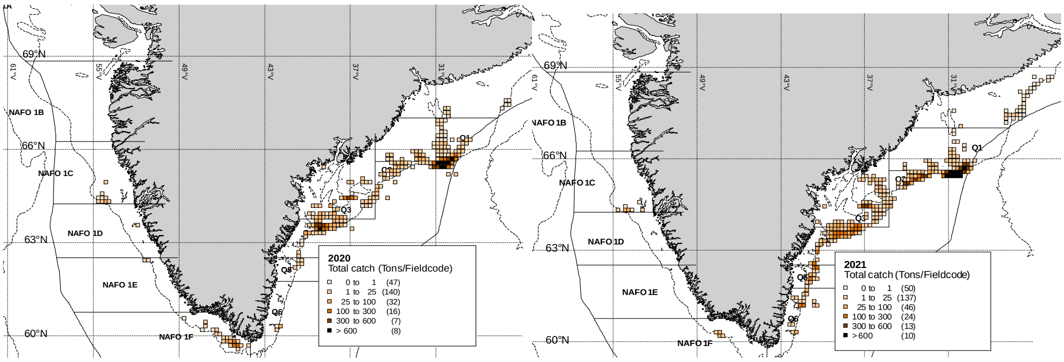


Figure 14.2.2.1: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

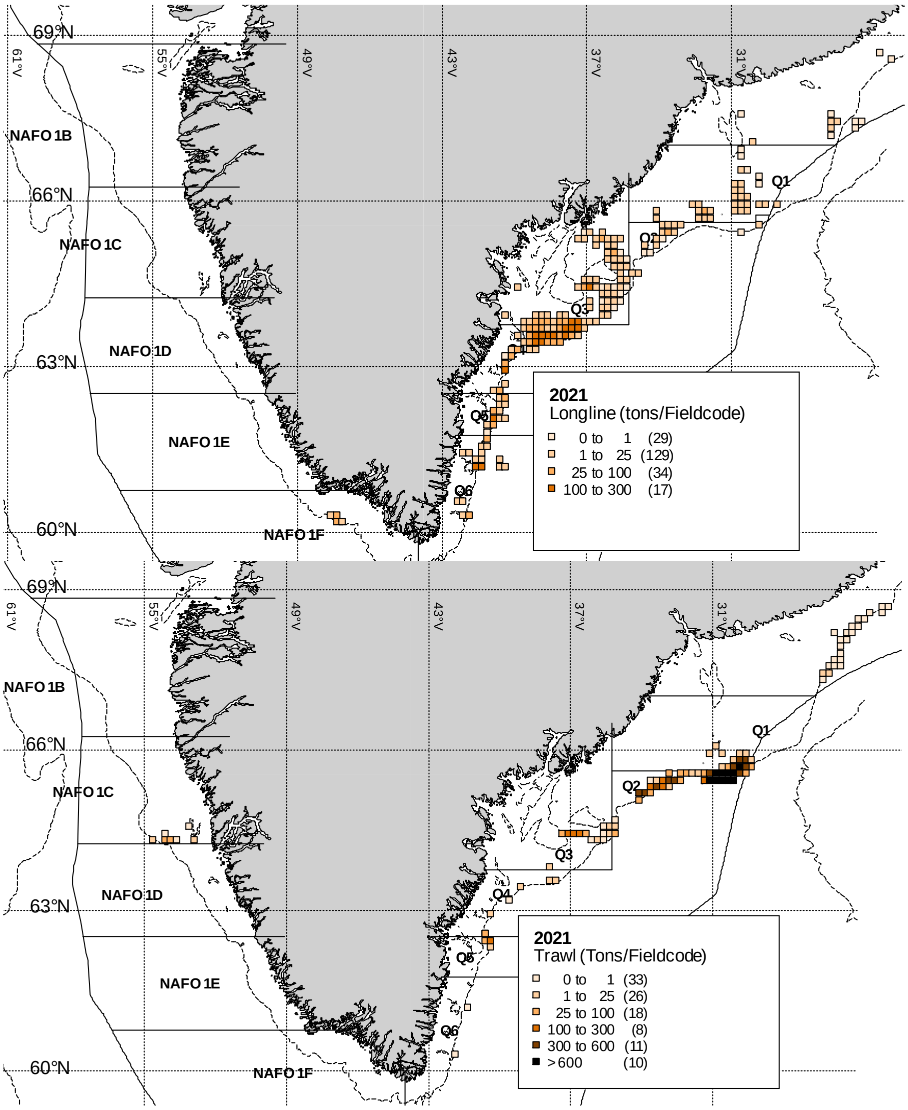


Figure 14.2.2.2: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

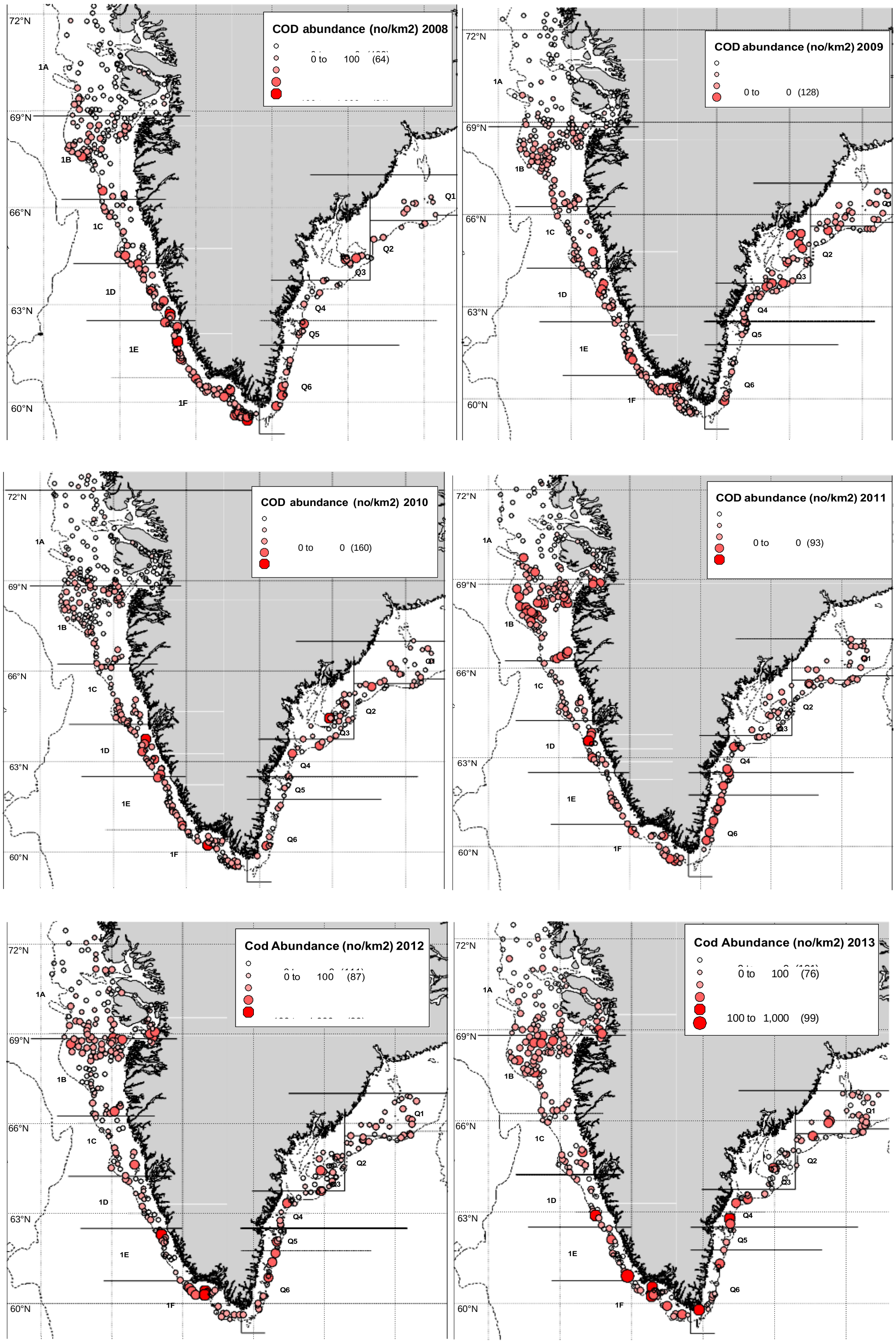


Figure 14.3.1.1. Greenland shrimp and fish survey. Abundance per km².

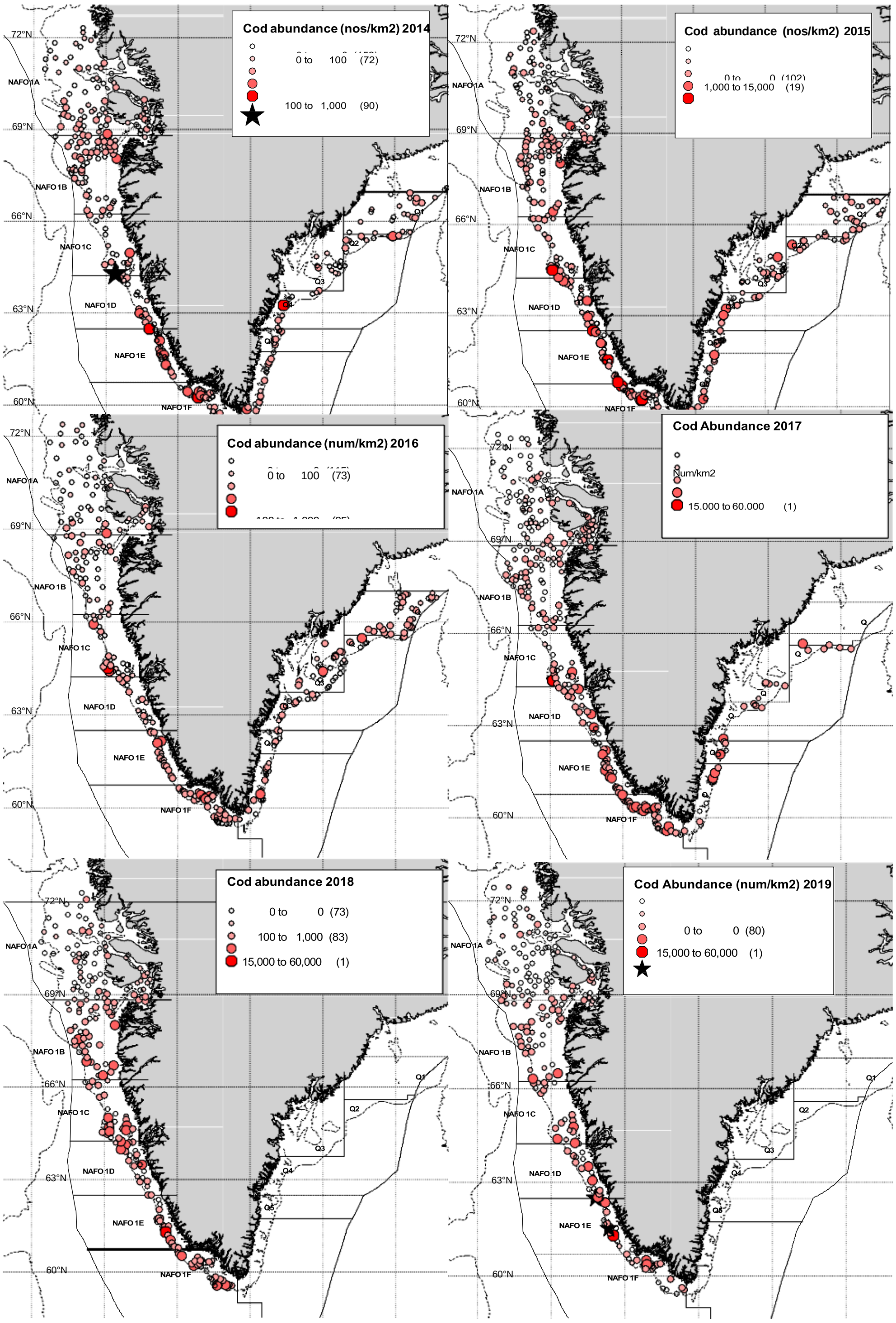


Figure14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per km².

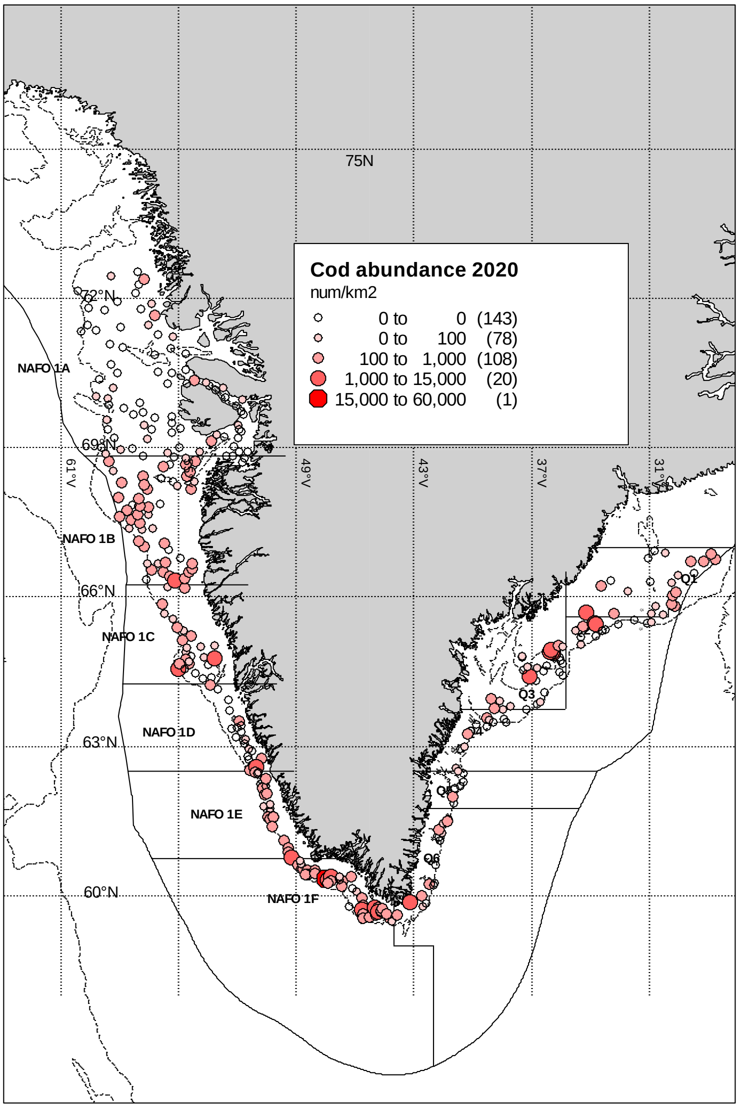


Figure 14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per km². No survey in 2021.

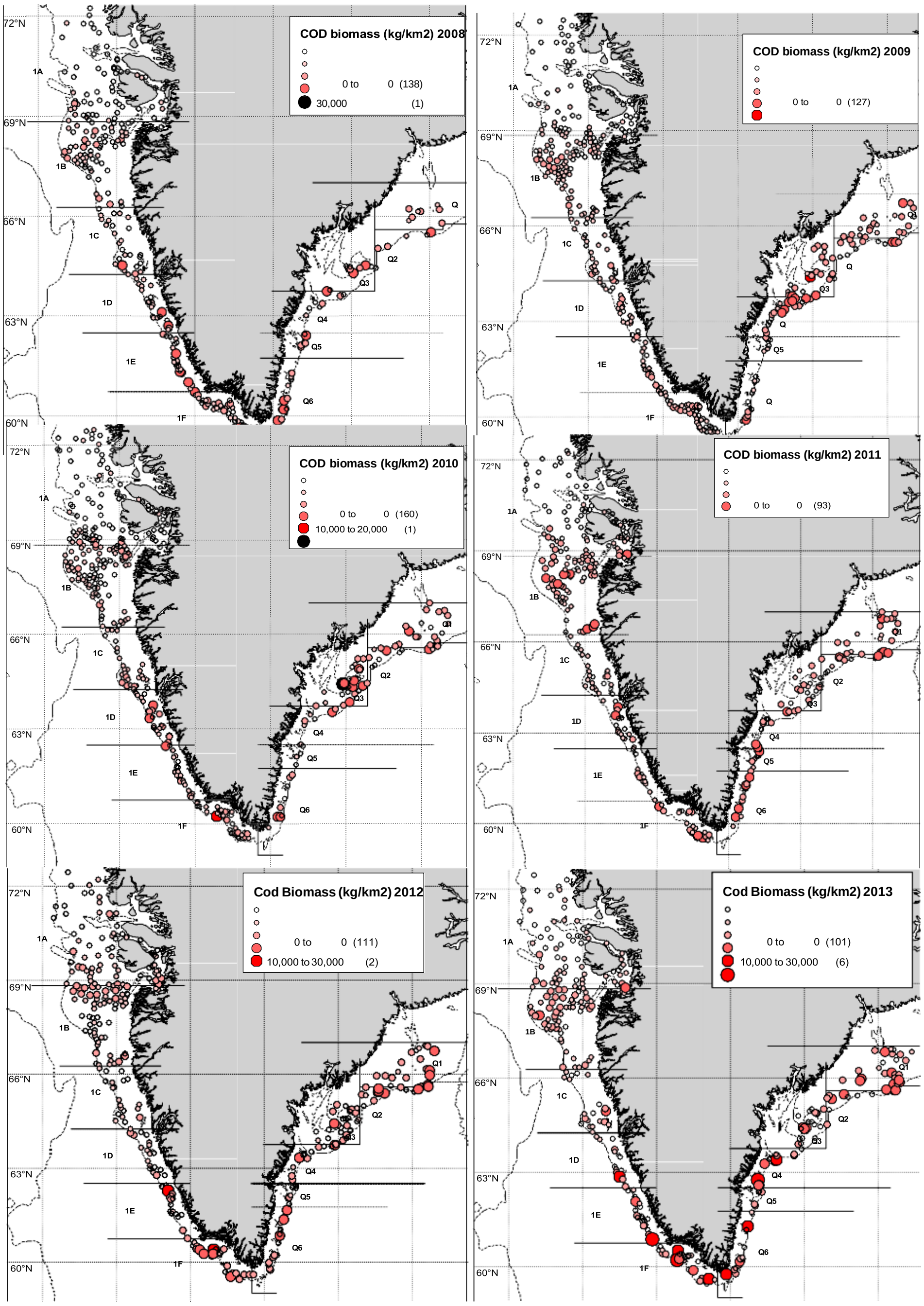


Figure 14.3.1.2. Greenland shrimp and fish survey. Catch weight kg per km².

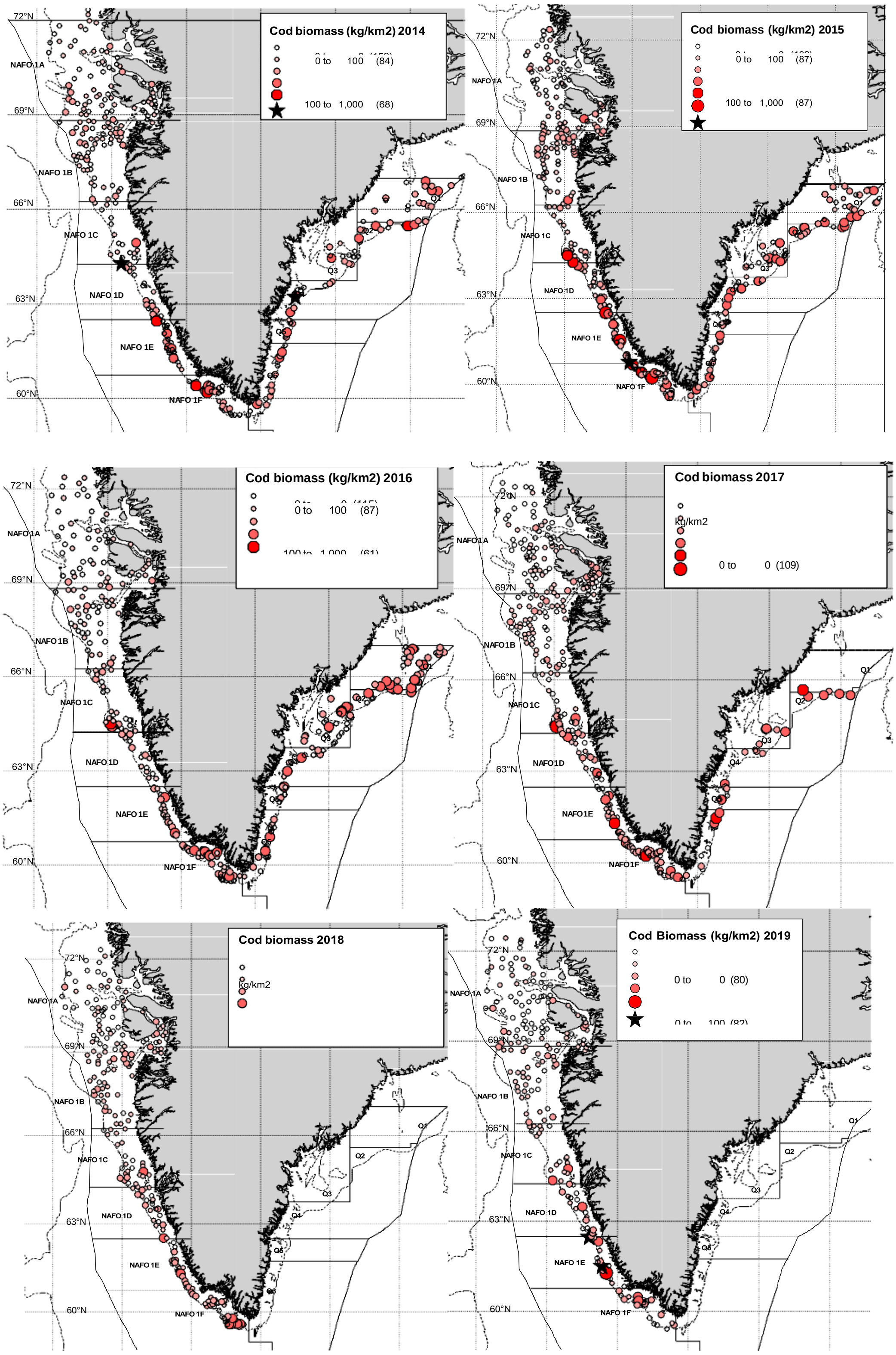


Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per km².

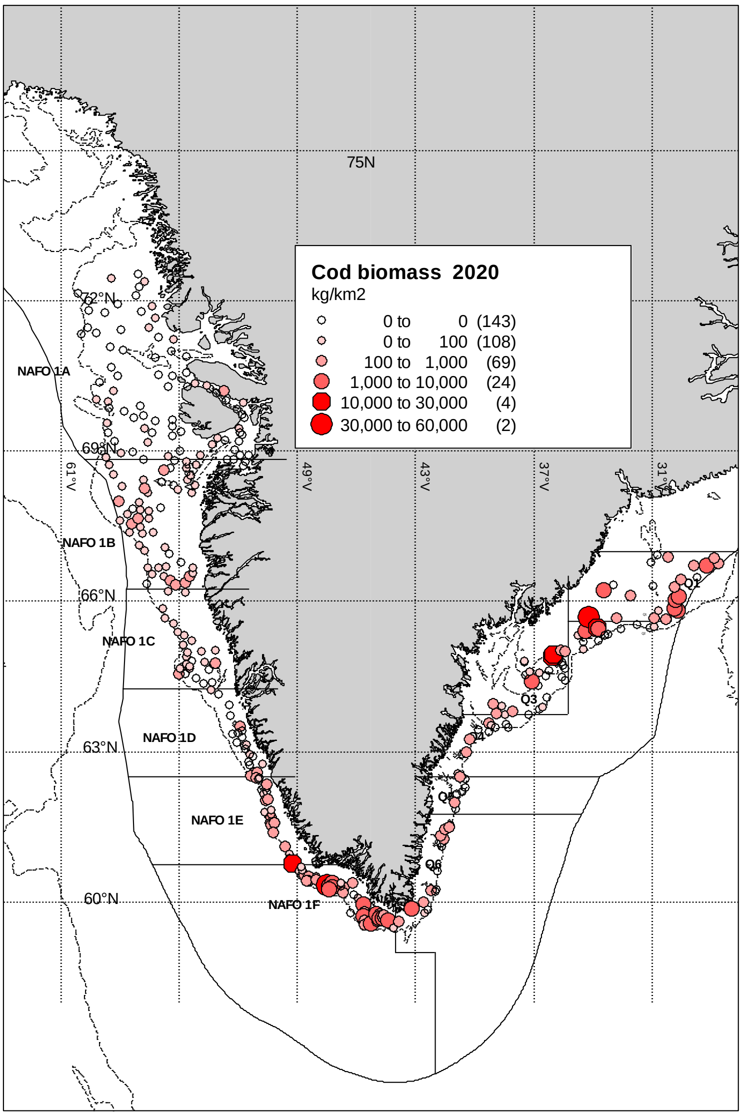


Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per km². No survey in 2021.

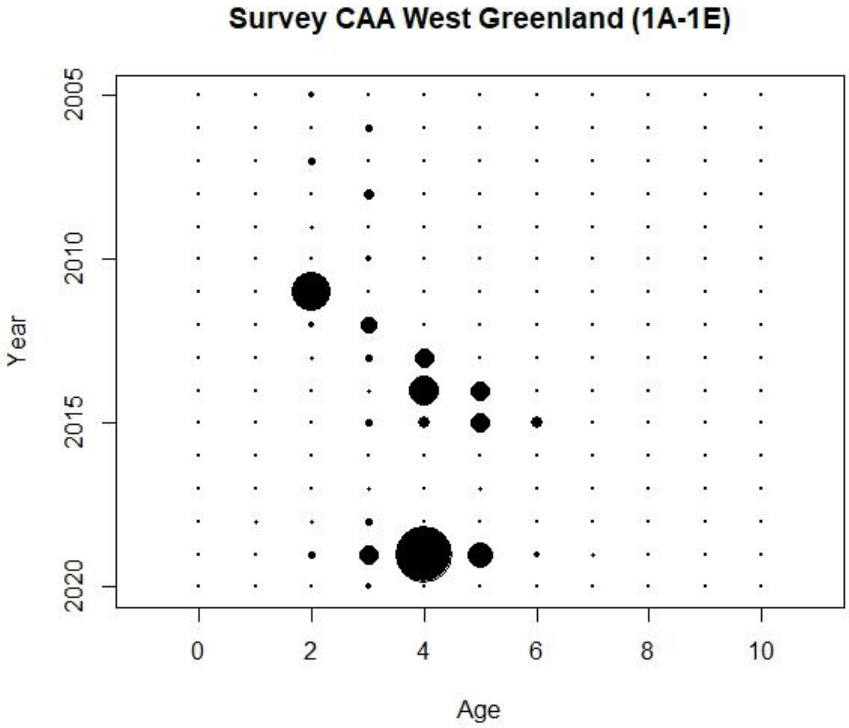


Figure 14.3.1.3: Abundance index by age in NAFO 1A–1E combined. Size of circles represents index size of index. No survey in 2021.

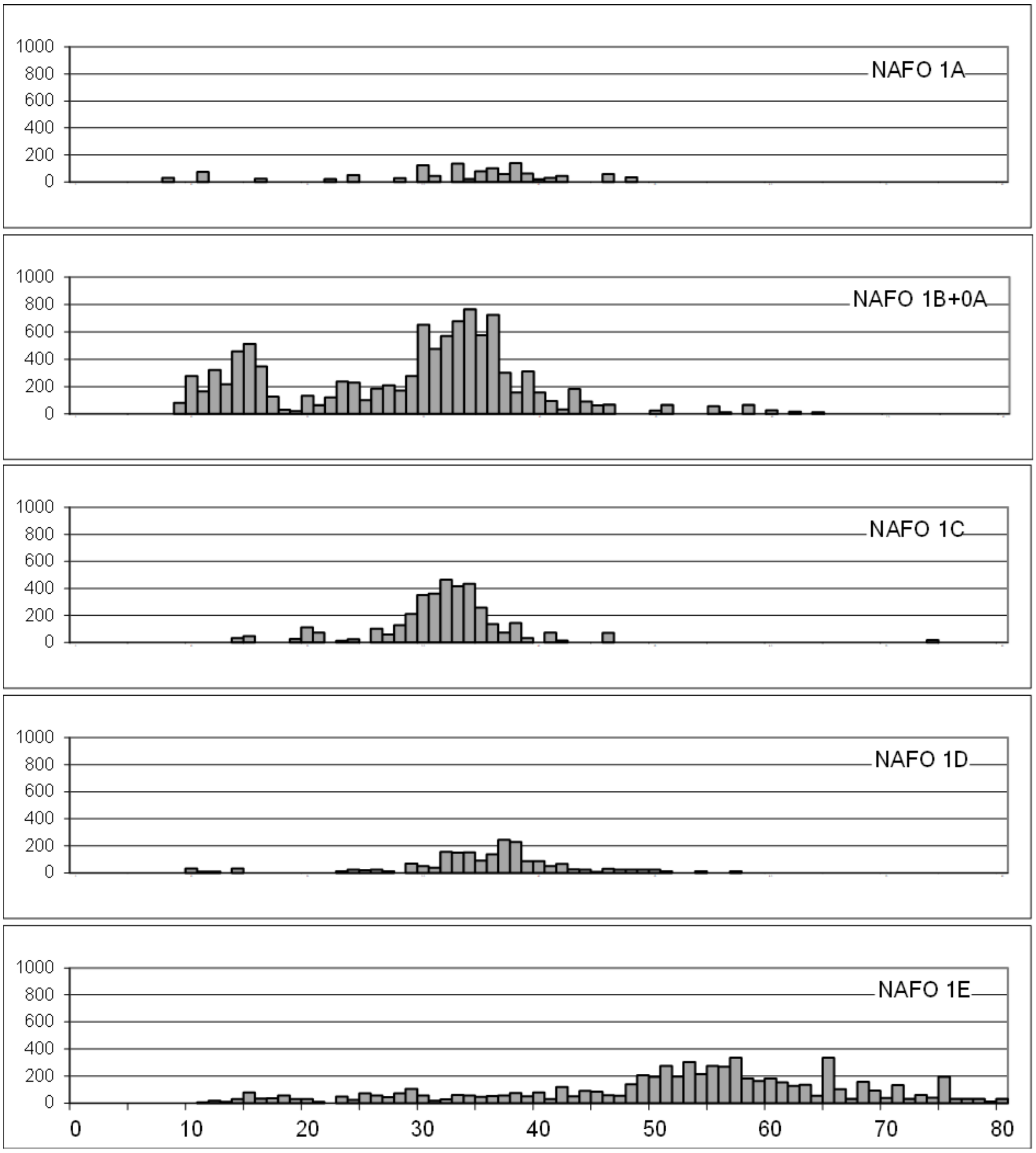


Figure 14.3.1.4: West Greenland Shrimp and fish survey. Abundance index by length (cm) and area. Areas from north (top) to south (bottom) are: NAFO division 1A; 1B+0A; 1C, 1D, 1E. No survey in 2021.

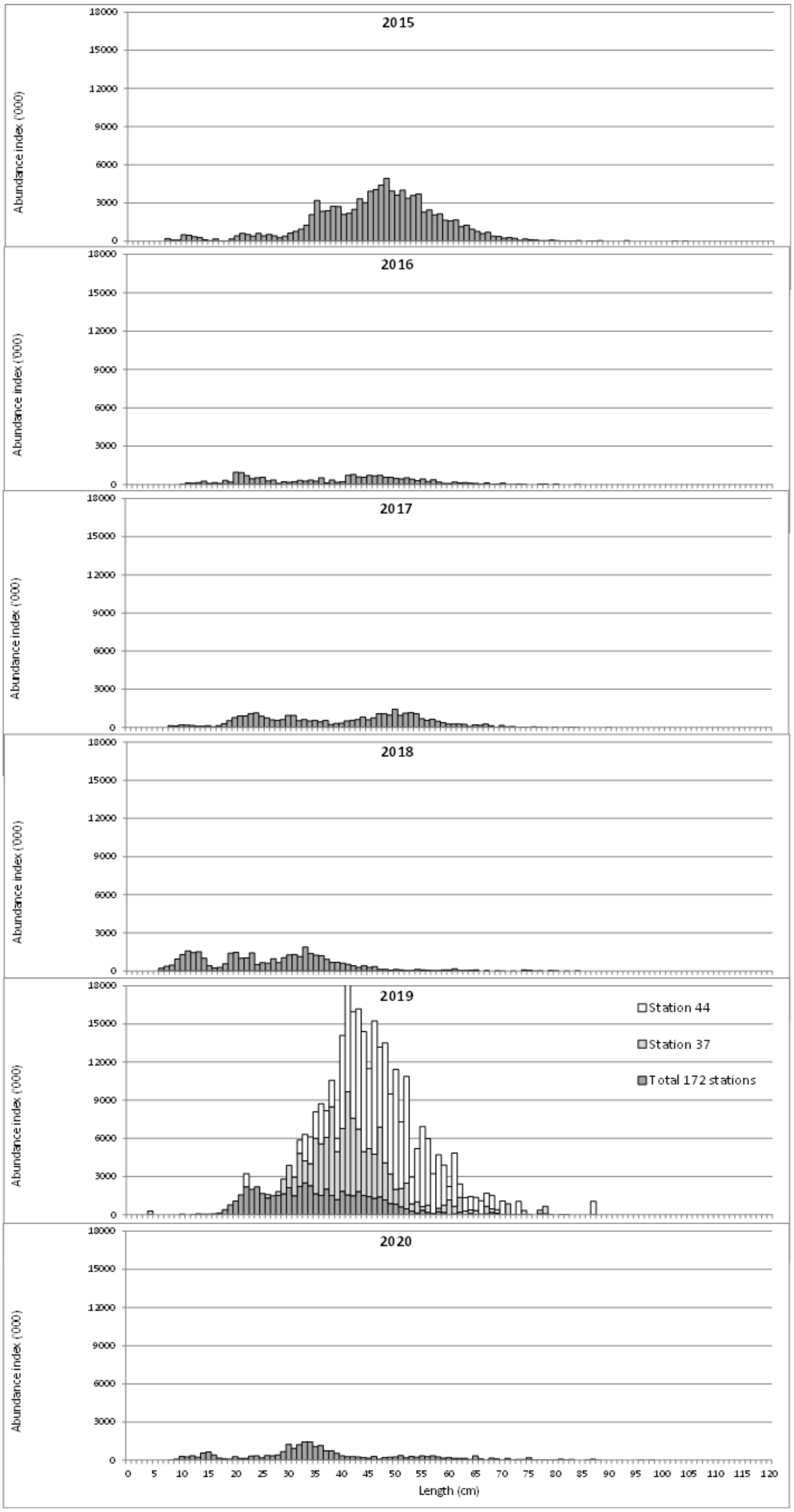


Figure 14.3.1.5: Total abundance indices by length in West Greenland shrimp and fish survey (NAFO 1A–1E). No survey in 2021.

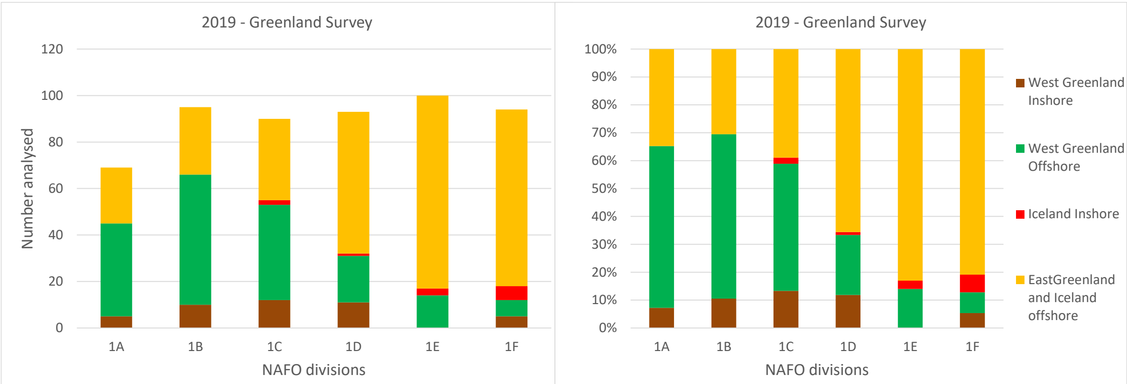


Figure 14.3.1.6: Genetic split in the 2019 trawl survey by NAFO divisions in numbers analyzed and %.

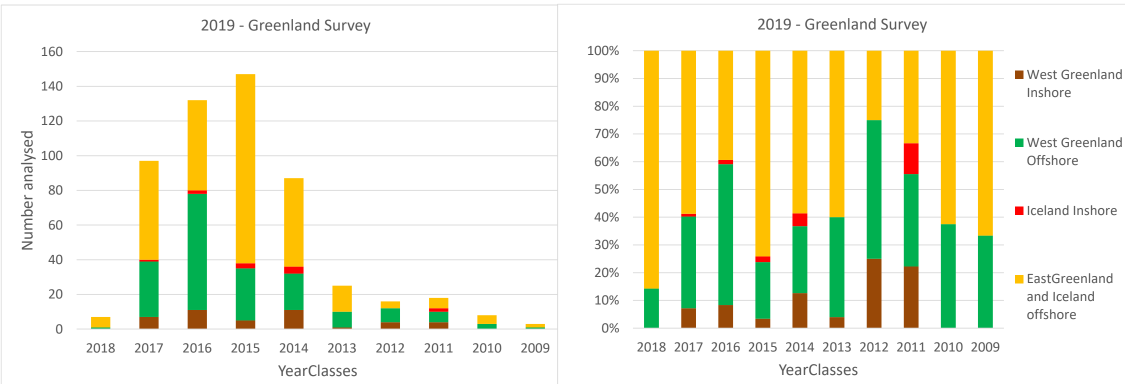


Figure 14.3.1.7: Genetic split in 2019 trawl survey by year-class in numbers analyzed and %.

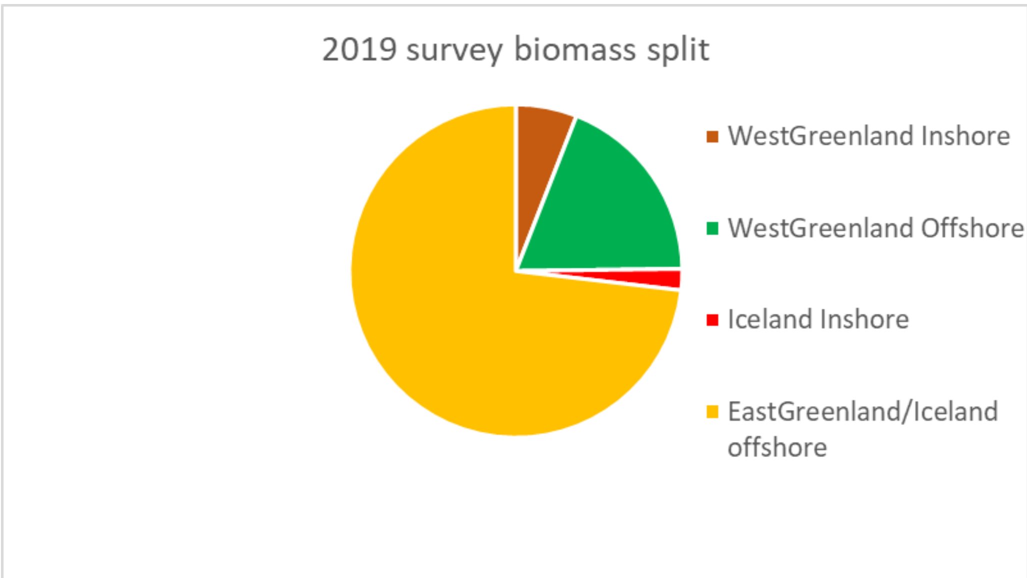


Figure 14.3.1.8: Genetic split weighted with biomass from each NAFO area in the 2019 survey biomass indices.

Figure 14.3.1.9: Genetic split in 2019 trawl survey by year class within NAFO divisions in numbers analyzed and %.

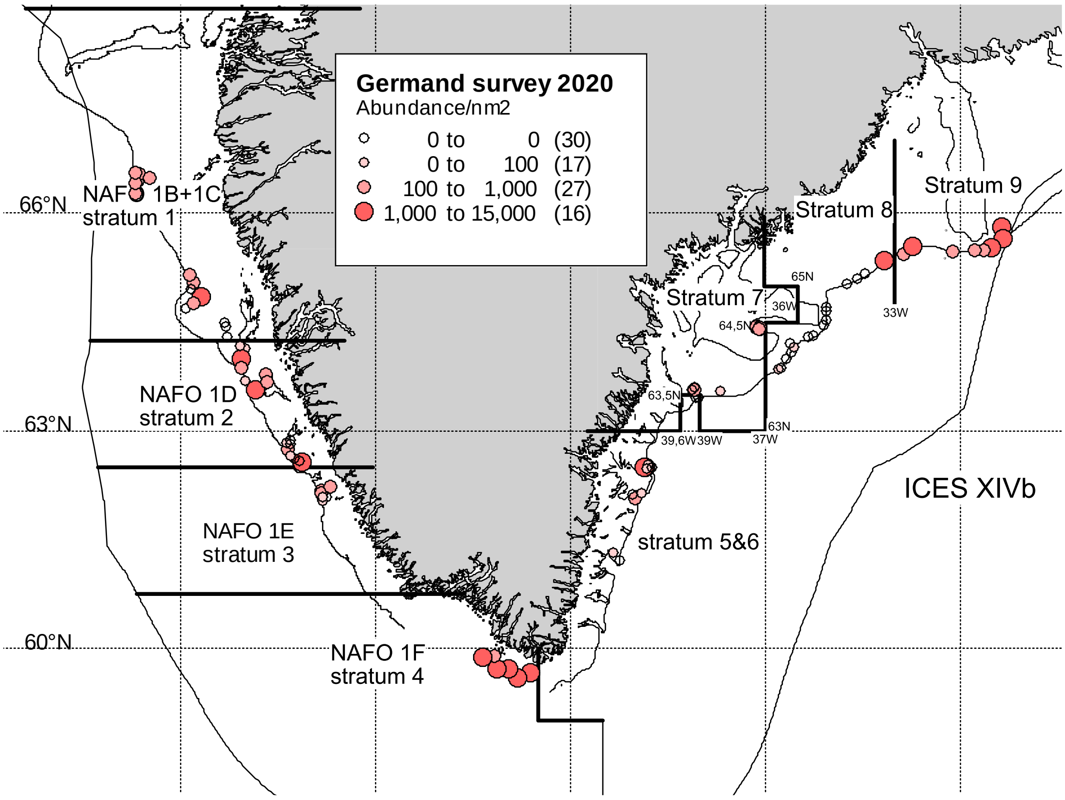


Figure 14.3.2.1. German ground fish survey. Abundance per nm². No survey in 2021.

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 tonnes in 2016. Catches have since then declined.

The present fishery

The TAC in 2021 was 21 000 tonnes. The 2021 catches were 13 580 t, which is a decrease of 25% compared to 2020 (Table 15.2.1). Pound net remains the dominant gear, accounting for 62% of the catches followed by the longlines (18%), hooks (13%) and gill nets (7%) (Table 15.2.2, Figure 15.2.1,). Approximately 63% of the total catch is fished from May-August with a peak (23%) in June (Table 15.2.3). More details on the inshore fishery are given in Retzel, 2022a.

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. 80% in 2021 to 1133 t. and they accounted for 8% of the total catch in 2021 (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)

7000 tonnes were fished in Midgreenland in 2021 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 37% of the total catch in 2021 (Table 15.2.2). The fishery is concentrated around the towns of Kangatsiaq, Sisimiut and Maniitsoq (figures 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 tonnes. This is the highest caught since 1990. Since then catches have decreased with almost 50% to 4700 t in 2021 (Table 15.2.3). The catches in NAFO 1D comprised 34% of the total catch in 2021.

South Greenland (NAFO divisions 1E and 1F)

The catches in South Greenland have over the last decade gradually declined to 421 tonnes 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). Same increase was not seen in NAFO 1E. In 2021 catches in NAFO 1F decreased to 629 t.

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 300 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 2014-2017) were caught in the inshore fishery in 2021, with the 2014 YC (age 5) 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 2021 was 54 in NAFO 1B and 53 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 (261 cod/100hr) has increased compared to 2020 and is well above time-series mean (Table 15.2.6 and figure 15.2.8). The index of age 3 (74 cod/100 hr) has decreased compared to 2020. As a consequence of the high numbers of 2-year olds the overall abundance index including all ages has increased (397 cod/100 hr) and is above the time-series mean (236 cod/100hr).

In NAFO 1D the abundance index of age 2 (46 cod/100hr) increased whereas the index of age 3 (20 cod/100 hr) decreased compared to 2020 (Table 15.2.6). The combined index for age 2 and 3 are around the time-series mean (figure 15.2.8). The overall abundance index including all ages has increased considerably (318 cod/100 hr) and is above well above the time-series mean (119 cod/100 hr). This is primarily caused by higher abundance of older ages from age 4 and up.

Combining 1B and 1D in a joint index across all ages results in an considerable increase compared to 2020, and is well above the time-series mean (Figure 15.2.8). The index is record high and is similar to the values in 2010–2013, 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 and 2021 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). In 2021, the overall index is at its lowest, caused by decreasing numbers of 5 and 6 year olds. Similar to 1B and 1D, however the number of 2 year olds increased to the highest level seen. 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 2021 46 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. In 2021 catch rates are still low.

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). Since 2016 catches have remained stable at a low level in the survey in Disko Bay. No survey was performed in 2021.

More details on inshore survey results can be found in Retzel (2022b).

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 Year classes 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 year classes revealed that in the Sisimiut area older year classes 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 5773 cod have been tagged inshore in West Greenland from 2003–2021, 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 2023.

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 2021 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 2022 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-WestInsNWWG2022, Buch *et al.*, 2022a).

The forecasts from the different scenarios are presented in Table 15.7.3. Fishing at F_{MSY} in 2023 will result in catches of 4590 t and a spawning stock biomass increase with 20% in 2024. Recently the catches have been above the ICES advice, and an F status quo will result in catches of 9913 t, but at the same time a decrease in the spawning stock biomass of 9% in 2024.

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 -0.166, 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 -0.024 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 spawningstock 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 2023

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 et al. 2022, Buch *et al.*, 2022b, Retzel, 2022a, Retzel, 2022c).

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.*, 2022b). 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.

15.18 References

Buch, T., Riget, F., Retzel, A., 2022a. A SAM assessment of the West Greenland Inshore cod stock (cod 21.1). ICES North Western Working Group (NWWG) Mai 2-7, 2022, WD 04.

Buch, T.B., Retzel, A., Riget, F., Jansen, T., Boje, J., Berg, C. 2022b. DNA split of Atlantic cod (*Gadus morhua*) stocks in Greenland waters. An Overview of data. ICES North Western Working Group (NWWG) May 2-7, 2022, WD 13.

Christensen, H.T., Rigét, F., Retzel, A., Nielsen, E.H., Nielsen, E.E., Hedeholm, R.B. 2022. Year-round genetic monitoring of mixed stocks in an Atlantic cod (*Gadus morhua*) fishery; implications for management. ICES Journal of Marine Science. 0, 1-15. DOI: 10.1093/icesjms/fsac076

Hansen, P.M. 1949. Studies on the biology of the cod in Greenland waters. B. Luno.

Horsted, S.A. 2000. A review of the cod fisheries at Greenland, 1910-1995. J.Northw.Atl.Fish.Sci. 28: 1-112.

Hurtado-Ferro, F., Szuwalski, C. S., Valero, J. L., Anderson, S. C., Cunningham, C. J., Johnson, K. F., Licandeo, R., McGilliard, C. R., Monnahan, C. C., Muradian, M. L., Ono, K., Vert-Pre, K. A., Whitten, A. R., and Punt, A. E. 2015 Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. ICES J. Mar. Sci., 72: 99–110.

ICES, 2007. Cod Stocks in the Greenland Area (NAFO Area 1 and ICES subdivision 14B). North Western Working Group (NWWG) report.

ICES. 2018. Report of the InterBenchmark Protocol on Greenland Cod (IBPGCod). ICES IBPGCod Report 2018 8–9 January 2018. Copenhagen, Denmark. ICES CM 2018/ ACOM:30. 205 pp.

Nielsen A, Berg CW. 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research. 158: 96-101.

Retzel, A. and Hedeholm, R. 2012. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2011. ICES North Western Working Group, 26 April-3 May 2012, Working Doc. 22

Retzel, A. 2022a. Greenland commercial data for Atlantic cod in Greenland inshore waters for 2021. ICES North Western Working Group (NWWG) Mai 2-7, 2022, WD 02.

Retzel, A. 2022b. Greenland inshore survey results for Atlantic cod in 2021. ICES North Western Working Group (NWWG) Mai 2-7, 2022, WD 03.

Statistics Greenland. http://www.stat.gl/dialog/topmain.asp?lang=da&subject=Fiskeri og fangst&sc=FI

Storr-Paulsen M., Wieland K., Hovgård H. and Rätz H.-J. (2004) Stock structure of Atlantic cod (Gadus morhua) in West Greenland: implications of transport and migra-tion. ICES Journal of Marine Science 61: 972-982.

Therkildsen, N.O., Hemmer-Hansen, J., Hedeholm, R.B., Wisz, M.S., Pampoulie, C., Meldrup, D., Bonanomi, S., Retzel, A., Olsen, S.M., Nielsen, E.E. 2013. Spatiotemporal SNP analysis reveal pronounced biocomplexity at the northern renge margin of At-lantic cod Gadus morhua. Evoltutionary Applications. DOI 10.1111/eva. 12055.

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
2021	1133	2910	4144	4671	93	629		13580	286

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	0.3%	0.01%	0.4%	1%	11%	22%	16%	6%	2%	1%	0.4%	1%	62%
Gillnet	0.5%	0.3%	1%	1%	0.3%	0.1%	0.2%	0.02%	0.3%	1%	2%	1%	7%
Jig	0.2%	0.3%	0.3%	0.1%	0.3%	1%	2%	2%	2%	3%	1%	0.2%	13%
Longline	3%	2%	1%	0.5%	1%	0.5%	0.4%	0.5%	1%	3%	3%	2%	18%
Total	4%	2%	3%	3%	12%	23%	19%	9%	6%	7%	6%	5%	

Gear/NAFO	1AUM	1AUP	1AX	1B	1C	1D	1E	1F	Total	14b
Poundnet	1%		1%	16%	21%	21%	0.4%	3%	62%	
Gillnet	0.1%		2%	4%	0.2%	1%	0.1%	0.4%	7%	
Jig	0.04%	0.3%	2%	1%	5%	3%	0.1%	1%	13%	1%
Longline	1%	0.1%	1%	0.1%	5%	10%	0.04%	1%	18%	99%
Total	2%	0.3%	6%	21%	31%	34%	1%	5%		

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	38	9	3	3	25	12	5	51	123	19	5	4	**297**	2%
1AUP			0.1	2	2	5	1	14	9	11	0.1		**44**	0.3%
1AX	24	36	42	33	27	42	148	121	124	82	97	16	**792**	6%
1B	49	4	28	91	228	779	869	131	111	152	183	284	**2910**	21%
1C	128	74	26	7	633	1009	819	412	161	390	360	124	**4144**	31%
1D	289	202	275	198	582	1127	630	446	272	276	192	183	**4671**	34%
1E	0.5	0.2	1	1	1	11	18	16	27	10	6	1	**93**	1%
1F	5	2	2	53	183	168	47	26	35	67	31	10	**629**	5%
Total	**533**	**328**	**376**	**388**	**1680**	**3154**	**2538**	**1218**	**861**	**1007**	**875**	**622**	**13580**	
%	4%	2%	3%	3%	12%	23%	19%	9%	6%	7%	6%	5%		
ICES 14b						0		61	83	93	49		**286**	

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
2021	3	1410	3775	1988	1334	222	133	27	13580

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
2021	-	54	51	53	-	158

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

Year	Age								All
	1	2	3	4	5	6	7	8+	
2001	na	na	na	na	na	na	na	na	na
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
2021	2	261	74	26	30	2	2	0	397

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
2021	0	46	20	119	68	43	19	3	318

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

Year	Age NAFO 1F								All
	1	2	3	4	5	6	7	8+	
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
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
2010–2021	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
2020-2021	na	na	na	na	na	na	na	na	Na

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
2021	0	55	23	17	6	1	2	0	104

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
2021		1.8	1.2	1.9	4.2	1.5	2.9	1.0	2.3	0.4	17.2

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. No trawl survey in 2021.

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
2021	-	-	-	-	-	-	-	-	-	-	-	-

Table 15.3.1. Number of tagged cod in the period of 2003 to 2021 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
2021	131			1084

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)	562	3	29	8
Bank (West) NAFO 1C, Tovqussaq		1		4
Bank (West) NAFO 1D+1E, Dana		2	69	
East Greenland			36	124
Iceland	3		47	197

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	$B_{lim} \times e^{1.645\sigma}$, σ = 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	14554	12654	62138	3690	1944	422	65	277	63	29
1977	21442	11359	10360	47937	2253	966	149	19	179	54
1978	39305	17087	8865	7874	31350	1010	359	39	10	115
1979	17135	38432	13617	7439	4779	15657	494	143	20	63
1980	36164	11544	37579	10779	4435	2055	7171	217	68	45
1981	15837	35962	7777	30947	5578	1963	858	2420	108	50
1982	8185	12703	35761	5657	15510	1848	841	269	843	73
1983	3044	6979	10190	30955	2569	5897	510	253	106	247
1984	8117	1953	5952	8173	14999	868	1883	112	110	108
1985	35014	6263	1253	4365	3465	5740	285	621	49	97
1986	24564	35883	4831	953	1630	1349	2143	88	290	58
1987	12732	20878	36773	3314	432	495	472	875	43	130
1988	16954	9930	19053	31023	1119	157	90	171	393	43
1989	8581	15644	8049	16546	14806	399	47	22	83	134
1990	4462	7937	12970	7011	8767	4162	88	15	11	53
1991	12937	2954	6795	9844	3214	2069	434	29	7	19

Year / Age	1	2	3	4	5	6	7	8	9	10
1992	4620	9707	2398	4829	3362	503	241	85	14	8
1993	2209	3648	6688	1934	1353	320	66	68	24	7
1994	2782	1605	2991	4500	693	100	50	18	26	8
1995	1859	2229	1183	2366	1575	90	20	13	7	13
1996	2488	1297	1502	971	1035	239	30	7	5	9
1997	3304	2039	863	1113	471	232	89	11	3	7
1998	3101	2448	1672	687	480	72	108	37	5	5
1999	4477	2340	1797	1322	291	33	39	49	20	5
2000	6382	3672	1767	1256	610	38	19	18	28	12
2001	7812	5324	3327	1697	626	103	22	9	11	20
2002	9932	6366	4442	2945	1002	130	54	11	6	16
2003	10254	7042	4628	3130	1376	252	60	28	8	10
2004	24124	8734	5078	3363	1376	293	98	23	17	7
2005	37563	19491	7181	3465	1280	260	105	39	13	10
2006	27236	30112	15956	5406	1153	202	89	43	22	10
2007	15189	22851	22936	10972	1710	205	83	33	24	15
2008	22106	11068	18772	16646	3916	314	73	35	16	19
2009	21517	18949	9233	14107	7012	686	97	31	22	18
2010	39687	16179	15614	7353	6826	1559	228	50	19	21
2011	34967	35136	11483	11559	4293	1802	417	100	26	16
2012	24730	27687	29365	9807	6739	1399	487	162	43	17
2013	18950	22410	21538	22289	7030	2650	424	197	83	21
2014	19494	16079	18569	17104	13394	3394	888	144	81	36
2015	15474	16888	14081	17563	13425	6389	1428	324	42	29
2016	10375	14901	15425	13564	14264	7356	2431	528	120	22
2017	11606	8234	14670	13709	11322	7576	3100	813	202	51
2018	13572	11008	8287	13871	10048	6101	2912	958	256	79
2019	9732	13944	11600	8418	11327	5182	2390	815	258	87
2020	15978	7192	14136	10871	6657	5766	1741	689	202	84

Year / Age	1	2	3	4	5	6	7	8	9	10
2021	9146	15122	5556	12111	8596	3368	1985	450	182	60

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	0.281	0.53	0.812	1.029	0.326	0.419	0.419
1977			0.035	0.274	0.567	0.749	1.034	0.391	0.511	0.511
1978			0.032	0.304	0.568	0.605	0.791	0.447	0.494	0.494
1979			0.034	0.362	0.633	0.632	0.751	0.541	0.496	0.496
1980			0.039	0.435	0.681	0.677	0.88	0.607	0.619	0.619
1981			0.035	0.496	0.815	0.743	0.96	0.748	0.708	0.708
1982			0.038	0.54	0.796	0.954	1.046	0.715	0.967	0.967
1983			0.035	0.585	0.831	0.94	1.174	0.651	0.871	0.871
1984			0.034	0.648	0.799	0.895	0.967	0.588	0.693	0.693
1985			0.027	0.688	0.791	0.858	0.93	0.578	0.752	0.752
1986			0.03	0.635	0.893	0.952	0.815	0.546	0.855	0.855
1987			0.028	0.691	0.865	1.327	0.889	0.598	1.107	1.107
1988			0.019	0.63	0.902	1.141	1.046	0.559	1.023	1.023
1989			0.012	0.602	1.129	1.346	0.982	0.52	1.157	1.157
1990			0.011	0.669	1.325	1.795	0.97	0.602	1.012	1.012
1991			0.01	0.825	1.676	1.96	1.141	0.648	0.967	0.967
1992			0.007	0.904	2.105	1.814	1.084	0.759	0.953	0.953
1993			0.006	0.802	2.325	1.624	1.067	0.747	0.919	0.919
1994			0.005	0.755	1.867	1.349	1.056	0.706	0.692	0.692
1995			0.004	0.638	1.678	0.955	0.871	0.673	0.617	0.617
1996			0.004	0.555	1.43	0.77	0.798	0.587	0.551	0.551
1997			0.005	0.581	1.702	0.597	0.687	0.507	0.543	0.543
1998			0.008	0.574	2.278	0.447	0.62	0.439	0.536	0.536
1999			0.012	0.54	1.84	0.34	0.578	0.382	0.53	0.53

Year Age	1	2	3	4	5	6	7	8	9	10
2000			0.014	0.502	1.577	0.37	0.55	0.34	0.53	0.53
2001			0.024	0.501	1.377	0.444	0.535	0.305	0.55	0.55
2002			0.039	0.581	1.222	0.531	0.545	0.278	0.606	0.606
2003			0.051	0.632	1.378	0.697	0.679	0.317	0.732	0.732
2004			0.071	0.766	1.474	0.779	0.688	0.314	0.666	0.666
2005			0.087	0.882	1.571	0.79	0.693	0.337	0.603	0.603
2006			0.089	0.866	1.529	0.71	0.715	0.358	0.562	0.562
2007			0.072	0.778	1.53	0.827	0.667	0.377	0.508	0.508
2008			0.054	0.588	1.484	0.943	0.627	0.35	0.484	0.484
2009			0.039	0.444	1.254	0.957	0.563	0.362	0.536	0.536
2010			0.026	0.339	1.074	1.118	0.644	0.47	0.711	0.711
2011			0.018	0.29	0.903	1.118	0.717	0.563	0.74	0.74
2012			0.013	0.235	0.735	0.998	0.742	0.559	0.824	0.824
2013			0.008	0.201	0.6	0.869	0.834	0.71	0.914	0.914
2014			0.005	0.165	0.555	0.788	0.82	0.89	1.103	1.103
2015			0.004	0.152	0.514	0.765	0.855	0.828	0.936	0.936
2016			0.003	0.15	0.515	0.756	0.908	0.836	0.893	0.893
2017			0.003	0.147	0.505	0.776	0.997	0.958	1.015	1.015
2018			0.003	0.152	0.51	0.798	1.063	1.094	1.142	1.142
2019			0.003	0.158	0.519	0.855	1.077	1.163	1.218	1.218
2020			0.003	0.154	0.525	0.874	1.127	1.139	1.317	1.317
2021			0.002	0.15	0.514	0.862	1.136	1.111	1.278	1.278

Table 15.7.3: Cod in NAFO Subarea 1, inshore. Catch scenarios for 2023 assuming $F_{2021} = F_{2022}$. All weights are in tonnes.

Rationale	Catch (2023)	F (2023)	SSB (2024)	% SSB change *	% advice change **	% TAC change ***
ICES advice basis						
MSY approach: F_{MSY}	4590	0.268	24 549	+20%	-4%	-78%
Other scenarios						
F = 0	0	0	30 348	+49%	-100%	-100%
$F = F_{2020}$ (*status quo*)	9913	0.755	18 549	-9%	+107%	-53%
$SSB_{2022} = B_{lim}$	25408	12.992	4346	-79%	+410%	+21%
$SSB_{2022} = B_{pa} =$ MSY $B_{trigger}$	23195	6.959	5983	-71%	+364%	+10%

*** SSB2024 relative to SSB2023.**
**** Advice value for 2023 relative to the advice value for 2022, from this updated assessment.**
***** Advice value for 2023 relative to the TAC in 2022, from this updated assessment.**

15.20 Figures

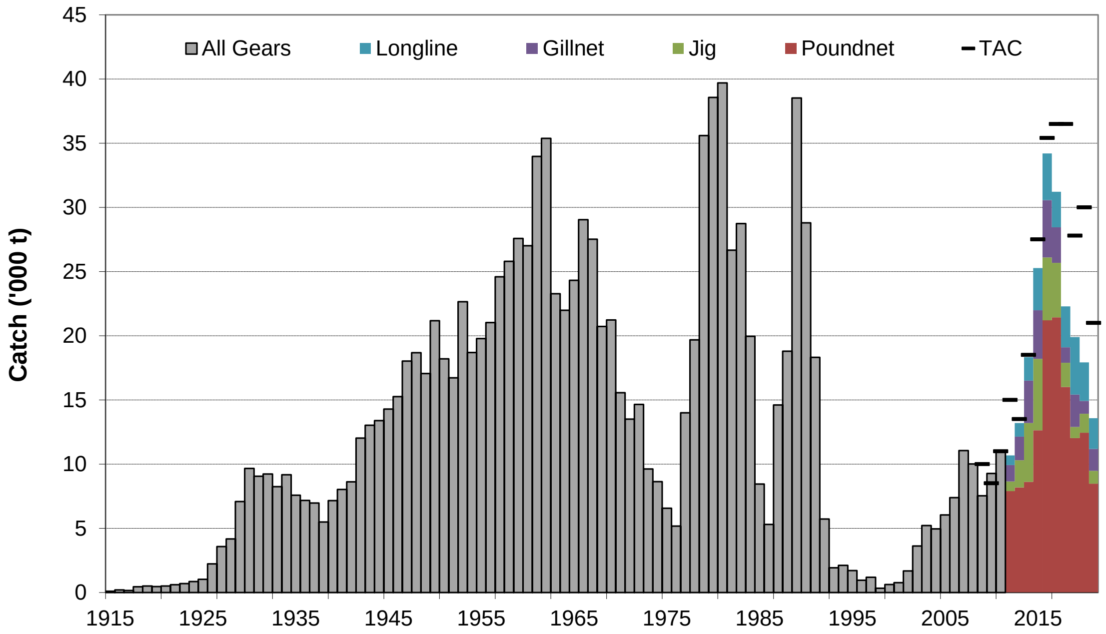


Figure 15.2.1 Inshore landings from West Greenland (Horsted, 1994; 2000). From 2012 divided into gears.

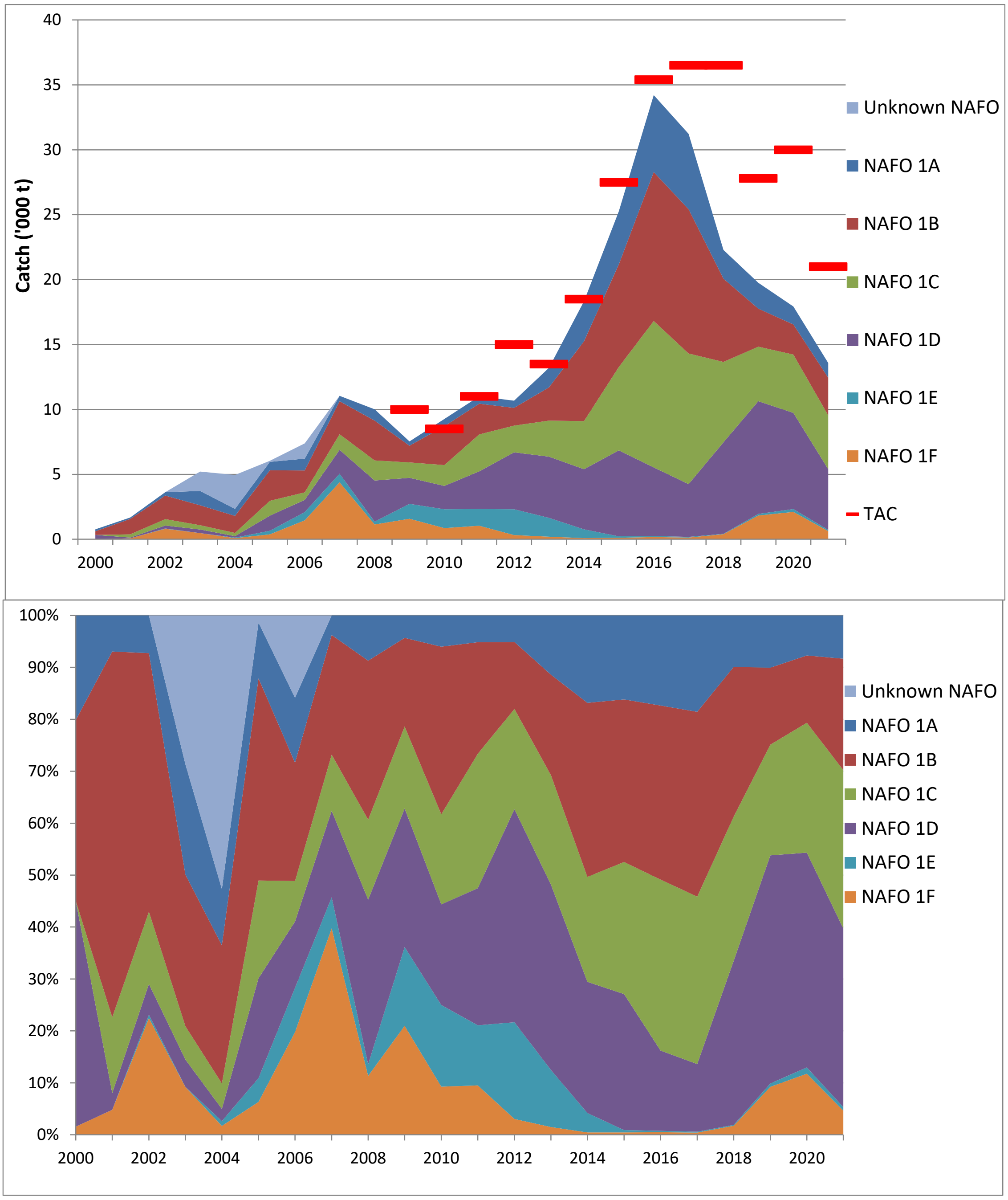


Figure 15.2.2. Total (top) and percentage (bottom) cod catches and TAC in the inshore fishery by NAFO divisions from 2000.

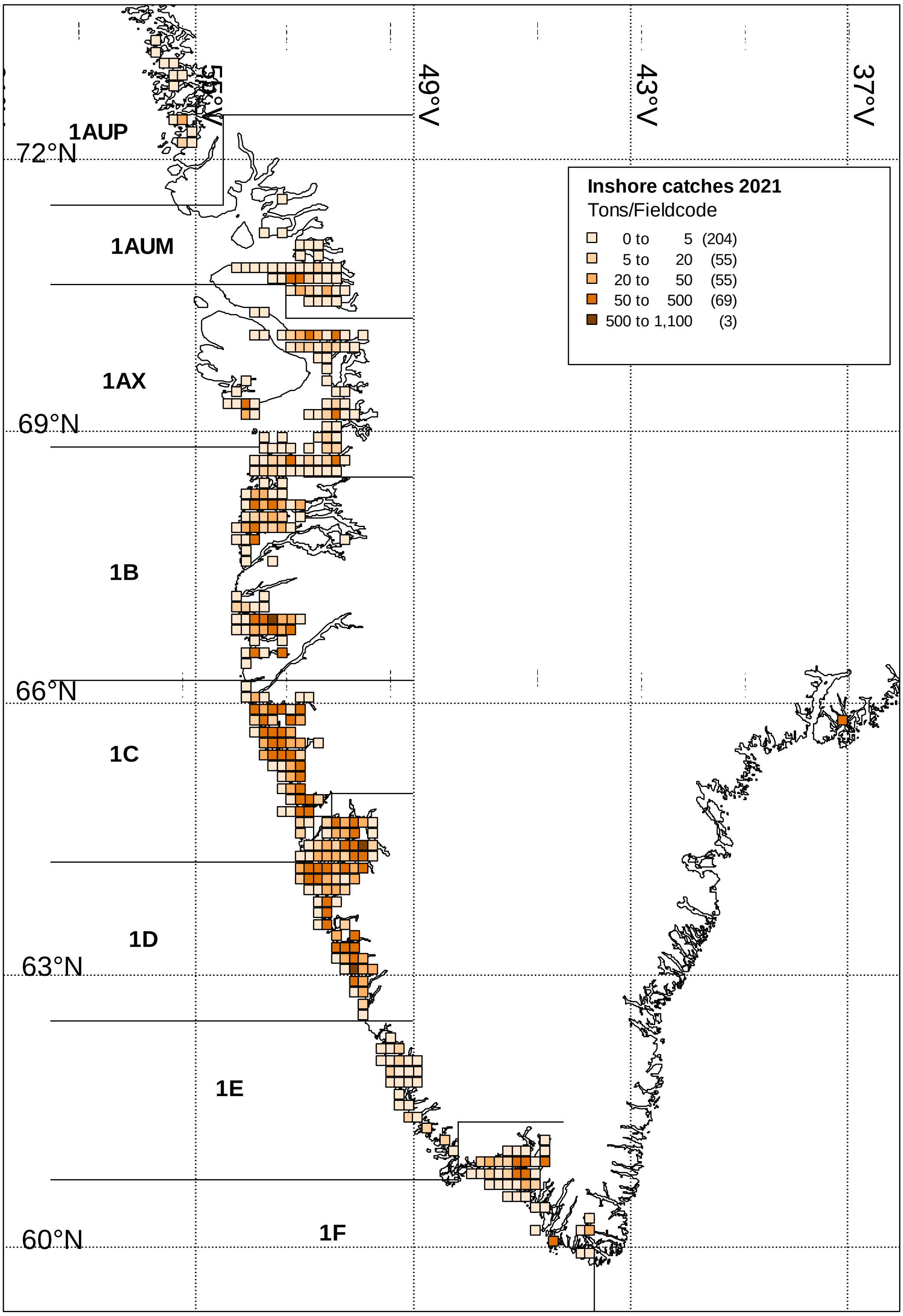


Figure 15.2.3. Distribution of commercial fishery along the coastline of West Greenland in total tonnes by field code.

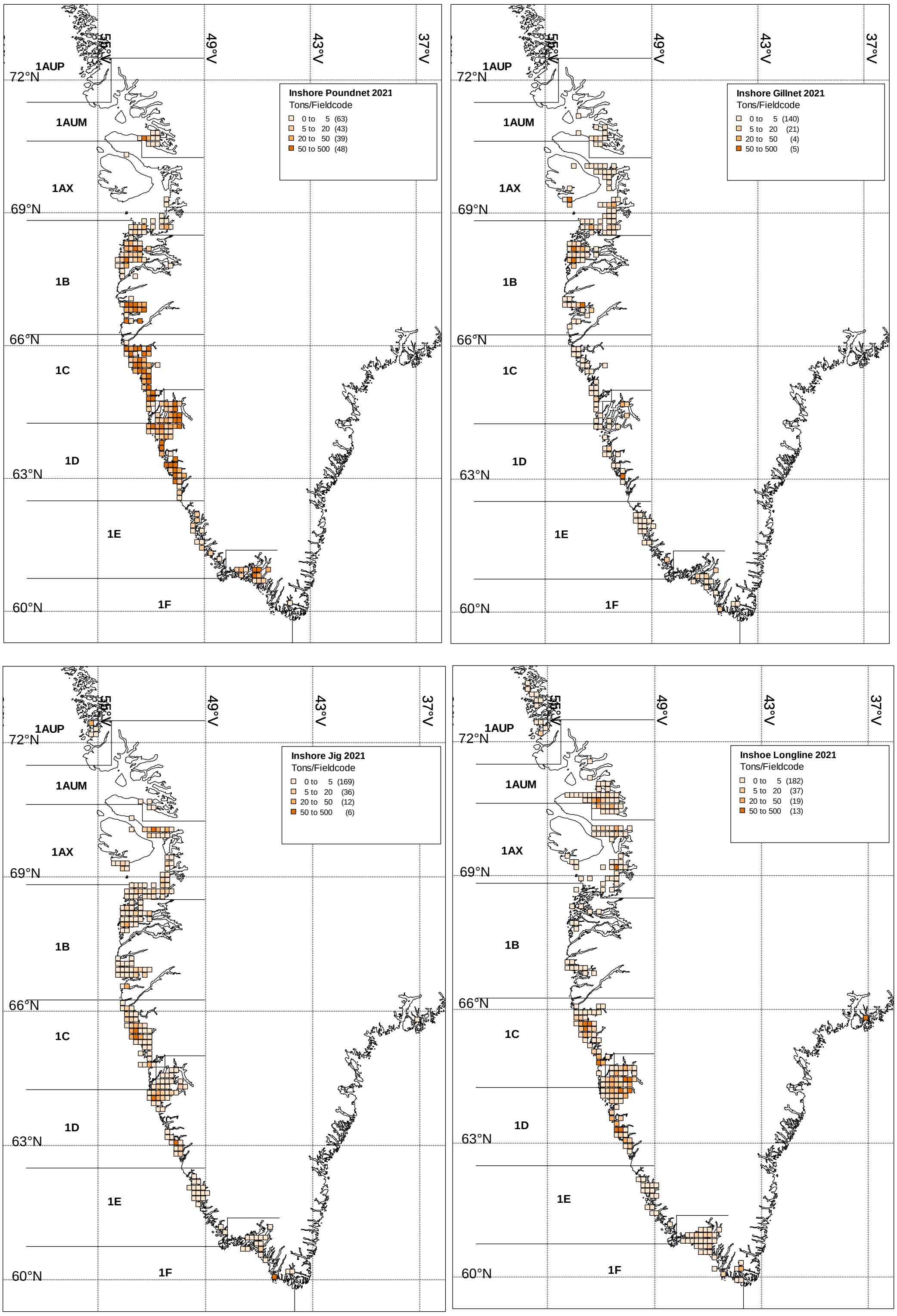


Figure 15.2.4 Distribution of the inshore commercial fishery by gear (tonnes/fieldcode).

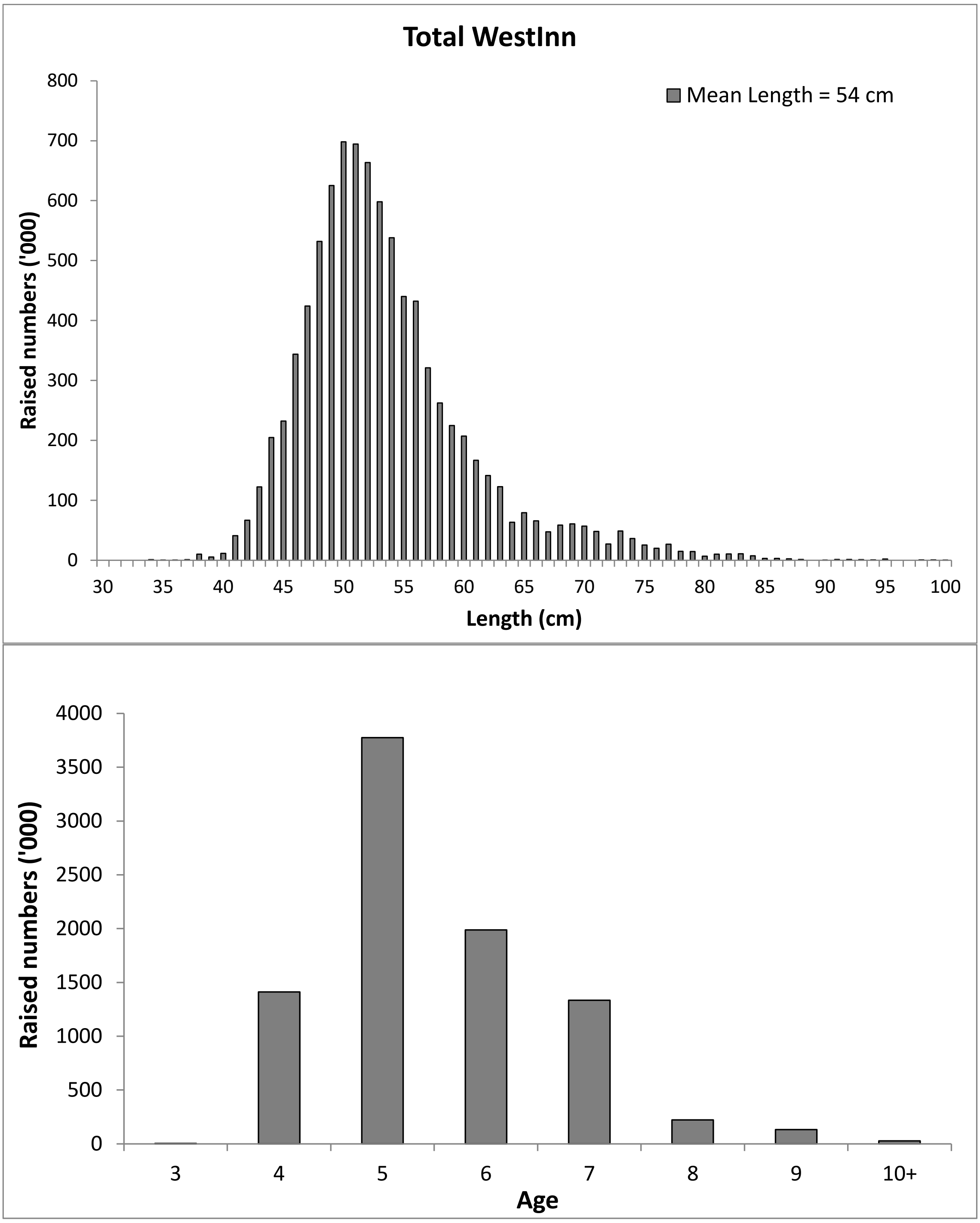


Figure 15.2.5. Total length and age distributions of inshore cod catches.

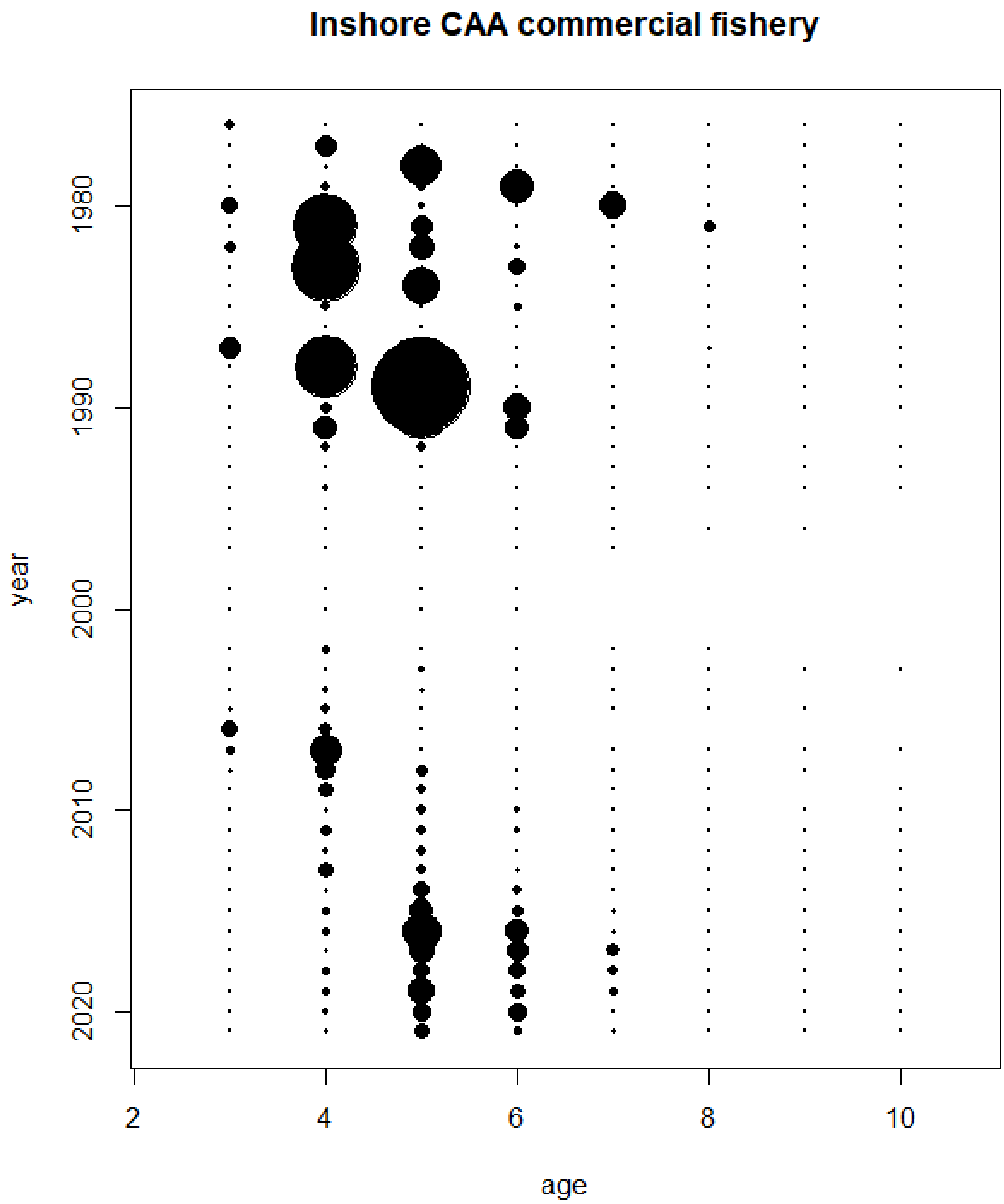


Figure 15.2.6. Catch-at-age in the commercial fishery in the West Greenland inshore area. Size of circles represents size of catch numbers.

