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H.C. Andersens Boulevard 44-46<br>DK-1553 Copenhagen V<br>Denmark<br>Telephone (+45) 33386700<br>Telefax (+45) 33934215<br>www.ices.dk<br>info@ices.dk

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## Editor

Teunis Jansen


#### Abstract

Authors

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


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## 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 904200 tonnes based on an acoustic survey in September.

In November 2021, ICES advised an initial quota of 400000 tonnes for the fishing season 2022/2023.

In February 2022, MFRI advised a final TAC of $869600 t$ 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 689000 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 $\mathrm{F}_{\text {msy }}$ ( 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 ( $>15000 \mathrm{t}$ ). 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 13500 tonnes in 2021. TAC in 2021 and 2022 is reduced to 21000 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 ( $\mathrm{F}_{5-10}$ ) was below $\mathrm{F}_{\text {MSY }}(0.29)$ since 1994 and was low until 2010 where F gradually increased. Since 2019 F is above FmSY. SSB has been declining since 2014 but is still above MSY $B_{\text {trigger }}$ (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 $35^{\circ} 15 \mathrm{~W}$ ) and the remaining part. TAC in the Dohrn bank management area is set at 20000 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 27430 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 56333 tonnes or $72 \%$ of the TAC of 78574 . 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 71300 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 $4+$ ( $B_{R e f}$ ) is 441.3 kt in the beginning of the year 2022. As the SSB will be above MGT $\mathrm{B}_{\text {trigger }}=200 \mathrm{kt}$, the catches in 2022/23 according to the Icelandic Management Plan would be $H R$ mgт $\times B_{\text {Ref }}=0.15 \times 441299$ tonnes $=66195$ 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 43426 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 $\mathrm{F}_{9-19}=0.097$ that is reduced linearly if the spawning stock is estimated below 220000 tonnes ( $\mathrm{B}_{\text {trigger) }}$. Blim is set at 160000 tonnes, lowest SSB in the 2012 run. The 2022 SSB was estimated at 220056 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 10588 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 ( $<18 \mathrm{~cm}$ ) 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 23802 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 BMSY. Fishing mortality has since 2013 been close and above $\mathrm{F}_{\text {MSY }}$ but is in 2021 below $\mathrm{F}_{\text {MSY }}$ ( $94 \%$ of $\mathrm{F}_{\text {MSY }}$ ). 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 $14 . \mathrm{b}$ 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 14500 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 ( $<20 \mathrm{~cm}$ ) 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, venue tbd, xx 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 $5^{\circ} \mathrm{W}$, 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 Fbar, 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 | Fbar | SSB | Recr |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Inshore West Greenland cod | cod.21.1 | 2020 | 5 | -0.024 | -0.166 | -0.483 |
| East Greenland, South <br> 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 <br> 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.

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.

## 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 ${ }_{\text {trigger }}$ was decreased from 65 to 61 thous. tonnes to be in line with ICES MSY Btrigger. Other reference points were unchanged except $H_{R}{ }_{\lim }$ and $H R_{\text {pa. }}$ were introduced to replace $\mathrm{F}_{\text {lim }}$ and $\mathrm{F}_{\mathrm{pa}}$.

### 8.2 Fisheries-dependent data

Landings of saithe in Icelandic waters in 2021 are estimated to have been 59774 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, 53248 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 $20^{\text {th }}$ 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.

$$
\begin{gathered}
C=T^{\gamma} \times \delta_{\text {year }} \\
C=T^{\gamma} \times \delta_{\text {year }} \delta_{\text {freeze }}
\end{gathered}
$$

Where C is catch of saithe, T hours trawled. $\delta_{y e a r}$ is an estimated year factor $\delta_{\text {freeze }}$ a factor indicating if the catch is frozen aboard the vessel. $\gamma$ 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 $\mathbf{y} / \mathbf{y} \mathbf{+ 1}$ is from September $1^{\text {st }}$ in the year $\mathbf{y}$ to August $31^{\text {st }}$ in year $\mathbf{y} \mathbf{+ 1}$. Assessment done in the spring of year $\mathbf{y}$, is used to give advice for the fishing year starting September $1^{\text {st }}$ 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 codequivalence 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 $\sim 90 \%$ 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 $\left(W=0.02498{ }^{*} L^{\wedge} 2.75674\right)$ 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 $2 / 3^{\text {rd }}$ 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 34 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 $\epsilon$ is a number that should avoid giving low values too much weight as they do in log-log fit. Typical value of $\epsilon$ 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 $\mathrm{Z} \sim 0.5$ 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 forwardprojecting 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 $\left(\frac{\log (I+\epsilon)}{\log (\hat{I}+\epsilon)}\right)$ 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 Bloss.

### 8.5 Reference points and HCR

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

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

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

$$
\text { If } S S B_{y} \geq M G M T B_{\text {trigger }}
$$

$$
\operatorname{Tac}_{y / y+1}=\frac{T a c_{y-1 / y}+0.2 \times B_{4+, y}}{2}
$$

If $S S B_{y} \leq M G M T B_{\text {trigger }}$

$$
\begin{gathered}
\operatorname{Tac}_{y / y+1}=\alpha \times \operatorname{Tac}_{y-1 / y}+(1-\alpha) \times \frac{S S B_{y}}{M G M T B_{\text {trigger }}} \times 0.2 \times B_{4+, y} \\
\alpha=0.5 \times \frac{S S B_{y}}{M G M T B_{\text {trigger }}}
\end{gathered}
$$

Where $T a c_{y / y+1}$ 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 $S S B$ changes from $M G M T B_{\text {trigger }}$ to 0 .
Reference points were also re-evaluated at WKICEMSE 2019 (See table below and ICES, 2019a). $B_{\text {lim, }} B_{\text {pa, }}$ MSY Btrigger, HRmsy and HRMgt were unchanged, MGMT Btrigger changed from 65 to 61 thous. tonnes and $H R R l i m_{\lim }$ and $\mathrm{HR}_{\mathrm{pa}}$ were defined but earlier $\mathrm{F}_{\mathrm{lim}}$ and $\mathrm{F}_{\mathrm{pa}}$ had been defined.

| Item | B $_{\text {lim }}$ | $\mathbf{B}_{\text {pa }}$ | MSY $\boldsymbol{B}_{\text {trigger }}$ | MGT $\boldsymbol{B}_{\text {trigger }}$ | HR $_{\text {MSY }}$ | HR $_{\text {Mgt }}$ | HR $_{\text {lim }}$ | HR $_{\text {pa }}$ |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Value | 44 | 61 | $61 / 65$ | 61 | 0.2 | 0.2 | 0.36 | $0.26 / 0.25$ |
| Basis | $\mathrm{B}_{\text {loss }} / 1.4$ | $\mathrm{~B}_{\text {loss }}$ | $\mathrm{B}_{\text {pa }}$ | $\mathrm{B}_{\text {pa }}$ |  | Stochastic simulations. |  |  |

The recipe to evaluate MSY $B_{\text {trigger }}$ and $H R_{\text {pa }}$ 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 $\mathrm{HR}_{\mathrm{pa}}=0.25$.

### 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 1990 s but has since 2016 been below HR $\mathrm{Mgt}^{\text {target }}$ 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 $H R>H_{R g t}$ 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 $\overline{\log \left(\frac{B_{y, y}}{B_{y, a s s Y}}\right)}$ and CV as $\sigma^{\log \left(\frac{B_{y, y}}{B_{y, a s s Y}}\right)}$. 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 (20182022). 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, $\approx 17 \%$ reduction in estimate of B4+ between assessment years 2021 and 2022 and $\approx 30 \%$ 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 <br> $\mathbf{2 0 2 2}$ | Winchorised <br> survey | Adapt | LessWeight <br> on survey | Reweighed <br> survey CV | Ages 3-14 <br> in survey. | Survey <br> CV | Std settings <br> $\mathbf{2 0 2 1}$ | 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 springspawning 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 $\epsilon$ in survey residuals in $\left(\frac{\log (I+\epsilon)}{\log (\hat{I}+\epsilon)}\right)$ the number of aged saithe in the survey is 900 and the average total index around 20. Four otoliths do therefore correspond to $\epsilon=$ 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 $\epsilon$ must be exactly the same in the linked separable and VPA model. In principle the objective function for models using the same pattern of $\epsilon$ can be compared but if $\epsilon$ is different the comparison might be questionable.

When compiling the survey indices, relative standard error in the estimation of the indices is also compiled $C V_{s, y, a}=\frac{\sigma_{I_{y, a}}}{I_{y, a}}$ 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 $C V_{s, y, a}$ but add to that an estimated $C V$ by age called $C V_{2, a} C V_{s, y, a}=\frac{\sigma_{I_{y, a}}}{I_{y, a}} . C V_{t o t, y, a}=\sqrt{\left(C V_{s, y, a}^{2}+C V_{2, a}^{2}\right)}$.
$C V_{2, a}$ can here be estimated for each age group as $C V_{\text {tot,y,a}}$ is never going to be 0 .
Using this approach, the variance-covariance matrix (approximately $9 \times 9$ ) 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. $\epsilon=0.1$ for all age groups. Age 2 not included and pattern of CV by age in the survey re-estimated.
3. surveyCV. Model uses estimated $C V_{y, a}$ in survey as described above.
4. Ages3to14. $\epsilon=0.1$ 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

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

|  | belgium | faroes | france | germany | iceland | norway | uk (e/w/ni) | uk (scot) | uk | total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1980 | 980 | 4930 |  |  | 52436 | 1 |  |  |  | 58347 |
| 1981 | 532 | 3545 |  |  | 54921 | 3 |  |  |  | 59001 |
| 1982 | 201 | 3582 | 23 |  | 65124 | 1 |  |  |  | 68931 |
| 1983 | 224 | 2138 |  |  | 55904 |  |  |  |  | 58266 |
| 1984 | 269 | 2044 |  |  | 60406 |  |  |  |  | 62719 |
| 1985 | 158 | 1778 |  |  | 55135 | 1 | 29 |  |  | 57101 |
| 1986 | 218 | 2291 |  |  | 63867 |  |  |  |  | 66376 |
| 1987 | 217 | 2139 |  |  | 78175 |  |  |  |  | 80531 |
| 1988 | 268 | 2596 |  |  | 74383 |  |  |  |  | 77247 |
| 1989 | 369 | 2246 |  |  | 79796 |  |  |  |  | 82411 |
| 1990 | 190 | 2905 |  |  | 95032 |  |  |  |  | 98127 |
| 1991 | 236 | 2690 |  |  | 99811 |  |  |  |  | 102737 |
| 1992 | 195 | 1570 |  |  | 77832 |  |  |  |  | 79597 |
| 1993 | 104 | 1562 |  |  | 69982 |  |  |  |  | 71648 |
| 1994 | 30 | 975 |  | 1 | 63333 |  |  |  |  | 64339 |
| 1995 |  | 1161 |  | 1 | 47466 | 1 |  |  |  | 48629 |
| 1996 |  | 803 |  | 1 | 39297 |  |  |  |  | 40101 |
| 1997 |  | 716 |  |  | 36548 |  |  |  |  | 37264 |
| 1998 |  | 997 |  | 3 | 30531 |  |  |  |  | 31531 |
| 1999 |  | 700 |  | 2 | 30583 | 6 | 1 | 1 |  | 31293 |
| 2000 |  | 228 |  | 1 | 32914 | 1 | $2$ |  |  | 33146 |
| 2001 |  | 128 |  | 14 | 31854 | 44 | 23 |  |  | 32063 |
| 2002 |  | 366 |  | 6 | 41687 | 3 | $7$ | 2 |  | 42071 |
| 2003 |  | 143 |  | 56 | 51857 | 164 |  |  | 35 | 52255 |
| 2004 |  | 214 |  | 157 | 62614 | $1$ | $105$ |  |  | 63091 |
| 2005 |  | 322 |  | 224 | 67283 | 2 |  |  | 312 | 68143 |
| 2006 |  | 415 |  | 33 | 75197 | 2 |  |  | 16 | 75663 |
| 2007 |  | 392 |  |  | 64008 | 3 |  |  | 30 | 64433 |
| 2008 |  | 196 |  |  | 69992 | 2 |  |  |  | 70190 |
| 2009 |  | 269 |  |  | 61391 | 3 |  |  |  | 61663 |
| 2010 |  | 499 |  |  | 53772 | $1$ |  |  |  | 54272 |
| 2011 |  | 735 |  |  | 50386 | 2 |  |  |  | 51123 |
| 2012 |  | 940 |  |  | 50843 |  |  |  |  | 51783 |
| 2013 |  | 925 |  |  | 57077 |  |  |  |  | 58002 |
| 2014 |  | 746 |  |  | 45733 | $4$ |  |  |  | 46483 |
| 2015 |  | 499 |  |  | 47973 | 3 |  |  |  | 48473 |
| 2016 |  | 287 |  |  | 48920 | $5$ |  |  |  | 49212 |
| 2017 |  | 261 |  |  | 48786 | 4 |  |  | 4 | 49057 |
| 2018 |  | 270 |  |  | 65090 |  |  |  |  | 65360 |


|  | belgium | faroes | france | germany | iceland | norway | uk (e/w/ni) |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 2019 | 231 | uk (scot) | uk | total |  |  |  |
| 2020 | 188 | 64295 | 6 | 64532 |  |  |  |
| 2021 | 156 | 50058 | 6 | 50253 |  |  |  |

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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 2019 | 1292 | 1585 | 6325 | 2752 | 4543 | 693 | 675 | 339 | $\mathbf{2 4 2}$ | $\mathbf{2 3 1}$ |
| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
|  | $\mathbf{B 4 +}$ | ssb | N3 | hr | f4-9 |
| model | 0.2115 | 0.2384 | 0.2025 | -0.1675 | -0.2099 |
| Stdsettings | 0.1882 | 0.2475 | 0.1687 | -0.152 | -0.1945 |
| ChangedCVpattern | 0.2095 | 0.2615 | 0.2478 | -0.1672 | -0.2117 |
| SurveyCV | 0.1652 | 0.1913 | 0.1467 | -0.1356 | -0.1738 |
| Ages3to14 |  |  |  |  |  |

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 | Stdsettings | 0.095 | 0.231 | 0.128 |
| N3 | ChangedCVpattern | -0.272 | 0.362 | -0.192 |
| N3 | SurveyCV | -0.301 | 0.318 | -0.224 |
| N3 | Ages3to14 | -0.174 | 0.271 | -0.132 |
| N3 | Stdsettings | -0.37 | 0.313 | -0.277 |
| ssb | ChangedCVpattern | -0.091 | 0.269 | -0.057 |
| ssb | -0.043 | 0.343 | 0.011 |  |
| ssb | Ages3to14 | 0.135 | 0.328 | 0.133 |
| ssb |  | 0.322 | 01 |  |
|  |  | -0.189 | 0. |  |

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

| $\mathbf{2 0 2 2}$ |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :--- |
| B4+ | SSB | Fbar | Landings |  |  |  |
| 325 | 168 | 0.255 | 67.7 |  |  |  |
| $\mathbf{2 0 2 3}$ |  |  |  |  |  |  |
| B4+ | SSB | Fbar | 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 $\mathbf{2 0 0 0}$ (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 $\mathbf{k g}$ 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+.


