ARCTIC FISHERIES WORKING GROUP (AFWG; outputs from 2022 meeting)

Version 2: correction to executive summary description of cap.27.1-2

VOLUME 5 | ISSUE 18

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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

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

ISSN number: 2618-1371

ICES Scientific Reports

Volume 5 | Issue 18

ARCTIC FISHERIES WORKING GROUP (AFWG)

Recommended format for purpose of citation:

ICES. 2023. Arctic Fisheries Working Group (AFWG; outputs from 2022 meeting). ICES Scientific Reports. 5:18. 507 pp. https://doi.org/10.17895/ices.pub.20012675

Editors

Daniel Howell

Authors

Jane Aanestad Godiksen • Caroline Aas Tranang • Erik Berg • Matthias Bernreuther • Bjarte Bogstad
Olav Nikolai Breivik • José Miguel Casas • Laura Clain • Elise Eidset • Elena Eriksen • Johanna Fall
Maria Fossheim • Harald Gjøsæter • Sofie Gundersen • Elvar H. Hallfredsson • Hannes Höffle • Daniel
Howell • Edda Johannesen • Kjell Nedreaas • Anders Nielsen • Georg Skaret • Arved Staby • Brian Stock
Samuel Subbey • Ross Tallman • John Tyler Trochta • Tone Vollen • Kristin Windsland

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

Contents

i Executive summary

On 30th March 2022, all Russian participation in ICES was suspended. Although the announcement of the suspension stressed the role of ICES as a "multilateral science organization", this suspension applied not only to research activities but also to the ICES work providing fisheries advice for the sustainable management of fish stocks and ecosystems. As a result of the suspension, it is not possible to run ICES stock assessments or provide ICES advice for the Barents Sea stocks of NEA cod, NEA haddock, *Sebastes mentella* or Greenland Halibut, as management and data collection for these stocks are shared between Norway and Russia. There are therefore no AFWG stock assessments for these stocks this year. This is especially unfortunate as NEA cod is currently declining, and updated assessments are required to ensure an appropriate management response. It is to be hoped that the political decision to exclude Russia from the ICES advice process which underlies our sustainable fisheries management does not lead to mismanagement of the shared stocks and the consequent ecological harm.

It should be noted that bilateral Russian-Norwegian advice is being provided to the managing body outside ICES for the affected stocks, and there is therefore no current management need for ICES advice. This year AFWG is therefore providing advice for saithe, coastal cod north, coastal cod south, and *S. norvegicus*. In addition, an assessment has been run for anglerfish, although there is no formal request for advice for this stock. The stock trends are as follows:

Stock-by-stock summaries

Cod in subareas 1 and 2 North of 67°N (Norwegian coastal cod North); cod.27.2.coastN.

- The existing coastal cod north assessment and B_{lim} from the 2022 benchmark gives an SSB estimate of 130 671 tonnes, up from 116 771 tonnes in 2021. An ICES HCR evaluation has been conducted at WKNCCHCR, which proposed slight modifications to the tuning data for the model. WKNCCHCR noted a high degree of uncertainty around any B_{lim} estimate, and therefore proposed a HCR based on a precautionary F0.1 and no formal B_{lim}. This HCR has been adopted, and the catch advice for 2023 is 29 347 tonnes. It should be noted that this stock cannot be directly managed via a quota (as the fish are not visually distinguishable from NEA cod in the same area), and therefore management is based on gear and area regulation.

Cod (Gadus morhua) in Subarea 2 between 62°N and 67°N (Norwegian coastal cod South); cod.27.2.coastS.

- The catch advice of 9136 tonnes is based on a standardized CPUE index, which increased to such an extent that the + 20% stability cap was reached. However, this index has high uncertainty, and auxiliary analyses show fairly poor status (SPR = 0.25 and F/M > 1). About half of the catch is immature, and this proportion has increased in the last 10 years.

Saithe in subareas 1 and 2 (Northeast Arctic)

- The NEA saithe stock is currently in good status, with the SSB well above Bpa at 715 674 tonnes (up from 568 972) in last year's assessment. Following the HCR (and constrained by a 15% stability constr, the catch advice is 226 794 tonnes (which is constrained by the 15% annual stability constraint). This stock, together with the associated North Sea saithe stock, is aiming for a benchmark, likely in 2024.

Redfish (Sebastes norvegicus) in subareas 1 and 2 (Northeast Arctic)

- The stock is continuing to be assessed as in a poor status, and with increasing catches is increasingly identified as overfished. A revision in the catch splitting between the two

redfish species resulted in an upwards revision of the catch and therefore SSB history but does not affect the overall downward trend of SSB in the assessment. The catch advice is therefore zero.