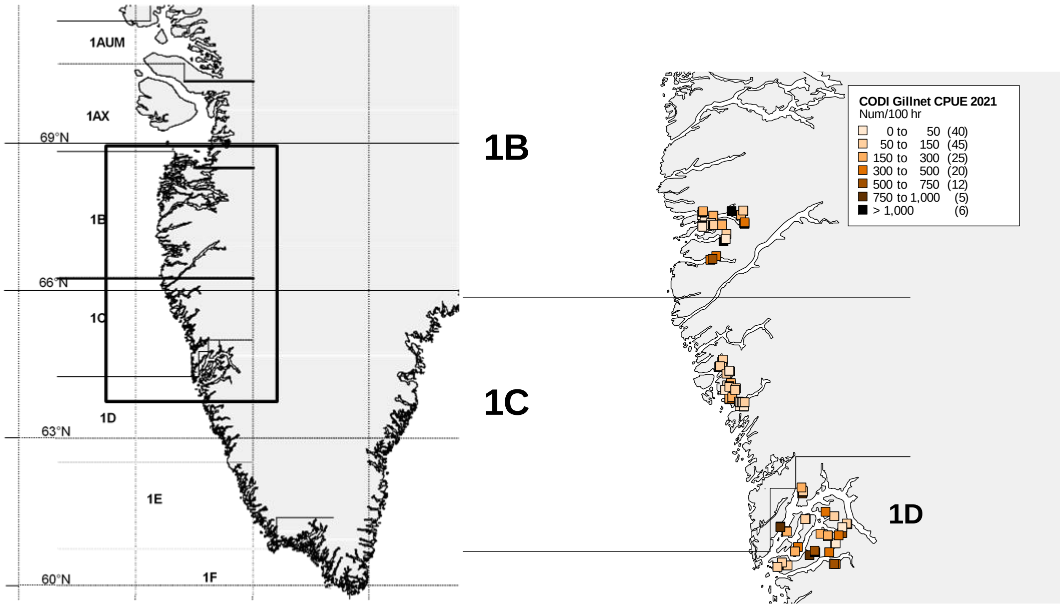


Figure 15.2.7. The inshore gill net survey area on the Greenland West coast. Survey catch rates are indicated on both as #caught/100h.

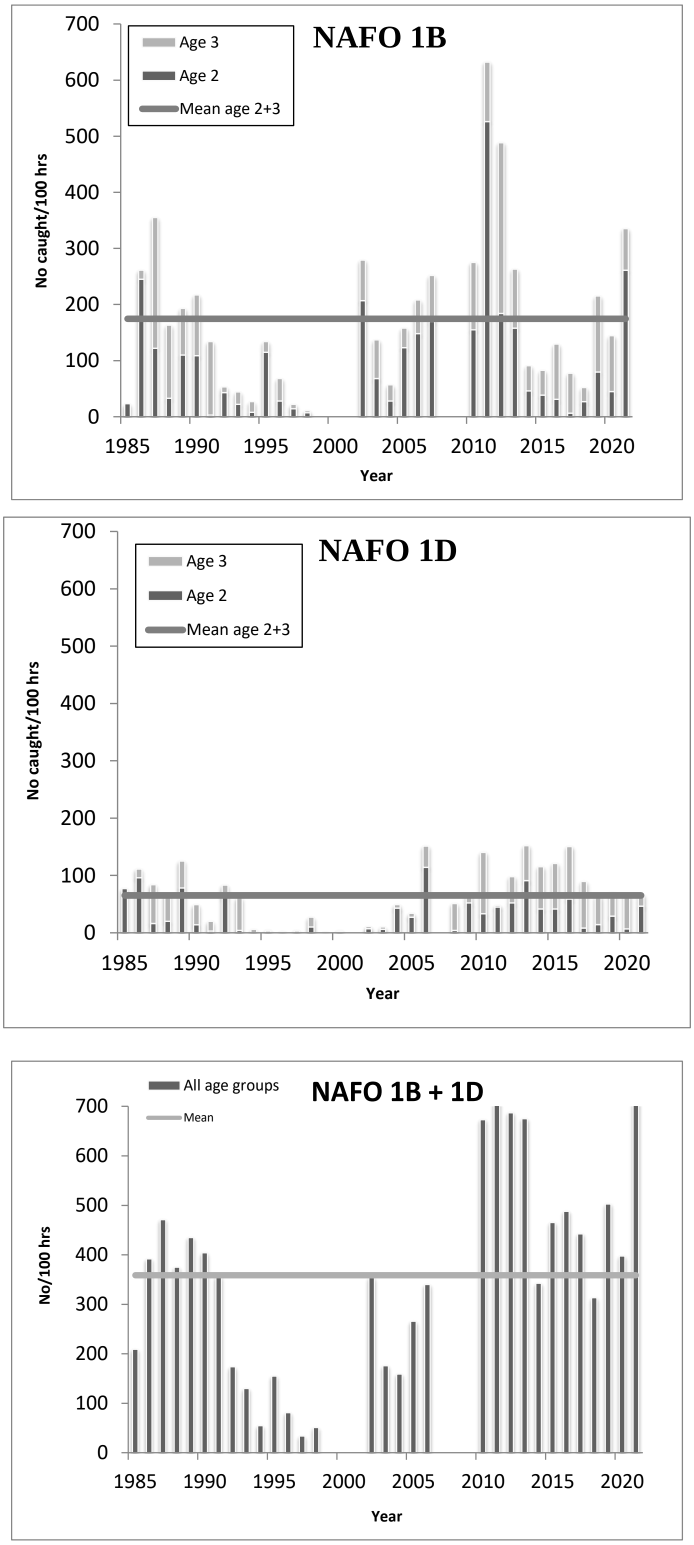


Figure 15.2.8: Recruitment indices (numbers caught/100 hr.) for ages 2 and 3 in 1B (top), 1D (middle) and all age groups (ages 1-8) 1B and 1D combined (lower) in West Greenland. Simultaneous surveys were not carried out 1999–2001 and 2007–2009.

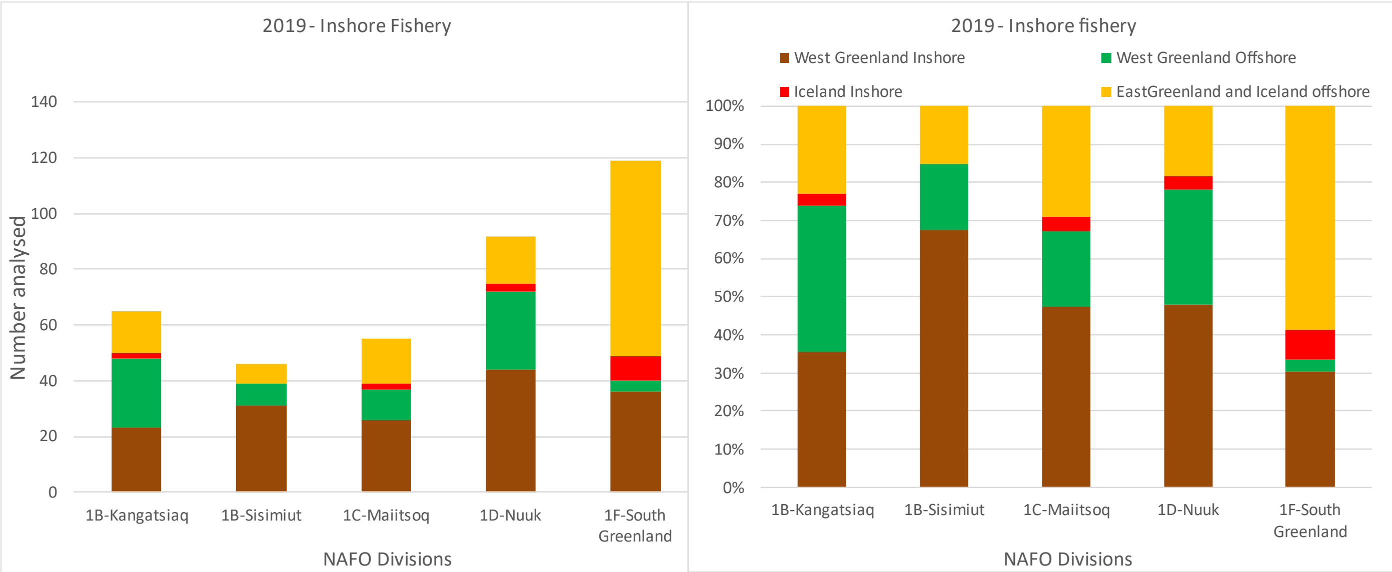


Figure 15.2.9: Genetic composition in the inshore fishery in 2019 by NAFO divisions. Left: Samples analysed, right: In percentage.

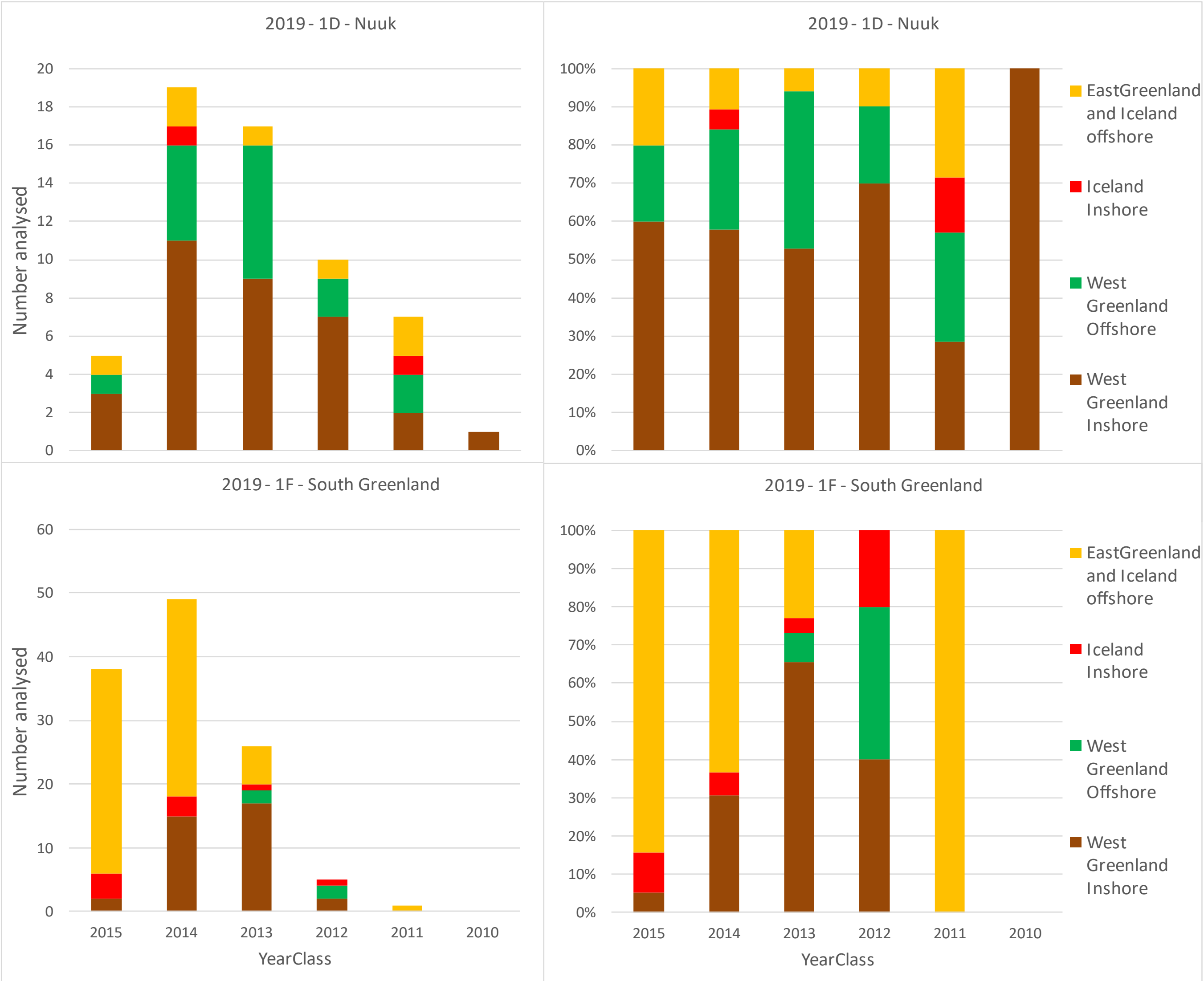


Figure 15.2.10: Genetic composition in the inshore fishery in 2019 by Year classes within NAFO division 1D and 1F. Left: Samples analysed, Right: in percentage.

Figure 15.2.11: Genetic composition in the inshore surveys by fjord systems. Left: Samples analysed, right: In percentage.

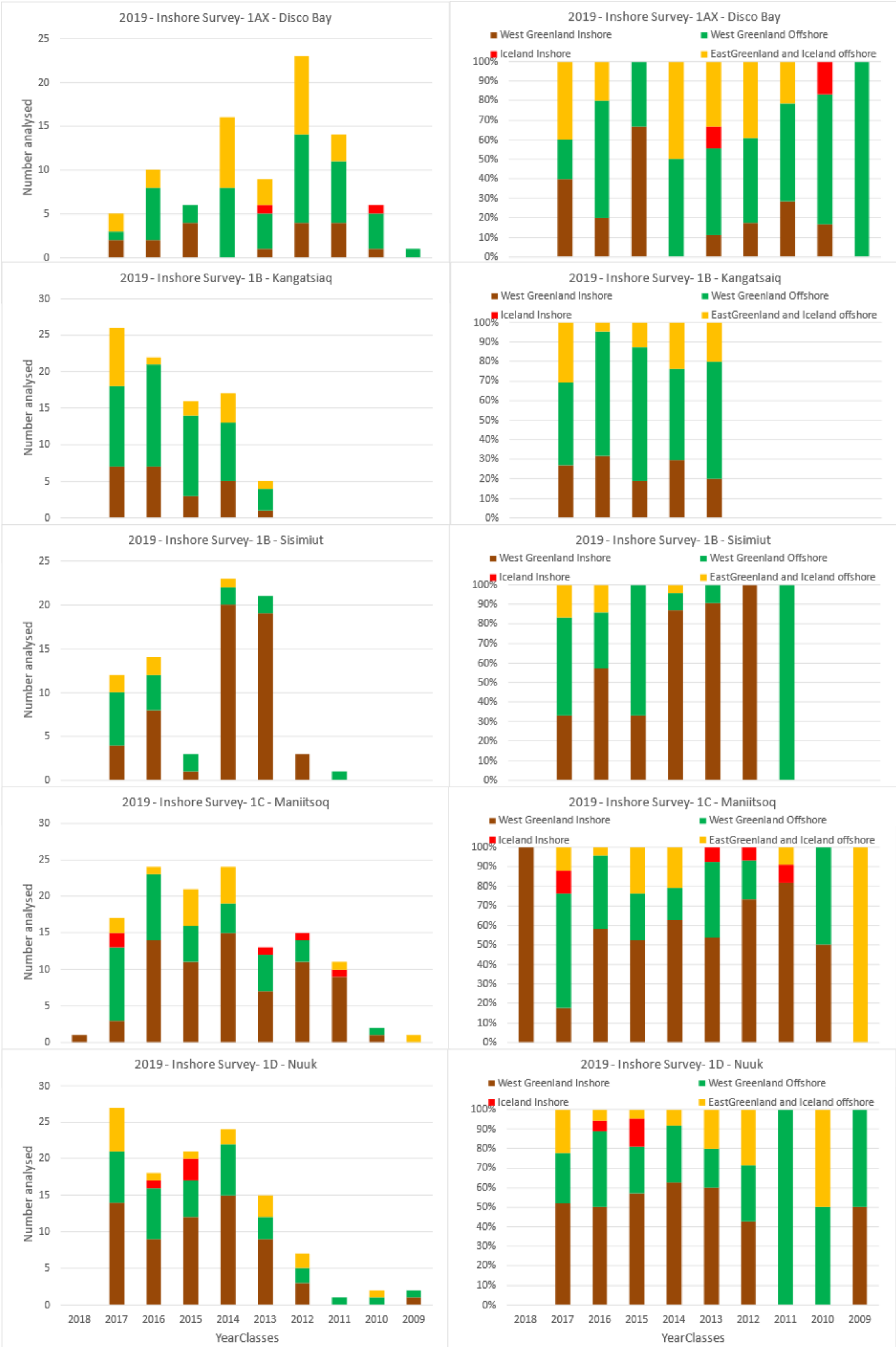


Figure 15.2.12: Genetic composition in the inshore surveys by year class and fjord systems. Left: Samples analysed, right: In percentage.

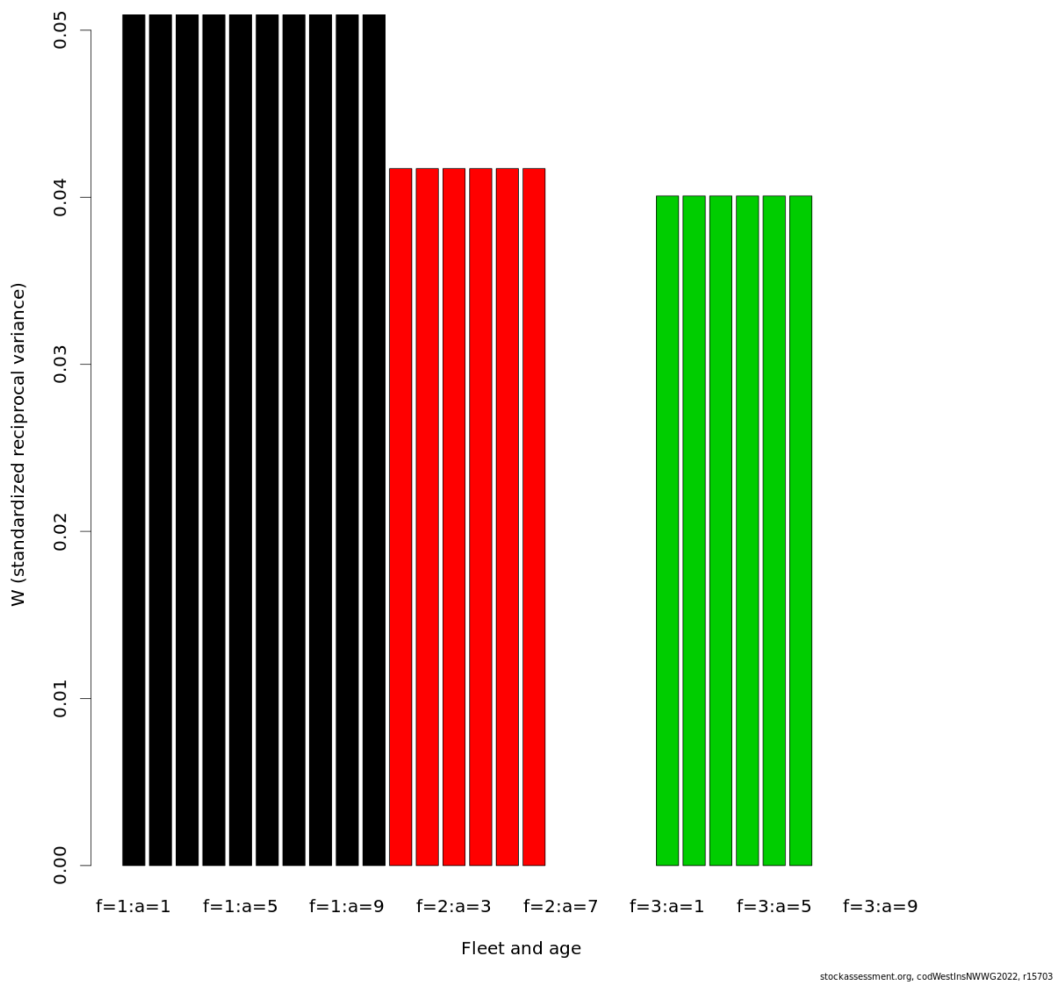


Figure 15.6.1: Standardized reciprocal variance from left to right: catches, 1B survey and 1D survey.

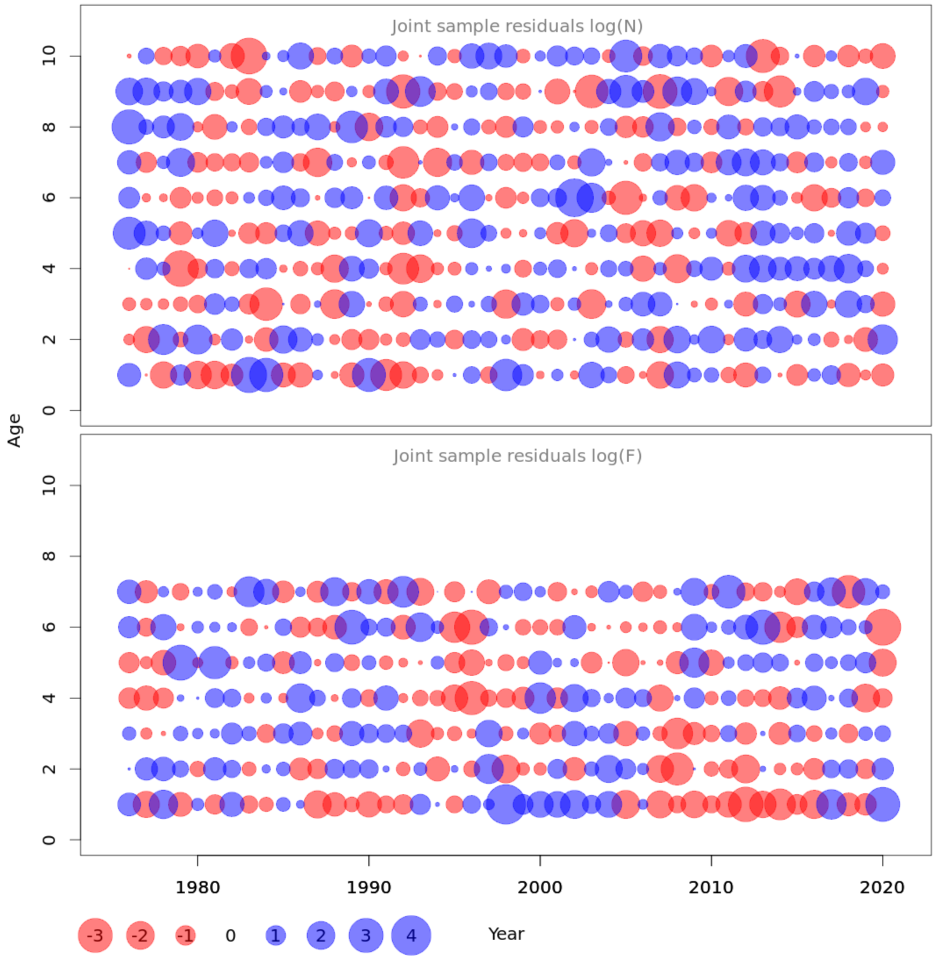


Figure 15.9.1: Normalized residuals derived from the SAM base run. Blue circles indicate positive residuals (observation larger than predicted) and filled red circles indicate negative residuals.

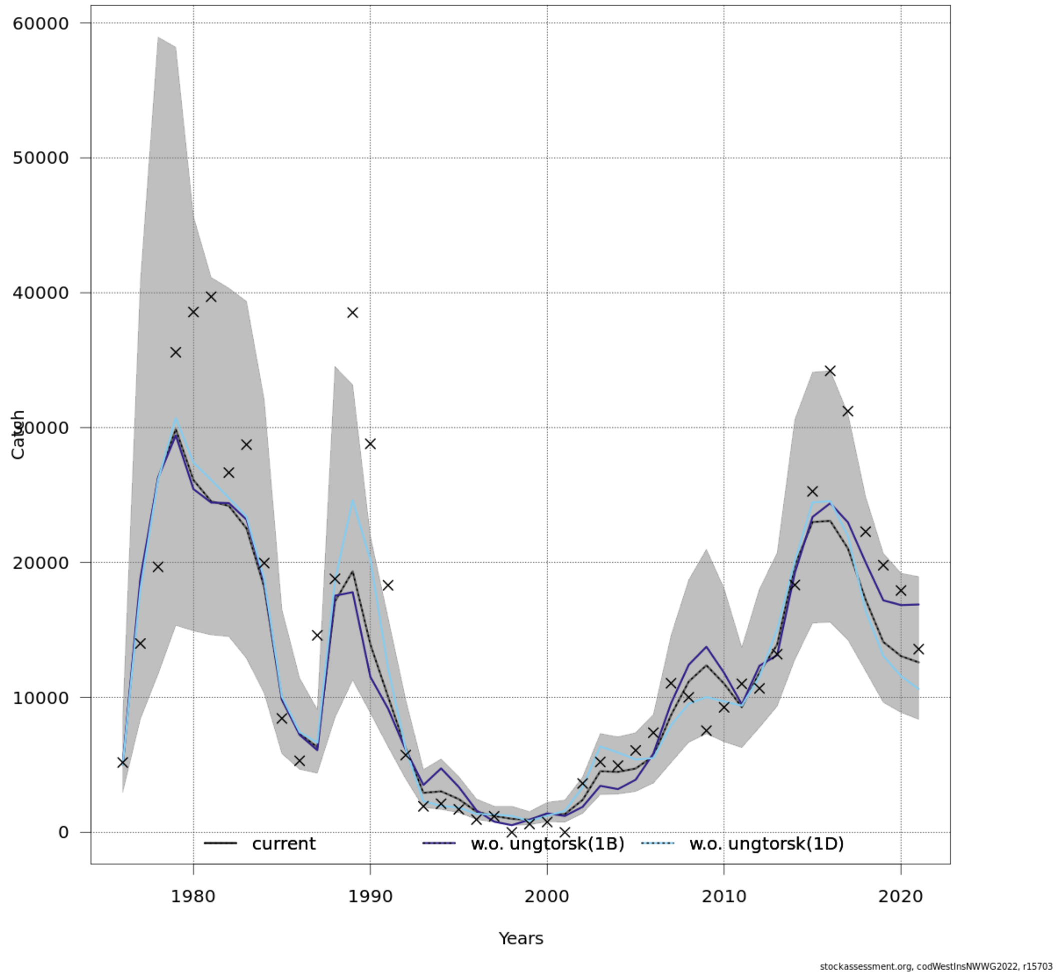


Figure 15.9.2: Estimated (line) and observed catch (x). Estimated catch is shown with 95% confidence intervals.

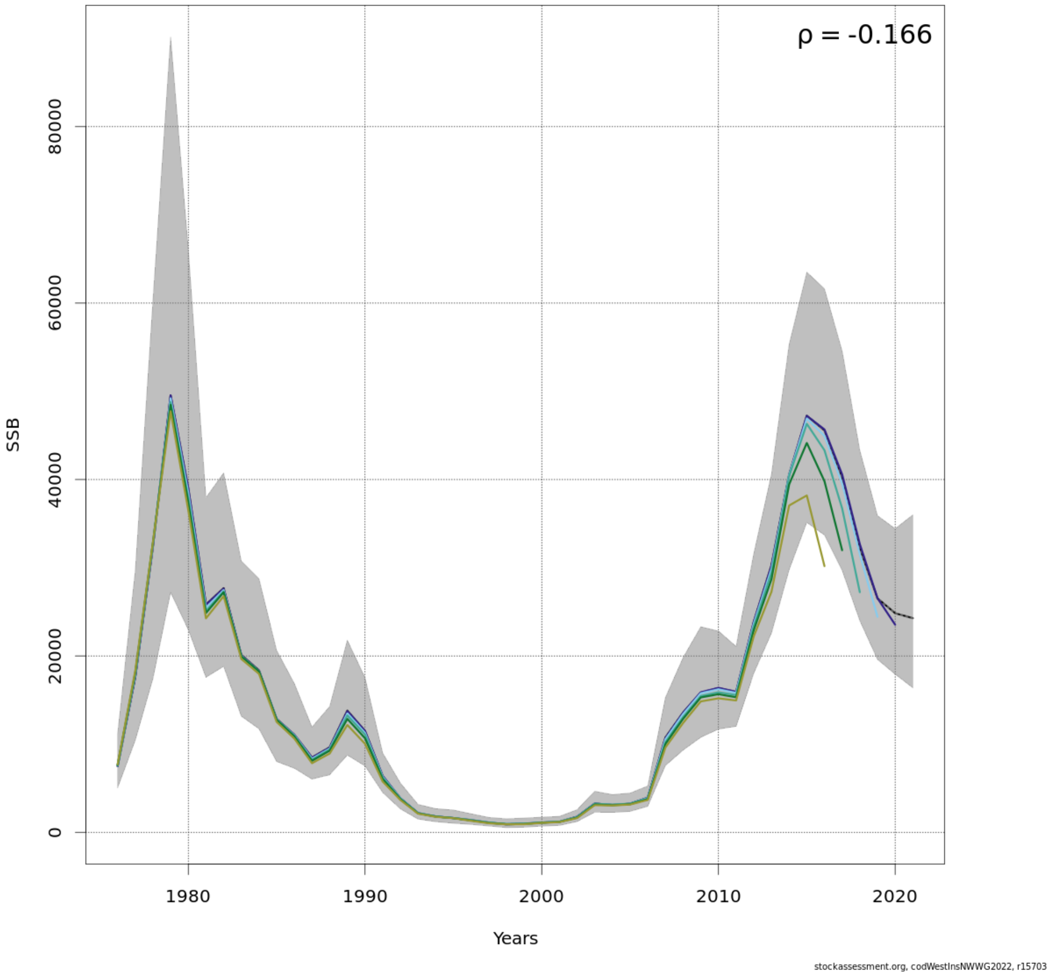


Figure 15.9.3: Analytical retrospective plots of spawning stock biomass. Mohn's rho is given in the upper right corner.

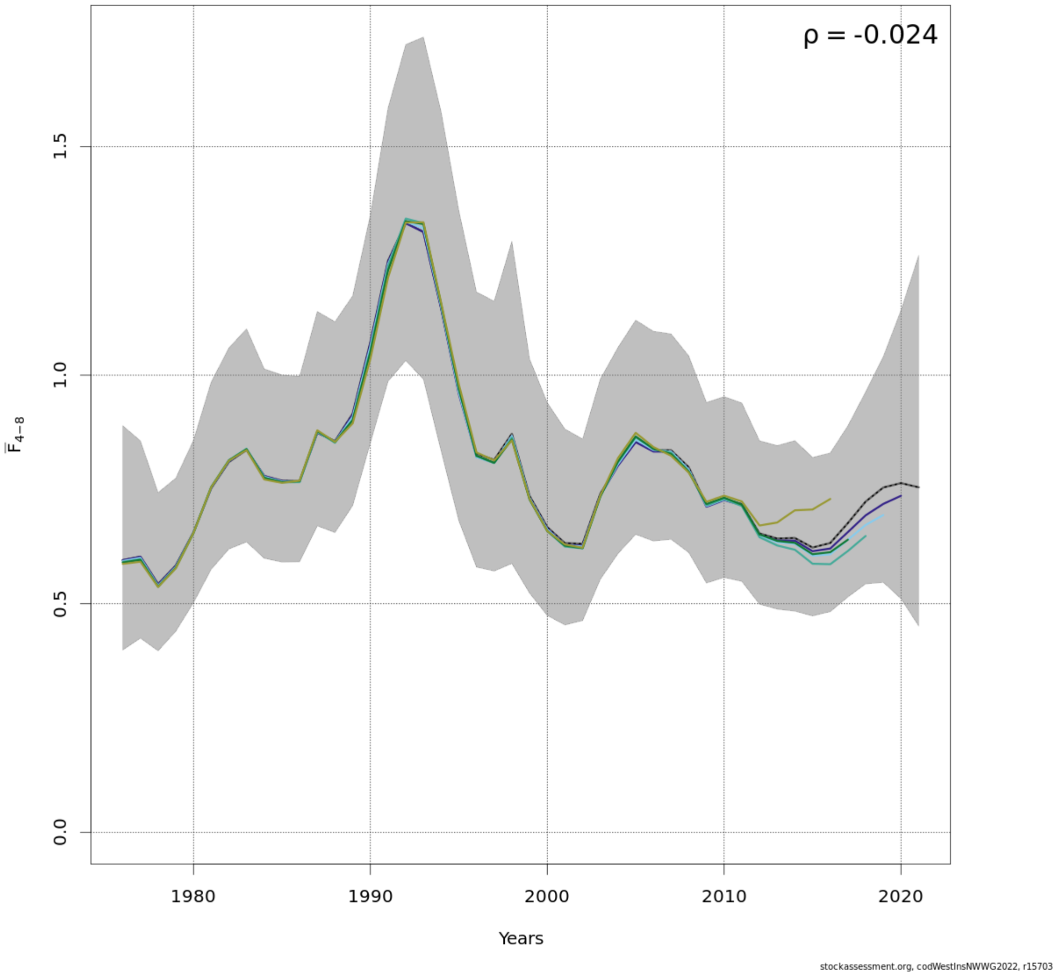


Figure 15.9.4: Analytical retrospective plots of $F_{4\text{-}8s}$. Mohn's rho is given in the upper right corner.

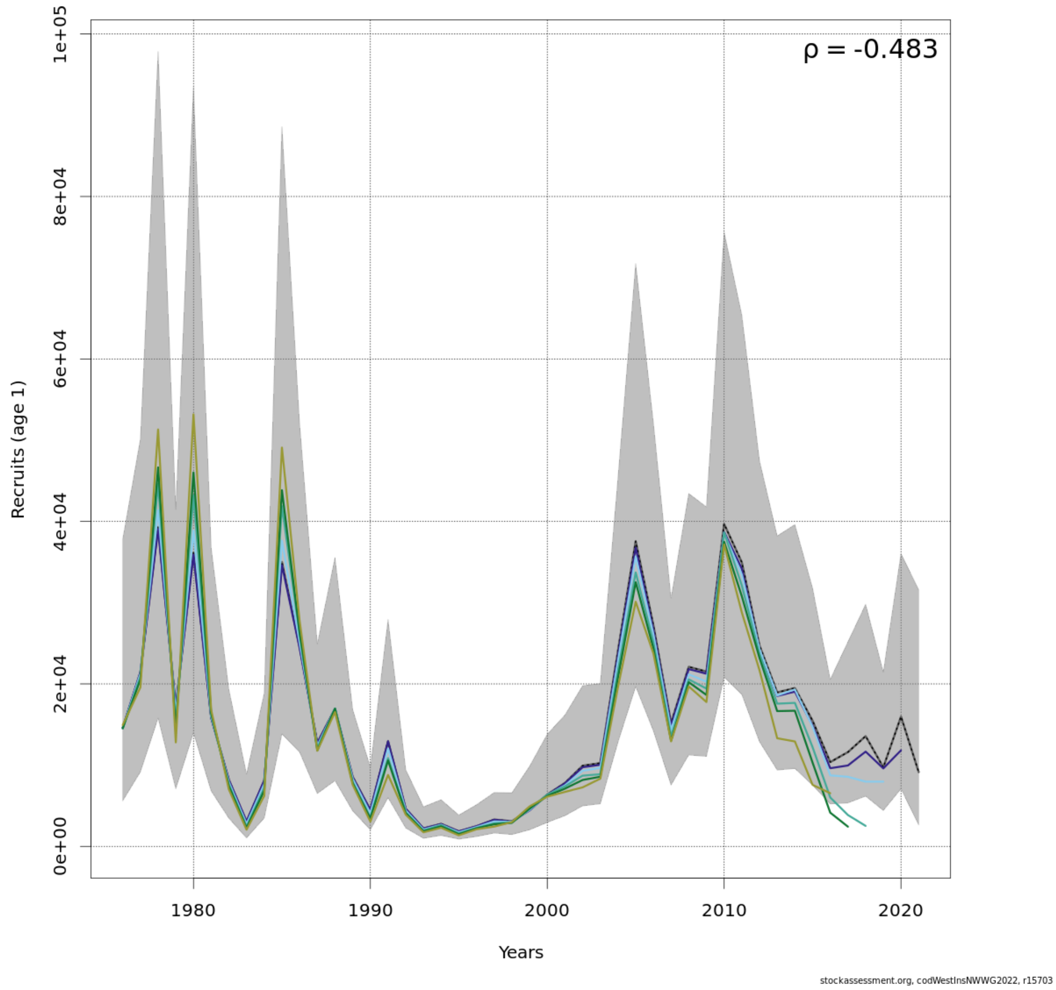


Figure 15.9.5: Analytical retrospective plots of Recruit. Mohn's rho is given in the upper right corner.

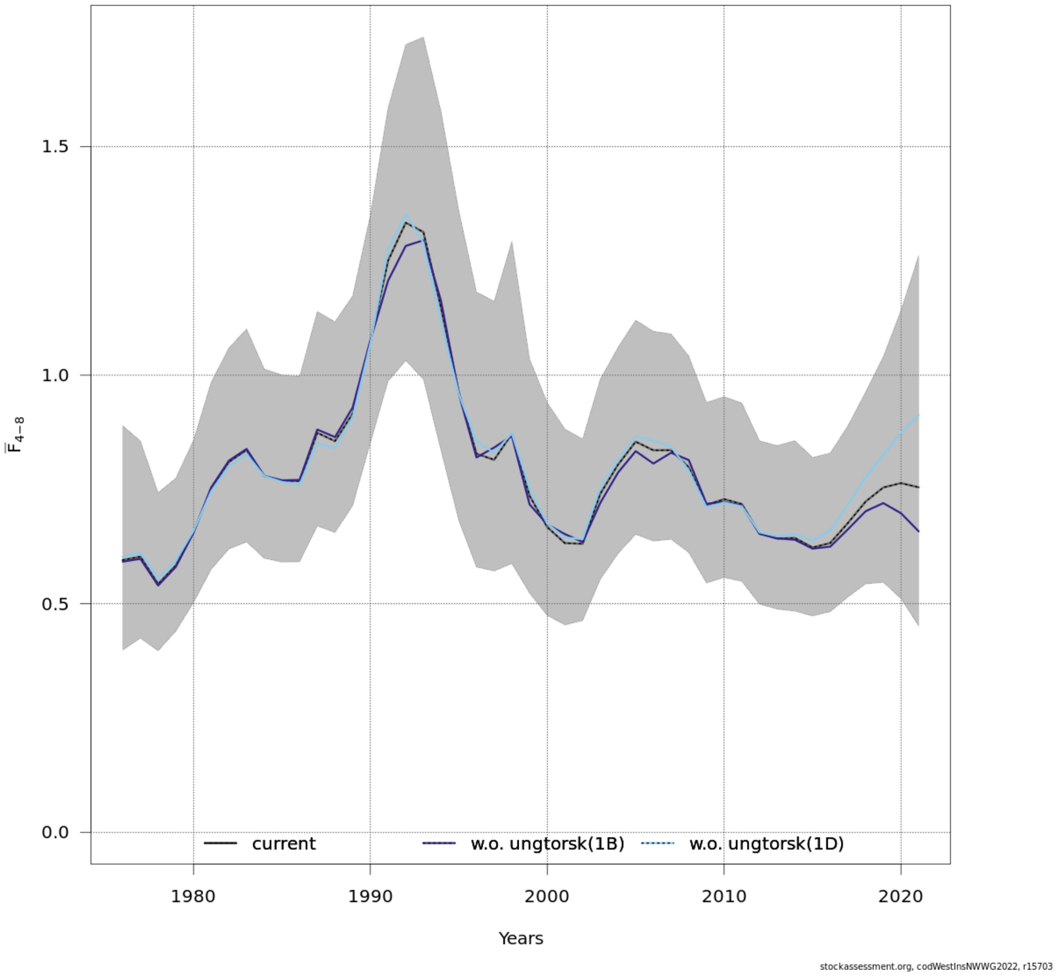


Figure 15.9.6: Leave out plot of F_{4-8}.

16 Cod (*Gadus morhua*) in ICES Subarea 14 and NAFO Division 1.F (East Greenland, South Greenland)

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 2021 was set at 26 091 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
Dohrn Bank	20 000	Greenland (17 800 t), EU (1950 t), Norway (250 t)
South and East Greenland	6091	Greenland (2691 t), Faeroes Island (2500 t), Norway (1100 t)

In 2021 a total of 25 829 tonnes with 192 tonnes caught in SouthWest Greenland (NAFO 1F) and 25 637 tonnes caught in East Greenland (Tables 16.2.1 and 16.2.2).

Trawlers fished 77% of the total catch (Table 16.2.3, Figure 16.2.1) almost exclusively (94% of their total catch) in the Dohrn Bank management area in a small square 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 almost exclusively (86% of their total catch) south of Dohrn Bank management area mainly on the Heimlandsridge (between 63-64°N).

A detailed description of the fishery is found in Retzel, 2022.

Catch-at-age

The 2015 YC (age 6) is dominating the total catches followed by the 2011 and older YC's (Table 16.2.4, Figure 16.2.4 and 16.2.5). The 2015 YC is dominating the catch in all areas, whereas the oldest of ages 10+ is found further to the north in Dohrn Bank area (Q1Q2, table 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.

Neither the Greenland nor the German survey was performed in 2021.

Greenland Shrimp and Fish survey

No survey was carried out in 2018, 2019 and 2021 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, figures 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 tonnes, 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, 2021.

German groundfish survey

No survey was carried out in 2018 and 2021.

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 tonnes respectively, and was highest in NAFO 1F (strata 4, table 16.2.12 and 16.2.13, figure 16.2.8). The 2015-year class (age 5) dominated the survey, followed by the 2014-year class (age 6, table 16.2.14). The 2015-year class 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 2022 NWWG no further years in the German survey had been reread.

A thorough analysis was performed on survey data from the German and Greenland survey in order to further investigate the differences between the two surveys (Bjare, 2022). It was found that the German survey capture cod that are on average 15 cm larger than those sampled by the Greenland survey. Several possible explanations such as seasonal effects and catch efficiency was investigated, but no clear explanations were found. The following studies are recommended:

- Conduct future surveys at the same time and at close locations using the same towing speed
- Compare observed size differences by area with knowledge of local population seasonal patterns (ie. migration) to assess potential biological effects
- Detailed analysis of the gears and procedures used by either survey to uncover potential selectivity issues
- More detailed analysis of CPUE by size-class for either survey compared with biological knowledge to see if the Greenlandic survey catches surprisingly few large fish or the German survey catches surprisingly few small fish (or both)
- Comparison of Greenlandic survey and commercial data as a reference dataset

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. However, in August 2021 an Inter-Benchmark Protocol on East and Southwest Greenland Cod 2 (IBPGCOD2) (ICES,2021) was established as a result of the rejection of the regular assessment in 2021 conducted by the North Western Working Group (NWWG) due to a violation of the predefined limits for retrospective bias. The most likely explanation for the difficulties in assessing the stock arises from the mixing of the stock with the neighbouring Icelandic cod on Dohrn Bank, an increasing fishing effort in the Dohrn bank area by the Greenlandic fleet means more of these fish are being caught. Furthermore, there is a drift of larvae from east to west, these migrate back to east Greenland and Icelandic waters for spawning. It was decided to focus on a short-term technical fix to solve the assessment problems, which was done by altering the natural mortality (M) to account for changes in immigration and emigration. A benchmark of the East Greenland cod is scheduled for the year 2023.

In connection with the Inter-Benchmark in August 2021 reference points were updated (ICES, 2021). 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.

16.5 State of the stock

The SSB has increased compared to year 2000 after having been decreasing since 2017. The SSB er well above MSY $B_{trigger}$. The $F_{5\text{-}10}$ has increased since 2010 and is above the revised F_{MSY}. No survey was performed in 2021 so no new information of number of recruits is available.

16.6 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.*, 2022).

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 2022 are set to 27 430 t and we assumed that managers will keep the already set TAC rather than following the advice. However, catching 27 430 t in 2022 implies a F of 1.0 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_{2022} (27 430 t) from the different scenarios are presented in Table 16.7.3.

16.7 Long term forecast

No long-term forecast was performed for this stock.

16.8 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. Again in 2021 no survey data was available. This adds uncertainties to the assessment.

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 values of Mohn's rho ($F_{5–10}$ 0.149 and SSB -0.122, which are within the acceptable range.

The NWWG group realized that changing the natural mortality in the most recent years as proposed and accepted in the Inter-Benchman in August 2021 (Riget *et al.*, 2021) should be considered as a technical fix to solve the retro bias rather than trying to reflect the cod stocks dynamic.

16.9 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. The assessment in 2021 was rejected and an Inter-Benchmark Protocol on East and Southwest Greenland Cod 2 (IBPGCOD2) (ICES, 2021) was established due to a violation of the predefined limits for retrospective bias. The Inter-Benchmark group found a solution (see above) that solved the problems with the retro bias. The East Greenland cod stock is planned for a benchmark in 2023.

16.10 Implemented management measures for 2022

The offshore quota for the total international fishery is set at 27 430 t. The following table shows the distribution of the TAC across management areas and countries.

Area	TAC (tonnes)
Dohrn Bank	20 000
South and East Greenland	7430

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).

16.11 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 27’00ºW), 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 (tonnes)
NorthEast Greenland east of 27’00ºW	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)

16.12 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.

16.13 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*., 2022).

16.14 Benchmark 2023

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.

16.15 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.

16.16 References

Bjare, F. (2022). Mean length and length at age comparison for cod caught in German and Greenlandic surveys. ICES North Western Working Group (NWWG), May 2-7, WD 11.

Buch, T.B., Retzel, A., Riget, F., Jansen, T., Boje, J., Berg, C. 2022. DNA split of Atlantic cod (*Gadus morhua*) stocks in Greenland waters. An Overview of data. ICES North Western Working Group (NWWG) May 2-7, WD 13.

GINR, 2018. Report on experimental fishery in East Greenland in April 2018. Greenland Institute of Natural Resources (GINR). ICES North Western Working Group (NWWG) April 25-May 1, 2019, WD 08.

Fock, H., Werner, K.M. 2019. Applying revised otolith age reading to groundfish survey results for the Atlantic Cod Greenland offshore component. ICES North Western Working Group (NWWG) April 26-May 1, 2019, WD 25.

Hedeholm, R., Riget, F., Retzel, A. 2018. Notes on the apparent differences in cod aging between Greenland and Germany. ICES North Western Working Group (NWWG) April 26-May 3, 2018, WD 13.

Hedeholm, R. 2018. Analysis of 2003-2016 tagging data from Greenland waters as it relates to assessment of the East Greenland offshore stock and the West Greenland inshore stock. WD03 in Report of the InterBenchmark Protocol on Greenland Cod (IBPGCod). ICES CM 2018/ACOM:30.

Horsted, S.A. 2000. A review of the cod fisheries at Greenland, 1910-1995. J.Northw.Atl.Fish.Sci. 28: 1-112. ICES, 2018. Report of the InterBenchmark Protocol on Greenland Cod (IBPGCod). ICES CM 2018/ACOM:30. Retzel, A., 2019. Report of the Workshop on Age Reading of Cod in Greenland. ICES North Western Working Group (NWWG) April 25-May 1, 2019, WD 09.

ICES. 2021. Inter-Benchmark Protocol on East and Southwest Greenland Cod 2 (IBPGCOD2). ICES Scientific Reports. 3:88. https://doi.org/10.17895/ices.pub.8288.

Retzel, A. 2022. Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2021. ICES North Western Working Group (NWWG) May 2-7, 2022, WD 05.

Retzel, A 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 (NWWG) April 22-29, 2021, WD 04.

Riget, F., Retzel, A., Boje, J., Buch, T. B. 2022. Cod East Greenland SAM assessment. ICES North Western Working Group (NWWG) May 2022, WD06.

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 (NWWG) April 22-29, 2021, WD 13

Therkildsen, N.O.,Hemmer-Hansen, J., Hedeholm, R.B., Wisz, M.S., Pampoulie, C., Meldrup, D., Bonanomi, S., Retzel, A., Olsen, S.M., Nielsen, E.E. 2013. Spatiotemporal SNP analysis reveal pronounced biocomplexity at the northern renge margin of Atlantic cod *Gadus morhua*. Evoltutionary Applications. DOI 10.1111/eva. 12055.

Werner, K., Fock, H., 2021. Update of Groundfish Survey Results for the Atlantic Cod Greenland offshore component. ICES North Western Working Group (NWWG) April 22-29, 2021, WD 18.

16.17 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
2021	0	0	96	0	0	192	0	25637	25829

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	24	25	2				51	0.2%
14.b (Q1Q2)	2661	1755	1959	1325	4688	2523	936	72	125	93	690	2867	19696	76%
14.b (Q3Q4)		898	698	744	1847	140	14	52	88	67	14	11	4572	18%
14.b (Q5Q6)			202	85	874	142	0.2				15	0.4	1317	5%
1F										136	55		192	1%
Total	2661	2653	2859	2155	7409	2806	973	149	214	297	774	2878	25829	
%	10%	10%	11%	8%	29%	11%	4%	1%	1%	1%	3%	11%		

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	22	18	1				43
	14.b (Q1Q2)				5	15	2	36	71	125	93	86	368	801
	14.b (Q3Q4)		245	641	729	1847	133	13	51	88	67	14		3828
	14.b (Q5Q6)				44	873	82					15		1014
	1F										136	55		192
	Total		245	641	777	2735	218	71	141	214	297	170	368	5876
Trawl	14.b (NQ1)							2	7	0.5				9
	14.b (Q1Q2)	2661	1755	1959	1321	4673	2522	900	1			604	2499	18896
	14.b (Q3Q4)		653	58	16		6	0.4	1				11	745
	14.b (Q5Q6)			202	41	0.4	59	0.2					0.4	303
	1F													
	Total	2661	2408	2219	1378	4674	2588	902	8	0.5		604	2510	19952

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
2021	52	97	365	2245	1052	434	378	1177

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
2021	0.569	1.035	2.027	3.266	4.274	5.228	6.271	7.217

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+**
14b (NQ1)				4	2	1	1	2
14.b (Q1Q2)	16	37	221	1660	821	318	284	867
14.b (Q3Q4)	18	37	102	417	169	87	71	227
NAFO 1F + 14.b (Q5Q6)	18	22	42	164	60	29	23	80

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
2021	-	-	-	-	-	-	-	-

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
2021	-	-	-	-	-	-	-	-	-

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		

Year	ICES 14.b						NAFO	Total	CV
	Q1	Q2	Q3	Q4	Q5	Q6	1F		
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
2021	-	-	-	-	-	-	-	-	-

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
2021					No	survey					

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
2021		No				survey					

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
2021				No survey					

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	
2021					No survey					

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

	NAFO 1F		ICES 14.b							
year	str4_1	str4_2	str5_1	str5_2	str7_1	str7_2	str8_2	str9_2	Sum	SD
1993	0	.	431	73	247	532	254	547	2084	588
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
2021	No survey									

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
2021						No survey							

Table 16.5.1. Updated reference point.

Framework	Reference Point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	18146	MSY $B_{trigger}$ = B_{pa}
	F_{MSY}	0.29	Simulated (below F_{p05})
Precautionary approach	B_{lim}	11738	Mean of 2003, 2004, 2005
	B_{pa}	18146	Blim * exp(1.645 * σ), σ = 0.27
	F_{lim}	1.98	F50 deterministic simulated
	F_{pa}	0.65	Flim * exp(-1.645 * σ), σ = 0.32

Table 16.7.1. Estimated stock numbers at age.

Year Age	1	2	3	4	5	6	7	8	9	10
1973	52079	10990	7040	3737	18143	3485	2513	621	2454	3889
1974	193807	40278	8998	5987	2831	12604	2144	1276	284	2573
1975	30891	181896	31151	7752	5692	2157	8465	1213	614	1211
1976	13778	24188	170718	24286	5976	4160	1373	4573	587	905
1977	13006	10920	18940	131185	20118	4086	2282	666	1673	676
1978	21256	10398	8654	14553	86427	13918	2185	856	227	853
1979	7639	18584	8313	8071	10706	47850	7701	1177	261	200
1980	15784	5798	16248	6587	6185	5594	22288	2590	254	84
1981	5361	13975	4400	12998	5149	4478	3285	10087	776	115
1982	5621	4180	12373	3332	11917	4355	3189	1703	3308	303
1983	2342	5502	3258	12296	3099	10090	2281	1093	355	836
1984	4301	1798	5385	2873	9250	1823	4994	671	337	359
1985	155111	4092	1518	4664	2282	5999	790	1927	180	233
1986	119280	134745	3794	1035	3784	1460	3641	363	987	164
1987	3091	92050	111040	3084	737	2620	789	2021	178	710
1988	2638	3068	61882	94823	2106	421	1663	378	902	372
1989	756	2374	2659	41777	71234	1148	168	766	165	428
1990	1503	707	2171	2132	26096	36220	456	57	270	135

Year Age	1	2	3	4	5	6	7	8	9	10
1991	2455	1040	607	1708	1083	10252	9993	128	28	74
1992	854	1733	598	405	713	284	2437	1389	37	13
1993	753	639	1061	376	202	317	75	222	159	9
1994	3492	629	550	755	255	118	182	34	50	60
1995	244	2959	732	430	562	181	74	117	17	55
1996	321	202	1949	620	339	290	105	42	61	39
1997	1577	248	167	1263	575	245	154	65	23	58
1998	5223	1313	194	150	709	336	148	69	34	45
1999	10150	4037	1205	218	171	322	196	84	36	43
2000	13984	6395	2787	1007	223	141	158	102	53	45
2001	8561	10876	4248	2030	878	232	108	85	52	55
2002	1605	6420	8426	3064	1612	794	217	75	47	63
2003	37736	1713	4658	6016	2252	1122	584	150	46	64
2004	329291	28833	1999	3594	4407	1523	656	347	84	64
2005	64328	252303	21322	2216	3039	3030	899	293	185	89
2006	35350	41901	158271	17481	2253	2298	1840	383	99	161
2007	14656	27604	25165	83361	12576	1781	1265	965	207	164
2008	22127	11013	20241	14820	39318	7793	1263	600	430	190
2009	49915	20488	9442	13343	9384	14690	3236	439	340	226
2010	54005	30636	14978	6236	9026	5501	7686	1715	278	274
2011	10715	41842	20137	14981	5431	5877	3242	3432	976	338
2012	5636	10067	37114	17712	15011	4555	3463	1759	1474	671
2013	2720	4340	8270	33031	14725	12467	3293	2005	955	1037
2014	1033	2115	3841	6684	25132	10487	7552	2002	1202	976
2015	5298	999	2099	4066	6764	15763	6847	3634	991	1038
2016	47421	5414	1326	1803	3370	4462	7893	3427	1684	926
2017	3874	38500	5479	1658	1924	3155	4050	5381	2261	1407
2018	7781	3788	25566	5096	1582	1703	2442	2983	3158	2150
2019	10314	6486	3704	21234	5035	1530	1411	1744	1853	3071

Year Age	1	2	3	4	5	6	7	8	9	10
2020	25521	8219	5407	3565	16608	4571	1247	1007	1053	2457
2021	25521	20894	8103	5087	3183	13142	3274	781	538	1739

Table 16.7.2. Estimated fishing mortality at age.

Year Age	1	2	3	4	5	6	7	8	9	10
1973			0.001	0.028	0.05	0.079	0.157	0.274	0.381	0.001
1974			0.002	0.022	0.046	0.076	0.14	0.26	0.335	0.002
1975			0.003	0.033	0.08	0.119	0.189	0.319	0.291	0.003
1976			0.005	0.034	0.085	0.189	0.267	0.505	0.417	0.005
1977			0.003	0.056	0.106	0.206	0.363	0.595	0.616	0.003
1978			0.002	0.053	0.131	0.196	0.253	0.668	1.152	0.002
1979			0.002	0.051	0.145	0.16	0.422	0.991	1.118	0.002
1980			0.003	0.024	0.068	0.091	0.241	0.671	0.6	0.003
1981			0.002	0.011	0.043	0.111	0.258	0.66	0.62	0.002
1982			0.002	0.012	0.076	0.277	0.594	1.08	0.899	0.002
1983			0.003	0.054	0.184	0.39	0.68	0.732	0.68	0.003
1984			0.012	0.082	0.181	0.386	0.509	0.679	0.539	0.012
1985			0.028	0.068	0.17	0.275	0.296	0.316	0.286	0.028
1986			0.017	0.062	0.142	0.242	0.27	0.283	0.197	0.017
1987			0.01	0.07	0.135	0.208	0.295	0.377	0.448	0.01
1988			0.01	0.11	0.207	0.345	0.39	0.435	0.642	0.01
1989			0.01	0.13	0.306	0.398	0.514	0.431	0.931	0.01
1990			0.011	0.325	0.508	0.767	0.728	0.373	1.11	0.011
1991			0.011	0.467	0.96	0.96	1.38	0.752	1.387	0.011
1992			0.005	0.301	0.547	0.809	1.907	1.707	1.159	0.005
1993			0.004	0.085	0.187	0.304	0.357	0.889	0.529	0.004
1994			0.027	0.064	0.136	0.169	0.179	0.339	0.183	0.027
1995			0.027	0.031	0.1	0.084	0.082	0.146	0.098	0.027
1996			0.017	0.029	0.106	0.073	0.084	0.133	0.084	0.017

Year Age	1	2	3	4	5	6	7	8	9	10
1997			0.011	0.03	0.155	0.074	0.095	0.136	0.091	0.011
1998			0.008	0.024	0.156	0.065	0.081	0.125	0.08	0.008
1999			0.005	0.02	0.076	0.045	0.059	0.089	0.059	0.005
2000			0.004	0.018	0.052	0.043	0.064	0.09	0.059	0.004
2001			0.002	0.014	0.034	0.039	0.055	0.075	0.048	0.002
2002			0.002	0.018	0.043	0.05	0.065	0.089	0.062	0.002
2003			0.001	0.017	0.035	0.047	0.071	0.101	0.065	0.001
2004			0.001	0.018	0.033	0.05	0.093	0.13	0.071	0.001
2005			0.001	0.018	0.032	0.054	0.119	0.176	0.078	0.001
2006			0.001	0.023	0.058	0.087	0.109	0.09	0.036	0.001
2007			0.002	0.026	0.079	0.119	0.155	0.126	0.086	0.002
2008			0.004	0.041	0.147	0.19	0.268	0.102	0.071	0.004
2009			0.008	0.052	0.121	0.067	0.09	0.086	0.034	0.008
2010			0.001	0.017	0.054	0.057	0.079	0.071	0.035	0.001
2011			0	0.007	0.034	0.076	0.115	0.129	0.101	0
2012			0	0.005	0.029	0.073	0.105	0.168	0.132	0
2013			0	0.002	0.016	0.066	0.106	0.172	0.171	0
2014			0	0.002	0.02	0.069	0.135	0.225	0.201	0
2015			0.001	0.008	0.056	0.119	0.21	0.301	0.285	0.001
2016			0.002	0.013	0.084	0.165	0.212	0.297	0.32	0.002
2017			0.001	0.01	0.073	0.172	0.27	0.337	0.285	0.001
2018			0.001	0.007	0.058	0.163	0.262	0.389	0.348	0.001
2019			0.001	0.007	0.066	0.201	0.316	0.451	0.52	0.001
2020			0.002	0.007	0.064	0.164	0.341	0.508	0.57	0.002
2021			0.004	0.014	0.1	0.189	0.388	0.665	0.915	0.004

Table 16.7.3. Short-term forecast for 2022 assuming that Catch = TAC_{2022} (27 430 t)

Variable				**Value**		
$F_{ages\ 5–10}$ (2022)				0.995		
SSB (2023)				48317		
$R_{age\ 1}$ (2022)				7781		
Total catch (2022)				27430 t		
Rationale	**Catch (2023)**	**F (2023)**	**SSB (2024)**	**% SSB change ***	**% advice change ****	**% TAC change *****
ICES advice basis						
MSY approach: F_{MSY}	8460	0.290	60722	+26%	-4%	-69%
Other scenarios						
F = 0	0	0	76675	+59%	-100%	-100%
F = F_{2022} (*status quo*)	19782	0.995	45552	-6	+126%	-28%

16.18 Figures

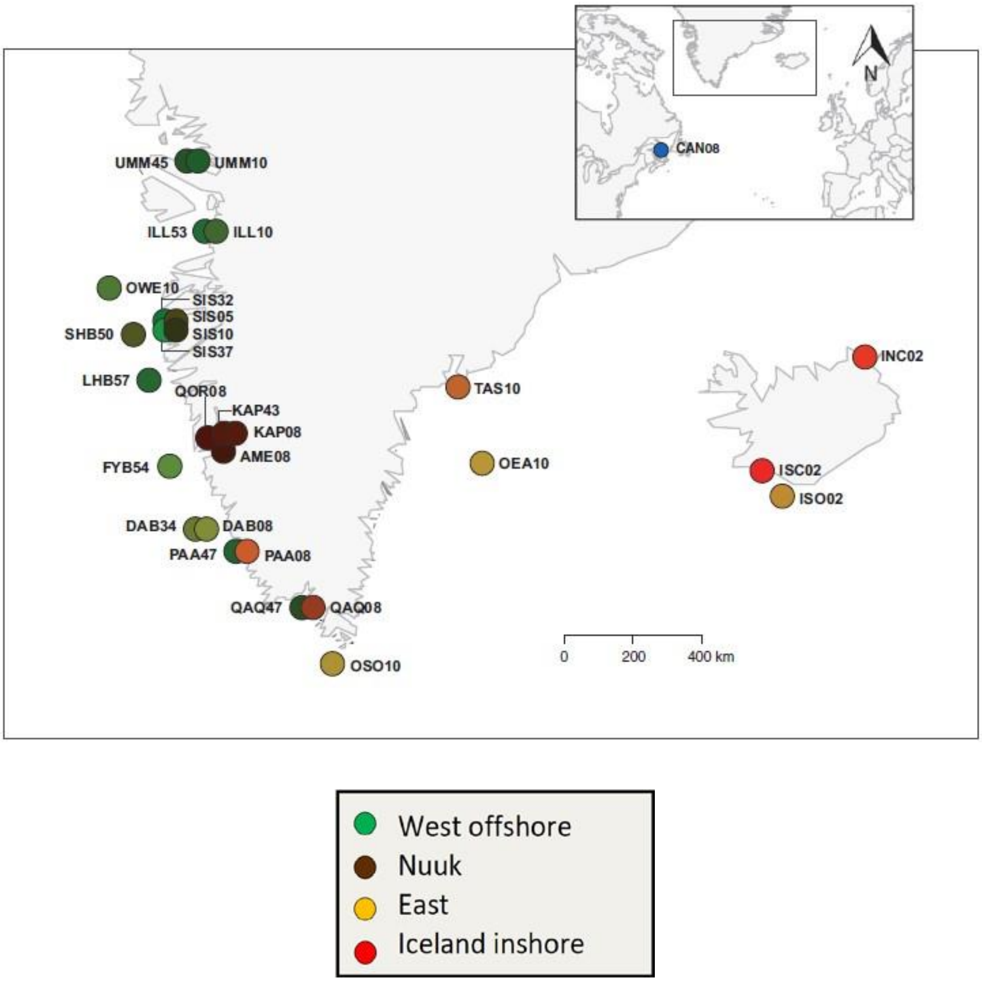


Figure. 16.1. Sampling location of spawning cod in Greenland and Iceland in the genetic project. The colours of the dots represent the blends of sample mean of the different spawning population: West offshore, Nuuk (inshore), East (Greenland and offshore Iceland) and Iceland inshore as signal intensities of green and red respectively. After Therkildsen *et al.*, 2013.

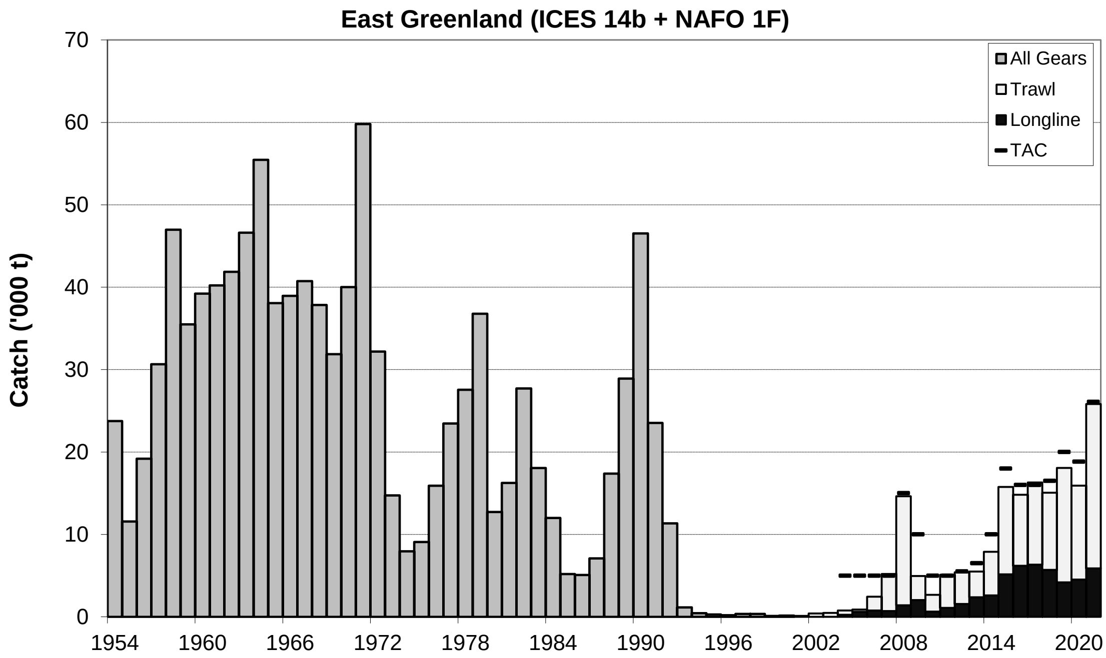


Figure 16.2.1. Annual total catch in South and East Greenland (NAFO Subarea 1F and ICES Subarea 14.b). From 2001 divided into gear. TAC until 2013 is for all the offshore area including West Greenland (NAFO Subarea 1A–1E).

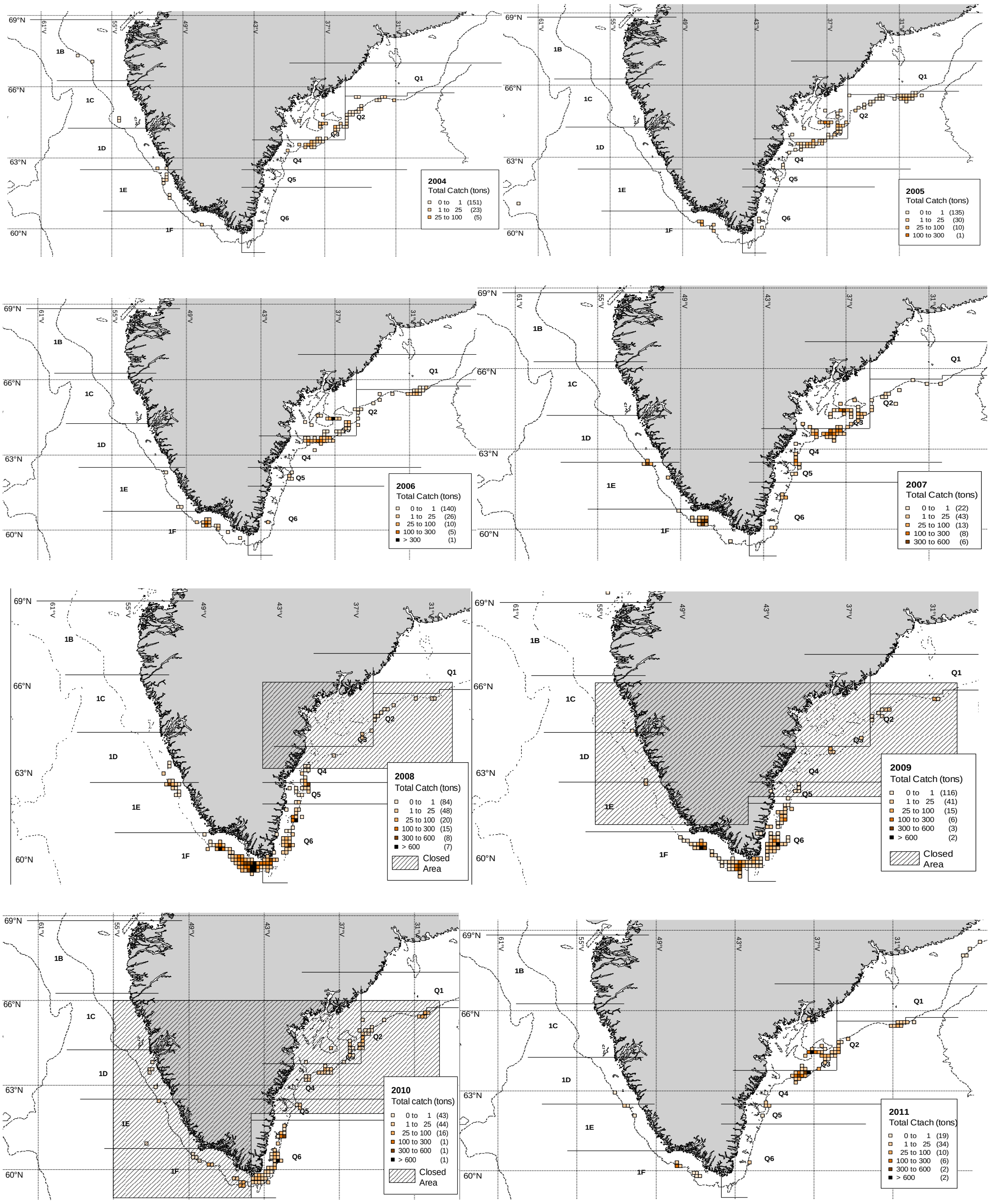


Figure 16.2.2: Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

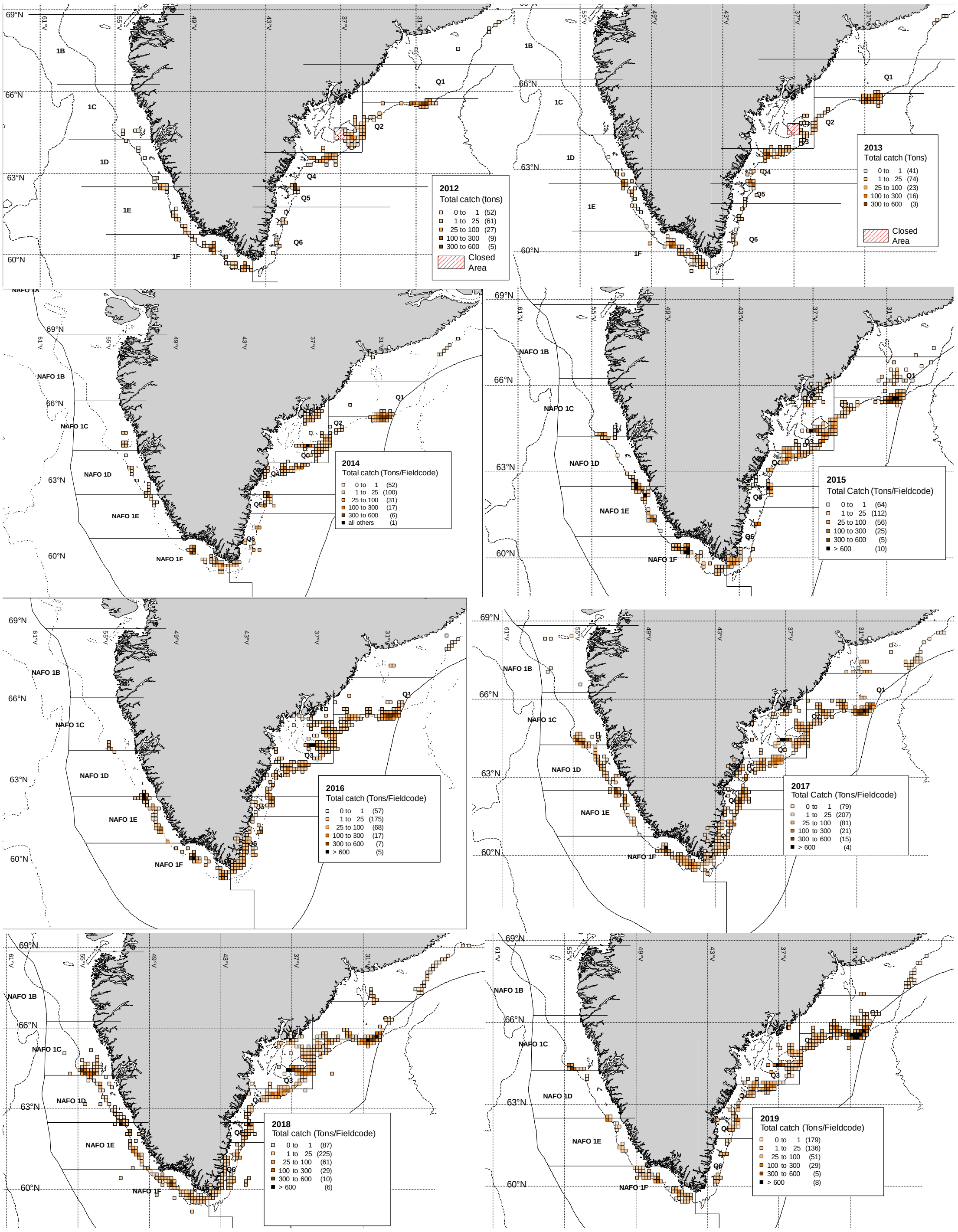


Figure 16.2.2: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

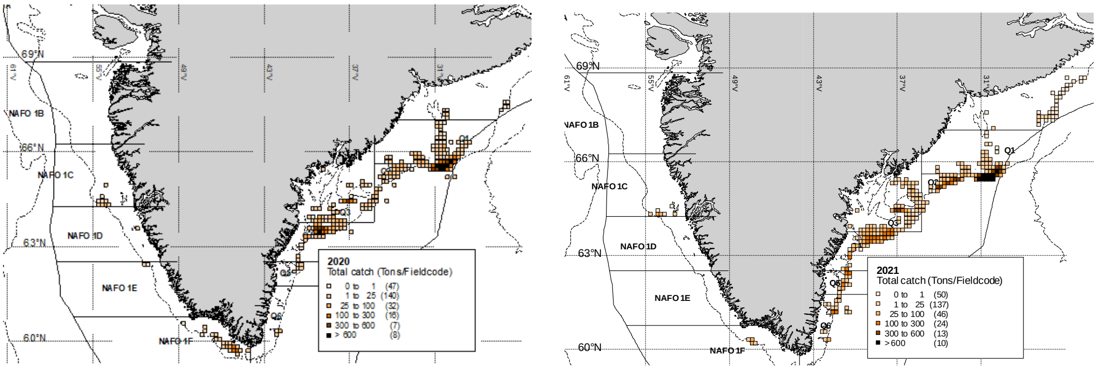


Figure 16.2.2: Continued. Annual distribution of total catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

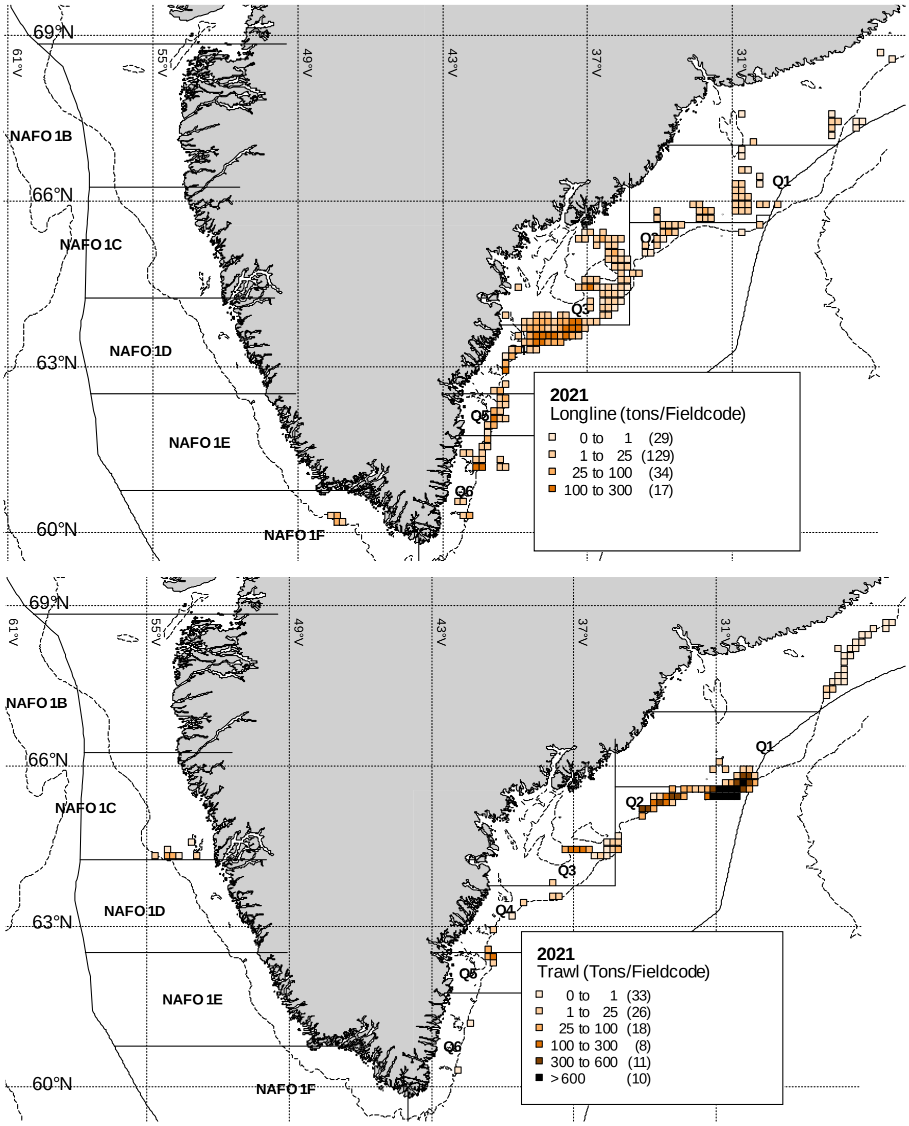


Figure 16.2.3: Distribution of Longline and Trawl catches of Atlantic cod in West and East Greenland. Q1–Q6 illustrates survey areas (strata) in the East Greenland shrimp and fish survey.

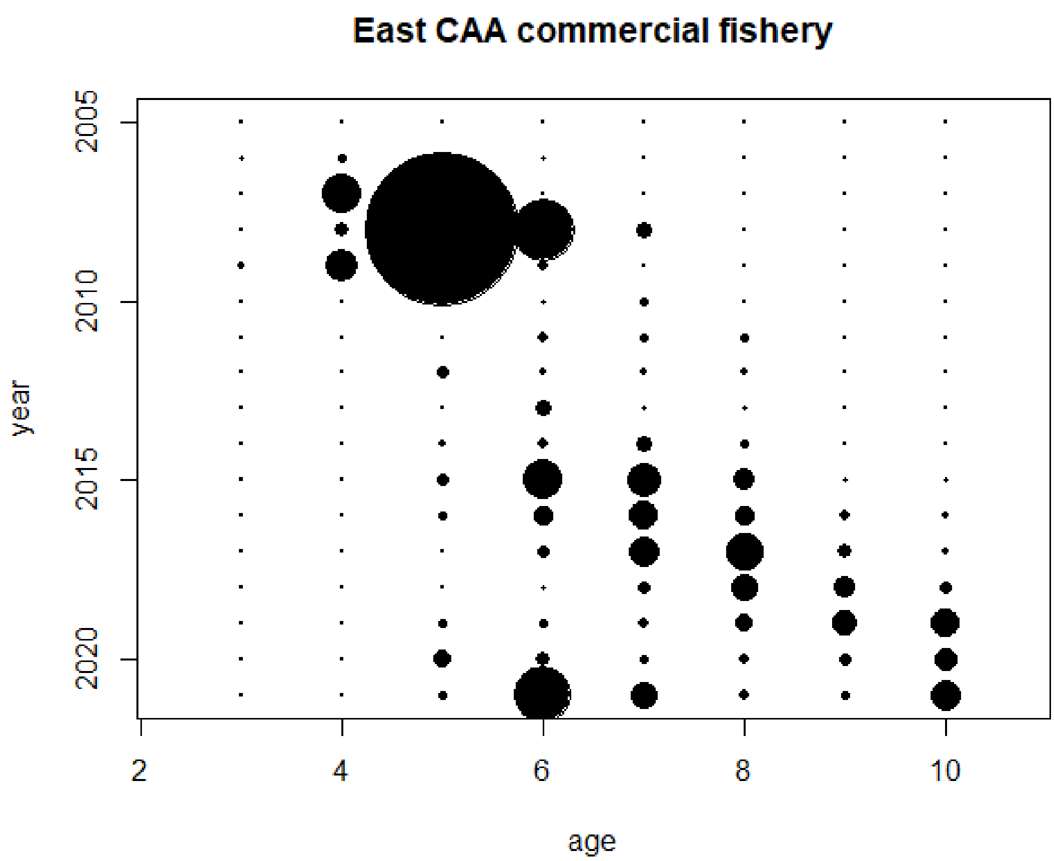


Figure 16.2.4: Catch at Age in the East Greenland (ICES 14. + NAFO 1F) commercial fishery. Size of circles represents size of catch numbers.