Age 6 vs age $5 \mathrm{r} 2=0.46$


Age 8 vs age $7 \mathrm{r} 2=0.26$


Age 5 vs age 4 r2 $=0.29$


Age 7 vs age 6 r2 $=0.3$



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 $\mathrm{Z}=0.5$.


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 $\operatorname{SSB}_{\text {trigger }}(220 \mathrm{kt})$ the decision rule is:

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

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:

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

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 <br> catch in the first four months of the next fishing year (1 September-31 <br> 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 | $\mathbf{p}$ |
| :--- | :---: |
| 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 $2021(143 \mathrm{kt})$, the catch that is expected to be taken from 1 September to 31 December 2021 ( $70 \mathrm{kt}, 1 / 3 \mathrm{rd}$ 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 $(\beta)$ and the intercept $(\alpha)$ 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 $\alpha$ and $\beta$ were estimated from:

$$
c W_{a, y-1}=\alpha+\beta * s W_{a, y-1}
$$

and the catch weights for 2022 then from:

$$
c W_{a, y}=\alpha+\beta * s W_{a, y}
$$

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 $\alpha$ and $\beta$ within each age group 3 to 9 (Figure 3.4) was explored:

$$
c W_{a}=\alpha+\beta * s W_{a}
$$

The catch weight in the assessment year would then be predicted using "each age" $\alpha$ and $\beta$ 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 $B_{4+}=977 \mathrm{kt}$ vs alternative 959 kt ). A retrospective analysis, using the current estimates of the parameters $\alpha$ and $\beta$, indicated that the overall predictive power of the reference biomass was better (cv of 0.035 vs 0.050 , bias $-0.0020 \mathrm{vs}-0.0049$ ) 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 $B_{\text {trigger }}$ and $H R_{m s y}$ ) were set the same as in the HCR. Other (redundant) fishing pressure reference points were set based on the conventional F (i.e. $F_{l i m}$ and $F_{p a}$ ). In the 2021 benchmark there was a requirement that ICES $B_{\text {trigger }}$ 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 $B_{\text {trigger }}$ 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 $H R_{p a}$ (same would a apply to any $F_{p a}$ derivation), which according to the guidelines is defined based on using the $B_{\text {trigger }}(265 \mathrm{kt})$ in the simulation. The actual value became $H R_{p a}=0.39$. This value is higher than $H R_{\text {lim }}=0.35$, the reason being that the latter is derived in the absence of a $B_{\text {trigger }}$ (which was hence conveniently left undefined). On its own, a $H R_{p a}=0.39$ 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 $B_{\text {trigger }}=$ 265 kt 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 $\sim 0.30$.

### 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:

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

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 19552021.

| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathbf{2 0 0 3}$ | 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 ( $\mathbf{k g}$ ) in period the 1955-2022. These weights are used to calculate the spawning stock biomass (SSB).

| year | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathbf{1 9 5 5}$ | 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 |
|  |  |  |  |  |  |  |  | 1 | 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 ( $B 4+, k t$ ), spawning stock biomass ( $k t$ ) 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 , ( $<55 \mathrm{~cm}$, top left) and biomass indices of 55 cm and larger ( $>55 \mathrm{~cm}$, 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 57599 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 $60 \mathrm{~cm}^{+}$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 $60 \mathrm{~cm}^{+}$the index of age $11^{+}$higher than seen before in March survey. This is assumed to be related to lower fishing mortality after the establishment of a management plan for haddock in 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:

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

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 $\rho$ 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 $45 \mathrm{~cm}^{+}$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:

$$
\log \left(\frac{W_{a+1, y+1}}{W_{a, y}}\right)=\alpha+\beta \log \left(W_{a, y 0}\right)+\delta_{y}
$$

where according to the stock annex the factor $\delta_{y}$ 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 $45 \mathrm{~cm}^{+}$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 2020year 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

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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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 <br> Trawl | Nr. Danish <br> Seine | Nr. Long <br> Line | Bottom <br> Trawl | Other | Danish <br> 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 <br> Trawl | Nr. Danish <br> Seine | Nr. Long <br> Line | Bottom <br> Trawl | Other | Danish <br> 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 $(\geq 27 \mathrm{~cm})$ 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 Minfected) died annually in the first three years of the outbreak $\left(\mathrm{M}_{\text {year, age }}=\mathrm{M}_{\text {fixed }}+\mathrm{Minfected}, \mathrm{year} \mathrm{age} \times\right.$,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 Minfected (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 70084 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 $25 \%(18 \mathrm{kt})$ of the catch was taken in Septem-ber-October in the east and the final $1 \%(1 \mathrm{kt})$ as bycatch in the fishery also in the east in JuneAugust (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 ( $\sim 90 \%$ ) 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 $26-29 \mathrm{~cm}$.

### 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 $\sim 2000$ 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; Oskarsson et al., 2010), while the positive block during 2000-2004 was previously found to be mainly caused by the large 1999year 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 $4+\left(B_{R e f}\right)$ is 441.3 kt in the beginning of the year 2022. As the SSB will be above MGT $B_{\text {trigger }}=200 \mathrm{kt}$, the advised TAC according to the Iceland Management Plan is $H R_{M G T} \times B_{R e f}=0.15 \times 441299=66195$ 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 $\mathrm{F}_{0.1}=\mathrm{F}_{\text {MSY }}=0.22$ 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 Blim $=200$ 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 $B_{l i m}$ and these data in accordance to the ICES Advice Technical Guidelines and became these: $\mathrm{B}_{\mathrm{pa}}=273 \mathrm{kt}\left(\mathrm{B}_{\mathrm{pa}}=\mathrm{B}_{\lim } \times \mathrm{e}^{1.645 \sigma}\right.$, where $\left.\sigma=0.19\right)$; $\mathrm{F}_{\lim }=$
 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 $\mathrm{F}_{0.1}=0.22$ could be a valid candidate for $\mathrm{F}_{\text {MSY. }}$. During a Management Strategy Evaluation (MSE) for the stock in April 2017 (ICES, 2017b), FMSY $=0.22$ was not considered to be significantly different from results of simulation giving 0.24. Thus, it was concluded adequate to keep $\mathrm{F}_{\mathrm{MSY}}=0.22$.

## 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 ( $\mathrm{FMGT}=0.22$ ), 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 ( $B_{r e f, ~}$ Y), a spawning stock biomass trigger (MGT $B_{\text {trigger }}$ ) is defined as 200 kt , and the harvest rate (HRмgт) 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 $\mathrm{Y}+1$ ) is calculated as follows:

When SSBy is equal or above MGT Btriger:
TACy/y+1 $=$ HRмqт $^{*}$ Bref,$y$
When SSBy is below MGT $B_{\text {trigger: }}$
$\mathrm{TACy}_{\text {/y }+1}=$ HRMGT $^{*}\left(\right.$ SSBy $\left._{y} / \mathrm{MGT} \mathrm{B}_{\text {trigger }}\right){ }^{*} \mathrm{~B}_{\text {ref }, \mathrm{y}}$
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 NFTAdapt 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: $\operatorname{SSB}(2022)=421.1 \mathrm{kt}$; Biomass age 4+ $\left(1\right.$ January 2022) $=441.3 \mathrm{kt}$; Catch $(2021 / 22)=70.1 \mathrm{kt} ; \mathrm{WF}_{5-10}(2021)=0.288 ; \mathrm{HCR}(2021)=0.15$.

### 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 421132 kt , which is above MGT Btrigger of 200 kt . Consequently, advised TAC on basis of the Management rule is $0.15 \times$ Biomass $4+(441299 \mathrm{kt})=66195 \mathrm{kt}$. This results in $\mathrm{F}_{\mathrm{W}-10}=0.202$ in 2022/23 and SSB $=403999 \mathrm{kt}$ 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 (Minfected, 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 2018year 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

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### 11.18 Tables

Table 11.1.1.1. Icelandic summer-spawning herring. Acoustic estimates (in millions) in the winters 1973/74-2021/22 (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.

| Year/age | Number of scales |  |  |  |  |  |  |  |  |  |  |  |  |  |  | N of samples |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15+ | Total | $\begin{aligned} & \text { To- } \\ & \text { tal } \end{aligned}$ | 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 $\ddagger$ | 42 | 266 | 554 | 273 | 220 | 252 | 198 | 165 | 126 | 114 | 69 | 61 | 12 | 2 | 2370 | 60 | 55 | 5 |



* No survey $\ddagger$ 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 agelength key.

Table 11.2.1. Icelandic summer spawners. Landings, catches, recommended TACs, and set National TACs in thousand tonnes.

| Year | Landings | Catches | Recom. <br> TACs | Nat. <br> TACs | Year | Landings | Catches | Recom. TACs | Nat. <br> 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 ${ }^{\ddagger}$ | 49.4 | 49.4 | 40 | 45 |
| 1977 | 28.925 | 28.925 |  |  | 2012/2013 ${ }^{\ddagger}$ | 72.0 | 72.0 | 67 | 68.5 |
| 1978 | 37.333 | 37.333 |  |  | 2013/2014 ${ }^{\ddagger}$ | 72.0 | 72.0 | 87 | 87 |
| 1979 | 45.072 | 45.072 |  |  | 2014/2015 ${ }^{\ddagger \S}$ | 95.0 | 95.0 | 83 | 83 |
| 1980 | 53.268 | 53.268 |  |  | 2015/2016 ${ }^{\ddagger}$ | 69.7 | 69.7 | 71 | 71 |
| 1981 | 39.544 | 39.544 |  |  | 2016/2017 ${ }^{\ddagger}$ | 60.4 | 60.4 | 63 | 63 |
| 1982 | 56.528 | 56.528 |  |  | 2017/2018 ${ }^{\ddagger}$ | 35.0 | 35.0 | 39 | 39 |
| 1983 | 58.867 | 58.867 |  |  | 2018/2019 ${ }^{\ddagger}$ | 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.
$\ddagger$ 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. | 7.009 | 5.481 | 1.045 | 0.438 | 0.296 | 0.134 | 0.092 | . 001 | . 001 | . 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 | 9.492 | 7.253 | 6.35 | 1.616 | 0.926 | 0.4 | . 01 | . 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 | 60.72 | 65.32 | 11.54 | 9.285 | 19. | 1.79 | 1.464 | 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 | 8.109 | 38.280 | 6.62 | 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 | . 100 | . 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 | 0.11 | 12.8 | 24.659 | 21.656 | 210 | 11.903 | 5.740 | 2.336 | 4.363 | 4.053 | 2.773 | 0.975 | . 480 | . 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 | 3.1 | 44.590 | 60.285 | . 62 | 19.751 | 46.240 | 15.232 | 13.963 | 10.179 | 13.216 | 6.224 | . 723 | 2.280 | 39 |
| 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 | 142.87 | 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 | 39.66 | 14.74 | 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 | 5.9 | 32.046 | 14.64 | 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 | . 539 | . 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 | 52.56 | 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 | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 2020 | 81 | 140 | 229 | 267 | 288 | 311 | 329 | 345 | 351 | 367 | 372 | 370 | 382 |
| 2021 | 90 | 154 | 212 | 253 | 272 | 296 | 314 | 325 | 337 | 356 | 352 | 361 | 372 |

Table 11.2.2.3. Icelandic summer-spawning herring. Proportion mature at age (1981 refers to season 1981/1982 etc.).

| Yearlage | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3}$ | $\mathbf{1 4}$ | $\mathbf{1 5 +}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 1982 | 0 | 0.03 | 0.65 | 0.99 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1983 | 0 | 0 | 0.05 | 0.85 | 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | 13 | 14 | 15 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $1987-2008$ | 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 |
| $2009^{*}$ | 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 |
| $2010^{*}$ | 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 |
| $2011^{*}$ | 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 |
| $2012-2016$ | 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| $2022^{* *}$ | 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 |  |  |  |  |  |  |  |  |  |  |  |  |  |

[^1]Table 11.3.2.2. Model settings and results of model parameters from the final NFT-Adapt run in $\mathbf{2 0 2 2}$ 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
$4 \quad 671014.455 \quad 0.339944 \mathrm{E}+06 \quad 0.506613 \mathrm{E}+00$
$5 \quad 509204.179 \quad 0.195627 \mathrm{E}+06 \quad 0.384181 \mathrm{E}+00$
$6 \quad 157671.665 \quad 0.532277 \mathrm{E}+05 \quad 0.337586 \mathrm{E}+00$
$\begin{array}{lllll}7 & 82271.990 & 0.281588 \mathrm{E}+05 & 0.342264 \mathrm{E}+00\end{array}$
$8 \quad 32656.999 \quad 0.113016 \mathrm{E}+05 \quad 0.346068 \mathrm{E}+00$
$9 \quad 56923.876 \quad 0.175491 \mathrm{E}+05 \quad 0.308290 \mathrm{E}+00$
$10 \quad 29574.628 \quad 0.902573 \mathrm{E}+04 \quad 0.305185 \mathrm{E}+00$
$11 \quad 27000.180 \quad 0.784834 \mathrm{E}+04 \quad 0.290677 \mathrm{E}+00$
$12 \quad 29431.270 \quad 0.921902 \mathrm{E}+04 \quad 0.313239 \mathrm{E}+00$

Catchability Values for Each Survey Used in Estimate
INDEX Catchability Std. Error CV

```
    0.976851E+00 0.996878E-01 0.102050E+00
    0.122127E+01 0.107875E+00 0.883301E-01
    0.131558E+01 0.745975E-01 0.567031E-01
    0.148712E+01 0.913680E-01 0.614394E-01
    0.163428E+01 0.126798E+00 0.775868E-01
    0.180057E+01 0.150146E+00 0.833882E-01
    0.191803E+01 0.200064E+00 0.104307E+00
    0.182053E+01 0.187039E+00 0.102739E+00
```

-- Non-Linear Least Squares Fit --
Maximum Marquadt Iterations $=100$
Scaled Gradient Tolerance $=6.055454 \mathrm{E}-05$
Scaled Step Tolerance $=1.000000 \mathrm{E}-18$
Relative Function Tolerance $=1.000000 \mathrm{E}-18$
Absolute Function Tolerance $=4.930381 \mathrm{E}-32$
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


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 1 Age | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ | $\mathbf{1 3 +}$ | 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 510.

| 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 |

[^2]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) | $\begin{aligned} & \text { SSB } \\ & \text { (kt) } \end{aligned}$ | Landings age 3+ (kt) | Yield/SSB | WF age $^{\text {5-10 }}$ | 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 <br> age 3 <br> (millions) | Biomass <br> age 3+ <br> (kt) | Biomass <br> age 4+ <br> (kt) | SSB <br> (kt) | Landings <br> age 3+ <br> (kt) | Yield/SSB | WF age 5-10 | 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 | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 NFTAdapt run.

| Age (year class) | Mean weights (kg) | M | Maturity ogive | Selection pattern | Mortality prop. before spawning |  | Number at age <br> 1 January 2021 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | F | M |  |
| 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 $\mathrm{M}_{\text {infection }}$ in 2022); Biomass age 4+ (1 January 2022) is 441.3 kt ; Catch (2021/22) 70.1 kt ; HR (2021) 0.19, and WF $\mathrm{F}_{5-10}(2021)$ 0.288.

| Rationale | Catches <br> (2022/2023) | Basis | F <br> $(2022 / 2023)$ | Biomass <br> of <br> age 4+ <br> (2023) | SSB <br> 2023 | \%SSB <br> change * | \% TAC <br> change ** |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Management <br> plan | 66.2 | $\mathrm{HR}=0.15$ | 0.202 | 423 | 404 | -4 | -8 |
| MSY approach | 72 | $\mathrm{~F}_{\mathrm{MSY}}=0.22$ | 0.220 | 417 | 399 | -5 | -1 |
| Zero catch | 0 | $\mathrm{~F}=0$ | 0 | 515 | 468 | 11 | -100 |
| $\mathrm{~F}_{\mathrm{pa}}$ | 128 | $\mathrm{~F}_{\mathrm{pa}}=0.43$ | 0.430 | 379 | 344 | -18 | 78 |
| Flim | $\mathrm{Flim}_{\mathrm{m}}=0.61$ | 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 southeast (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 19992017. 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 $\mathrm{Z}=\mathbf{0 . 4}$. 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 19892017. Grey lines correspond to $Z=0.4$.