- As a result of a move to new age readers, a discrepancy in the age readings for older fish in the last three years compared with previous data was noted. This was dealt with by excluding the data on 30+ fish in the tuning series, but this feeds into a strong desire for a benchmark for this stock before the next advice is due in 2024.

Anglerfish (Lophius budegassa, Lophius piscatorius) in subareas 1 and 2 (Northeast Arctic)

- Data-limited model results based on length data from the fishery suggest that the biomass seems to be doing well and that the exploitation pattern is appropriate, while the rate might be near/slightly above the level that would lead to maximum yield. Management is based on technical measures rather than a quota. AFWG does not currently give advice on this stock but considers the current assessment of sufficient quality to base catch advice on if requested by the managers.

Barents Sea capelin

- Following ToR b), the data on Barents Sea capelin were updated. No assessment is conducted during the spring AFWG meeting, the assessment occurs in autumn following the ecosystem survey (which in 2022 will be conducted outside ICES). An ICES benchmark will be held in late 2022 for this stock together with capelin in the Iceland-East Greenland-Jan Mayen area (WKCAPELIN).

ii Expert group information

Expert group name	Arctic Fisheries Working Group (AFWG)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chair	Daniel Howell, Norway
Meeting venues and dates	21–27 April 2022[1], incl. data review meeting 20 April 2022, online (28 participants)

[1] Note: The Workshop on the evaluation of northern Norwegian coastal cod harvest control rules (WKNCCHCR) was rescheduled to take place as part of the work of AFWG 26–27 April 2022 after it had been delayed. See: ICES. 2022. Workshop on the evaluation of northern Norwegian coastal cod harvest control rules (WKNCCHCR). ICES Scientific Reports. 4:49. 115 pp. https://doi.org/10.17895/ices.pub.20012459

1 Introduction and ecosystem considerations

2022 report of the Arctic Fisheries Working Group

1.1 Terms of reference

2021/2/FRSG02

Approved November 2021

The Arctic Fisheries Working Group (AFWG), chaired by Daniel Howell, Norway, will meet online 21–27 April 2022 to:

a) Address generic ToRs for Regional and Species Working Groups, for all stocks except the Barents Sea capelin, which will be addressed at a meeting in autumn;
b) For Barents Sea capelin oversee the process of providing intersessional assessment;
c) Conduct reviews as required of time any series computed using the STOX and ECA open-source software for use in assessment in the Barents Sea.

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 to the meeting must be available to the group on the dates specified in the 2022 ICES data call.

AFWG will report by 6 May 2022 and October 2022 for Barents Sea capelin[2] for the attention of the Advisory Committee.

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 Additional requests

There were no additional requests.

1.3 Responses to terms of reference

Under ToR a (address generic ToRs), the stock assessments and advice were conducted according to generic ToRs c and d, while the generic ToR e benchmark review can be found further down in this introduction and the haddock, NEA cod, and coastal cod sections. Work on generic ToRs a and b will be conducted intersessionally as it becomes appropriate.

ToR b is handled in detail by the capelin subgroup of AFWG, held in autumn after the capelin survey. A brief report on the previous capelin assessment is given in this report.

ToR c is to review data changes as required, and this was not required in 2021.

[2] Note: no autumn assessment for Barents Sea capelin was conducted in 2022 as originally planned.

1.4 Benchmarks

A cod benchmark (WKBARFAR 2021) was conducted in early 2021 (ICES, 2021a). This benchmark resulted in a modification of the existing NEA cod SAM assessment model. For coastal cod, the benchmark resulted in the stock being split into two, a category one northern stock (with a SAM stock assessment) and a category three southern stock (2-over-3 rule based on a CPUE series).

Capelin[3] is scheduled to have a benchmark in 2022, with HCR revision conducted at the benchmark. Greenland halibut is scheduled for a benchmark in 2023[4], followed by an HCR evaluation.

1.5 Total catches

In this report, the terms ‘landings’ and ‘catches’ are, somewhat incorrectly, used as synonyms, as discards are in no cases used in the assessments. This does not mean, however, that discards have not occurred, but the WG has no information on the possible extent. In contrast, available information indicates low discard rates at present (less than 5% of catch), and it is assumed that discards are negligible in the context of the precision of the advice.

In previous years a report from the Norwegian-Russian Analysis group dealing with estimation of total catch of cod and haddock in the Barents Sea in 2021 was available to AFWG. The report presents estimated catches made by Norwegian, Russian and third countries separately. According to that report, the total catches of both cod and haddock reported to AFWG are very close (within 1%) to the estimates made by the analysis group. Thus, it was decided to set the IUU catches for 2021 to zero.

For further information on under- and misreporting, we refer to the 2016 AFWG report.