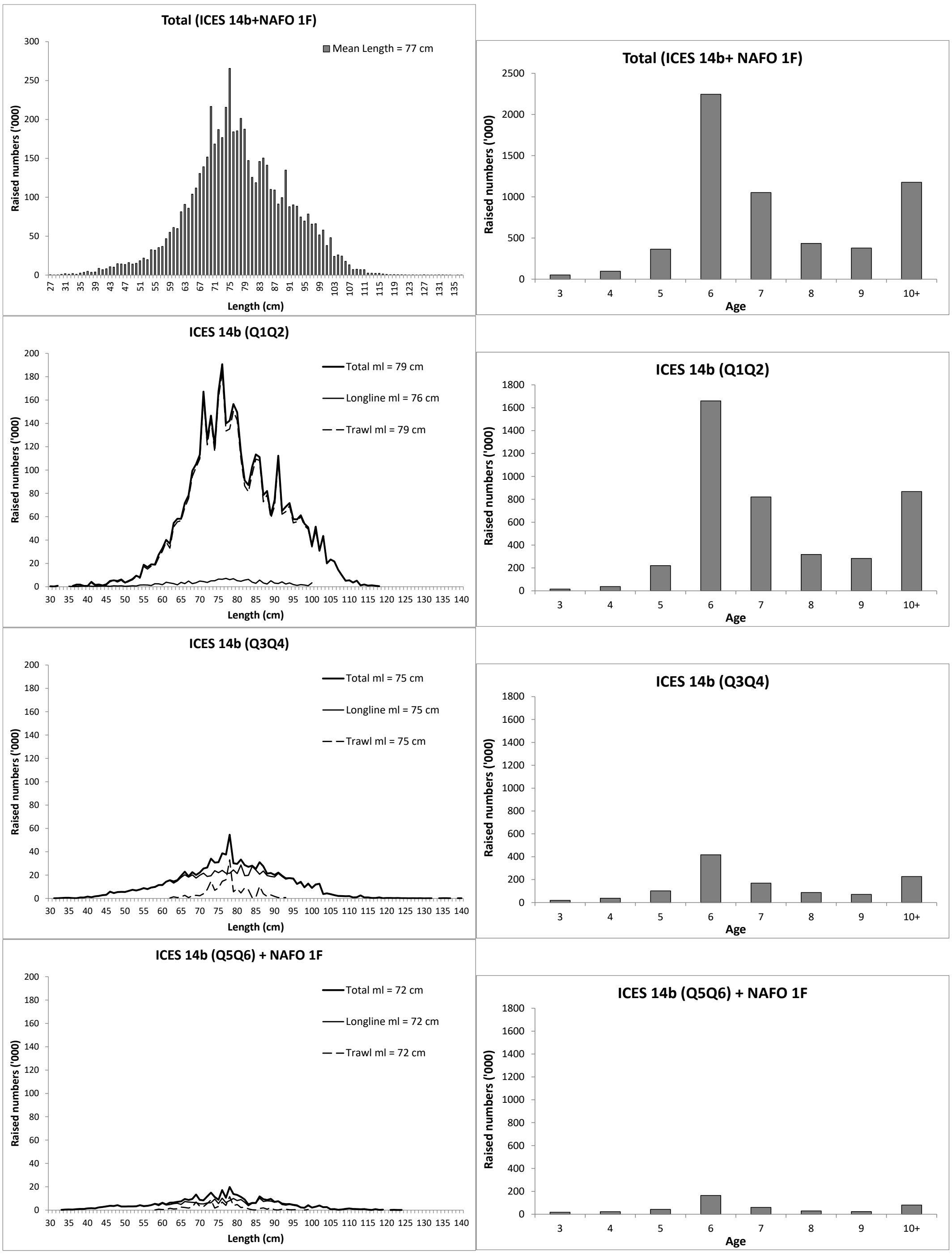


Figure 16.2.5. Age and Length distributions total and by gear of commercial cod catches in 4 management areas of South (ICES 14b (Q5Q6) + NAFO 1F) and East Greenland (Q1Q2 furthest north).

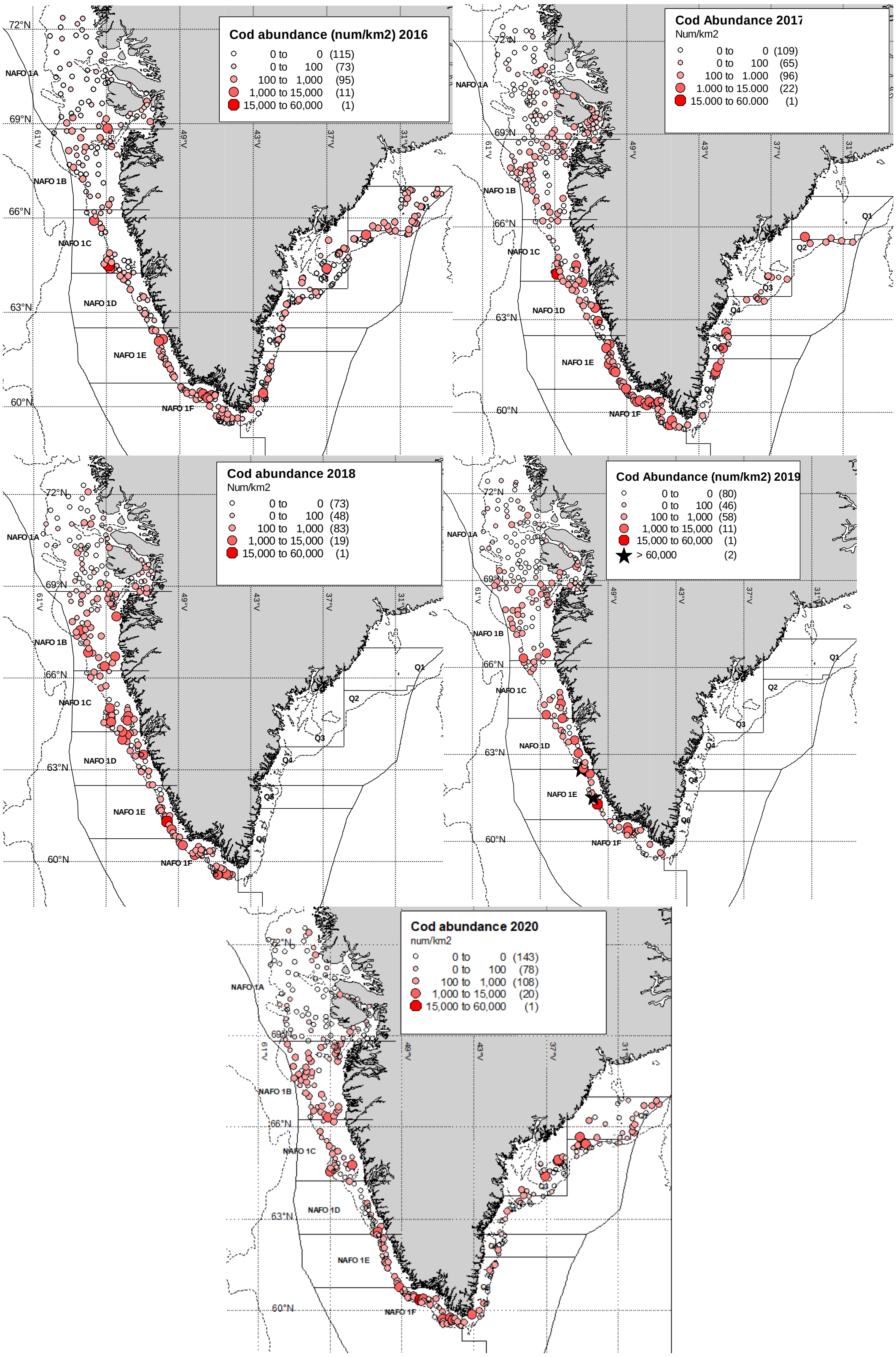


Figure 16.2.6. Greenland shrimp and fish survey. Abundance per km². No survey in 2021.

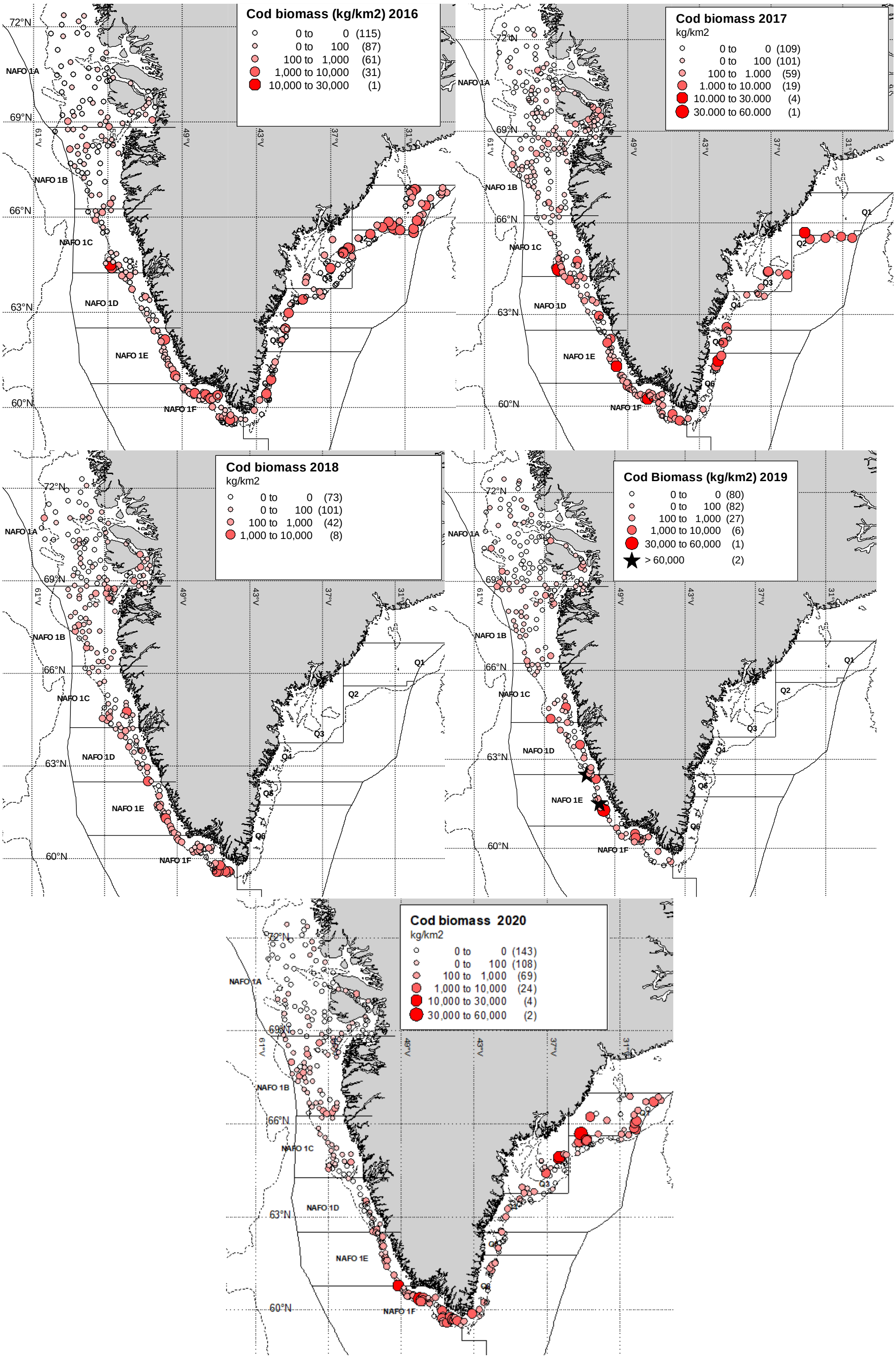


Figure 16.2.7. Greenland shrimp and fish survey. Catch weight kg per km². No survey in 2021.

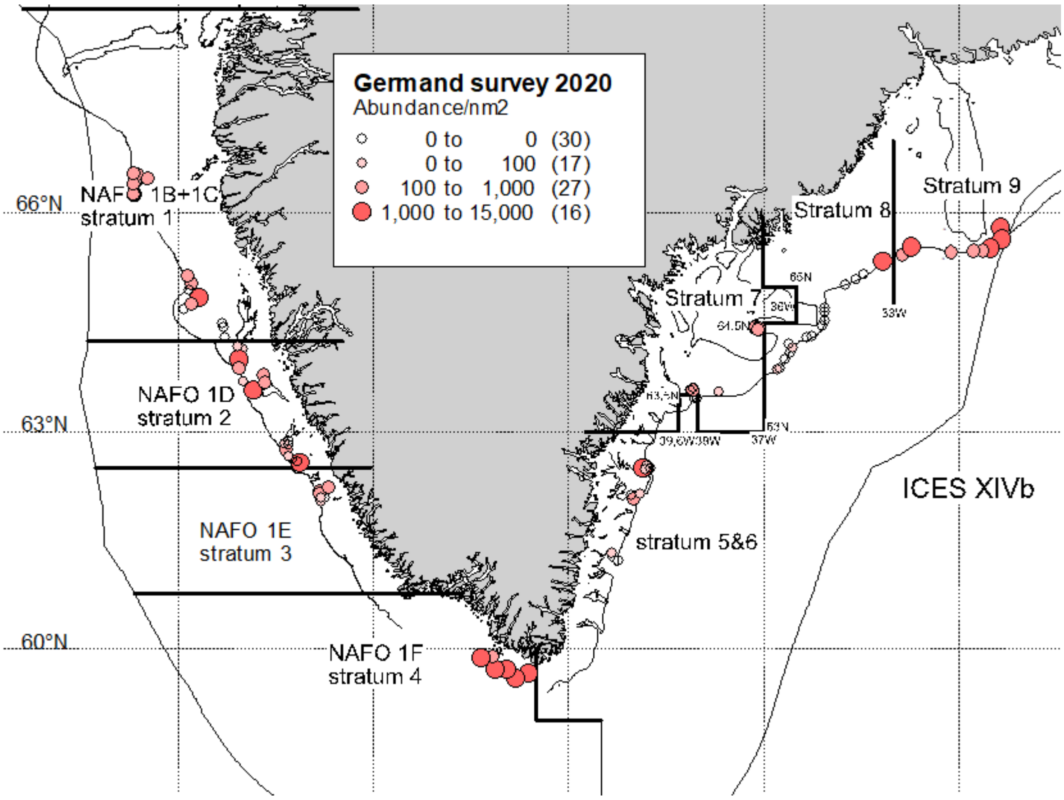


Figure 16.2.8. German ground fish survey. Abundance per nm^2. No survey in 2021.

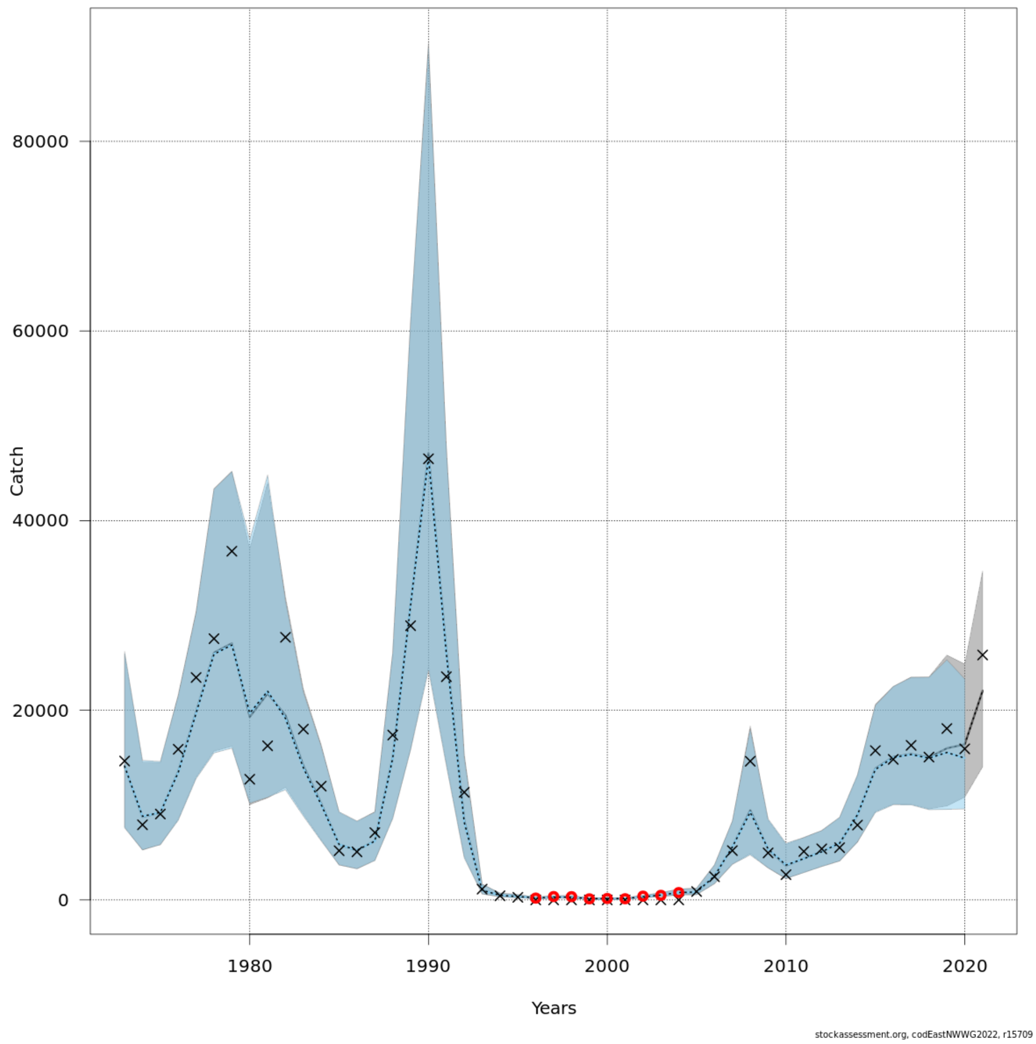


Figure 16.9.1. Estimated catch and with observed catch shown as crosses. Note the period 1996–2004 with near zero catches because no age disaggregated catch data were available.

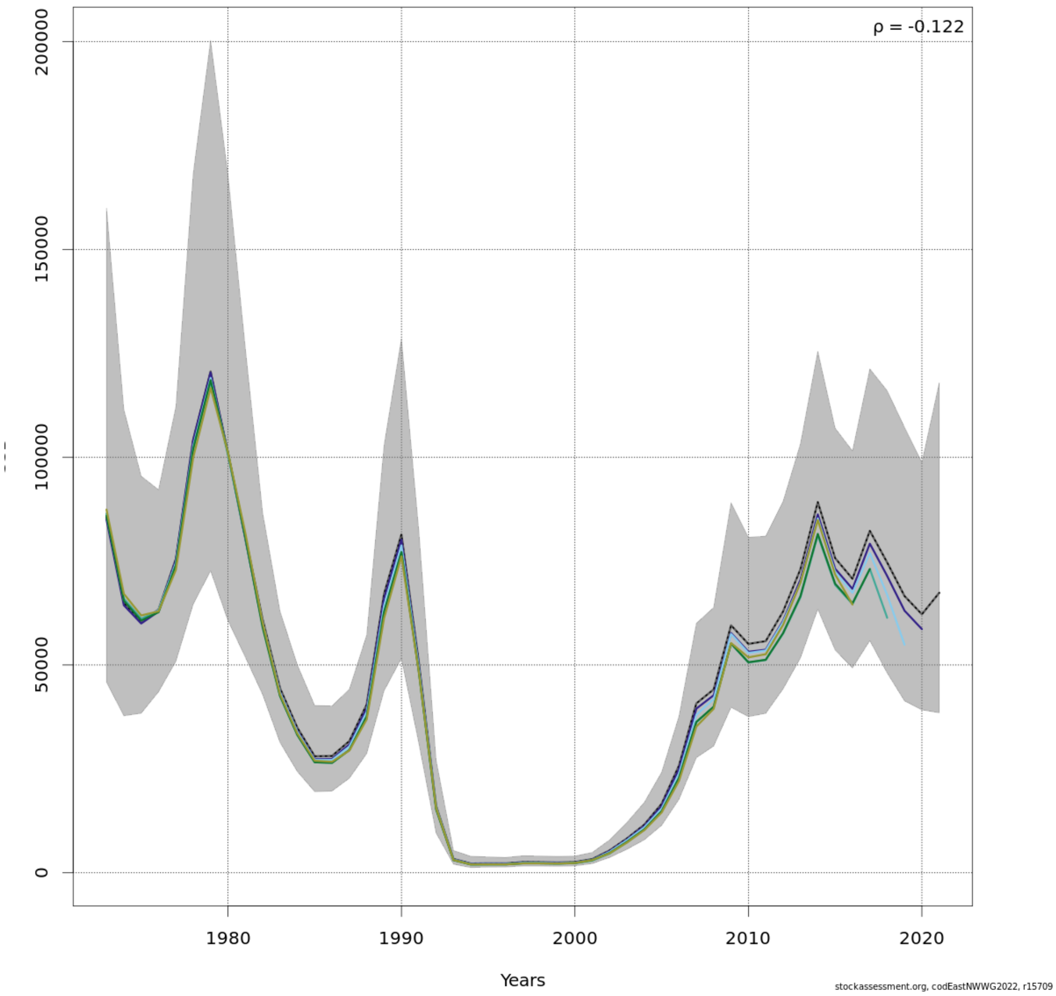


Figure 16.9.2. Retrospective plot of SSB.

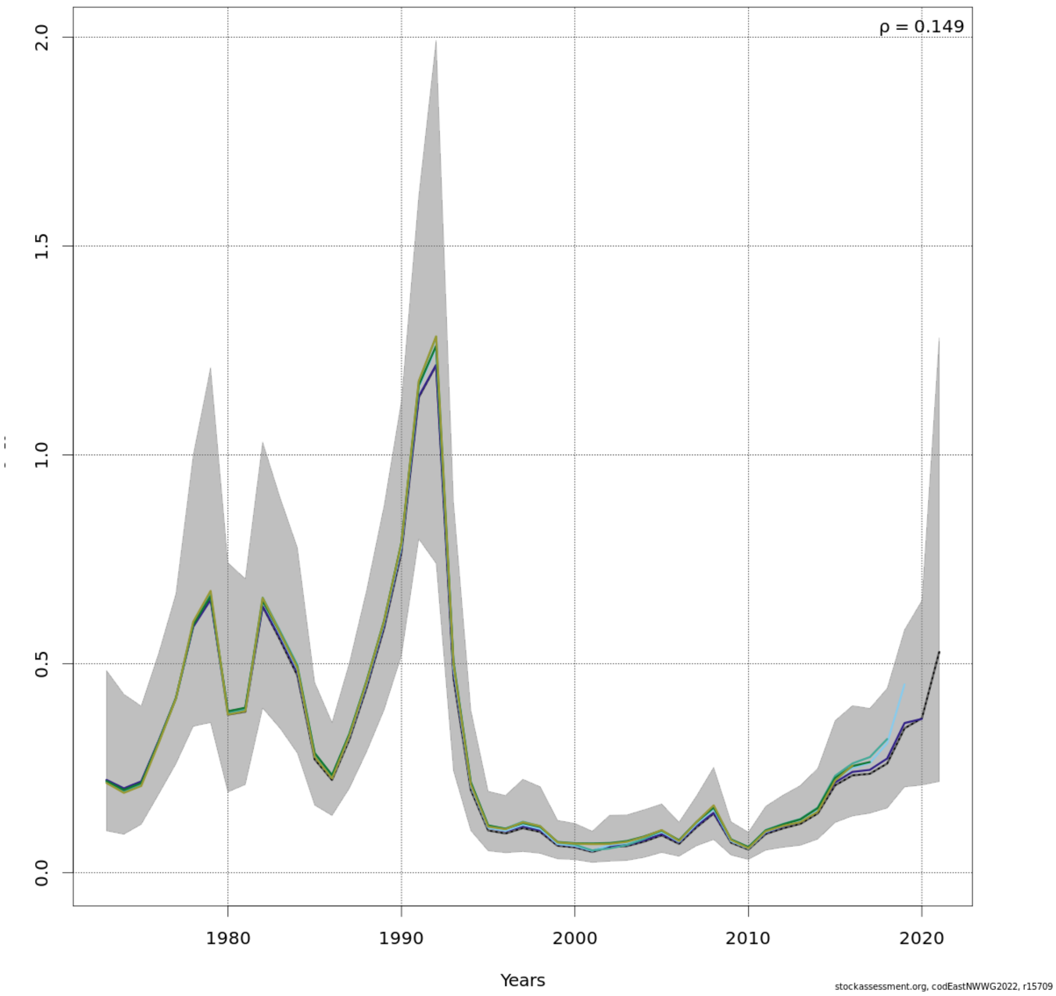


Figure 16.9.3. Retrospective plot of F5-10.

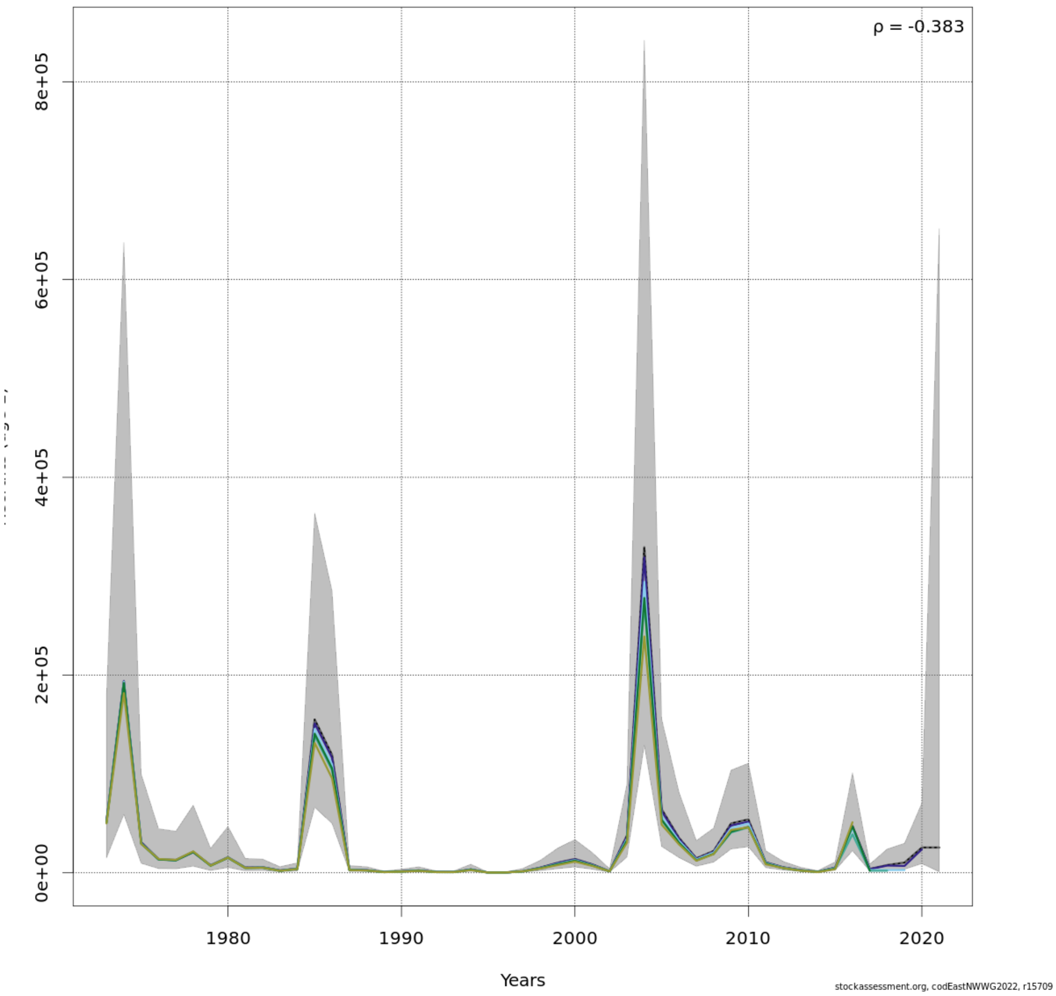


Figure 16.9.4. Retrospective plot of Recruits.

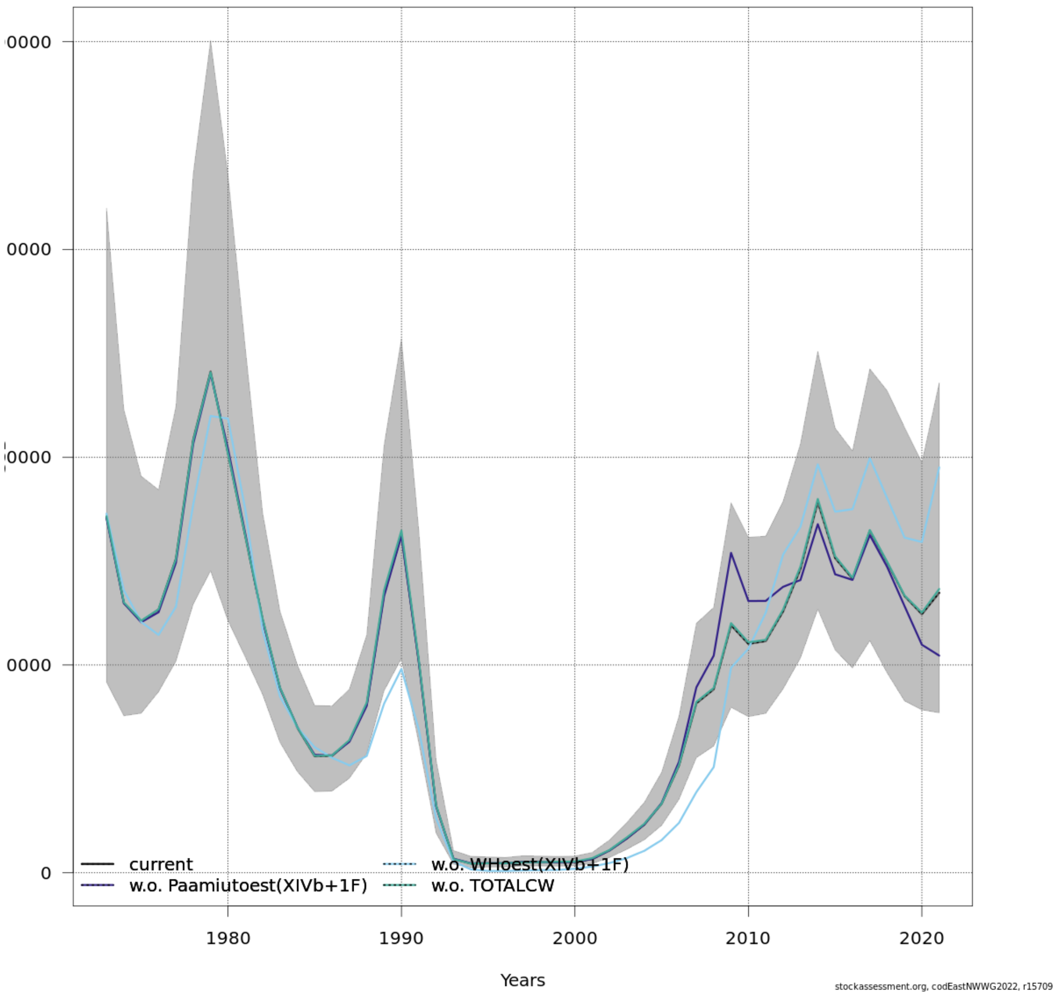


Figure 16.9.5. Leave out plot of SSB.

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 1981–2021 in Tables 17.1.1–17.1.6 and since 1961 in Figure 17.1.1. Catches increased in 2021 by 5% to 23 802 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. Catches in 5b decreased slightly in 2021 while it increased in 5a and 14.

17.1.2 Fisheries and fleets

In 2021 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.

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 2021 fishery and historic effort and catch in the trawl fishery in Subareas 5, 6, 12 and 14 is provided in Figures 17.1.2–3. 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 17.1.4). In recent years and in 2021 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 2019-21 a significant part of the landings were from gillnets (Figure 17.1.5).

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 17.1.5–17.1.6).

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 1985–2021 is provided in Table 17.2.1 and Figures 17.2.1–2. The overall CPUE index for the Icelandic fishery is compiled as the average of the standardised indices from four areas. In 2021 there was a slight overall decrease in catch rates in this fishery.

Catch rates of Icelandic bottom trawlers decreased for all fishing grounds during 1990–1996 (Figure 17.2.1), 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 17.2.2). In 2021 the western and northern areas decreased in their catch rates while the southern and eastern increased.

17.2.2 Division 5.b

Information from logbooks from the Faroese otterboard trawl fleet (>1000 hp) was available for the years 1995-2021 (Table 17.2.1, Figure 17.2.3.). The bulk of the fishery has historically been on the south-east slope of the Faroe Plateau. CPUE has generally fluctuated in this fishery, but there is an overall trend of a decrease until 2018 from where catch rates has increased to 2021.

17.2.3 Division 14.b

CPUE and effort from logbooks in area 14 are provided in Table 17.2.1 and Figure 17.2.4–5. After a record high CPUE of 450 kg/hr trawling in 2016 a decrease is evident since then although still above time series average (330 kg(hr). There is no clear latitudinal trend in catch rates (Fig. 17.2.5).

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 (Table 17.1.5-6). 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).

17.4.3 Division 14.b

The Greenland survey have not been conducted since 2016 due to a shift in research vessel without possibilities to have a replacement before delivery of a new vessel. It is expected that the new research vessel TARAJOQ will resume the survey in autumn 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 1961–2021 was used as yield data (Table 17.5.1, Figure. 17.2.1). Since the fishery has no major discarding 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 721–1067 kt (Table 17.5.3).

The posterior for MSY was positively skewed with upper and lower quartiles at 27 kt and 38 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 2021 observations have, however, high residuals for both indices (-4% and 18%) but inside the 95% CI of the model estimate (Figure. 17.5.2).

The retrospective runs suggest high consistency for both biomass and fishing mortality within +- 20% (range 2.2% - 5.4%, 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 about 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 2021 below F_{MSY} (0.94, 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 (2022) 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 2022, a fishery at F_{MSY} ($F / F_{MSY} = 1$) in 2023 will lead to catches of 26 710 t (Table 17.5.7). Fishing at this level in 2023 will result in a 5% increase in biomass in 2024 compared to 2023 and is an increase in advice of 0.2%.

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 upper left panel)). Only catches of less or equal to 20 kt will lead the biomass to reach B_{MSY} 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 27 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 between the Barents Sea and Iceland and also connectivity to West Greenland. 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), 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. This is especially the case for SA 14 (East Greenland) where sampling have been inadequate so far.

17.8 Research needs and recommendations

Stock structure and connectivity between the main fishing areas and neighbouring regions 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 have analysed historic tag-recapture data with the objective to outline stock structure with focus on evaluating present stock entities in the entire North Atlantic. This knowledge will be combined with studies based on several methods,. genetics, otolith microstructure, drift modelling and use of survey and fisheries data. These studies will be final in early 2023 and most likely contribute with valuable biological information to re-evaluate stock perception

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 on age calibration. With respect to this stock Iceland has now progressed so far that an ALK is available for the 6 previous years. The Greenland institute of Natural Resources has also initiated age reading. 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 17.1.1 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	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Denmark	-	-	-	-	-	-	6	+	-	-
Faroe Islands	767	1,532	1,146	2,502	1,052	853	1,096	1,378	2,319	1,803
France	8	27	236	489	845	52	19	25	-	-
Germany	3,007	2,581	1,142	936	863	858	565	637	493	336
Greenland	+	1	5	15	81	177	154	37	11	40
Iceland	15,457	28,300	28,360	30,080	29,231	31,044	44,780	49,040	58,330	36,557
Norway	-	-	2	2	3	+	2	1	3	50
Russia	-	-	-	-	-	-	-	-	-	-
UK (Engl. and Wales)	-	-	-	-	-	-	-	-	-	27
UK (Scotland)	-	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-	
Total	19,239	32,441	30,891	34,024	32,075	32,984	46,622	51,118	61,156	38,813
Working Group estimate	-	-	-	-	-	-	-	-	61,396	39,326

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 17.1.1 Continued. 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	2021[1]
Estonia	-
Faroe Islands	2,070
France	82
Germany	4,354
Greenland	2,834
Iceland	12,837
Ireland	
Lithuania	
Norway	993
Poland	
Portugal	
Russia	390
Spain	
United Kingdom	243
Total	23,802
Working Group estimate	

[1] Provisional data

Table 17.1.2 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 [4]	2,277 [4]	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]	2021[1]
Faroe Islands	17	31			24
Germany	246	552	259		391
Greenland	3		1	110	
Iceland	11,926	15,214	12,390	12,535	12,837
Norway					158
Russia					
Poland					
UK	15				
Total	12,207	15,797	12,649	12,645	13,410
Working Group estimate					

1) Provisional data
2) Includes 223 t catch by Norway.
3) Includes 7290 t taken in SA14 in Iceland EEZ

Table 17.1.3 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	1999	2000[1]	2001[1]	2002[1]	2003[1]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	2021
Denmark					
Faroe Islands	3,548	2,903	1,973	1,888	1,825
France	7	8	7	18	15
Germany					
Iceland					
Ireland					
Norway	6	5	1	2	4
United Kingdom	15	1	5	10	22
Total	3,576	2,917	1,986	1,919	1,865
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 17.1.4 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]	2021 [1]
Estonia					
Faroe Islands	434	15	0		220
Germany	2,747	3,911	4,225	4,769	3963
Greenland	2,689	2,970	2,999	1,882	2834
Iceland					
Ireland					
Norway	995	931	993	811	831
Poland					
Portugal					
Russia	599	400	398	399	390
Spain					
United King-	1	1	0	3	
Total	7,466	8,228	8,615	7,864	8,238
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 17.1.5 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 Ire-									
land Lithua-									
nia		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]	2021 [1]
Faroe Islands								
France Ire-								
land Lithua-								
nia Poland								
Spain [2]	67	91	78	74	95	62	75	
UK								
Russia								
Norway			0					
Estonia								
Total	67	91	78	74	95	62	75	0
WG estimate	67	91	78	74	95	62		

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.1.6 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]	2019 [1]	2020 [1]	2021 [1]
Estonia								
Faroe Islands	1		1					1
France		89	72	44	63	71	79	67
Poland								
Spain [2]		18	17	39	30	21	25	
UK	42	119	348	58	12	24	63	221
Russia						0		
Norway	0	1	3	1	0	0		
Lithuania								
Total	43	227	440	142	105	117	167	289
WG estimate	43	227	440	142	105	117	167	289

[1] Provisional data

[2] Based on estimates by observers onboard vessels

Table 17.2.1. 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	16
	1989	1.04	19	59,272	57	1
	1990	0.75	-28	37,308	50	-12
	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	20
	1996	0.30	-13	22,073	73	-7
	1997	0.33	7	16,792	51	-29
	1998	0.51	56	10,595	21	-59
	1999	0.57	12	11,138	20	-6
	2000	0.60	6	14,607	24	24
	2001	0.62	3	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	-8
	2005	0.28	-6	13,172	47	-10
	2006	0.37	34	11,817	32	-33
	2007	0.47	25	10,525	23	-29
	2008	0.41	-13	9,580	24	5
	2009	0.42	4	15,782	37	58
	2010	0.42	-1	13,565	33	-13
	2011	0.44	5	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	2
	2018	0.42	-2	15,797	38	33
	2019	0.48	15	12,649	26	-31
	2020	0.52	9	12,645	24	-8
	2021	0.51	-2	13,410	26	8
Greenland 14b	1991	1.0		875	1	
	1992	1.0	-3	1,176	1	39
	1993	2.5	160	2,249	1	-27
	1994	3.3	32	3,125	1	5
	1995	3.3	-2	5,077	2	66
	1996	3.1	-5	7,283	2	51
	1997	3.2	2	8,558	3	15
	1998	3.1	-3	5,940	2	-28
	1999	2.3	-24	5,376	2	19
	2000	2.1	-9	6,958	3	43
	2001	2.2	7	7,216	3	-3
	2002	2.4	8	6,621	3	-15
	2003	2.4	0	8,017	3	21
	2004	2.3	-6	9,854	4	31
	2005	3.2	40	10,185	3	-26
	2006	3.3	3	8590	3	-18
	2007	3.1	-5	10261	3	26
	2008	3.1	0	8,952	3	-13
	2009	2.6	-17	10,567	4	42
	2010	2.7	4	10,402	4	-5
	2011	2.7	0	10,761	4	4
	2012	3.1	17	12,475	4	-1
	2013	2.9	-8	12,476	4	8
	2014	3.1	5	7,526	2	-43
	2015	3.4	11	9,534	3	14
	2016	4.3	26	7,534	2	-37
	2017	4.2	-3	7,466	2	2
	2018	4.0	-4	8,228	2	14
	2019	3.9	-3	8,615	2	8
	2020	3.7	-4	7,864	2	-5
	2021	3.3	-12	8,238	2	19
Faroe Islands 5b	1995	1.00		3,832	4	
	1996	0.98	-2	6,469	7	72
	1997	0.98	-1	4,870	5	-24
	1998	0.95	-3	3,825	4	-19
	1999	0.99	4	4,057	4	2
	2000	0.98	-1	5,079	5	26
	2001	0.98	0	3,951	4	-22
	2002	0.92	-6	209	0	-94
	2003	0.98	6	265	0	19
	2004	0.92	-6	1,771	2	609
	2005	0.94	1	892	1	-50
	2006	0.94	1	873	1	-3
	2007	0.91	-4	1,060	1	27
	2008	0.96	6	1,759	2	57
	2009	0.98	2	1,739	2	-4
	2010	0.93	-5	1,413	2	-14
	2011	0.94	1	1,489	2	4
	2012	0.97	3	2,162	2	41
	2013	0.89	-8	2,582	3	30
	2014	0.94	6	2,958	3	8
	2015	0.90	-5	3,231	4	15
	2016	0.91	1	4,658	5	42
	2017	0.86	-5	3,576	4	-19
	2018	0.80	-7	2,917	4	-12
	2019	0.83	3	1,986	2	-34
	2020	0.85	2	1,919	2	-6
	2,021	0.88	4	1,865	2	-7

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	0.84	45.8
2020	22.643	0.91	58.5
2021	23.802	0.90	61.8
2022	25.000		

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(-10,1)
Catchability Greenland survey	q_{Green}	reference	$\ln(q_{Green})$~dunif(-10,1)
Catchability Iceland CPUE	q_{cpue}	reference	$\ln(q_{cpue})$~dunif(-10,1)
Initial biomass ratio	P_1	informative	dnorm(2,0.071)
Precision survey	$1/s_{surv}^2$	low informative	dgamma(2.5,0.03)
Precision Iceland CPUE	$1/s_{cpue}^2$	low informative	dgamma(2.5,0.03)
Precision model	$1/s_P^2$	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)	32.90	9.59	27.05	32.44	38.10
K (ktons)	901	251	721	890	1067
r	0.16	0.07	0.11	0.15	0.20
q_{cpue}	0.003	0.001	0.002	0.002	0.003
q_{Survey}	0.23	0.08	0.17	0.21	0.27
P_{1985}	1.57	0.12	1.49	1.57	1.65
P_{2020}	0.79	0.11	0.72	0.79	0.86
s_{cpue}	0.09	0.02	0.08	0.09	0.10
s_{Survey}	0.20	0.03	0.18	0.20	0.22
s_P	0.15	0.02	0.13	0.15	0.16

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	-2.21	0.57		-
1986	-1.11	0.54		-
1987	1.07	0.46		-
1988	3.02	0.40		-
1989	-8.79	0.77		-
1990	3.43	0.38		-
1991	-2.16	0.57		-
1992	-3.17	0.60		-
1993	0.35	0.49		-
1994	0.68	0.48		-
1995	4.71	0.35		-
1996	12.55	0.15	-22.00	0.84
1997	14.50	0.11	-36.97	0.95
1998	-2.56	0.59	-20.32	0.82
1999	-1.58	0.55	-4.89	0.59
2000	-1.52	0.55	-2.87	0.55
2001	-4.94	0.66	-16.43	0.78
2002	-4.18	0.64	14.28	0.25
2003	1.08	0.46	10.59	0.31
2004	2.04	0.43	25.65	0.12
2005	8.64	0.23	-18.60	0.81
2006	-7.39	0.74	36.74	0.05
2007	-12.76	0.86	26.82	0.11
2008	0.34	0.48	11.41	0.30
2009	2.41	0.42	-21.03	0.83
2010	-0.52	0.52	14.58	0.25
2011	0.53	0.48	-1.99	0.54
2012	1.99	0.43	-13.15	0.73
2013	1.13	0.46	-17.26	0.79
2014	4.28	0.36	-8.17	0.65
2015	0.59	0.48	-11.50	0.70
2016	1.35	0.46	-5.79	0.61
2017	4.05	0.37	-23.38	0.86
2018	2.32	0.42	7.72	0.36
2019	-7.06	0.72	37.35	0.04
2020	-6.97	0.72	21.06	0.17
2021	-3.87	0.62	17.64	0.21

Table 17.5.5. Stock status for 2021 and predicted to the end of 2022 assuming catches of 25000 t in 2022.

Status	2021	2022
Risk of falling below B_{lim} ($0.3B_{MSY}$)	0%	0%
Risk of falling below B_{MSY}	100%	79%
Risk of exceeding F_{MSY}	43%	44%
Risk of exceeding F_{lim} ($1.7F_{MSY}$)	7%	9%
Stock size (B/Bmsy), median	0.79	0.80
Fishing mortality (F/Fmsy),	0.94	0.93
Productivity (% of MSY)	95%	96%

*Predicted catch in 2022 = 25ktons

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	2.000	2.138	1.863	0.000	0.803	1.212	0.531
1961	2.000	2.131	1.869	0.029	0.000	0.001	0.000
1962	2.000	2.127	1.872	3.071	0.047	0.102	0.028
1963	1.992	2.118	1.867	4.275	0.066	0.142	0.039
1964	1.982	2.109	1.860	4.748	0.074	0.159	0.044
1965	1.973	2.101	1.851	7.421	0.115	0.249	0.069
1966	1.960	2.088	1.837	8.030	0.126	0.272	0.075
1967	1.947	2.076	1.824	9.597	0.152	0.326	0.090
1968	1.932	2.064	1.809	8.337	0.133	0.285	0.079
1969	1.923	2.056	1.799	26.200	0.419	0.902	0.248
1970	1.871	2.014	1.740	33.823	0.558	1.191	0.326
1971	1.810	1.965	1.660	28.973	0.496	1.051	0.287
1972	1.769	1.931	1.609	26.473	0.464	0.983	0.266
1973	1.739	1.907	1.573	20.463	0.365	0.776	0.207
1974	1.727	1.896	1.563	36.280	0.652	1.395	0.368
1975	1.679	1.859	1.497	23.494	0.435	0.933	0.243
1976	1.666	1.849	1.484	6.045	0.113	0.244	0.063
1977	1.697	1.872	1.524	16.578	0.302	0.666	0.169
1978	1.699	1.874	1.524	14.349	0.261	0.580	0.146
1979	1.707	1.881	1.528	23.622	0.427	0.960	0.239
1980	1.689	1.868	1.506	31.157	0.569	1.284	0.316
1981	1.656	1.844	1.466	19.239	0.359	0.814	0.198
1982	1.656	1.845	1.461	32.441	0.605	1.385	0.333
1983	1.623	1.821	1.421	30.891	0.588	1.352	0.321
1984	1.597	1.806	1.387	34.024	0.658	1.527	0.356
1985	1.567	1.785	1.346	32.075	0.633	1.478	0.340
1986	1.549	1.962	1.238	32.984	0.659	1.545	0.339
1987	1.490	1.923	1.177	46.622	0.968	2.268	0.496
1988	1.445	1.872	1.134	51.118	1.094	2.565	0.559
1989	1.526	1.983	1.180	61.396	1.249	2.932	0.628
1990	1.235	1.612	0.965	39.326	0.986	2.310	0.503
1991	1.161	1.508	0.904	37.950	1.014	2.372	0.514
1992	1.035	1.344	0.807	35.487	1.064	2.499	0.539
1993	0.853	1.108	0.670	41.247	1.496	3.500	0.762
1994	0.701	0.911	0.550	37.190	1.642	3.832	0.839
1995	0.587	0.770	0.462	36.288	1.908	4.472	0.983
1996	0.542	0.720	0.426	35.932	2.043	4.808	1.050
1997	0.594	0.795	0.466	30.309	1.574	3.694	0.804
1998	0.783	1.024	0.614	20.382	0.806	1.873	0.406
1999	0.890	1.154	0.698	20.371	0.709	1.658	0.360
2000	0.945	1.222	0.741	26.644	0.874	2.050	0.445
2001	0.939	1.218	0.733	27.291	0.902	2.113	0.455
2002	0.747	0.961	0.585	29.158	1.211	2.835	0.617
2003	0.576	0.742	0.454	30.891	1.659	3.881	0.854
2004	0.480	0.620	0.378	27.102	1.745	4.107	0.901
2005	0.483	0.628	0.381	24.249	1.552	3.641	0.798
2006	0.556	0.715	0.432	21.432	1.197	2.811	0.610
2007	0.655	0.845	0.504	20.957	0.994	2.342	0.502
2008	0.644	0.830	0.507	22.169	1.197	2.803	0.612
2009	0.675	0.876	0.532	27.349	1.254	2.940	0.640
2010	0.665	0.859	0.524	25.995	1.209	2.833	0.619
2011	0.700	0.906	0.552	26.424	1.168	2.734	0.597
2012	0.736	0.958	0.581	29.309	1.231	2.877	0.627
2013	0.749	0.976	0.590	27.045	1.118	2.612	0.568
2014	0.716	0.934	0.564	21.069	0.910	2.126	0.464
2015	0.745	0.968	0.587	25.677	1.066	2.500	0.544
2016	0.724	0.941	0.571	25.397	1.085	2.537	0.554
2017	0.705	0.920	0.557	23.466	1.029	2.408	0.524
2018	0.675	0.872	0.532	27.141	1.242	2.916	0.637
2019	0.709	0.913	0.550	23.428	1.025	2.406	0.522
2020	0.769	0.991	0.595	22.643	0.916	2.159	0.465
2021	0.785	1.020	0.604	23.802	0.941	2.244	0.475
2022	0.803	1.212	0.531				

Table 17.5.7. Catch forecast. Upper: Assumptions for interim year (2022) and Lower: catch scenarios for 2023.

Variable	Value	Source	Notes
F (2022)	0.93	ICES (2022)	F/F_{msy} set eq to catches of 25000 t in 2022
Biomass (2023)*	0.802	ICES (2022)	B/B_{MSY} when fishing at F/F_{MSY}=0.93
Total catch (2022)	25000	ICES (2022)	Based on TACs of Iceland, Greenland, and assumed catches from Faroe Islands. Tonnes

Basis	Total catch (2023) In 000 tonnes	F_{total} (2023) F/Fmsy	Biomass (2024) B/Bmsy	Biomass change *	Advice change
ICES advice basis					
MSY approach: F_{MSY}	26.710	1	0.84	5%	0.23%
Other options					
F = 0	0	0	0.88	10%	-100%
$F = F_{2021}$	25.190	0.93	0.85	6%	-5.48%
$F = F_{lim}$	45.380	1.70	0.79	-1%	70%

17.11 Figures

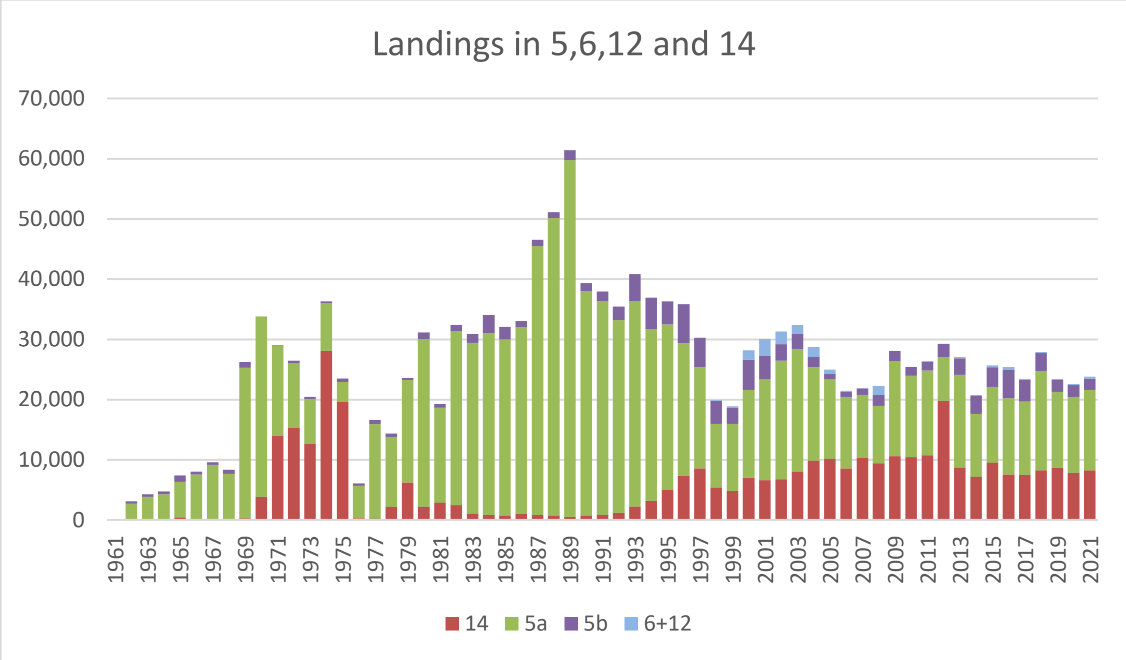


Fig. 17.1.1. Landings of Greenland halibut in Divisions 5, 6, 12 and 14. As the landings within Icelandic waters, since 1976, have not officially been separated and reported according to the defined ICES statistical areas, they are set under area 5a by the NWWG. In 2012 Icelandic landings in Div 14 were only partly recorded in 14, while for remaining years all landings are recorded in 5a.

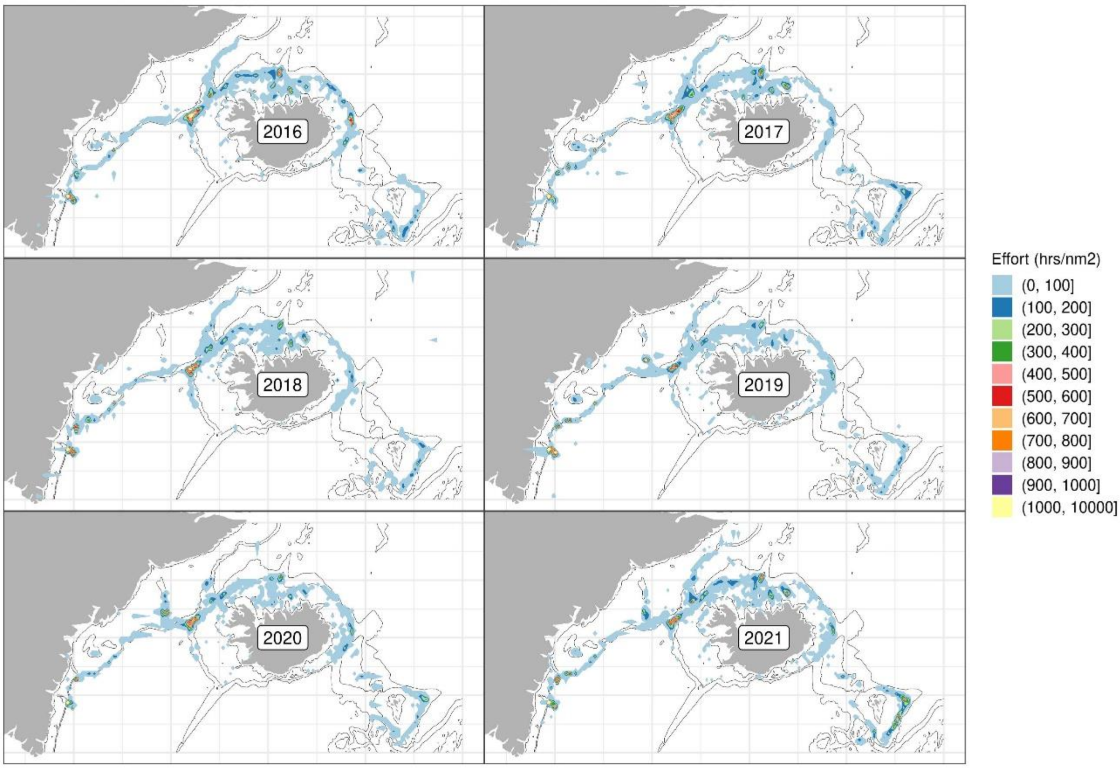


Fig. 17.1.2 Greenland halibut 5+14. Distribution of fishing effort 2016-2021. 500m and 1000 m depth contours are shown.

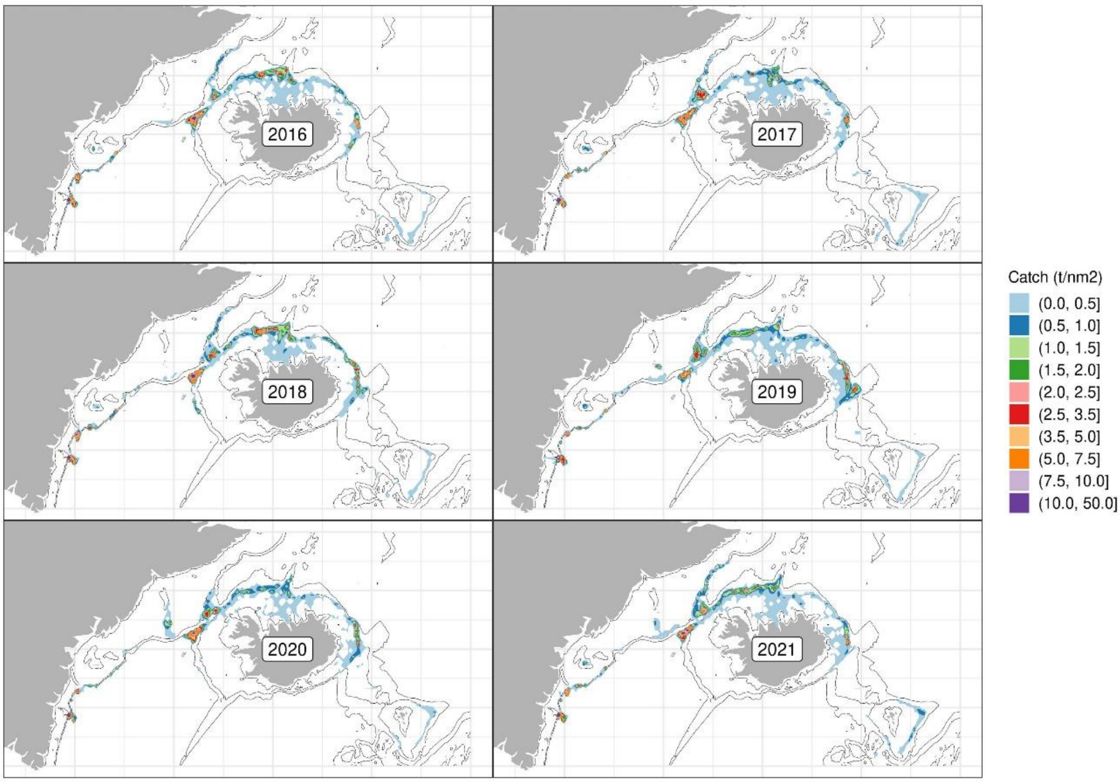


Fig. 17.1.3. Greenland halibut 5+14. Distribution of catches in the fishery 2016-2021. 500m and 1000 m depth contours are shown.

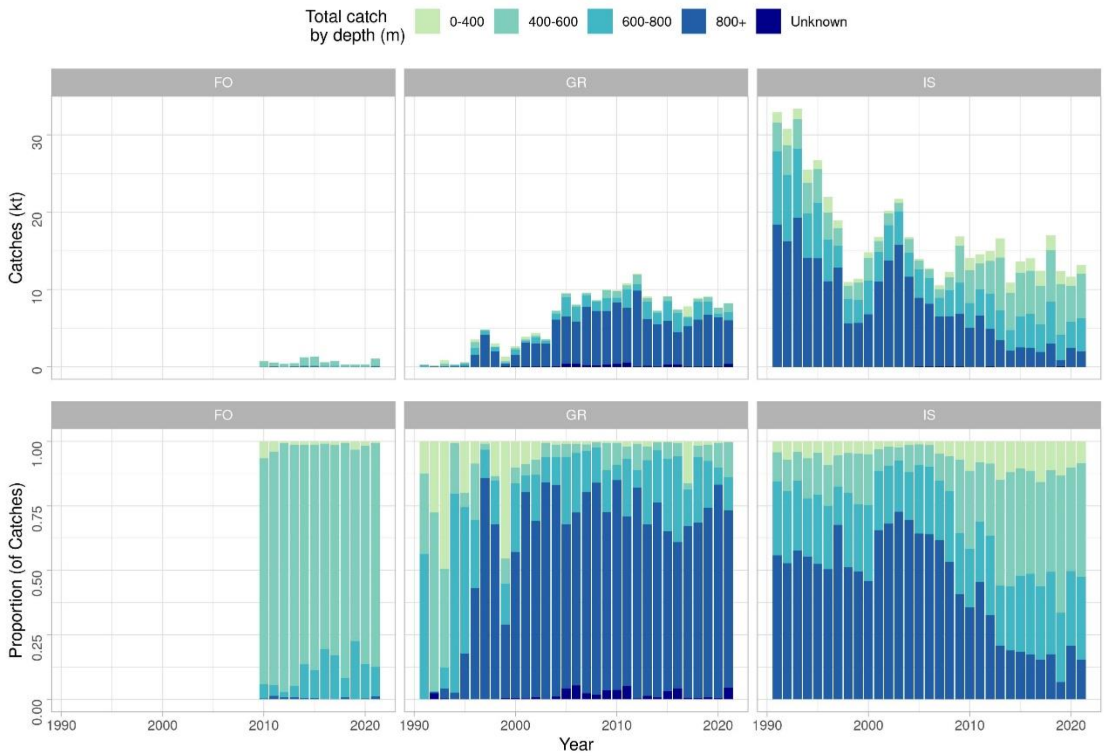


Fig 17.1.4. Greenland halibut 5+14. Depth distribution by EEZ from 1990 to 2021.

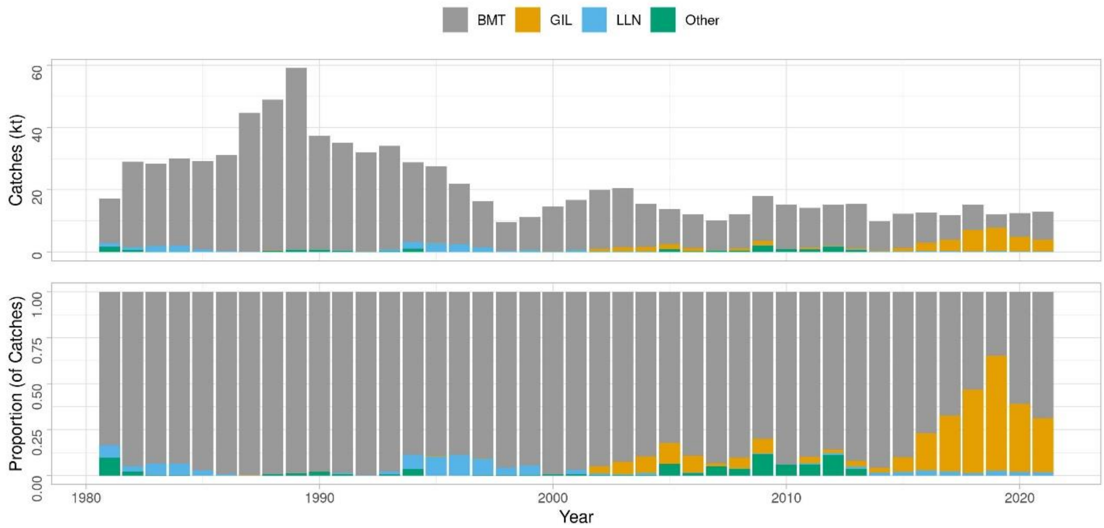


Fig. 17.1.5. Greenland halibut 5+14. Landings by gear in 5a.

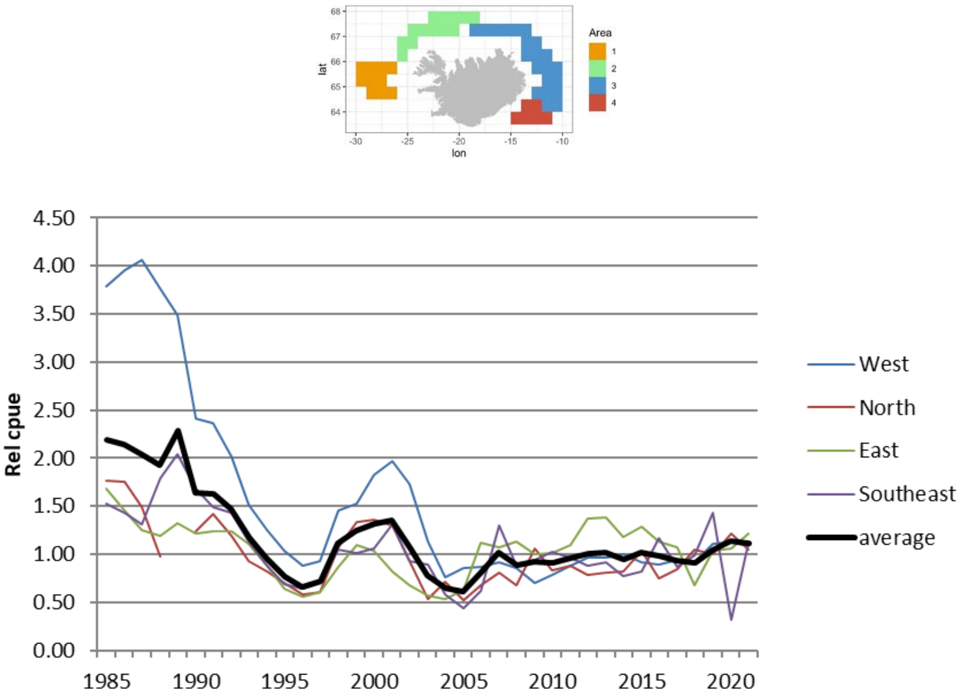


Fig. 17.2.1. Standardised CPUEs from the Icelandic trawler fleet in 5a. Area 1-4 are west, north, east and south-east, respectively. The average index of the four areas is used as biomass indicator in the stock production model.

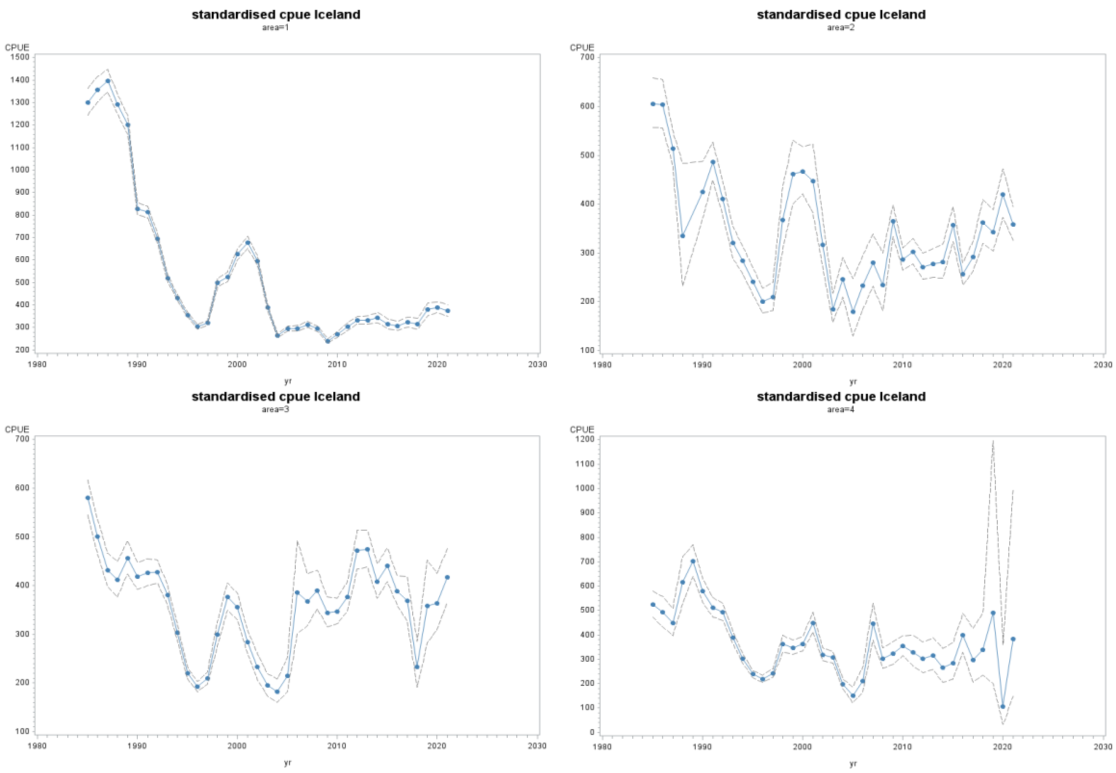


Fig. 17.2.2 Standardised CPUE from the Icelandic trawler fleet in Div 5a by four main fishing areas in 5a. 95% CI indicated. Areas 1-4 are West, North, East and South-east of Iceland, respectively. (see Fig. 17.3.1).

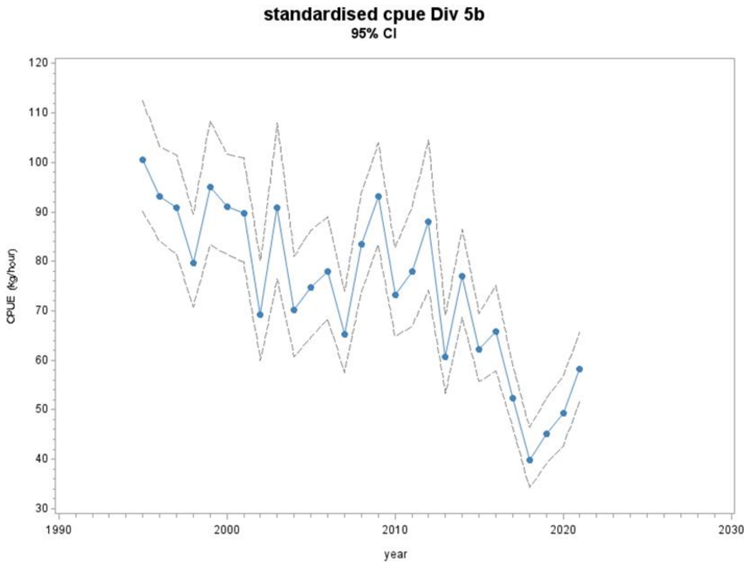


Figure 17. 2.3. Standardised CPUE from the Faroese trawler fleet. 95% CI indicated

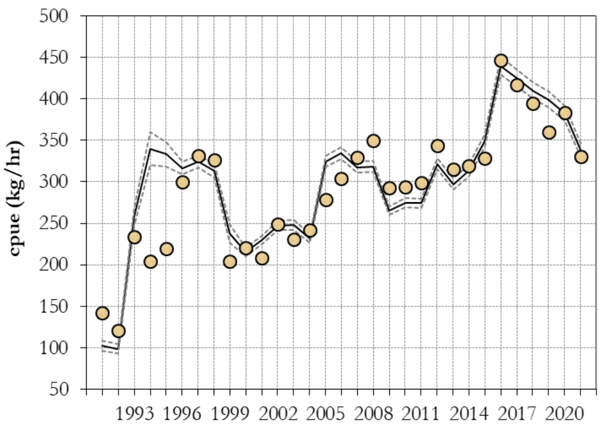


Fig. 17.2.4. Standardised CPUE from trawler fleets in 14b. 95% CI and observed CPUE (avg) indicated.

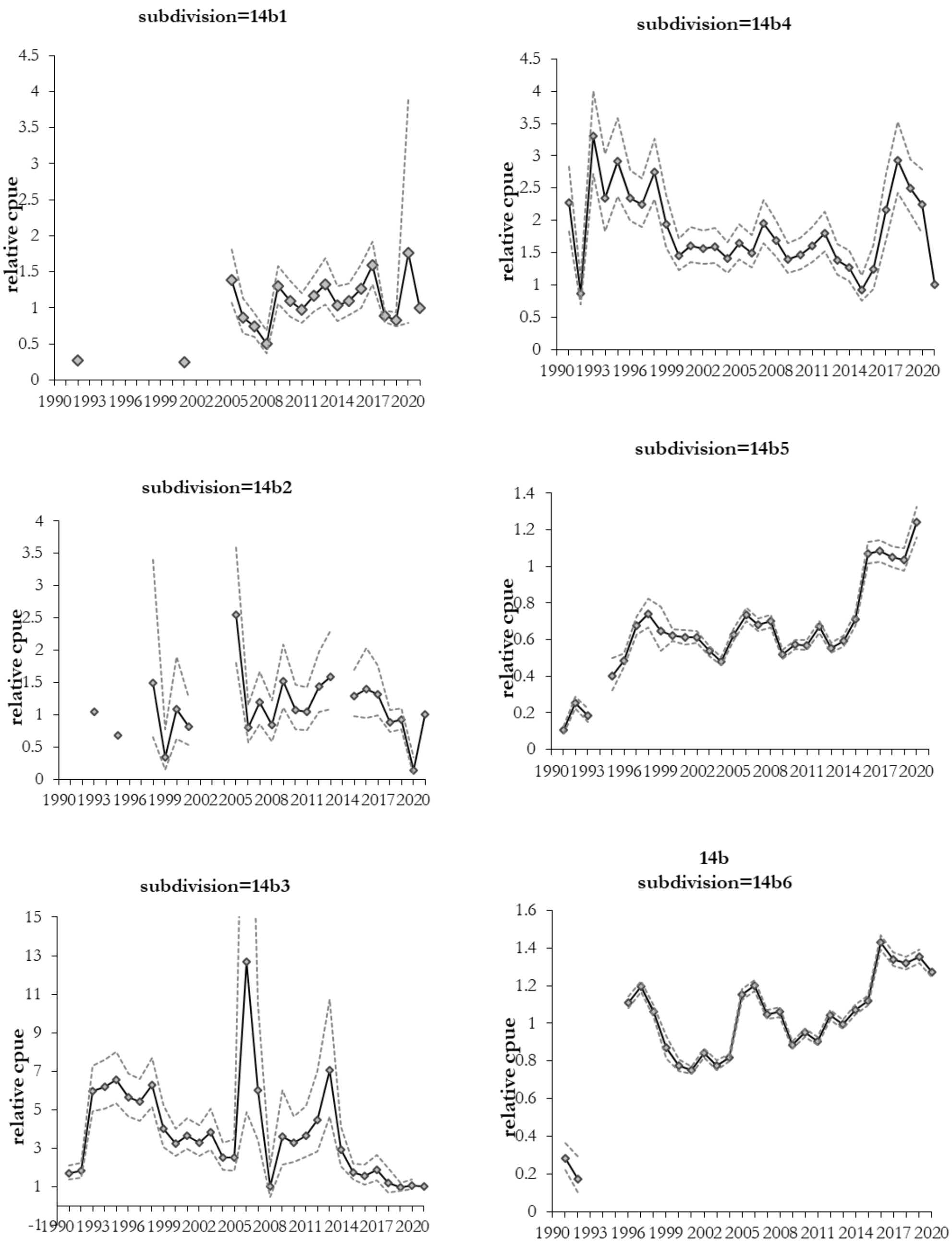


Fig. 17.2.5. Standardised CPUE from trawler fleets in 14b shown by subdivisions in a north-south direction. 95% CI indicated.

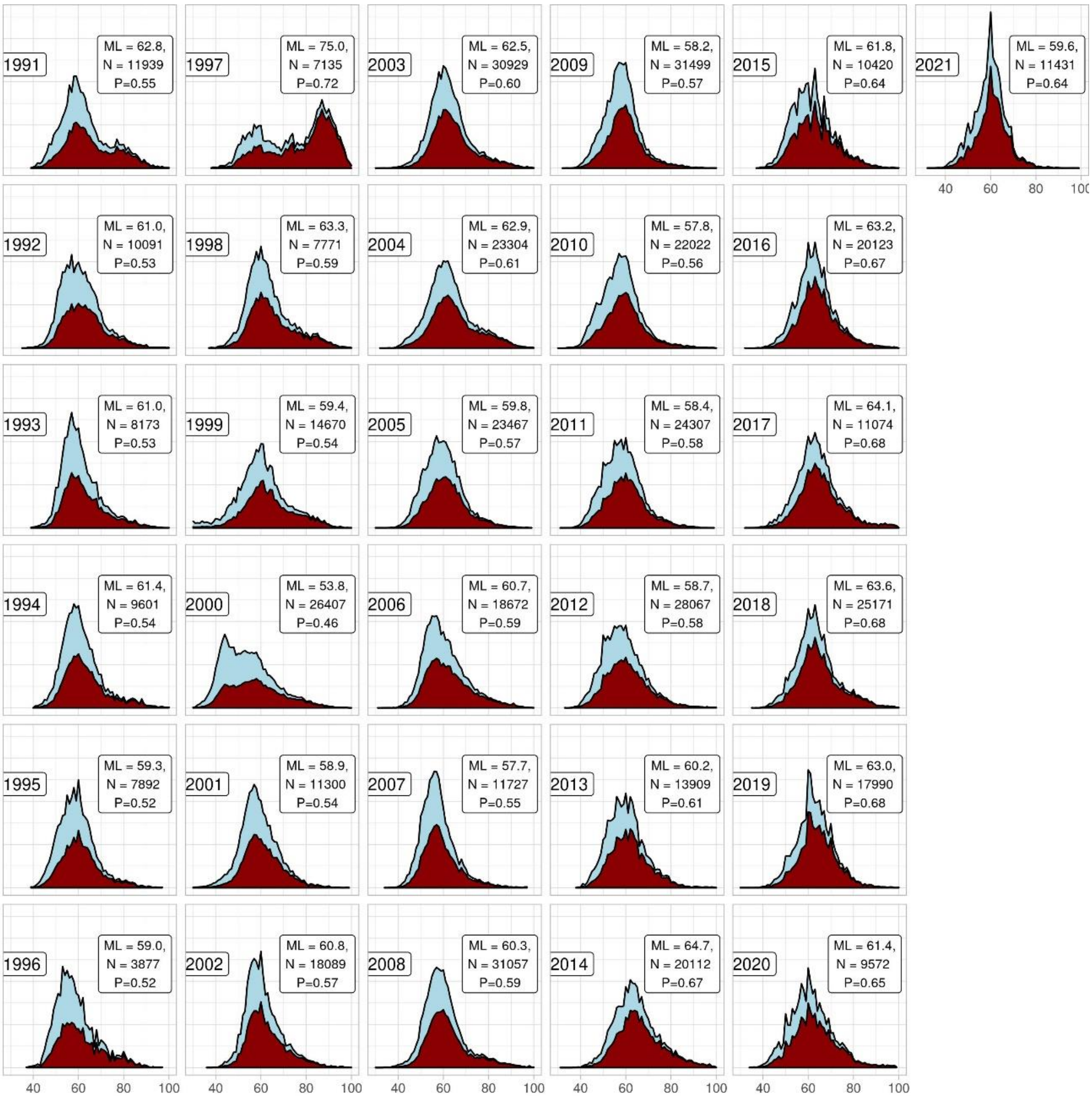


Fig. 17.3.1. Length distributions from the commercial trawl fishery in the western fishing grounds of Iceland (5a) in the years 1991-2021. Blue indicate males and red indicates females.

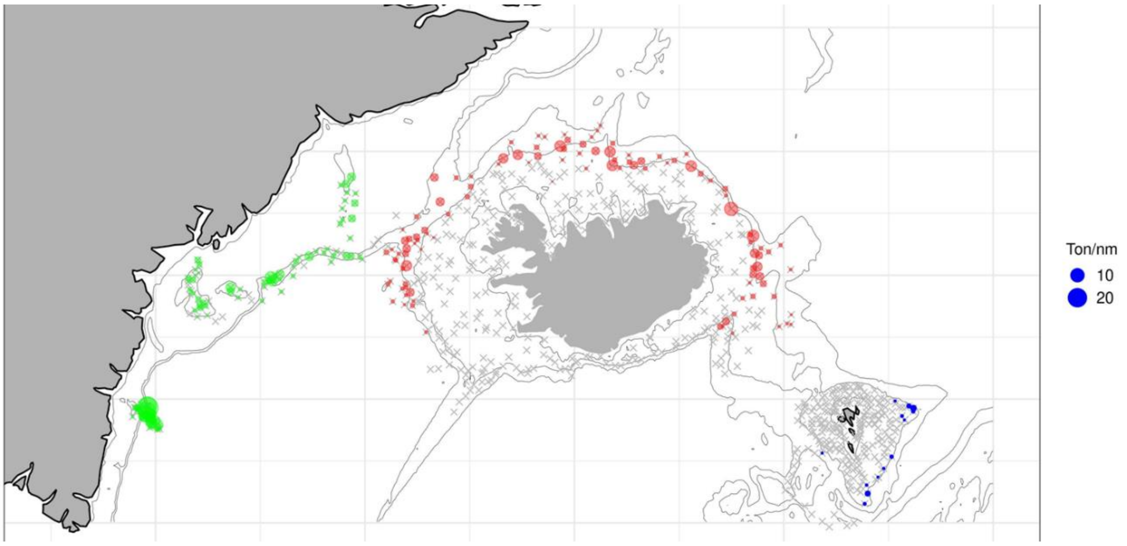


Fig. 17.4.1. Stations covered by scientific surveys in SA 5 in 2021 by Iceland. The Greenland survey stations are from last conducted survey in 2016. Red indicate Iceland survey, green is Greenland survey and blue is Faroe survey. Size of circles indicate catch rates and grey crosses are zero catches. The Greenland survey has not been conducted since 2016 and 2016 values are shown here.