Figure 11.3.2.1. Icelandic summer-spawning herring. The catchability ( $\pm \mathbf{2} \mathbf{~ S E}$; 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 $\mathbf{N}$ weighted $\mathrm{F}_{5-10}$ (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.


Year class

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 66195 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 $64^{\circ} 30^{\prime} \mathrm{N}$ towards about $75^{\circ} 15^{\prime} \mathrm{N}$, 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 $73^{\circ} 27$ 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 2894000 tonnes of which about 2447000 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 1834000 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 904200 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 404000 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 903600 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 105000 tonnes and 109000 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 400000 tonnes (ICES, 2020), but no summer fishery took place in 2021.

The intermediate TAC advice based on the autumn survey 2021 recommended TAC = 904200 tonnes (MFRI, 2021) and this advice was updated to a final quota of 869600 t in winter 2022 (MFRI, 2022). In total, 689000 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 150000 tonnes (= $\mathrm{Blim}_{\mathrm{lim}}$ ) 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 $1 \frac{1}{2}$ 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 150000 tonnes ( $=\mathrm{Bl}_{\mathrm{lim}}$ ) 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 400000 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 Blim of 150000 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 1833630 in September-October 2021 and 938700 tonnes in January - February 2022. The predation model (ICES, 2015), accounting for catches (in this case total catch of 689000 t ) and predation between surveys and spawning by cod, saithe and haddock, estimated that 699000 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 150000 tonnes was left for spawning. This was above Blim 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 400000 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 400000 t initial quota was advised and intermediate TAC was set to 904000 tonnes while final advice was 870000 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 $\mathrm{NW}-\mathrm{N}$ - 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 $14^{\circ} 30 \mathrm{~W}$ to $18^{\circ} \mathrm{W}$, 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.

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### 12.18 Tables

Table 12.2.1 Icelandic Capelin. Estimated stock size of the capelin total stock component in numbers (millions) by age (years) and length (cm), and biomass (thous. tonnes) from the acoustic survey in 6. September - 24. October 2021.

| Length (cm) | Numbers at Age (109) |  |  |  | Numbers (109) | Biomass ( $10^{3} \mathrm{t}$ ) | 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. $\mathbf{T}=$ Total, $\mathbf{S}=$ Stock, $\mathbf{N}=$ Numbers (billions), W = Weight(grams), L = Length(Cm), p=\%

|  |  | Age |  | Total | Mean |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 | 96.2579825 | 19 |

Table 12.2.2. Icelandic Capelin. Abundance of age-classes in numbers $\left(10^{9}\right)$ measured in acoustic surveys in autumn.

| Year | Month | Day | Age1 <br> Imm. | Age1 <br> Mat. | Age2 <br> Imm. | Age2 <br> Mat. | Age3 <br> Imm. | Age3 <br> Mat. | Age4 <br> Mat. | Age5 <br> 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 | Age1 | Age2 | Age2 | Age3 | Age3 | Age4 | Age5 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Imm. | Mat. | Imm. | Mat. | Imm. | Mat. | Mat. | 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 < 50000 t .
2011 - Only limited coverage of the traditional capelin distribution area. 2001-2009 and 2016-Not full coverage of stock.

Table 12.2.3. Icelandic Capelin. Mean weight (g) of age-classes measured in acoustic surveys in autumn. (imm = immature, mat = mature). See footnotes in Table 12.2.2.

| Year | Mon | Age1 | Age1 | Age2 | Age2 | Age3 | Age3 | Age4 | Age5 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Imm. | Mat. | Imm. | Mat. | Imm. | Mat. | Mat. | Mat. |
| 1978 | 10 |  |  |  | 19.8 |  | 25.4 | 26.3 |  |
| 1979 | 10 | 6.2 |  |  | 15.7 | 23.0 | 20.8 |  |  |
| 1980 | 10 | 7.3 |  |  | 19.4 | 26.7 |  |  |  |
| 1981 | 11 | 3.6 | 12.3 | 19.4 | 22.5 |  |  |  |  |
| 1982 | 10 | 3.8 | 8.5 | 16.5 | 24.1 |  |  |  |  |
| 1983 | 10 | 5.1 | 9.5 | 16.8 | 22.5 | 23.0 |  |  |  |
| 1984 | 11 | 2.9 | 8.3 | 15.8 | 25.7 | 23.2 |  |  |  |


| Year | Mon | Age1 | Age1 <br> Mat. |  | Age2 <br> Mat. |  | Age3 <br> Mat. | Age4 <br> Mat. | Age5 <br> Mat. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Imm. |  |  |  |  |  |  |  |
| 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 (109) |  |  |  | Numbers ( $\mathbf{1 0}^{\mathbf{9}}$ ) | Biomass ( $10^{3} \mathrm{t}$ ) | 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. $\mathrm{T}=$ Total, $\mathbf{S}=$ Stock, $\mathbf{N}=$ Numbers(billions), $\mathbf{W}=$ Weight(grams), $L=$ Length (Cm), $p=\%$

|  | Age |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 2 | 3 |  | Total | Mean |
| 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 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 (Jan-uary-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 |
| $1993 / 9^{1}$ | 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 | 2255 | 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 ${ }^{6}$ | 4005 | 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, 15000 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 (' $\mathbf{0 0 0} \mathrm{t}$ ) 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 $\mathbf{2}$ 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 ( $\mu \mathrm{g} \mathrm{l}-1$ ), 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 reasons) 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 $-2.0 \mathrm{~m} / \mathrm{sec}$, 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 (DecemberFebruary) 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-normol temperature conditions at Nuuk are linked to "high-index" years and hence indicate a nagative correlation of Nuuk winter air temperatures with the NAO. Correlation between both time sefries is significant ( $\mathrm{r}=-0.73, \mathrm{p} \ll 0.001$; Stein, 2004). This is seen for instance in 2009, 2010 and 2011 where air temperature anomalies at $\operatorname{Nuuk}(1.0 \mathrm{~K}, 4.8 \mathrm{~K}$ and 2.9 K$)$ 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. 19611990)


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 $<3.0 \mathrm{~m} / \mathrm{sec}$ ), 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 60 s 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 $72^{\circ} \mathrm{N}$ and north to Upernavik at 74.30 N , 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 $61-72^{\circ} \mathrm{N}$. 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 $64-72{ }^{\circ} \mathrm{N}$, with the main landings at $66^{\circ} \mathrm{N}$. Bycatch in this fishery is considered insignificant.

Snow crabs are caught in traps in areas $62-70^{\circ}$ N. 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 100000 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 450000 tonnes. The offshore stock collapsed in the late 1960searly 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 150000 tonnes. The stock decreased thereafter and is now at the low 1990 level with an advised TAC for 2015 of 60000 tonnes. The advised TAC for 2016 increased to 90000 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 15000 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 $20-60 \mathrm{~m}$. 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 35000 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 15800 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 1985year 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 $(40 \mathrm{~cm})$. 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. $\sim 70 \%$ ) 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 $68^{\circ} \mathrm{N}$ ). 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 30000 tonnes annually ( 15000 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 13000 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 32000 tonnes in 2015. Mackerel is known to feed on various species, including fish larvae, and it competes with others pelagic species, such as herring, for resources (Langøy et al., 2012). Thus, it might/can have a key role on the ecosystem of many commercial important species in Greenland.

### 13.2.11 Herring

A fishery for Norwegian spring-spawning herring in Greenland water has increased in recent years and in 2014 catches increased to 9000 tonnes. The herring has shifted distribution more west in recent years.

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## 14 Cod (Gadus morhua) in NAFO Subdivisions 1A-1E (Offshore West Greenland)

### 14.1 Stock definition


#### Abstract

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 1AE) 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 400000 tonnes annually in the 1960 s. 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 $66^{\circ} 15-66^{\circ} 30 \mathrm{~N}$, 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 ( $<25 \mathrm{~m}$ ) 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 $67^{\circ} \mathrm{N}$ 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 $72^{\circ} \mathrm{N}$ 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 ( $\mathrm{p}=0.32$ ). 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 15000 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 $<40 \mathrm{~cm}$, 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 $63^{\circ} \mathrm{N}, \mathrm{b}$ ) 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 26596 cod have been tagged in different regions of Greenland in the period of 20032020 (Table 14.5.1). Cod on two banks in West Greenland have been tagged; 2667 on Tovqussaq bank in NAFO division 1C and 6649 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.

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### 14.13 Tables

Table 14.2.1. Offshore catches ( t ) divided into NAFO divisions in West Greenland. 1924-1991: Horsted 2000, 2004-present: Greenland Fisheries License Control.
$\left.\begin{array}{llll}\text { Year } & \text { NAFO 1A NAFO 1B } & \text { NAFO 1C } & \text { NAFO 1D } \\ \text { NAFO 1E } \\ \text { 1F }\end{array}\right\}$

| Year | NAFO 1A | NAFO 1B | NAFO 1C | NAFO 1D | NAFO 1E | NAFO 1F | Unknown NAFO div. | NAFO 1A1E |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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. | $\begin{aligned} & \text { NAFO 1A- } \\ & \text { 1E } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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. | $\begin{aligned} & \text { NAFO 1A- } \\ & \text { 1E } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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 73000 t in 1977 and 1978, 1979: 99000 t , 1980: 54000 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 <br> To- <br> tal | $\%$ |  |  |  |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| $1 C$ |  |  |  |  |  | 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 |

Table 14.2.3.1. Cod in Greenland. Catch at age (' 000 ) and Weight at age ( $\mathbf{k g}$ ) 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 | 0.390 | 1.008 | 1.500 | 1.997 | 2.646 | 3.126 | 4.006 | 6.895 |
| 2019 |  |  |  |  |  |  |  | 4.259 |
| 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 | OA | 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 | OA | 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 |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | OA | 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. OA |  |  |  |  |  |  |  |  |  |  |  |
| 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.

| Year/age | 0 | 1 | 2 | 3 | WEST GREENLAND |  | 6 | 7 | 8 | 9 | 10+ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  | 4 | 5 |  |  |  |  |  |
| 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 | . | - | . | $\cdot$ | . | . | - |
| 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 | $\mathbf{2 0 2 0}$ | 2019 | $\mathbf{2 0 1 8}$ | $\mathbf{2 0 1 7}$ | $\mathbf{2 0 1 6}$ | $\mathbf{2 0 1 5}$ | 2014 | $\mathbf{2 0 1 3}$ | $\mathbf{2 0 1 2}$ | $\mathbf{2 0 1 1}$ | $<2010$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Age | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0 +}$ |
| Strat 1 <br> (NAFO 1C) | 49 | 78 | 128 | 787 | 500 | 215 | 51 | 20 | 51 | 131 |  |
| Strat 2 <br> (NAFO 1D) | 4 | 214 | 22 | 570 | 445 | 243 | 55 | 11 | 31 | 43 |  |
| Strat 3 <br> (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) <br> NAFO 1D+1E <br> Dana | East Greenland |
|  |  | NAFO 1C |  |  |
|  |  | Tovqussaq |  |  |
| 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) <br> NAFO 1C <br> Tovqussaq | Bank (West) <br> NAFO 1D+1E <br> Dana | East Greenland |
| Fjord (West) | 562 | 3 | 29 | 8 |
| Bank (West) |  | 1 |  | 4 |
| NAFO 1C, Tovqussaq |  |  |  |  |
| Bank (West) |  | 2 | 69 |  |
| NAFO 1D+1E, Dana |  |  |  |  |
| 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 $\mathbf{k m}^{2}$.


Figure 14.3.1.1. continued. Greenland shrimp and fish survey. Abundance per $\mathbf{k m}^{2}$. 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 $\mathbf{k m}^{2}$.


Figure 14.3.1.2. continued. Greenland shrimp and fish survey. Catch weight kg per $\mathrm{km}^{2}$. 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 $20^{\text {th }}$ century, and by 1960 it peaked at 35000 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 21000 tonnes. The 2021 catches were 13580 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 22000 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 ( $\mathrm{n}=484 \mathrm{cod}$ ). 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 ( $\mathrm{n}=3326 \mathrm{cod}$ ). 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 $1987(\mathrm{SE}=0.18)$, and 4.32 years $(\mathrm{SE}=0.04)$ 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 ( $74 \mathrm{cod} / 100 \mathrm{hr}$ ) 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 ( $397 \mathrm{cod} / 100 \mathrm{hr}$ ) and is above the time-series mean ( 236 cod/100hr).