Discards estimates (1994–2021) of redfish, cod, haddock, and Greenland halibut juveniles in the commercial shrimp fishery in the Barents Sea are presented in Figure 0.1. These estimates are obtained with a spatio-temporal model based on a procedure elaborated in Breivik *et al*. (2017). In Breivik *et al.* (2017) an extensive validation study indicates that the new procedure obtains bycatch estimates with approximately correct uncertainty. Previous estimates for the period 1982–2015 are given in earlier reports (e.g. AFWG 2018), and we have not been able to compare these two time-series in detail. Such a comparison should be performed on a relatively fine spatio-temporal resolution. The bycatch estimates illustrated in Figure 0.1 and are available for each quarter in each main statistical area (not shown in report). Note that it is still a work in progress regarding improving the new estimates.

The new time-series in Figure 0.1 are obtained by scaling the estimated bycatch in the Norwegian fishery with the international fishery in each ICES area. The scaling procedure assumes that the Norwegian fishery is representative of the international fishery. This assumption is necessary because the international catch data are available only to a low spatio-temporal resolution. If the international vessels in a relatively high degree trawl at locations not trawled by Norwegian vessels, the bycatch estimates illustrated in figure 0.1 may be biased.

[3] Currently part of benchmark process WKCAPELIN 2022, expected to report conclusions in 2023.

[4] Currently part of benchmark process WKBNORTH 202, together with NWWG Greenland halibut (ghl.27.561214).

1.5.1 Uncertainty in catch data

For the Norwegian estimates of catch numbers at-age and mean weight-at-age for cod and haddock methods for estimating the precision have been developed, and the work is still in progress (Aanes and Pennington, 2003; Hirst *et al.*, 2004; Hirst *et al.*, 2005; Hirst *et al.*, 2012). The methods are general and can in principle be used for the total catch, including all countries' catches, and provide estimates both at-age and at-length groups. Typical error coefficients of variation for the catch numbers-at-age are in the range of 5–40% depending on age and year. It is evident that the estimates of the oldest fish are the most imprecise due to the small numbers in the catches and resulting small number of samples on these age groups. From 2006 onwards, the Norwegian catch-at-age in the assessment has been calculated using the ECA method described by Hirst *et al.* (2005). The methodology for using ECA to split cod catches into NEA cod and coastal cod is still under development (WKARCT 2015). ECA has now been implemented for saithe, and with partial success for *S. mentella*. A new version of the program (StoX-ECA) is now being tested.

Aging error is another source of uncertainty, which causes increased uncertainty in addition to bias in the estimates: An estimated age distribution appears smoother than it would have been in absence of ageing error. Some data have been analysed to estimate the precision in ageing (Aanes, 2002). If the ageing error is known, this can currently be taken into account for the estimation of catch-at-age described above.

For capelin, the uncertainty in the catch data is not evaluated. The catch data are used, however, only when parameters in the predation model are updated at infrequent intervals, and the uncertainty in the catch data are considered small compared with other types of uncertainties in the estimation.

We note that the SToX survey methodology reviewed by the group can produce uncertainty estimates for the survey time-series.

Additional sources of uncertainty arising from sources beyond sampling or age-reading errors have implications for a number of the stocks assessed here. Coastal cod catches, and to a lesser extent catches of the much larger NEA cod stock, have uncertainty issues due to the difficulty of splitting catches between the two stocks. A similar issue applies to small *S. norvegicus* stock and the larger *S. mentella* stock, where species misidentification can be a significant source of error. Finally, there is no agreement between Norway and Russia on an age-reading methodology for Greenland halibut, and such data are not used for tuning the model. The absence of age data creates an important (but unquantifiable) source of error on the GHL stock estimate.

1.5.2 Sampling effort–commercial fishery

Concerns about commercial sampling: The main Norwegian sampling program for demersal fish in ICES subareas 1 and 2 has been port sampling, carried out onboard a vessel travelling from port to port for approximately 6 weeks each quarter. A detailed description of this sampling program is given in Hirst *et al.* (2004). However, this program was, for economic reasons, terminated 1 July 2009. Sampling by the 'reference fleet' and the Coast Guard has increased in recent years. However, the reduction in port sampling of many different vessels seems to have increased the uncertainty in the catch-at-age estimates from 2009 onwards (WD6, 2010). A Norwegian port sampling program was restarted in 2011, although with a lower effort, this improved the basis for the 2011–2019 catch-at-age estimates. From 2014 this program is run by 4-year contracts of a vessel that sails between fish landing sites along the coast from about 66°N to Varanger (70°N, 30°E) three periods a year during the first, second, and fourth quarters, altogether up to 120 days. This is a reduction compared to about 180 days a year before 2009. The catch sampling is done of landed fish, mainly from the fleet fishing in coastal waters, and usually inside the plant, and the rented vessel acts as a transport, accommodation and working (age reading, data work) platform. AFWG recommends that such sampling is also carried out during the third quarter.