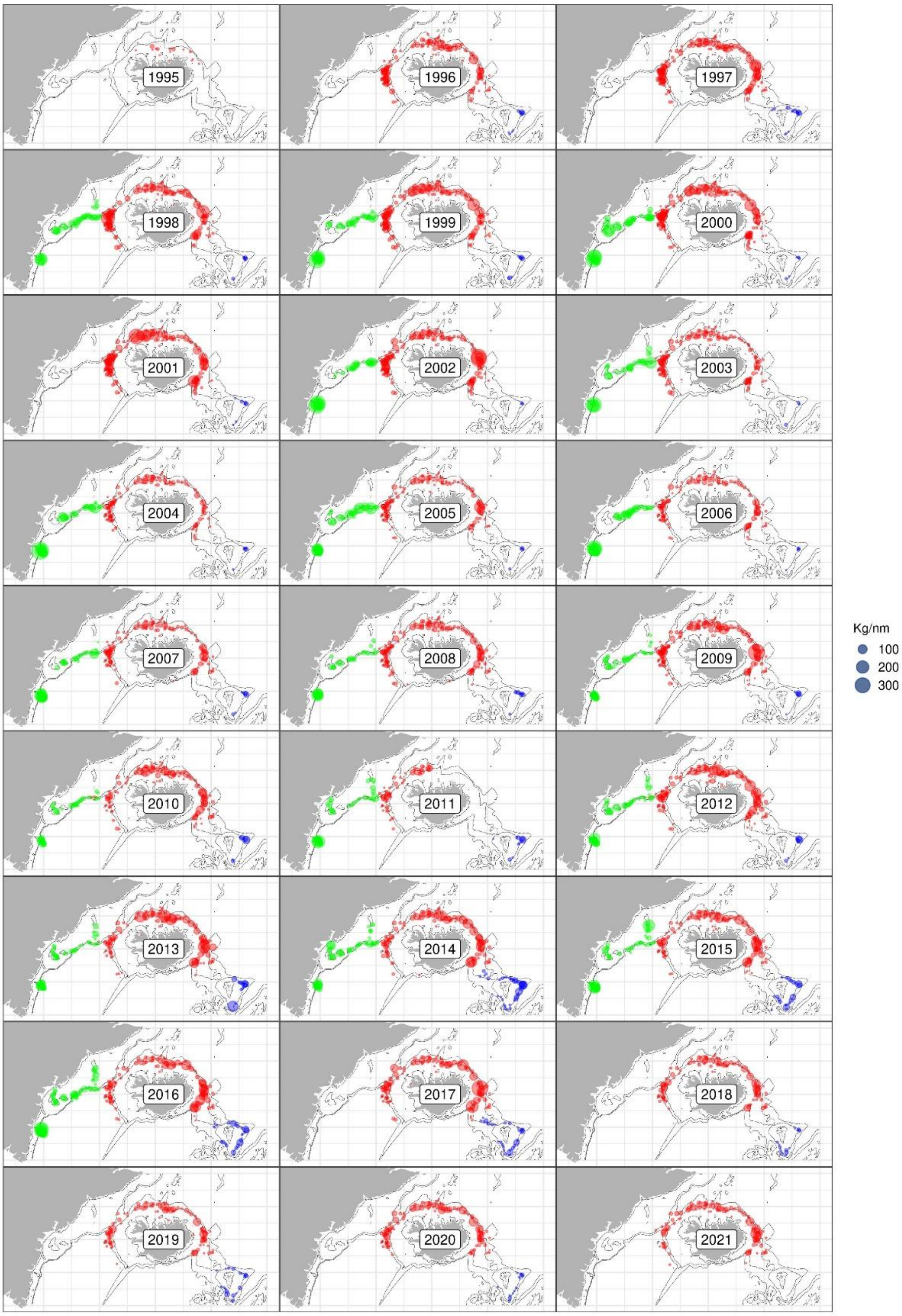


Fig. 17.4.2. Distribution of Greenland halibut catch rates from the three national surveys since 1996.

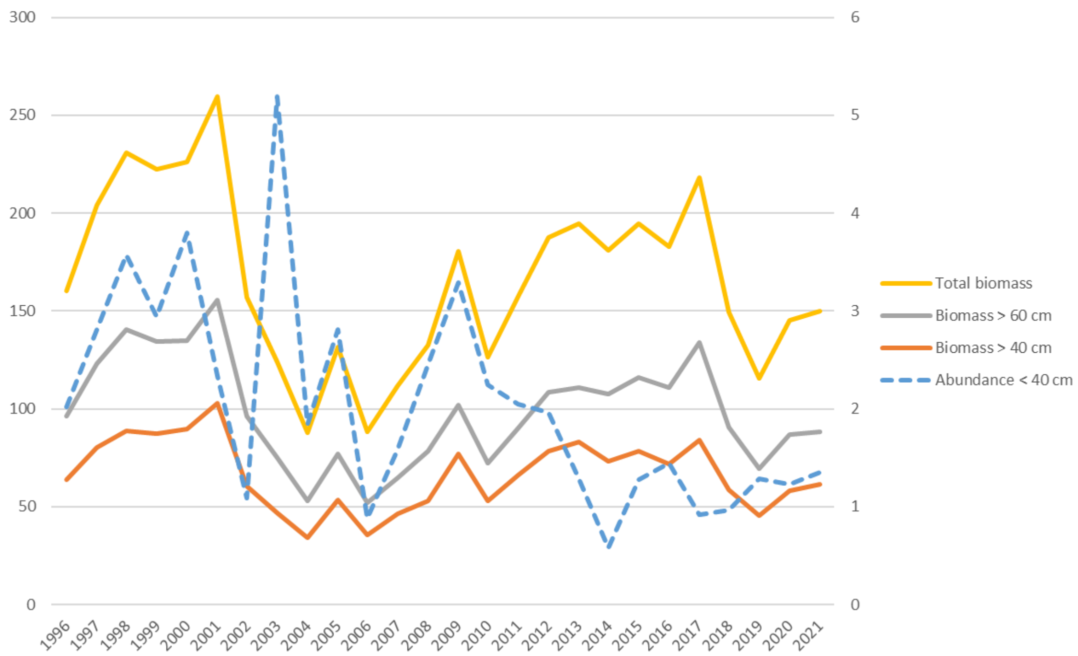


Fig. 17.4.3. Index of Greenland halibut in the Iceland, Greenland and the combined survey. No Iceland survey was conducted in 2011 and Greenland survey ceased in 2016. Greenland survey values are considered constant since 2016.

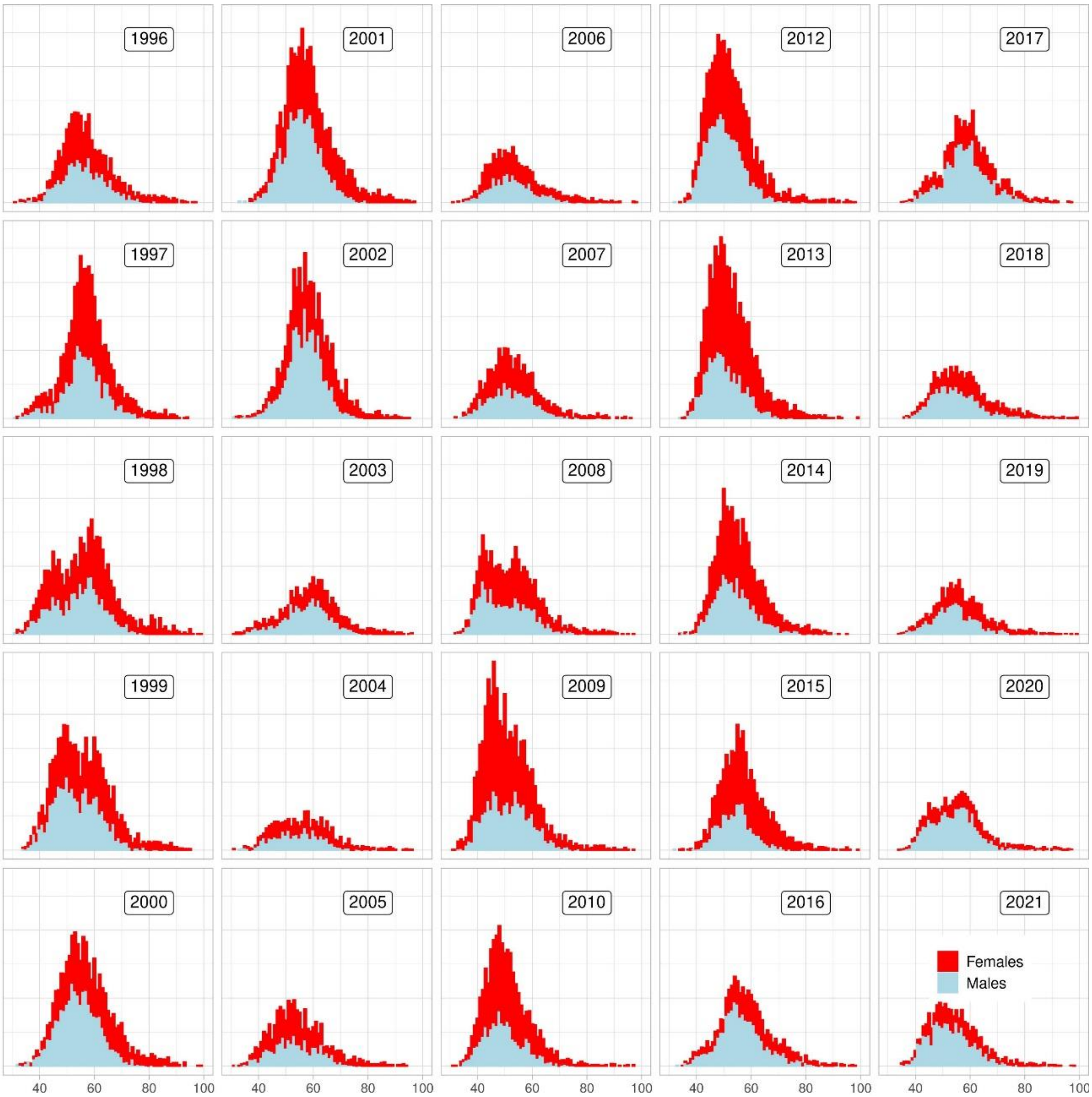


Fig. 17.4.4. Abundance indices by length for the Icelandic fall survey 1996-2021. No survey was conducted in 2011.

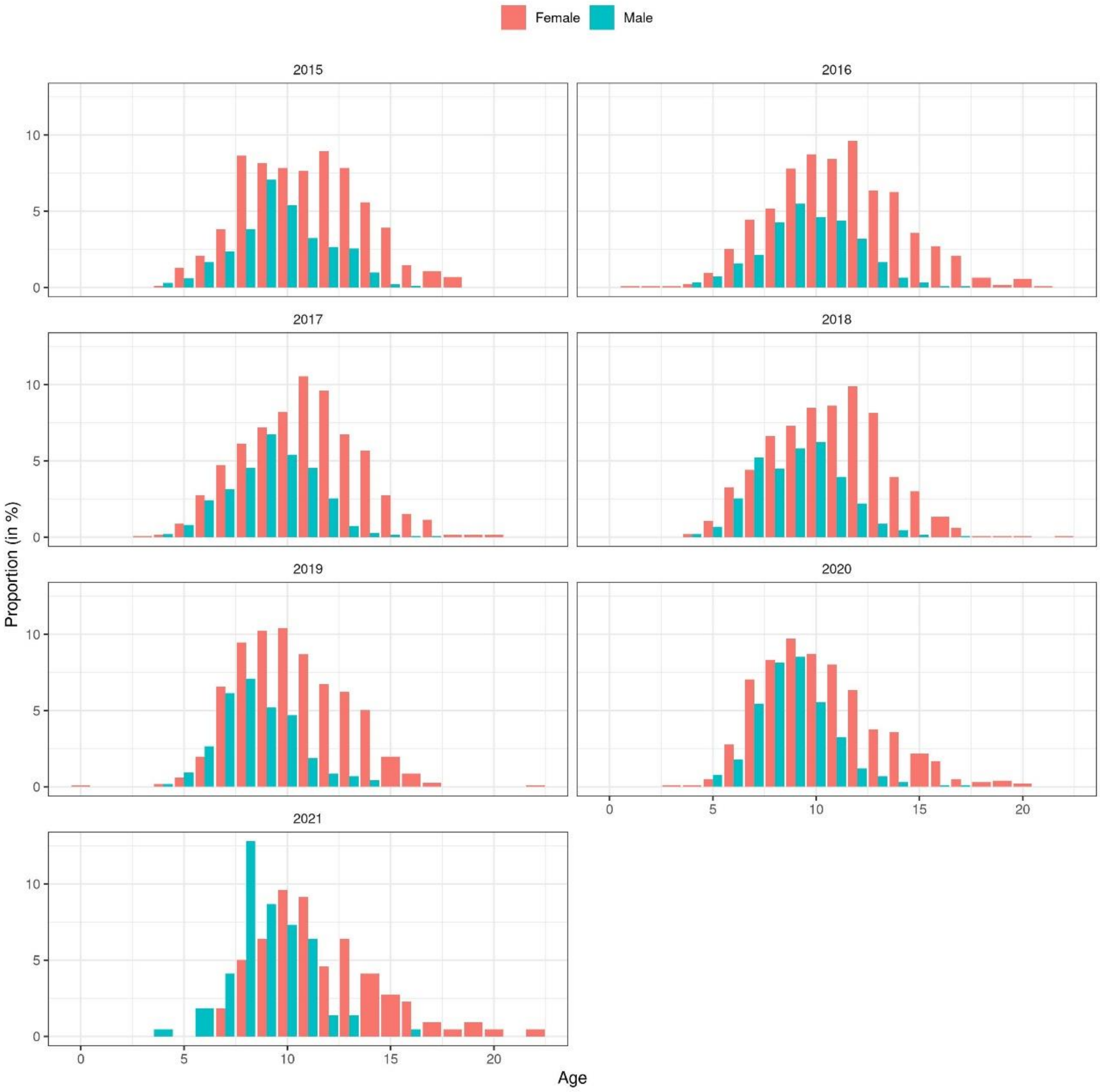


Figure 17.4.5. Age/sex distribution from Icelandic fall survey 2015-2021.

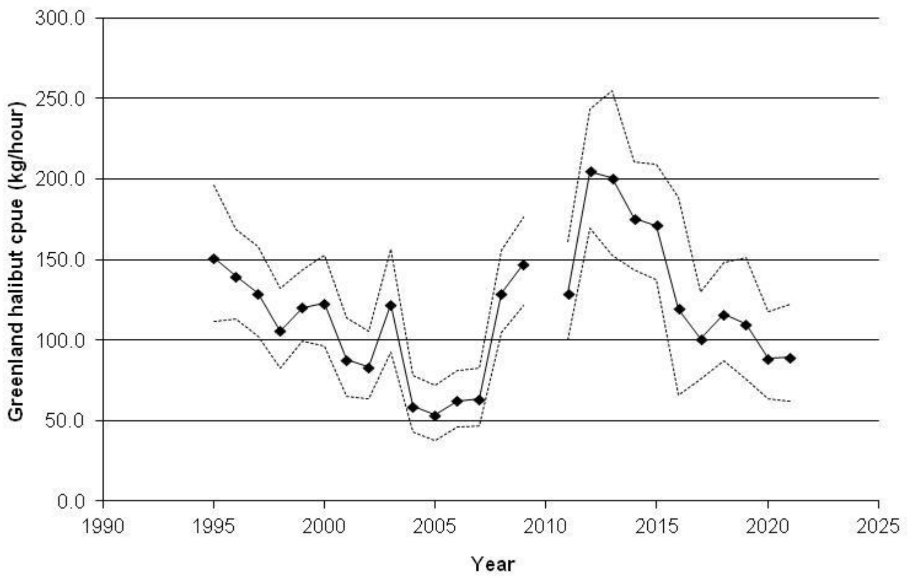


Figure 17.4.6. Standardised catch rates from a combined survey/fisherman's survey in 5b.

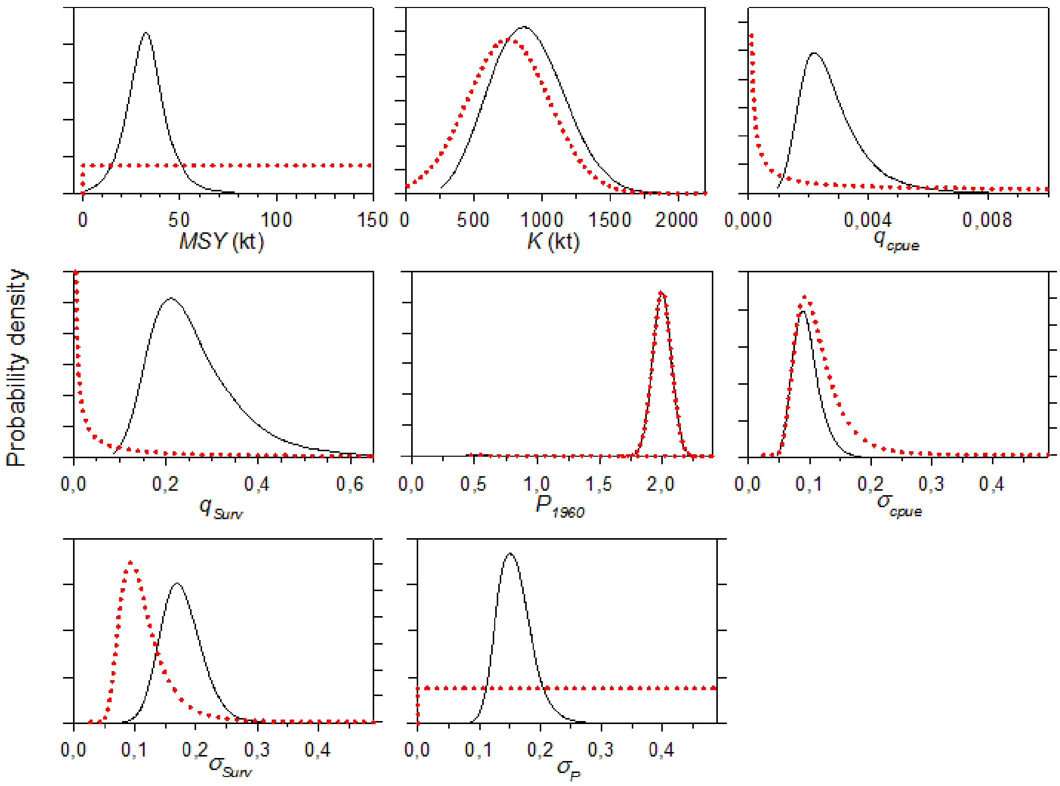


Figure 17.5.1. Probability density distributions of model parameters: estimated posterior (solid line) and prior (broken line) distributions.

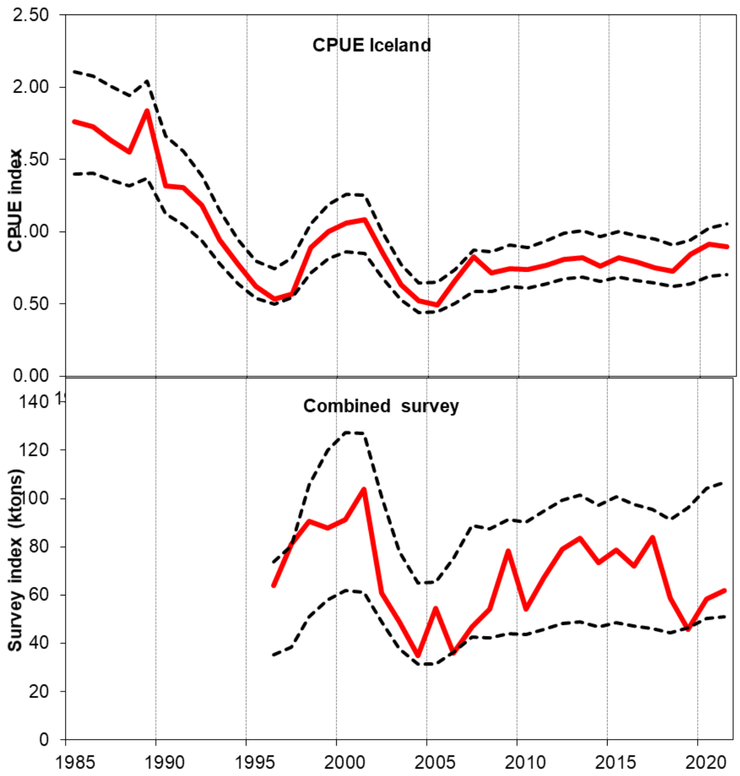


Figure 17.5.2. Observed (red curve) and predicted (dashed lines) series of the two biomass indices input to the model. Dashed lines 95% CI of the model estimates.

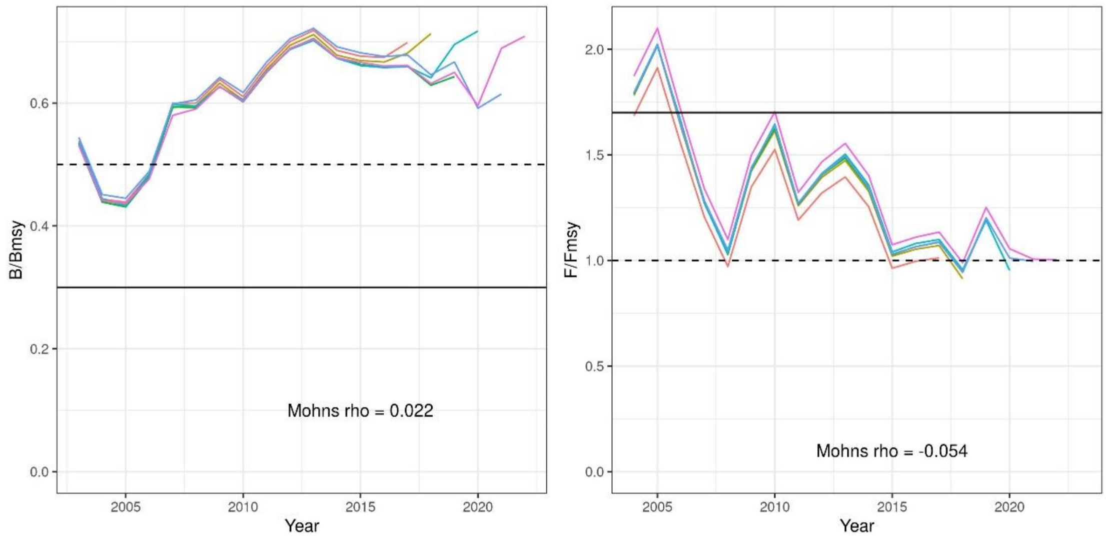


Figure 17.5.3. Retrospective analyses of medians of relative biomass (*B/B$_{msy}$*) and fishing mortality (*F/Fmsy*)

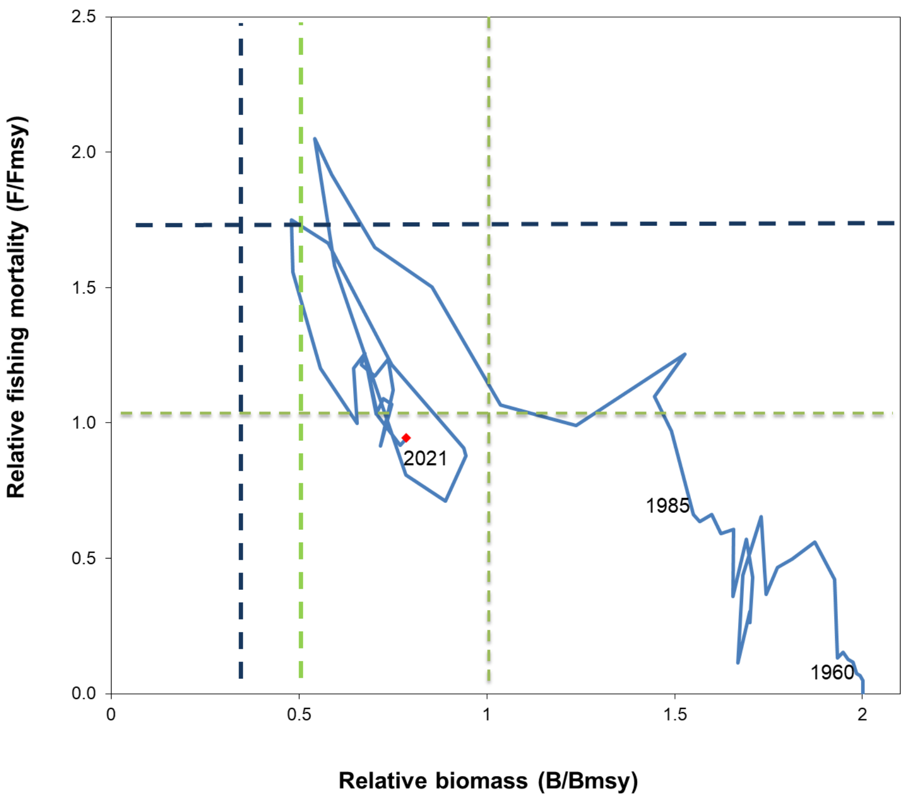


Figure 17.5.4. Stock trajectory 1960-2021. Estimated annual median biomass-ratio (B/BMSY) and fishing mortality-ratio (F/FMSY). B_{lim}, MSY $B_{trigger}$ and F_{lim} are indicated.

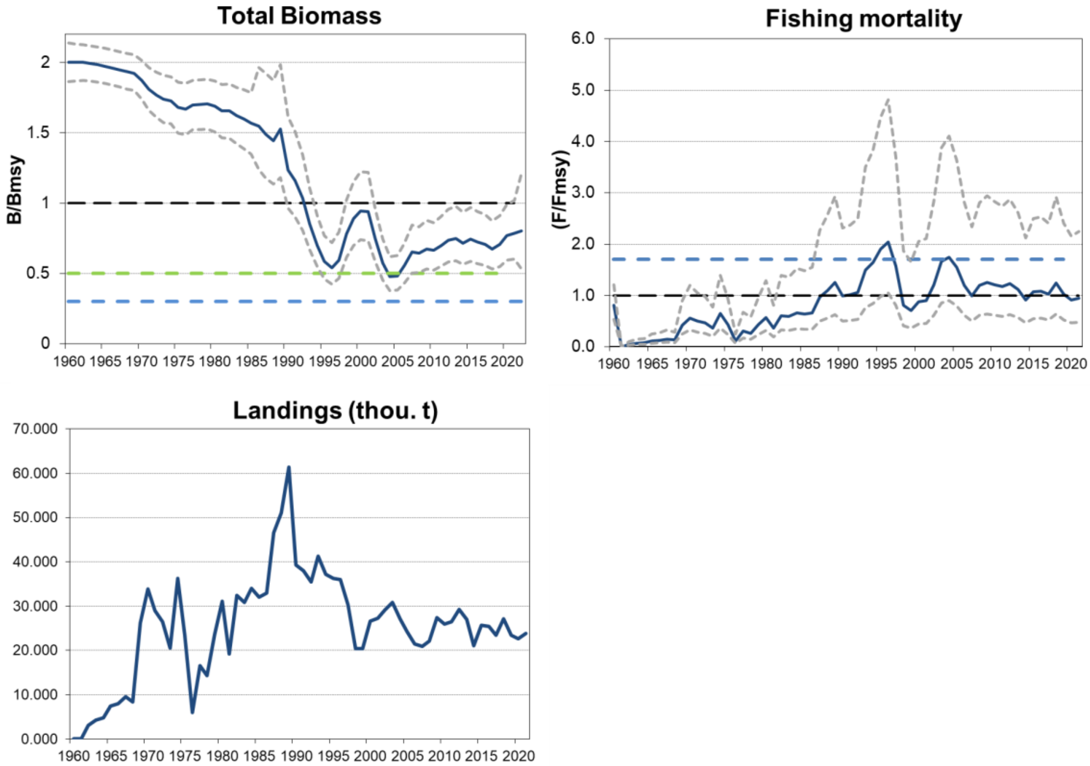


Figure 17.5.5. Stock summary, upper panel right: fishing mortality (F/Fmsy) and 95% conf limits, left: total biomass (B/Bmsy) and 95% conf limits and lower panel is landings since start of the fishery. MSY $B_{trigger}$ (green dashed line), B_{lim} and F_{lim} (blue dashed lines) are indicated.

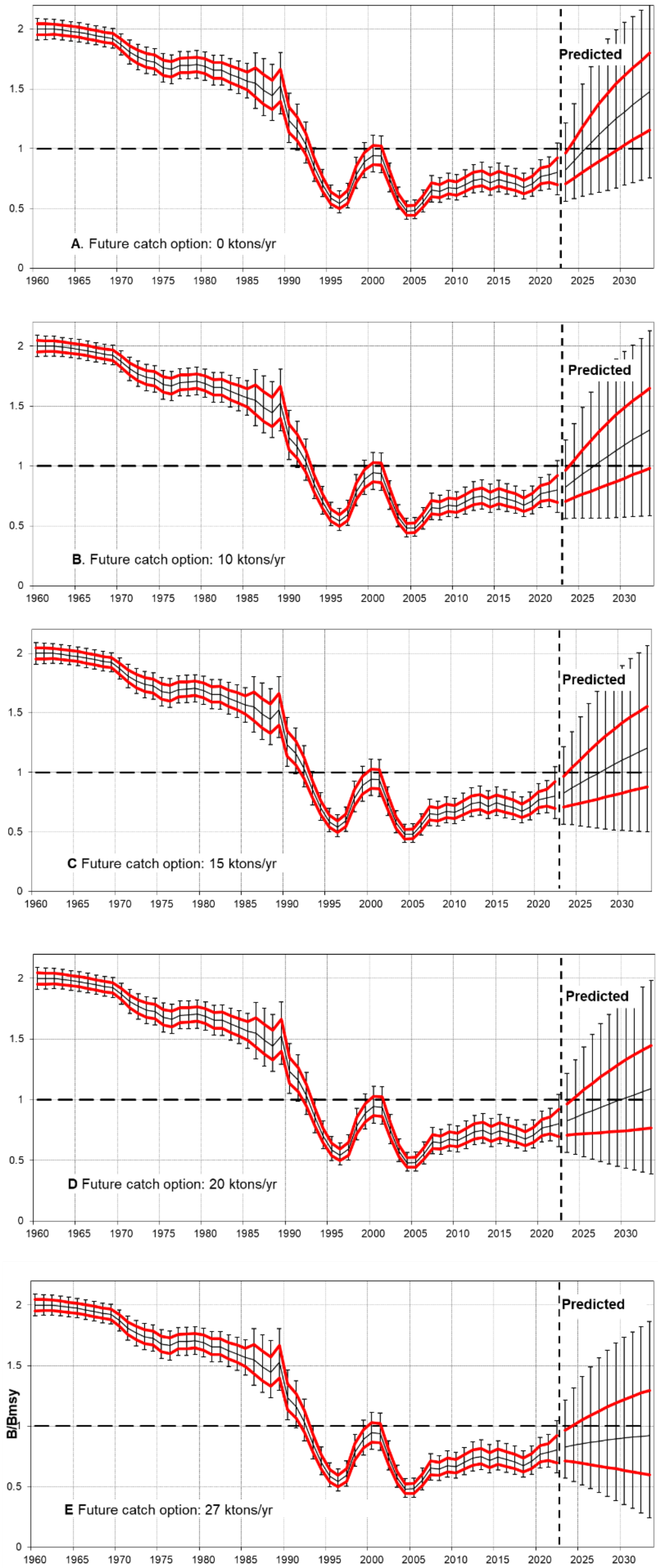


Fig. 17.5.6 Estimated time series of relative biomass (B_t/B_{msy}) under different catch option scenarios: 0, 10, 15, 20 and 27 kt catch from upper to lower panel. Bold red lines are inter-quartile ranges and the solid black line is the median; the error bars extend to cover the central 90 per cent of the distribution.

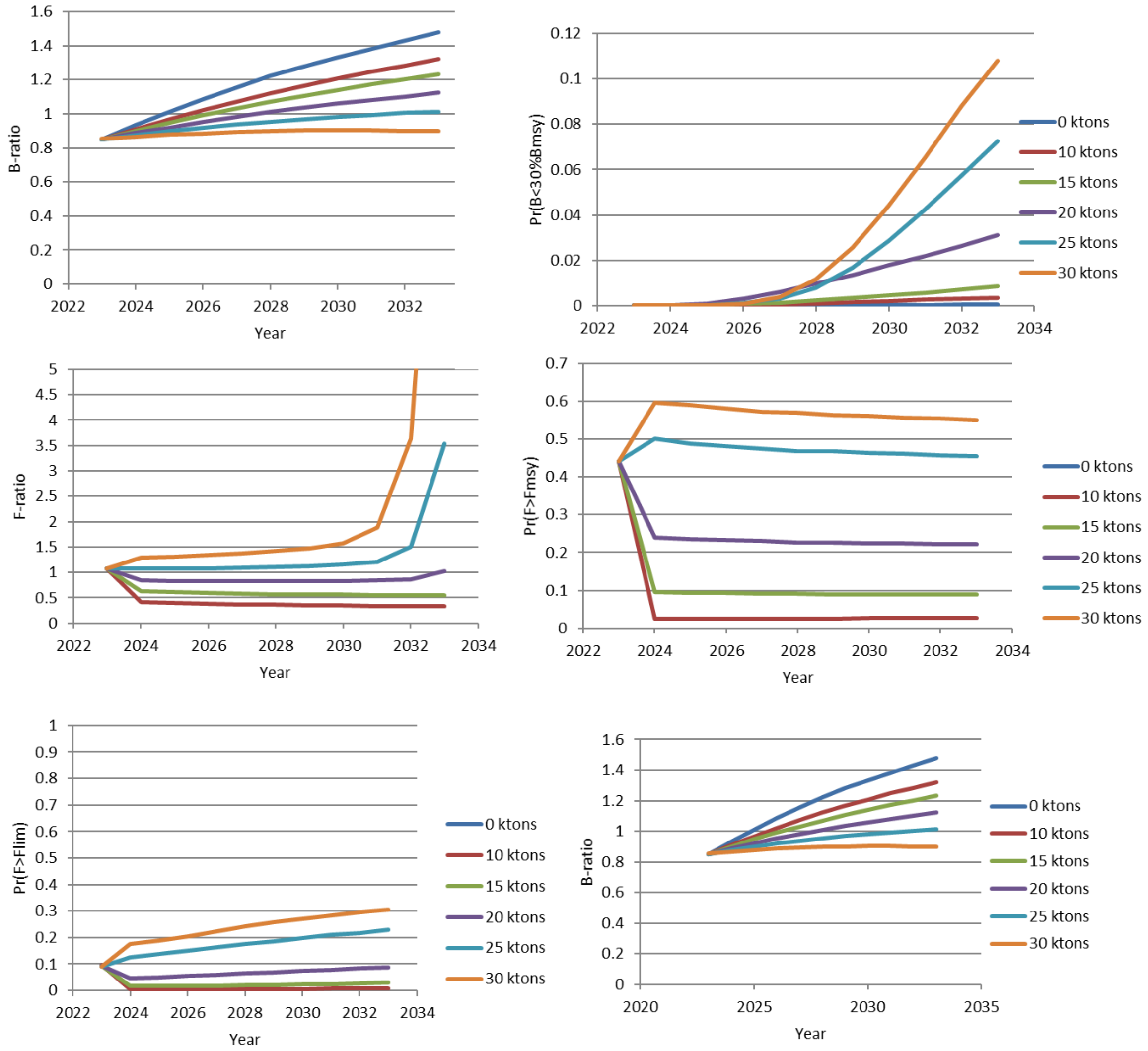


Figure 17.5.7. Projections: Medians of estimated posterior biomass- and fishing mortality ratios; estimated risk of exceeding F_{msy} or going below and $B_{MSYtrigger}$ given catch ranges at 0 -30 ktons.

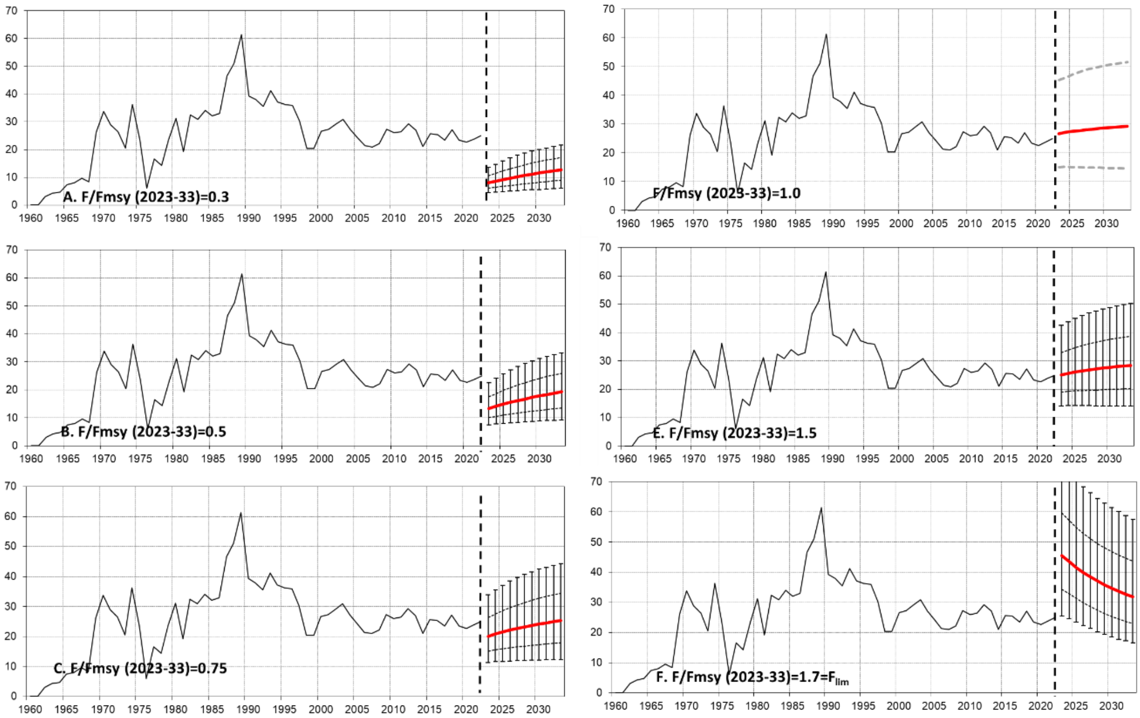


Figure 17.5.8. Historic landings and projected landings 2023-2033 under various F ratio options from 0.3-1.7 F/Fmsy Solid red line is median, quartiles and 90% conf limit indicated.

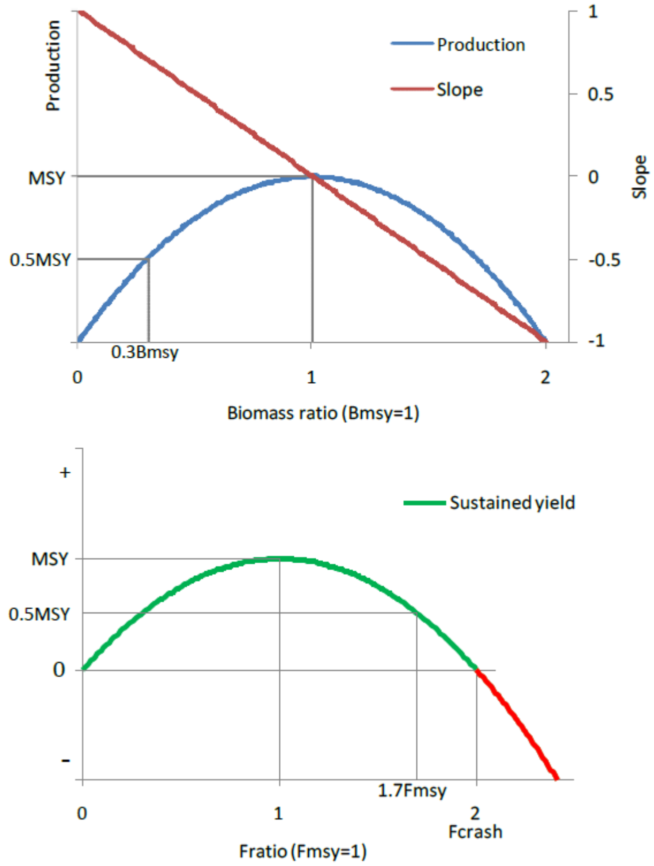


Figure 17.5.9. The logistic production curve in relation to stock biomass (B/Bmsy) (*upper*) and fishing mortality (F/Fmsy) (*lower*). *Upper*: points of maximum sustainable yield (MSY) and corresponding stock size are shown as well as the slope (red line) of the production curve (blue line); *lower*: 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 Demersal *S. mentella* in 5.b and 6

18.5.1 Demersal *S. mentella* in 5.b

18.5.1.1 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.

18.5.1.2 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 863 t in 2021.

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.

18.5.2 Demersal *S. mentella* in 6

18.5.2.1 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.

18.6 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).

18.7 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 respec-tive 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*.

18.8 References

Artamonova V., Makhrov A., Karabanov D., Rolskiy A., Bakay Yu., Popov V. 2013. Hybridization of beaked redfish (Sebastes mentella) with small redfish (S. viviparus) and diversification of redfishes in the Irminger Sea. Journal of Natural History, DOI:10.1080/00222933.2012.752539.

Einarsson, H., 1960. The fry of Sebastes in Icelandic waters and adjacent seas. Rit Fiskideildar 2: 1–67. Fernholm, B. and A. Wheeler 1983. Linnaean fish specimens in the Swedish Museum of Natural History,

Stockholm. Zool. J. Linn. Soc. 78: 199–286.

ICES 1983. Report on the NAFO/ICES Study Group on biological relationships of the West Greenland and Irminger Sea redfish stocks. ICES CM 1983/G:3, 11 pp.

ICES 1998. Report of the Study Group on Redfish Stocks. ICES CM 1998/G:3, 30 pp.

ICES. 2003. Report of the Planning Group on Redfish Stocks (PGRS), 9-10 July 2003, Hamburg, Germany.

ICES CM 2003/D:08. 43 pp.

ICES. 2005. Report of the Study Group on Redfish Stocks (SGRS), 25-27 July 2005, ICES Headquarters, Copenhagen. ICES CM 2005/D:03. 49 pp.

ICES. 2007. Report of the Study Group on Redfish Stocks (SGRS), 31 July -2 August 2007, Hamburg, Germany. ICES CM 2007/RMC:12. 54 pp.

ICES. 2009a. Report of the Workshop on Redfish Stock Structure (WKREDS), 22-23 January 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:37. 71 pp.

ICES. 2009b. Report of the Planning Group on Redfish Surveys (PGRS), 28-30 July 2009, Reykjavík, Iceland.

ICES CM 2009/RMC:05. 56 pp.

ICES. 2012. Report of the Third Workshop on Redfish and Oceanographic Conditions (WKRDOCE3), 16-17 August 2012, Johann Heinrich von Thunen Institute, Hamburg, Germany. ICES CM 2012/ACOM:25. 70 pp.

ICES. 2013a. Report of the Working Group on Redfish Surveys (WGRS), 6-8 August 2013, Hamburg, Germany. ICES CM 2013/SSGESST:14. 56 pp.

ICES. 2013b. ICES Advice 2013, Book 2.

Magnússon, J. and Magnússon, J.V. 1975. On the distribution and abundance of young redfish at Iceland 1974. Rit Fiskideilar 5(3), 22 pp.

Magnusson, J., Kosswig, K. and Magnusson, J.V. 1988. Young redfish on the nursery grounds in the East Greenland shelf area. ICES CM 1988/G:38, 13 pp.

Magnusson, J., Kosswig, K. and Magnusson, J.V. 1990. Further studies on young redfish in the East Greenland shelf area. ICES CM 1990/G:43, 15 pp.

Magnússon, J.V. and Jóhannesson, G. 1997. Distribution and abundance of 0-group redfish in the Irminger Sea and off East Greenland: relationships with adult abundance indices. ICES J. Mar. Sci. 54, 830-845.

Makhrov A. A., Artamonova V. S., Popov, V. I., Rolskiy A. Yu., and Bakay Y. I. 2011. Comment on: Cadrinet al. (2010) "Population structure of beaked redfish, Sebastes mentella: evidence of divergence associated with different habitats. ICES Journal of Marine Science, 67: 1617– 1630.

Malmberg, S. A. Mortensen, J., and Jonsson, S. 2001. Ocean fluxes in Icelandic waters, 2001. ICES CM 2001/W: 08

Mortensen, J., and Valdimarsson. H. 1999. Thermohaline changes in the Irminger Sea. ICES CM 1999/L: II. 11 pp

Palsson, Ó. K., Steinarsson, B. Æ., Jonsson, E., Gudmundsson, G, Stefansson, G., Bjornsson, H. and Schopka, S.A. 1997. Icelandic groundfish survey. ICES CM 1997/Y:29, 35 pp.

Pedchenko, A. P. 2005. The role of interannual environmental variations in the geographic range of spawning and feeding concentrations of redfish Sebastesmentella in the Irminger Sea. ICES Journal of Marine Science 62: 1501-1510.

Saborido-Rey, F., Garabana, D., Stransky, C., Melnikov, S. and Shibanov, V. 2004. Review of the population structure and ecology of S. mentella in the Irminger Sea and adjacent waters. Rev. Fish Biol. Fish. 14: 455-479.

Saha, A., Johansen, T., Hedeholm, R., Nielsen, E.E., Westgaard, J-I., Hauser, L., Planque, B., Cadrin, S.X. and Boje, J. 2016. Geographic extent of introgression in Sebastes mentella and its effect on genetic population structure. Evolutionary Application 1-14. DOI: 10.1111/eva.12429.

Sigurdsson, T., Kristinsson, K., Rätz, H.-J., Nedreaas, K.H., Melnikov, S.P. and Reinert, J. 2006. The fishery for pelagic redfish (Sebastes mentella) in the Irminger Sea and adjacent waters. ICES J. Mar. Sci., 63: 725-736.

Stransky, C. 2000. Migration of juvenile deep-sea redfish (Sebastes mentellaTravin) from the East Greenland shelf into the central Irminger Sea. ICES CM 2000/N:28, 10 pp.

Zelenina D.A., Shchepetov D.M., Volkov A.A., Barmitseva A.E., Mel'nikov S.P., Miuge N.S. 2011. Population structure of beaked redfish (Sebastes mentellaTravin, 1951) in the Irminger Sea and adjacent waters inferred from microsatellite data. Genetika. 2011 Nov; 47(11):1501-13.

18.9 Tables

Table 18.4.1. Landings of *S. viviparus* in Division 5.a 1996–2021.

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
2021	96

Table 18.6.1. Nominal landings (tonnes) of demersal *S. mentella* 1978–2021 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	375	0
2018	438	0
2019	367	0
2020	427	0
2021[1)]	863	0

1) Provisional

18.10 Figures

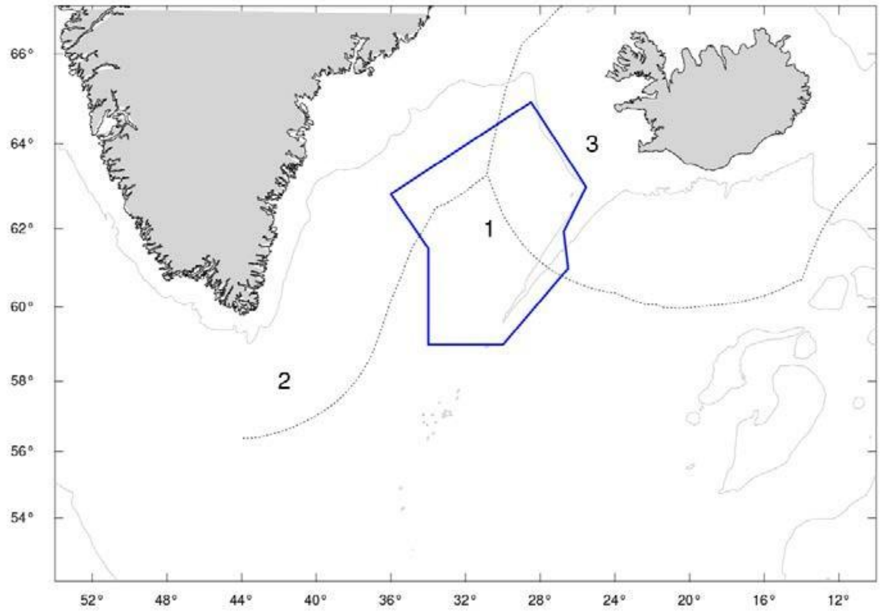


Figure 18.1.1 Potential management unit boundaries. The polygon bounded by blue lines, i.e., 1, indicates the region for the 'deep pelagic' management unit in the northwest Irminger Sea, 2 is the "shallow pelagic" management unit in the southwest Irminger Sea, and 3 is the Icelandic slope management unit.

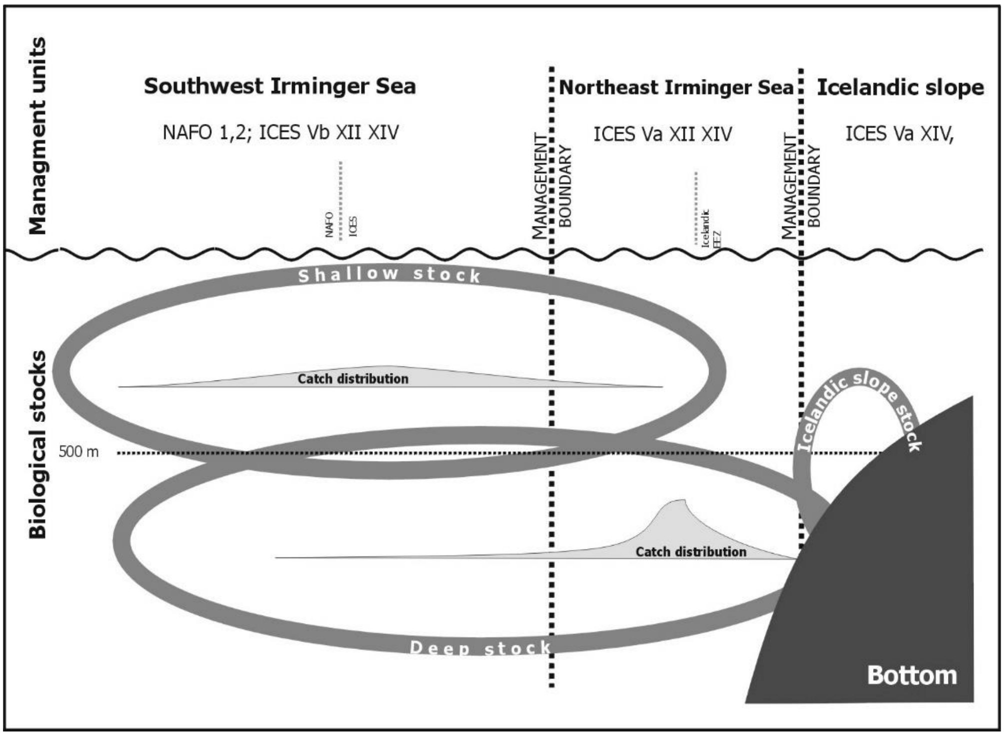


Figure 18.1.2 Schematic representation of biological stocks and potential management units of *S. mentella* in the Irminger Sea and adjacent waters. The management units are shown in Figure 18.1.1. Included is a schematic representation of the geographical catch distribution in recent years. Note that 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.

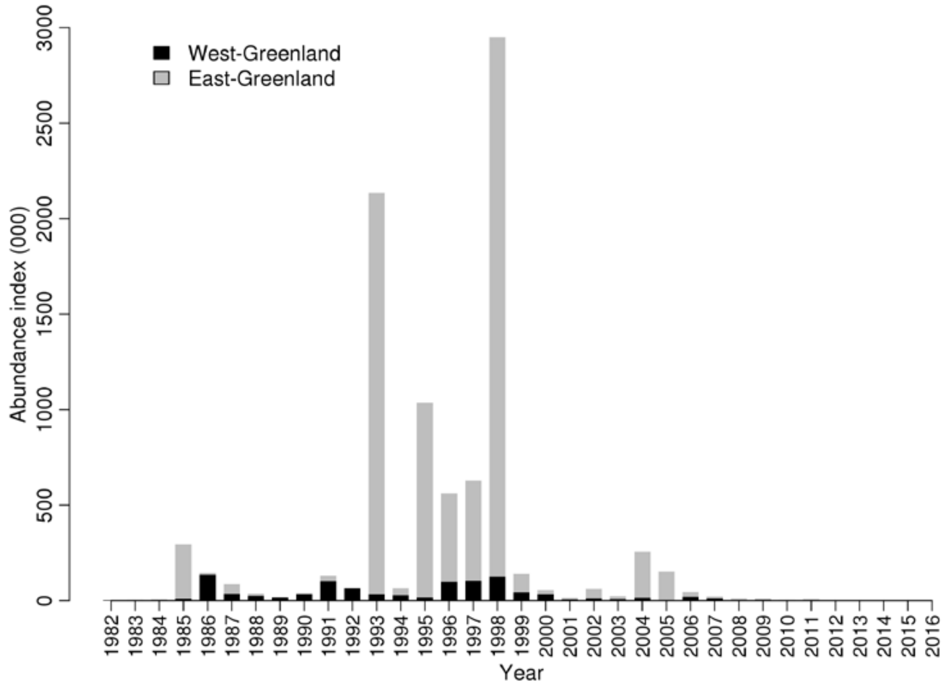


Figure 18.2.1 Survey abundance indices of *Sebastes spp.* (<17 cm) for East and West Greenland from the German groundfish survey 1982–2016. No data were available in 2017-2020.

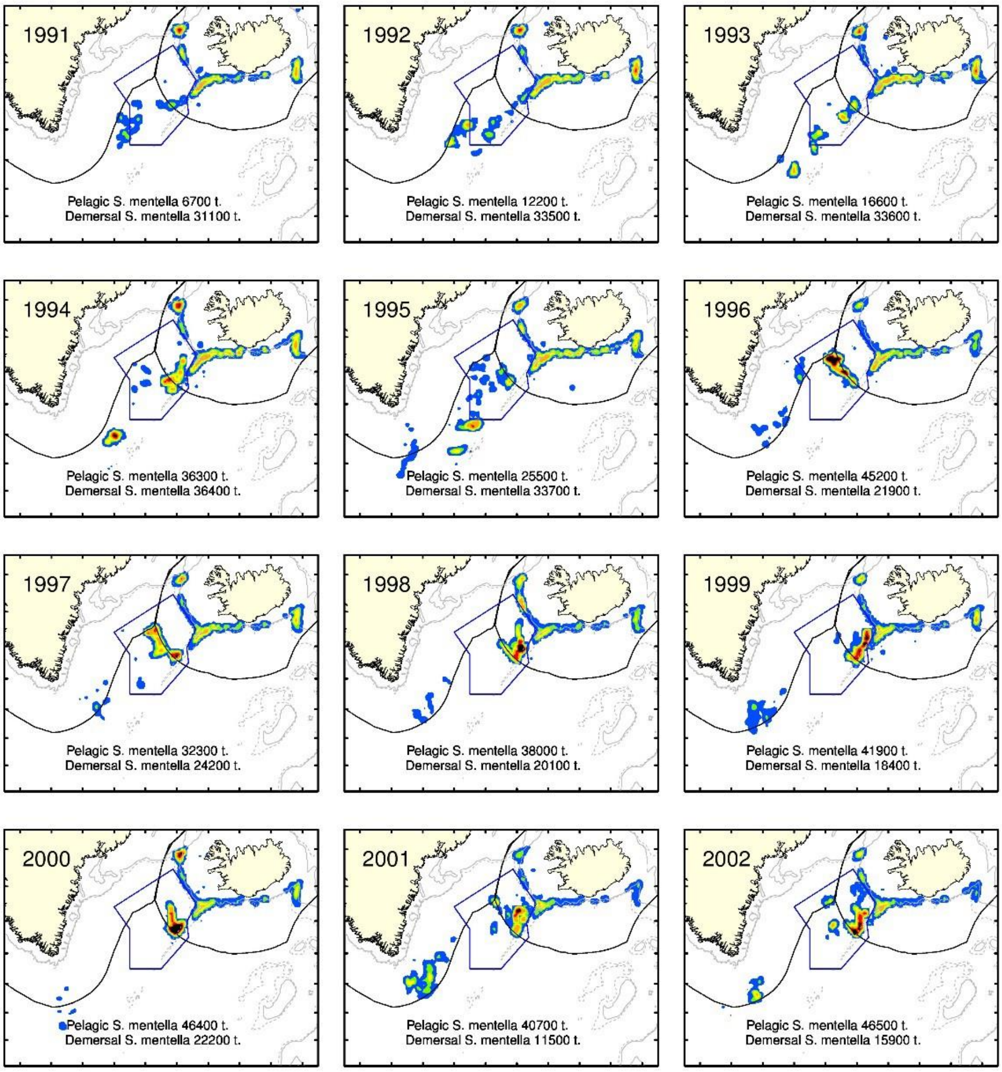


Figure 18.4.1Geographical distribution of the Icelandic catches of *S. mentella* 1991–2002. The colour scale indicates catches (tonnes per NM2). Not updated for 2019-2020.

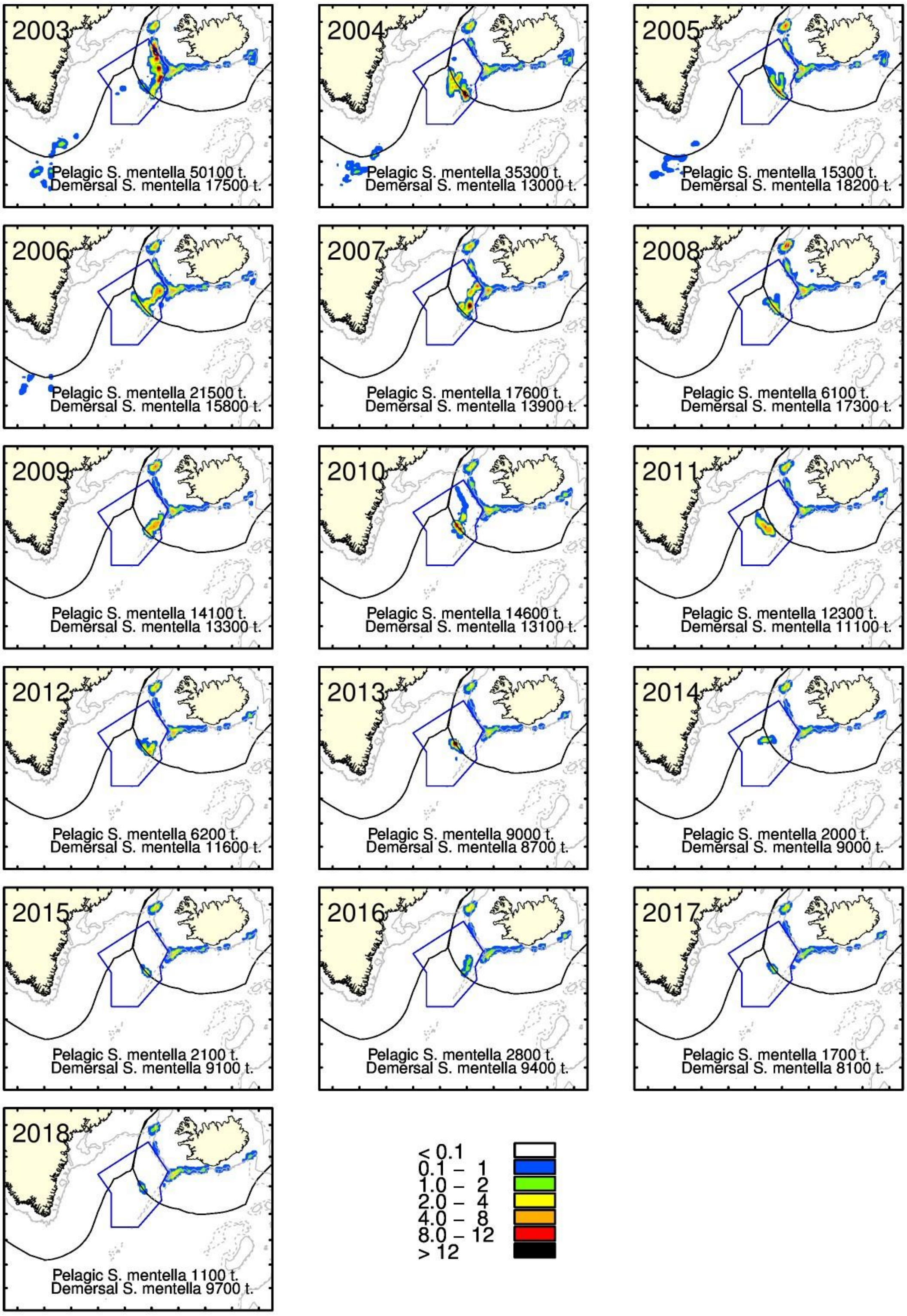


Figure 18.4.1 ***cont.*** **Geographical distribution of the Icelandic catches of *S. mentella* 2003–2018. The colour scale indicates catches (tonnes per NM²). Not updated for 2019-2020.**

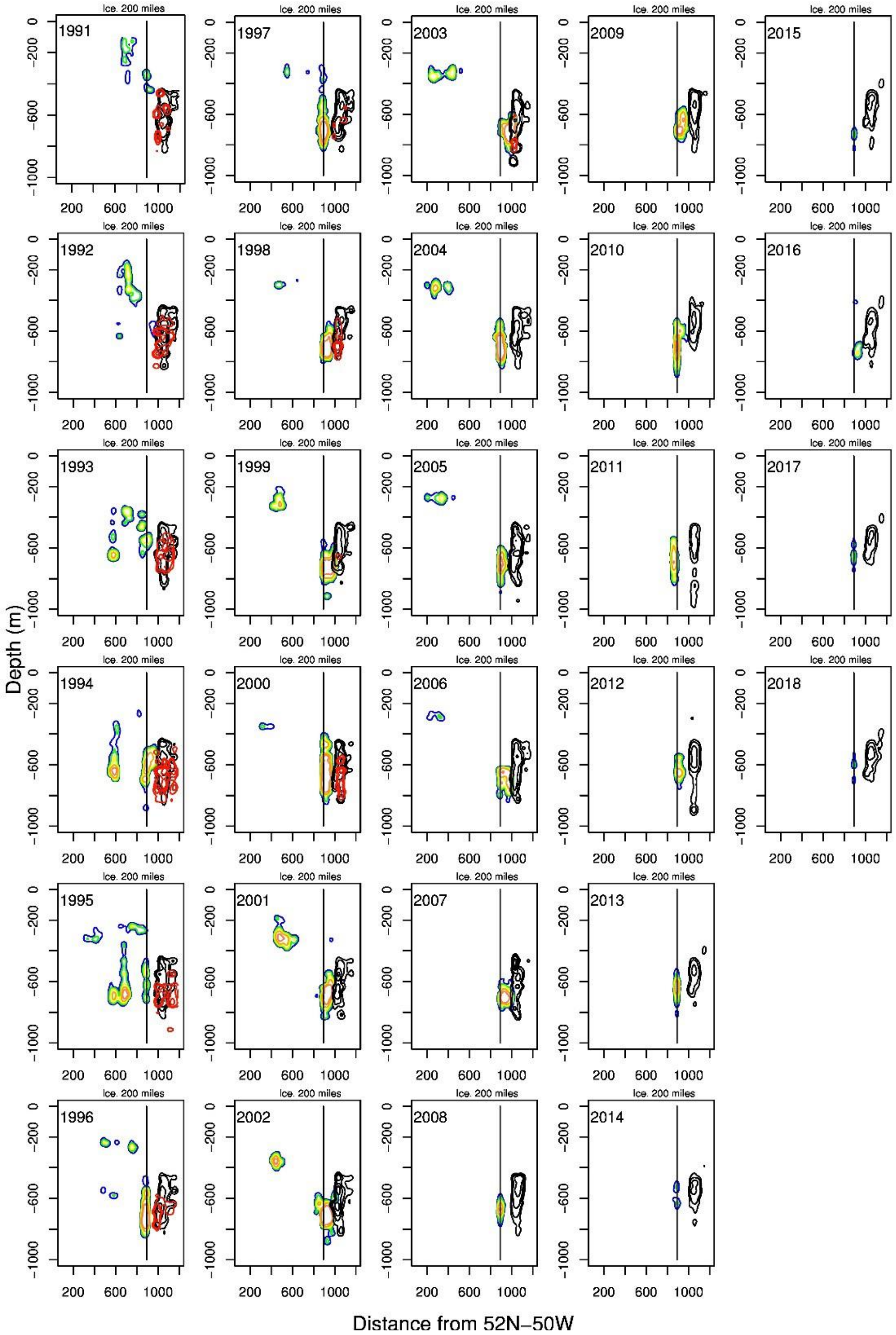


Figure 18.4.2 Distance-depth plot for Icelandic *S. mentella* catches, where distance (in NM) from a fixed position (52°N 50°W) is given. The contour lines indicate catches in a given area and distance. The coloured contours represent the fishery on pelagic *S. mentella*, the black contours indicate 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.

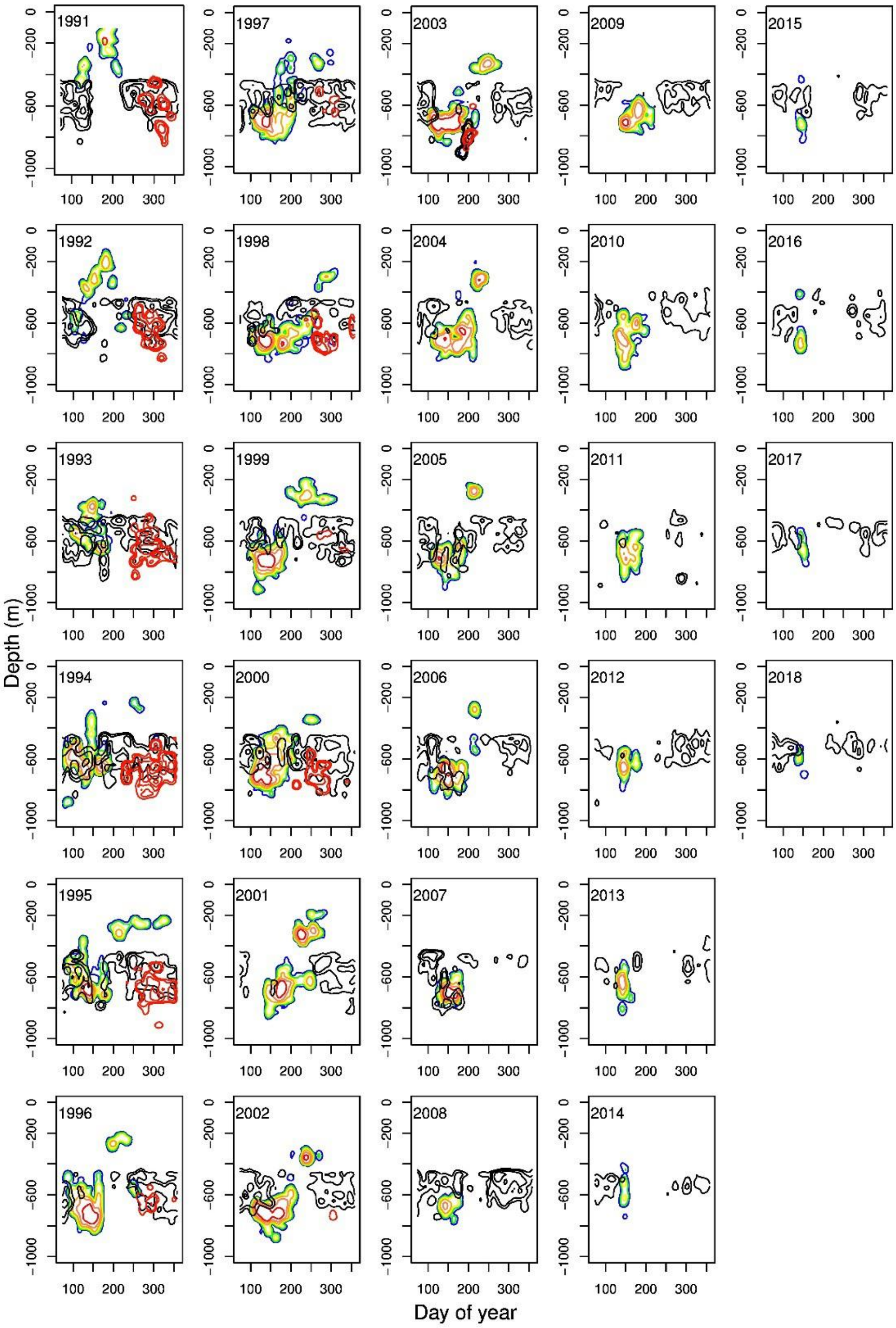


Figure 18.4.3 Depth-time plot for Icelandic *S. mentella* catches 1991–2016 where the y-axis is depth, the x-axis is day of the year and the colour indicates the catches. The coloured contours represent the fishery on pelagic *S. mentella*, the black contours indicate bottom trawl catches of demersal *S. mentella*, and the red contours represent catches of demersal *S. mentella* taken with pelagic trawls. Not updated for 2019-2020.

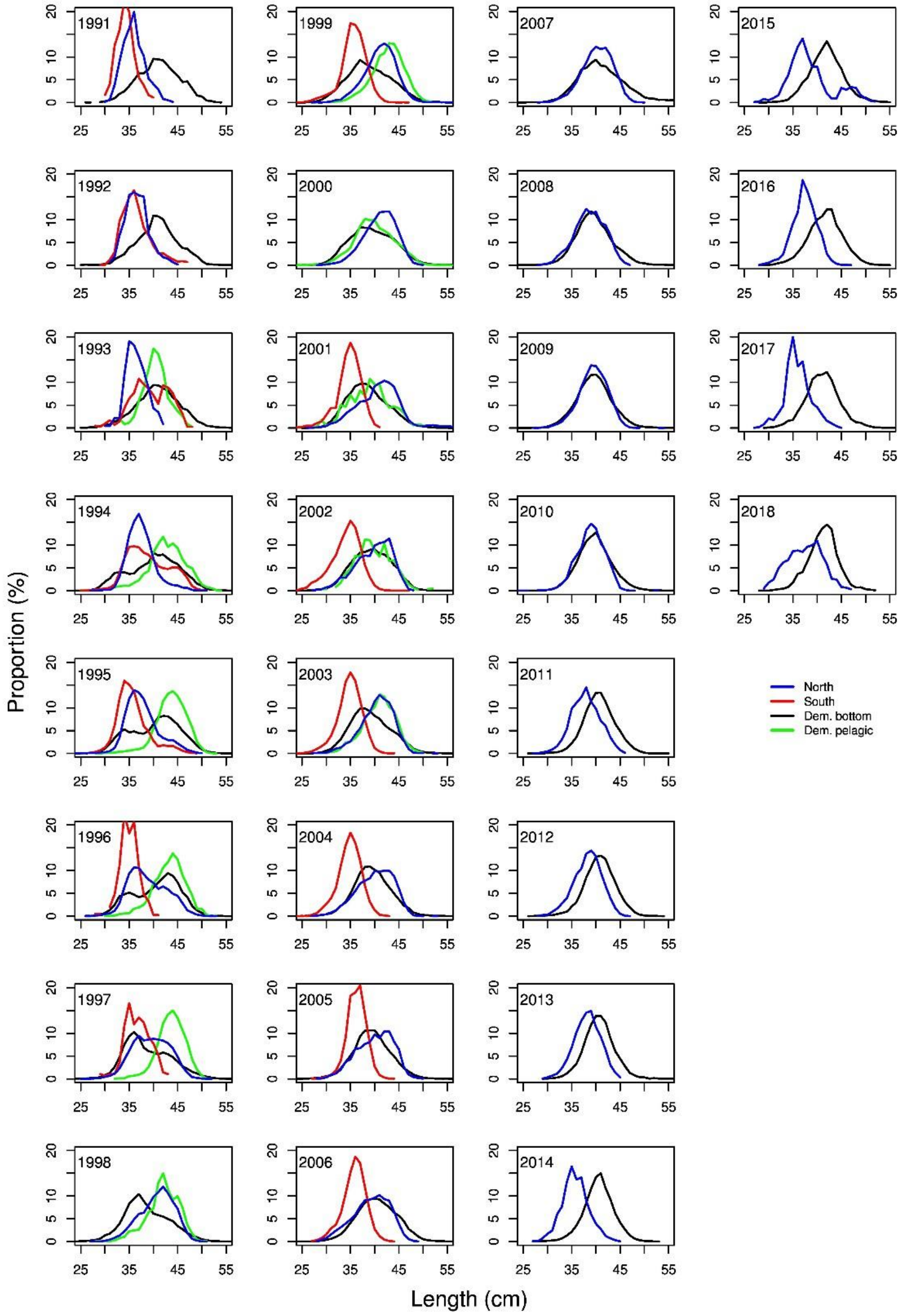


Figure 18.4.4 Length distributions from different Icelandic *S. mentella* fisheries, 1991–2018. The blue lines represent the fishery on pelagic *S. mentella* in the northeastern area, the red lines the pelagic fishery in the southwestern area, the black lines indicate bottom trawl catches of demersal *S. mentella*, and the green lines represent catches of demersal *S. mentella* taken with pelagic trawls. Not updated for 2019-2020.

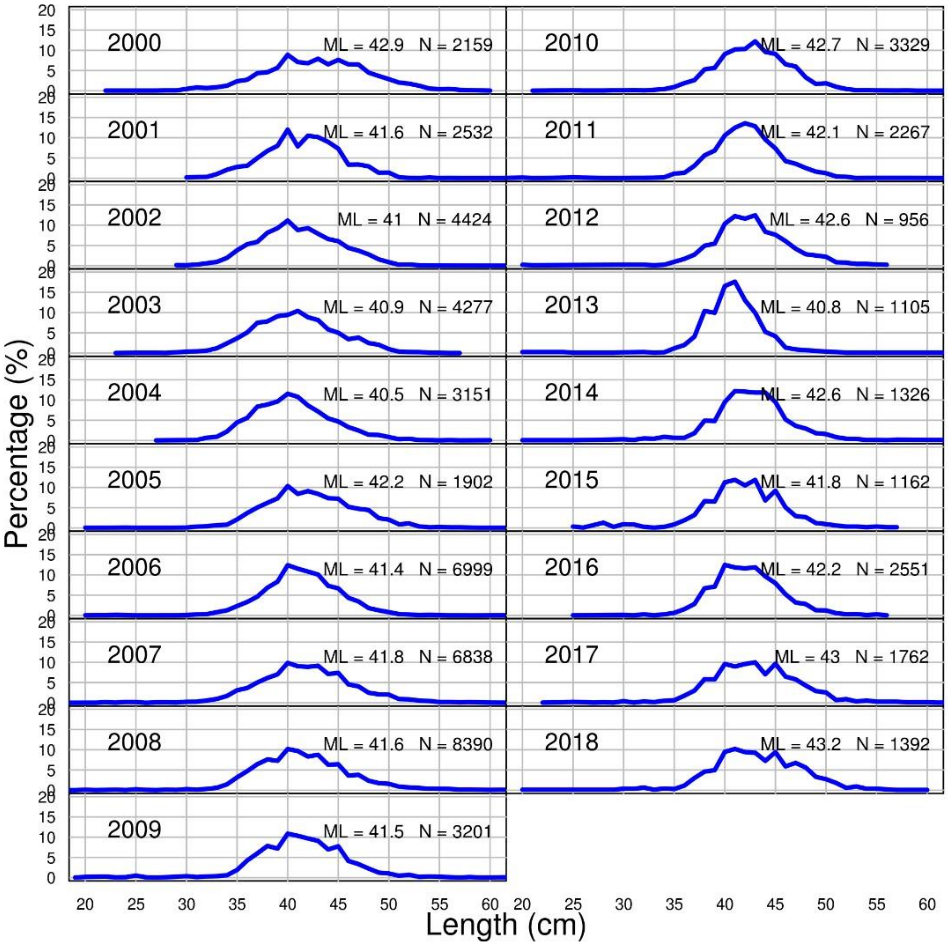


Figure 18.7.1 Length distribution of demersal *S. mentella* from landings of the Faeroese fleet in Division 5.b 2000–2018. Not updated for 2019–2021.

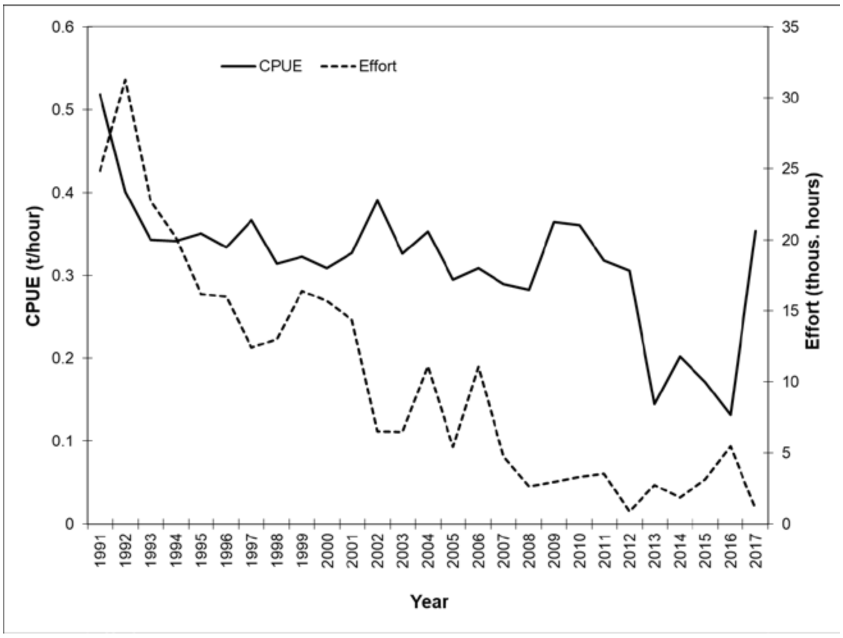


Figure 18.7.2 Demersal *S. mentella*, CPUE (t/hour) and fishing effort (in thousands hours) from the Faeroese CUBA fleet 1991–2017 and where 70% of the total catch was demersal *S. mentella*. Not updated for 2018-2021.

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 2019-2022 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 and 2021 (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 2009-2020, very little of small redfish has been observed in the spring survey but in recent two years the index increased (Figure 19.2.1). The recruitment index in 2022 was the highest value observed since 2000.

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 1994–2022 and the summer survey 1996–2021 (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 decreased gradually to the lowest level in 2020 but increased in 2021. The fish caught in the surveys in Division 5.b is on the average larger than the fish caught in the Icelandic surveys and the survey conducted in East Greenland waters. The modes of the length distribution in both surveys in Faroes waters have shifted to the right towards larger fish, and very little of fish smaller than 35 cm is caught. This is the same trend as observed in Icelandic and East Greenland waters.

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 and 2021 because of various factor such as research vessel breakdown, bad weather and the Covid-19 pandemic.

Relative abundance and biomass indices for golden redfish (fish >17 cm) from the German groundfish survey are illustrated in Figure 19.2.8. 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 19.2.8). 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 19.2.8*a*). 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 19.2.8*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 and 2021) also shows very little juvenile redfish (<18 cm, not classified to species) were present (see Figure 23.2.8).

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 2021 were 43 426 t, which is 2771 t less than in 2020. 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 39 616 t in 2021, 1072 t less than in 2020. The landings for the 2020/2021 fishing year were 18% higher than allocated quota of 34 379 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 2021, 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 2021 decreased to 178 t ,1126 t less than in 2020 and similar as in 2016. 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 2021 were 3532 t, 573 t less than in 2020.

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 2006–2021 and were estimated to be 100 t in 2021.

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 2021.

Area	Nation	Gear	Landings (t)	Samples	No. length measured	No. Age read
5.a	Iceland	Bottom trawl	40 688	65	9191	834
5.b	Faroe Islands	Bottom trawl	178			
14	Greenland	Bottom trawl	3532			

19.3.4 Landings by length and age

The length distributions from the Icelandic commercial trawler fleet in 1976–2021 show that most of the fish caught are 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 2012–2021 are narrower than previously, with less than average of small fish (<35 cm) caught, and the mean length has increased by almost 5 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 2004–2009 cohorts (ages 12–17) were the most dominant year classes in the fishery in 2021. 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 from 2006 to the highest level in the time-series in 2017-2019. CPUE has in since then decreased although it remains high. 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 on in the Gadget framework (see http://www.hafro.is/gadget for further details). The settings of the model for golden redfish 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 1985–2022 and the German survey in East Greenland 1984–2020. The German survey index in 2018 (survey not conducted) is based on the average of the 2017 and 2019 and the 2021 (survey not conducted) index is set as the same as in 2020.
- 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 1996–2021.
- Age-length keys and mean length at age from the Icelandic commercial catch 1995–2020.

Model settings:

- The simulation period is from 1970 to 2027 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 (54 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 2023 and onwards was set as the average of the five smallest estimated year classes 1980–2007 or 39.5 million. The reason is an indication of poor recruitment in recent years, but estimated recruitment was even lower.
- Catches in 2022 were set as the sum of expected landings, accounting for interannual transfer from 2021.
- 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 and was om the beginning of 2022 estimated to be close to $B_{trigger}$. 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 further.

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 analytical retrospective pattern (five-year peel) of the assessment is presented in Figure 19.4.5.The table below shows the Mohn's rho values for SSB, F and recruitment for five and ten year peels:

Variable	Value	
	Five-year peel	Ten-year peel
F_{bar}	-0.0141	-0.0442
SSB	0.00589	0.0231
Recruitment	0.704	0.268

The Mohn's rho values for F_{bar} and SSB are low (-1.4% and 0.6% respectively) but indicates that fishing mortality has been underestimated and SSB been overestimated (Figure 19.4.5). Mohn's rho for recruitment is on the other hand high (70%) 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. When extending the peel to 10 years the Mohn's rho value drops to 27%.

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 2022 (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 2021 SSB was estimated at 260 090 t, and according to the management plan the TAC advice for 2022 was 31 855 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 below 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 is scheduled 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 1985–2022 and the autumn survey 1996–2021.