In NAFO 1D the abundance index of age $2(46 \mathrm{cod} / 100 \mathrm{hr})$ increased whereas the index of age 3 $(20 \mathrm{cod} / 100 \mathrm{hr})$ 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 ( $318 \mathrm{cod} / 100 \mathrm{hr}$ ) and is above well above the time-series mean (119 $\operatorname{cod} / 100 \mathrm{hr}$ ). 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 202146 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 20052012 (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 WestGreenland 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 WestGreenland 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 EastGreenlandIceland 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, $\mathrm{F}_{\text {lim }}$ and $\mathrm{F}_{\mathrm{pa}}$ 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 21000 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 shortterm forecast. The forecast procedure starts from the last year's estimate of the state $(\log (N)$ and $\log (\mathrm{F}))$. 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: codWestInsNWWG2022, Buch et al., 2022a).

The forecasts from the different scenarios are presented in Table 15.7.3. Fishing at Fmsy 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 FMSY 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 (poundnet).

### 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.

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### 15.19 Tables

Table 15.2.1. Cod catches ( $t$ ) divided into NAFO divisions, caught in the inshore fishery (1911-1993: Horsted 2000, 19942006: 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 |

$\left.\begin{array}{lllllllll}\hline \text { NAFO divisions } & & \\ \hline \text { Year } & \text { 1A } & \text { 1B } & \text { 1C } & \text { 1D } & \text { 1E } & \text { 1F } & \begin{array}{l}\text { Unknown } \\ \text { NAFO div. }\end{array} & \begin{array}{c}\text { Total West } \\ \text { Greenland }\end{array} \\ \hline \text { ICES 14b }\end{array}\right]$

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\% |
| 1 C | 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 <br> Landed |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ |  |
| 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 <br> Landed |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ |  |
| 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 |
| :--- | :--- | :--- | :--- | :--- |


| 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. $\mathrm{Na}=$ 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 |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | 4 |  |  |  |  |  |
| 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. $\mathrm{Na}=$ Data not available.



| Year | Age NAFO 1B (Kangatsiaq) |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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 |



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. $\mathrm{Na}=$ 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 |
| $\begin{aligned} & 2016 \text { cod } \\ & \text { st. } \end{aligned}$ | 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.
\(\left.$$
\begin{array}{ccccc}\hline \text { Year } & \text { Fjord } & \begin{array}{c}\text { Bank (West) } \\
\text { NAFO 1C } \\
\text { Tovqussaq }\end{array} & \begin{array}{c}\text { TAGGED } \\
\text { Bank (West) } \\
\text { NAFO 1D + 1E } \\
\text { Dana }\end{array}
$$ <br>

\hline 2003 \& 599 \& \& \& East Greenland\end{array}\right]\)|  |
| :--- |
| 2004 |
| 2005 |

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.

|  | Fjord (West) | Bank (West) <br> NAFO 1C <br> Tovqussaq | Bank (West) <br> NAFO 1D + 1E <br> Dana | East Greenland |
| :--- | :---: | :---: | :---: | :---: |

Table 15.5.1: Reference points

| Framework | Reference point | Value | Technical basis | Source |
| :---: | :---: | :---: | :---: | :---: |
| MSY approach | MSY $\mathrm{B}_{\text {trigger }}$ | 5983 t | Assumed at $\mathrm{B}_{\mathrm{pa}}$ | ICES (2018a) |
|  | $\mathrm{F}_{\text {MSY }}$ | 0.27 | Stochastic simulations with segmented regression and a Beverton-Holt stock-recruitment curve from 1973 to 2018. | ICES (2018a) |
| Precautionary approach | $\mathrm{Blim}_{\text {l }}$ | 4346 t | Breakpoint in segmented regression | ICES (2018a) |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 5983 t | $\mathrm{B}_{\lim } \times \mathrm{e}^{1.645 \sigma}, \sigma=0.194$ | ICES (2018a) |
|  | $\mathrm{F}_{\text {lim }}$ | - | Not defined |  |
|  | $\mathrm{F}_{\mathrm{pa}}$ | - | Not defined |  |
| Management plan | $S_{S B}{ }_{\text {mgt }}$ | - | - |  |
|  | $\mathrm{F}_{\mathrm{mgt}}$ | - | - |  |

Table 15.7.1: Estimated number at age in the stock

| Year |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| / | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Age |  |  |  |  |  |  |  |  |  |  |
| 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 <br> / 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 <br> / <br> Age | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 2021 | 9146 | 15122 | 5556 | 12111 | 8596 | 3368 | 1985 | 450 | 182 | 60 |

Table 15.7.2: Estimated fishing mortality-at-age in the stock

| Year <br> Age | 12 | 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 |


| $\begin{aligned} & \text { Year } \\ & \text { Age } \end{aligned}$ | 12 | 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 | $\begin{aligned} & \text { Catch } \\ & \text { (2023) } \end{aligned}$ | $\begin{gathered} F \\ (2023) \end{gathered}$ | $\begin{gathered} \text { SSB } \\ (2024) \end{gathered}$ | $\begin{gathered} \text { \% SSB } \\ \text { change * } \end{gathered}$ | \% advice change ** | $\% \text { TAC }$ <br> change *** |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| ICES advice basis |  |  |  |  |  |  |
| MSY approach: $\mathrm{F}_{\text {MSY }}$ | 4590 | 0.268 | 24549 | +20\% | -4\% | -78\% |
| Other scenarios |  |  |  |  |  |  |
| $F=0$ | 0 | 0 | 30348 | +49\% | -100\% | -100\% |
| $\mathrm{F}=\mathrm{F}_{2020}$ (status quo) | 9913 | 0.755 | 18549 | -9\% | +107\% | -53\% |
| $\mathrm{SSB}_{2022}=\mathrm{Bl}_{\text {lim }}$ | 25408 | 12.992 | 4346 | -79\% | +410\% | +21\% |
| $S^{\text {S }} \mathrm{E}_{2022}=\mathrm{B}_{\mathrm{pa}}=$ MSY $\mathrm{B}_{\text {trigger }}$ | 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.

## Inshore CAA commercial fishery



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, $1 B$ 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 $\mathrm{F}_{4-8 \mathrm{~s}}$. 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 $\mathrm{F}_{4-8}$.

## 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 40000 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 26091 t . The TAC was divided between the following countries and management areas (se section 16.12 for definition of management areas):

| Management Area | TAC <br> (tonnes) | Country |
| :---: | :---: | :--- |
| Dohrn Bank | 20000 | Greenland (17 800 t), EU (1950 t), Norway (250 t) |
| South and East Greenland | 6091 | Greenland $(2691 \mathrm{t})$, Faeroes Island $(2500 \mathrm{t})$, Norway <br> $(1100 \mathrm{t})$ |

In 2021 a total of 25829 tonnes with 192 tonnes caught in SouthWest Greenland (NAFO 1F) and 25637 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 areain a small square between $65-66^{\circ} \mathrm{N} ; 29-31^{\circ} \mathrm{W}$ 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 $63-64^{\circ} \mathrm{N}$ ).

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 117000 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 $(\mathrm{M})$ 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 $\mathrm{B}_{\text {trigger. }}$ The $\mathrm{F}_{5-10}$ has increased since 2010 and is above the revised $\mathrm{F}_{\text {msy. }}$. 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 shortterm forecast. The forecast procedure starts from the last year's estimate of the state $(\log (N)$ and $\log (\mathrm{F})$ ). 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 $27430 t$ and we assumed that managers will keep the already set TAC rather than following the advice. However, catching 27430 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 $=$ $\mathrm{TAC}_{2022}(27430 \mathrm{t})$ 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, $\mathrm{F}_{510}$ and recruits. The retrospective runs show values of Mohn's rho ( $\mathrm{F}_{5-10} 0.149$ 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 27430 t . The following table shows the distribution of the TAC across management areas and countries.

| Area | TAC (tonnes) |
| :--- | :--- |
| Dohrn Bank | 20000 |
| 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 $27^{\prime} 00^{\circ} \mathrm{W}$ ), Dohrn Bank and South of Dohrn Bank. The management plan tries to take the scientific advice, migration between the Dohrn Bank region and Iceland and protection of spawning grounds into account. In order to protect the spawning stock, it is not allowed to fish from 1 March to 31 May in a square comprising Kleine Bank (shaded black in the figure below):


TAC is set by the following rules:

| Area | TAC (tonnes) |
| :--- | :---: |
| NorthEast Greenland east of $27^{\prime} 00^{\circ} \mathrm{W}$ | Free |
| Dohrn Bank | 20000 |
| 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.

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### 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 $1 \mathrm{~F}+\mathrm{ICES}$ 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 | 354771 | 180002 | 23455* |
| 1978 | 0 | 0 | 11856 | 2638 | 3715 | 549 | 345631 | 260002 | 27561* |
| 1979 | 0 | 16 | 6561 | 4042 | 1115 | 537 | 511391 | 340002 | 36775* |
| 1980 | 0 | 1800 | 2200 | 2117 | 1687 | 384 | 72411 | 120002 | 12724* |
| 1981 | 0 | 0 | 4289 | 4701 | 4508 | 255 | 0 | 160002 | 16255 |
| 1982 | 0 | 133 | 6143 | 10977 | 11222 | 692 | 1174 | 270002 | 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 73000 t in 1977 and 1978 , 1979 : 99000 $\mathrm{t}, 1980$ : 54000 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 $14 . \mathrm{b}+$ 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 |
| $\begin{gathered} \text { NAFO } 1 F+14 . b \\ (0.5 Q 6) \end{gathered}$ | 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 1 F .


| Year/Strata | ICES 14.b |  |  |  |  | NAFO |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | 1F |  |
| 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.

| Year | ICES 14.b |  |  |  |  |  | NAFO |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | 1F | Total | CV |
| 1992 |  |  |  |  |  |  |  |  |  |
| 1993 |  |  |  |  |  |  |  |  |  |
| 1994 |  |  |  |  |  |  |  |  |  |
| 1995 |  |  |  |  |  |  |  |  |  |
| 1996 |  |  |  |  |  |  |  |  |  |
| 1997 |  |  |  |  |  |  |  |  |  |
| 1998 |  |  |  |  |  |  |  |  |  |
| 1999 |  |  |  |  |  |  |  |  |  |
| 2000 |  |  |  |  |  |  |  |  |  |
| 2001 |  |  |  |  |  |  |  |  |  |
| 2002 |  |  |  |  |  |  |  |  |  |
| 2003 |  |  |  |  |  |  |  |  |  |
| 2004 |  |  |  |  |  |  |  |  |  |
| New survey Gear Introduced |  |  |  |  |  |  |  |  |  |
| 2005 |  |  |  |  |  |  |  |  |  |
| 2006 |  |  |  |  |  |  |  |  |  |


| Year | ICES 14.b |  |  |  |  |  | NAFO |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 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.

| Year | ICES 14.b |  |  |  |  |  | NAFO |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | 1F | Total | cv |
| 1992 |  |  |  |  |  |  |  |  |  |
| 1993 |  |  |  |  |  |  |  |  |  |
| 1994 |  |  |  |  |  |  |  |  |  |
| 1995 |  |  |  |  |  |  |  |  |  |
| 1996 |  |  |  |  |  |  |  |  |  |
| 1997 |  |  |  |  |  |  |  |  |  |
| 1998 |  |  |  |  |  |  |  |  |  |
| 1999 |  |  |  |  |  |  |  |  |  |
| 2000 |  |  |  |  |  |  |  |  |  |
| 2001 |  |  |  |  |  |  |  |  |  |
| 2002 |  |  |  |  |  |  |  |  |  |
| 2003 |  |  |  |  |  |  |  |  |  |
| 2004 |  |  |  |  |  |  |  |  |  |
| New survey Gear Introduced |  |  |  |  |  |  |  |  |  |
| 2005 |  |  |  |  |  |  |  |  |  |
| 2006 |  |  |  |  |  |  |  |  |  |
| 2007 |  |  |  |  |  |  |  |  |  |


| Year | ICES 14.b |  |  |  |  |  | NAFO |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | 1F | Total | CV |
| 2008 | 8692 | 2430 | 24101 | 1482 | 2173 | 8838 | 21236 | 68952 | 23 |
| 2009 | 10844 | 8874 | 27251 | 7827 | 252 | 3094 | 503 | 58645 | 28 |
| 2010 | 16014 | 3151 | 81064 | 6202 | 23 | 4203 | 3142 | 113799 | 51 |
| 2011 | 27064 | 8128 | 5561 | 12486 | 5235 | 22664 | 3280 | 84418 | 19 |
| 2012 | 24736 | 10058 | 9347 | 5802 | 160 | 14322 | 16213 | 80638 | 16 |
| 2013 | 45018 | 9639 | 15017 | 48518 | 977 | 40319 | 47818 | 207306 | 22 |
| 2014 | 17182 | 20637 | 15574 | 90795 | 734 | 8884 | 30754 | 184560 | 45 |
| 2015 | 33105 | 13803 | 27050 | 11609 | 513 | 18724 | 49931 | 154735 | 20 |
| 2016 | 40580 | 4831 | 33065 | 4841 | 426 | 5670 | 4671 | 94084 | 18 |
| 2017 | 45774 | 27405 | 18257 | 4777 | 1749 | 31635 | 7823 | 137420 | 41 |
| 2018 |  |  |  |  |  |  | 8498 |  |  |
| 2019 |  |  |  |  |  |  | 3841 |  |  |
| 2020 | 49921 | 2185 | 33763 | 584 | 262 | 5478 | 24780 | 116973 | 18 |
| 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 |  |  |  |  |  | rvey |  |  |  |  |  |
| 2019 |  |  |  |  |  | rvey |  |  |  |  |  |
| 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 |  |  |  | rvey |  |  |  |  |  |

Table 16.2.11 German survey. Numbers of valid hauls by stratum in South and East Greenland, stratum 9 furthest to the north.

| year | NAFO 1 F |  | ICES 14.b | Str 5.2 | Str 7.1 | Str 7.2 | Str 8.2 | Str 9.2 | Sum |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Str 4.1 | Str 4.2 | Str 5.1 |  |  |  |  |  |  |
| 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 |


| year | NAFO 1 F |  | ICES 14.b | Str 5.2 | Str 7.1 | Str 7.2 | Str 8.2 | Str 9.2 | Sum |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Str 4.1 | Str 4.2 | Str 5.1 |  |  |  |  |  |  |
| 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.

| Year | NAFO 1F |  | ICES 14.b | str5_2 | str7_1 | str7_2 | str8_2 | str9_2 | Sum | SD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | str4_1 | str4_2 | str5_1 |  |  |  |  |  |  |  |
| 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 |


| Year | NAFO 1F |  | ICES 14.b | str5_2 | str7_1 | str7_2 | str8_2 | str9_2 | Sum | SD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | str4_1 | str4_2 | str5_1 |  |  |  |  |  |  |  |
| 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.