Tables 0.1–0.4 show the development of the Norwegian, Russian, Spanish and German sampling of commercial catches in the period 2008–2021. The tables show the total sampling effort, but do not show how well the sampling covers the fishery. Indices of coverage should be developed to indicate this. The main reason for the general strong decrease in numbers of Norwegian samples in the first part of this period is the termination of the port sampling program in northern Norway. This program is now up and running again. It should be considered whether catch sampling carried out by different countries fishing by trawl for the same time and area could be coordinated and data shared on a detailed level to a greater extent than is done today. Due to the Russian suspension not all these tables are updated with 2021 data.

1.5.2.1 Cod, haddock, and saithe

Available catch-at-age and length data covered the largest portion of catches by the respective fisheries. However, there was a period in spring 2020 when port sampling was at a lower level than usual due to the COVID-19 situation. However, the aggregation level (time and space) used when splitting these catches into Northeast Arctic cod and Norwegian Coastal Cod is also an important issue. Despite the improvement in sampling coverage in 2016–2020, the number of samples should be increased in the coming years, with the aim of covering all quarters and areas contributing the highest catches.

Due to the adopted amendments of the Russian Federal Law "On fisheries and preservation of aquatic biological resources" coming into force, especially concerning the destruction of biological resources caught under scientific research, sampling activities (age sample numbers and length/weight measurements of fish) on board fishing vessels are also reduced, especially in ICES subareas 2.a and 2.b, which may result in greater uncertainty of the stock assessments due to possible biases in the age–length distributions of the commercial catch.

Length measurements of fish and age sampling by Russia have been especially low in ICES subareas 2.a and 2.b in the first half of 2020 due to administrative difficulties in arrangement (stationing) observers onboard fishing vessels (a prolonged procedure via open contest). Available Norwegian data on cod and haddock length measurements onboard Russian vessels made by the Norwegian Coast Guard in the Norwegian economic zone have been used, where possible, in calculations of catch-at-age data by Russia.

1.5.2.2 Data issues with *S. mentella*

There is still a concern about the biological sampling from the fishery and scientific surveys that may have become critically low, however, there is also a lag of several years between collection of age samples and the processing of them. This is elaborated in the section for this stock.

1.5.2.3 Data issues with *S. norvegicus*

Despite a recent increase in age-reading for this species, age data are rather poor, and effort in age sampling from the catches is required. The other main source of uncertainty is species misidentification from *S. mentella*, and consequently, careful monitoring that species composition is being reported correctly is required.

1.5.2.4 Data issues with NEA Greenland halibut

There is still a concern about the biological sampling from the fishery that may have become critically low. Age information is not available, due to disagreements on age reading method, and may affect precision in the assessment which now is length-based. Norwegian landings are split on Greenland halibut by sex for area, gear groups, and quarters. Annual sample level has decreased in the last years and may affect the precision of the catch distribution.

The samples and data basis behind each stock assessment are discussed more in detail under each stock-specific section of this report (e.g. the coastal cod). The number of aged individuals per 1000 t is now well below the standard set by the EU in their Data Collection regulations. For several stocks sampling is inadequate for area/quarter/gear combinations making up considerable proportions of the total catch.

Discontinuation of the Russian autumn survey decreased considerably the biological sampling (age sample numbers, abundance indices evaluations, maturity status of fish definitions, feeding data collections, etc.).

1.5.3 The percentage of the total catch that has been taken in the NEAFC regulatory areas by year in the last year

Generic ToR c-iii asks for the percentage of the total catch that has been taken in the NEAFC regulatory area by year in the last year. In the area where AFWG stocks are distributed, there are two areas outside national EEZs which are part of the NEAFC regulatory area: The International area in ICES Subarea 1 in the Barents Sea ("loophole", denoted as 1.a or 27_1_A) and the International area in ICES divisions 2.a and 2.b in the Norwegian Sea ("banana hole", denoted as 2.a.1 and 2.b.1 or 27_2_A_1 and 27_2_B_1). In the table below the WG presents the most likely landings from these areas based on the official reports and discussions within the WG. The text table below shows the percentages for *S. mentella*, Northeast Arctic cod and haddock and Greenland halibut. For the other AFWG stocks, no catches are taken in those areas. The highest precision in these numbers is probably the *S. mentella* figures since these figures have been tabulated each year since 2004, and have been given regular and special attention, also by NEAFC.