Year	Spring Survey		Autumn Survey	
	Biomass	CV	Biomass	CV
1985	307 926	0.095		
1986	327 765	0.120		
1987	322 121	0.122		
1988	253 559	0.095		
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	171 135	0.097		
1995	146 102	0.102		
1996	195 697	0.164	199 793	0.248
1997	212 558	0.216	120 628	0.279
1998	206 461	0.136	186 505	0.348
1999	297 090	0.143	262 691	0.310
2000	221 279	0.176	141 940	0.200
2001	192 724	0.176	177 456	0.155
2002	250 420	0.173	192 813	0.150
2003	333 901	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	257 010	0.157	279 290	0.335
2007	339 778	0.224	219 951	0.252
2008	247 895	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	461 921	0.204	343 115	0.225
2013	457 451	0.177	317 325	0.156
2014	402 773	0.174	431 369	0.232
2015	406 150	0.281	360 722	0.173
2016	615 712	0.313	401 135	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	441 154	0.194	269 053	0.199
2022	378 907	0.177		

Table 19.2.2 Golden redfish in 5.a. Age disaggregated indices (in millions) from the autumn groundfish survey 1996–2021. 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
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	
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	

Year/Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0	0.4	0.3
2	0.0	0.0	0.2	0.1	0.0	0.3	0.2	0.1	0.2	0.2
3	0.1	0.0	0.3	0.6	0.0	0.3	0.4	0.4	1.0	0.2
4	1.4	0.2	0.1	0.3	1.8	0.2	0.1	0.8	0.7	0.6
5	4.1	1.0	0.8	0.1	0.3	1.6	0.2	1.5	1.3	1.3
6	3.1	4.1	1.8	1.2	0.8	1.3	3.0	0.9	0.8	2.5
7	23.5	3.0	12.8	7.6	3.9	1.6	2.5	15.3	0.7	1.3
8	70.3	41.8	24.6	28.3	29.1	10.4	2.0	7.8	10.9	1.6
9	60.6	84.8	96.9	33.1	63.8	38.1	5.9	7.4	3.9	12.4
10	62.9	56.3	151.8	86.4	48.1	93.8	36.7	20.3	7.4	7.0
11	103.8	41.3	90.8	100.7	87.5	56.9	72.1	46.8	18.4	9.0
12	74.2	68.6	69.7	52.9	97.2	95.7	58.4	91.5	41.0	30.4
13	43.3	47.5	67.5	47.6	54.3	87.8	65.7	58.7	39.1	35.9
14	39.1	26.5	50.4	41.7	45.3	41.9	54.9	62.7	24.3	48.7
15	19.6	31.7	27.0	40.3	35.8	27.4	27.3	45.4	39.0	14.9
16	16.7	18.7	26.6	21.1	31.9	28.8	20.2	36.1	25.7	36.4
17	6.1	12.8	17.1	20.0	20.3	35.6	21.9	18.7	10.5	23.2
18	5.9	7.2	12.3	10.0	22.1	17.8	21.1	21.7	12.1	13.1
19	3.9	5.2	6.0	10.0	16.1	14.7	12.9	22.1	12.0	10.3
20	3.9	4.5	5.9	9.9	8.9	16.8	11.3	13.7	11.1	10.8
21	3.5	4.8	4.8	3.3	3.0	11.5	6.0	14.7	6.9	12.4
22	18.3	2.4	3.6	2.5	3.9	4.8	10.3	12.3	4.6	9.2
23	2.9	18.2	3.4	2.1	3.7	6.1	6.9	7.2	4.1	8.4
24	2.0	2.6	12.7	1.1	2.8	4.8	2.8	3.7	3.3	5.6
25	1.2	1.2	1.5	13.1	3.4	2.9	2.6	1.3	2.5	4.4
26	1.7	1.1	0.9	1.5	15.0	2.6	2.9	2.0	1.8	2.7
27	7.5	0.8	0.9	1.4	1.0	13.9	2.6	1.3	1.9	1.5
28	0.4	8.7	0.5	1.6	1.0	1.7	11.5	1.7	0.8	0.8
29	0.4	0.5	3.3	1.0	0.9	1.8	1.5	10.4	1.3	2.7
30+	2.1	3.5	2.6	6.9	6.7	7.9	7.5	5.3	9.6	14.8
Total	582.5	499.2	696.9	546.3	608.9	629.0	472.0	531.8	297.4	322.6

Table 19.3.1 Official landings (in tonnes) of golden redfish, by area, 1978–2021 as officially reported to ICES. Landings statistics for 2021 are provisional.

Year	Area				Total
	5.a	5.b	6	14	
1978	31 300	2039	313	15 477	49 129
1979	56 616	4805	6	15 787	77 214
1980	62 052	4920	2	22 203	89 177
1981	75 828	2538	3	23 608	101 977
1982	97 899	1810	28	30 692	130 429
1983	87 412	3394	60	15 636	106 502
1984	84 766	6228	86	5040	96 120
1985	67 312	9194	245	2117	78 868
1986	67 772	6300	288	2988	77 348
1987	69 212	6143	576	1196	77 127
1988	80 472	5020	533	3964	89 989
1989	51 852	4140	373	685	57 050
1990	63 156	2407	382	687	66 632
1991	49 677	2140	292	4255	56 364
1992	51 464	3460	40	746	55 710
1993	45 890	2621	101	1738	50 350
1994	38 669	2274	129	1443	42 515
1995	41 516	2581	606	62	44 765
1996	33 558	2316	664	59	36 597
1997	36 342	2839	542	37	39 761
1998	36 771	2565	379	109	39 825
1999	39 824	1436	773	7	42 040
2000	41 187	1498	776	89	43 550
2001	35 067	1631	535	93	37 326
2002	48 570	1941	392	189	51 092
2003	36 577	1459	968	215	39 220
2004	31 686	1139	519	107	33 451

Year	Area				Total
	5.a	5.b	6	14	
2005	42 593	2484	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	1653	38 648
2011	43 773	493	83	1005	45 354
2012	43 089	491	41	2017	45 633
2013	51 330	372	92	1499	53 279
2014	47 769	202	60	2706	50 743
2015	48 769	270	44	2562	51 645
2016	54 036	179	50	5442	59 707
2017	50 119	1418	93	4501	56 141
2018	48 014	1129	80	4004	53 227
2019	44 746	1119	101	2665	48 530
2020	40 688	1304	100	4105	46 197
2021[1)]	39 616	178	100	3532	43 426

[1)] **Provisional**

Table 19.3.2 Golden redfish in 5.a. Observed catch in weight (tonnes) by age and years in 1995–2021. 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	1057	936	359	558	612	555	475
9	1432	867	481	586	1592	825	402	736	1312	501	1877	2134	1727	2164	1689	2218	1626	1603	2197	1752
10	8598	3887	1039	1193	1252	4180	1653	808	1080	2107	1496	3605	2442	5006	3059	2725	4772	3444	3886	6176
11	2570	9575	2708	1118	1843	1843	7768	3192	1160	828	3093	2017	3319	3997	4964	2786	5699	6725	5952	6751
12	1286	2170	11609	3221	2521	2224	1810	10955	3863	989	1899	2789	1911	4682	4457	4921	4899	7345	9488	5807
13	3616	1354	2828	12425	2447	1665	1930	3012	9576	2017	1366	1624	3068	2297	3430	3895	6235	4021	6896	5809
14	5787	1523	1366	2068	15536	2329	1243	2548	2304	8612	3021	1275	1050	2819	1848	2740	3772	4721	4032	4776
15	6229	4293	3106	2020	1242	14598	826	1805	1932	2148	11840	2818	955	1546	2008	1378	2501	2668	4466	3061
16	1833	5033	3579	2394	1250	1752	11487	2998	1202	1656	2073	10318	2168	1067	1247	1201	1309	1525	3043	2538
17	912	954	2968	3404	1795	1170	515	11726	2231	870	1447	2074	9337	1804	681	820	981	820	1720	1921
18	395	372	869	2029	2619	1602	769	2054	6494	1381	1243	1191	1329	8188	1502	648	602	813	1205	1245
19	1244	252	616	1013	2194	2400	1025	1150	784	5065	1241	722	741	1503	6158	1086	691	492	764	464
20	1232	343	919	723	1237	2141	1684	622	390	1093	6387	956	717	966	970	4980	987	808	488	1202
21	549	1059	440	528	452	538	916	1360	585	342	387	5524	876	567	654	901	5052	627	510	438
22	674	698	534	397	211	438	386	982	840	464	456	552	4765	831	576	762	1056	3512	772	425
23	1521	790	641	426	326	283	399	697	788	599	758	226	732	4231	342	519	753	477	3298	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	2561	665	204	324	183	2929
25	777	0	703	536	810	408	119	270	307	239	417	457	599	254	98	2151	134	225	199	183
26	396	0	263	382	264	361	109	176	71	94	94	97	329	433	97	199	1336	237	171	195
27	372	0	135	432	592	220	265	80	74	187	253	254	345	337	199	348	77	1326	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	1152	1015	1280	643	636	1484	962	1024	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	2021
7	14	49	0	0	214	0	41
8	563	751	104	51	144	507	26
9	902	2717	949	212	64	288	1276
10	3154	3713	4503	2279	1227	575	766
11	7118	8111	3523	4890	4678	2185	373
12	7104	9393	7077	4812	6176	4928	2440
13	5553	6688	8748	6507	4028	4154	4056
14	5673	4705	5370	7779	5710	3148	4743
15	4774	4024	3790	4278	5127	8115	3794
16	3015	2629	3576	3243	4006	5032	5350
17	2651	2729	3012	2748	2607	2253	4801
18	1861	2013	1866	2614	2301	1545	2310
19	780	1724	1412	1282	1376	1329	1167
20	1192	663	1187	1347	1512	1564	1646
21	288	536	990	1211	1147	788	1261
22	275	350	438	629	508	970	768
23	196	223	489	496	518	522	942
24	424	241	313	277	161	600	799
25	1816	304	324	336	56	82	152
26	243	1335	148	167	184	45	443
27	214	176	1265	35	350	62	28
28	189	29	87	1663	103	122	186
29	87	25	192	26	1161	162	214
30+	682	907	756	1133	1387	1713	2030
Total	48 770	54 043	50 117	48 015	44 745	40 689	39 616

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_{9-19}
1971	534 085	338 242	210.6	67 880	0.115
1972	532 312	326 889	161.7	50 890	0.089
1973	545 411	331 438	456.7	43 719	0.076
1974	604 345	347 290	220.5	50 598	0.083
1975	639 480	362 455	117.9	61 920	0.097
1976	654 476	373 340	195.9	94 420	0.145
1977	645 558	361 350	191.0	53 753	0.087
1978	678 240	389 424	129.6	48 736	0.071
1979	709 833	425 542	165.5	77 212	0.106
1980	715 593	439 297	100.2	89 143	0.120
1981	699 854	441 430	86.9	101 966	0.142
1982	665 192	429 215	64.2	130 322	0.193
1983	593 378	386 355	66.1	106 050	0.171
1984	540 066	357 097	71.8	95 288	0.163
1985	493 226	330 502	129.5	78 531	0.138
1986	466 558	312 661	123.3	76 908	0.146
1987	439 463	291 881	63.4	76 559	0.158
1988	404 205	266 908	39.1	89 804	0.212
1989	349 457	226 159	42.5	56 645	0.150
1990	325 284	211 258	347.6	66 314	0.199
1991	326 320	187 851	57.5	56 015	0.186
1992	309 854	172 180	38.6	55 826	0.206
1993	289 910	156 762	52.1	50 179	0.205
1994	275 205	147 027	61.7	42 520	0.183
1995	267 797	144 733	325.4	44 263	0.195
1996	289 841	143 002	83.5	35 595	0.155
1997	298 610	149 041	38.5	38 996	0.165
1998	298 230	152 952	38.8	39 694	0.165

Year	Biomass	SSB	$R_{(age5)}$	Catches	F_{9-19}
1999	295 290	157 102	76.5	42 463	0.175
2000	291 814	159 403	47.5	42 607	0.172
2001	283 408	160 947	103.2	36 744	0.142
2002	290 677	167 273	111.8	50 730	0.195
2003	285 287	161 447	163.6	38 219	0.148
2004	301 906	166 336	101.6	32 766	0.123
2005	316 429	176 691	154.3	46 619	0.173
2006	326 245	177 413	151.7	42 108	0.161
2007	347 359	185 875	98.4	39 154	0.146
2008	362 743	199 321	119.8	46 195	0.165
2009	375 258	210 288	184.1	39 301	0.133
2010	408 289	230 741	155.3	38 504	0.119
2011	439 377	254 843	83.2	45 146	0.130
2012	450 600	274 185	123.6	45 423	0.123
2013	468 061	293 834	76.1	53 223	0.137
2014	467 648	305 377	36.3	50 697	0.126
2015	459 245	315 360	11.0	51 621	0.124
2016	440 842	319 575	13.3	59 711	0.142
2017	409 897	310 673	35.9	56 355	0.136
2018	382 627	298 542	4.5	53 167	0.133
2019	349 029	282 338	8.2	48 550	0.128
2020	317 118	264 207	19.1	46 116	0.129
2021	286 687	242 926	26.2	43 337	0.134
2022	258 329	220 056	47.2		

Table 19.4.2 Assumption and output from short term prognosis. All weights are in tonnes.

Biomass (2022)	SSB (2022)	$F_{9\text{-}19}$ (2022)	Landings (2022)	Biomass (2023)	SSB (2023)
258 329	220 056	0.128	37 241	238 910	200 045

Basis	Total catch (2023)	$F_{9\text{-}19}$ (2023)	Biomass 5+ (2024)	SSB (2024)
Management plan	25 545	0.097	229 871	189 588
Other catch options				
F_0	0	0	255 771	213 812
$F_{sq} = F_{2021}$	31 152	0.134	224 183	184 271

19.19 Figures

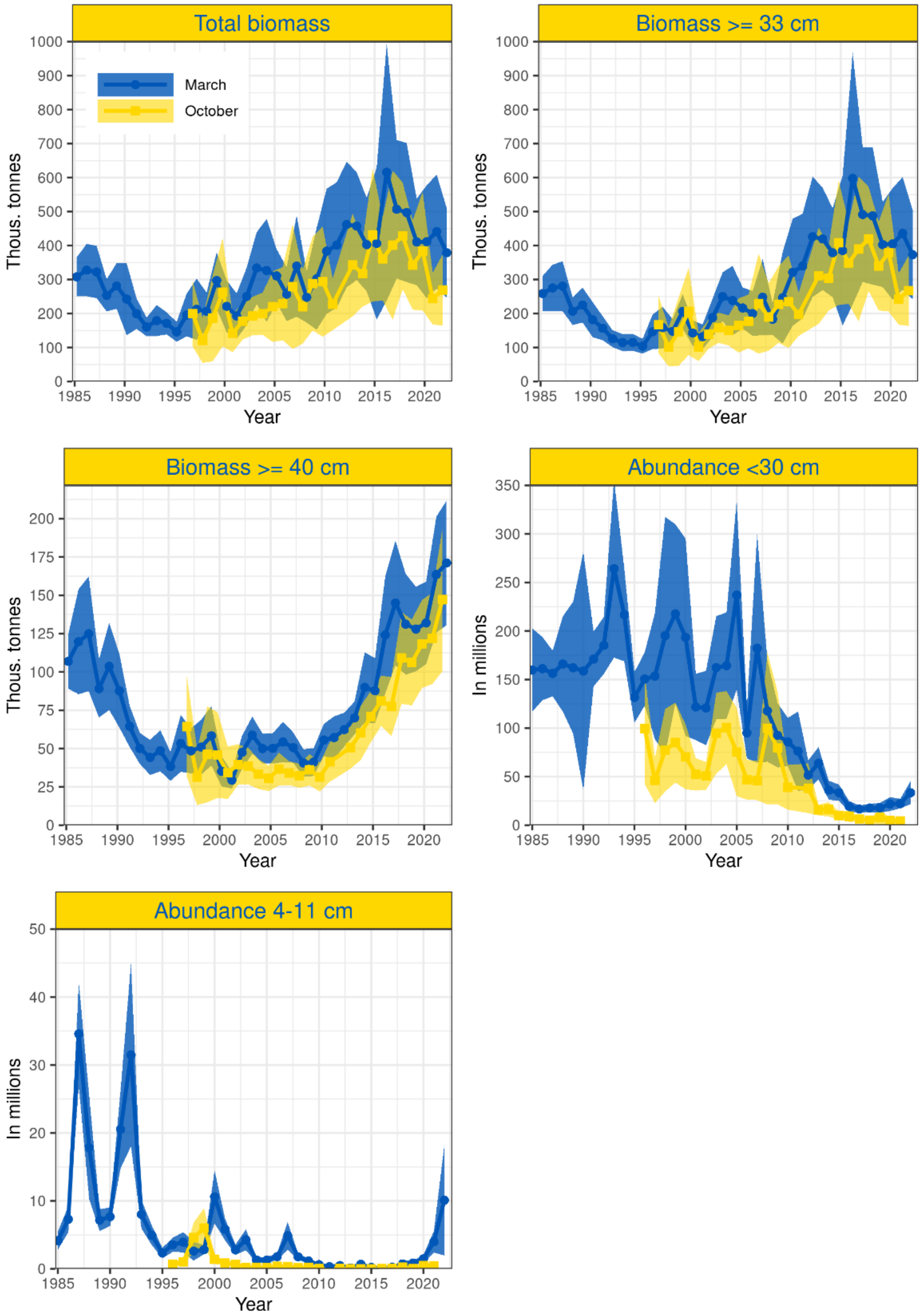


Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 1985–2022 (blue line and shaded area) and October 1996–2021 (yellow lines and shaded areas). The shaded areas represent 95% CI.

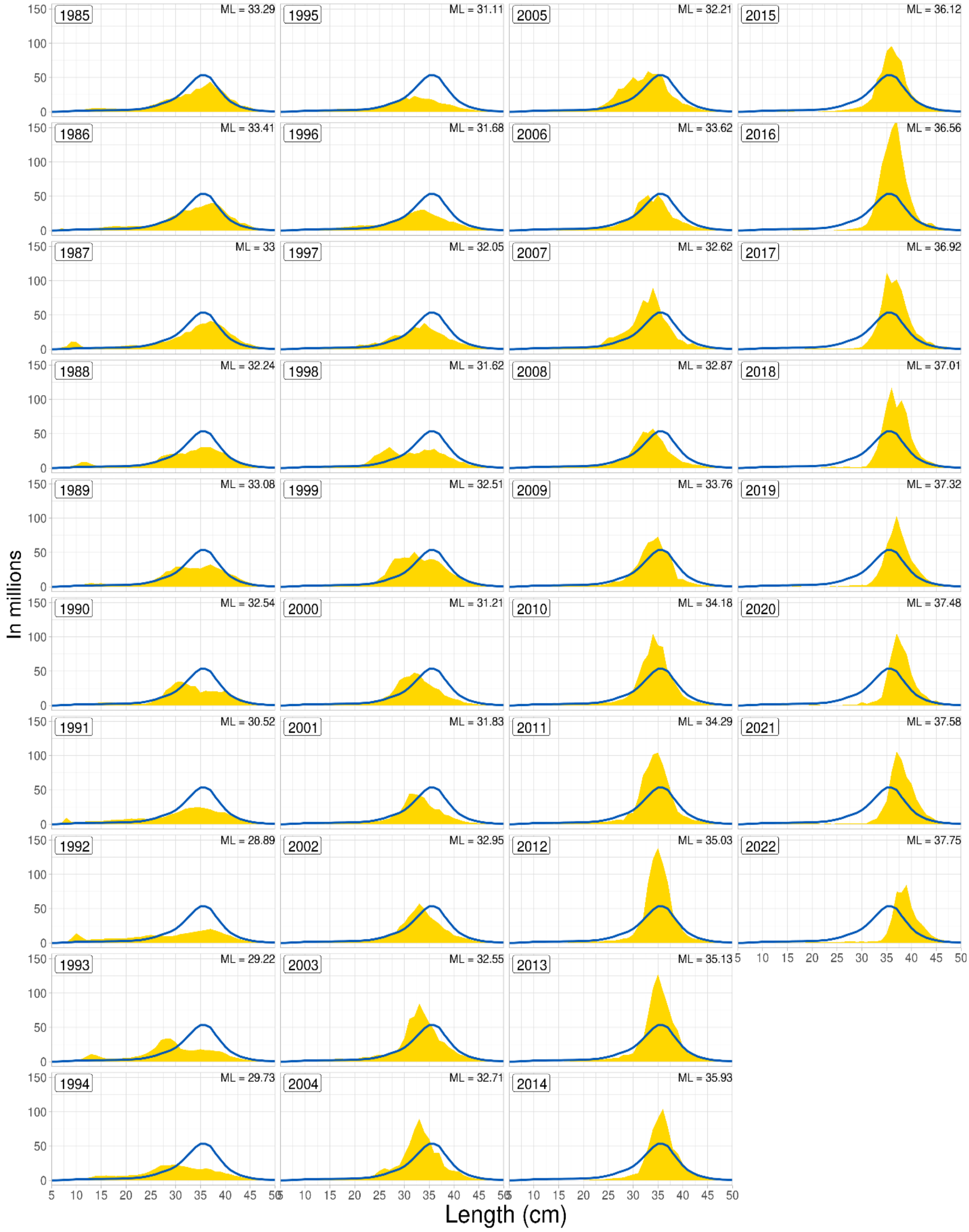


Figure 19.2.2. Length disaggregated abundance indices (yellow area) of golden redfish from the bottom trawl survey in March 1985-2022 conducted in Icelandic waters. The blue line is the mean of total indices 1985–2022.

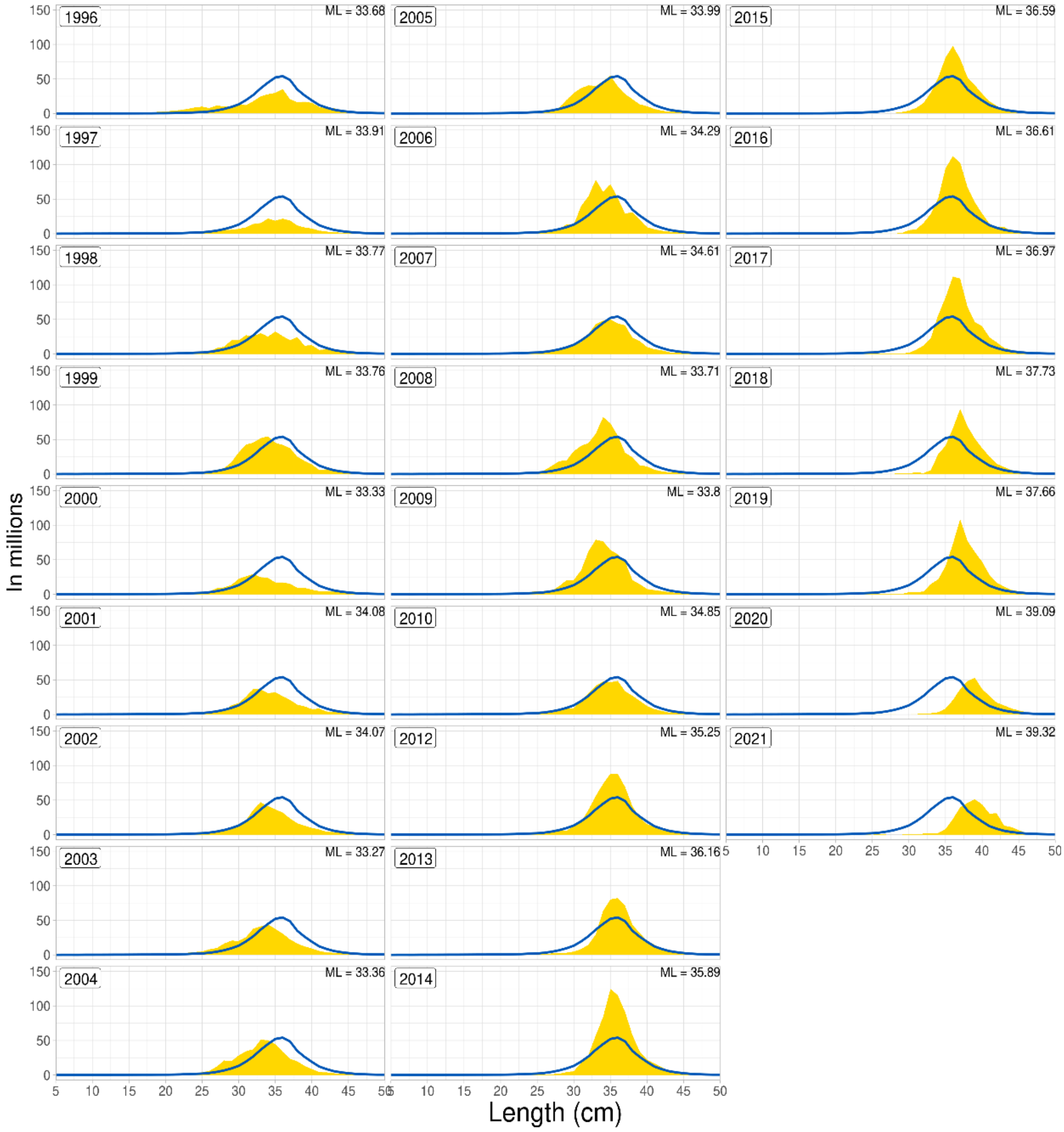


Figure 19.2.3. Length disaggregated abundance indices (yellow area) of golden redfish from the bottom trawl survey in October 1996–2021 conducted in Icelandic waters. The blue line is the mean of total indices 1996–2021. The survey was not conducted in 2011.

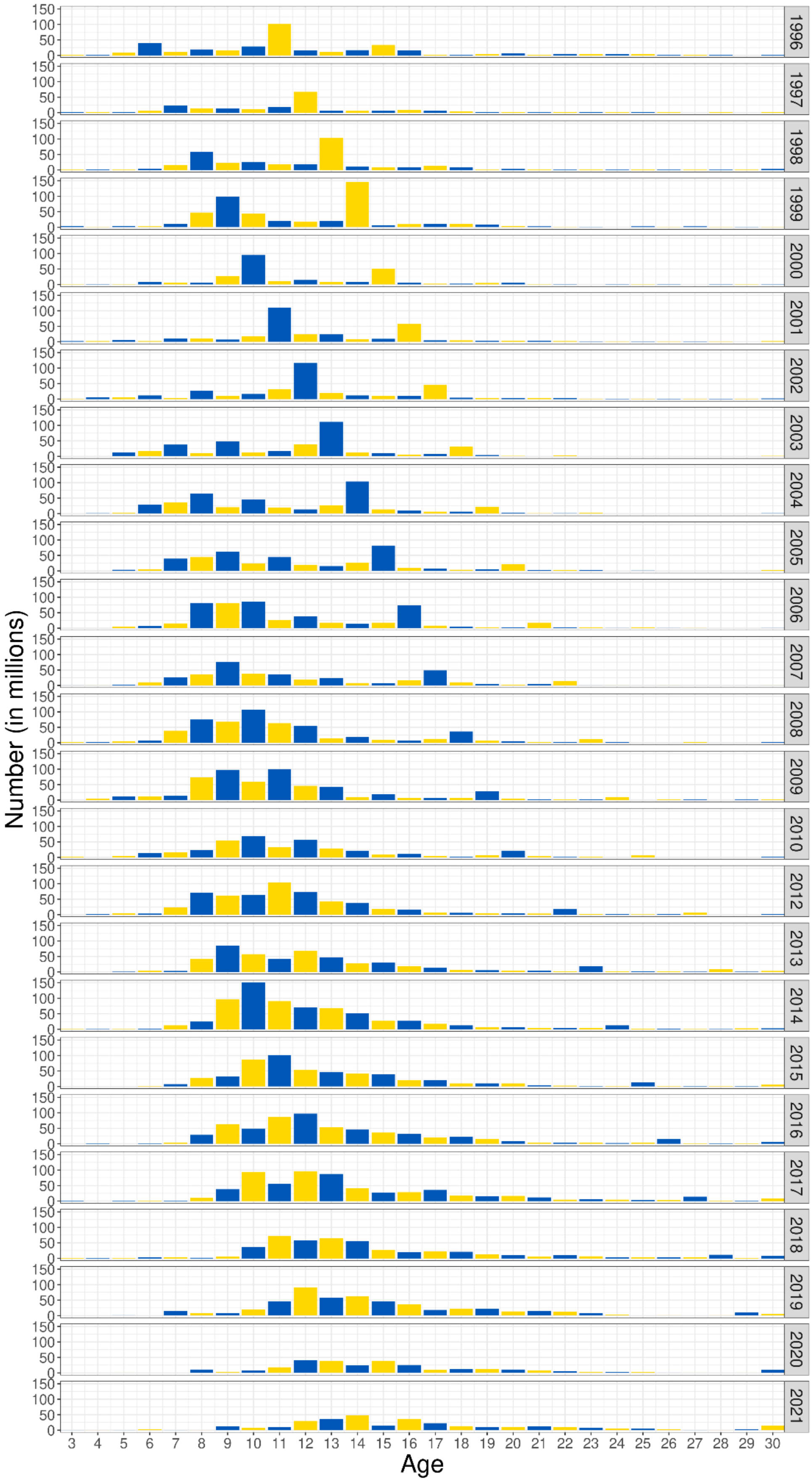


Figure 19.2.4 Age disaggregated abundance indices of golden redfish in the bottom trawl survey in October conducted in Icelandic waters 1996–2021. The survey was not conducted in 2011.

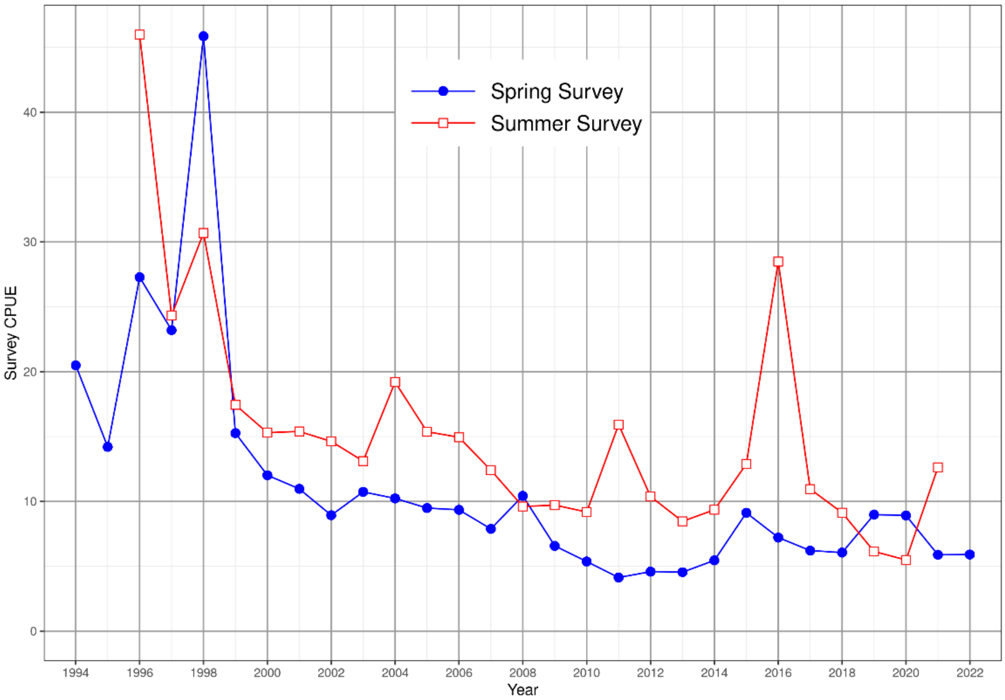


Figure 19.2.5 CPUE of golden redfish in the Faeroes spring groundfish survey 1994–2022 (blue line) and the summer groundfish survey 1996–2021 (red line) in ICES Division 5.b.

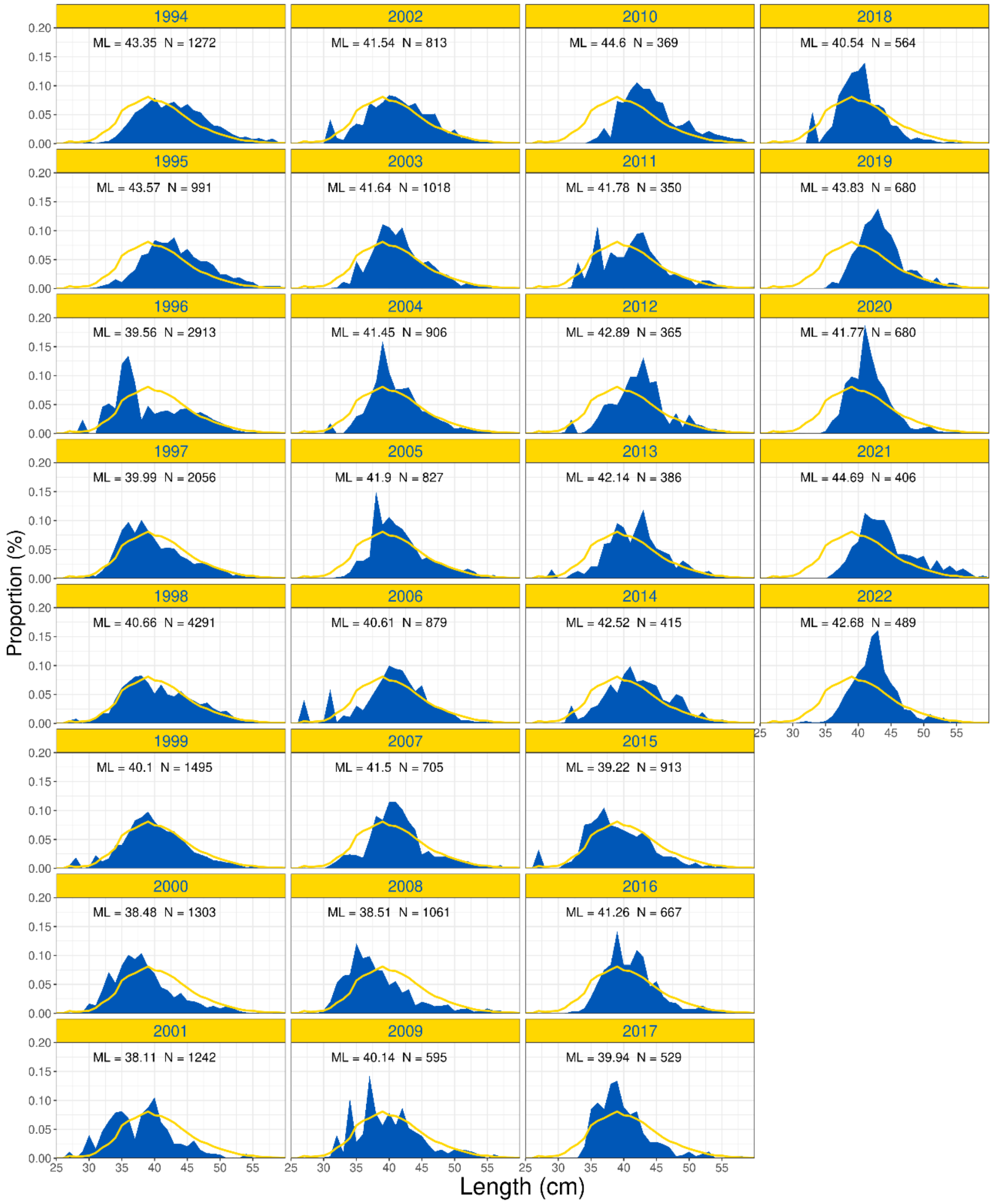


Figure 19.2.6 Length distribution (yellow area) of golden redfish in the Faeroes spring groundfish survey 1994–2022. The blue line is the mean for 1994–2022.

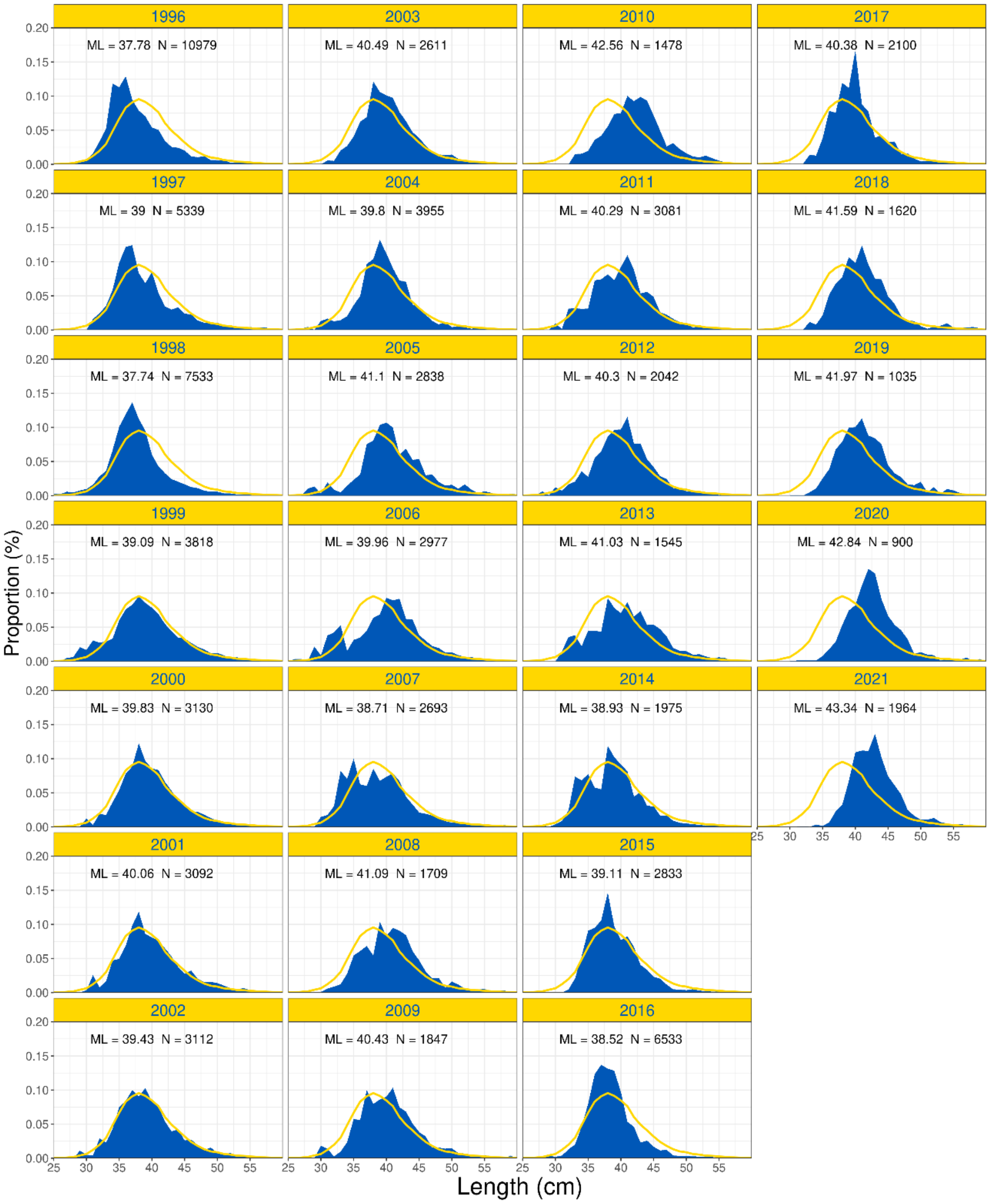


Figure 19.2.7 Length distribution (yellow area) of golden redfish in the Faeroes summer groundfish survey 1996–2021. The blue line is the mean for 1996–2021.

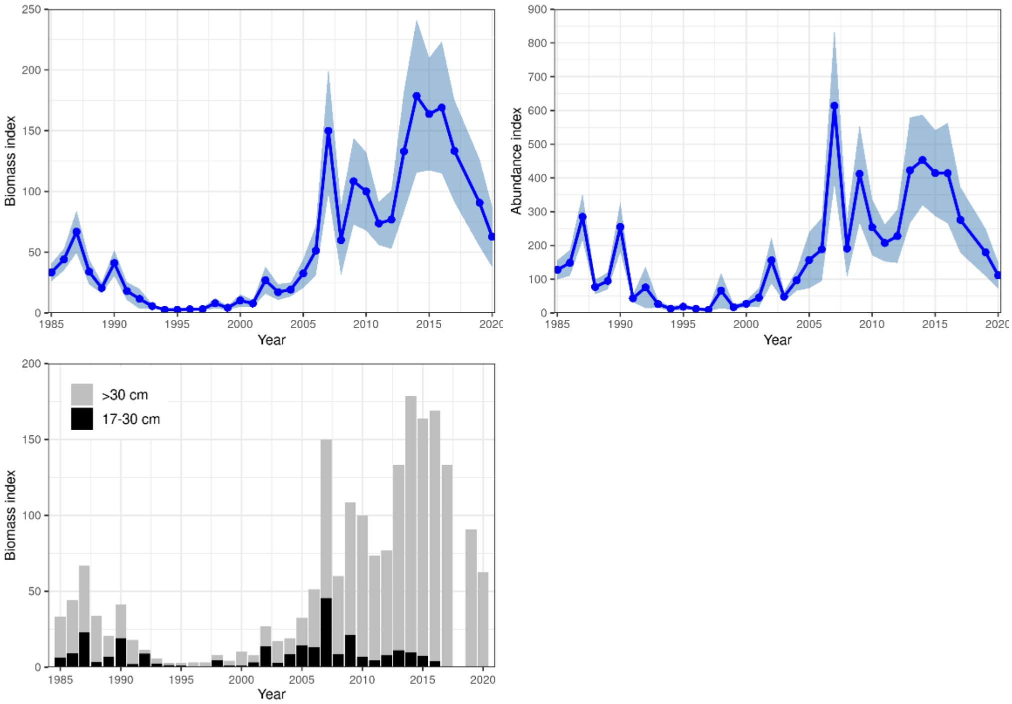


Figure 19.2.8 Golden redfish (> 17 cm). Survey abundance indices for East Greenland (ICES Subarea 14) from the German groundfish survey 1985–2020. a) Total biomass index, b) total abundance index, c) biomass index divided by size classes (17–30 cm and > 30 cm). The survey was not conducted in 2018 and 2021.

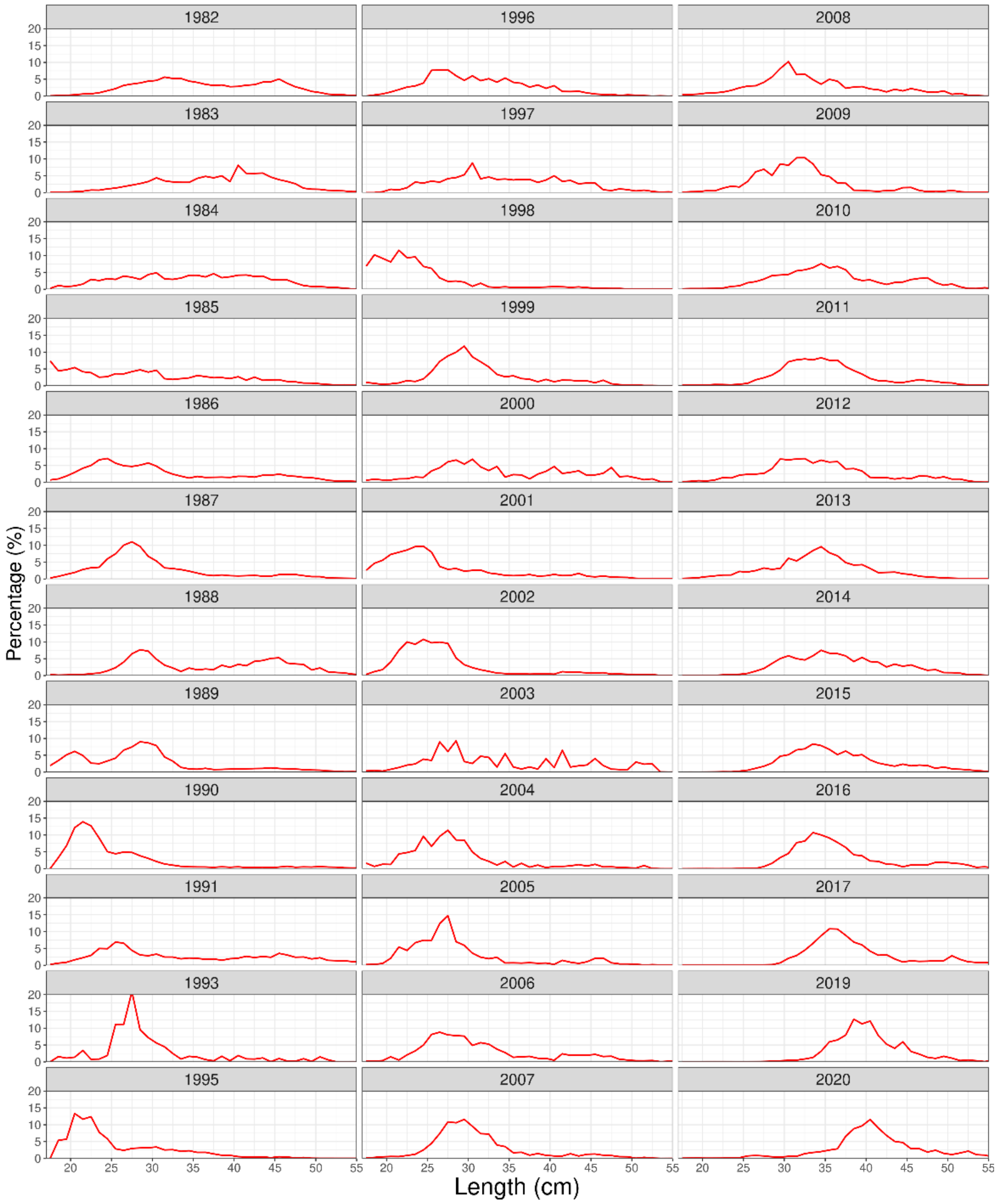


Figure 19.2.9 Golden redfish (>17 cm). Length frequencies for East Greenland (ICES Subarea 14) 1982–2020. The survey was not conducted in 2018 and 2021.

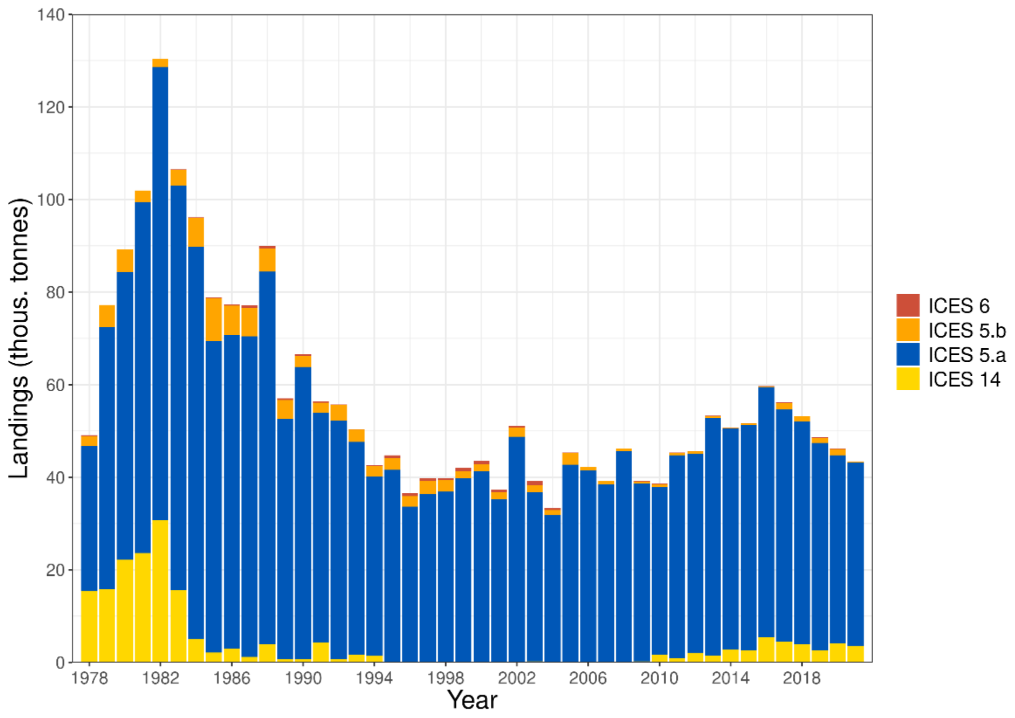


Figure 19.3.1 Nominal landings of golden redfish in tonnes by ICES Divisions 1978–2021. Landings statistics for 2021 are provisional.

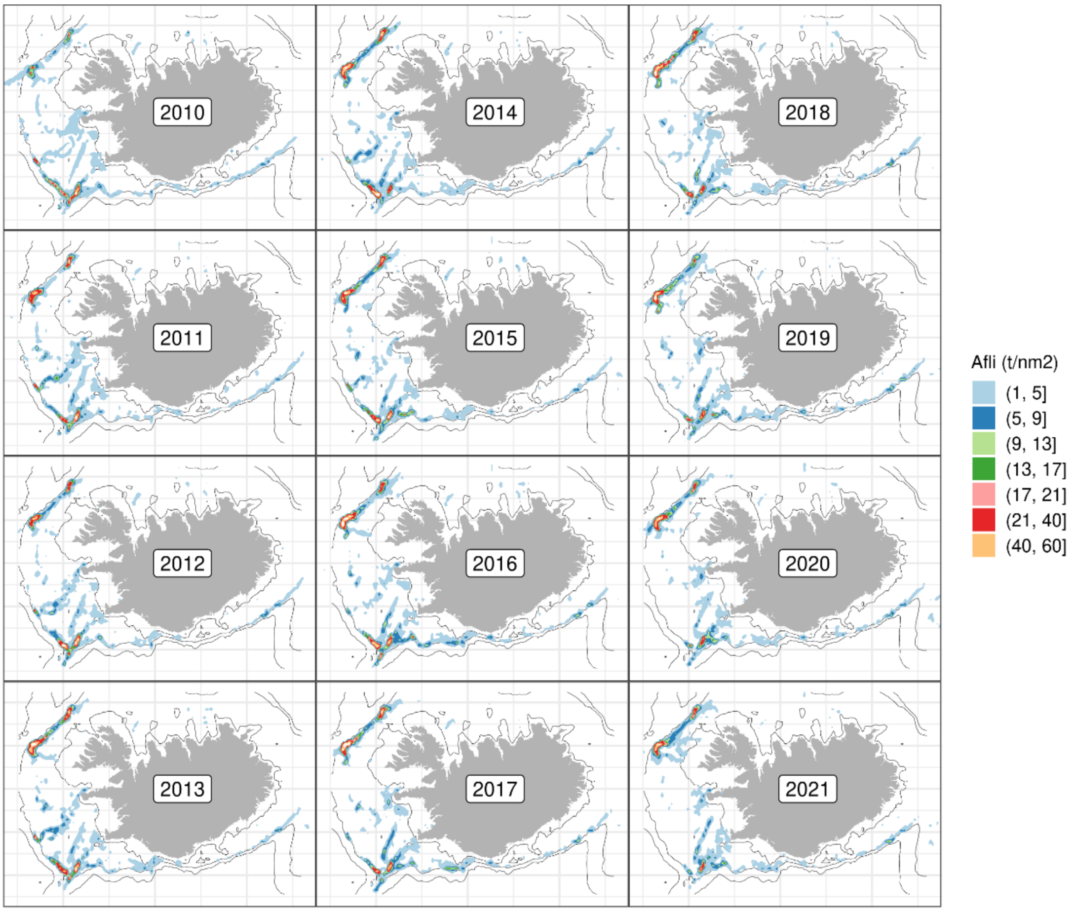


Figure 19.3.2 Geographical distribution of golden redfish bottom trawl catches in Division 5.a 2010–2021.

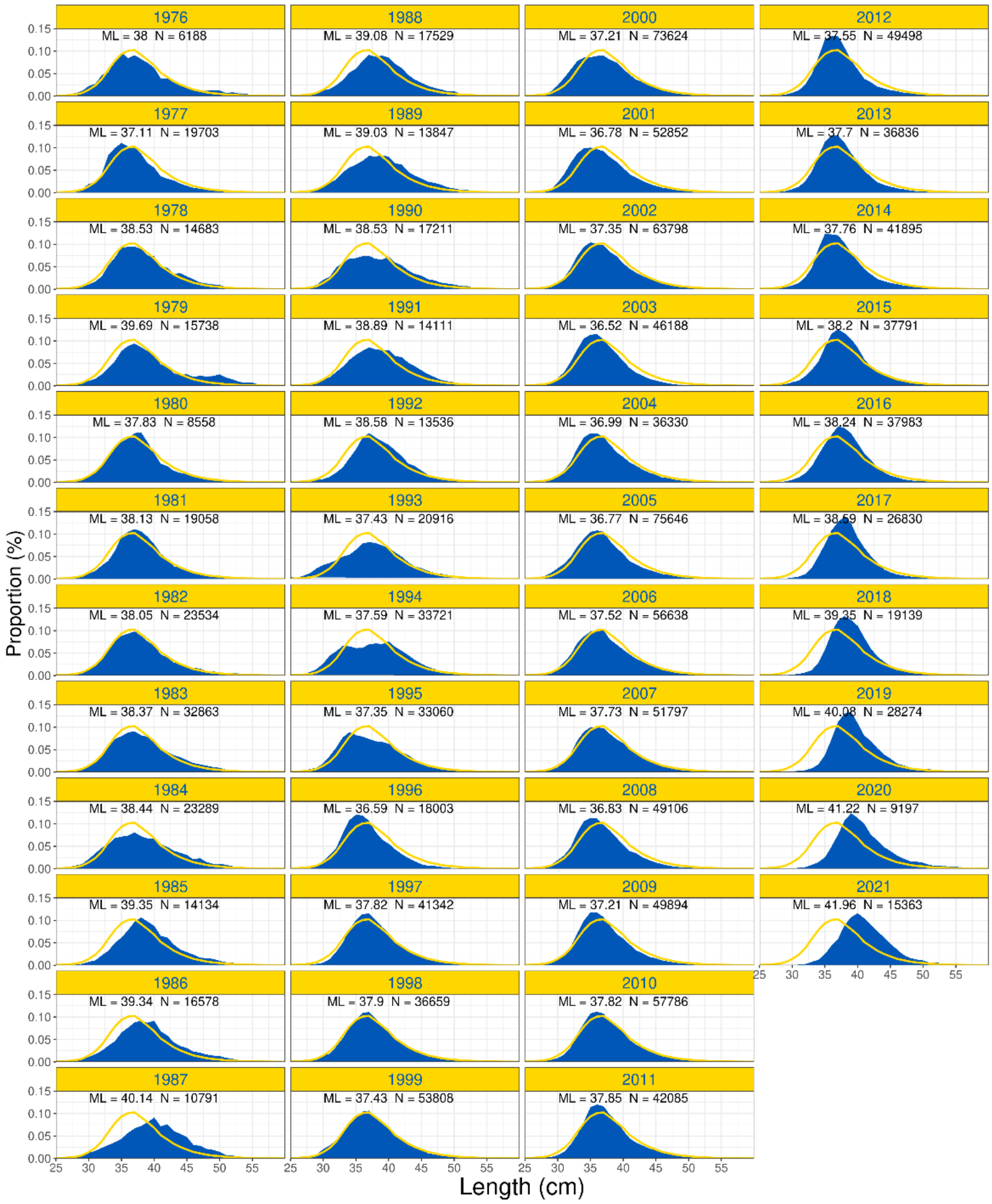


Figure 19.3.3 Length distribution (grey shaded area) of golden redfish in Icelandic waters (ICES Division 5.a) in the commercial landings of the Icelandic bottom trawl fleet 1976–2021. The yellow line is the mean of the years 1976–2021.

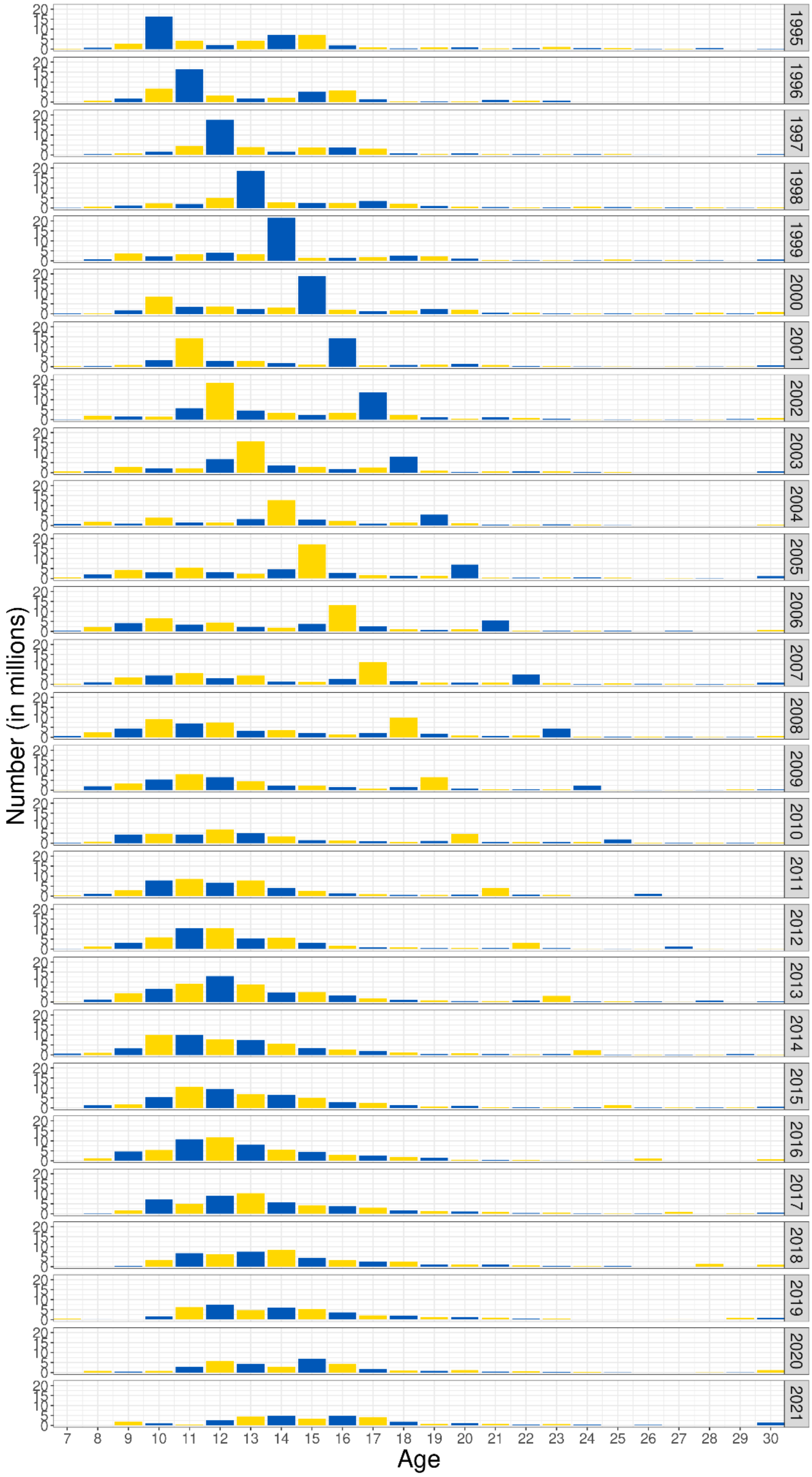


Figure 19.3.4 Catch-at-age of golden redfish in numbers in ICES Division 5.a 1995–2021.

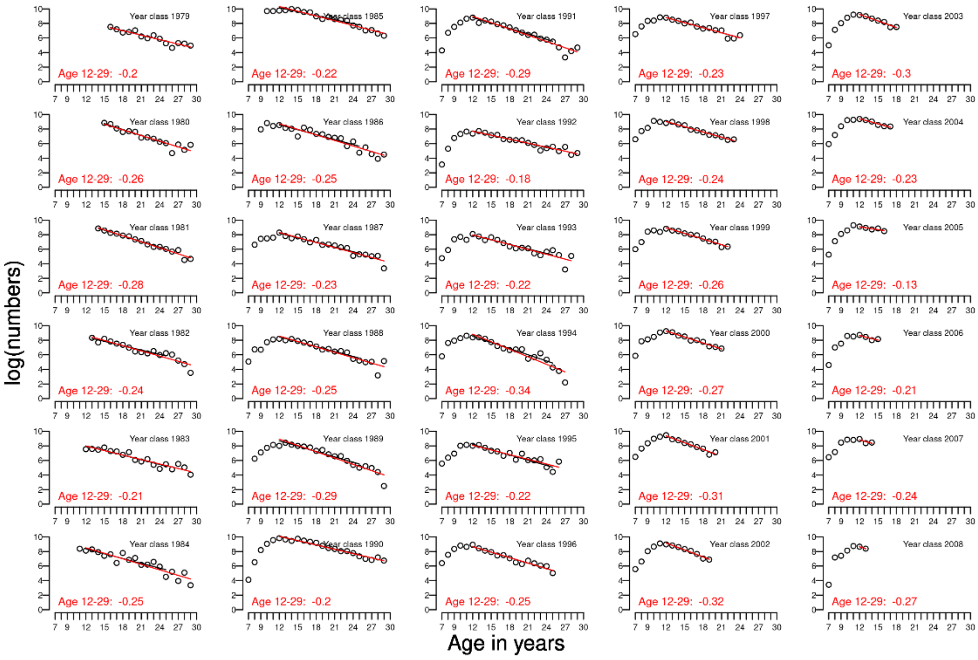


Figure 19.3.5 Catch curve of the 1981–2005 year-classes of golden redfish based on the catch-at-age data in ICES Division 5.a 1995–2020.

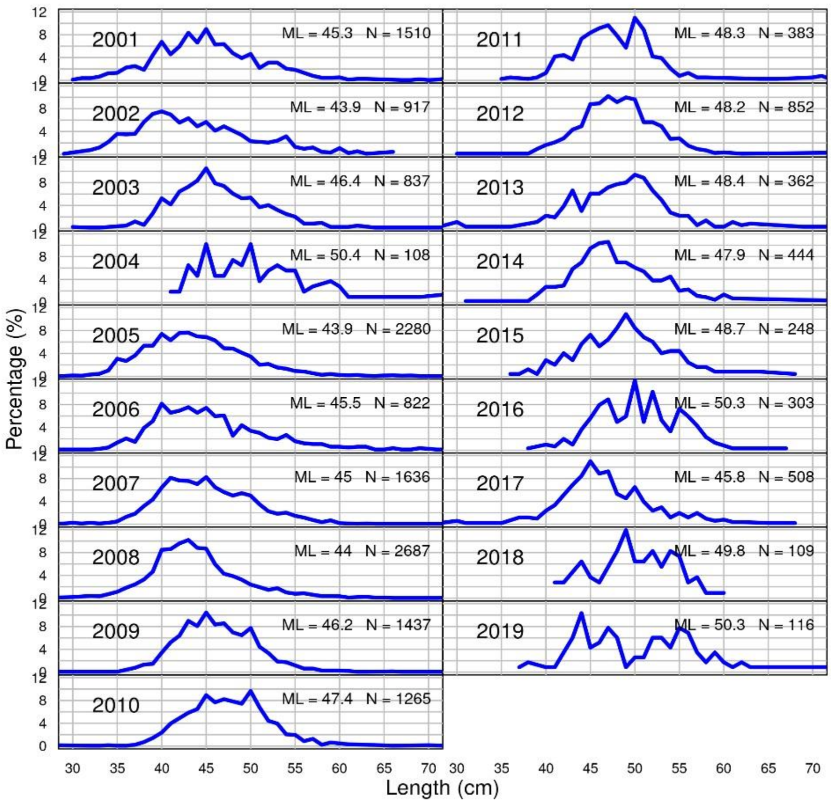


Figure 19.3.6 Length distribution of golden redfish from Faroese catches in ICES Division 5.b in 2001–2019.

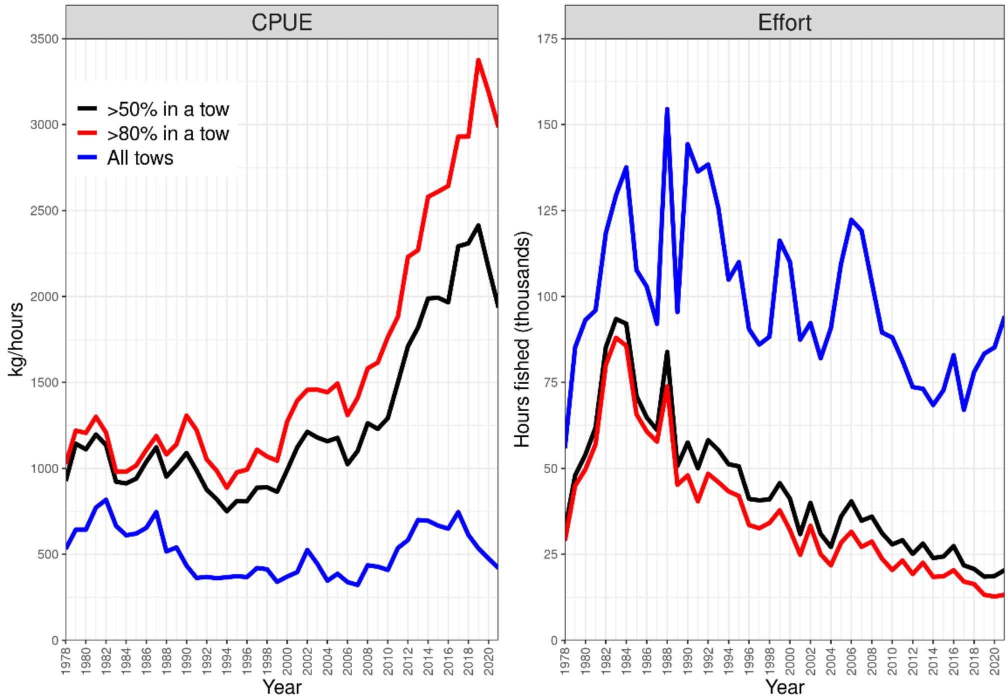


Figure 19.3.7 CPUE of golden redfish from Icelandic trawlers 1978–2021 where golden redfish catch composed at least 50% of the total catch in each haul (black line), 80% of the total catch (red line) and in all tows where golden redfish was caught (blue line). The figure shows the raw CPUE index (sum(yield)/sum(effort)) and effort.

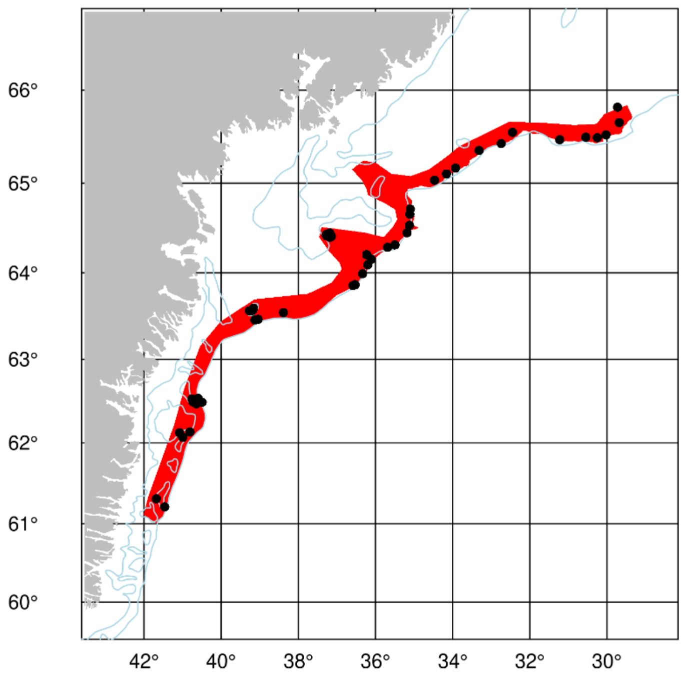


Figure 19.4.1 Stations in the German survey in East Greenland in 2020 with an area used to compile the indices for Gadget shown. This area corresponds to giving a weight of 0.5 to the results in Figure 19.2.7.

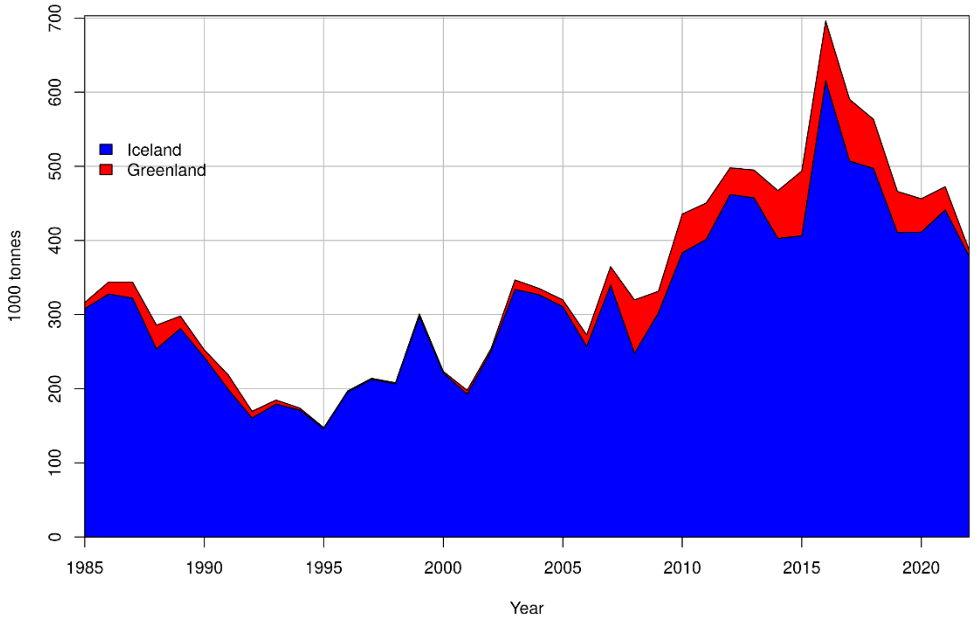


Figure 19.4.2 Biomass index from Iceland (blue) and Greenland (red), based on weighting the German survey data in Figure 19.2.7 by 0.5. In 2019, the survey index is based on the Icelandic survey and the average of the 2017 and 2019 values from the German survey in Greenland because it was not conducted in 2018. The survey was not conducted in 2021 in Greenland waters so the value for the German survey is the same as in 2020.

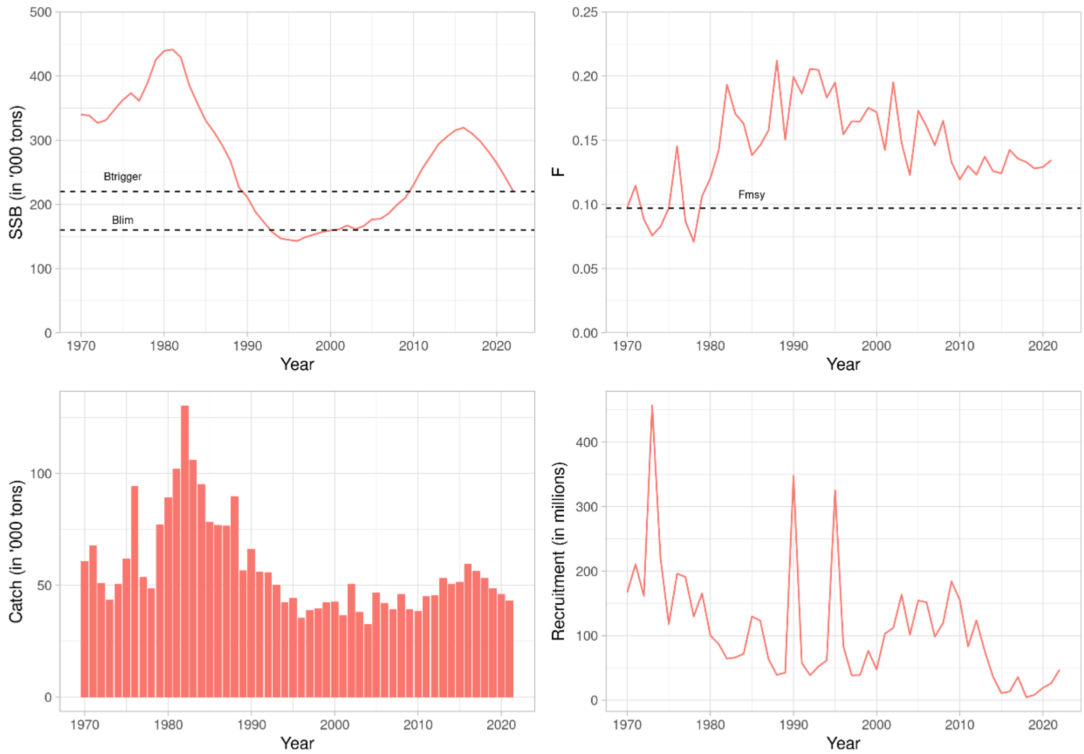


Figure 19.4.3. Summary from the assessment in 2022.

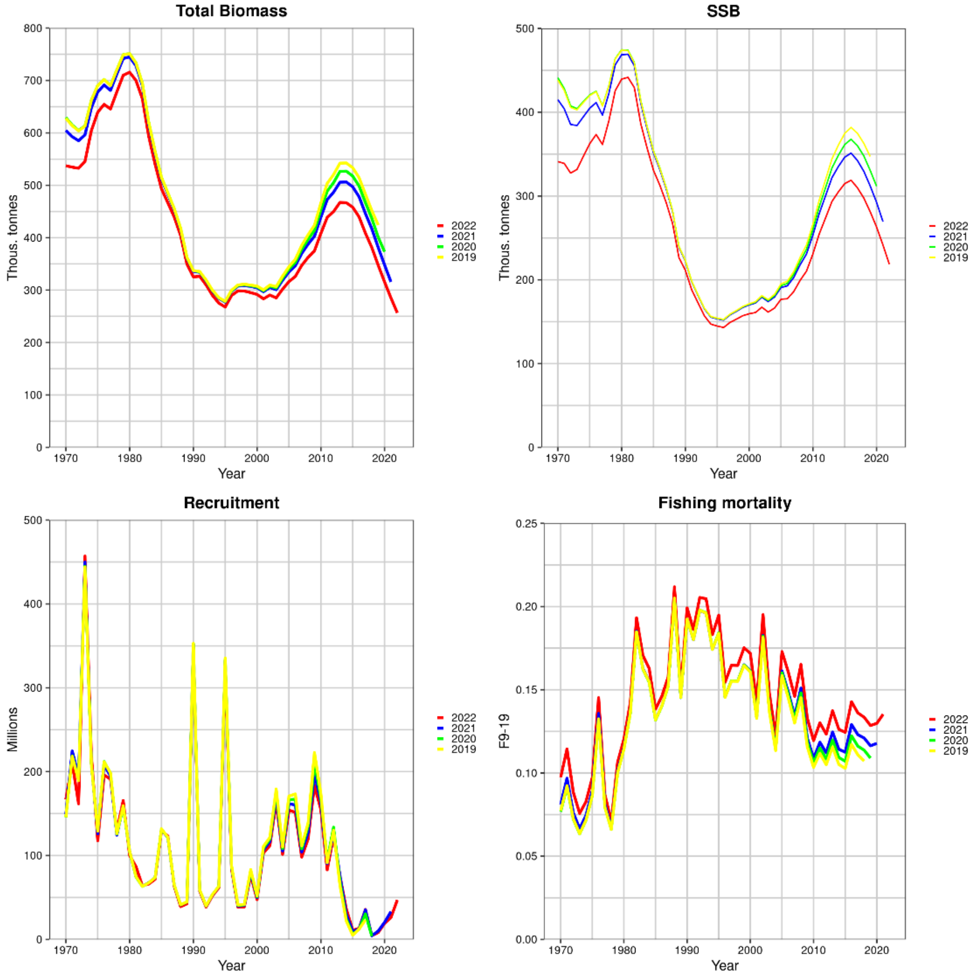


Figure 19.4.4. Comparison of the current assessment (red line) and the same assessment done in 2019-2021 for the total biomass, spawning stock biomass, fishing mortality and recruitment.

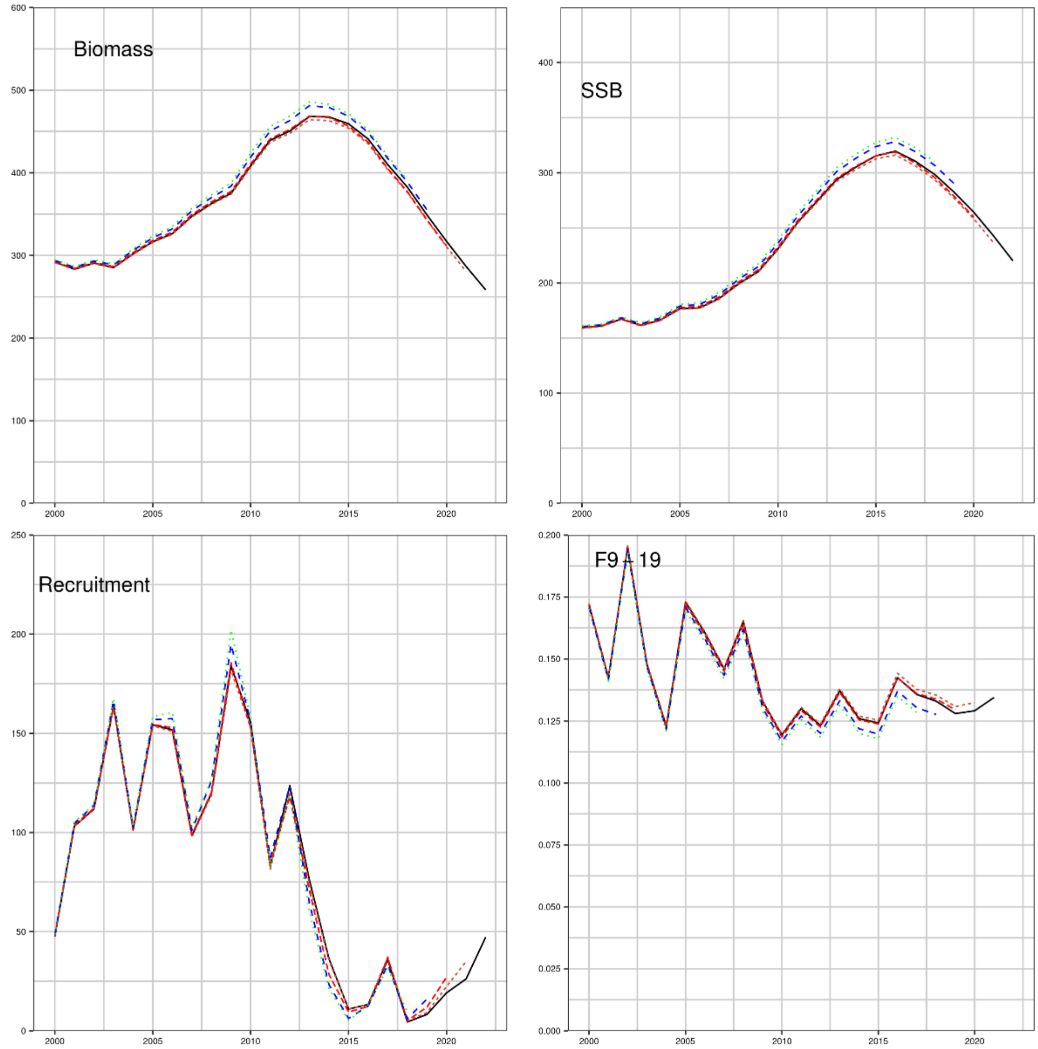


Figure 19.4.5. Analytical retrospective pattern of the base run. Recruitment is at age 5 and F shows the development of ages 9–19.

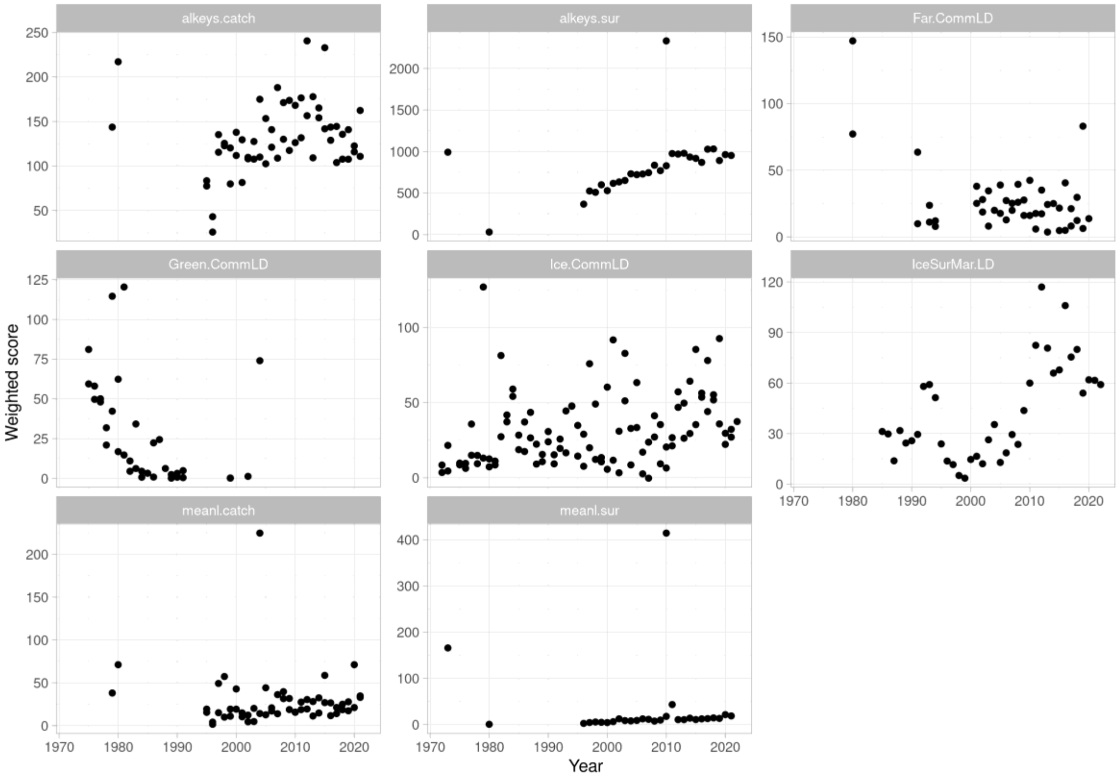


Figure 19.4.6. Development of component of the objective function with time.