| year | NAFO 1F |  | ICES 14.bstr5_1 | str5_2 | str7_1 | str7_2 | str8_2 | str9_2 | Sum | SD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | str4_1 | str4_2 |  |  |  |  |  |  |  |  |
| 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 |


| year | NAFO 1F |  | ICES 14.b | str5_2 | str7_1 | str7_2 | str8_2 | str9_2 | Sum | SD |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | str4_1 | str4_2 | str5_1 |  |  |  |  |  |  |  |
| 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 |  |  |  |  |  | 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 | $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 2018 |  |  |  |  |  |  |  |  | No survey |  |  |  |  |
| 2019 | 52 | $\cdot$ | $\cdot$ | 679 | 8296 | 2301 | 516 | 468 | 554 | 820 | 626 |  |  |
| 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 1 (Strat 4) and ICES 14.b, Strat 9 furthest to the north).

| year | stratum | index0 | index1 | index2 | index3 | index 4 | 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 $\mathrm{B}_{\text {trigger }}$ | 18146 | MSY $\mathrm{B}_{\text {trigger }}=\mathrm{B}_{\mathrm{pa}}$ |
|  | $\mathrm{F}_{\mathrm{MSY}}$ | 0.29 | Simulated (below $\mathrm{F}_{\mathrm{p} 05}$ ) |
| Precautionary approach | $\mathrm{Bl}_{\text {lim }}$ | 11738 | Mean of 2003, 2004, 2005 |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 18146 | $\begin{aligned} & \mathrm{Blim} * \exp (1.645 * \sigma), \sigma= \\ & 0.27 \end{aligned}$ |
|  | $\mathrm{Flim}^{\text {lim }}$ | 1.98 | F50 deterministic simulated |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.65 | $\begin{aligned} & \text { Flim } * \exp (-1.645 * \sigma), \sigma= \\ & 0.32 \end{aligned}$ |

Table 16.7.1. Estimated stock numbers at age.

| $\begin{aligned} & \text { Year } \\ & \text { Age } \end{aligned}$ | 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 <br> 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 <br> Age | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 <br> Age | 12 | 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 | 12 | 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 $=$ TAC2022 $^{(27430 t)}$

| Variable | Value |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{F}_{\text {ages 5-10 }}$ (2022) | 0.995 |  |  |  |  |  |
| SSB (2023) | 48317 |  |  |  |  |  |
| $\mathrm{R}_{\text {age } 1}(2022)$ | 7781 |  |  |  |  |  |
| Total catch (2022) | 27430 t |  |  |  |  |  |
| Rationale | $\begin{aligned} & \text { Catch } \\ & \text { (2023) } \end{aligned}$ | F (2023) | SSB (2024) | $\begin{gathered} \text { \% SSB } \\ \text { change * } \end{gathered}$ | \% advice change ** | \% TAC change *** |
| ICES advice basis |  |  |  |  |  |  |
| MSY approach: $\mathrm{F}_{\text {MSY }}$ | 8460 | 0.290 | 60722 | +26\% | -4\% | -69\% |
| Other scenarios |  |  |  |  |  |  |
| $\mathrm{F}=0$ | 0 | 0 | 76675 | +59\% | -100\% | -100\% |
| $\mathrm{F}=\mathrm{F}_{2022}$ (status quo) | 19782 | 0.995 | 45552 | -6 | +126\% | -28\% |

### 16.18 Figures



```
West offshore
- Nuuk
O East
Iceland inshore
```

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.

East CAA commercial fishery


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 nm². 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 23802 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 $14 . \mathrm{b}$ 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 5 a. Only minor catches in 5 a and 14 b are taken as bycatches 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 bycatches 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 19852021 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 ( $>1000 \mathrm{hp}$ ) 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 $450 \mathrm{~kg} / \mathrm{hr}$ trawling in 2016 a decrease is evident since then although still above time series average ( $330 \mathrm{~kg}(\mathrm{hr}$ ). 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 $14 . \mathrm{b}$ 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 $14 . \mathrm{b}$ 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 $E_{\mathrm{t}}$, and a combined trawl-survey biomass index ( 5 a and 14b) for 1996-2020, Isurt,. 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 $95 \% \mathrm{CI}$ 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 $\mathrm{K}(2 \times B$ 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, Bmš. Some rebuilding towards Bmsy 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 BMSY and has in recent years increased to about $80 \%$ of Bmsy. The median fishing mortality ratio ( $\mathrm{F} / \mathrm{F}_{\mathrm{MSY}}$ ) has exceeded Fmsy since the 1990 s, but has in recent years decreased and are in 2021 below Fmsy ( 0.94 , Figures 17.5.4-5 and Table 17.5.5- $^{2}$ 6 ). Relative fishing mortality can only be estimated with large uncertainty and the posteriors therefore also include values below Fmsy. However, the probability that F exceed Fmsy 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 25000 t based on agreed TACs for Iceland and Greenland EEZ and a continued catch level in Faroese waters.

Assuming catches of 25000 t in 2022, a fishery at $\mathrm{F}_{\text {MSY }}$ (F / $\mathrm{FmSY}_{\text {M }}=1$ ) in 2023 will lead to catches of 26710 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 Bmš 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 Btrigger ( $50 \%$ of $\mathrm{B}_{\mathrm{MSY}}$ ) and a fishery at Fmš is advised according the ICES MSY advice rule. Fishing at Fmsy 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 Fmsy. 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 agebased assessment models should be conducted.

### 17.9 References

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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 |  |
| Working Group estimate |  |

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 <br> Greenland |  |  |  |  |  |  |  |  |  |
| Iceland <br> Norway | 15,455 | 28,300 | 28,359 | 30,078 | 29,195 | 31,027 | 44,644 | 49,000 | 58,330 |
| Total |  |  | + | + | 2 |  |  |  |  |
| Working Group estimate | 15,780 | 28,969 | 28,392 | 30,124 | 29,197 | 31,027 | 44,659 | 49,379 | 59,049 |


| 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 | $2008^{1}$ | $2009^{1}$ | $2010^{1}$ | $2011^{1}$ | $2012^{1}$ | $2013^{1}$ | $2014^{1}$ | $2015^{1}$ | $2016^{1}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 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 |


| 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 |  |
| lceland | 11,926 | 15,214 | 12,390 | 12,535 | 12,837 |
| Norway |  |  |  |  | 158 |
| Russia |  |  |  |  |  |
| Poland | 15 |  |  |  |  |
| UK | 12,207 | 15,797 | 12,649 | 12,645 | 13,410 |
| Total |  |  |  |  |  |
| 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 | $\begin{array}{r} 2,105 \\ 3 \end{array}$ |  | $\begin{array}{r} 4,058 \\ 2 \end{array}$ | $\begin{array}{r} 5,163 \\ 1 \end{array}$ | $\begin{array}{r} 3,603 \\ 28 \end{array}$ | $\begin{array}{r} 6,004 \\ 29 \end{array}$ | $\begin{array}{r} 4,750 \\ 11 \end{array}$ | $\begin{array}{r} 3,660 \\ 8 \end{array}$ |
| 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 | 3 | 20 |  |  | 28 | 16 |
| Germany |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Iceland |  |  |  |  |  |  |  |  |  |  |  |  | 45 |  |
| Ireland |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Norway 1 |  | 1 |  | 5 |  |  |  |  |  |  |  | 3 | 10 | 8 |
| United Kingdom 32 |  | 117 |  | 336 |  | 11 |  |  |  | 2 | 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 | 20201 |  | 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 |  | 1.98 |  | 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 |
|  |  |  |  | - | - | - | - | - | 1 |


| 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 |  |  |

[^3]Includes 125 t by Faroe Islands and 206 t by Greenland.
Excluding 4732 t reported as area unknown.
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.
Does not include most of the Icelandic catch as those are included in WG estimate of Va.
Excluding 138 t reported as area unknown.

Table 17.1.5 GREENLAND HALBUT. Nominal landings (tonnes) by countries inSub-area 12, as officially reported to the ICES and estimated by WG.

| Country | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | $2003^{1}$ | $2004^{11}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| Faroe Islands |  | 47 |  |  | 1 |  | 40 |  |  |
| France |  |  |  |  | 1 | 49 |  | 4 | 30 |
| Ireland |  |  |  |  |  |  |  | 2 | 1 |
| Lithuania |  |  |  |  |  | 2 |  | 2 | 1 |
| Poland | 2 | 42 | 67 | 137 | 751 | 1338 | 28 | 730 | 1145 |
| Spain $^{2}$ |  |  |  |  | 7 | 5 |  |  |  |
| UK | 2 |  |  |  | 553 | 500 | 316 | 201 | 119 |
| Russia |  |  |  |  |  |  |  |  |  |
| Norway <br> Estonia | 4 | 89 | 67 | 137 | 1,312 | 1,894 | 384 | 939 | 1,296 |
| Total |  |  |  |  |  |  |  |  |  |
| 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- <br> nia |  | 2 | 3 | 566 |  |  |  | 97 |  |
| Poland |  |  |  |  |  |  |  |  |  |
| Spain ${ }^{2}$ | 501 |  |  |  |  |  |  |  |  |
| UK | 3 |  |  |  |  |  |  |  |  |
| Russia |  | 46 | 1 |  | 762 |  |  |  |  |
| Norway |  | 2 |  |  | 94 |  |  |  |  |
| Estonia |  |  |  |  |  |  |  |  |  |
| 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 <br> France Ire- <br> land Lithua- <br> nia Poland |  |  |  |  |  |  |  |  |
| Spain ${ }^{2}$ |  |  |  |  |  |  |  |  |

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.


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 |
|  |  | 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 | $\begin{array}{r} \text { Catch } \\ \text { (ktons) } \end{array}$ | CPUE (index) | $\begin{gathered} \begin{array}{c} \text { Survey } \\ \text { (ktons) } \end{array} \\ \hline \end{gathered}$ |
| :---: | :---: | :---: | :---: |
| 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 | $q_{\text {Ice }}$ | reference | $\ln \left(\mathrm{q}_{\text {Ice }}\right) \sim \operatorname{dunif}(-10,1)$ |
| Catchability Greenland survey | $q_{\text {Green }}$ | reference | $\ln \left(\mathrm{q}_{\text {Green }}\right) \sim \operatorname{dunif}(-10,1)$ |
| Catchability Iceland CPUE | $q_{\text {cpue }}$ | reference | $\ln \left(\mathrm{q}_{\text {cpue }}\right) \sim \operatorname{dunif}(-10,1)$ |
| Initial biomass ratio | $P_{1}$ | informative | dnorm(2,0.071) |
| Precision survey | $1 / s_{\text {surv }}{ }^{2}$ | low informative | dgamma $(2.5,0.03)$ |
| Precision Iceland CPUE | $1 / s_{\text {cpue }}{ }^{2}$ | 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 $\mathbf{2 5}, \mathbf{5 0}$, and 75 percentiles of the posterior distribution of selected parameters (symbols as in the text).

|  | Mean | sd | $25 \%$ | Median | $75 \%$ |
| :--- | :---: | :---: | :---: | :---: | :---: |
| $M S Y$ (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 |
| $q_{\text {cpue }}$ | 0.003 | 0.001 | 0.002 | 0.002 | 0.003 |
| $q_{\text {Survey }}$ | 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 |
| $s_{\text {cpue }}$ | 0.09 | 0.02 | 0.08 | 0.09 | 0.10 |
| $s_{\text {Survey }}$ | 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).

| Year | CPUE |  | Survey |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 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 $B_{\text {lim }}\left(0.3 B_{M S Y}\right)$ | $0 \%$ | $0 \%$ |
| Risk of falling below $B_{M S Y}$ | $100 \%$ | $79 \%$ |
| Risk of exceeding $F_{M S Y}$ | $43 \%$ | $44 \%$ |
| Risk of exceeding $F_{\text {lim }}\left(1.7 F_{M S Y}\right)$ | $7 \%$ | $9 \%$ |
| Stock size $(\mathrm{B} /$ Bmsy), median | 0.79 | 0.80 |
| Fishing mortality (F/Fmsy), | 0.94 | 0.93 |
| Productivity (\% of MSY) | $95 \%$ | $96 \%$ |

*Predicted catch in $2022=25$ ktons

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 <br> 25000 set eq to catches of <br> 2022 |
| Biomass $(2023)^{*}$ | 0.802 | ICES (2022) | B/B <br> F/FY |
| Total catch (2022) fishing at |  |  |  |
| F | 25000 | ICES (2022) | Based on TACs of Iceland, <br> Greenland, and assumed <br> catches from Faroe Islands. <br> Tonnes |


| Basis | Total catch (2023) <br> In 000 tonnes | $F_{\text {total }}(2023)$ <br> F/Fmsy | Biomass (2024) <br> B/Bmsy | Biomass change * | Advice change |
| :---: | :---: | :---: | :---: | :---: | :---: |
| ICES advice basis |  |  |  |  |  |
| MSY approach: $\mathrm{F}_{\text {MSY }}$ | 26.710 | 1 | 0.84 | 5\% | 0.23\% |
| Other options |  |  |  |  |  |
| $\mathrm{F}=0$ | 0 | 0 | 0.88 | 10\% | -100\% |
| $\mathrm{F}=\mathrm{F}_{2021}$ | 25.190 | 0.93 | 0.85 | 6\% | -5.48\% |
| $\mathrm{F}=\mathrm{F}_{\text {lim }}$ | 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.


Effort (hrs/nm2)
$\square(0,100]$

- $(100,200]$
(200, 300]
$-\quad(400,500$
(500, 60
$(600,700$

$(700,800$
$(800,900$
$\square(900,1000)$
(1000, 10000

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 5 a.



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\% Cl 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 14 b . $95 \% \mathrm{Cl}$ and observed CPUE (avg) indicated.
subdivision=14b1







14b
subdivision $=14 \mathrm{~b} 6$


Fig. 17.2.5. Standardised CPUE from trawler fleets in 14b shown by subdivisions in a north-south direction. 95\% Cl 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 $\mathbf{5 b}$.


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 ( $B / B_{m s y}$ ) and fishing mortality ( $F / F m s y$ )


Figure 17.5.4. Stock trajectory 1960-2021. Estimated annual median biomass-ratio (B/BMSY) and fishing mortality-ratio (F/FMSY). $\mathrm{B}_{\text {lim }}$, MSY $\mathrm{B}_{\text {trigger }}$ and $\mathrm{F}_{\text {lim }}$ are indicated.


Figure 17.5.5. Stock summary, upper panel right: fishing mortality (F/Fmsy) and 95\% conf limits, left: total biomass ( $B / B m s y$ ) and $95 \%$ conf limits and lower panel is landings since start of the fishery. MSY $B_{\text {triger }}$ (green dashed line), $B_{\text {lim }}$ and $\mathrm{F}_{\text {lim }}$ (blue dashed lines) are indicated.