	ICES 1.a	ICES 2.a.1	ICES 2.b.1	Total	%NEAFC
2021					
NEA cod	1896	2	0	758383	0.25%
Coastal cod (south+north)	0	0	0	52705	0.0%
Commercial catches	0	0	0	42043	0.0%
Recreational catches	0	0	0	10662	0.0%
NEA haddock	0	0	0	203118	0.0%
NEA saithe	0	2	0	188175	<0.1%
Sebastes mentella	0	2872	0	63482	4.5%
Sebastes norvegicus	0	0	0	10193	0.0%
Greenland halibut	638	23	0	28713	1.5%
Capelin	0	0	0	0	0.0%
Anglerfish	0	0	0	2601	0.0%
2020					

	ICES 1.a	ICES 2.a.1	ICES 2.b.1	Total	%NEAFC
NEA cod	1607	9	0	692903	0.23%
Coastal cod	0	0	0	56653	0.0%
NEA haddock	0	0	0	182468	0.0%
NEA saithe	0	3	0	169405	<0.1%
Sebastes mentella	0	5469	0	53631	10.2%
Sebastes norvegicus	0	0	0	9646	0.0%
Greenland halibut	450	0	0	28713	1.5%
Capelin	0	0	0	0	0.0%
Anglerfish	0	0	0	2280	0.0%
2019					
NEA cod	1094	0	0	692609	0.16%
Coastal cod	0	0	0	52807	0.0%
NEA haddock	394	0	0	175402	0.225%
NEA saithe	250	7	0	163180	0.001%
Sebastes mentella	0	6060	0	45954	13.2%
Sebastes norvegicus	0	0	0	8285	0.0%
Greenland halibut	1108	3	0	28832	3.8%
Capelin	0	0	0	0	0.0%
Anglerfish	0	0	0	2809	0.0%
2018					
NEA cod	1724	2	0	778627	0.22%
Coastal cod	0	0	0	49075	0.0%
NEA haddock	24.1	0	0	191276	0.013%
NEA saithe	2.4	0	0	181280	0.001%
Sebastes mentella	3	7823	0	38765	20.2%
Sebastes norvegicus	0	0	0	6647	0.0%
Greenland halibut	798	0	0	28544	2.80%
Capelin	0	0	0	0	0.0%
Anglerfish	0	0	0	1903	0.0%

	ICES 1.a	ICES 2.a.1	ICES 2.b.1	Total	%NEAFC
2017					
NEA cod	1212	12	0	868276	0.14%
Coastal cod	0	0	0	51053	0.0%
NEA haddock	90	0	0	227588	0. 0004%
NEA saithe	70	11	0	145403	0.06%
Sebastes mentella	0	6463	0	31200	20.7%
Sebastes norvegicus	5	0	0	5340	0.1%
Greenland halibut	592	6	0	26380	2.3%
Capelin	0	0	0	0	0.0%
Anglerfish	0	0	0	1478	0.0%
2016					
NEA cod	3619	0	0	849422	0.4%
Coastal cod	0	0	0	54767	0.0%
NEA haddock	7	0	0	233416	0.003%
NEA saithe	81	0	0	140392	0.06%
Sebastes mentella	0	7170	0	35429	20.2%
Sebastes norvegicus	10	0	0	4674	0.2%
Greenland halibut	363	5	0	24972	1.5%
Capelin	0	0	0	0	0.0%
Anglerfish	0	0	0	1435	0.0%
2015					
NEA cod	9	0	0	864384	0.001%
Coastal cod	0	0	0	35843	0.0%
NEA haddock	702	0	0	194756	0.4%
NEA saithe	30	0	0	131765	0.0%
Sebastes mentella	0	4752	0	25856	18.4%
Sebastes norvegicus	13	0	0	3632	0.4%
Greenland halibut	55	0	0	24748	0.2%
Capelin	0	0	0	115044	0.0%

	ICES 1.a	ICES 2.a.1	ICES 2.b.1	Total	%NEAFC
Anglerfish	0	0	0	1043	0.0%
2014					
NEA cod	534	0	0	986449	0.1%
Coastal cod	0	0	0	33660	0.0%
NEA haddock	0	0	0	177522	0.0%
NEA saithe	0	0	0	132005	0.0%
Sebastes mentella	0	4020	0	18780	21.4%
Sebastes norvegicus	0	0	0	4438	0.0%
Greenland halibut	211	0	0	23025	0.9%
Capelin	0	0	0	66000	0.0%
Anglerfish	0	0	0	1657	0.0%

1.6 Uncertainties in survey data

This section is retained for information, although 2021 data were not available to ICES due to the decision to suspend Russian participation. This section is therefore not updated for 2021.