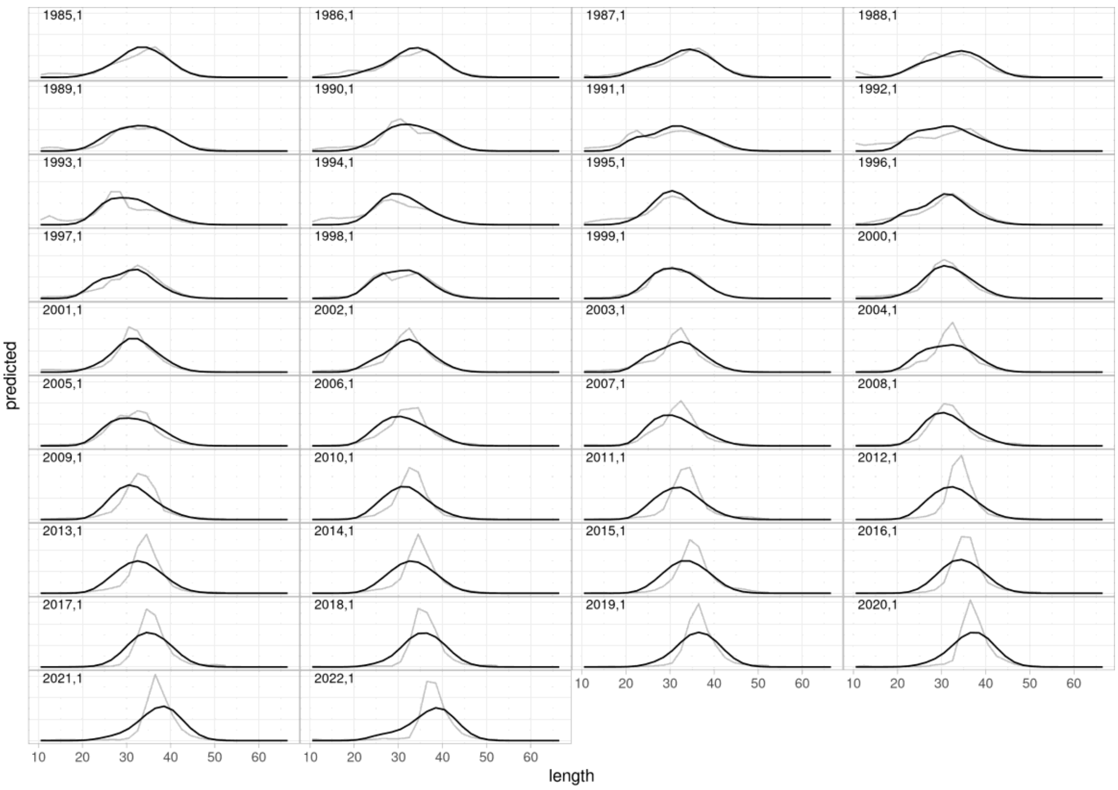


Figure 19.4.7. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions in the spring survey (grey lines).

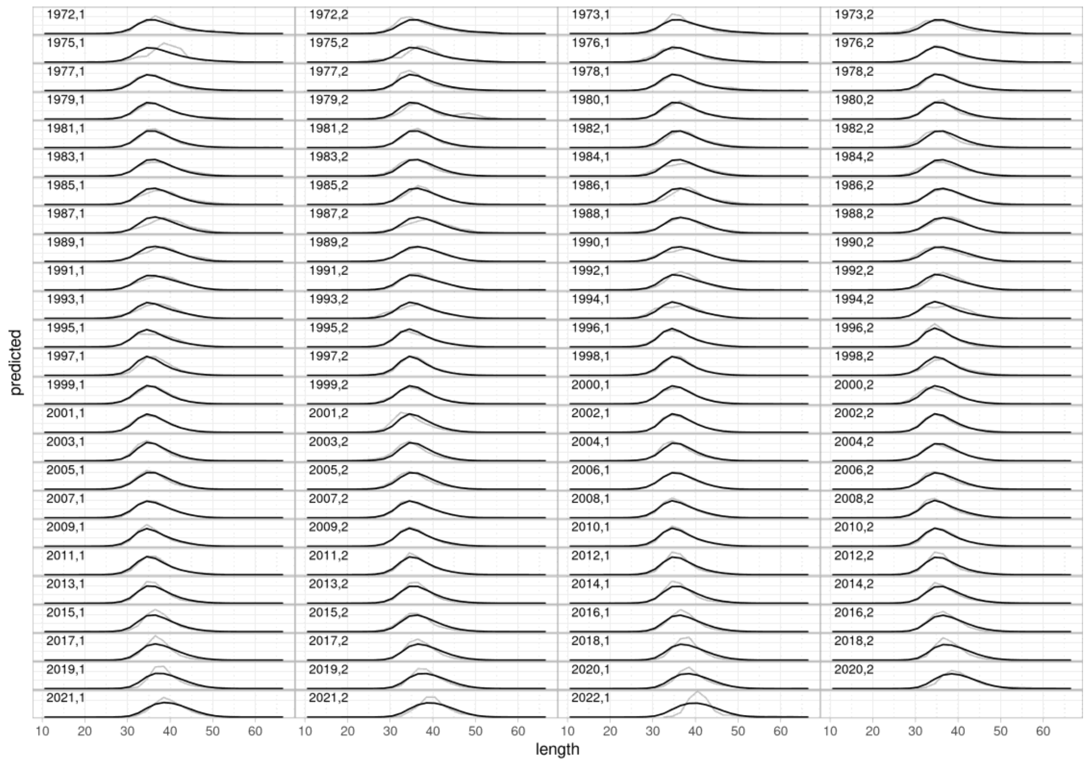


Figure 19.4.8. Fitted proportions-at-length from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

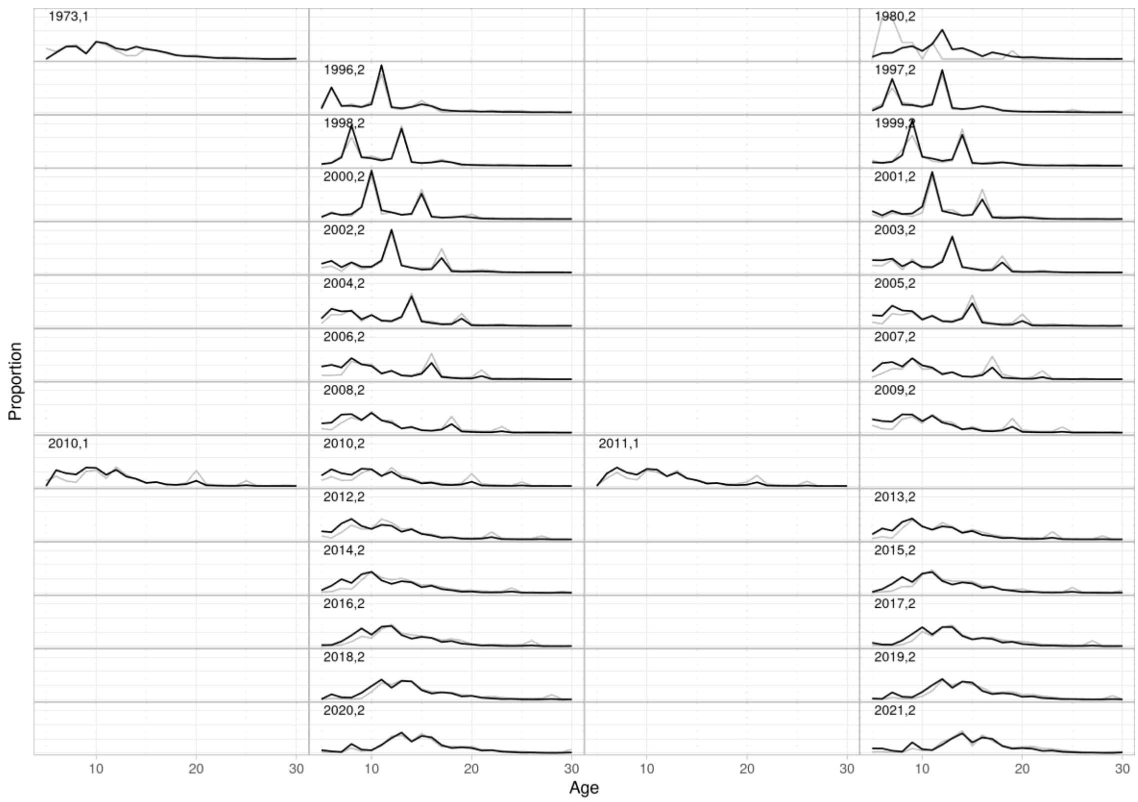


Figure 19.4.9. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions in the autumn survey (grey lines).

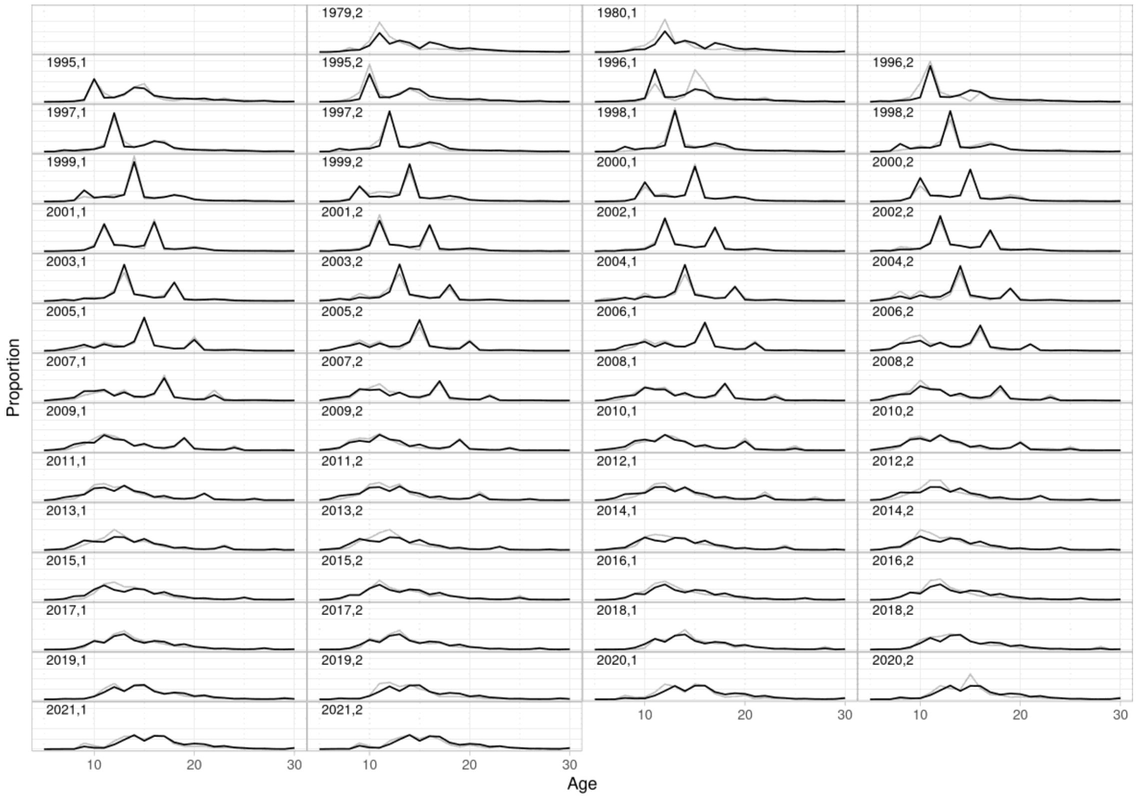


Figure 19.4.10. Fitted proportions-at-age from the Gadget model (black lines) compared to observed proportions from the Icelandic commercial catches (grey lines).

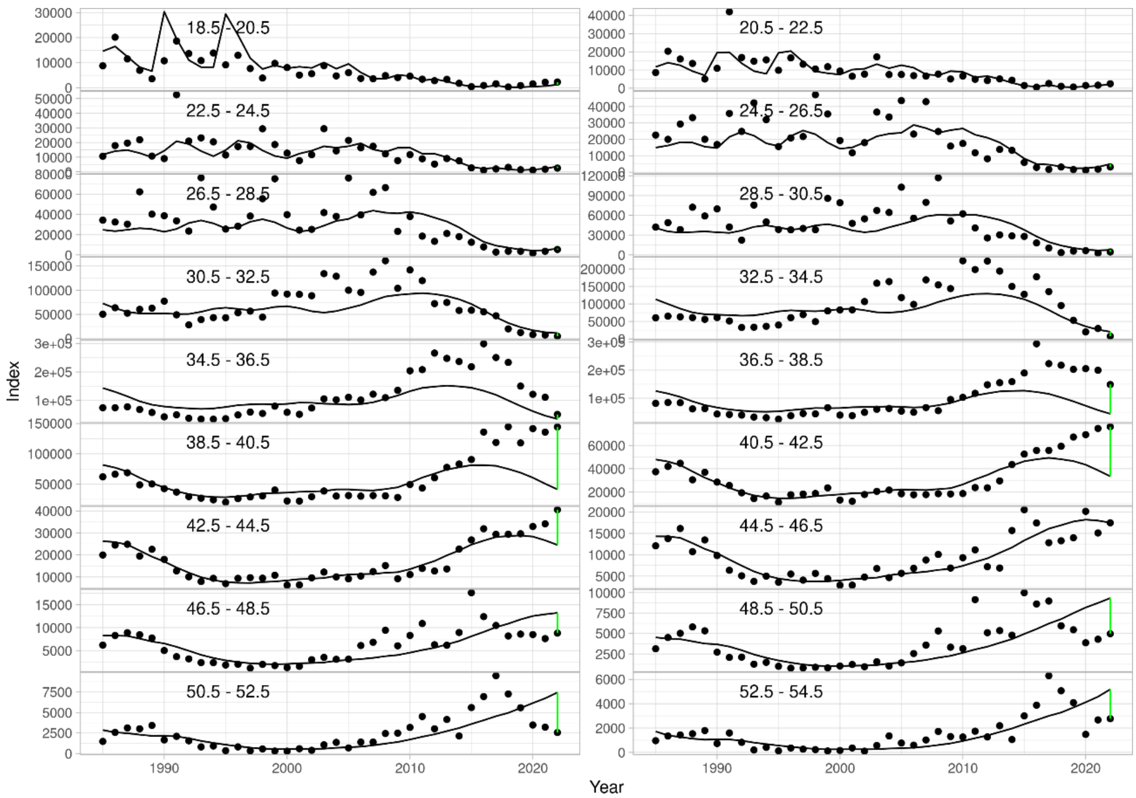


Figure 19.4.11 Gadget fit to indices from disaggregated abundance by length indices from the spring survey.

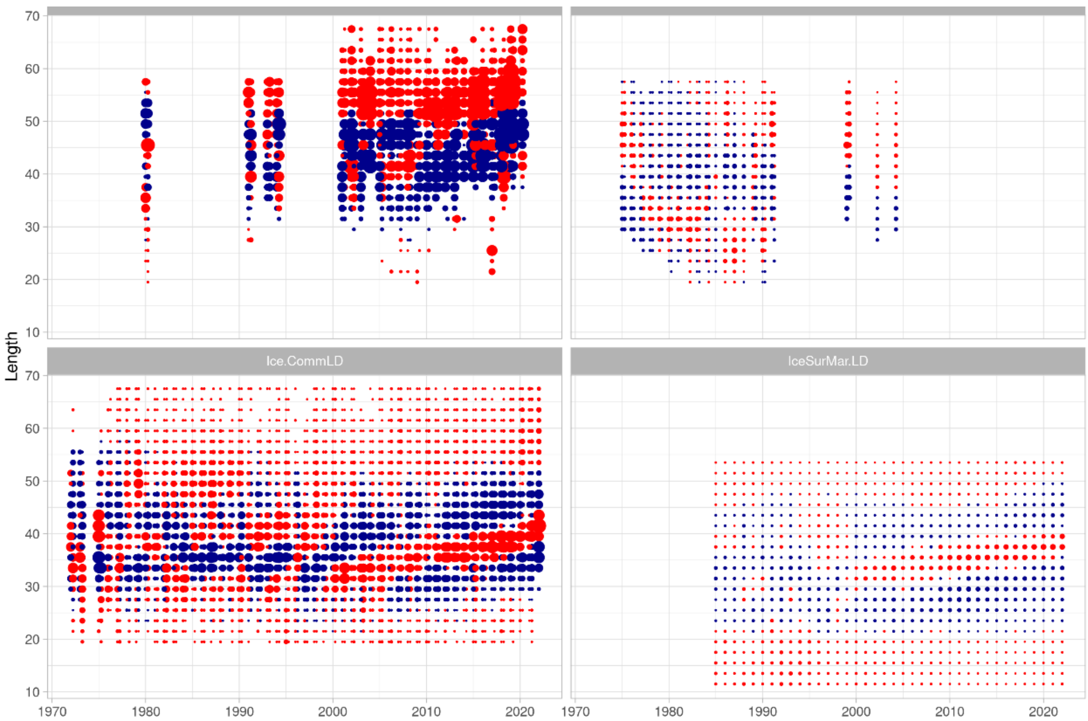


Figure 19.4.12. Residuals from the fit between model and survey indices. The red circles indicate positive residuals (survey results exceed model prediction). Largest residuals correspond to log(obs/mod) = 1

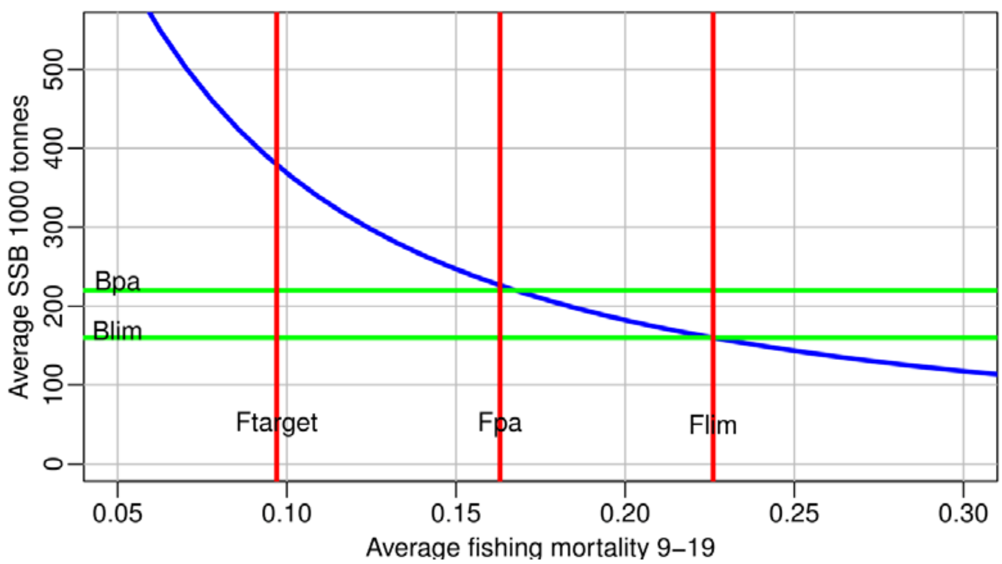


Figure 19.5.1. Average SSB against average fishing mortality and defined reference points.

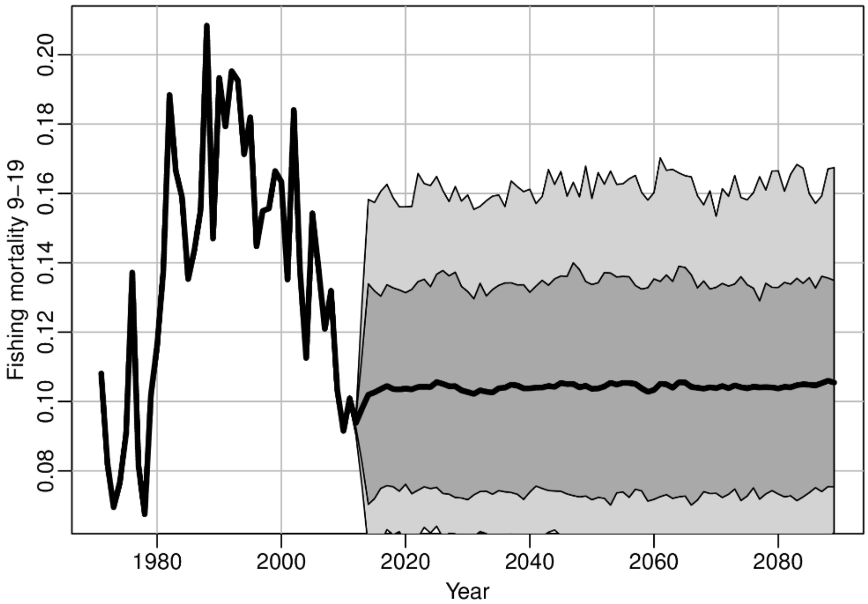


Figure 19.5.2. Development of $F_{9–19}$ based on F_{9-19} = 0.097. The light grey area shows fifth and 95th quantile and the dark areas 16th and 84th quantile.

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 2000–2021. 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 the highest level in 2021 (Figure 20.2.1). The abundance index of fish 30 cm and smaller (recruits) has been at very low level since 2007 and no fish below 30 cm was observed in the 2021 survey (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 2012-2021 (Figure 20.2.2). During this period the mean length of the fish caught has increased from 37.4 cm to 43 cm in 2021 (Figure 20.2.2). This is a large increase in mean length for a species which annual growth is around 1-2 cm and where very few individuals larger than 50 cm are observed. This confirms the recruitment failure.

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) 1950–2021 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 2011-2021 were between 8300 and 12 000 t. The total catch in 2021 were 10 588 t, a slight decrease from previous year.

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 2001-2021, 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 2021 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 pandemic 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	10 588	23	4005

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 2004-2021 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 2021 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

Ministry of Food, Agriculture and Fisheries (MFAF) in Iceland 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 1 September 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 2004-2021 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 1995–2021 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.

20.9.1 *rfb* rule

During the meeting the *rfb* rule (part of Category 3 MSY advice rule), which is meant to replace the usual 2-over-3 rule, was explored for the stock. The method requires abundance index, in this case from the IS-SMH, and length information.

The *rfb* rule:

$$A_{y+1} = A_y * r * f * b * m$$

where A_{y+1} is the advice for next year, $A_y$is the advice for current year, r is the 2-over-3 ratio from the survey, f is ratio of mean length relative to target reference length, b is the biomass safeguard adjustment, and m is a tuning parameter to ensure the *rfb* rule precautionary. The table below describes how various parameter are defined and calculated.

Component	Definition	Description and use
A_y		The most recent year's advised catch.
A_{y+1}	$A_y \times r \times f \times b \times m$	The advised catch for next year y+1 (set on a biennial basis).
r	$\frac{\sum_{i=y-2}^{y-1}(I_i/2)}{\sum_{i=y-5}^{y-3}(I_i/3)}$	The rate of change in the biomass index (I), based on the average of the two most recent years of data (y−2 to y−1) relative to the average of the three years prior to the most recent two (y−3 to y−5), and termed the "2 over 3" rule. y = assessment (intermediate) year
f	$\frac{\bar{L}_{y-1}}{L_{F=M}}$	Fishing proxy is the mean length relative to MSY proxy length. The ratio of the mean length ($\bar{L}_{y-1}$) in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where. L_c is defined as length at 50% of modal abundance (ICES, 2018b). Moves the stock towards MSY. Follows Beverton and Holt (1957), derived by Jardim et al. (2015). Assumes M/k = 1.5
b	$\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger} = 1.4I_{loss}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger}, b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. $I_{trigger}$ may need to be adapted if the stock has been exploited only heavily or lightly in the past. Ideally, $I_{trigger}$ should correspond to $MSY_{Btrigger}$.
m	[0,1]	A tuning parameter to ensure that the rfb rule is precautionary (that risk does not exceed 5%). It does not decrease advice continuously, it adjusts the advice to a target. m is linked to von Bertalanffy k and based on generic MSE simulations. Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0.
Stability clause	$min\{max(0.7C_y, A_{y+1}), A\}$	Asymmetric conditional uncertainty cap. Limits the amount the advised catch can change upwards or downwards between years. The recommended values are +20% and −30%; i.e. the catch would be limited to a 20% increase or a 30% decrease relative to the previous year's advised catch. The stability clause does not apply when b < 1.

The table below shows the parameter values for the Icelandic slope beaked redfish:

Parameter	Description	Value
A_y	Advice for 2022	7926 t
I_A	Average survey index 2020-2021	110 930
I_B	Average survey index 2017-2019	111 020
k	Growth parameter from von Bertalanffy	0.142
r	Index ratio (I_A/I_B)	1
f	$\frac{\bar{L}_{y-1}}{L_{F=M}}$	1.101
b	$I_{y-1} > I_{trigger}$	1
m	$k < 0.2$	0.95
L_∞	From von Bertalanffy	49 cm
L_c	Length at 50% of modal abundance in the catch	34.5 cm
$L_{F=M}$	$0.75L_c + 0.25L_\infty$	39.25 cm
$\bar{L}_{y-1}$	Mean length from the observed catch in 2021	43.23
$I_{trigger}$	$1.4I_{loss}$; ($I_{loss} = 63188$, lowest value in the survey)	88 460
I_{y-1}	Survey index value for 2021	138 489
A_{y+1}	Advice for 2023	8296 t

The advice for 2023 would then be:

$$A_{2023} = 7926 * 1 * 1.101 * 1 * 0.95 = 8296\ t$$

The increase in catch advice is driven by increased mean length (growth) in the catch as all other parameters pretty much fixed.

Issues:

1. Mean length in the commercial catch has been increasing (Figure 20.3.3) and this trend can also be seen in the survey (Figure 20.2.2).
2. The reason for this increase in mean length is that there is no incoming recruitment. Since 2010 recruitment (defined as fish <30 cm) has been at very low levels and in the 2021 survey no fish <30 cm was observed (Figure 20.2.1).
3. The total biomass index has been relatively stable in the 2002-2021 period (Figure 20.2.1), resulting in the *r* value fluctuating around 1.
4. With the *f* ratio parameter increasing annually (increased mean length in the commercial catch) with all other parameters being constant will lead to an increase in the advice.
5. Results from exploratory analytical assessment indicate that the stock has been depleted to low levels and is most likely below any possible reference points (Figure 20.12.10).

Conclusion: This method is probably not precautionary for this stock (slow-growing and late-maturing) as it does not incorporate the lack of recruitment (in this case for more than 10 years).

The NWWG group recommends that the current 2-over-3 rule should be used to give advice for 2023. The stock will be benchmarked in early 2023 (prior to the 2023 NWWG meeting, see Chapter 20.11).

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 2023

The stock will be benchmarked in early 2023 (WKNORTH 2023). 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.

20.14 Tables

Table 20.2.1 Total biomass index (tonnes) of Icelandic slope *S. mentella* in the Icelandic Autumn Groundfish survey 2000–2021. 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	-	-	-
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
2021	131 489	92 831	170 147

Table 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* 1950–2021 from the Iceland Sea ecoregion (ICES Division 5.a and Subarea 14 within the Icelandic EEZ).

Year	Iceland	Others	Total
1950	1458	36 269	37 727
1951	1944	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	1404	29 301	30 705
1976	715	28 632	29 346
1977	590	22 427	23 018
1978	3693	209	3902
1979	7448	246	7694
1980	9849	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	1115	28 590
2000	30 185	1208	31 393
2001	15 415	1815	17 230
2002	17 870	1175	19 045
2003	26 295	2183	28 478
2004	16 226	1338	17 564
2005	19 109	1454	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	8761	0	8761
2014	9500	0	9500
2015	9311	0	9311
2016	9536	0	9536
2017	8371	0	8371
2018	9995	0	9995
2019	8716	0	8716
2020	11 375	0	11 375
2021[1)]	10 588	0	10 588

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 1991–2021.

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%
2008-2021	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}

20.15 Figures

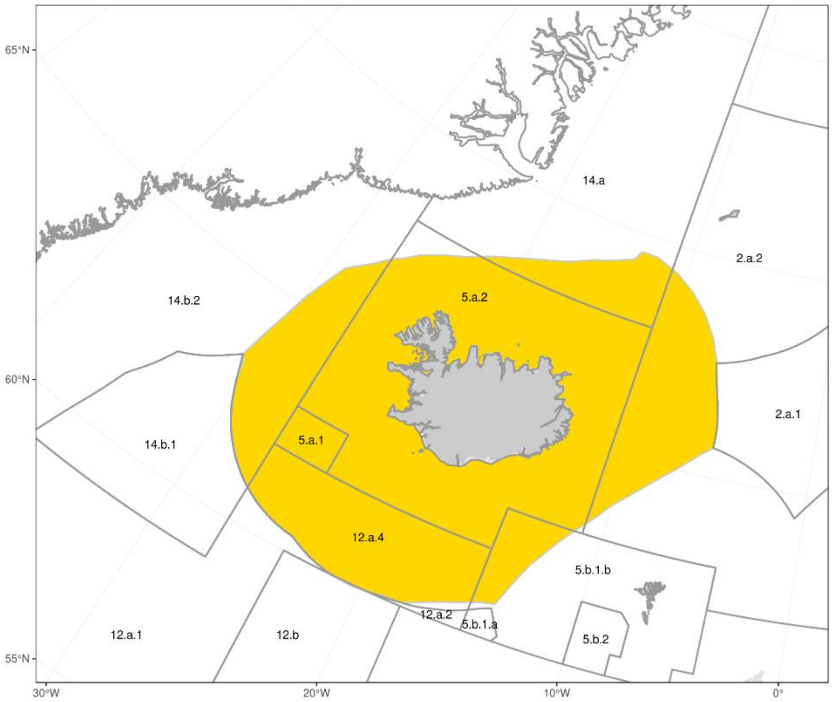


Figure 20.1.1 The Iceland Sea ecoregion (in yellow) as defined by ICES. The relevant ICES statistical areas are shown.

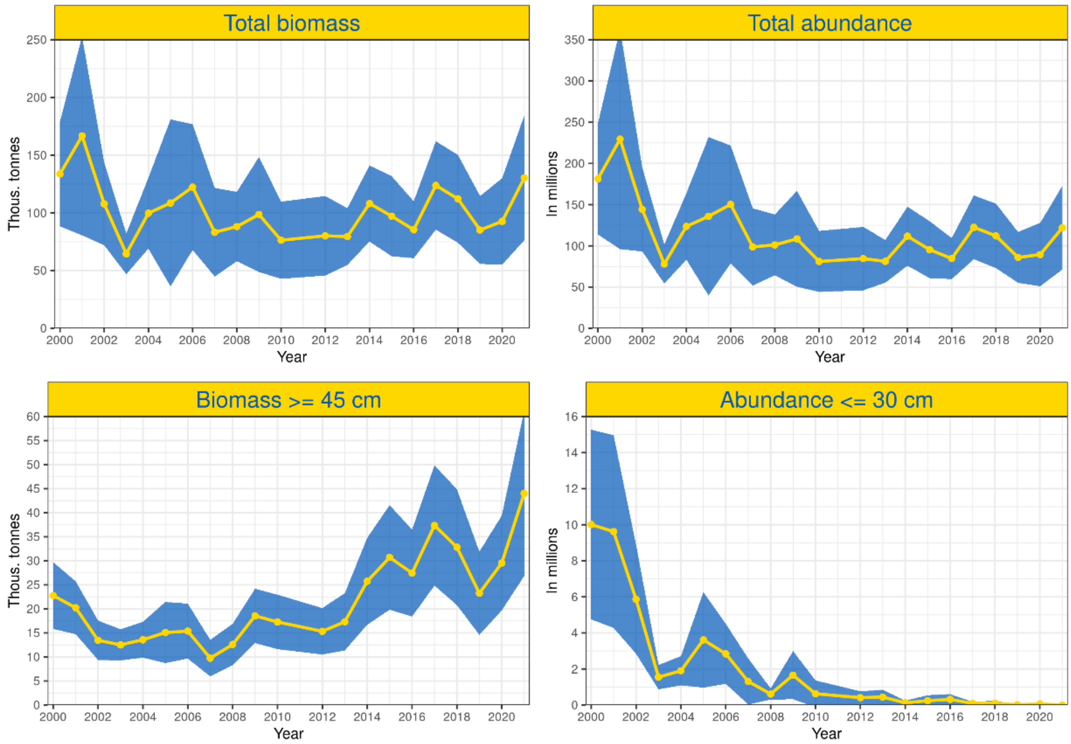


Figure 20.2.1 Survey indices of the Icelandic slope *S. mentella* in the autumn survey in Icelandic waters (ICES Division 5.a and part of Subarea 14) 2000–2021. No survey was conducted in 2011. The figure shows the total biomass index, total abundance index in millions of fish, biomass index of fish 45 cm and larger and abundance index of fish 30 cm and smaller.

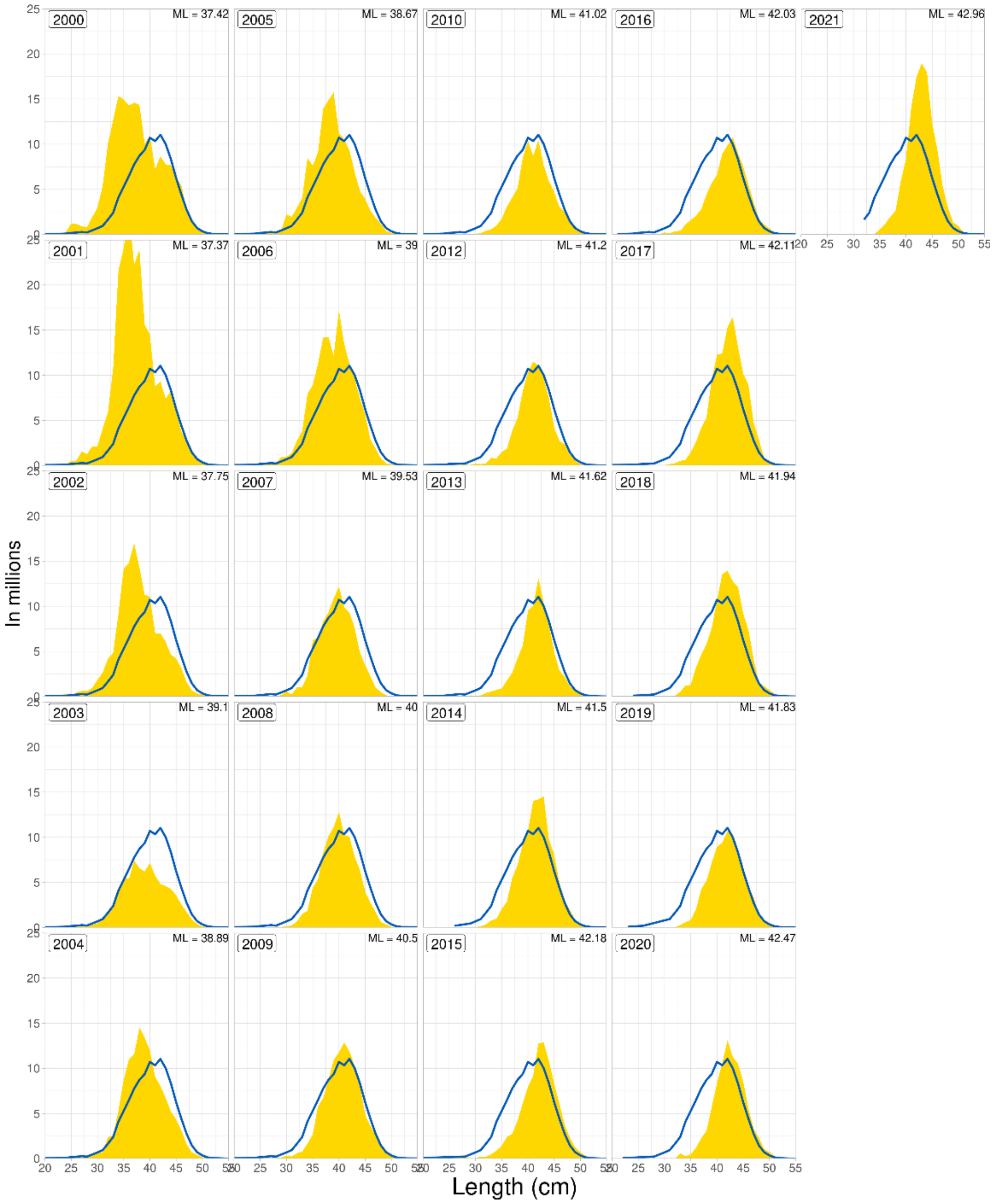


Figure 20.2.2 Length distribution of Icelandic slope *S. mentella* in the Autumn Groundfish Survey in October 2000–2021 in Icelandic waters (ICES Division 5.a and part of Subarea 14). No survey was conducted in 2011. The blue line is the mean of 2000–2021.

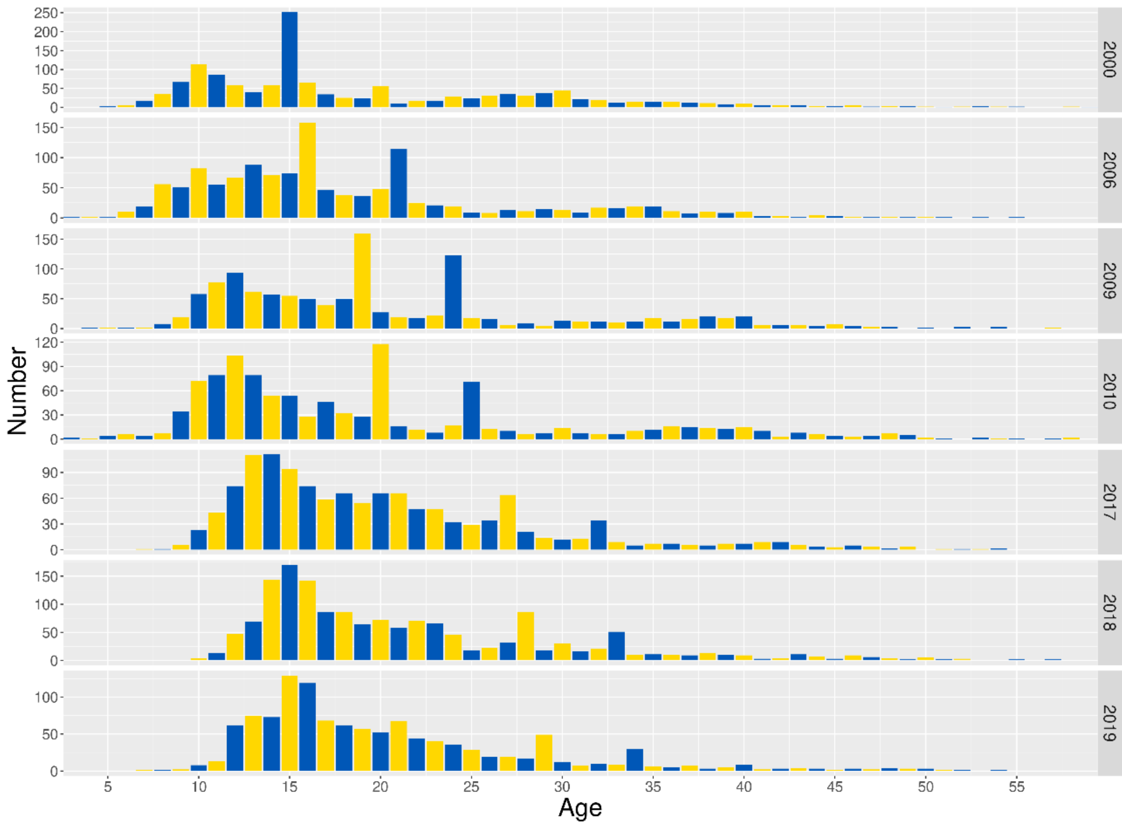


Figure 20.2.3 Age distribution of Icelandic slope *S. mentella* from the Autumn Survey in 2000 (n = 1 405), 2006 (n = 536), 2009 (n = 1 205), 2010 (n = 1 099), 2017 (n = 1 298), 2018 (n = 1 568), and 2019 (n = 1 176). The age class 60 are the combined age-classes of 60 years and older.

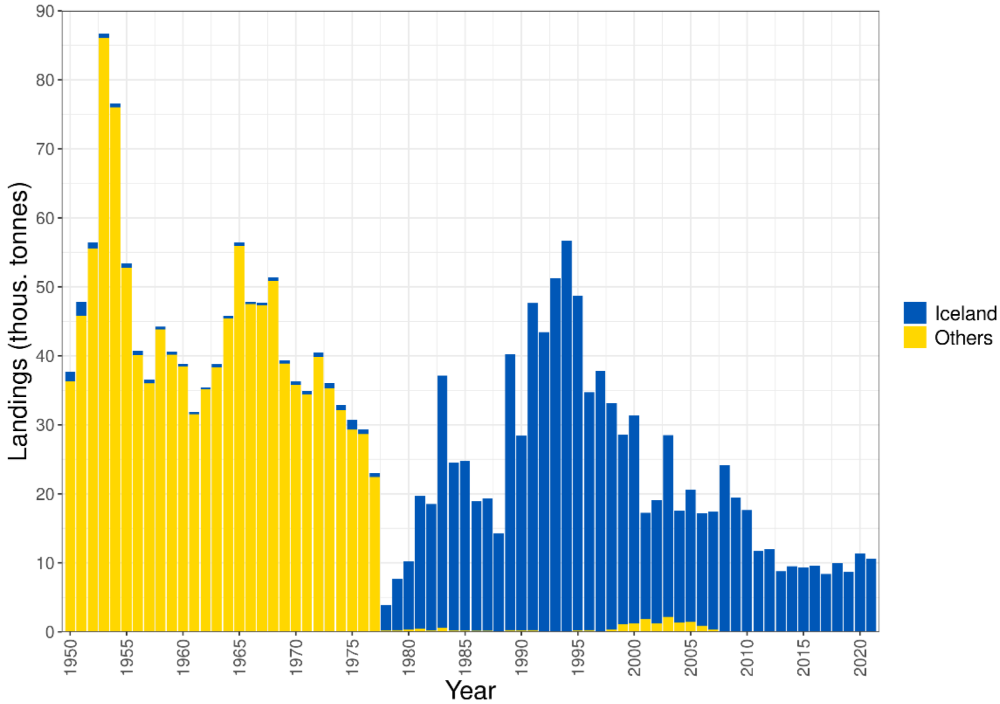


Figure 20.3.1 Nominal landings (in tonnes) of Icelandic slope *S. mentella* from Icelandic waters (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1950–2021.

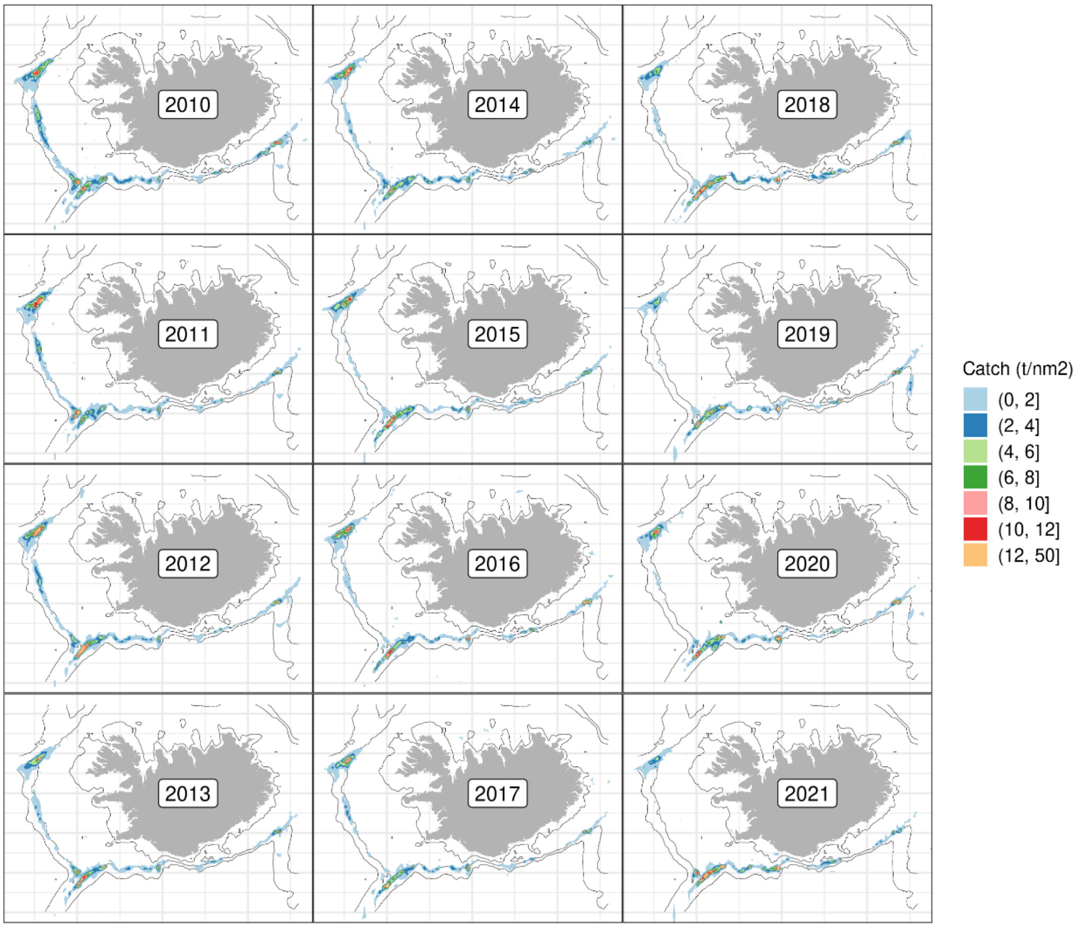


Figure 20.3.2 Geographical location of the Icelandic slope *S. mentella* catches (t/nmi², coloured area) in Icelandic waters (ICES Division 5.a and Subarea 14 and within the Icelandic EEZ) 2010–2021 as reported in logbooks (rep. catch) of the Icelandic fleet using bottom trawl. The black solid line indicates the boundaries of the Icelandic EEZ.

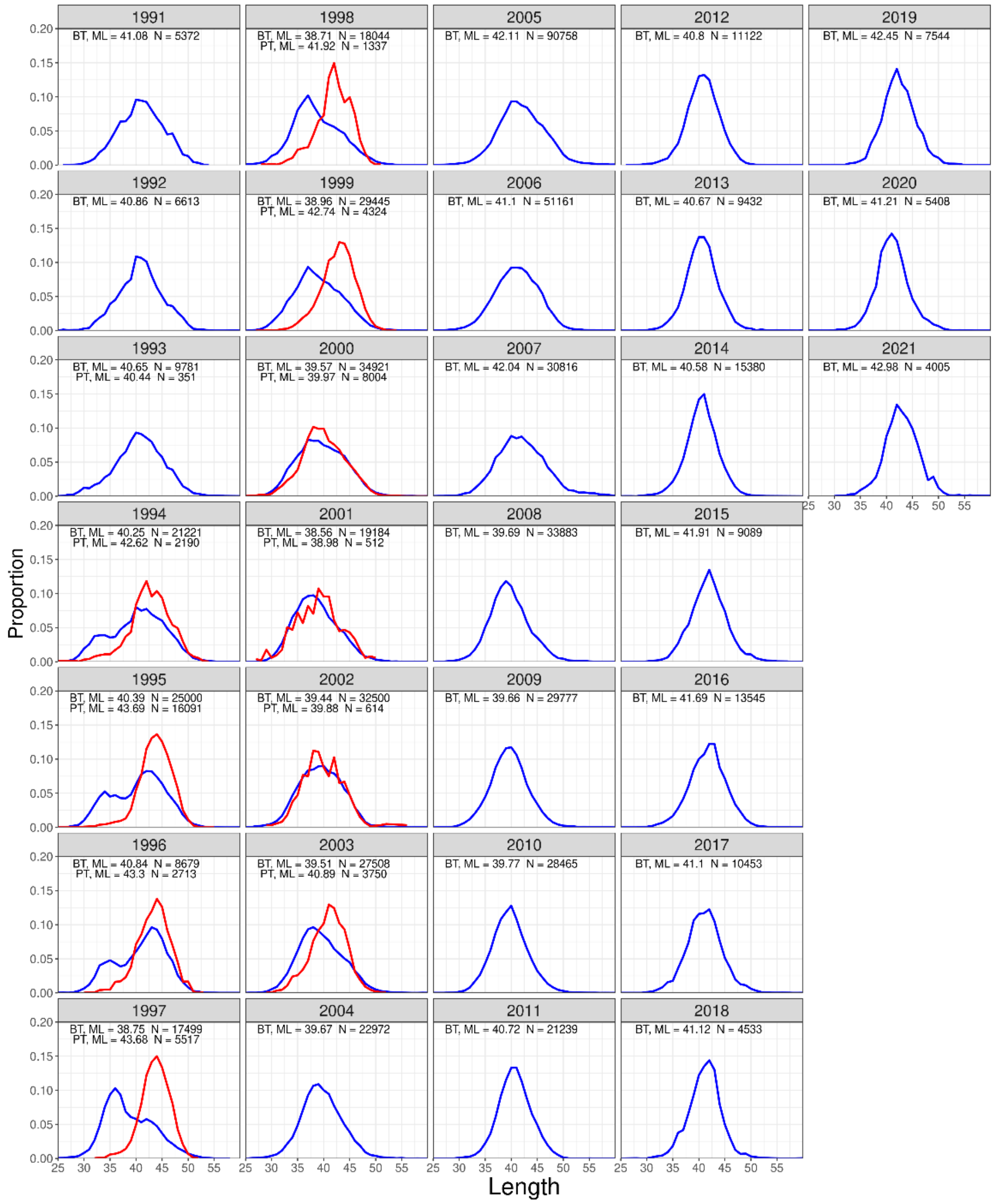


Figure 20.3.3Length distributions of Icelandic slope *S. mentella* from the Icelandic landings taken with bottom trawl (blue line) and pelagic trawl (red line) in Icelandic waters (ICES Division 5.a and Subarea 14) 1991–2020.

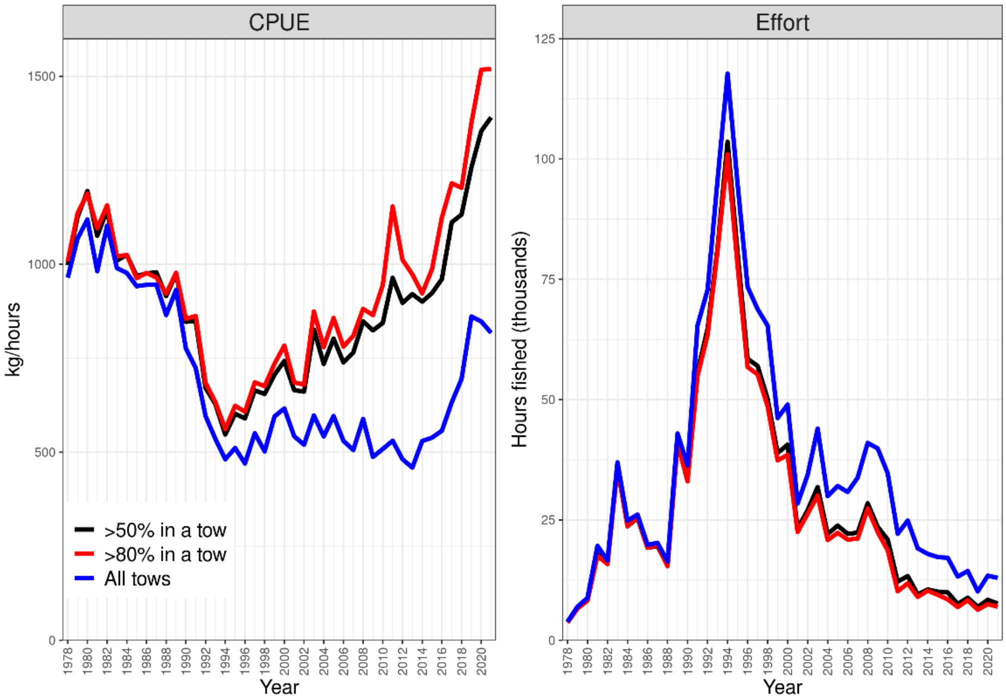


Figure 20.3.4 Non-standardized CPUE (kg/hour) and effort (thousand hours fished) of Icelandic slope *S. mentella* from the Icelandic bottom trawl fishery in Icelandic waters (ICES Division 5.a and Subarea 14 within the Icelandic EEZ) 1978–2020. The black lines show CPUE/effort where more than the 50% 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.

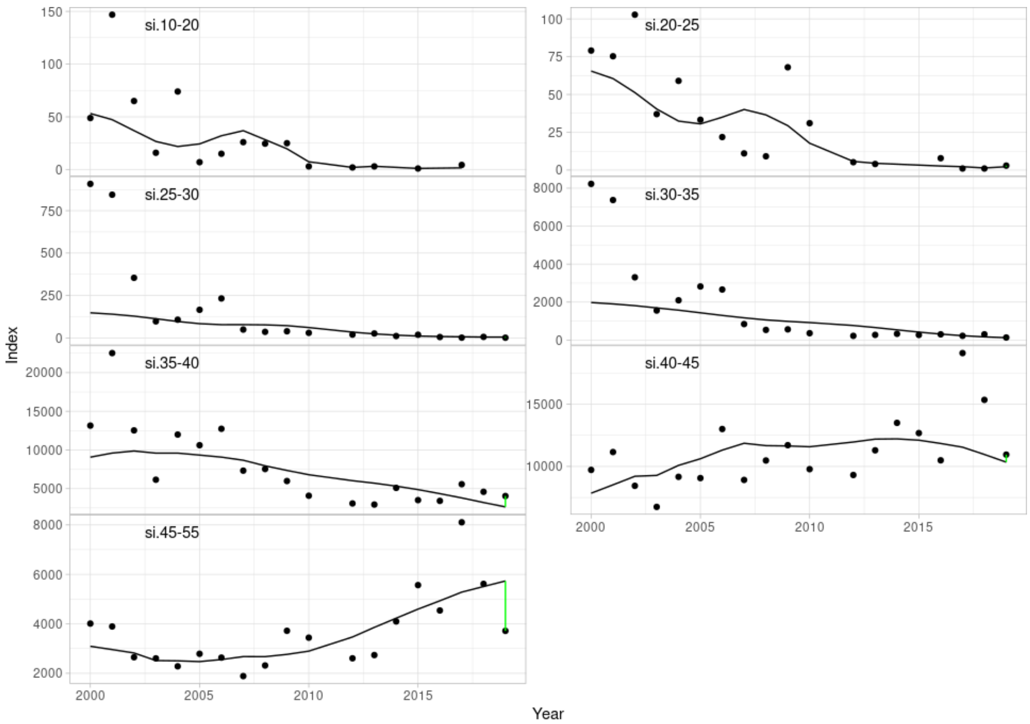


Figure 20.12.1. Icelandic slope beaked redfish. Autumn survey index number fits (lines) to data (points). The green line indicates the difference between model and data values in the last year.

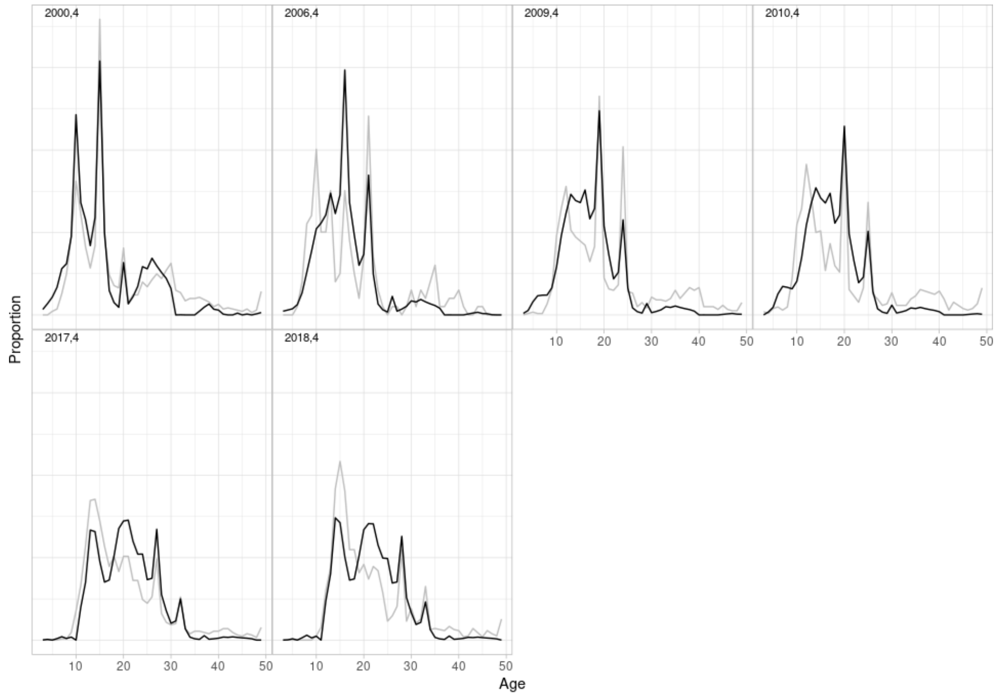


Figure 20.12.2. Icelandic slope beaked redfish. Comparison of autumn survey age distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

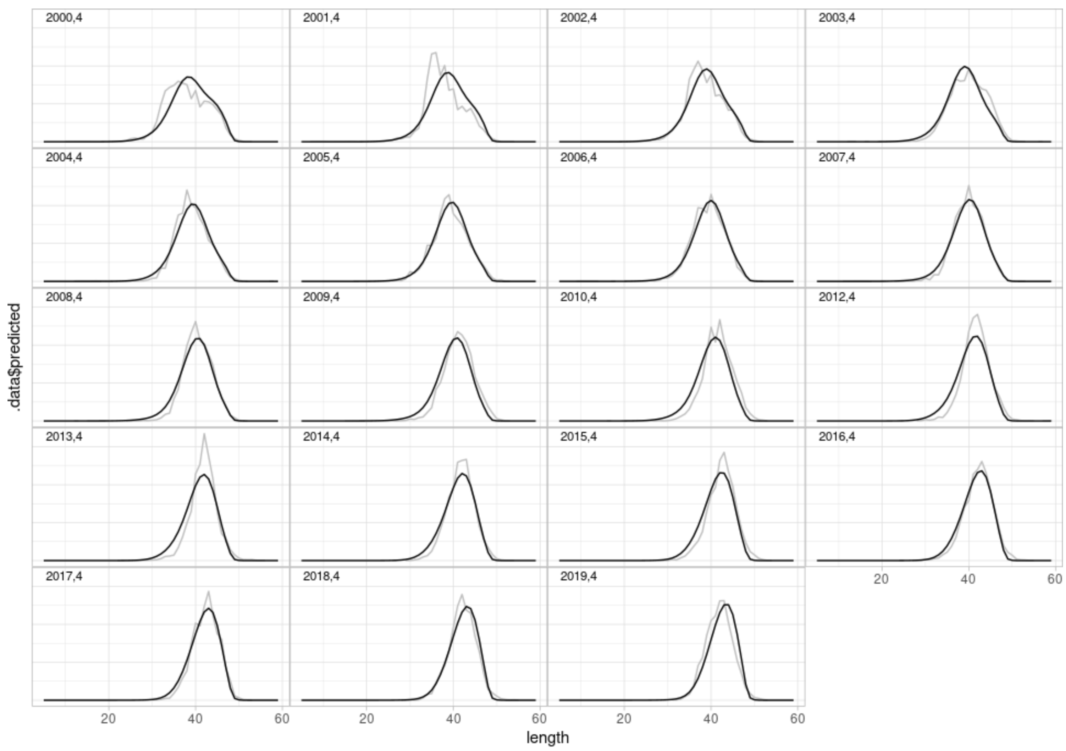


Figure 20.12.3. Icelandic slope beaked redfish. Comparison of autumn survey length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

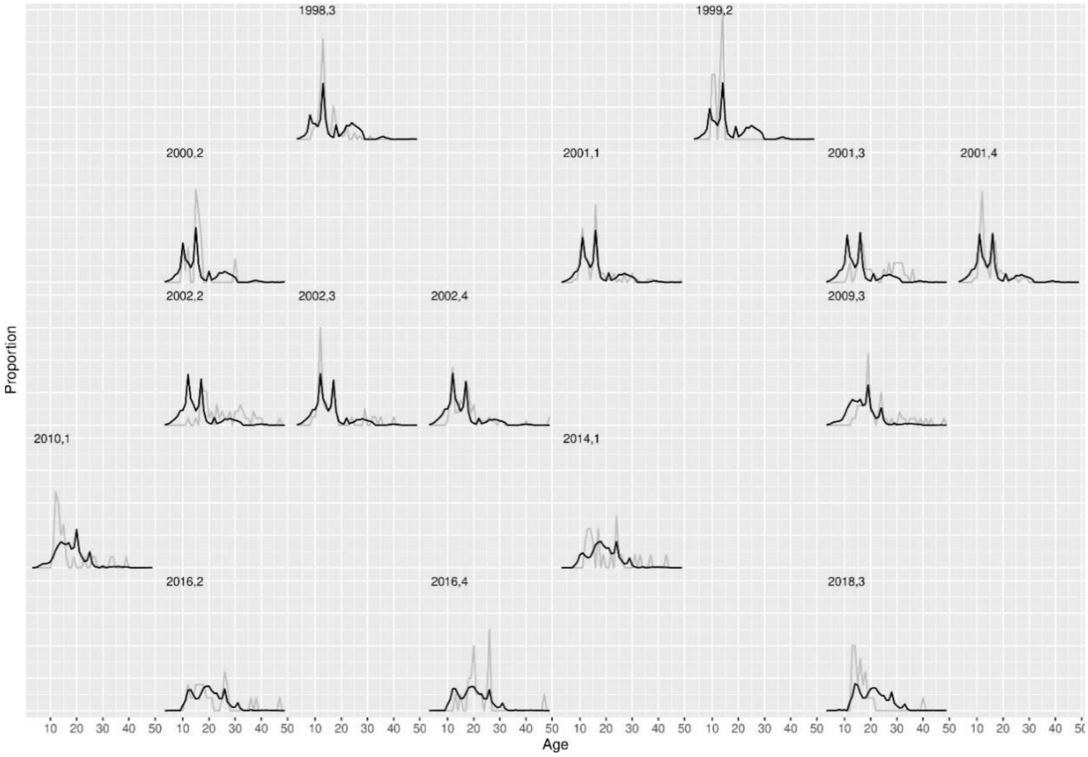


Figure 20.12.4. Icelandic slope beaked redfish. Comparison of commercial sample age-length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

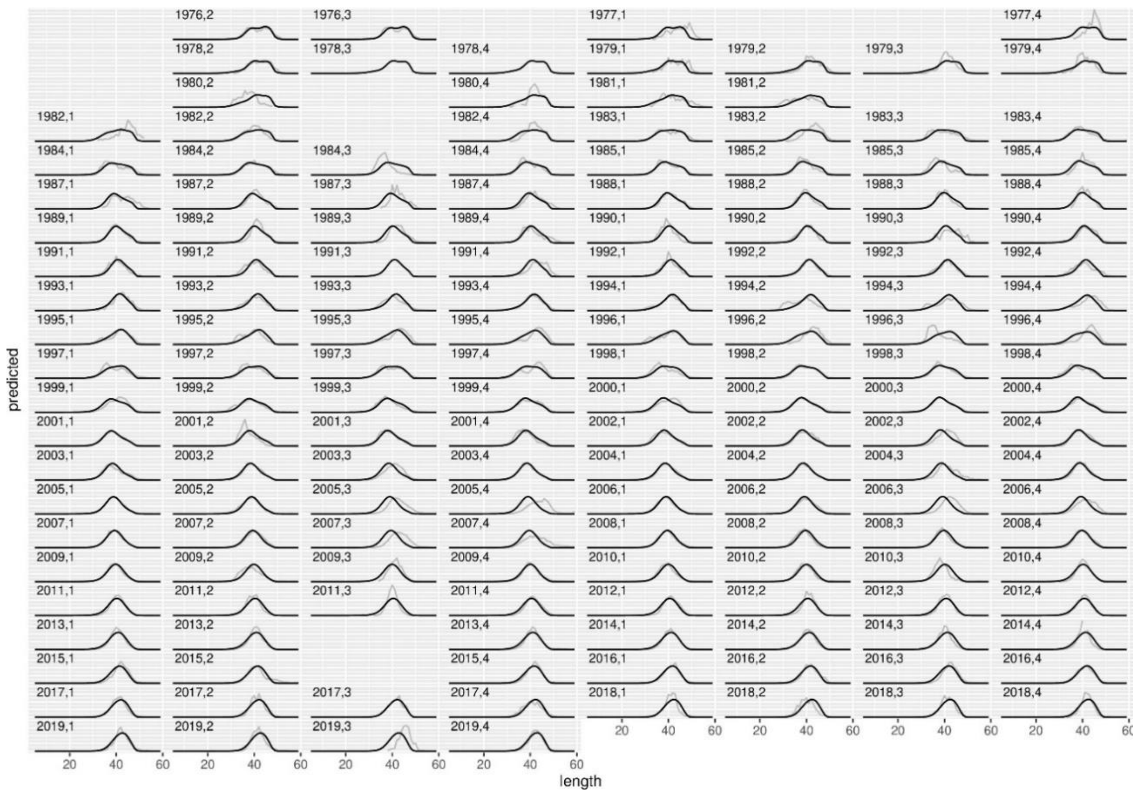


Figure 20.12.5. Icelandic slope beaked redfish. Comparison of commercial sample length distribution fits between model fits (black) and data (grey). Labels indicate the year and step of data sampled and model comparison.

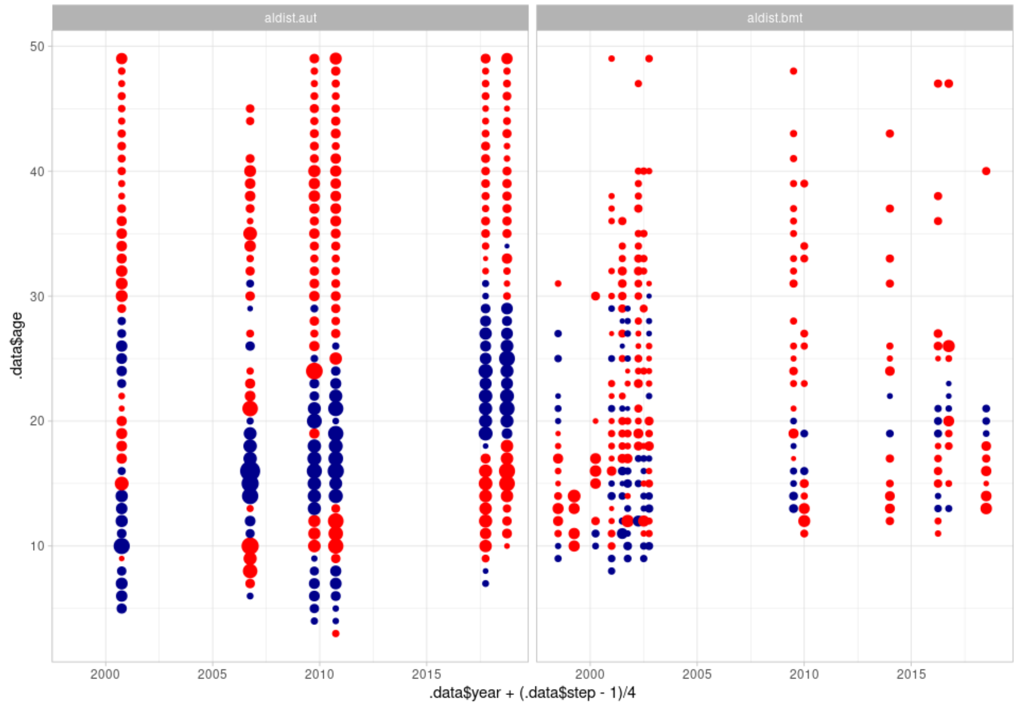


Figure 20.12.6. Icelandic slope beaked redfish. Bubble plots illustrating age-length distribution residuals between model predictions and data. Red bubbles indicate positive residuals (underestimation); blue bubbles indicate negative residuals (overestimation).

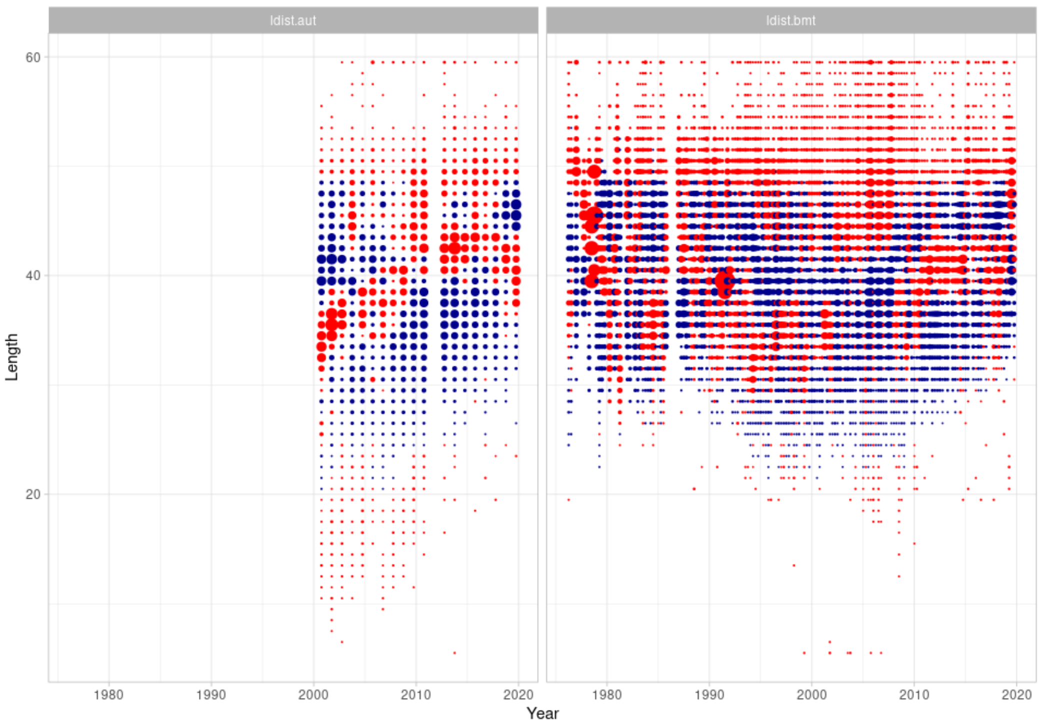


Figure 20.12.7. Icelandic slope beaked redfish. Bubble plots illustrating length distribution residuals between model predictions and data. Red bubbles indicate positive residuals (underestimation); blue bubbles indicate negative residuals (overestimation).

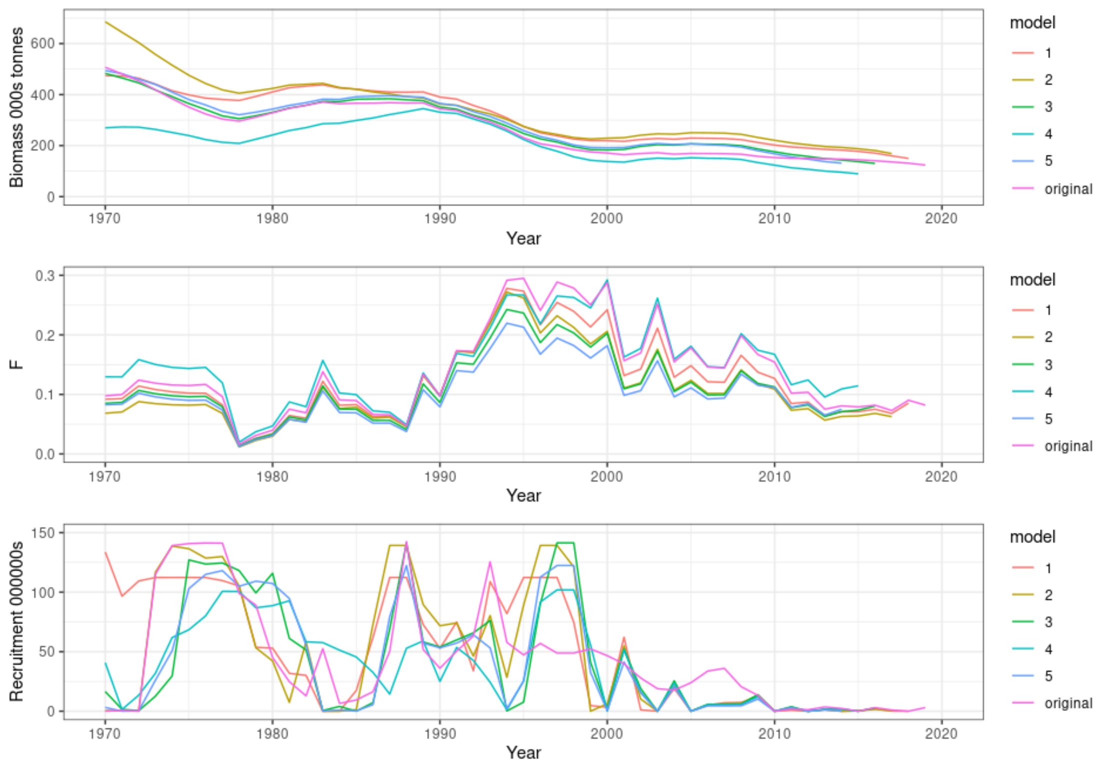


Figure 20.12.8. Icelandic slope beaked redfish. Retrospective plots illustrating stability in model estimates over a 5-year 'peel' in data. Results of spawning stock biomass, fishing mortality F, and recruitment (age 3) are shown.

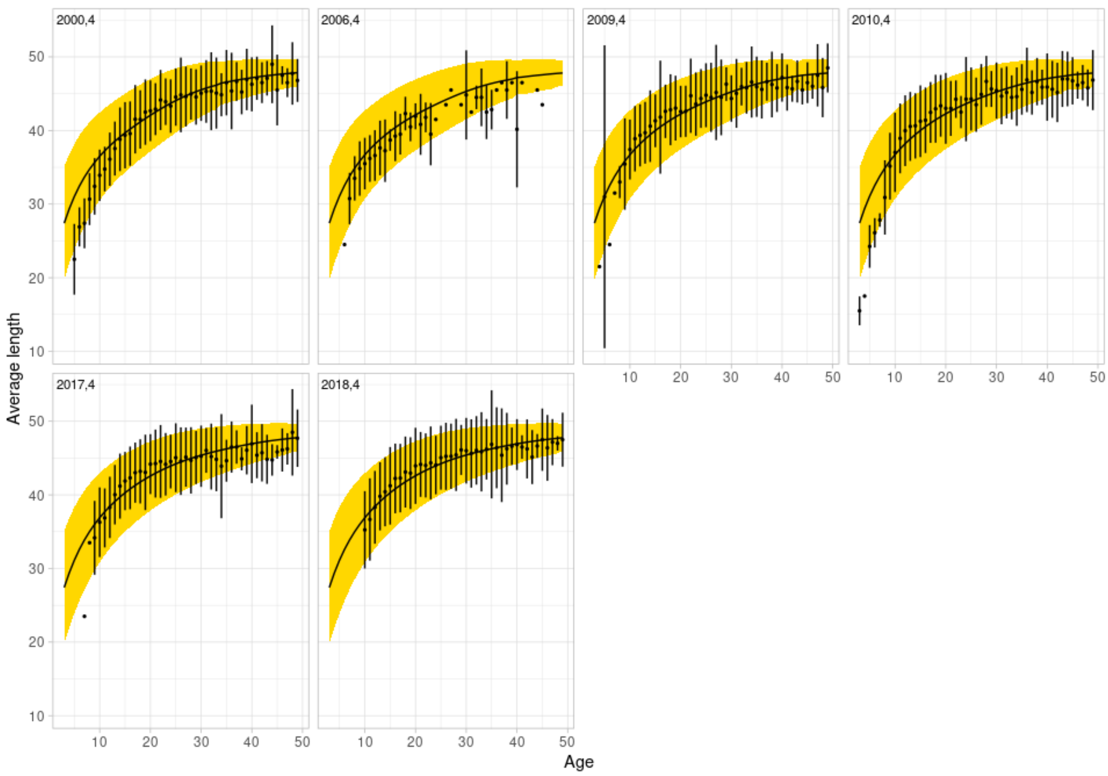


Figure 20.12.9. Icelandic slope beaked redfish. Growth estimations by fleet from the Gadget model. Yellow bands and the black line show where the mean and 95% confidence intervals of the of model predictions, whereas the points and error bars show the mean and 95% confidence intervals of the data.

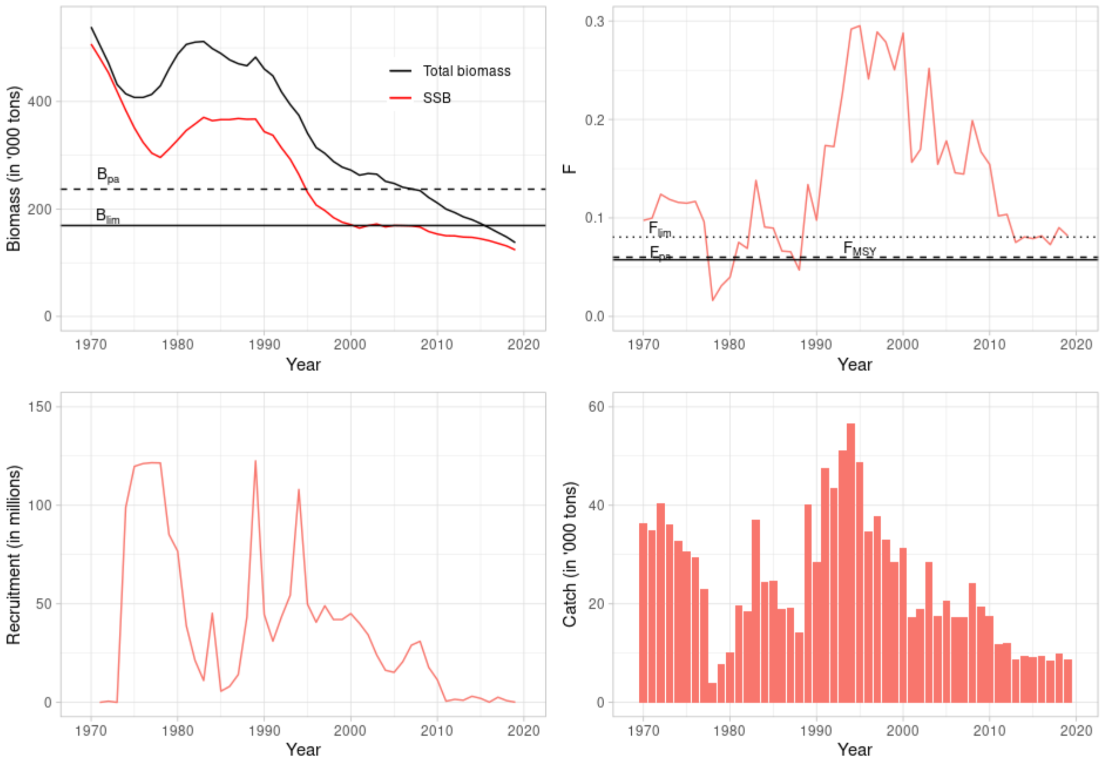


Figure 20.12.10. Icelandic slope beaked redfish. Summary from the assessment 2020.

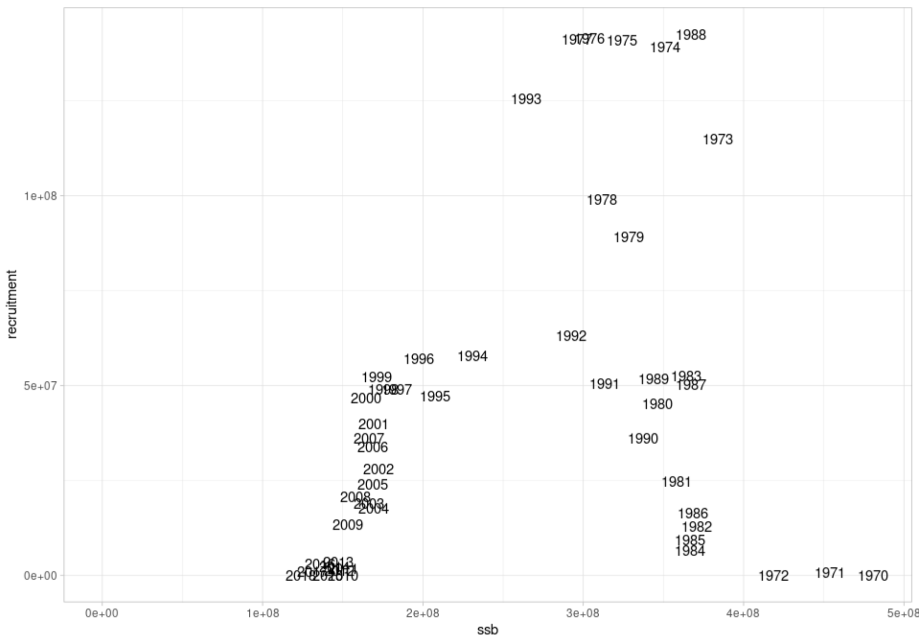


Figure 20.12.11. Icelandic slope beaked redfish. Plots of the estimated recruitment age 3 versus spawning stock biomass (lagged by 1 year).

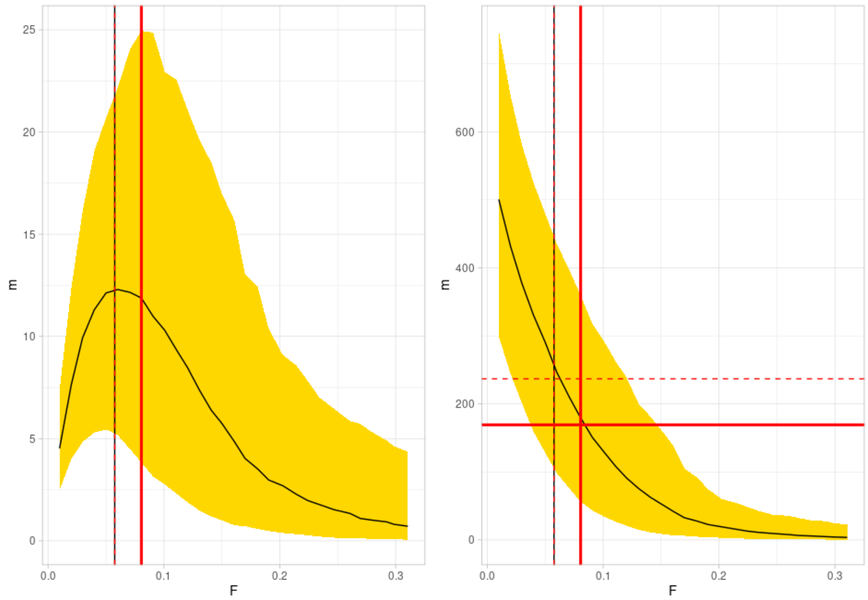


Figure 20.12.12. Icelandic slope beaked redfish. Yield-per-recruit (left) and average SSB against average fishing mortality (right). Also shown are the defined reference points.