Fig. 17.5.6 Estimated time series of relative biomass ( $B_{t} / B_{m s y}$ ) 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 $F_{m s y}$ or going below and $B_{M S Y t r i g g e r}$ 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 ( $F \geq$ 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, $14>500 \mathrm{~m}$ ) - primarily pelagic habitats, and including demersal habitats west of the Faeroe Islands;
- a 'Shallow Pelagic' stock (NAFO 1-2, ICES 5, 12, $14<500 \mathrm{~m}$ ) - 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);
- $\quad$ 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 autumnearly 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 multistage 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 $58^{\circ} \mathrm{N}, 40^{\circ} \mathrm{W}, 300 \mathrm{~m}, 34.89$ and $4.4^{\circ} \mathrm{C}$, respectively. The spatial distribution of S. mentella in the Irminger Sea mainly in waters $<500 \mathrm{~m}$ (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 $\left(>4.5^{\circ} \mathrm{C}\right.$ and $\left.>34.94\right)$ 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 $0-200 \mathrm{~m}$ 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 $60^{\circ} \mathrm{N}$ 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 ( $0-500 \mathrm{~m}$ ) 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$4.5^{\circ} \mathrm{C}$, 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 $150-250 \mathrm{~m}$. The landings of S. viviparus decreased from 1160 t in 1997 to $2-9 \mathrm{t}$ 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 $5 . \mathrm{b}$ 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 15000 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 $35-50 \mathrm{~cm}$ 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 $500 \mathrm{~kg} / \mathrm{hour}$ in 1991 to $300 \mathrm{~kg} /$ 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.

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### 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 $\mathbf{3}$ 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. ( $<17 \mathrm{~cm}$ ) 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 NM ${ }^{2}$ ). 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 ( $52^{\circ} \mathrm{N}$ $50^{\circ} \mathrm{W}$ ) 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 $4-11 \mathrm{~cm}$, 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 20002003 (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 (smr5614 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 Covid19 pandemic.

Relative abundance and biomass indices for golden redfish (fish $>17 \mathrm{~cm}$ ) 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 19.2.8a). 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 19.2.8c).

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 ( $<18 \mathrm{~cm}$, 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 130429 t in 1982 to 43515 t in 1994 (Table 19.3.1 and Figure 19.3.1). Since then, the annual landings of the stock have varied between 33451 t and 59698 t . The total landings in 2021 were 43426 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 97899 t in 1982 to 38669 t in 1994 (Table 19.3.1). Since then, landings have varied between 31686 t and 54041 t , highest in 2016. The annual landings since 2016 have decreased and were 39616 t in 2021, 1072 t less than in 2020. The landings for the 2020/2021 fishing year were $18 \%$ higher than allocated quota of 34379 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 tin 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 30962 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 $3532 \mathrm{t}, 573 \mathrm{t}$ 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 | 40688 | 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 ( $<35 \mathrm{~cm}$ ) 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 20072010 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 $19-54 \mathrm{~cm}$ 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.
- $\quad$ 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).
- $\quad$ 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.
- $\quad$ Recruitment was set at age 5 .

Estimated parameters are:

- Number of fishes when the simulation starts (8 parameters).
- $\quad$ Recruitment at age 5 each year ( 54 parameters).
- Length at recruitment (3 parameters).
- $\quad$ Parameters in the growth equation; (2 parameters).
- Parameter $\beta$ of the beta-binomial distribution controlling the spread of the length distribution.
- $\quad$ Selection pattern of the three commercial fleets assuming logistic selection (S-shape) (3x2 parameters).
- $\quad$ 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 $\mathrm{B}_{\text {trigger. }}$. 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 |
| Fbar | -0.0141 | -0.0442 |
| SSB | 0.00589 | 0.0231 |
| Recruitment | 0.704 | 0.268 |

The Mohn's rho values for $\mathrm{F}_{\mathrm{bar}}$ 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 ( $30-40 \mathrm{~cm}$ 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 $30-40 \mathrm{~cm}$ 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 $35-42 \mathrm{~cm}$ fish, the observed indices have been above predictions for 5-11 years. The indices for $41-50 \mathrm{~cm}$ 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 $19-34 \mathrm{~cm}$ fish. When looking at the temporal patterns, longevity of the fish must be considered. Positive residuals in size groups $33-38 \mathrm{~cm}$ 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 $\mathrm{F}_{9}-19=0.097$ reducing linearly if the spawning stock is estimated below 220000 t (Btrigger). Blim was proposed as 160000 t , lowest SSB in the 2012 run. The 2021 SSB was estimated at 260090 t , and according to the management plan the TAC advice for 2022 was 31855 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 ( $\mathrm{CV}=0.25$, $\mathrm{rho}=0.9$ ).

Yield-per-recruit analysis show that when average size at age 5 was allowed to change after year class 1996, F9-19, Max changed from 0.097 to 0.114 . The proposed fishing mortality of 0.097 is therefore around $85 \%$ of $\mathrm{Fmax}^{\text {with }}$ current settings. Stochastic simulations indicate that it leads to very
low probability of spawning stock going below $\mathrm{B}_{\text {trigger }}$ and $\mathrm{B}_{\mathrm{lim}}$, even with relatively large autocorrelated assessment error.

At WKREDMP 2014, $B_{l i m}=B_{l o s s}=160000 t$ was defined as the lowest SSB in the 2012 Gadget run. $B_{\text {trigger }}=B_{p a}$ was defined as $220000 t$ by adding a precautionary buffer to the proposed $B_{l i m}$ of $160000 \mathrm{t}: 160^{*} \exp \left(0.2^{*} 1.645\right)$. Recruitment in the stochastic simulations was the average of yearclasses 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 $\mathrm{F}_{\mathrm{lim}}=0.226$ and $\mathrm{F}_{\mathrm{pa}}$ is then $0.226 / \exp \left(1.645^{*} 0.2\right)=0.163$ (Figure 19.5.1). The spawning stock decreased considerably from early 1980s to mid-1990s or from 400000 t to 200000 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 $\mathrm{SSB}<\mathrm{B}_{\text {trigger }}$ is estimated $2.7 \%$. For simplicity, the action of $\mathrm{B}_{\text {trigger }}$ 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 Btrigger it will only be noted in $<15 \%$ of the cases. The reason is that the spawning stock is only likely to go below $\mathrm{B}_{\text {trigger }}$ 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 Btrigger 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 $\mathrm{B}_{\text {trigger. }}$
Figure 19.5.2 shows the development of $\mathrm{F}_{9-19}$ based on $\mathrm{F}_{9-19}=0.097$. F is expected to be within the range of the fifth and $95^{\text {th }}$ quantile and the $16^{\text {th }}$ and $84^{\text {th }}$ quantile.

### 19.6 State of the stock

The results from Gadget indicate that fishing mortality has been low since 2009 but above FMSY $^{\text {M }}$ (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 F9-19 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 ( $<30 \mathrm{~cm}$ ). 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 $5 . \mathrm{b}$ 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 $30-40 \mathrm{~cm}$; 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 sur- vey 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 Fp 0.5 . 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 P. 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 19962021.

| Year | Spring Survey |  | Autumn Survey |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Biomass | CV | Biomass | CV |
| 1985 | 307926 | 0.095 |  |  |
| 1986 | 327765 | 0.120 |  |  |
| 1987 | 322121 | 0.122 |  |  |
| 1988 | 253559 | 0.095 |  |  |
| 1989 | 281117 | 0.122 |  |  |
| 1990 | 242450 | 0.223 |  |  |
| 1991 | 199128 | 0.114 |  |  |
| 1992 | 160545 | 0.088 |  |  |
| 1993 | 179275 | 0.130 |  |  |
| 1994 | 171135 | 0.097 |  |  |
| 1995 | 146102 | 0.102 |  |  |
| 1996 | 195697 | 0.164 | 199793 | 0.248 |
| 1997 | 212558 | 0.216 | 120628 | 0.279 |
| 1998 | 206461 | 0.136 | 186505 | 0.348 |
| 1999 | 297090 | 0.143 | 262691 | 0.310 |
| 2000 | 221279 | 0.176 | 141940 | 0.200 |
| 2001 | 192724 | 0.176 | 177456 | 0.155 |
| 2002 | 250420 | 0.173 | 192813 | 0.150 |
| 2003 | 333901 | 0.161 | 199450 | 0.159 |
| 2004 | 326868 | 0.236 | 220308 | 0.241 |
| 2005 | 310635 | 0.129 | 229013 | 0.240 |
| 2006 | 257010 | 0.157 | 279290 | 0.335 |
| 2007 | 339778 | 0.224 | 219951 | 0.252 |
| 2008 | 247895 | 0.154 | 288149 | 0.244 |
| 2009 | 302204 | 0.253 | 294028 | 0.282 |
| 2010 | 383407 | 0.245 | 227335 | 0.171 |


| Year | Spring Survey |  | Autumn Survey |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Biomass | CV | Biomass | CV |
| 2011 | 401358 | 0.235 |  |  |
| 2012 | 461921 | 0.204 | 343115 | 0.225 |
| 2013 | 457451 | 0.177 | 317325 | 0.156 |
| 2014 | 402773 | 0.174 | 431369 | 0.232 |
| 2015 | 406150 | 0.281 | 360722 | 0.173 |
| 2016 | 615712 | 0.313 | 401135 | 0.279 |
| 2017 | 507058 | 0.205 | 428351 | 0.187 |
| 2018 | 497092 | 0.210 | 342467 | 0.195 |
| 2019 | 410550 | 0.158 | 383532 | 0.233 |
| 2020 | 411320 | 0.206 | 244099 | 0.159 |
| 2021 | 441154 | 0.194 | 269053 | 0.199 |
| 2022 | 378907 | 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 | 31300 | 2039 | 313 | 15477 | 49129 |
| 1979 | 56616 | 4805 | 6 | 15787 | 77214 |
| 1980 | 62052 | 4920 | 2 | 22203 | 89177 |
| 1981 | 75828 | 2538 | 3 | 23608 | 101977 |
| 1982 | 97899 | 1810 | 28 | 30692 | 130429 |
| 1983 | 87412 | 3394 | 60 | 15636 | 106502 |
| 1984 | 84766 | 6228 | 86 | 5040 | 96120 |
| 1985 | 67312 | 9194 | 245 | 2117 | 78868 |
| 1986 | 67772 | 6300 | 288 | 2988 | 77348 |
| 1987 | 69212 | 6143 | 576 | 1196 | 77127 |
| 1988 | 80472 | 5020 | 533 | 3964 | 89989 |
| 1989 | 51852 | 4140 | 373 | 685 | 57050 |
| 1990 | 63156 | 2407 | 382 | 687 | 66632 |
| 1991 | 49677 | 2140 | 292 | 4255 | 56364 |
| 1992 | 51464 | 3460 | 40 | 746 | 55710 |
| 1993 | 45890 | 2621 | 101 | 1738 | 50350 |
| 1994 | 38669 | 2274 | 129 | 1443 | 42515 |
| 1995 | 41516 | 2581 | 606 | 62 | 44765 |
| 1996 | 33558 | 2316 | 664 | 59 | 36597 |
| 1997 | 36342 | 2839 | 542 | 37 | 39761 |
| 1998 | 36771 | 2565 | 379 | 109 | 39825 |
| 1999 | 39824 | 1436 | 773 | 7 | 42040 |
| 2000 | 41187 | 1498 | 776 | 89 | 43550 |
| 2001 | 35067 | 1631 | 535 | 93 | 37326 |
| 2002 | 48570 | 1941 | 392 | 189 | 51092 |
| 2003 | 36577 | 1459 | 968 | 215 | 39220 |
| 2004 | 31686 | 1139 | 519 | 107 | 33451 |


| Year | Area |  |  |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | 5.0 | 5.b | 6 | 14 |  |
| 2005 | 42593 | 2484 | 137 | 115 | 45329 |
| 2006 | 41521 | 656 | 0 | 34 | 42211 |
| 2007 | 38364 | 689 | 0 | 83 | 39134 |
| 2008 | 45538 | 569 | 64 | 80 | 46251 |
| 2009 | 38442 | 462 | 50 | 224 | 39177 |
| 2010 | 36155 | 620 | 220 | 1653 | 38648 |
| 2011 | 43773 | 493 | 83 | 1005 | 45354 |
| 2012 | 43089 | 491 | 41 | 2017 | 45633 |
| 2013 | 51330 | 372 | 92 | 1499 | 53279 |
| 2014 | 47769 | 202 | 60 | 2706 | 50743 |
| 2015 | 48769 | 270 | 44 | 2562 | 51645 |
| 2016 | 54036 | 179 | 50 | 5442 | 59707 |
| 2017 | 50119 | 1418 | 93 | 4501 | 56141 |
| 2018 | 48014 | 1129 | 80 | 4004 | 53227 |
| 2019 | 44746 | 1119 | 101 | 2665 | 48530 |
| 2020 | 40688 | 1304 | 100 | 4105 | 46197 |
| 2021 ${ }^{1)}$ | 39616 | 178 | 100 | 3532 | 43426 |

[^4]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 | 41515 | 33558 | 36339 | 36771 | 39823 | 41188 | 35066 | 48569 | 36576 | 31688 | 42591 | 41520 | 38364 | 45537 | 38443 | 36156 | 43773 | 43088 | 51328 | 47768 |


| 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 | 48770 | 54043 | 50117 | 48015 | 44745 | 40689 | 39616 |