While the area coverage of the winter surveys for demersal fish was incomplete in 1997 and 1998, the coverage was normal for these surveys in 1999–2002. In autumn 2002, 2006 and winter 2003, 2007, 2016 and 2017 however, surveys were again incomplete due to lack of access to both the Norwegian and Russian Economic Zones. This affects the reliability of some of the most important survey time-series for cod and haddock and consequently also the quality of the assessments.

It is very important that the Norwegian and Russian authorities give each other's research vessels full access to the respective economic zones when assessing the joint resources, as was the case for Joint winter surveys (BS-NoRu-Q1 (Btr) and BS-NoRu-Q1 (Aco)) in 2004–2005, 2008–2011 and 2013, for example. This is the case regardless of if advice is conducted within or outside ICES.

The area coverage in the winter survey was extended from 2014 onwards (Figure 0.2, Table 3.5). With the recent expansion of the cod distribution, it is likely that in years before 2014 the coverage in the February survey (BS-NoRu-Q1 (BTr) and BS-NoRu-Q1 (Aco)) has been incomplete, in particular for the younger ages. This could cause a bias in the assessment, but the magnitude is unknown. The 2014–2021 surveys covered considerably larger areas than earlier winter surveys and showed that cod, haddock and Greenland halibut was distributed far outside the standard survey area. The 2017 and 2018 surveys were restricted by ice Northeast of Hopen Island, and the survey did not extend quite as far as in the years 2014–2016. In 2019 the coverage was almost as extensive as in 2014. Coverage in 2020-2022 was less extensive mainly due to increased ice cover in the east. For all stocks except Greenland halibut, mainly younger age groups are found in the northern area. It should however be noted that the survey index from this survey is currently not used in the assessment of Greenland halibut.

The survey estimates within the new, extended area are now used for the tuning data for cod, but with the bottom trawl series split in 2014, as decided at the WKBARFAR 2021 benchmark.

For haddock, the new northern area is also included as decided at the WKDEM benchmark in 2020.

There are also other issues with incomplete survey coverage of stocks, e.g. haddock off the Norwegian coast south of Finnmark is not covered in the winter survey and the *S. mentella* survey in the Norwegian Sea does not cover the entire distribution area.

From 2004 onwards, a joint Norwegian-Russian survey has been conducted in August-September. This is a multi-purpose survey termed an "ecosystem survey" because most of the ecosystem is covered; including an acoustic survey for the pelagic species, which is used for capelin assessment, and a bottom trawl survey which includes non-commercial species. The ecosystem survey is now included in both cod and haddock assessments. The survey is also utilized in the assessment of redfish and Greenland halibut.

In 2018, a large area in the eastern Barents Sea was not covered due to technical problems with one vessel, while in 2019, most of the Barents Sea was covered except parts of the International waters and the Northeastern most part. In 2020 the spatial coverage was good, but for COVID-19 related reasons, the survey was less synoptic than usual as the time between the start and end of the survey was 13 weeks while the normal is about 8 weeks. Also, one of the vessels used had not previously been used in this type of bottom trawl surveys. The bottom trawl survey indices for cod and haddock from this survey in 2020 were considerably lower than expected, in particular for cod, but it was decided to include them in the assessment. Also, the survey coverage for capelin was not complete at the time assessment and advice had to be provided. Although this did not affect the advice this year, which would have been zero catch even when using the final estimate for the entire area, that may not be the case in future. Spatial coverage in 2021 was good except that the International waters ("Loophole") was not covered.

It is very important that this survey should be continued with complete spatial coverage and as synoptic as possible. In addition to being the only survey used in capelin assessment and being used in assessment of demersal stocks, it has been shown to be valuable for sampling of synoptic ecosystem information, cover the entire area of fish distribution in the Barents Sea, and provide additional data on geographical distribution of demersal fish, which could prove valuable in future inclusion of more ecosystem information in the fish stock assessments.

The Norwegian coastal survey (NOcoast-Aco-4Q) has in its current design been conducted since 2002. The survey covers the coastal area, including most fjords, and shelf area, including banks, between Kirkenes in northern Norway and Stadt off central Norway. The survey area is divided into seventeen strata, each containing several substrata, and is generally covered by two vessels, which collect acoustic data along defined transects and catch and biological data from both fixed bottom trawl stations and trawl stations identifying acoustic registrations. The coverage of the area has been fairly consistent throughout the time-series. In 2020 bad weather prevented the coverage of three substrata in the southern part of the survey area. Historically the contribution of these areas to the saithe and coastal cod survey index has been low, and it is therefore assumed that the lack of coverage of these areas in the 2020 estimate will not affect the final survey index.