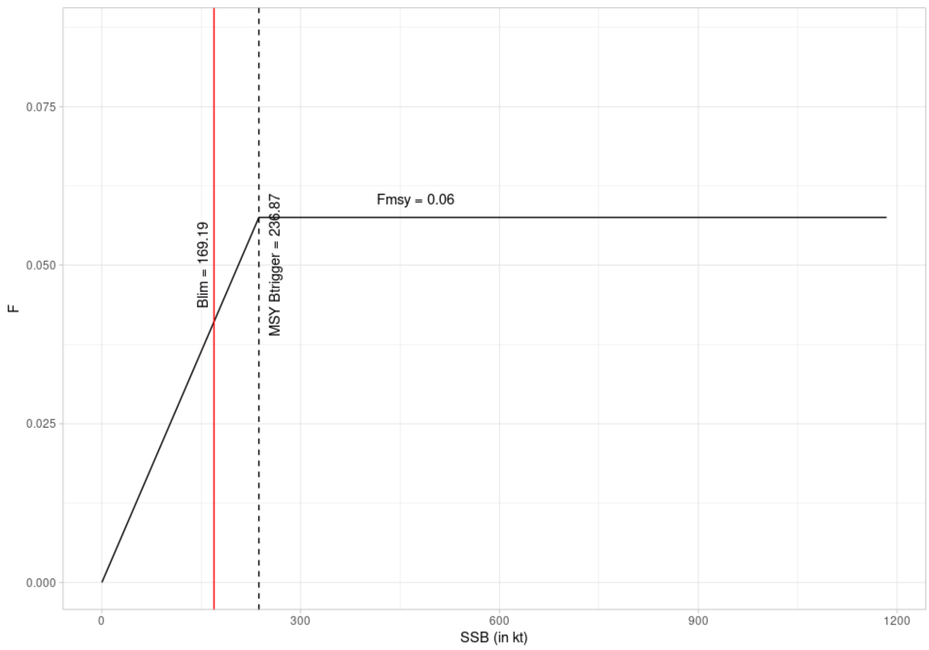


Figure 20.12.13. Icelandic slope beaked redfish. Proposed management plan.

21 Shallow Pelagic *Sebastes mentella*

This section was not updated during the NWWG meeting in May 2022 due to the temporary suspension, beginning 30 March 2022, on all Russian Federation delegates, members, and experts from participation in ICES activities.

Please see the NWWG 2021 report for most updated information on this stock:

ICES. 2021. Northwestern Working Group (NWWG). ICES Scientific Reports. 3:52. 766 pp. https://doi.org/10.17895/ices.pub.8186

22 Deep Pelagic *Sebastes mentella*

This section was not updated during the NWWG meeting in May 2022 due to the temporary suspension, beginning 30 March 2022, on all Russian Federation delegates, members, and experts from participation in ICES activities.

Please see the NWWG 2021 report for most updated information on this stock:

ICES. 2021. Northwestern Working Group (NWWG). ICES Scientific Reports. 3:52. 766 pp. https://doi.org/10.17895/ices.pub.8186

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, 2019 and 2021. The Greenland halibut survey has been conducted since 1998 but not since 2016 due to lack of research vessel. 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 and 2021. 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). Due to the lack of both Greenland and German survey, no new data was collected in 2021.

In the german survey, a large number of *Sebastes* spp. smaller than 17 cm was found from 1993–1998 (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 2020 representing the lowest biomass for the last 20 years (Figure 23.2.). Since 2013 and onwards, both biomass and abundance indices have been very low. 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 2018-2021, 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). In 2021, there was no survey due to lack of research vessel.

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 nearly a decade (Figure 23.2.5).

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*. Only negligible amounts are considered to be *Sebastes viviparous*. 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 from the logbooks. In 2020, the proportion shifted back again and *S. norvegicus* dominated. The shift was supported by Greenland shallow water survey (79:31), logbooks (60:40) as well as samples from the commercial fishery (71:29) analysed at Greenland Institute of Natural Resources. In 2021, no survey data was available for evaluating and neither was samples from the commercial fishery available for analysis at the Greenland Institute of Natural Resources. Like previous year, the proportion according to logbooks in 2021 was that S. norvegicus dominated *S. mentella* (78:22). 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 23.3.1.1. 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. Over the past 10 years, there has been a decreasing trend in landings of demersal S. mentella with the lowest level of 1302 tonnes being reached in 2021.

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), while it dropped to 5782 tonnes and 4825 tonnes in 2020 and 2021, respectively. 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 redfish 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 2021 (Figure 23.3.2.2). Until 2015, the fishery takes place in a geographically 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 (figures 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 and 2022, 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 2023. The stock will be benchmarked in 2024.

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

Bernreuther, M., Stransky, C. and Fock, H. 2013. German commercial catches of demersal redfish (Sebastes mentella and Sebastes marinus) on the East Greenland shelf (ICES Division XIVb) up to 2012. ICES NWWG WD#11, 10 pp.

Christensen H.T. and Hedeholm R. 2018. Greenland Shrimp and Fish Survey Results for Redfish in East Greenland Offshore Waters in 2017. ICES NWWG WD#11.

Christensen H.T. 2020a. The fishery for demersal Redfish (S. mentella) in ICES Div. 14.b in 2019. ICES NWWG WD#08.

Christensen H.T. 2020b. Forsøgsfiskeri efter rødfisk i Østgrønland 2019 (in Danish). Report from Greenland Institute of Natural Resources.

Fock, H., C. Stransky and M. Bernreuther. 2013. Abundance and length composition for Sebastes marinus L., deep sea S. mentella and juvenile redfish (Sebastes spp.) off Greenland-based on groundfish surveys 1985-2012. ICES NWWG WD#30.

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* 1974–2021 ICES division 14.b.

Demersal S. mentella			
1974	0	2013	6761
1975	4400	2014	4608
1976	59 700	2015	5977
1977	0	2016	3061
1978	5403	2017	3027
1979	5131	2018	1972
1980	10 406	2019	3998
1981	19 391	2020	1677
1982	12 140	2021	1302
1983	15 207		
1984	9126		
1985	9376		
1986	12 138		
1987	6407		
1988	6065		
1989	2284		
1990	6097		
1991	7057		
1992	7022		
1993	14 828		
1994	19 305		
1995	819		
1996	730		
1997	199		
1998	1376		
1999	853		
2000	982		
2001	901		

Demersal S. mentella	
2002	2109
2003	446
2004	482
2005	267
2006	202
2007	226
2008	92
2009	895
2010	6613
2011	7376
2012	6243

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

Year	DEU	ESP	EU	FRO	GBR	GRL	ISL	NOR	POL	RUS	UNK	Sum
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
2021	808		894	32		2051		1002		38		4825
Sum	15 649	3	7717	1193	536	57 056	336	10 453	3	1949	856	95 749

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
2021	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
2021	113	164	369	275	284	1090	846	1184	235	10	127	124	4825
Sum	4333	10 229	10 985	10 379	10 143	15 563	10 750	7300	4033	4013	4648	3559	95 954

23.9 Figures

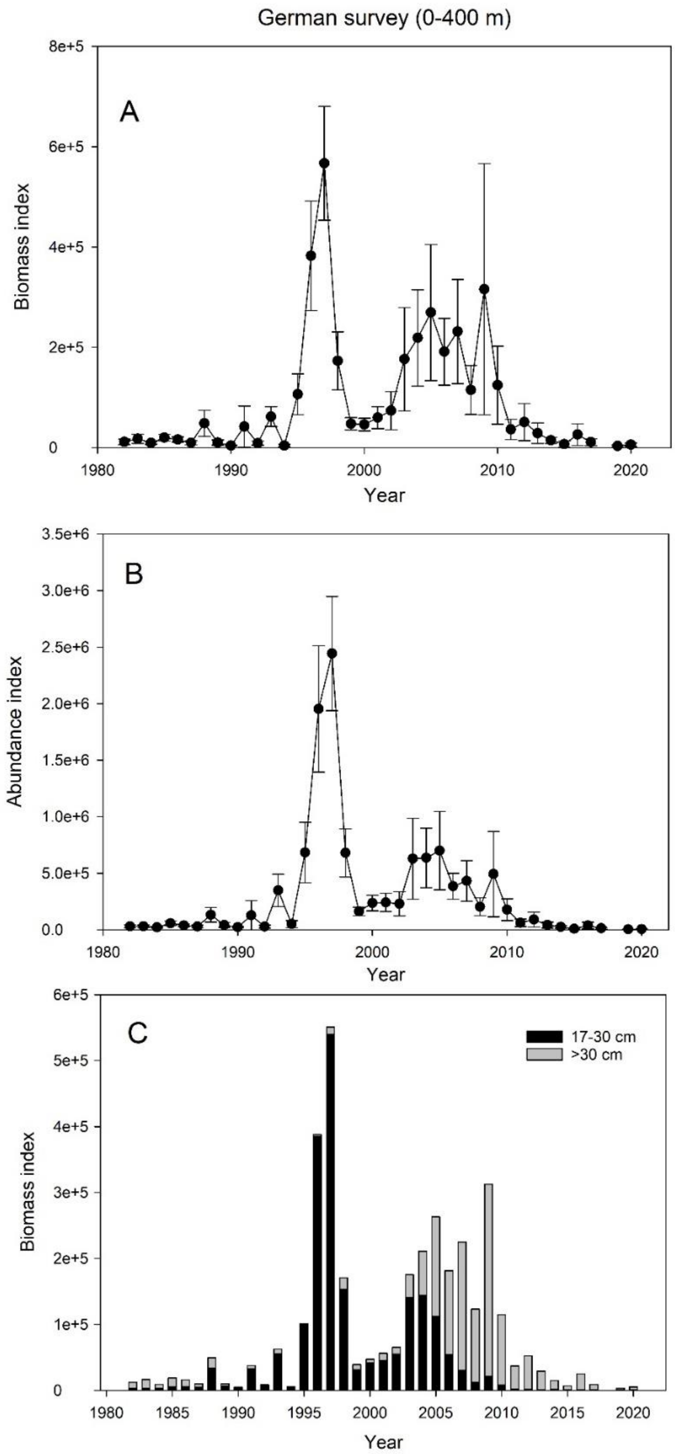


Figure 23.2.1. Indices from the German East Greenland survey of *S. mentella* larger than 17 cm. Biomass (A), abundance (B), and biomass split on length (C). On figure (C) the grey bars represent the biomass of *S. mentella* larger than 30 cm and the dark bars biomass in fish from 17–30 cm. No survey was conducted in 2018.

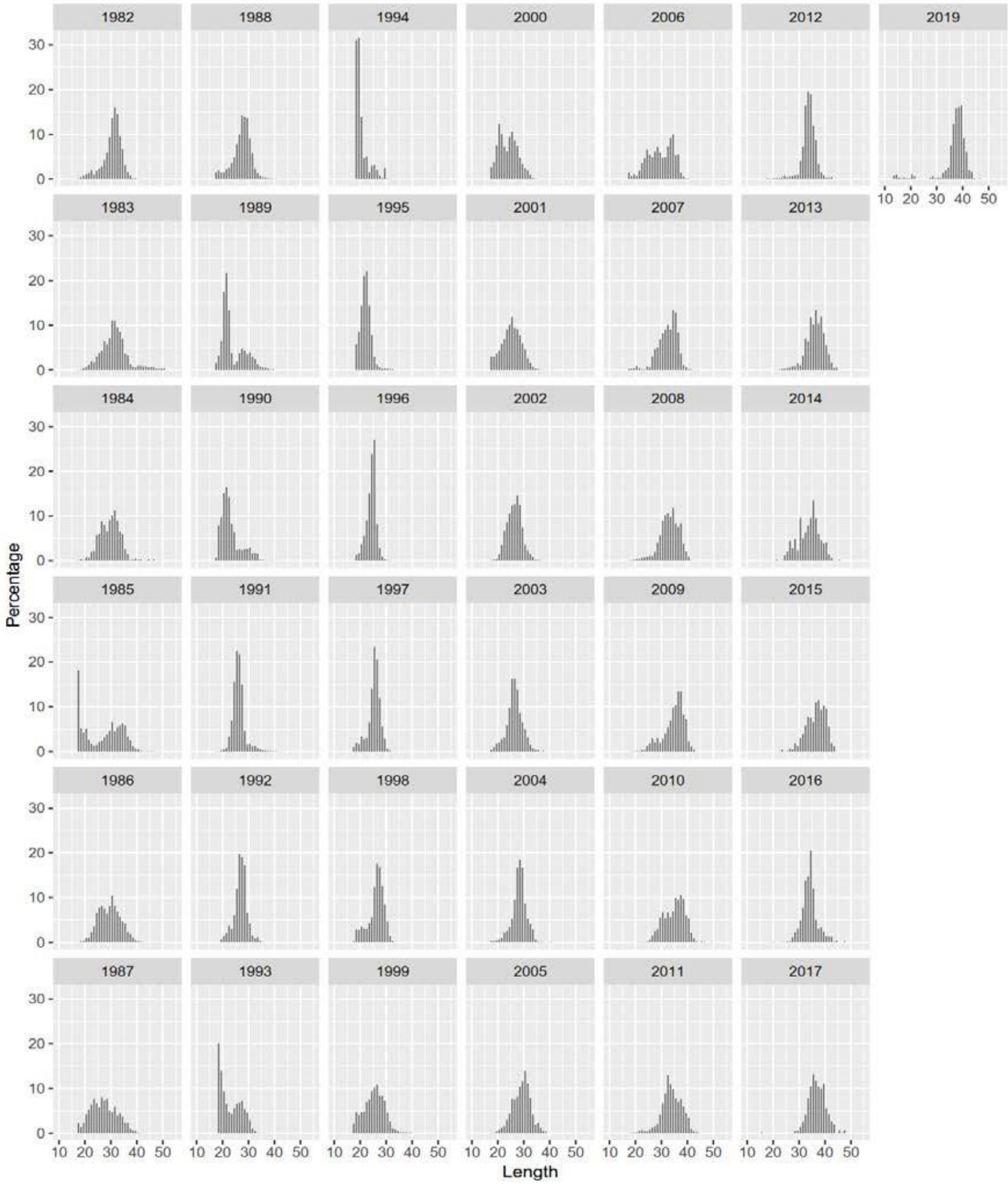


Figure 23.2.2. Length distributions from the German East Greenland survey 1985–2019. In 2018, the survey was not conducted due to break down of the German research vessel. Not updated for 2020.

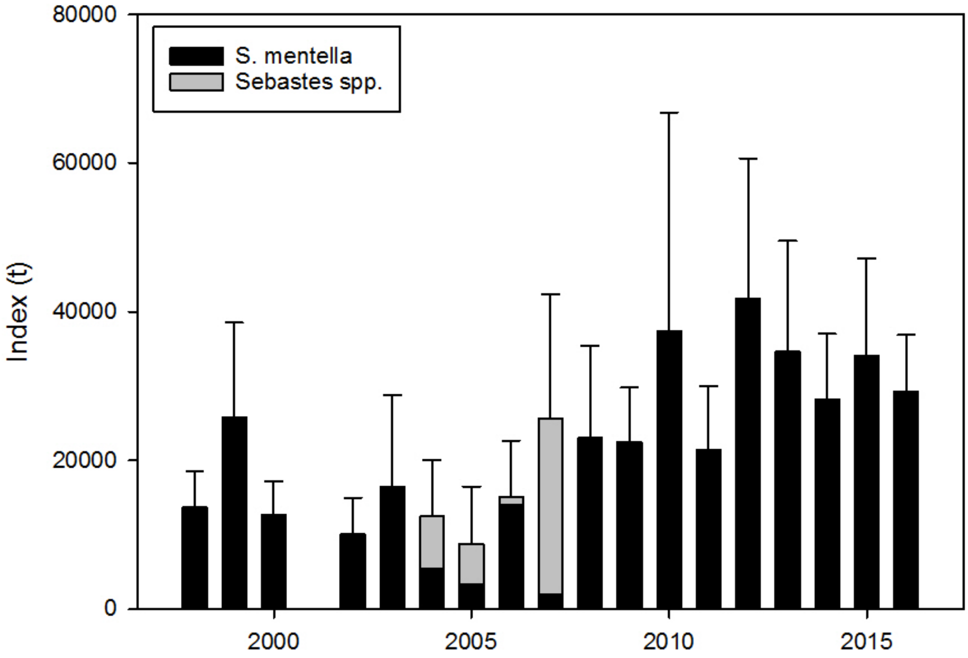


Figure 23.2.3. Biomass of *S. mentella* and *Sebastes* spp. derived from the Greenland deepwater survey. Bars indicate 2SE of the biomass of *S. mentella* including *Sebastes* spp. No survey in 2001. In 2004, 2005 and 2007 a large proportion of the redfish were not determined to species and only reported 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.

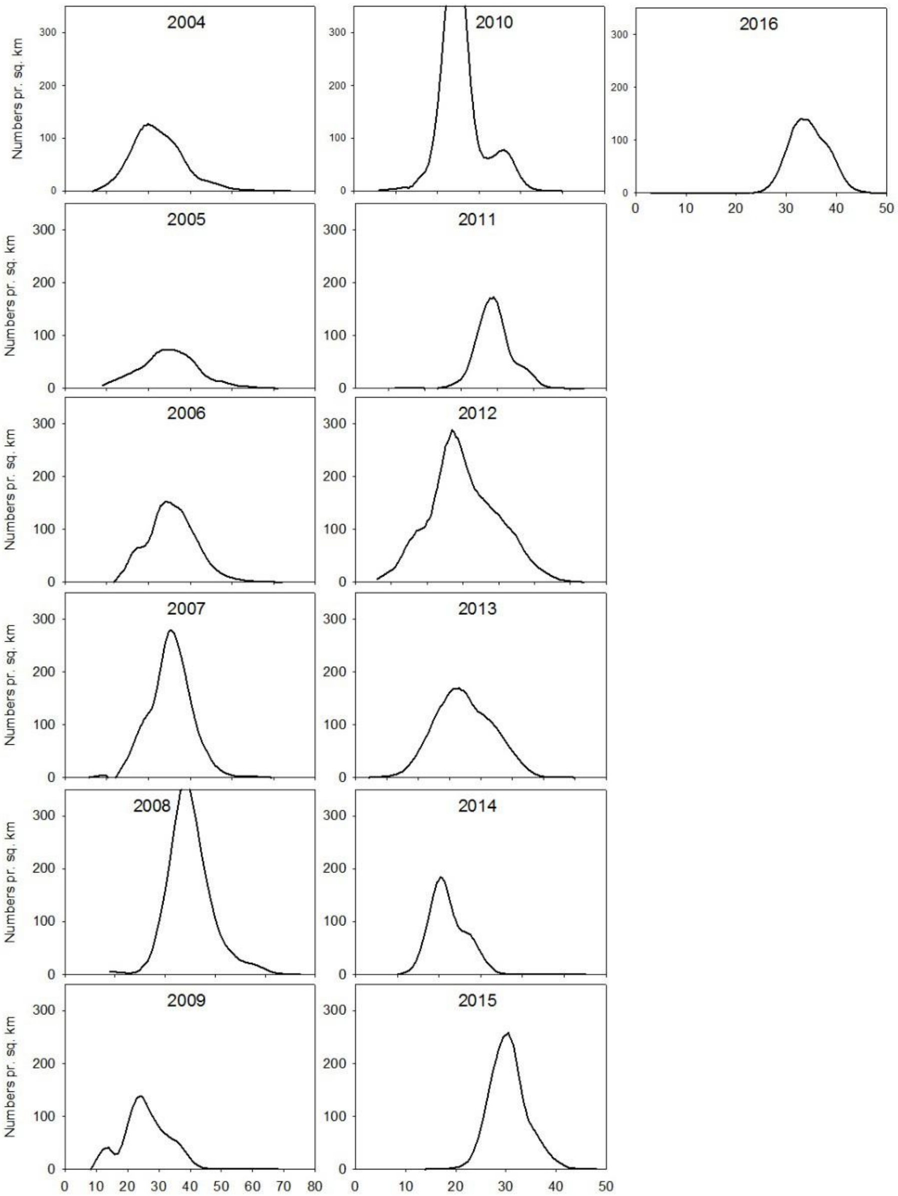


Figure 23.2.4. Overall length distribution of *Sebastes mentella* (number per km²) from the deep Greenland survey. In 2017, the survey was aborted due to vessel break down. In 2018 and 2019, no research vessel was available and in 2020, only Greenland shallow survey was carried out. Therefore, no new data is available.

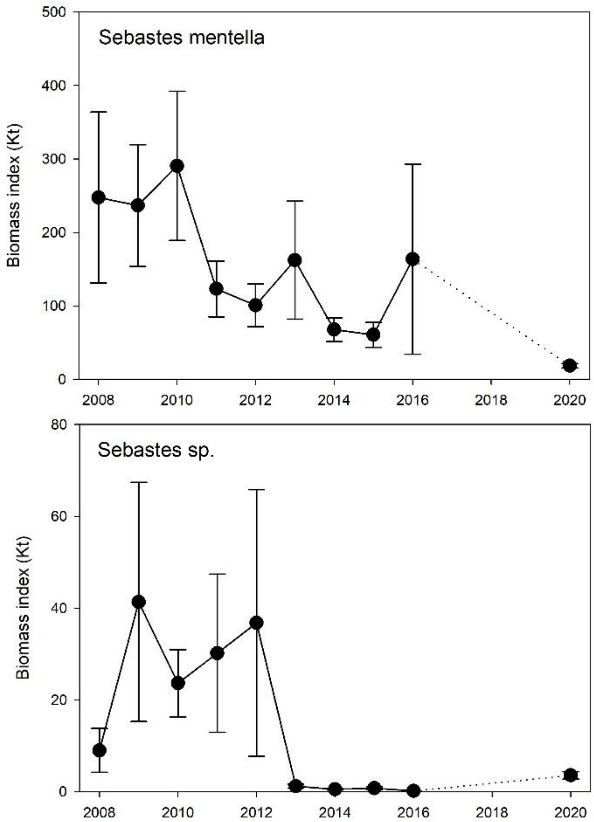


Figure 23.2.5: Biomass (kg*10^6, kt) (±CV%) indices for *S. mentella* (top) and *Sebastes* sp. (< 18 cm) (bottom) off East Greenland in 2008–2016 and in 2020 from the Greenlandic shallow water survey. All surveyed areas are combined (Q1–Q6). In 2017, the survey was aborted due to vessel break down. In 2018 and 2019, no research vessel was available. In 2020, a full survey was carried out.

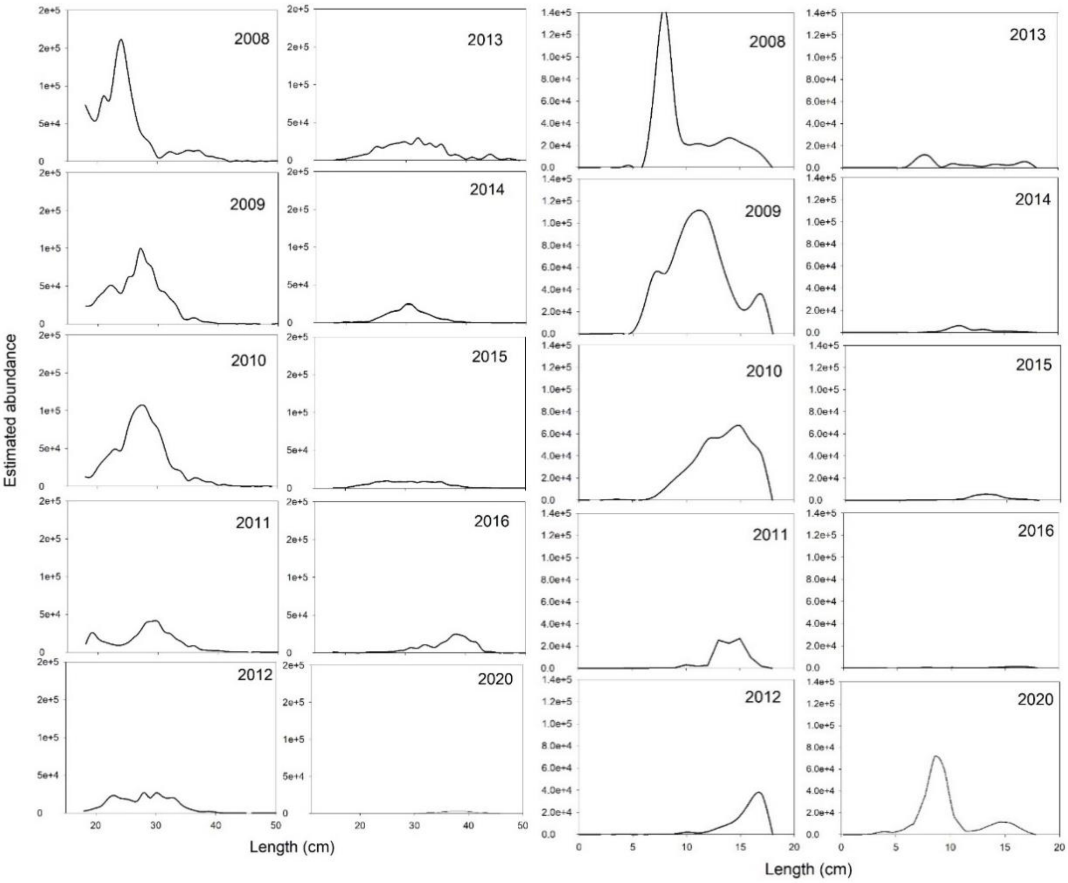


Figure 23.2.6. Overall length distributions for *S. mentella* (left) and *Sebastes spp.* <18 cm (right) from the Greenland shallow water survey. All surveyed areas combined (Q1–Q6). In 2017, the survey was aborted due to vessel break down and in 2018 and 2019, no research vessel was available. In 2020, a full survey was conducted.

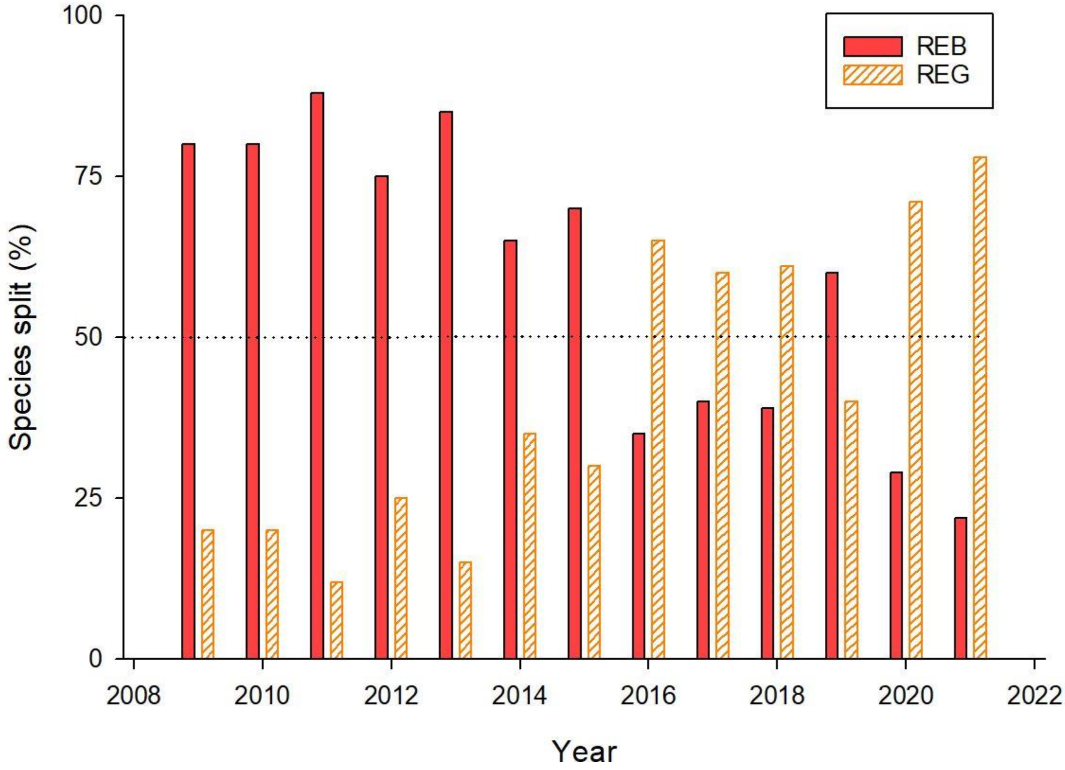


Figure 23.3.1.1. Development in split of *S. mentella* (REB) and *S. norvegicus* (REG) in the fisheries on the Greenland slope.

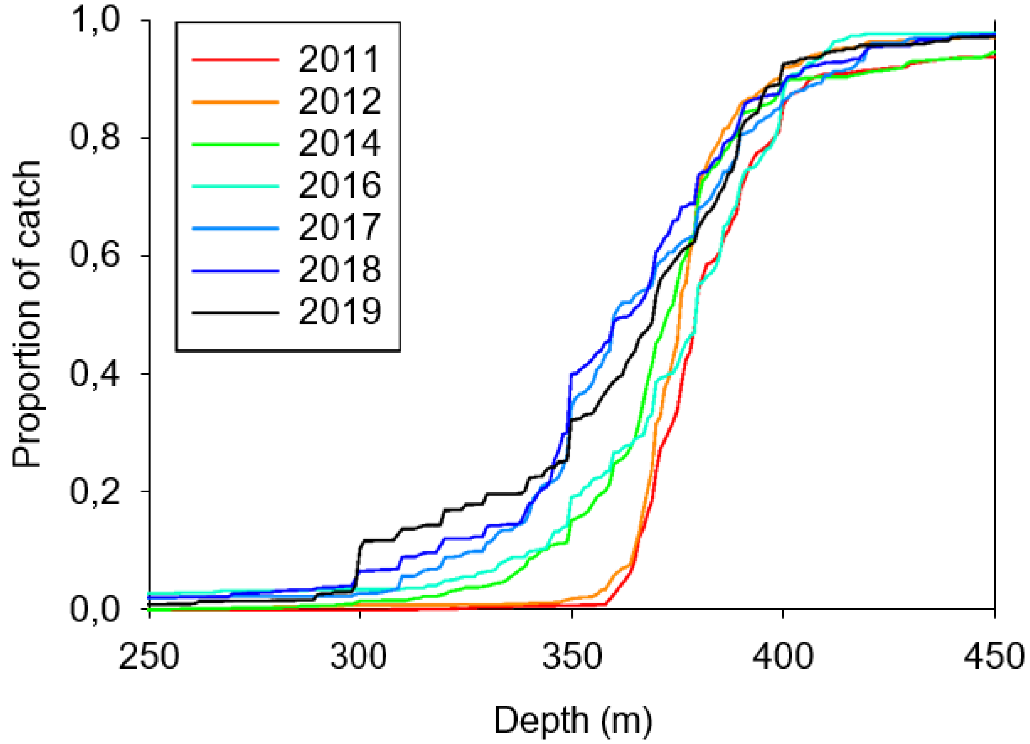


Figure 23.3.1.2 Development in catch depth of *Sebastes* (*S. mentella* and *S. norvegicus* combined). Not updated for 2020.

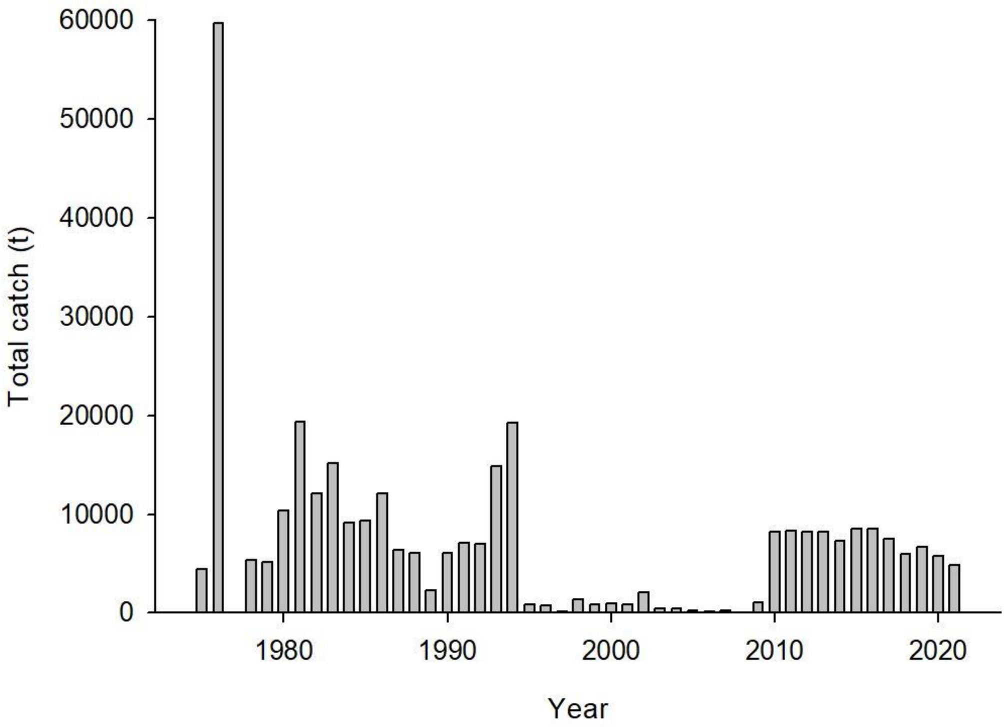


Figure 23.3.1.3 Landings of redfish (mixed) in subarea 14.b. Landings of *S. mentella* have been estimated based on split, which is made annually from either survey or commercial catches (logbooks).

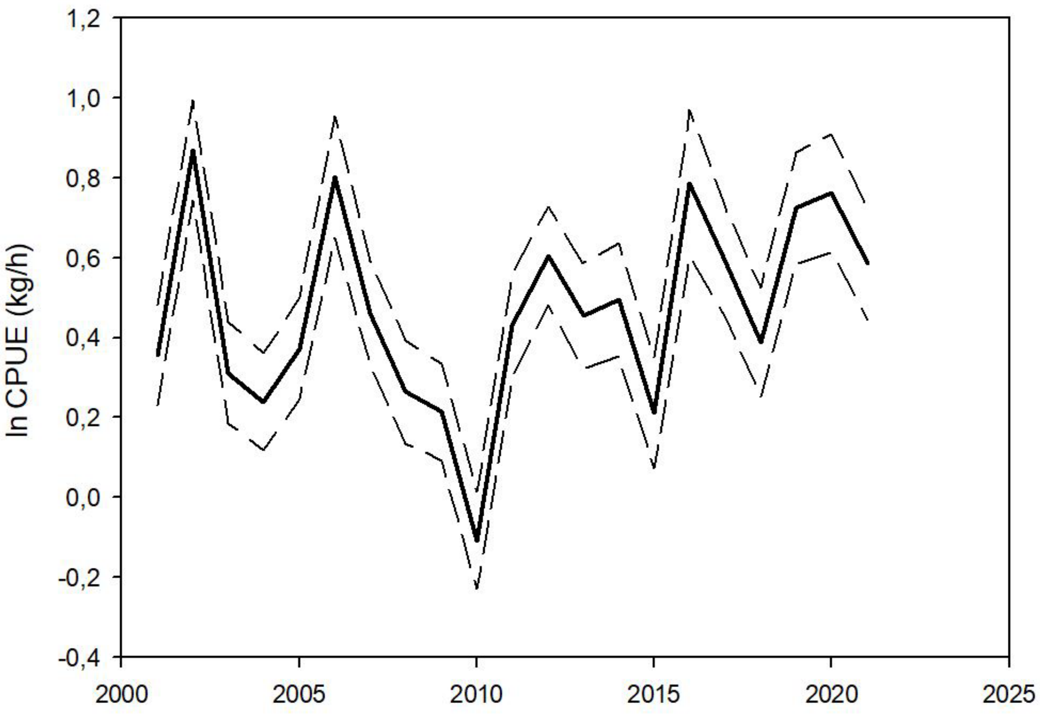


Figure 23.3.2.1 Standardized redfish bycatch CPUE in the directed fishery for Greenland halibut in ICES 14.b as a function of year. CPUE was estimated from the GLM model: lnCPUE = year + ICES Subdivision + depth. Bars represent standard error. Only hauls made below 1000m were used in the analyses.

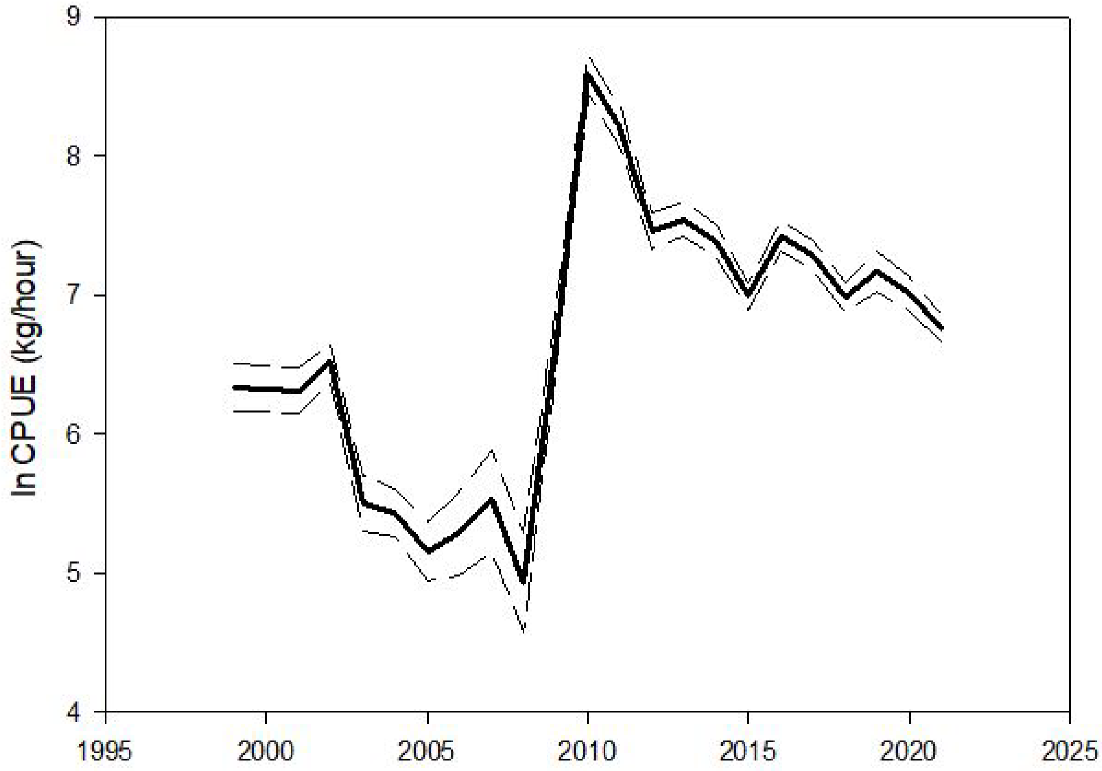


Figure 23.3.2.2 Standardized redfish CPUE in the redfish directed fishery ICES 14.b as a function of year. CPUE was estimated from the GLM model: lnCPUE = year + ICES Subdivision + depth. Dashed lines represent standard error.

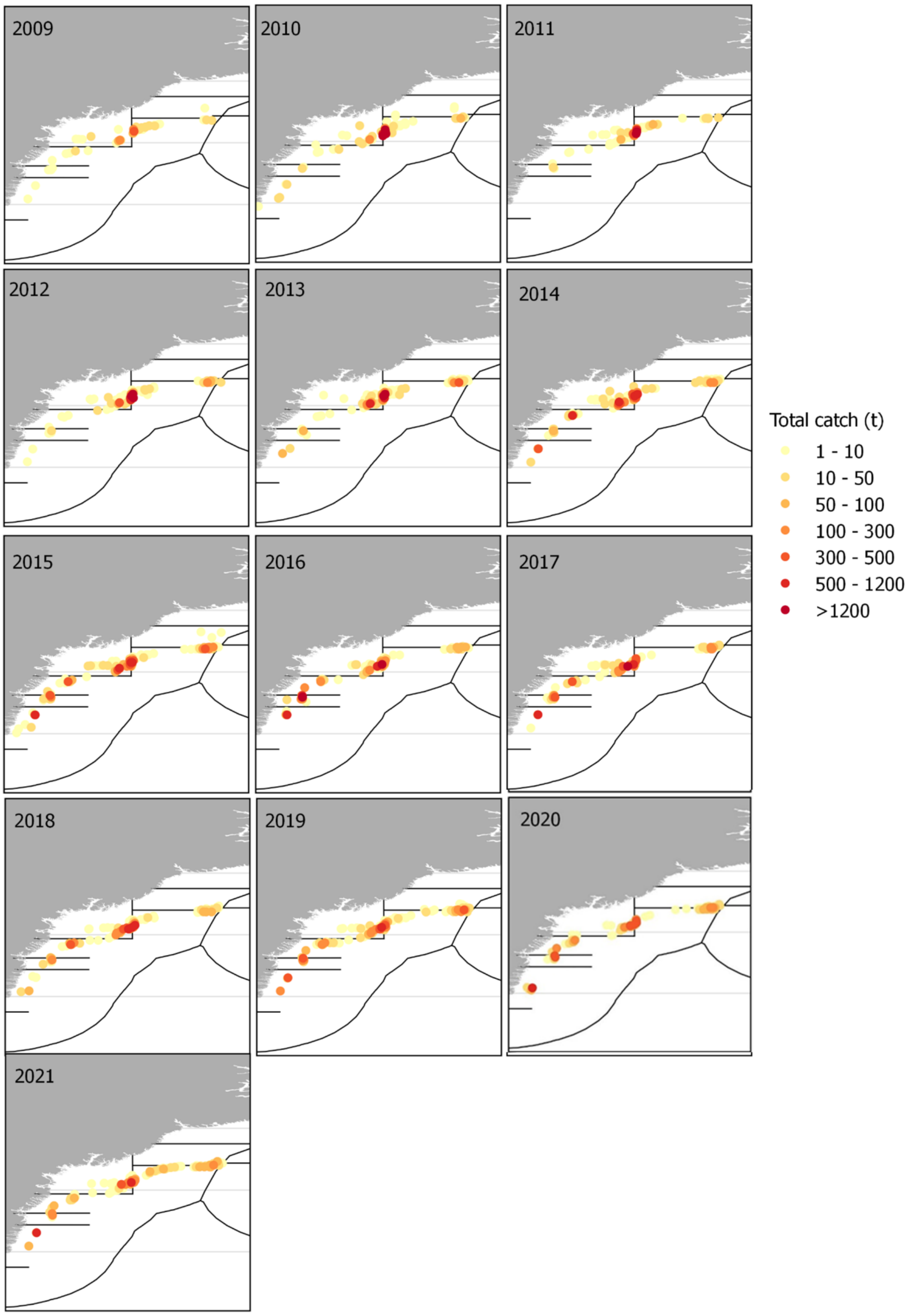


Figure 23.3.3.1 Distribution of catches of demersal redfish (*S. mentella* and *S. norvegicus*) between 2009 and 2021 in ICES 14.b.

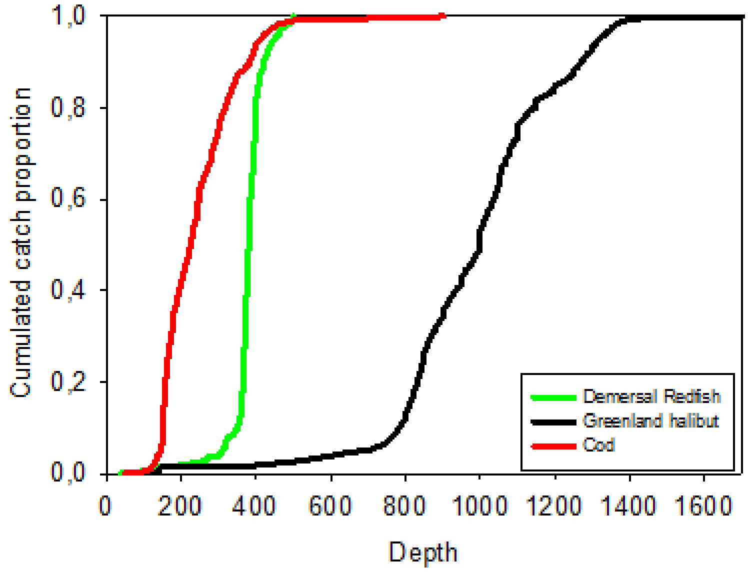


Figure 23.3.3.2. Lines represent the share of the total commercial catch caught at a given depth from 1999–2011 in *G. morhua*, demersal redfish (mixed *S. mentella* and *S. norvegicus)* and *R. hippoglossoides*.

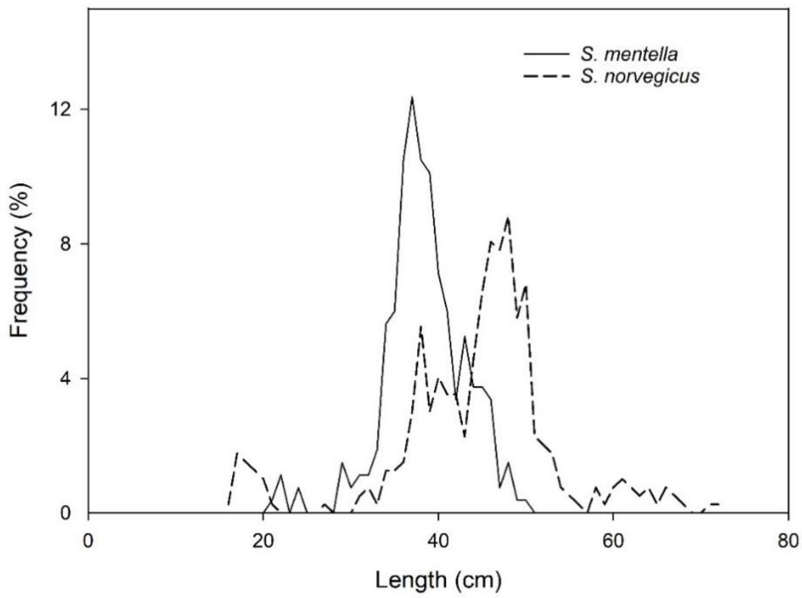


Figure 23.3.5.1: Length distribution of 672 redfish analysed by the Greenland Institute of Natural Resources in 2020 separated into *S. mentella* (N=273) and *S. norvegicus* (N=399).

24 Icelandic plaice in 5.a

24.1 General information

Icelandic plaice (*Pleuronectes platessa*) 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 and 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 and Hjörleifsson, 2001).

Genetic studies (Le Moan *et al.,* 2021, Hoarau *et al.,* 2004) suggest that plaice found on the Icelandic and Faroese shelf areas are genetically different from plaice found elsewhere. Aðalsteinn Sigurðsson (1982) observed long distance migrations to the Barents Sea. Similar migrations were not observed in recent tagging studies in Icelandic waters (Sólmundsson *et al.,* 2005) and the validity of these older observations are considered questionable (Sigurdsson pers. comm). Furthermore, the older observations are in conflict with the results from (Le Moan *et al.,* 2021).

Tagging data suggests considerable movement within Icelandic waters, this is in accordance with the observed distributional shifts between the spring and autumn surveys, and suggests that sub-stock structure for plaice in Icelandic waters is negligible.

24.2 Fishery

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 24.2.1 and Figure 24.2.2). Seiners dominate the coastal plaice fishery, but trawlers catch them deeper and further offshore. Plaice is caught in relatively shallow water, with most of the catch (60–80%) taken at depths of 21–80 m (Figure 24.2.3). Plaice fishing grounds in 2013–2021 in 5a, as reported by mandatory logbooks, are shown in Figure 24.2.1.

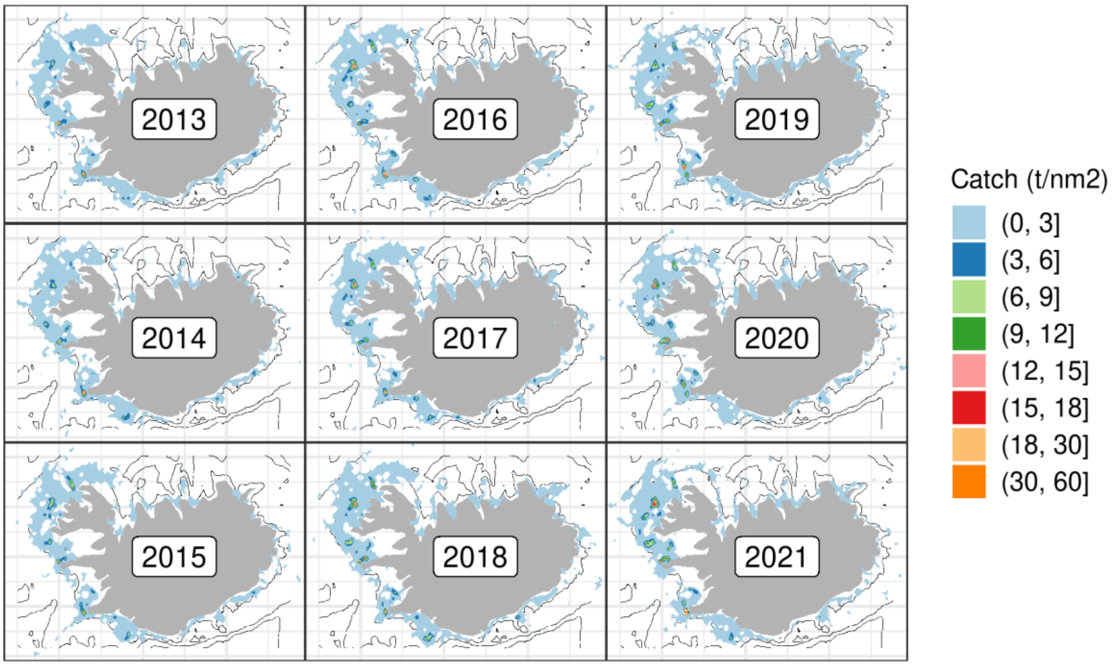


Figure 24.2.1. Plaice in 5a. Spatial distribution of the catch according to Icelandic logbooks.

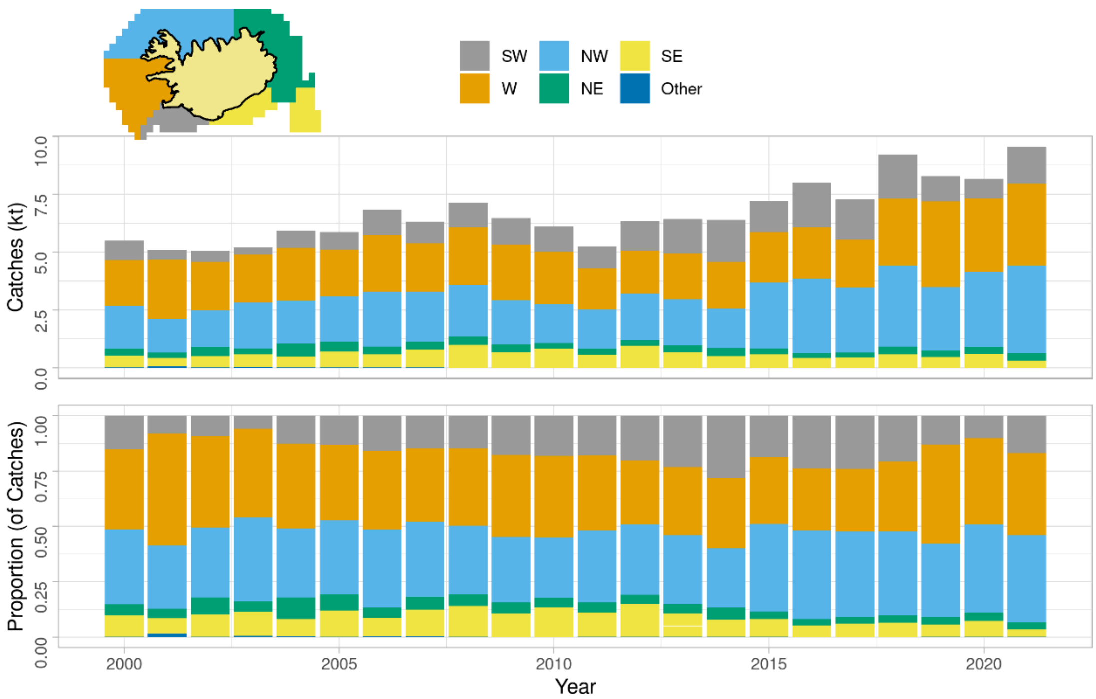


Figure 24.2.2: Plaice in 5.a. Changes in spatial distribution of plaice catches as recorded in Icelandic logbooks.

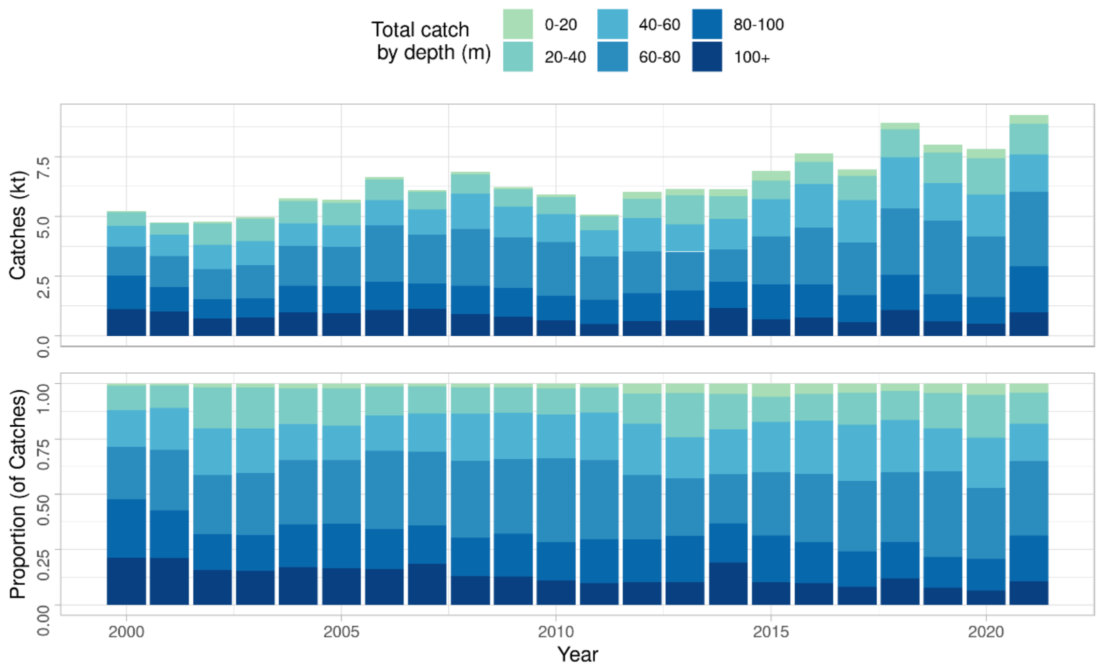


Figure 24.2.3: Plaice in 5.a. Depth distribution of plaice catches from bottom trawl and demersal seine according to Icelandic logbooks.

24.2.1 Landing trends

The plaice fishery in 5.a has been entirely Icelandic since the expansion of the Icelandic EEZ in 1975. Plaice in 5a. is mainly caught in mixed seine fisheries where the target species are predominantly flatfish species, plaice in particular. Fishery has been considered stable in last two decades regarding landings and annual landed catch has been between 5 and 8 thous. tonnes (Figure 24.2.4. and Figure 24.2.5). Landings in 2021 exceeded the numbers observed in last two decades and are estimated to have been 8677 tonnes, about 1170 t more than in previous year see Figure 24.2.4 and Table 24.1.1. Landings in 5.a. reached highest levels in mid-1980s with approximately 14.5 thous. tonnes landed in 1985.

Demersal seine is the main fishing gear for plaice (65–71% since 2011) in 5.a. followed by demersal trawl (23–30%), while a small proportion of the catch is taken in gillnets and longline (Figure 24.2.4).

Landings by foreign vessels were considerable before 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 fleets.

Since 2000, the number of vessels reporting annual catches over 1000 kg of plaice in total 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 35 in 2021. The number of trawlers has remained relatively stable since 2010 (Table 24.1.1).

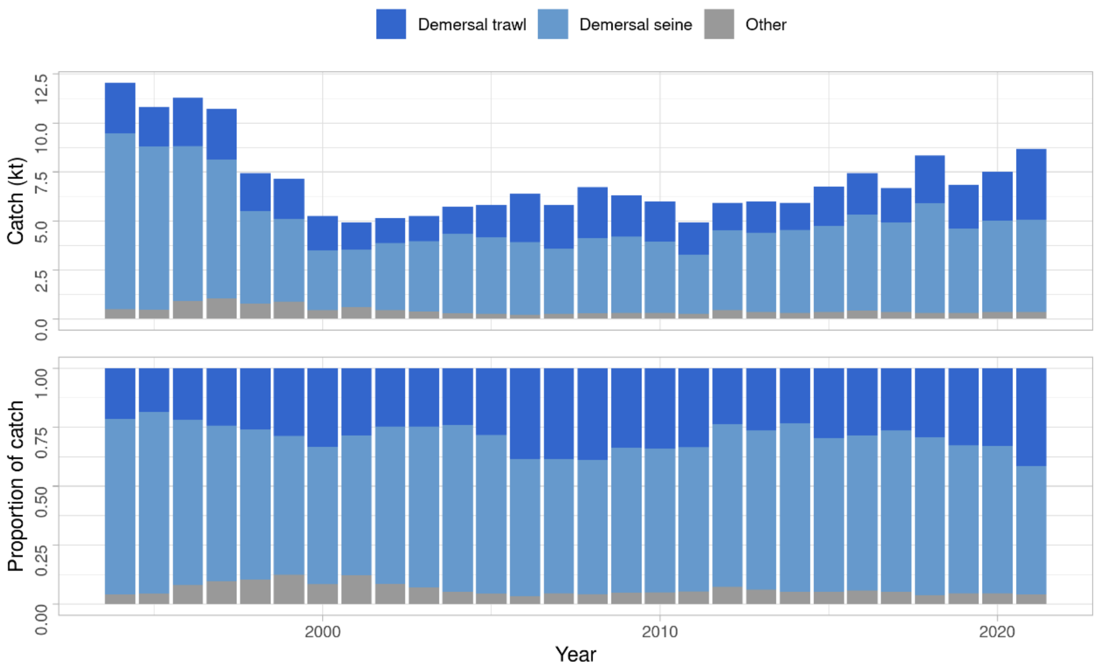


Figure 24.2.4: Plaice in Division 5.a. Landings in kilotonnes and percent of total by gear and year.

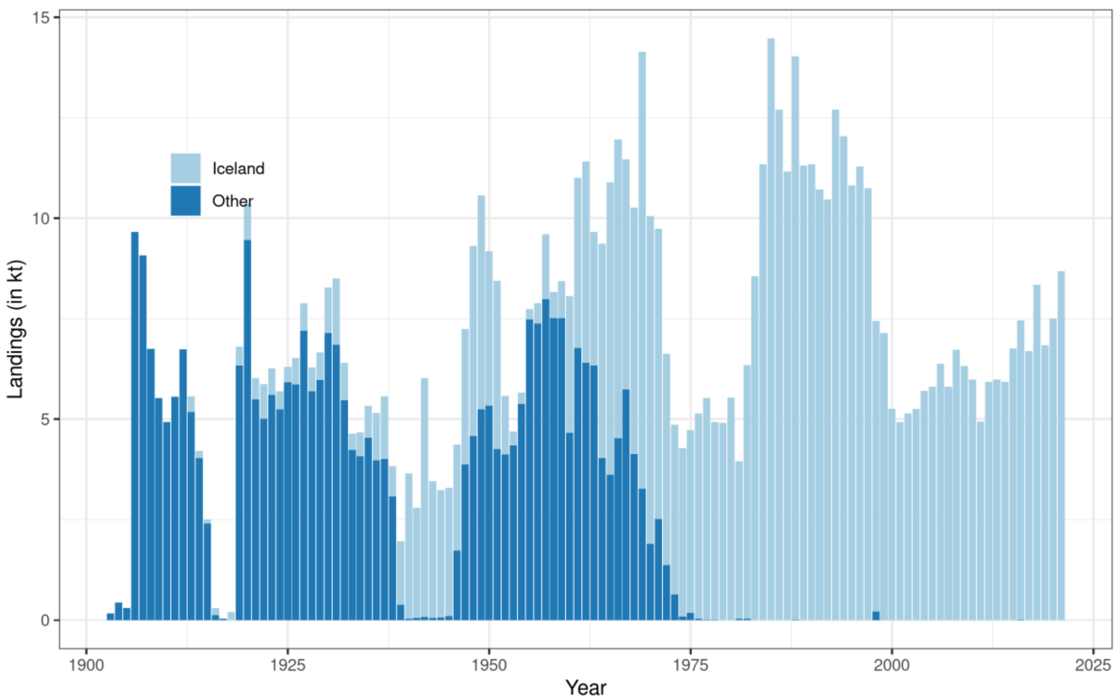


Figure 24.2.5: Plaice in Division 5.a. Recorded landings 1903–2021.

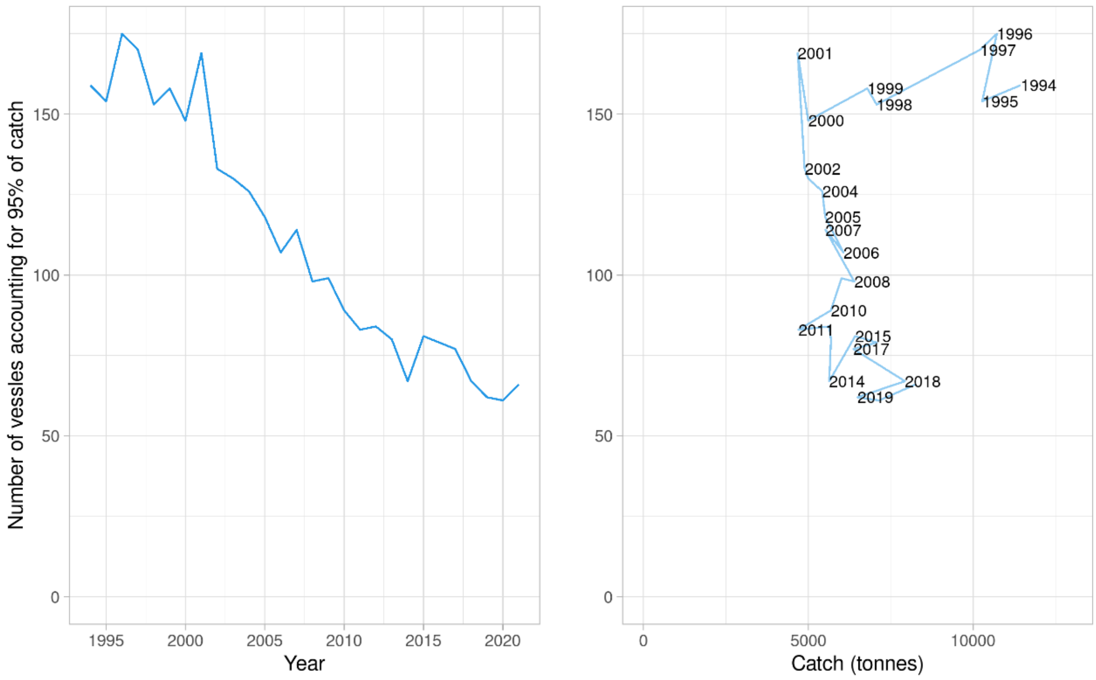


Figure 24.2.6. Plaice in 5a. Number of vessels (all gear types) accounting for 95% of the total catch annually since 1994. Left: Plotted against year. Right: Plotted against total catch. Data from the Directorate of Fisheries.

24.3 Data available

Sampling of biological data from main gears (demersal 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 2021 is shown in Figure 24.3.1.

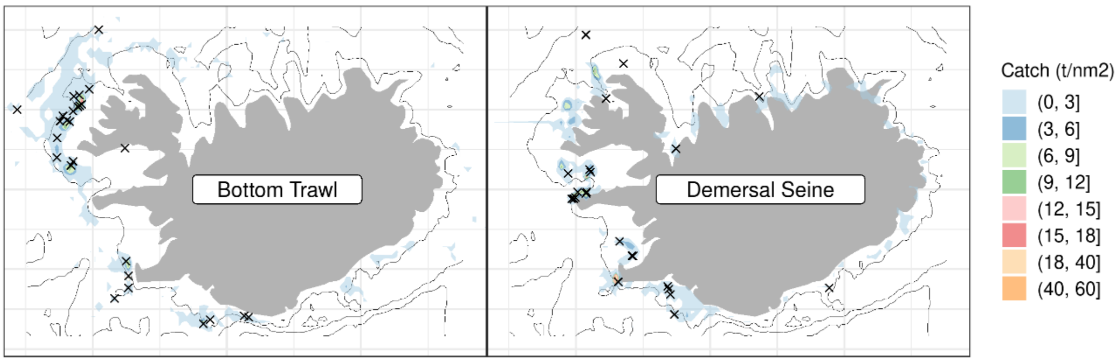


Figure 24.3.1: Plaice in 5.a. Fishing grounds in 2021 as reported in logbooks (colours) and positions of samples taken from landings (asterisks) by main gear types.

24.3.1 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. According to Pálsson *et al.* (2004), the discard rate for plaice caught in demersal seine was high, 7.11% of the landed catch and involved mainly fish under 40 cm length. However, following discards measurements show no discards of plaice caught in demersal seine (Pálsson *et al.*, 2007). Discards are therefore assumed to be negligible, or at least consistent between years.

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.

24.3.2 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. Plaice caught by bottom trawl and demersal seine appears to be fairly stable, range between 35 and 55 cm, with visible shift towards larger fish in both gears in the last decade. As a result, the average length in the samples taken from commercial catch has increased from 35 cm in 1991 to 44 cm in 2021.

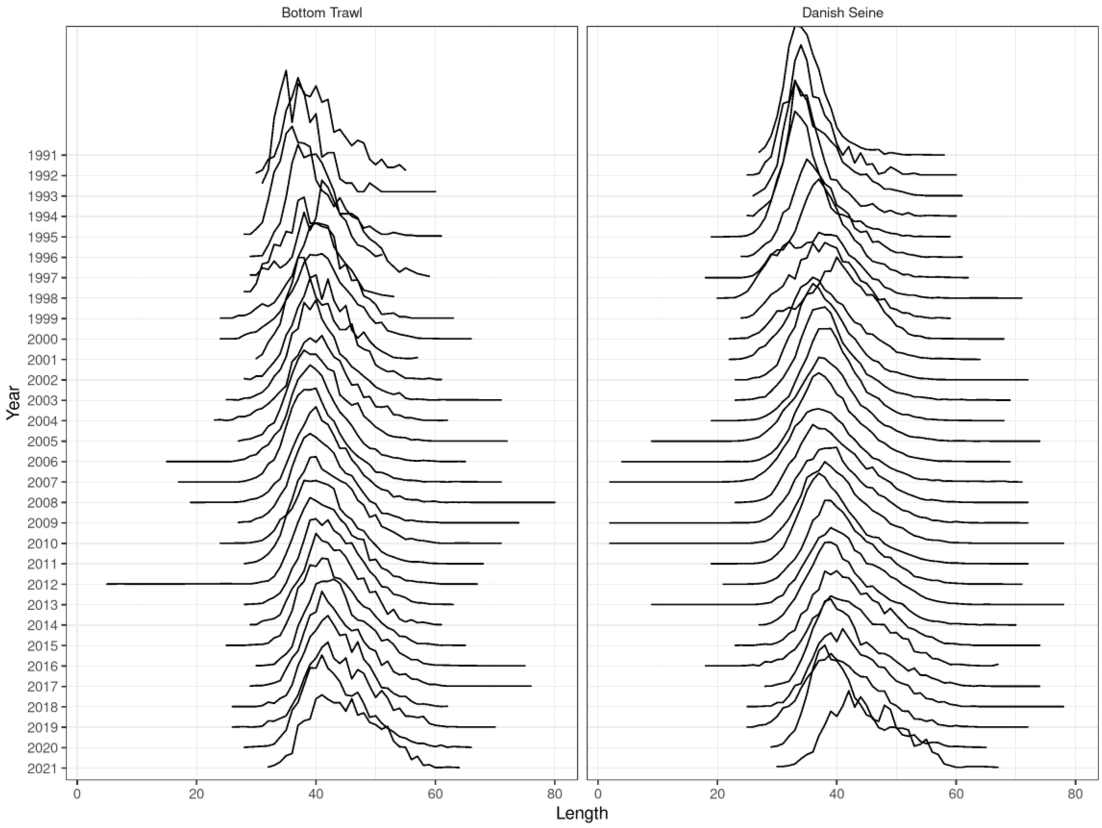


Figure 24.3.2: Plaice in 5.a. Commercial length distributions by gear and year.

24.3.3 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 24.3.3). The proportion of these age classes in the catch then decreased and for the last years it has been 40–45%. Plaice in the catch have gradually become older, and in recent years the largest cohorts have been 6–8-year-old fish. The catches in 2021 are mainly composed of the 2014-2016 and older year classes.

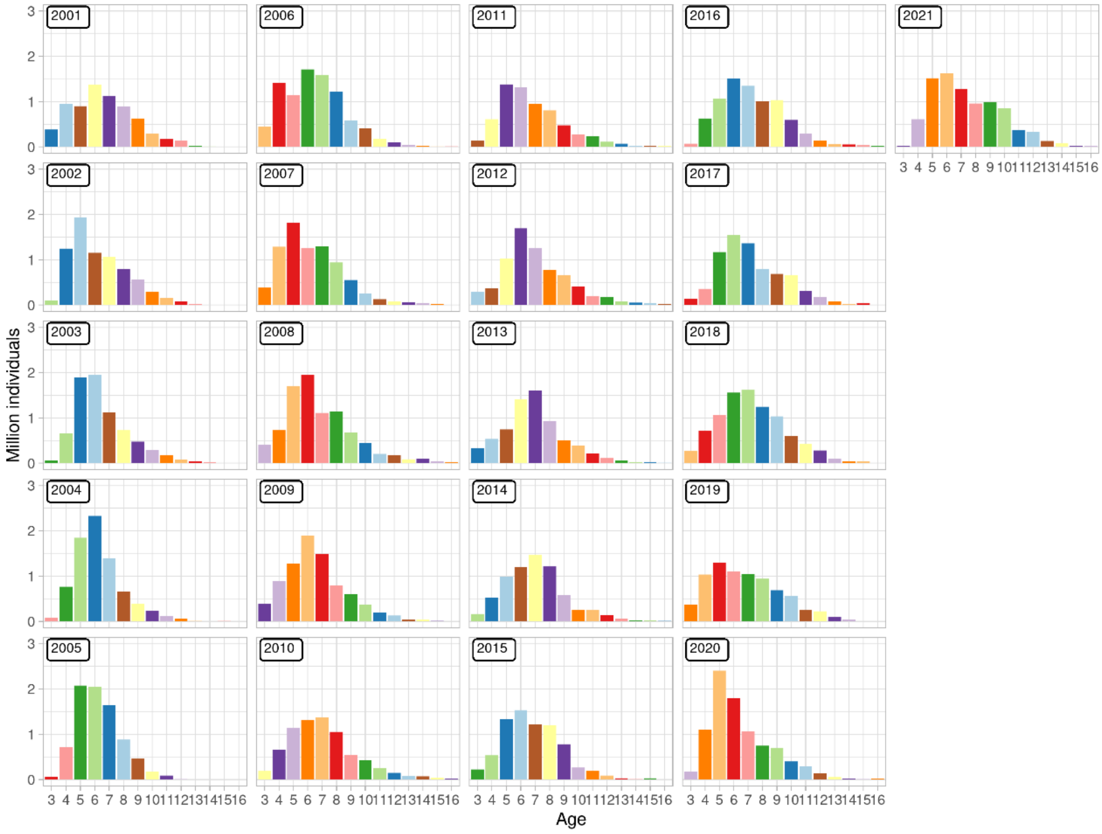


Figure 24.3.3: Plaice in 5.a. Estimated age distribution of landed catch based on landings and otoliths collected from landed catch.

24.3.4 Weight-at-age

Mean weight at age in the catch is shown in Figure 24.3.4. Those data are obtained from the commercial catches. Mean weight-at-age has been increasing in all age groups.

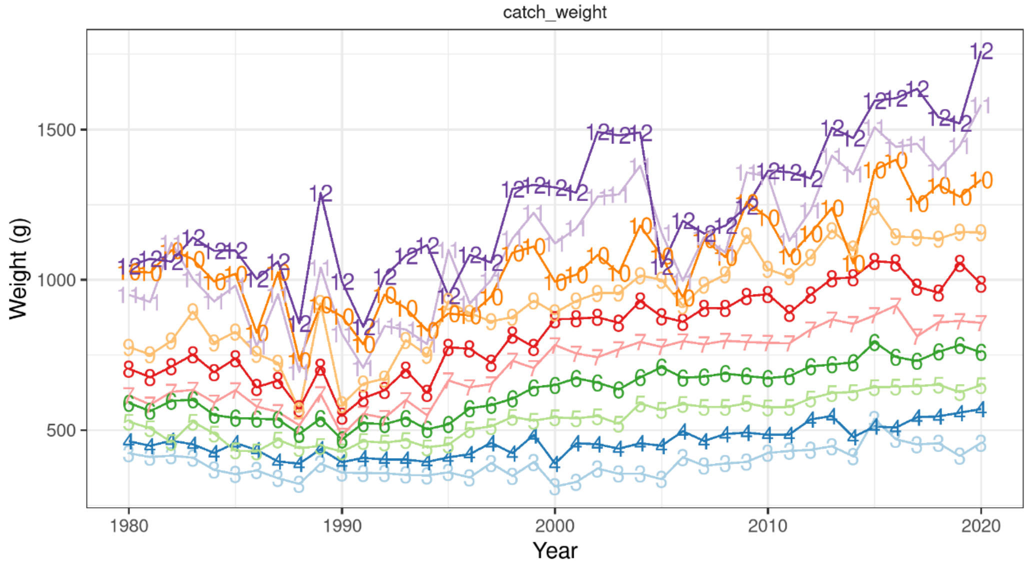


Figure 24.3.4: Plaice in 5a. Weight at age from the commercial catch.

24.3.5 Catch, effort and research vessel data

24.3.5.1 Catch per unit of effort (CPUE) 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. Since 2000 CPUE both for both gears increased rapidly and are at the highest levels (Figure 24.3.5).

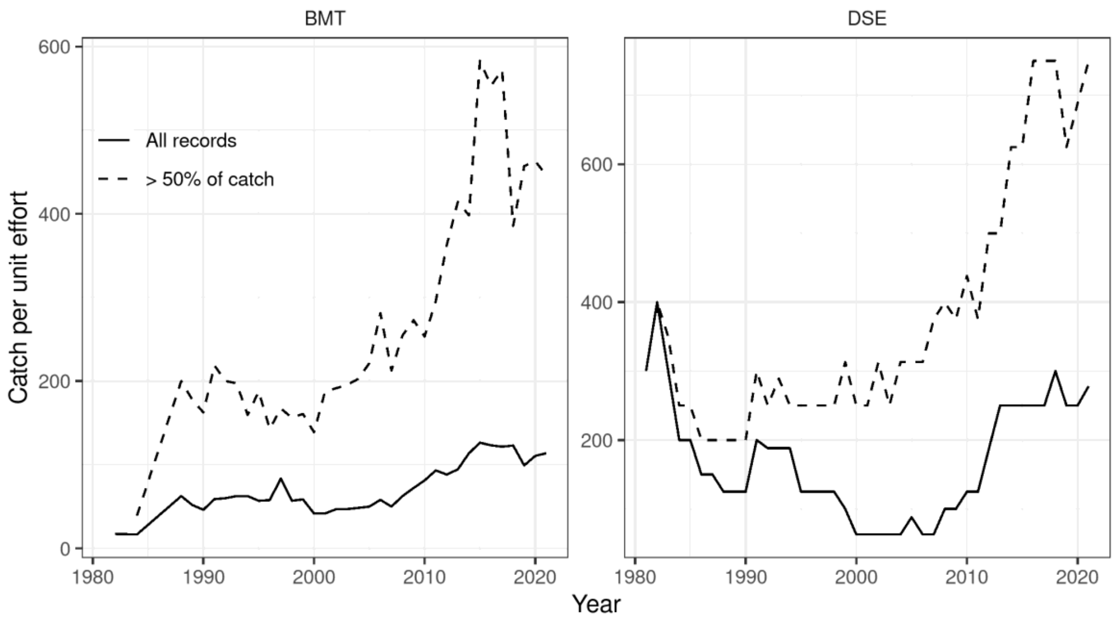


Figure 24.3.5: Plaice in 5a. Non-standardised estimates of CPUE from demersal trawl (left) and demersal seine (right).

24.3.5.2 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 (see stock annex). The plan is to incorporate this survey in the stock assessment for plaice in the future.

Figure 24.3.6 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 24.3.7 and 24.3.8, and abundance and changes in spatial distribution in Figures 24.3.9–24.3.11.

Total biomass index of plaice and plaice larger than 30 cm (harvestable part of the stock) from spring survey, decreased rapidly in the first years of the spring survey and was at the lowest level in 1997–2002. Since 2001, the biomass index increased and has been stable since with minor fluctuations. This year's spring survey biomass index is in correspondence with the biomass from early 1990. The index of plaice larger than 47 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. However, in the last 8 years autumn survey indices for total and harvestable biomass indices are well above the spring survey but standard deviations in the measurements are also very high indicating that they are few stations with large catch in the autumn survey.

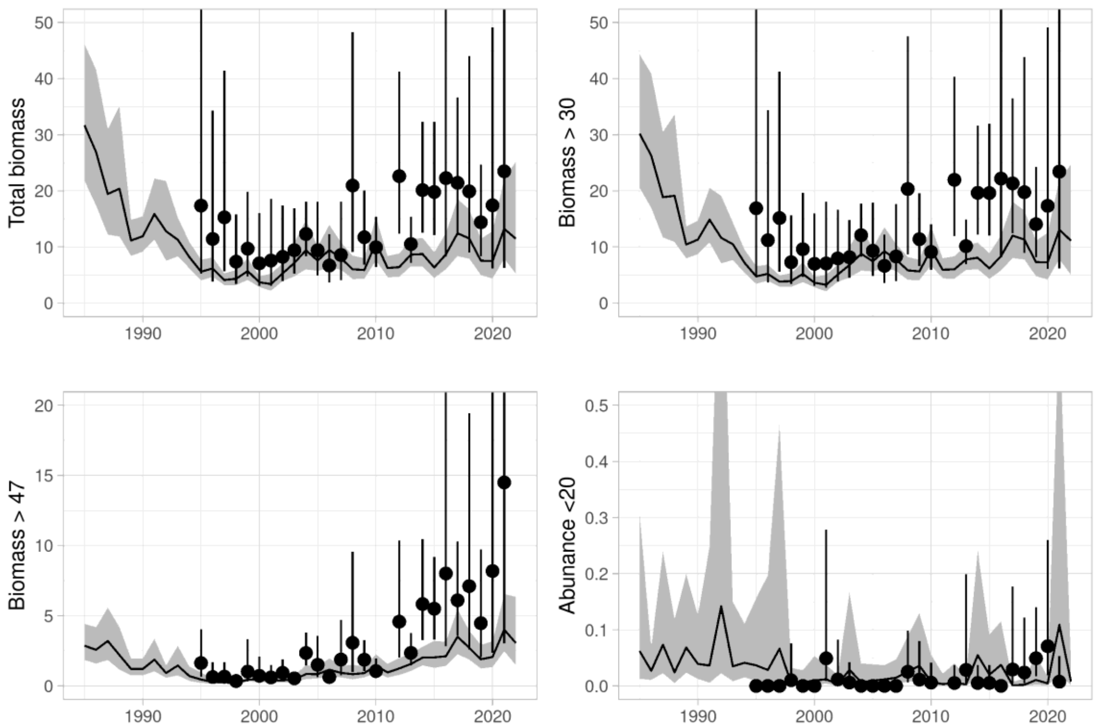


Figure 24.3.6. Plaice in 5a. Indices in the Spring Survey (March) from 1985 and onwards (black line shaded area) and the autumn survey 1996 and onwards (points ranges).

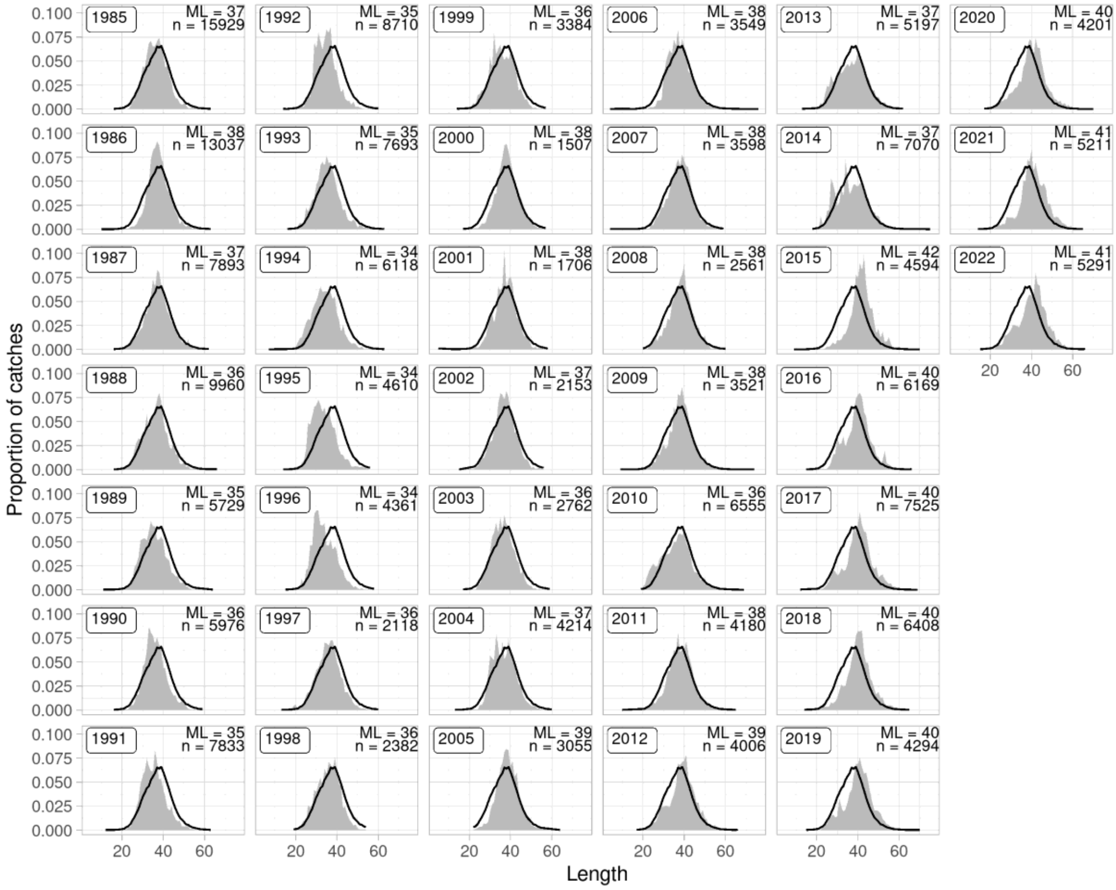


Figure 24.3.7. Plaice in 5a. Length disaggregated abundance indices from the spring survey (March) 1985 and onwards.