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 | $\mathbf{R}_{\text {(age5) }}$ | Catches | $\mathrm{F}_{9-19}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1971 | 534085 | 338242 | 210.6 | 67880 | 0.115 |
| 1972 | 532312 | 326889 | 161.7 | 50890 | 0.089 |
| 1973 | 545411 | 331438 | 456.7 | 43719 | 0.076 |
| 1974 | 604345 | 347290 | 220.5 | 50598 | 0.083 |
| 1975 | 639480 | 362455 | 117.9 | 61920 | 0.097 |
| 1976 | 654476 | 373340 | 195.9 | 94420 | 0.145 |
| 1977 | 645558 | 361350 | 191.0 | 53753 | 0.087 |
| 1978 | 678240 | 389424 | 129.6 | 48736 | 0.071 |
| 1979 | 709833 | 425542 | 165.5 | 77212 | 0.106 |
| 1980 | 715593 | 439297 | 100.2 | 89143 | 0.120 |
| 1981 | 699854 | 441430 | 86.9 | 101966 | 0.142 |
| 1982 | 665192 | 429215 | 64.2 | 130322 | 0.193 |
| 1983 | 593378 | 386355 | 66.1 | 106050 | 0.171 |
| 1984 | 540066 | 357097 | 71.8 | 95288 | 0.163 |
| 1985 | 493226 | 330502 | 129.5 | 78531 | 0.138 |
| 1986 | 466558 | 312661 | 123.3 | 76908 | 0.146 |
| 1987 | 439463 | 291881 | 63.4 | 76559 | 0.158 |
| 1988 | 404205 | 266908 | 39.1 | 89804 | 0.212 |
| 1989 | 349457 | 226159 | 42.5 | 56645 | 0.150 |
| 1990 | 325284 | 211258 | 347.6 | 66314 | 0.199 |
| 1991 | 326320 | 187851 | 57.5 | 56015 | 0.186 |
| 1992 | 309854 | 172180 | 38.6 | 55826 | 0.206 |
| 1993 | 289910 | 156762 | 52.1 | 50179 | 0.205 |
| 1994 | 275205 | 147027 | 61.7 | 42520 | 0.183 |
| 1995 | 267797 | 144733 | 325.4 | 44263 | 0.195 |
| 1996 | 289841 | 143002 | 83.5 | 35595 | 0.155 |
| 1997 | 298610 | 149041 | 38.5 | 38996 | 0.165 |
| 1998 | 298230 | 152952 | 38.8 | 39694 | 0.165 |


| Year | Biomass | SSB | $\mathbf{R}_{\text {(age5) }}$ | Catches | $\mathbf{F 9 - 1 9}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1999 | 295290 | 157102 | 76.5 | 42463 | 0.175 |
| 2000 | 291814 | 159403 | 47.5 | 42607 | 0.172 |
| 2001 | 283408 | 160947 | 103.2 | 36744 | 0.142 |
| 2002 | 290677 | 167273 | 111.8 | 50730 | 0.195 |
| 2003 | 285287 | 161447 | 163.6 | 38219 | 0.148 |
| 2004 | 301906 | 166336 | 101.6 | 32766 | 0.123 |
| 2005 | 316429 | 176691 | 154.3 | 46619 | 0.173 |
| 2006 | 326245 | 177413 | 151.7 | 42108 | 0.161 |
| 2007 | 347359 | 185875 | 98.4 | 39154 | 0.146 |
| 2008 | 362743 | 199321 | 119.8 | 46195 | 0.165 |
| 2009 | 375258 | 210288 | 184.1 | 39301 | 0.133 |
| 2010 | 408289 | 230741 | 155.3 | 38504 | 0.119 |
| 2011 | 439377 | 254843 | 83.2 | 45146 | 0.130 |
| 2012 | 450600 | 274185 | 123.6 | 45423 | 0.123 |
| 2013 | 468061 | 293834 | 76.1 | 53223 | 0.137 |
| 2014 | 467648 | 305377 | 36.3 | 50697 | 0.126 |
| 2015 | 459245 | 315360 | 11.0 | 51621 | 0.124 |
| 2016 | 440842 | 319575 | 13.3 | 59711 | 0.142 |
| 2017 | 409897 | 310673 | 35.9 | 56355 | 0.136 |
| 2018 | 382627 | 298542 | 4.5 | 53167 | 0.133 |
| 2019 | 349029 | 282338 | 8.2 | 48550 | 0.128 |
| 2020 | 317118 | 264207 | 19.1 | 46116 | 0.129 |
| 2021 | 286687 | 242926 | 26.2 | 43337 | 0.134 |
| 2022 | 258329 | 220056 | 47.2 |  |  |

Table 19.4.2 Assumption and output from short term prognosis. All weights are in tonnes.

| Biomass (2022) | SSB (2022) | $\mathrm{F}_{9-19}(2022)$ | Landings (2022) | Biomass (2023) | SSB (2023) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 258329 | 220056 | 0.128 | 37241 | 238910 | 200045 |
| Basis | Total cat | 223) | $\mathrm{F}_{9-19}(2023)$ | Biomass 5+ (2024) | SSB (2024) |
| Management plan |  | 545 | 0.097 | 229871 | 189588 |
| Other catch options |  |  |  |  |  |
| $\mathrm{F}_{0}$ |  | 0 | 0 | 255771 | 213812 |
| $\mathrm{F}_{\text {sq }}=\mathrm{F}_{2021}$ |  | 152 | 0.134 | 224183 | 184271 |

### 19.19 Figures







Figure 19.2.1 Indices of golden redfish in ICES Division 5.a (Icelandic waters) from the groundfish surveys in March 19852022 (blue line and shaded area) and October 1996-2021 (yellow lines and shaded areas). The shaded areas represent 95\% Cl.


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 $>\mathbf{3 0} \mathrm{cm}$ ). The survey was not conducted in 2018 and 2021.


Figure 19.2.9 Golden redfish ( $>17 \mathrm{~cm}$ ). 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 $\log (\mathrm{obs} / \mathrm{mod})=1$


Figure 19.5.1. Average SSB against average fishing mortality and defined reference points.


Figure 19.5.2. Development of $\mathrm{F}_{9-19}$ based on $\mathrm{F}_{9-19}=\mathbf{0 . 0 9 7}$. The light grey area shows fifth and $95^{\text {th }}$ quantile and the dark areas $16^{\text {th }}$ and $84^{\text {th }}$ 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 3639 cm in 2000 to about $42-45 \mathrm{~cm}$ 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 $1-2 \mathrm{~cm}$ 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 87000 t but
gradually decreased to about 23000 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 57000 t in 1994 to 17000 t in 2001. Landings in 2001-2010 fluctuated between 17000 and 20500 t except in 2003 and 2008 when annual landings were 28500 and 24000 t , respectively. Annual landings in 2011-2021 were between 8300 and 12000 t . The total catch in 2021 were 10588 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/ <br> Subarea | Nation | Gear | Landings (t) | No. samples | No. length measured |
| :--- | :--- | :--- | ---: | ---: | ---: |
| $5 . a / 14$ | Iceland | Bottom trawl | 10588 | 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 $2 \mathrm{~cm} / \mathrm{yr}$ ) 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 ( $>18 \mathrm{~cm}$ ), and no juveniles are present $(<18 \mathrm{~cm})$. 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 $B_{\text {trigger }}$ 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, $\mathrm{z}>\mathrm{x}$, and $\mathrm{C}_{\mathrm{y}-1}$ 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 $r f b$ 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 $r f b$ 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 $r f b$ 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 $\mathrm{y}+1$ (set on a biennial basis). |
| $r$ | $\frac{\sum_{i=y-2}^{y-1}\left(I_{i} / 2\right)}{\sum_{i=y-5}^{y-3}\left(I_{i} / 3\right)}$ | 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 $3^{\prime \prime}$ rule. $\mathrm{y}=$ assessment (intermediate) year |
| $f$ | $\frac{\bar{L}_{y-1}}{L_{F=M}}$ | Fishing proxy is the mean length relative to MSY proxy length. <br> 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). <br> The target reference length is $L_{F=M}=0.75 L_{c}+0.25 L_{\infty}$, where. $L_{c}$ is defined as length at $50 \%$ of modal abundance (ICES, 2018b). <br> Moves the stock towards MSY. <br> Follows Beverton and Holt (1957), derived by Jardim et al. (2015). <br> 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 $I_{\text {trigger }}=1.4 I_{\text {loss }}$ such that $b$ is set equal to $I_{y-1} / I_{\text {trigger }}$. <br> When the most recent index data $I_{y-1}$ is greater than $I_{\text {trigger }}, b$ is set equal to 1. <br> $I_{\text {loss }}$ is generally defined as the lowest observed index value for that stock. $I_{\text {trigger }}$ may need to be adapted if the stock has been exploited only heavily or lightly in the past. Ideally, $I_{\text {trigger }}$ should correspond to $\mathrm{MSY}_{\text {Brrigger }}$. |
| $m$ | [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. <br> $m$ 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 im to less than $5 \%$. May range from 0 to 1.0. |
| Stability clause | $\min \left\{\max \left(0.7 C_{y}, A_{y+1}\right), A\right\}$ | Asymmetric conditional uncertainty cap. <br> 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. <br> The stability clause does not apply when $\mathrm{b}<1$. |

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 | 110930 |
| $I_{B}$ | Average survey index 2017-2019 | 111020 |
| $k$ | Growth parameter from von Bertalanffy | 0.142 |
| $r$ | Index ratio $\left(I_{A} / I_{B}\right)$ | 1 |
| $f$ | $\frac{\bar{L}_{y-1}}{L_{F=M}}$ | 1.101 |
| $b$ | $I_{y-1}>I_{\text {trigger }}$ | 1 |
| $m$ | $k<0.2$ | 0.95 |
| $L_{\infty}$ | From von Bertalanffy | 49 cm |
| $L_{c}$ | Length at 50\% of modal abundance in the catch | 34.5 cm |
| $L_{F=M}$ | $0.75 L_{c}+0.25 L_{\infty}$ | 39.25 cm |
| $\bar{L}_{y-1}$ | Mean length from the observed catch in 2021 | 43.23 |
| $I_{\text {trigger }}$ | $1.4 I_{\text {loss }} ;\left(I_{\text {loss }}=63188\right.$, lowest value in the survey $)$ | 88460 |
| $I_{y-1}$ | Survey index value for 2021 | 138489 |
| $A_{y+1}$ | 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 $<30 \mathrm{~cm}$ ) has been at very low levels and in the 2021 survey no fish $<30 \mathrm{~cm}$ 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 latematuring) 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 $/$ <br> possible direction of solution | Data needed to be able to <br> do this: are these available <br> / where should these come <br> from |
| :--- | :--- | :--- | :--- |
| pert from |  |  |  |


| 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 $<18 \mathrm{~cm}$ ). 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 $10-20 \mathrm{~cm}, 21-25 \mathrm{~cm}, 26-30 \mathrm{~cm} \ldots 41-45 \mathrm{~cm}$ and $46-55 \mathrm{~cm}$. 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, $k, L_{\infty}$, informed by age-length frequencies.
- Parameter $\beta$ 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 $\eta_{s a}$ and $a \in\left(3,50^{+}\right)$. $\sigma_{a}^{2}$, 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, $\lambda, l_{50}$, was estimated from survey data.
- Length at recruitment, $l_{0,}$ or: mean length (at age 3) and std. deviation in length at recruitment.
- Number of recruits by year, $R_{y}$, and $\mathrm{y} \in(1970,2019)$.
- Length-weight relationship $\mu_{s}, \omega_{k}$, 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 $\eta_{s a}$ 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 $25-30 \mathrm{~cm}$ and $30-35 \mathrm{~cm}$ 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, $45-55 \mathrm{~cm}$, 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-yearold 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 $<20 \mathrm{~cm}$ ), good estimation of the sizes contributing most to the exploitable fishery (roughly $30-50 \mathrm{~cm}$ ), and an underestimation of the largest fish (roughly $>50 \mathrm{~cm}$ (Figures 20.12 .6 and 20.12.7). Because inter-age and interlength 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 Flim in 2013-2019, but above Fmsy. 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 $\mathrm{F}_{\mathrm{mSY}}=0.06$. Blim $=169200 \mathrm{t}$ is defined as the median of SSB in 2000-2005 when the stock was stable at low levels. $\mathrm{B}_{\mathrm{pa}}$ was defined as 236880 t by adding precautionary buffer to the proposed $\mathrm{Blim}^{*} 1.4$ (approximation of $169000^{*} \exp \left(0.2^{*} 1.645\right)$. The plot of the average spawning stock against fishing mortality show that $\mathrm{F}_{\mathrm{lim}}=0.08$ and $\mathrm{F}_{\mathrm{pa}}$ is then $0.08 / \exp \left(1.645^{*} 0.2\right)=0.058$ (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 20002021. No survey was conducted in 2011.

| Year | Biomass | lower 5th percentile | upper 95th percentile |
| :---: | :---: | :---: | :---: |
| 2000 | 135994 | 96811 | 175176 |
| 2001 | 161733 | 104040 | 219427 |
| 2002 | 95059 | 68975 | 121143 |
| 2003 | 63188 | 47459 | 78916 |
| 2004 | 96465 | 64134 | 128797 |
| 2005 | 109196 | 55690 | 162702 |
| 2006 | 123018 | 82993 | 163043 |
| 2007 | 82035 | 52610 | 111459 |
| 2008 | 80011 | 57899 | 102123 |
| 2009 | 93653 | 61714 | 125592 |
| 2010 | 77800 | 54317 | 101283 |
| 2011 | - | - | - |
| 2012 | 74604 | 53402 | 95806 |
| 2013 | 69935 | 48552 | 91319 |
| 2014 | 103051 | 64473 | 141629 |
| 2015 | 107423 | 70788 | 144059 |
| 2016 | 80855 | 61363 | 100348 |
| 2017 | 125611 | 83265 | 167957 |
| 2018 | 122292 | 72196 | 172387 |
| 2019 | 85157 | 61456 | 108858 |
| 2020 | 90371 | 64687 | 116054 |
| 2021 | 131489 | 92831 | 170147 |

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 | 36269 | 37727 |
| 1951 | 1944 | 45825 | 47769 |
| 1952 | 885 | 55554 | 56439 |
| 1953 | 658 | 86011 | 86669 |
| 1954 | 577 | 75972 | 76459 |
| 1955 | 654 | 52784 | 53438 |
| 1956 | 674 | 40047 | 40721 |
| 1957 | 558 | 35993 | 36551 |
| 1958 | 409 | 43820 | 44229 |
| 1959 | 398 | 40175 | 40573 |
| 1960 | 407 | 38428 | 38836 |
| 1961 | 307 | 31534 | 31841 |
| 1962 | 264 | 35122 | 35386 |
| 1963 | 456 | 38338 | 38794 |
| 1964 | 362 | 45414 | 45776 |
| 1965 | 473 | 55930 | 56403 |
| 1966 | 332 | 47491 | 47823 |
| 1967 | 357 | 47313 | 47670 |
| 1968 | 494 | 50892 | 51386 |
| 1969 | 486 | 38358 | 39345 |
| 1970 | 500 | 35800 | 36300 |
| 1971 | 495 | 34376 | 34871 |
| 1972 | 593 | 39874 | 40468 |
| 1973 | 794 | 35251 | 36045 |
| 1974 | 806 | 32103 | 32909 |
| 1975 | 1404 | 29301 | 30705 |
| 1976 | 715 | 28632 | 29346 |
| 1977 | 590 | 22427 | 23018 |
| 1978 | 3693 | 209 | 3902 |
| 1979 | 7448 | 246 | 7694 |
| 1980 | 9849 | 348 | 10197 |
| 1981 | 19242 | 447 | 19689 |
| 1982 | 18279 | 213 | 18492 |
| 1983 | 36585 | 530 | 37115 |
| 1984 | 24271 | 222 | 24493 |
| 1985 | 24580 | 188 | 24768 |
| 1986 | 18750 | 148 | 18898 |
| 1987 | 19132 | 161 | 19293 |
| 1988 | 14177 | 113 | 14290 |


| Year | Iceland | Others | Total |
| :---: | :---: | :---: | :---: |
| 1989 | 40013 | 256 | 40269 |
| 1990 | 28214 | 215 | 28429 |
| 1991 | 47378 | 273 | 47651 |
| 1992 | 43414 | 0 | 43414 |
| 1993 | 51221 | 0 | 51221 |
| 1994 | 56674 | 46 | 56720 |
| 1995 | 48479 | 229 | 48708 |
| 1996 | 34508 | 233 | 34741 |
| 1997 | 37876 | 0 | 37876 |
| 1998 | 32841 | 284 | 33125 |
| 1999 | 27475 | 1115 | 28590 |
| 2000 | 30185 | 1208 | 31393 |
| 2001 | 15415 | 1815 | 17230 |
| 2002 | 17870 | 1175 | 19045 |
| 2003 | 26295 | 2183 | 28478 |
| 2004 | 16226 | 1338 | 17564 |
| 2005 | 19109 | 1454 | 20563 |
| 2006 | 16339 | 869 | 17208 |
| 2007 | 17091 | 282 | 17373 |
| 2008 | 24123 | 0 | 24123 |
| 2009 | 19430 | 0 | 19430 |
| 2010 | 17642 | 0 | 17642 |
| 2011 | 11738 | 0 | 11738 |
| 2012 | 11965 | 0 | 11965 |
| 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 | 11375 | 0 | 11375 |
| 2021 ${ }^{1 /}$ | 10588 | 0 | 10588 |