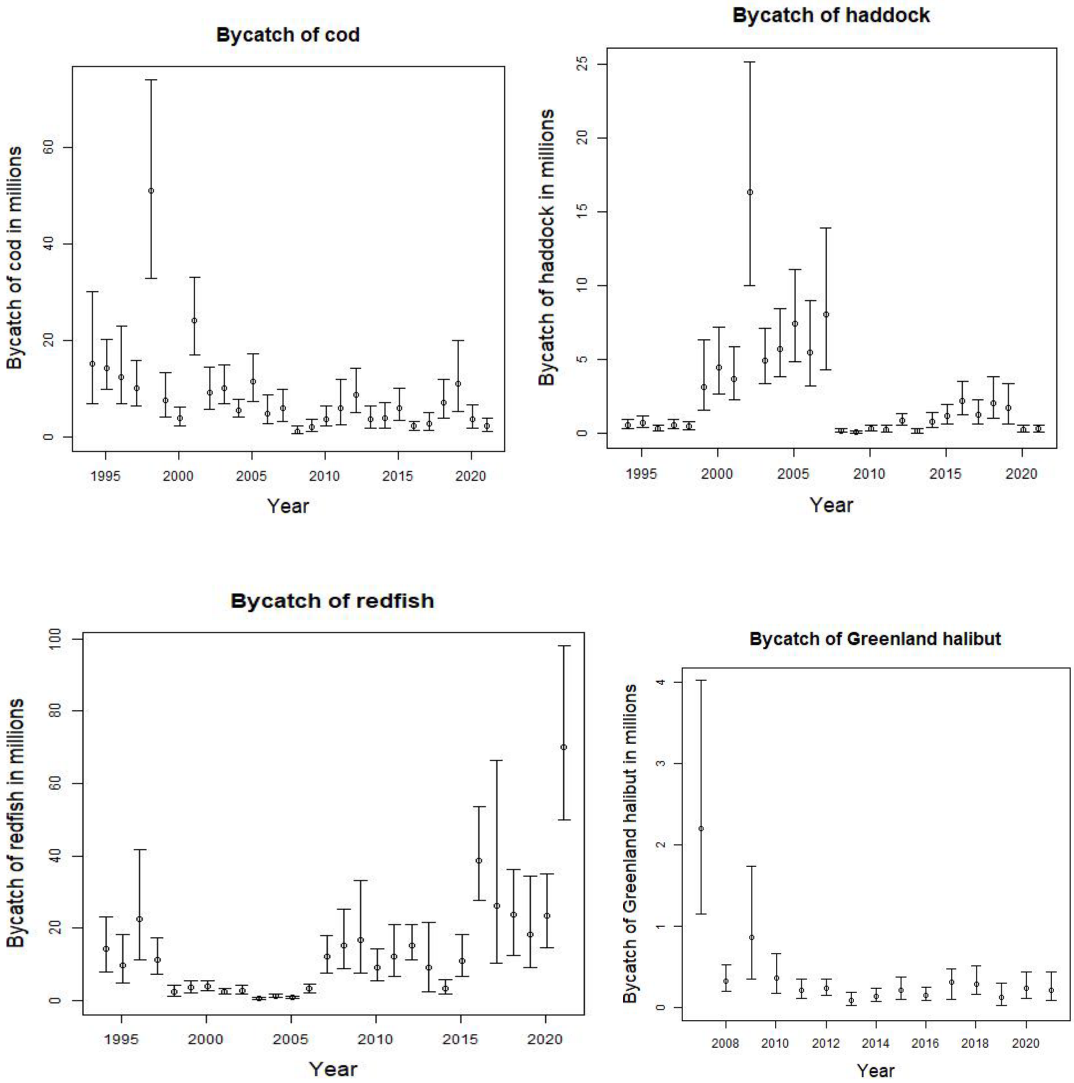


Figure 0.1. Estimated bycatch of cod, haddock, redfish and Greenland halibut in the Barents Sea shrimp fishery. Intervals are 90% confidence intervals.