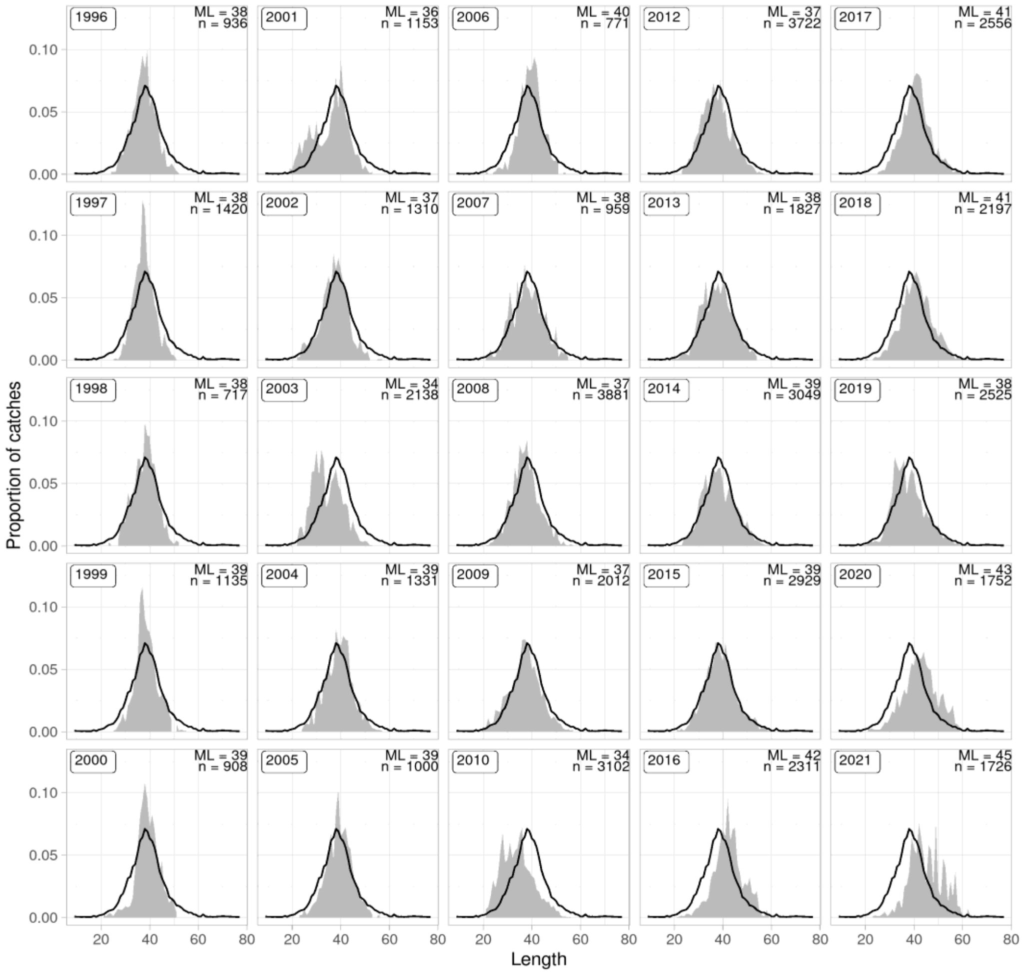


Figure 24.3.8. Plaice in 5a: Length disaggregated abundance indices from the autumn survey (October) 1996 and onwards, except 2011.

Figure 24.3.9. Plaice in 5a. Changes in geographical distribution of the survey biomass.

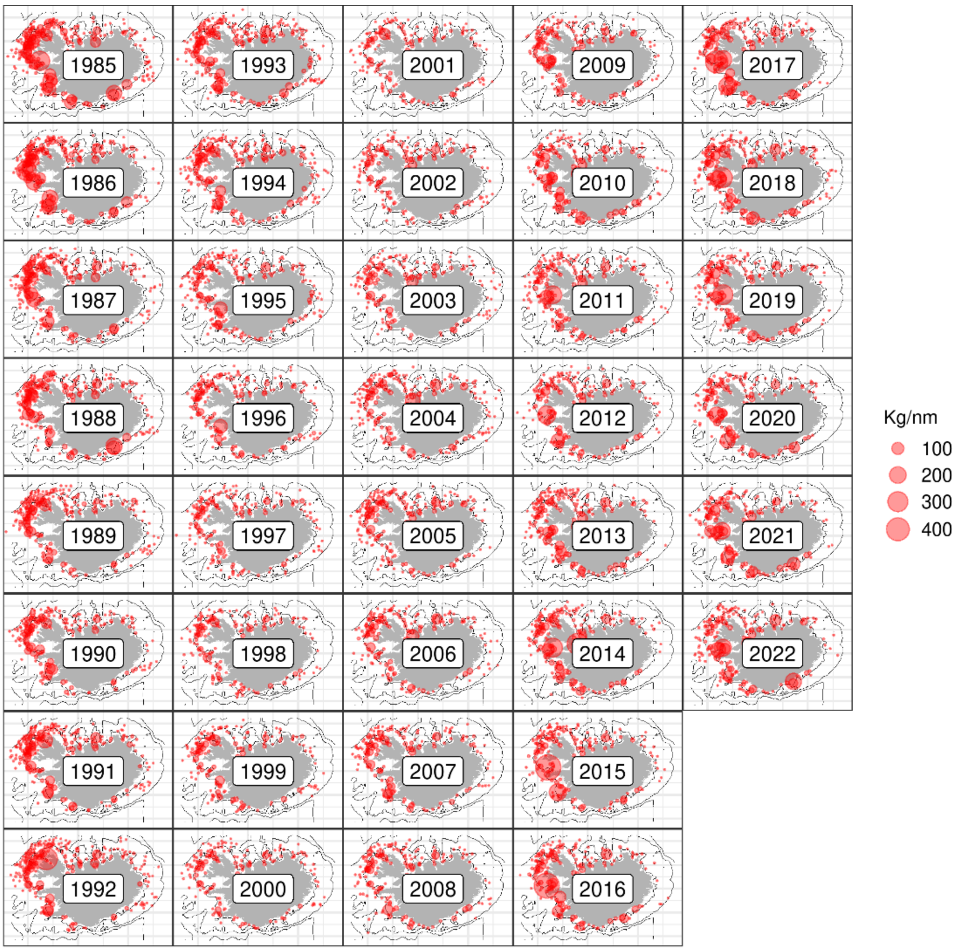


Figure 24.3.10. Plaice in 5a. Location of plaice in the spring survey, bubble sizes are relative to catch sizes.

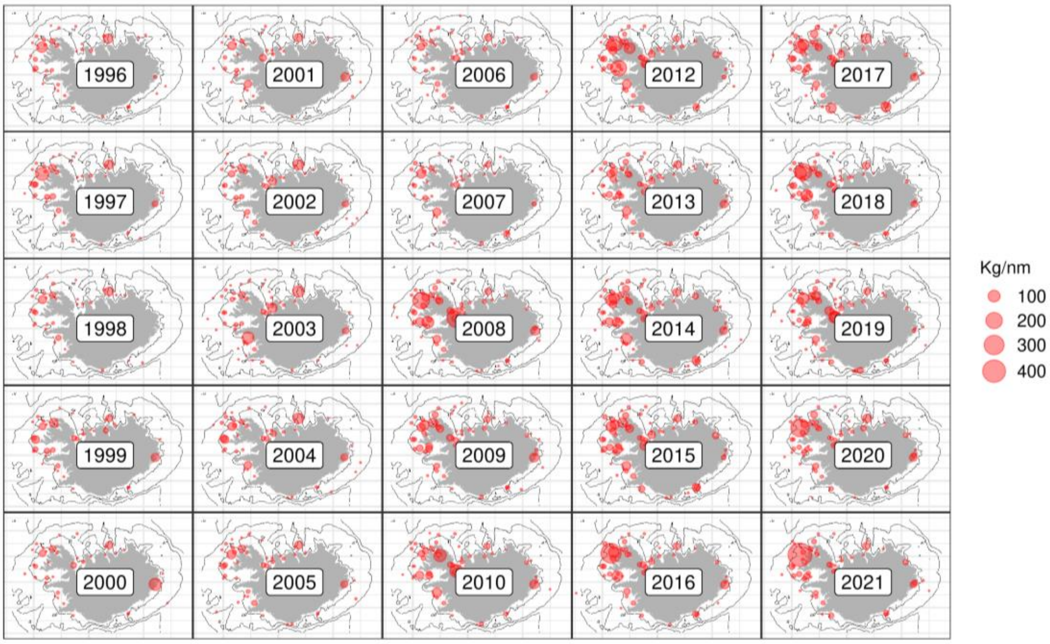


Figure 24.3.11. Plaice in 5a. Location of plaice in the autumn survey, bubble sizes are relative to catch sizes.

24.3.6 Stock weights

Mean weight at age in the stock is shown in Figure 24.3.12. This data is obtained from the groundfish survey in March. Stock weights are also used as mean weight at age in the spawning stock. The weights are approximated from lengths. For stock weights for age 9 are smoothed using a running 3-year average. Prior to 1985 the stock weights are assumed fixed at 1985 levels.

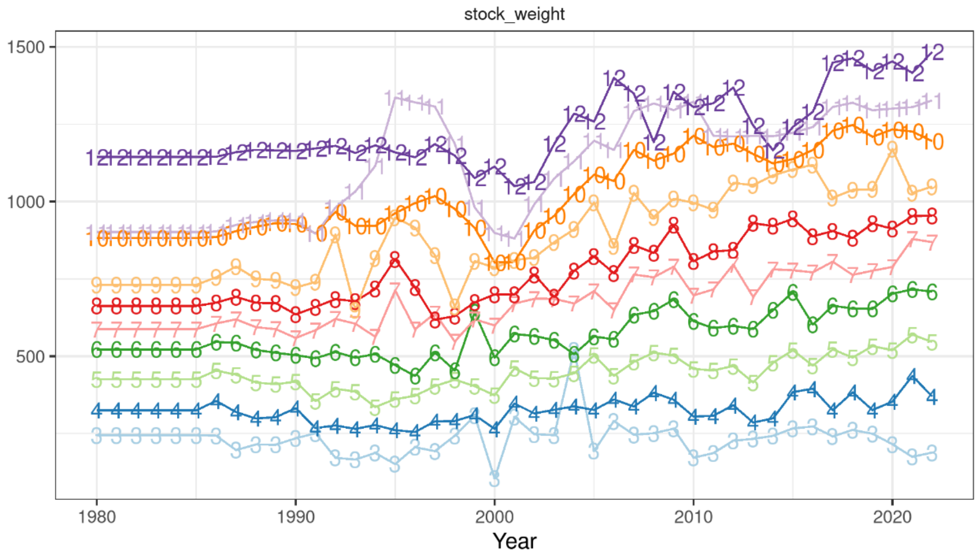


Figure 24.3.12. Plaice in 5a. Weight at age observed in the spring survey.

24.3.7 Maturity-at-age

Maturity-at-age data are given in Figure 24.3.13. Those data are obtained from the groundfish survey in March. Based on guidelines from PGCCDBS it was decided to use mature females as the basis for maturity at age. Prior to 1985 the proportion mature is assumed fixed at 1985 levels. Maturity at age is estimated from yearly maturity at length ogives estimated using logistic regression treating individuals as fixed effects. Maturity-at-age was smoothed with a 3-year running average.

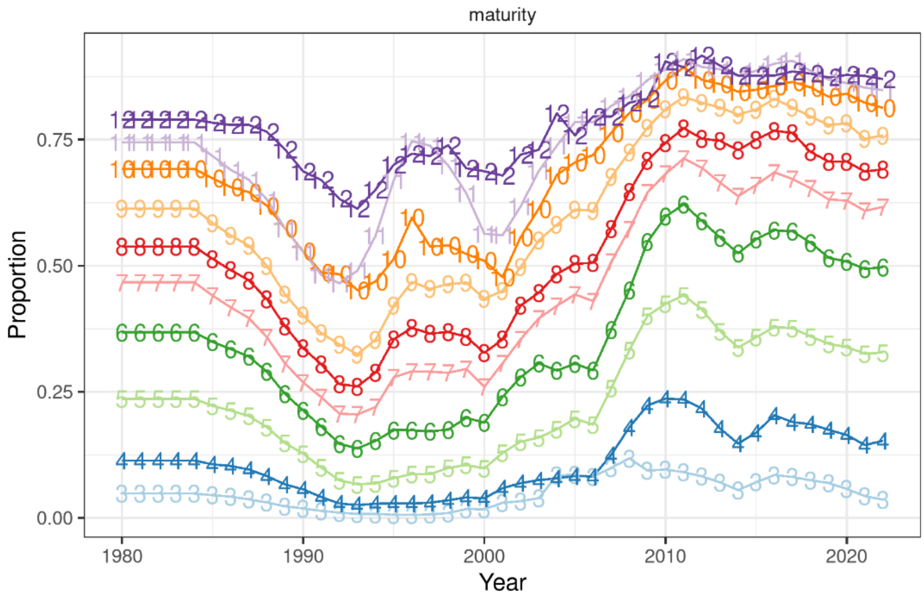


Figure 24.3.13: Plaice in 5a. Proportion mature females at age from spring survey.

24.3.8 Natural mortality

No information is available on natural mortality. For assessment and advisory purpose, the natural mortality is set to 0.15 for all age groups.

24.4 Data analysis

24.4.1 Analytical assessment

Assessment on plaice in Icelandic waters using SAM

Plaice in 5.a is new to ICES where it became a part of the ICES assessment process after an MoU between Iceland and ICES was signed on December 1st, 2019.

During the benchmark in April 2022, a SAM model (State-space stock assessment model) was agreed for use in the assessment.

24.4.1.1 Data used by the assessment and model settings

The new assessment model is a statistical catch at age model based on:

- commercial catch-at-age and landings data from 1979 onwards
- the Icelandic spring groundfish survey from 1985
- Recruitment at age 3 every year.

Model setup and settings are described in the Stock Annex.

Figure 24.4.1. Plaice in 5.a. Estimated numbers of 3–12-year-old fish in the commercial catch (1980–2021) and age-disaggregated survey indices from the spring survey (1985–2022). Input data for the stock assessment.

24.4.1.2 Model fit

The model fit to survey indices and catch-at-age data are shown in figures 24.4.2 and 24.4.3. Generally, the model closely follows the catch-at-age and spring survey data, which are in good agreeance.

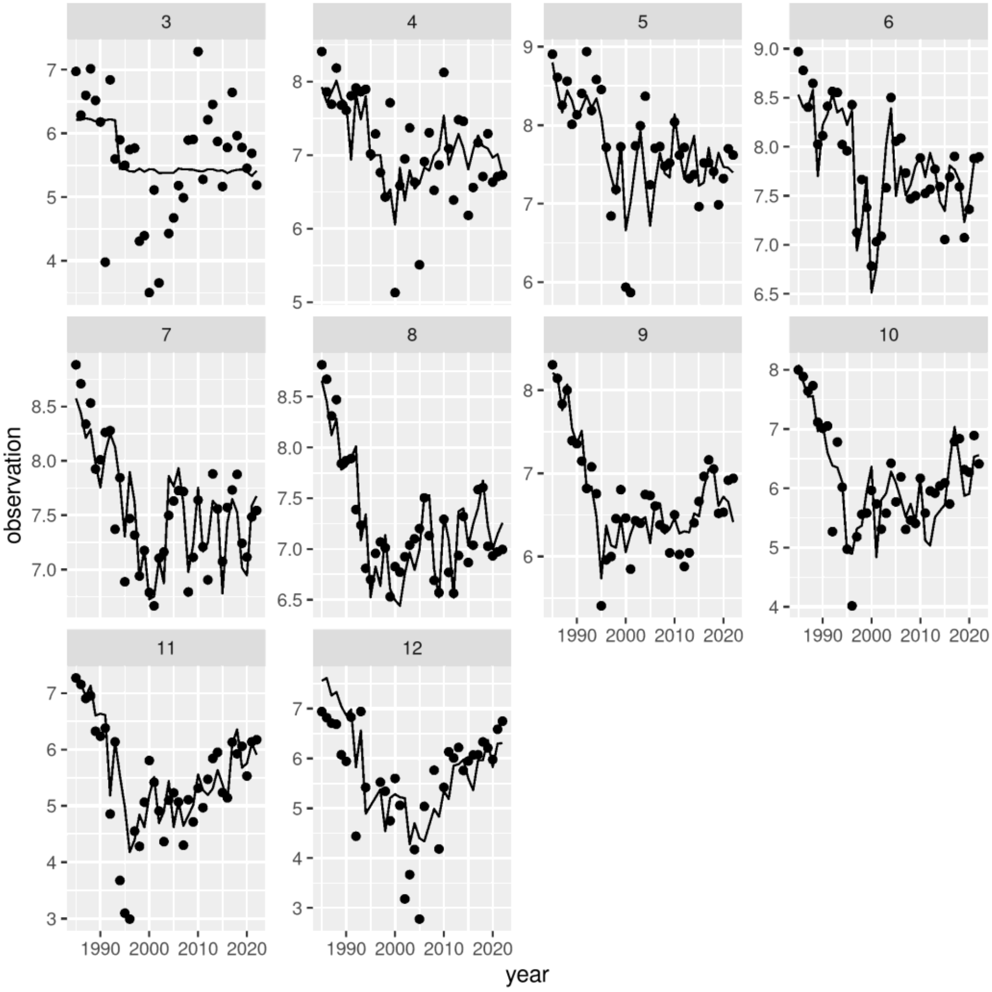


Figure 24.4.2. Plaice in 5a. Illustration of the model fit to the survey data by age. Points indicate the log observation while the solid lines the model fit.

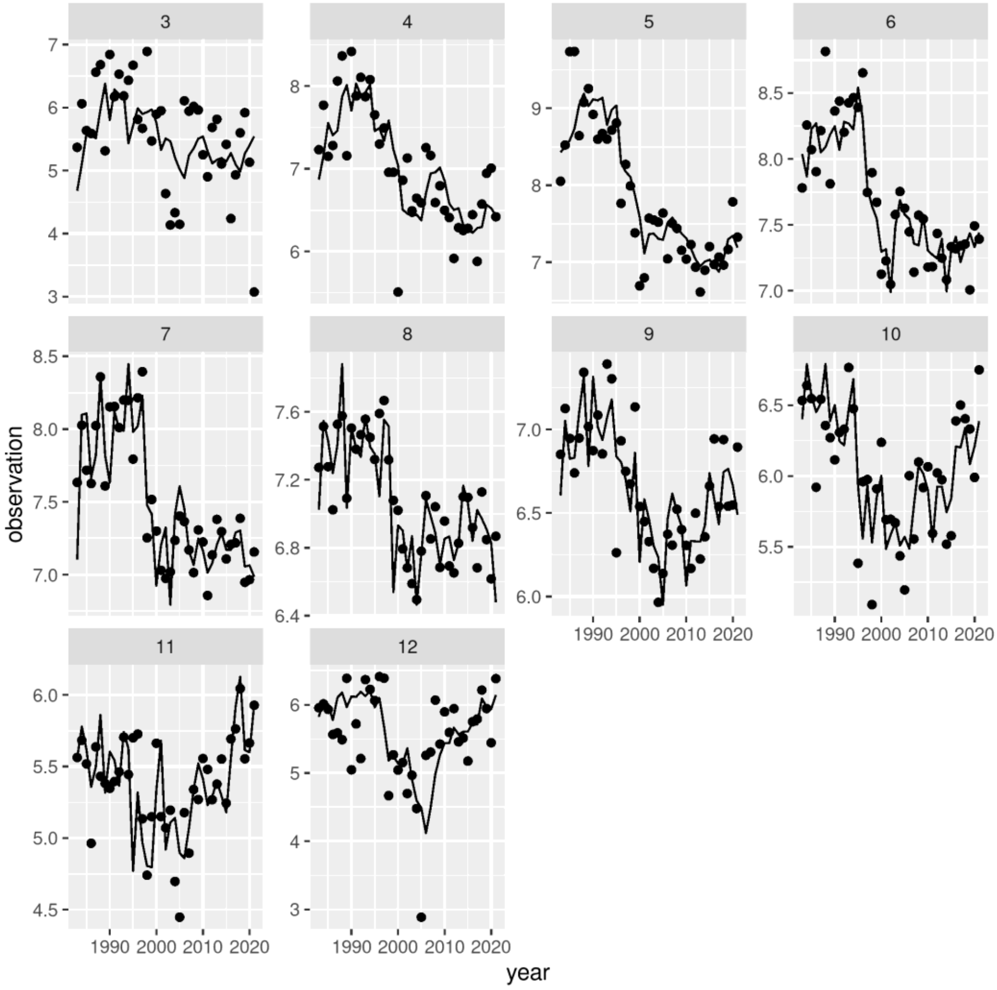


Figure 24.4.3. Plaice in 5a. Illustration of the model fit to the catch data by age. Points indicate the log observation while the solid lines the model fit.

24.4.1.3 Model results

Model results have shown spawning stock biomass gradually decline prior to 2000, historical low was reached then. Steep increase followed in period 2001-2015 in SSB which has levelled in most recent years. Excluding biomass values earlier than 1985, which are highly uncertain because spring survey data begin in 1985, current total biomass levels are at historical highest. Fishing mortality decreased gradually after 1999 and remained stable in most recent years. Recruitment displays two productivity regimes, high in the 1980s with rapid drop in mid-1990s and stable period since. Therefore, with stable recruitment and moderate fishing levels spawning stock biomass is expected to remain at current levels.

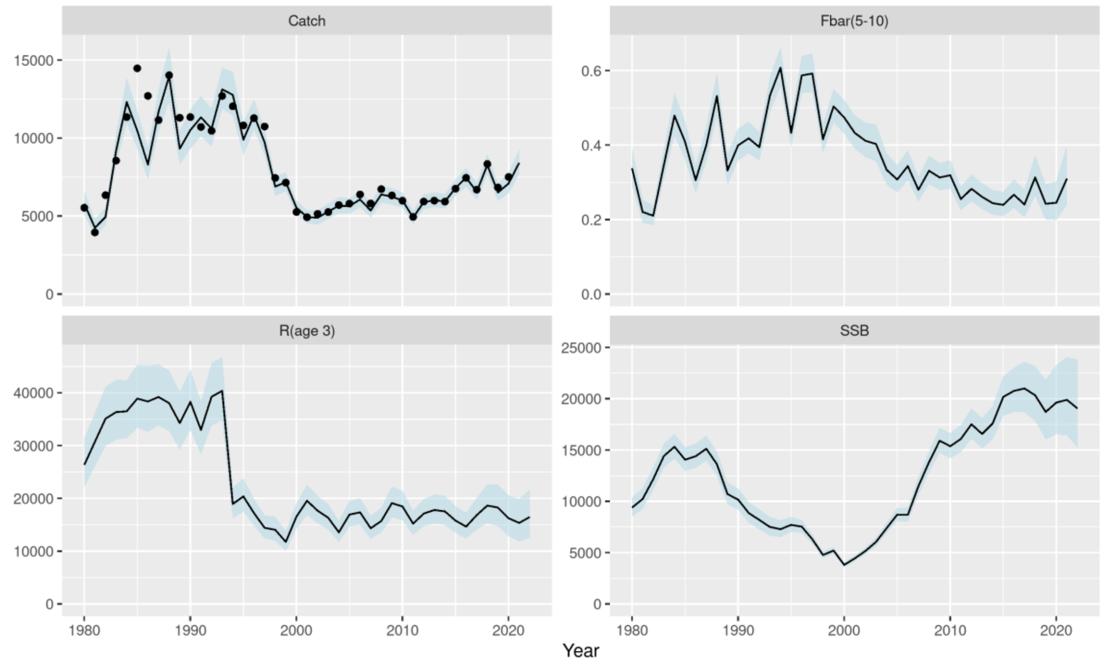


Figure 24.4.4. Plaice in 5.a. Summary from the assessment 2022. Estimates of catch, fishing mortality (Fbar5-10), recruitment (age 3) and spawning stock (SSB) are shown. Black line represents the point estimates as the blue ribbon the 95% confidence intervals.

24.4.1.4 Retrospective analysis

The results of an analytical retrospective analysis are presented (Figure 24.4.5). The analysis indicates generally consistent model results over the 5-year peel. Mohn's rho was estimated to be -0.0773 for SSB, 0.0675 for F, and -0.0231 for recruitment.

The proposed model had low Mohn's ρ statistic values for spawning stock biomass, fishing mortality, and recruitment. Analytical retrospective plots do not indicate any substantial deviations in assessment (Figure 24.4.5). These Mohn's ρ values are well within the acceptable ranges (Carvalho *et al.*, 2021).

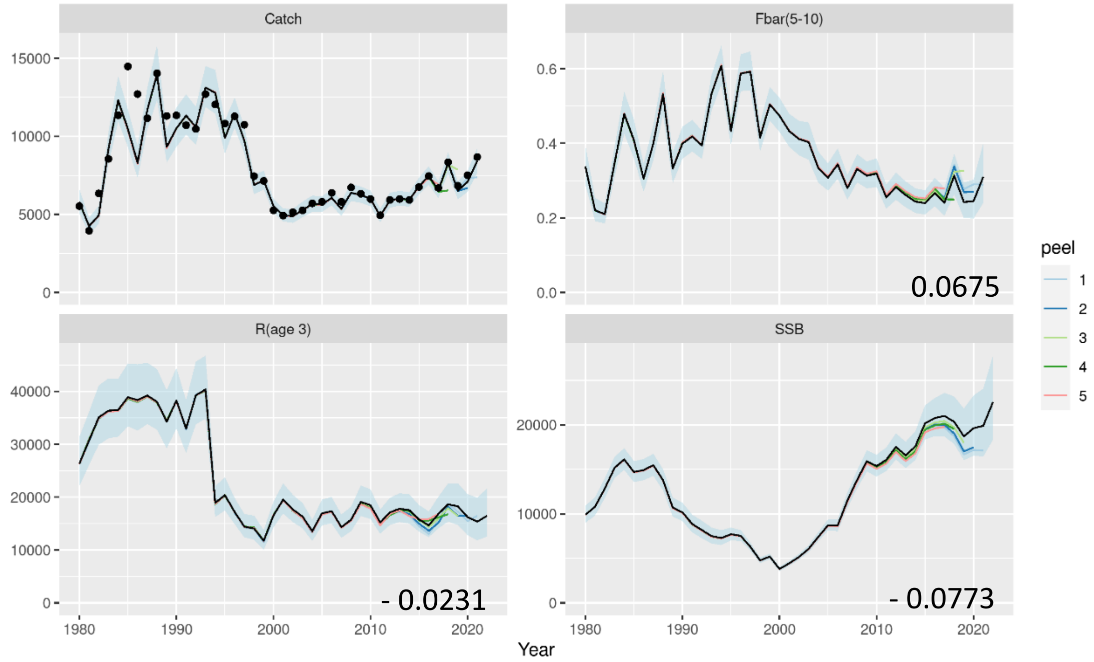


Figure 24.4.5. Plaice in 5.a. Analytical retrospective estimates illustrating stability in model estimates over a 5-year 'peel' in data. Results of catch, fishing mortality (Fbar5-10), recruitment (age 3) and spawning stock (SSB) are shown. Mohns rho is indicated in the bottom right corner.

Observation and process $\log(N)$ and $\log(F)$ residuals show no concerning patterns, shown in Figure 24.4.6 and 24.4.7, respectively.

Figure 24.4.8 shows the estimated model parameters. Observation variances are lowest for the spring survey and commercial catches for ages 5 to 8 and 7 to 8 respectively, with the highest variances at either ends of the age range. Survey variances are in general higher than that of the commercial catches. Strong positive correlations were estimated between ages for the commercial catches, less for survey catches. Process variances were fixed across all ages for both $\log(N)$ and $\log(F)$, with populations variances estimated at 0.06.

Survey catchability showed an increasing trend with age, peaking at the age of 10, while slightly lower at 11 and 12.

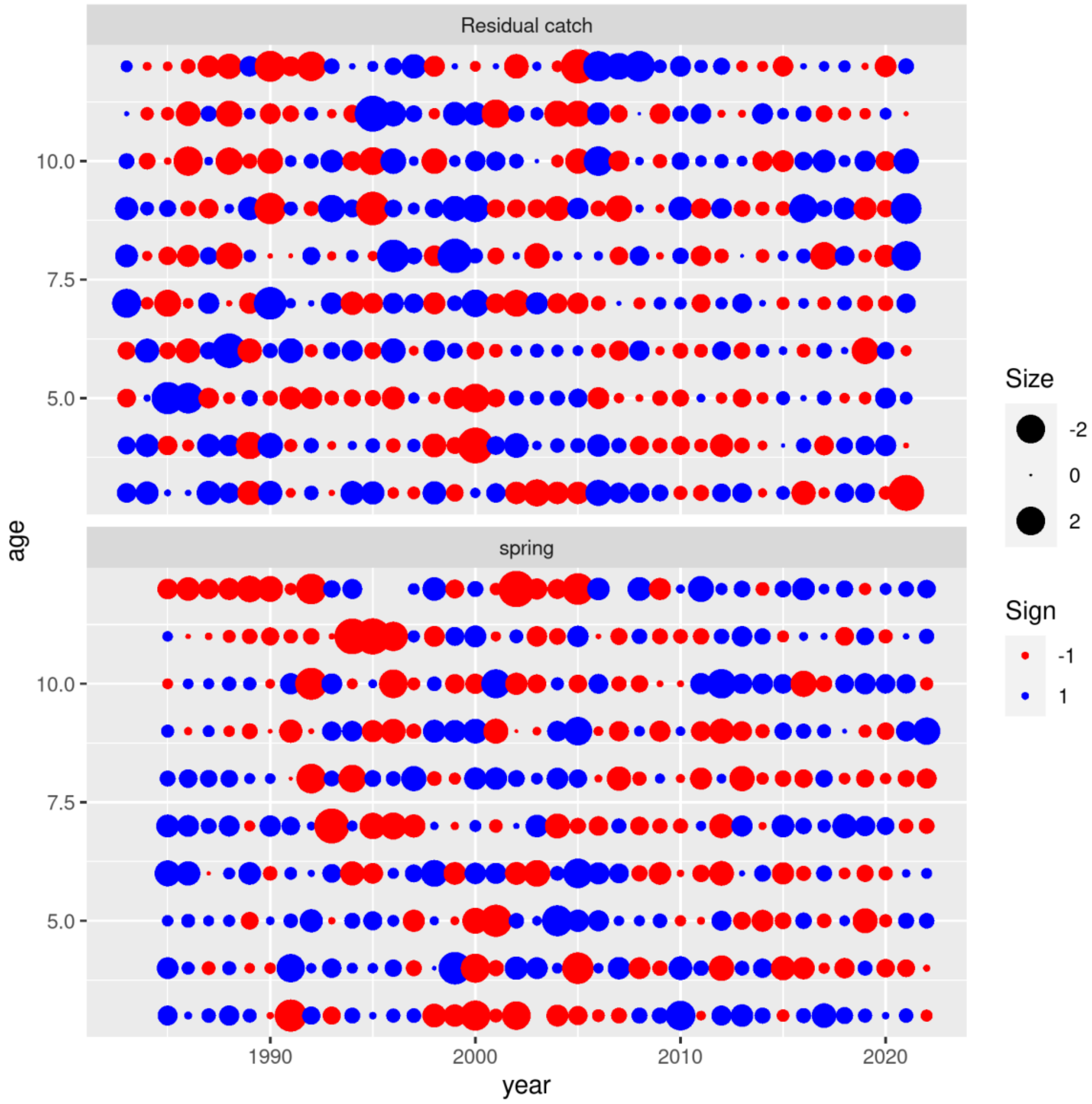


Figure 24.4.6. Plaice in 5.a. Residuals of the model fit to spring survey indices and catch data by age. Red circles indicate where the model estimates are lower than the observed while blue indicate model estimates lower that the observed.

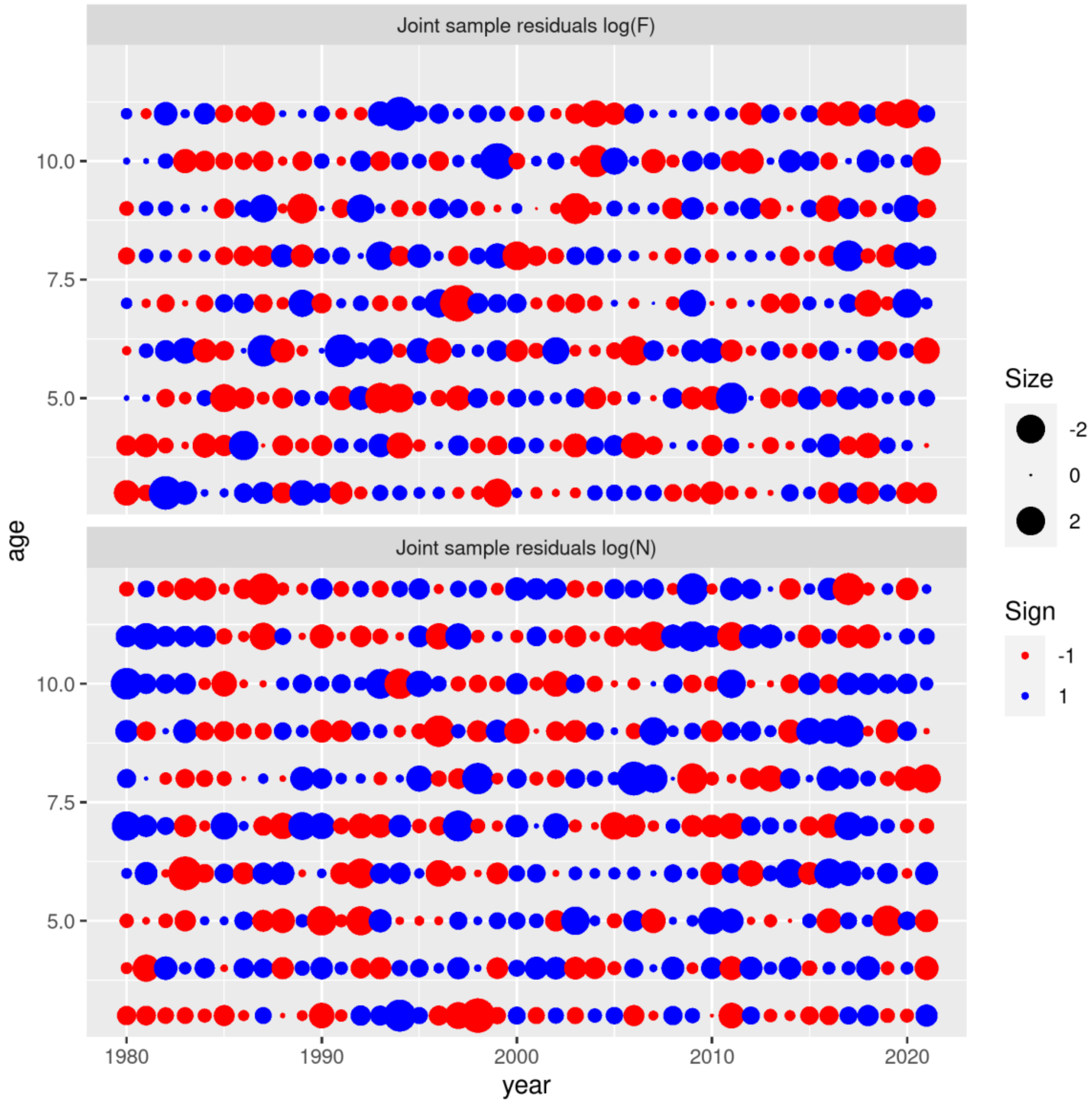


Figure 24.4.7. Plaice in 5a. Process residuals from the assessment model.

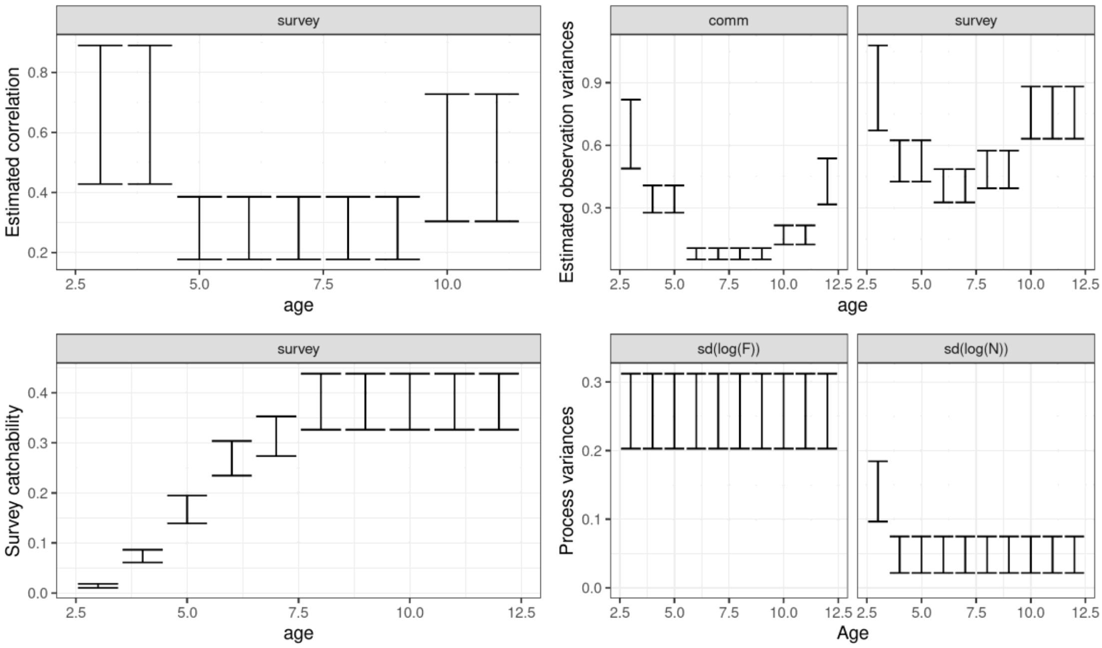


Figure 24.4.8. Plaice in 5a. Illustration of estimated model parameters.

24.4.1.5 Reference points

As part of the WKICEMP 2022, HCR evaluations requested by Iceland the following reference points were defined for the stock.

Framework	Reference points	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	12 400	B_{pa}	ICES (2022b)
	F_{MSY}	0.41	Fishing mortality that leads to MSY. Estimated using stochastic simulations.	
Precautionary approach	B_{lim}	10 000	Lowest SSB (1990) where large recruitment was observed.	
	B_{pa}	12 400	B_{lim} x $e^{1.645 * \sigma B}$, using σ_B = 0.12	
	F_{lim}	0.57	Fishing mortality that in stochastic equilibrium will result in median SSB at B_{lim}.	
	F_{pa}	0.46	F_{p05}, maximum F at which the probability of SSB falling below B_{lim} is <5%	
Management plan	MGT $B_{trigger}$	12 400	MSY $B_{trigger}$	
	F_{MGT}	0.30	From the management plan.	

The management plan proposed by Iceland was:

The proposed HCR for the plaice fishery in Iceland, which sets a TAC for the fishing year y/y+1 (1 September of year y to 31 August of year y+1) based on a fishing mortality F_{mgt} of 0.3 applied to ages 5 to 10 modified by the ratio SSB_y/MGT $B_{trigger}$ when SSB_y < MGT $B_{trigger}$, maintains a high yield while being precautionary as it results in lower than 5% probability of SSB < B_{lim} in the medium and long term. WKICEMSE 2022 concluded that the HCR was precautionary and in conformity with the ICES MSY approach.

24.5 Management considerations

All the signals from commercial catch and survey data indicate that plaice in 5.a is at present in a good state. This is also confirmed in the assessment. Considerable uncertainty is present in the model due to limited information on recruitment from spring survey. However, the information on recruitment pulses is present from Icelandic coastal beam trawl survey, which is specially designed to target young plaice, but series is still too short to include in the assessment (Stock Annex).

24.6 Management

The Ministry of Food, Agriculture and Fisheries is responsible for management of the Icelandic fisheries and implementation of legislation. The Ministry issues regulations for commercial fishing for each fishing year (1. September – 31. August), including an allocation of the TAC for each stock subject to such limitations. 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 for this practice was that no formal harvest rule existed for this stock. The landings have been fluctuating between the over- or undershoot the set TAC and this is related to the management system that allows 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 24.6.1. Regulations regarding protection of spawning plaice are also in place in area 5.a, where specific spawning grounds in the west and southwest of Iceland are closed to fishing during spawning period in April.

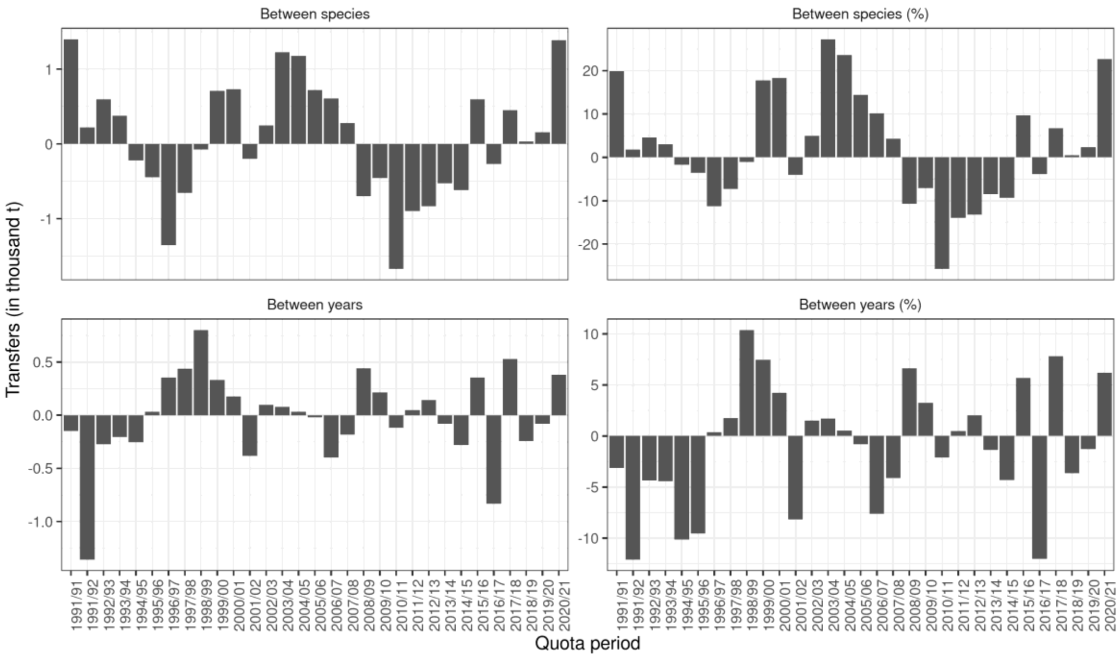


Figure 24.6.1. Plaice in 5.a. An overview of the net transfers of quota between years and species transformations in the fishery in 5.a.

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.

Year	Number of vessels			Catches (Tonnes)			
	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	52	41	51	2475	4681	350	7505
2021	55	35	52	3603	4719	358	8677

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
2021	6922/53	5067/42	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
2021	1225/49	900/36	0/0

***Few samples taken due to COVID-19 pandemic.**

Table 24.1.4. Plaice in 5a. Age disaggregated survey indices from the groundfish survey in March.

Year	3	4	5	6	7	8	9	10	11	12
1985	1.068	4.484	7.367	7.873	7.216	6.719	4.047	2.972	1.437	1.032
1986	0.537	2.595	5.490	6.499	6.059	5.827	3.437	2.653	1.280	0.913
1987	0.732	2.189	3.846	4.460	4.180	4.062	2.524	2.076	0.998	0.817
1988	1.113	3.584	5.225	5.695	5.075	4.770	2.981	2.276	1.048	0.801
1989	0.677	2.166	3.013	3.058	2.764	2.543	1.623	1.230	0.558	0.434
1990	0.482	2.016	3.401	3.337	3.010	2.618	1.564	1.109	0.511	0.381
1991	0.053	2.458	4.471	4.507	3.875	2.672	1.271	1.155	0.591	0.923
1992	0.935	2.735	7.620	5.248	3.935	1.617	0.914	0.194	0.128	0.085
1993	0.269	2.598	3.596	5.179	1.588	1.387	1.185	0.880	0.462	1.033
1994	0.365	2.684	5.332	3.049	2.552	0.907	0.857	0.411	0.040	0.225
1995	0.244	1.115	4.694	2.861	0.979	0.812	0.222	0.145	0.022	0.000
1996	0.313	1.462	2.249	4.580	1.754	1.051	0.387	0.056	0.020	0.000
1997	0.320	0.865	0.937	1.243	1.505	1.175	0.402	0.178	0.095	0.250
1998	0.074	0.620	1.313	2.136	1.032	1.111	0.635	0.260	0.072	0.209
1999	0.081	2.235	2.265	1.604	1.306	0.686	0.900	0.266	0.159	0.115
2000	0.033	0.169	0.378	0.883	0.888	0.922	0.641	0.389	0.332	0.270
2001	0.166	0.724	0.353	1.131	0.785	0.874	0.346	0.310	0.226	0.157
2002	0.038	1.041	2.295	1.198	1.217	1.017	0.620	0.203	0.135	0.024
2003	0.000	1.589	2.961	1.962	1.289	1.139	0.601	0.265	0.079	0.039
2004	0.084	0.759	4.314	4.925	1.805	1.213	0.849	0.616	0.164	0.065
2005	0.107	0.247	1.395	3.154	2.060	1.342	0.838	0.321	0.187	0.016
2006	0.178	1.004	2.223	3.257	2.266	1.815	0.739	0.489	0.159	0.154
2007	0.147	1.487	2.272	2.283	2.247	1.250	0.589	0.202	0.074	0.000
2008	0.363	0.679	1.771	1.754	0.892	0.806	0.562	0.235	0.166	0.318
2009	0.367	0.958	1.845	1.808	1.227	0.714	0.421	0.223	0.112	0.066
2010	1.457	3.376	3.103	2.661	2.078	1.470	0.666	0.478	0.203	0.226
2011	0.196	1.197	2.036	1.852	1.350	0.872	0.412	0.266	0.144	0.460
2012	0.500	0.595	2.243	1.933	0.997	0.710	0.357	0.386	0.238	0.407
2013	0.636	1.776	1.510	2.371	2.644	1.029	0.421	0.371	0.344	0.502

Year	3	4	5	6	7	8	9	10	11	12
2014	0.355	1.738	1.590	1.985	1.915	1.512	0.604	0.420	0.384	0.317
2015	0.175	0.483	1.056	1.157	1.179	0.961	0.782	0.443	0.188	0.382
2016	0.323	0.706	1.845	2.189	1.942	1.139	1.056	0.310	0.171	0.432
2017	0.767	1.300	1.850	2.703	2.280	1.968	1.288	0.888	0.460	0.434
2018	0.389	0.819	1.652	1.980	2.631	2.009	1.154	0.932	0.374	0.561
2019	0.323	1.467	1.082	1.179	1.396	1.127	0.677	0.553	0.428	0.497
2020	0.233	0.760	1.511	1.574	1.229	1.026	0.686	0.528	0.252	0.394
2021	0.295	0.818	2.211	2.644	1.779	1.067	1.008	0.983	0.462	0.724

Table 14.1.5. Plaice in 5a. Catch-at-age in numbers from the commercial fishery in Icelandic waters.

Year	3	4	5	6	7	8	9	10	11	12
1980	149.464	1011.728	2313.331	1721.177	1462.224	976.030	543.776	394.754	159.958	154.703
1981	133.418	855.562	1828.714	1286.903	1074.210	690.655	380.976	259.031	101.657	97.430
1982	104.515	703.175	6059.506	1338.680	1139.529	750.690	442.429	330.723	145.754	172.176
1983	214.605	1380.094	3138.501	2392.462	2065.807	1439.442	944.389	687.372	260.526	386.299
1984	429.164	2364.212	5030.730	3855.846	3060.968	1833.236	1243.149	764.881	293.850	409.059
1985	280.382	1273.490	16897.202	3197.237	2246.930	1447.229	1039.030	696.901	249.198	377.556
1986	267.338	1453.169	16941.591	2706.363	2051.388	1122.290	845.320	372.823	143.057	261.111
1987	706.602	3166.969	5674.413	3693.818	3051.974	1858.001	1041.205	693.828	280.689	267.659
1988	796.672	4292.376	8750.645	6736.507	4266.312	1950.406	1543.614	576.748	228.481	241.829
1989	202.934	1283.528	10465.978	2468.554	2017.078	1201.020	1114.659	528.852	217.285	595.671
1990	937.044	4527.312	7479.365	4286.015	3473.653	1816.802	966.196	452.163	210.076	155.756
1991	480.059	2642.321	5416.260	4621.942	3481.372	1603.411	1194.585	548.624	220.438	305.229
1992	686.067	3310.932	5836.780	3649.154	3011.859	1747.796	947.029	561.679	235.768	183.561
1993	485.580	2619.432	5425.593	4559.032	3637.684	1913.357	1621.864	868.026	300.257	583.452
1994	621.623	3222.215	6098.515	4747.634	3633.101	1719.485	1484.903	648.931	231.392	506.486
1995	789.612	2106.097	6688.957	4407.089	2425.547	1509.587	524.553	217.972	299.019	429.863
1996	334.364	1478.096	2355.935	5725.390	3695.972	1979.024	1024.004	387.699	306.948	610.405
1997	290.272	1797.004	3908.333	2310.695	4420.401	2136.322	853.553	393.522	169.836	596.335
1998	983.070	1050.173	2955.049	2687.439	1412.184	1505.975	792.216	162.783	114.456	106.624
1999	237.779	1050.320	1606.903	2145.965	1837.076	1186.630	1254.960	368.798	172.378	193.959
2000	362.925	246.924	807.196	1243.453	1480.203	1118.783	691.577	511.783	287.883	155.046
2001	383.967	953.696	896.085	1375.741	1130.466	891.234	631.746	296.412	172.463	172.910
2002	102.976	1247.683	1943.370	1151.160	1068.919	797.625	560.452	297.343	159.323	109.961
2003	62.600	659.733	1899.622	1954.968	1118.559	726.507	477.463	289.956	180.318	143.802
2004	76.060	768.141	1844.523	2327.818	1387.925	661.149	389.701	229.551	109.595	88.268
2005	63.277	726.032	2075.960	2051.117	1640.552	879.934	463.181	180.663	85.359	17.938
2006	449.586	1414.543	1145.483	1714.954	1580.350	1220.233	585.981	404.572	177.283	192.525
2007	381.158	1288.200	1816.533	1262.451	1299.189	945.458	548.773	258.658	133.526	201.799
2008	410.770	727.977	1701.895	1945.821	1112.148	1142.599	679.954	445.486	208.311	432.233

Year	3	4	5	6	7	8	9	10	11	12
2009	387.971	891.757	1280.102	1890.872	1491.145	799.172	602.237	371.721	194.296	227.032
2010	190.620	663.770	1141.456	1312.367	1372.685	1049.893	547.576	430.875	258.650	363.991
2011	134.505	607.843	1381.465	1315.847	950.912	806.256	477.351	269.311	239.902	269.290
2012	294.126	370.572	1028.346	1693.184	1256.173	774.341	664.134	412.371	194.049	382.024
2013	334.869	537.726	744.734	1405.653	1603.326	921.519	504.880	393.112	216.329	234.692
2014	164.879	519.504	988.763	1192.688	1474.539	1212.172	576.440	249.364	257.662	248.023
2015	224.963	533.700	1343.142	1532.331	1221.570	1207.304	781.593	264.723	189.406	176.895
2016	69.285	629.153	1065.311	1506.874	1350.799	1010.811	1036.057	595.351	296.607	315.235
2017	138.608	357.564	1171.957	1542.513	1364.078	797.517	691.541	665.557	318.305	327.904
2018	270.309	715.378	1057.055	1562.077	1614.588	1246.512	1031.835	604.471	422.082	501.242
2019	372.330	1037.511	1295.557	1103.959	1040.788	941.623	692.479	562.476	258.258	382.345
2020	169.480	1104.460	2402.214	1794.130	1059.398	747.501	698.203	399.588	288.527	231.546

Table 24.1.6. Plaice in 5a. Catch weights at age from the commercial fishery in Icelandic waters.

Year	3	4	5	6	7	8	9	10	11	12
1980	423	463	528	590	616	704	777	1028	950	1046
1981	410	448	506	563	585	676	751	1024	926	1070
1982	415	465	460	597	627	711	797	1098	1122	1060
1983	408	453	528	601	634	751	894	1069	1003	1141
1984	368	424	489	550	592	693	791	994	928	1097
1985	354	458	432	540	633	738	826	1020	981	1097
1986	366	434	429	538	578	643	754	823	779	1003
1987	340	396	468	536	560	665	724	1025	952	1061
1988	321	388	440	487	516	572	566	732	694	855
1989	389	437	447	539	620	711	921	917	1041	1289
1990	358	393	429	469	482	548	585	878	820	994
1991	357	408	463	523	554	606	654	785	707	844
1992	357	402	458	520	540	633	671	951	846	1011
1993	351	402	467	539	601	700	799	905	835	1080
1994	349	394	443	503	549	623	749	831	786	1115

Year	3	4	5	6	7	8	9	10	11	12
1995	360	410	451	519	665	775	928	888	1100	946
1996	343	420	503	572	642	771	889	881	921	1083
1997	390	458	512	583	653	724	862	944	999	1057
1998	347	423	544	604	731	817	876	1090	1137	1302
1999	394	484	532	642	706	776	930	1110	1223	1315
2000	312	389	543	650	783	868	890	993	1121	1307
2001	328	457	539	673	755	871	930	1017	1171	1290
2002	372	453	546	658	742	876	955	1082	1276	1492
2003	354	438	521	635	769	856	956	1023	1284	1480
2004	355	456	589	675	793	930	1014	1181	1379	1490
2005	337	448	566	709	777	878	1000	1080	1157	1043
2006	410	496	586	674	796	860	915	940	996	1196
2007	381	464	578	678	786	906	982	1134	1142	1154
2008	389	487	576	688	797	905	1018	1075	1090	1180
2009	394	492	590	680	793	945	1148	1258	1357	1244
2010	424	484	576	673	790	952	1035	1207	1344	1363
2011	430	486	577	680	789	889	1011	1078	1130	1358
2012	434	536	606	712	835	950	1075	1154	1231	1337
2013	446	547	623	718	868	1004	1164	1239	1412	1506
2014	413	477	627	725	853	1008	1103	1055	1351	1471
2015	537	512	643	793	882	1062	1245	1365	1507	1595
2016	470	508	644	743	914	1056	1144	1399	1442	1604
2017	452	543	646	730	812	977	1141	1254	1452	1635
2018	457	546	651	760	859	957	1136	1315	1366	1541
2019	414	558	626	783	863	1056	1159	1276	1446	1520
2020	458	570	649	759	857	986	1157	1333	1582	1761

Table 24.1.7. Plaice in 5.a. Stock weights-at-age from the March survey in Icelandic waters. The survey started in 1985, thus for the years 1980-1984 the same weights at age as in the 1985 survey are assumed.

Year	3	4	5	6	7	8	9	10	11	12
1980	245	325	426	522	587	663	731	882	902	1144
1981	245	325	426	522	587	663	731	882	902	1144
1982	245	325	426	522	587	663	731	882	902	1144
1983	245	325	426	522	587	663	731	882	902	1144
1984	245	325	426	522	587	663	731	882	902	1144
1985	245	325	426	522	587	663	731	882	902	1144
1986	243	356	454	546	606	673	755	885	903	1145
1987	197	320	440	543	619	692	790	904	924	1159
1988	215	299	415	521	594	672	750	918	934	1167
1989	214	303	410	511	588	672	746	930	939	1165
1990	235	332	418	503	559	635	722	927	939	1164
1991	251	268	355	494	584	659	740	897	896	1172
1992	172	276	395	513	621	684	893	967	980	1180
1993	166	265	386	495	605	678	649	921	1033	1157
1994	187	277	336	507	563	717	816	921	1115	1182
1995	151	261	361	471	713	814	949	962	1336	1159
1996	206	255	372	436	587	722	916	995	1321	1143
1997	193	290	403	512	639	618	826	1018	1307	1186
1998	243	291	424	454	547	630	660	976	1187	1148
1999	308	310	403	642	619	674	807	915	981	1076
2000	105	265	374	496	600	700	786	803	899	1113
2001	303	347	461	572	670	700	810	805	881	1050
2002	248	315	429	566	686	764	819	907	991	1063
2003	245	327	428	552	686	691	869	954	1075	1187
2004	520	338	445	507	670	776	910	1025	1130	1284
2005	193	326	503	564	711	822	997	1087	1197	1258
2006	290	360	437	555	650	768	856	1066	1166	1400
2007	246	337	482	634	764	859	1027	1167	1292	1349

Year	3	4	5	6	7	8	9	10	11	12
2008	251	382	512	646	755	834	949	1132	1317	1192
2009	266	360	502	683	790	924	1009	1155	1295	1355
2010	172	305	459	613	697	807	996	1213	1323	1305
2011	187	308	454	591	716	838	974	1176	1213	1318
2012	227	342	468	598	796	843	1060	1187	1210	1368
2013	233	286	415	588	691	930	1053	1154	1212	1246
2014	243	299	479	649	781	921	1085	1123	1211	1166
2015	267	384	520	707	778	945	1104	1137	1222	1241
2016	273	395	469	602	771	888	1119	1167	1241	1290
2017	240	325	522	663	806	904	1012	1229	1306	1449
2018	262	383	496	654	763	882	1038	1247	1319	1463
2019	249	326	533	653	776	929	1039	1210	1295	1422
2020	215	353	519	702	789	912	1169	1233	1300	1453

Table 24.1.8. Plaice in 5a. Sexual maturity-at-age in the stock (from the March survey). The survey started in 1985, thus for the years 1980-1984 the same maturity at age as in the 1985 survey are assumed.

Year	3	4	5	6	7	8	9	10	11	12
1980	0.048	0.114	0.236	0.368	0.467	0.538	0.613	0.692	0.745	0.790
1981	0.048	0.114	0.236	0.368	0.467	0.538	0.613	0.692	0.745	0.790
1982	0.048	0.114	0.236	0.368	0.467	0.538	0.613	0.692	0.745	0.790
1983	0.048	0.114	0.236	0.368	0.467	0.538	0.613	0.692	0.745	0.790
1984	0.048	0.114	0.236	0.368	0.467	0.538	0.613	0.692	0.745	0.790
1985	0.045	0.106	0.222	0.349	0.441	0.514	0.585	0.673	0.717	0.784
1986	0.042	0.103	0.213	0.335	0.418	0.491	0.560	0.656	0.690	0.779
1987	0.037	0.096	0.202	0.320	0.396	0.471	0.540	0.646	0.671	0.779
1988	0.031	0.083	0.180	0.290	0.358	0.434	0.500	0.619	0.631	0.765
1989	0.023	0.066	0.148	0.246	0.306	0.380	0.443	0.574	0.574	0.731
1990	0.019	0.057	0.127	0.213	0.269	0.336	0.401	0.528	0.527	0.687
1991	0.014	0.041	0.100	0.181	0.239	0.304	0.367	0.487	0.482	0.670
1992	0.010	0.028	0.075	0.147	0.207	0.265	0.344	0.483	0.465	0.632
1993	0.008	0.025	0.067	0.138	0.205	0.261	0.325	0.451	0.490	0.613
1994	0.008	0.028	0.068	0.153	0.220	0.288	0.353	0.469	0.560	0.651
1995	0.006	0.029	0.079	0.174	0.279	0.354	0.421	0.514	0.670	0.700
1996	0.006	0.029	0.087	0.174	0.290	0.377	0.468	0.595	0.747	0.722
1997	0.007	0.030	0.087	0.172	0.290	0.365	0.454	0.538	0.738	0.718
1998	0.010	0.035	0.099	0.175	0.288	0.368	0.464	0.540	0.699	0.739
1999	0.017	0.041	0.105	0.198	0.295	0.359	0.466	0.523	0.644	0.693
2000	0.017	0.039	0.098	0.189	0.260	0.327	0.435	0.510	0.563	0.687
2001	0.030	0.059	0.129	0.240	0.306	0.354	0.450	0.477	0.560	0.679
2002	0.033	0.069	0.151	0.279	0.354	0.421	0.497	0.557	0.617	0.720
2003	0.039	0.075	0.159	0.306	0.395	0.446	0.550	0.613	0.687	0.730
2004	0.084	0.079	0.176	0.292	0.421	0.484	0.582	0.680	0.738	0.802
2005	0.086	0.083	0.197	0.306	0.443	0.504	0.611	0.705	0.785	0.758
2006	0.081	0.082	0.185	0.293	0.430	0.506	0.609	0.720	0.785	0.796
2007	0.099	0.125	0.257	0.373	0.508	0.573	0.676	0.764	0.817	0.796

Year	3	4	5	6	7	8	9	10	11	12
2008	0.118	0.180	0.332	0.452	0.573	0.647	0.725	0.803	0.836	0.823
2009	0.094	0.223	0.401	0.547	0.645	0.709	0.774	0.830	0.868	0.831
2010	0.096	0.236	0.425	0.597	0.682	0.744	0.810	0.867	0.890	0.905
2011	0.091	0.235	0.441	0.622	0.713	0.772	0.834	0.893	0.910	0.893
2012	0.082	0.217	0.413	0.589	0.694	0.752	0.823	0.869	0.894	0.917
2013	0.071	0.178	0.370	0.556	0.665	0.748	0.814	0.860	0.890	0.897
2014	0.055	0.147	0.338	0.524	0.638	0.729	0.800	0.845	0.877	0.877
2015	0.071	0.169	0.358	0.553	0.660	0.750	0.810	0.849	0.886	0.877
2016	0.085	0.204	0.378	0.570	0.685	0.768	0.831	0.857	0.901	0.877
2017	0.081	0.190	0.376	0.568	0.672	0.763	0.814	0.865	0.906	0.885
2018	0.075	0.186	0.360	0.546	0.654	0.726	0.796	0.853	0.886	0.881
2019	0.069	0.175	0.345	0.516	0.631	0.706	0.779	0.835	0.869	0.873
2020	0.057	0.164	0.339	0.508	0.629	0.706	0.782	0.841	0.862	0.878

Table 24.1.9: 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

Fishing year	Rec. TAC	National TAC	Catch
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	9082
2021/22	7805	7805	
2022/23	7587		

24.7 References

Carvalho, F., et al. “A cookbook for using model diagnostics in integrated stock assessments”. In: *Fisheries Research* 240 (2021), p. 105959.

Hoarau, G., et al. “Population structure of plaice (Pleuronectes platessa L.) in northern Europe: a comparison of resolving power between microsatellites and mitochondrial DNA data”. In: *Journal of Sea Research* 51.3-4 (2004), pp. 183–190.

Jónsson, G., & Pálsson, J. (2013). *Íslenskir fiskar* (2nd ed., p. 493). Mál og menning.

Le Moan, A., Bekkevold, D. and Hemmer-Hansen, J. (2021) “Evolution at two time frames: ancient structural variants involved in post-glacial divergence of the European plaice (Pleuronectes platessa)”. In: *Heredity* 126.4 (2021), pp. 668–683.

Pálsson, J., & Hjörleifsson, E. (2001). Skarkoli á fyrsta aldursári rannsakaður. *Hafrannsóknir*, *56*, 86–89.

Pálsson Ó. K., et al. “Brottkast og meðafli 2004 Mælingar á brottkasti botnfiska og meðafli í kolmunnaveiðum 2004”. In: *Hafrannsóknastofnunin. Fjölrit nr. 116* 116 (2004), pp. 3–35.

Pálsson Ó. K., et al. “Mælingar á brottkasti botnfiska 2006”. In: *Hafrannsóknastofnunin. Fjölrit nr.134* 134 (2007), pp. 2–18.

Sigurdsson, A. (1982). “Long distance migration of plaice (Pleuronectes platessa L.)” In: *Rit Fiskideildar* 4 (1982), pp. 27–31.

Sigurðsson, A. (1989). Skarkolamerkingar við Ísland árin 1953-1965. *Hafrannsóknir*, *39*, 5–24.

Solmundsson, J., Palsson, J., & Karlsson, H. (2005). Fidelity of mature Icelandic plaice () to spawning and feeding grounds. *ICES Journal of Marine Science*, *62*(2), 189–200.

Annex 1: List of participants

Northwestern Working Group 2–7 May 2022

Name	Institute	Country	Email
Anja Retzel	Greenland Institute for Natural Re-sources	Greenland	AnRe@natur.gl
Birkir Bardarson	Marine and Freshwater Research Insti-tute	Iceland	birkir.bardarson@hafogvatn.is
Bjarki Thor Elvarsson	Marine and Freshwater Research Insti-tute	Iceland	bjarki.elvarsson@hafogvatn.is
Einar Hjörleifsson	Marine and Freshwater Research Insti-tute	Iceland	einar.hjorleifsson@hafogvatn.is
Elzbieta Baranowska	Marine and Freshwater Research Insti-tute	Iceland	elzbieta.baranowska@hafogvatn.is
Frank Farsø Riget	Greenland Institute for Natural Re-sources	Greenland	frri@natur.gl
Helga Bára Mohr Vang	Faroe Marine Research Institute	Faroe Islands	helgab@hav.fo
Höskuldur Björnsson	Marine and Freshwater Research Insti-tute	Iceland	hoskuldur.bjornsson@hafogvatn.is
Jesper Boje	The National Institute of Aquatic Re-sources Sec- tion for Fisheries Advice	Denmark	jbo@aqua.dtu.dk
Julius Nielsen	Greenland Institute for Natural Re-sources	Greenland	juni@natur.gl
Karl-Michael Werner	Johann Heinrich von Thünen Institute, Institute for Sea Fisheries	Germany	karl-michael.werner@thuenen.de
Karolin Adorf	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries	Germany	kadorf@uni-bremen.de
Kristján Kristinsson	Marine and Freshwater Research Insti-tute	Iceland	kristjan.kristinsson@hafogvatn.is
Lísa Anne Libungan	Marine and Freshwater Research Insti-tute	Iceland	lisa.libungan@hafogvatn.is
Petur Steingrund	Faroe Marine Research Institute	Faroe Islands	peturs@hav.fo
Ruth Fernandez	ICES Secretariat	Denmark	ruth.fernandez@ices.dk
Søren Post	Greenland Institute for Natural Re-sources	Greenland	sopo@natur.gl
Tanja B Buch	Greenland Institute for Natural Re-sources	Greenland	tabb@natur.gl
Teunis Jansen (Chair)	Greenland Institute for Natural Re-sources and DTU AQUA	Greenland	tej@aqua.dtu.dk

Northwestern Working Group 24–27 October 2022

Name	Institute	Country	Email
Bjarki Thor Elvarsson	Marine and Freshwater Research Institute	Iceland	bjarki.elvarsson@hafogvatn.is
David Miller	ICES Secretariat		david.miller@ices.dk
Einar Hjörleifsson	Marine and Freshwater Research Institute	Iceland	einar.hjorleifsson@hafogvatn.is
Frank Farsø Riget	Greenland Institute for Natural Resources	Greenland	frri@natur.gl
Helga Bára Mohr Vang	Faroe Marine Research Institute	Faroe Islands	helgab@hav.fo
Höskuldur Björnsson	Marine and Freshwater Research Institute	Iceland	hoskuldur.bjornsson@hafogvatn.is
Luis Ridao Cruz	Faroe Marine Research Institute	Faroe Islands	Luisr@hav.fo
Petur Steingrund	Faroe Marine Research Institute	Faroe Islands	peturs@hav.fo
Rui Catarino	ICES Secretariat		rui.catarino@ices.dk
Tanja B Buch	Greenland Institute for Natural Resources	Greenland	tabb@natur.gl
Teunis Jansen (Chair)	Greenland Institute for Natural Resources and DTU AQUA	Greenland	tej@aqua.dtu.dk

Annex 2: Resolutions

NWWG – North-Western Working Group

2021/2/FRSG05 The **North-Western Working Group** (NWWG), chaired by Teunis Jansen, Denmark, will meet in ICES HQ, Copenhagen, Denmark 2–7 May 2022 to:

a) Address generic ToRs for Regional and Species Working Groups for all stocks, except stocks mentioned in ToRs c)
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 24-27 October 2022 to:

c) 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 2022 ICES data call.

NWWG will report by 19 May and 10 November 2022 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

WD01: The fishery for Greenland halibut in ICES Div. 14b in 2021. J. Boje

WD02: Greenland commercial data for Atlantic cod in Greenland inshore waters for 2021. Anja Retzel

WD03: West Greenland inshore survey results for Atlantic cod in 2021. Anja Retzel

WD04: SAM assessment of the West Greenland Inshore cod stock (cod.21.1). Tanja B. Buch, Frank Rigét and Anja Retzel

WD05: Greenland commercial data for Atlantic cod in East Greenland offshore waters for 2021. Anja Retzel

WD06: Cod East Greenland SAM assessment. Frank Rigét, Anja Retzel, Jesper Boje and Tanja B. Buch

WD07: Greenland commercial data for Atlantic cod in West Greenland offshore waters for 2021. Anja Retzel

WD08: The fishery for demersal Redfish (*S. mentella*) in ICES Div. 14b in 2021. Julius Nielsen

WD09: Greenland halibut CPUE for the research vessel operating on the slope on the Faroe Plateau in May-June 1995-2021. Petur Steingrund

WD10: Greenland halibut CPUE for commercial trawlers operating on the slope on the Faroe Plateau 1991-2021. Petur Steingrund

WD11: Mean length and length at age comparison for cod caught in German and Greenlandic surveys. Frederik Bjare

WD12: Note on age at length for genetically differentiated Greenland cod stocks. Frederik Bjare

WD13: DNA split of Atlantic cod (*Gadus morhua*) stocks in Greenland waters. An overview of data. Tanja B. Buch, Anja Retzel, Frank Rigét, Teunis Jansen, Jesper Boje, Casper Berg, Frederik Bjare

WD14: Bardarson, B., Jonsson, S., Bjarnason, S., Heilmann, L., and Jansen, T. Preliminary cruise report: Acoustic assessment of the Iceland-East Greenland-Jan Mayen capelin stock in autumn 2021 (Ad hoc). ICES Scientific Reports. 3:105. 10 pp. https://doi.org/10.17895/ices.pub.9244

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 content type Stock Annexes. Enter the stock code, year, ecoregion, species, and/or acronym of the relevant ICES expert group into the search box, and sort by Publication date to see the results. Follow the need help? link for searching tips.

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
ple.27.5a_SA	Plaice (*Pleuronectes platessa*) in Division 5.a (Iceland grounds)	May 2022	ple.27.5a_SA
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

Stock ID	Stock name	Last updated	Link
reb.2127.dp_SA	Deep Pelagic beaked redfish *(Sebastes mentella*) in ICES	May 2012	smn-dp_SA.pdf
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

Her.27.5a

Review of ICES Scientific Report, NWWG 2022 2-7 May.

Reviewers: Höskuldur Björnsson

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

General

The assessment of Icelandic herring is challenging due to variable spatial distribution, and in last 15 years Ichthyophonus epidemic. Surveys covering age one herring have not been conducted on regular enough basis to be used in the assessment but they might be useful. The assessment has shown considerable bias (overestimation) in last 30 years, but has been doing well in last 5 years and Mohns rho of ssb is -0.11. The management plan for herring was evaluated in 2017 and changed to a plan where the TAC next fishing year is based on B4+ in the beginning of the assessment year. The harvest rate is low to take into account observed bias and possible future infections. The form of the HCR is selected so the TAC does not require short term prediction of infection.

For single-stock summary sheet advice

Icelandic herring

Short description of the assessment as follows:

1. **Assessment type:** Update
2. **Assessment:** Accepted
3. **Forecast:** Accepted
4. **Assessment model:** NFT adapt.
5. **Consistency:** Good in last 5 years but over longer time period considerable bias.
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 for herring in order to provide long-term maximum sustainable yield and keep the SSB > Blim with high probability, even in periods of Ichthyophonus infection. The harvest rate according to the management plan is 0.14 and the reference biomass 4+.

Conclusions:

The assessment has been performed according to the stock annex. Some points requiring corrections were found in the report and the main assessor informed.

Cod.27.5a

Review of ICES Scientific Report, NWWG 2022 2-7 May.

Reviewers: Anja Retzel 17 May 2022

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

General

- The stock has been assessed in agreement with the stock annex.
- Mean weight at age in the catches for the assessment year needs to be predicted and are based on the spring survey weight measurement using the slope and the intercept from a linear relationship between survey and catch weights of ages 3-9 in preceding years. The result is high mean catch weight for age 3 and 4 because prediction for these age groups are also based on older age groups. At the NWWG a slightly altered method was presented where estimates of the slope and intercept were based on weight at age within each age group 3 to 9. NWWG concluded that this was an improvement, but due to the prospect of setting up an interim benchmark for this minor change the group decided to remain with the original predictions. Advice for the altered method would have deviated with -1%.

For single stock summary sheet advice:

8. **Assessment type:** update
9. **Assessment:** analytical
10. **Forecast:** presented
11. **Assessment model:**
    Separable statistical catch at age model (MUPPET) - 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.
12. **Data issues:** All data is available as described in the Stock Annex
13. **Consistency:** This is a highly consistent assessment.
14. Stock status: $SSB_{trigger}$ is 220 kt and SSB in 2022 is estimated at 356.697 kt. Reference biomass (B4+) was estimated at 976.590 t in 2022. Harvest rate in 2021 is 0.23. Hence the stock is well above limits and is fished at the management target.
15. **Management Plan:** The advice follows the outline defined in the management plan. Because SSB> $SSB_{trigger}$, the $TAC_{2022/2023}$ is set as ($TAC_{2021/2022}$ + 0.2*$B_{B4+,2022}$)/2. In accordance with this plan, the proposed TAC for 2022/23 is 209.028 kt.

General comments

This was a well-documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

None

Conclusions

The assessment has been performed in accordance with the Stock annex and the results can be used as basis for advice.

Reb.27.14b

Review of ICES Scientific Report, NWWG 2022 2-7 May.

Reviewers: Bjarki Þór Elvarsson

Expert group Chair: Teunis Jansen

General

Recommendations, general remarks for expert groups, etc. (use bullet points and subheadings if needed)

For single-stock summary sheet advice

Stock

Beaked redfish (*Sebastes mentella*) in Division 14.b, demersal (Southeast Greenland)

Short description of the assessment as follows:

1. **Assessment type:** Update assessment
2. **Assessment:** accepted
3. **Forecast:** not presented
4. **Assessment model:** DLS (cat 5), no recent survey data were presented
5. **Consistency:** Advice for 0 catch is consistent with previous advice.
6. **Stock status:** All signs suggest that the stock is in poor conditions and recent survey estimates are the lowest in the time series
7. **Management plan:** N/A

General comments

Survey information is generally lacking, a new survey is planned to start this year.

Technical comments

None

Conclusions

Cap.27.2a514

Review of ICES Scientific Report, NWWG, 2022, 2-7 May.

Reviewer: Lísa Anne Libungan

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez, Jette Fredslund

Stock

Capelin in the Iceland-East Greenland area

General

None

For single-stock summary sheet advice

No advice sheet. Preliminary advice in autumn, final advice outside ICES umbrella and issued by the Marine and Freshwater Research Institute (MFRI) in Iceland.

General comments

Comments were added to the technical report and stock assessor was informed.

Technical comments

None

Conclusions

The assessment is expected to be performed correctly and since the final advice is outside ICES review procedure no further scrutinization can be performed in this assessment.

Had.27.5a

Review of ICES Scientific Report, NWWG, 2022, 2-7 May.

Reviewers: Tanja Buch

Expert group Chair: Teunis Jansen

Secretariat representative: Jette Fredslund, Ruth Fernandez

General

- The stock underwent a benchmark in 2019 and at the same meeting management strategy evaluation were carried out, which resulted in new reference points.
- There was reduced sampling effort for the commercial fisheries in 2020 due to the COVID outbreak. In 2021 more sampling were carried out but not at the same level as prior to 2020. 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

Stock: Haddock in Division 5.a (Iceland ground).

Short description of the assessment as follows:

1. **Assessment type:** Category 1, Statistical catch-at-age model.
2. **Assessment:** accepted
3. **Forecast:** accepted
4. **Assessment model:** Muppet (Statistical catch-at-age model). Using catch-at-age and two survey indices for tuning.
5. **Consistency:** The model from the 2019 benchmark have been used in 2019-2022. 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.
6. **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}.
7. **Management plan:** Management plan is consistent with both precautionary approach and the ICES MSY approach. The advice follows the management plan, the advice for 2021/2022 is 62219 tonnes which is an increase from the three 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 1.9.2022 to 30.8.23.
- The TAC for the 2020/2021 fishing year was increased by 8000t by the Government of Iceland, this increase has been subtracted from the 2021/2022 TAC. This, combined with transfer from other species, means that the 2020/2021 landings were well above the set TAC for the period.

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.

Pok.27.5a

Review of ICES Scientific Report, NWWG, 2022, 2-7 May.

Reviewers: Petur Steingrund/Helga Bára Mohr Vang

Expert group Chair: Teunis Jansen

Secretariat representative: Ruth Fernandez

General

The assessment of Icelandic saithe has its challenges and is relatively uncertain, this year's assessment results in a considerable downward revision of the SSB, Mohn Rho = 25%. This is mostly due to uncertainty in survey indices, caused by saithe's schooling behaviour and being semi-pelagic. The indices in 2022 are low but comparable with indices the most recent years and it can be speculated that the assessment model is somehow slow to react to the indices. It may be expected that the model now has caught up with the tendency in the indices as judged by the catch residuals and survey residuals (they are not so negative/positive compared with other years).

The management plan is though designed to include these uncertainties. The stock status is good, it has been above all reference points since beginning of assessment. However, the fleet has for many years not fished the whole TAC and this could though indicate that the stock size is overestimated. Despite that, Icelandic saithe is not considered threatened by overfishing, partly due to a low market price and high cost to catch it.

For single-stock summary sheet advice

Stock: Icelandic saithe

Short description of the assessment as follows:

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.

Conclusions:

The assessment has been performed according to the stock annex.

Sai.5b

Review of ICES Scientific Report, NWWG, 2022, 24. October 2022 – 27 October 2022

Reviewers: Tanja Buch

Expert group Chair: Teunis Jansen

Secretariat representative: Rui Catarino

General

An interbenchmark IBPFAR was carried out prior to the NWWG meeting. NWWG recommend following the IBPFAR recommendations, using a category 1 approach for this advice. However, a category 3 advice where also prepared at the meeting. This audit focusses mainly on the category 1 approach.

For single-stock summary sheet advice

Stock: Faroes Saithe pok.5b
Short description of the assessment as follows (examples in grey text):

1. **Assessment type:** update based on interbenchmark IBPFAR settings
2. **Assessment:** accepted
3. Forecast: accepted
4. **Assessment model:** SAM - tuning by one comm + two surveys (name: fsaithe-NWWG-2022)
5. **Consistency:** last year's assessment had issues with mohn's rho (33% for SSB), therefore an interbenchmark was proposed with the goal on including interim catch at age data. The remaining SAM set up was the same. The changes improved mohn's rho (23%). The pattern of overestimating SSB remains, however all peels are within the confidence interval.
6. **Stock status:** F<Fmsy in recent years after a period of being above Fmsy. B>Blim, recruitment at a low level, but generally fluctuation.
7. **Management plan:** Implemented in 2021 by Faroes authorities, with a control rule that regulates the number of fishing days for cod, haddock, and saithe in the Faroe Plateau fishery. The management plan has not been evaluated by ICES and therefore ICES bases its advice on the MSY approach.

General comments

The addition of interim catch-at-age in the SAM model improved the retrospective bias. The retrospective bias for the SSB is still borderline (23%), however all peels were within the confidence limits. The group agreed that it was preferred to use the SAM model rather than downgrading to a category 3 approach, as more data is incorporated in this approach.

The recruitment is estimated at the lowest level in the time series.

Advice based on category 3 approach (rfb rule) were also prepared, given that the mohn's rho for SSB is just above what is recommended by ICES. The Faroese summer survey was used as biomass index. For this scenario F is above the Fmsy proxy and stock size index is below MSY Btrigger proxy.

Technical comments

During the IBPFAR interim catch-at-age were estimated based on a regression analysis of half-year data and final catch data for previous years. The predicted total catch was then distributed into catch-at-age based on fractions from the first part of the year. This approach adds uncertainty to the estimates, and this was accounted for by doubling observation variance of the last year's catches.

Poor internal consistency for ages below age 5 in the survey.

New reference points were estimated using eqSim and the same settings as for previous reference points, the only difference being that the reference period was 10 years whereas before it was 5 years.

Conclusions

The assessment was conducted based on what was agreed at the interbenchmark. It is recommended to use the category 1 approach for giving advice.

Further improvements can be made during a full benchmark in the future when more analyses are ready.

The final report sections and stock annex were not available at the time of the review.

Faroe haddock

Data of catch of age and length distribution were presented. Catches has increased in recent years, recruitment is on a low level, F is close to Fmsy and SSB has increased in recent years and is above MSY trigger. Using the MSY approach the catches in 2023 should be no more than 13.000 t corresponding to a 50% increase compared to last year advice. A concern of the assessment was that there was no sampling from the open boats, which constitute above 50% of the total catch, which likely have another catch composition than longliners and trawlers.

Frank Farsø Riget.