## 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 |
| :--- | :--- | :--- | :--- | :--- |
| aldist.aut | 4 | $2000-2019$ | 1 cm | Age- length distribution |
| aldist.comm | All quarters | $1998-2018$ | 1 cm | Age- length distribution |
| Idist.aut | 4 | $2000-2019$ | 1 cm | Length distribution |
| Idist.comm | All quarters | $1976-2019$ | 1 cm | Length-distribution |
| matp.aut | 4 | $2000-2019$ |  | Ratio of immature:mature by length |
| si.10-20.aut | 4 | $2000-2019$ | $10-20 \mathrm{~cm}$ | Survey indices |
| si.20-25.aut | 4 | $2000-2019$ | $20-25 \mathrm{~cm}$ | Survey indices |
| si.25-30.aut | 4 | $2000-2019$ | $25-30 \mathrm{~cm}$ | Survey indices |
| si.30-35.aut | 4 | 4 | $2000-2019$ | $30-35 \mathrm{~cm}$ |
| si.35-40.aut | 4 | Survey indices |  |  |
| si.40-45.aut | 4 | 4 | Survey indices |  |
| si.45-55.aut | $40-40-2019$ | cm | Survey indices |  |

Table 20.12.1: Reference points from stochastic simulations.

| Framework | Reference points | Value | Technical basis |
| :---: | :---: | :---: | :---: |
| MSY approach | MSY $\mathrm{B}_{\text {trigger }}$ | 236880 t | $\mathrm{B}_{\mathrm{pa}}$ |
|  | $\mathrm{HR}_{\text {MSY }}$ | 0.06 | $\mathrm{F}_{\text {MSY }}$ |
|  | $\mathrm{F}_{\text {MSY }}$ | 0.06 | Stochastic simulations. |
| Precautionary approach | $\mathrm{Blim}^{\text {lim }}$ | 169200 t | Median SSB for 2000-2005 |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 236880 t | $\mathrm{Blim}_{\text {lim }}$ * 1.4 |
|  | $\mathrm{HR}_{\text {lim }}$ | 0.08 | $\mathrm{F}_{\text {lim }}$ |
|  | $\mathrm{F}_{\text {lim }}$ | 0.08 | Equilibrium F that will maintain the stock above $\mathrm{B}_{\text {lim }}$ with a $50 \%$ probability |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.058 | $\mathrm{F}_{\text {lim }} / \exp (0.2 * 1.645)$ |
|  | $\mathrm{HR}_{\text {pa }}$ | 0.055 | $\mathrm{F}_{\mathrm{pa}}$ |

### 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 $\mathbf{3 0} \mathrm{cm}$ 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 ( $\mathrm{n}=1$ 405), 2006 ( $\mathrm{n}=536$ ), 2009 ( $n=1$ 205), 2010 ( $n=1$ 099), 2017 ( $n=1$ 298), 2018 ( $n=1568$ ), 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 ( $\mathrm{t} / \mathrm{nmi}^{2}$, 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) 19782020. 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 ( $0-400 \mathrm{~m}$ ) (Fock et al., 2013), the Greenland deep-water survey ( $400-1500 \mathrm{~m}$ ) 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 14.6 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 19931998 (data not shown). This coincided with a large increase in the amount of $17-30 \mathrm{~cm}$ 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 ( $<17 \mathrm{~cm}$ ) 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 $(17-30 \mathrm{~cm})$ 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 20182021, 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 $(18.4 \mathrm{kt})$ 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 $14 . \mathrm{b}$ 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 20000 tonnes with a very high peak at nearly 60000 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 $63.5^{\circ} \mathrm{N}$ and $65^{\circ} \mathrm{N}$, 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 ( $0-600 \mathrm{~m}$ ) and the German survey $(0-400 \mathrm{~m})$ 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 $13-14 \mathrm{~cm}$. 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 100200 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 (Linf, $M$ 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 20172019, 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

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### 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 | 59700 | 2015 | 5977 |
| 1977 | 0 | 2016 | 3061 |
| 1978 | 5403 | 2017 | 3027 |
| 1979 | 5131 | 2018 | 1972 |
| 1980 | 10406 | 2019 | 3998 |
| 1981 | 19391 | 2020 | 1677 |
| 1982 | 12140 | 2021 | 1302 |
| 1983 | 15207 |  |  |
| 1984 | 9126 |  |  |
| 1985 | 9376 |  |  |
| 1986 | 12138 |  |  |
| 1987 | 6407 |  |  |
| 1988 | 6065 |  |  |
| 1989 | 2284 |  |  |
| 1990 | 6097 |  |  |
| 1991 | 7057 |  |  |
| 1992 | 7022 |  |  |
| 1993 | 14828 |  |  |
| 1994 | 19305 |  |  |
| 1995 | 819 |  |  |
| 1996 | 730 |  |  |
| 1997 | 199 |  |  |
| 1998 | 1376 |  |  |
| 1999 | 853 |  |  |
| 2000 | 982 |  |  |
| 2001 | 901 |  |  |



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

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 | 10229 | 10985 | 10379 | 10143 | 15563 | 10750 | 7300 | 4033 | 4013 | 4648 | 3559 | 95954 |

### 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 $\mathbf{3 0} \mathbf{~ c m}$ 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 $\mathrm{km}^{\mathbf{2}}$ ) from the deep Greenland survey. In 2017, the survey was aborted due to vessel break down. In 2018 and 2019, no research vessel was available and in 2020, only Greenland shallow survey was carried out. Therefore, no new data is available.


Figure 23.2.5: Biomass ( $\mathrm{kg}^{*} 10^{6}, \mathrm{kt}$ ) ( $\pm$ CV\%) indices for S. mentella (top) and Sebastes sp . ( $<\mathbf{1 8 \mathrm { cm } \text { ) (bottom) off East Green- }}$ land 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. $<18 \mathrm{~cm}$ (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: InCPUE = year + ICES Subdivision + depth. Bars represent standard error. Only hauls made below 1000 m 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: InCPUE = 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 ( $\mathrm{N}=273$ ) and S. norvegicus ( $\mathrm{N}=399$ ).

## 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 $50-100 \mathrm{~m}$ 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 $21-80 \mathrm{~m}$ (Figure 24.2.3). Plaice fishing grounds in 2013-2021 in 5a, as reported by mandatory logbooks, are shown in Figure 24.2.1.


Catch (t/nm2)
$(0,3]$
$(3,6]$
$(6,9]$
$(9,12]$
$(12,15]$
$(15,18]$
$(18,30]$
$(30,60]$

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.responsiblefisher-ies.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 24.3.924.3.11.

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 $(<20 \mathrm{~cm})$ 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 $\rho$ 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 $\rho$ 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 | 12400 | $\mathrm{B}_{\mathrm{pa}}$ | ICES (2022b) |
|  | $\mathrm{F}_{\text {MSY }}$ | 0.41 | Fishing mortality that leads to MSY. Estimated using stochastic simulations. |  |
| Precautionary approach | Blim | 10000 | Lowest SSB (1990) where large recruitment was observed. |  |
|  | $\mathrm{B}_{\mathrm{pa}}$ | 12400 | $\mathrm{B}_{\text {lim }} \times \mathrm{e}^{1.645}{ }^{*} \mathrm{\sigma BB}^{\text {b }}$, using $\sigma_{\mathrm{B}}=0.12$ |  |
|  | Flim | 0.57 | Fishing mortality that in stochastic equilibrium will result in median SSB at $\mathrm{B}_{\text {lim }}$. |  |
|  | $\mathrm{F}_{\mathrm{pa}}$ | 0.46 | $\mathrm{F}_{\mathrm{p} 05}$, maximum F at which the probability of SSB falling below $\mathrm{B}_{\text {lim }}$ is $<5 \%$ |  |
| Management plan | MGT B ${ }_{\text {trigger }}$ | 12400 | MSY $\mathrm{B}_{\text {trigger }}$ |  |

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 $\mathrm{y}+1$ ) based on a fishing mortality $F_{m g t}$ of 0.3 applied to ages 5 to 10 modified by the ratio $\mathrm{SSB}_{y} / \mathrm{MGT} \mathrm{B}_{\text {trigger }}$ when $\mathrm{SSB}_{y}<\mathrm{MGT}_{\text {trigger }}$, maintains a high yield while being precautionary as it results in lower than $5 \%$ probability of SSB $<B_{\text {lim }}$ 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | 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 5 a. 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 | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | $\mathbf{6}$ | $\mathbf{7}$ | $\mathbf{8}$ | $\mathbf{9}$ | $\mathbf{1 0}$ | $\mathbf{1 1}$ | $\mathbf{1 2}$ |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 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 |
| 20069 | 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

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Please note: This report will be published in parts. Estimated publication dates for the various sections and for the full report are outlined below.

15 June 2022

- Section i

Executive summary

- Section 1

Introduction

- Section 7

Overview on ecosystem, fisheries and their management in Icelandic waters

- Section 8

Icelandic saithe

- Section 9
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Icelandic cod in 5.a
Haddock in 5.a
Icelandic summer spawning herring

- Section 12

Capelin in the Iceland-East Greenland-Jan Mayen Area

- Section 13 Overview on ecosystem, fisheries and their management in Greenland waters
- Section 14

Cod (Gadus morhua) in NAFO Subdivisions 1A-1E (Offshore West Green-
land)

- Section 1
- Section 16

Cod (Gadus morhua) in NAFO Subarea 1, inshore (West Greenland cod)
Cod (Gadus morhua) in ICES Subarea 14 and NAFO Division 1.F
(East Greenland, South Greenland)

- Section 17 Greenland Halibut in Subareas 5, 6, 12, and 14
- Section 18 Redfish in subareas 5, 6, 12 and 14
- Section 19 Golden redfish (Sebastes norvegicus) in subareas 5, 6 and 14
- Section 20 Icelandic slope Sebastes mentella
- Section 21 Shallow Pelagic Sebastes mentella
- Section 22 Deep Pelagic Sebastes mentella
- Section 23 Beaked redfish (Sebastes mentella) in Division 14.b, demersal (Southeast Greenland)
- Section $24 \quad$ Icelandic plaice in 5.a
- Annex 1 List of Participants
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- Annex 5 Audit reports


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- Section 2
- Section 3
- Section 4 Faroe Plateau cod
- Section 5 Faroe haddock
- Section 6 Faroe saithe

Faroe Bank cod

- Full report

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

## Annex 1: List of participants

Northwestern Working Group 2-7 May 2022

| Name | Institute | Country | Email |
| :---: | :---: | :---: | :---: |
| Anja Retzel | Greenland Institute for Natural Resources | Greenland | AnRe@natur.gl |
| Birkir Bardarson | Marine and Freshwater Research Institute | Iceland | birkir.bardarson@hafogvatn.is |
| Bjarki Thor Elvarsson | Marine and Freshwater Research Institute | Iceland | bjarki.elvarsson@hafogvatn.is |
| Einar Hjörleifsson | Marine and Freshwater Research Institute | Iceland | einar.hjorleifsson@hafogvatn.is |
| Elzbieta Baranowska | Marine and Freshwater Research Institute | Iceland | elzbieta.baranowska@hafogvatn.is |
| Frank Fars $\varnothing$ 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 |
| Jesper Boje | The National Institute of Aquatic Resources Sec- tion for Fisheries Advice | Denmark | jbo@aqua.dtu.dk |
| Julius Nielsen | Greenland Institute for Natural Resources | 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 Institute | Iceland | kristjan.kristinsson@hafogvatn.is |
| Lísa Anne Libungan | Marine and Freshwater Research Institute | 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 Resources | Greenland | sopo@natur.gl |
| 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 $5^{\circ} \mathrm{W}$, 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, summerspawning 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 <br> updated | Link |
| :--- | :--- | :--- | :--- |
| reb.2127.dp_SA | Deep Pelagic beaked redfish (Sebastes mentella) in <br> ICES | May 2012 | smn-dp SA.pdf |
| reb.27.14b_SA | Beaked redfish (Sebastes mentella) in Division 14.b <br> (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 <br> and Faroes grounds, West of Scotland, North of <br> 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: $\mathrm{B}>\mathrm{Blim}$ and $\mathrm{B}>\mathrm{MSYB}$ trigger for a while; $\mathrm{HR}<\mathrm{HRlim}$ and $\mathrm{HR}<\mathrm{HRmsy}$; 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 $_{\text {trigger }}$ 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 ${ }_{\text {trigger, }}$ the $\mathrm{TAC}_{2022 / 2023}$ is set as $\left(\mathrm{TAC}_{2021 / 2022}+0.2^{*} \mathrm{~B}_{\text {B4 } 4,2022}\right) / 2$. 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 Pór 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 Btrigger, BPa and Blim. Fishing pressure is above both HRmsy and HRpa and below HRblim.
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
 good recruitment in recent years
6. 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.


[^0]:    ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

[^1]:    * 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.

[^2]:    * 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 .

[^3]:    Provisional data
    WG estimate includes additional catches as described in working Group reports for each year and in the report from 2001.

[^4]:    ${ }^{1)}$ Provisional