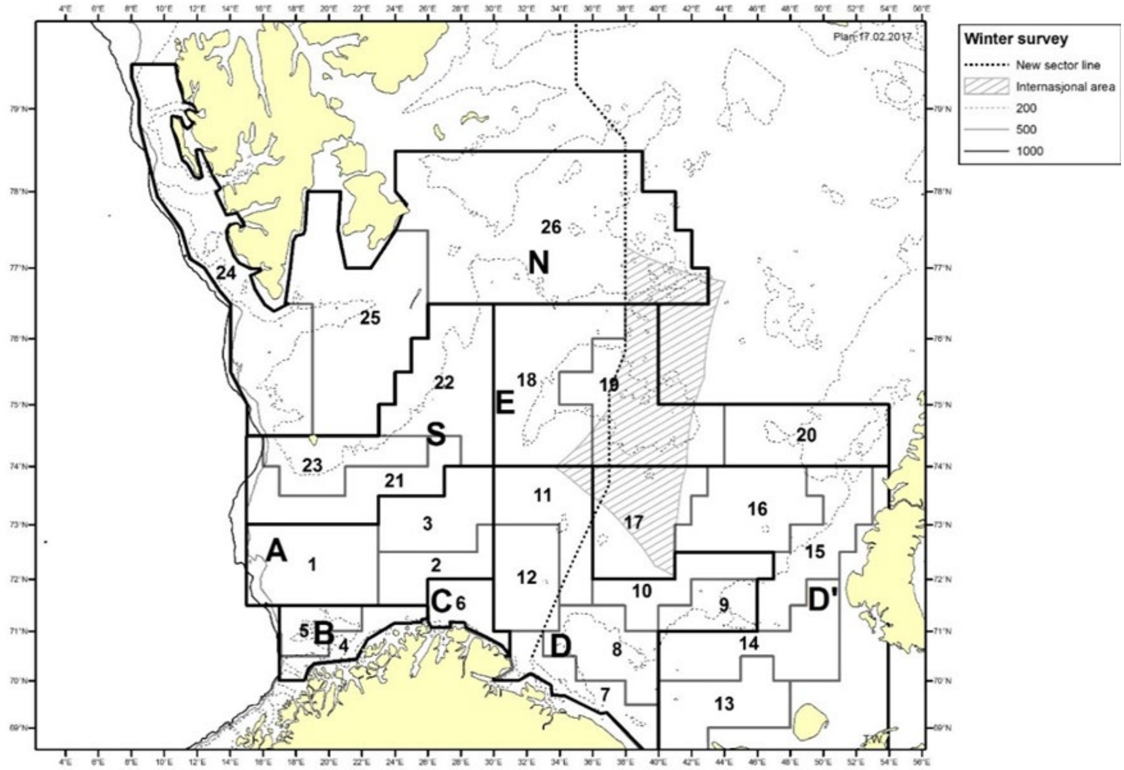


Figure 0.2. Strata (1–26) and main areas (A,B,C,D,D',E and S) used for swept-area estimations and acoustic estimations with StoX. Strata (24–26, main area N) are covered since 2014, and are now included in the standard time-series.

After AFWG 2021 minor errors were discovered in the Norwegian SToX dataseries for 2021 for NEA cod and haddock. The advice has been updated and reflects the corrected data. However the values presented in this report are prior to the correction. More detail is given in the relevant stock sections.

1.7 Age reading

In 1992, PINRO, Murmansk and IMR, Bergen began a routine exchange program of cod otoliths to validate age readings and ensure consistency in age interpretations (Yaragina *et al.*, 2009b, AFWG 2008, WD 20). Later, a similar exchange program has been established for haddock, capelin, and *S. mentella* otoliths. Once a year (now every second year, no exchanges of redfish age readers so far) the age readers have come together and evaluated discrepancies, which are seldom more than 1 year, and the results show an improvement over the period, despite still observing discrepancies for cod in the magnitude of 15–30%. An observation that is supported by the results of an NEA cod otolith exchange between Norway, Russia, and Germany (Høie *et al.*, 2009; AFWG 2009, WD 6). 100 cod otoliths were read by three Norwegian, two Russian and one German reader, reaching nearly 83% agreement (coefficient of variation 8%). The age reading comparisons of these 100 cod otoliths show that there are no reading biases between readers within each country. However, there is a clear trend of bias between the readers from different countries, Russian age readers assign higher ages than the Norwegian and German age readers. This systematic difference is a source of concern and is also discussed in Yaragina *et al.* (2009b). This seems to be a persistent trend and will be revealed in the following annual otolith and age reader exchanges.

From 2009 onwards, it was decided to have meetings between cod and haddock otolith readers only every second year. The overall percentage agreement for the 2017–2018 exchange was 87.7% for cod (WD 08), which was a little lower than at the previous meeting. The general trend is that the Russian readers assigned slightly higher ages than the Norwegian readers compared to the modal age for age group 7 years and older. The main reason for cod ageing discrepancies between Russian and Norwegian specialists was still a result of different interpretations of the false zones. This can partly be caused by different reading techniques, i.e. IMR reading opaque zones and PINRO reading translucent zones. For haddock, the main reason for discrepancies between PINRO and IMR readers was a different interpretation of the otolith summer structures in the first and second year of fish, life due to false zones. Sometimes discrepancies were caused by a different interpretation of the latest increments that were very thin in some cases.

For both species, the samples collected in autumn appeared to be the hardest to interpret. The main reason for that seems to be difficulties in determining if the marginal increment represents summer (opaque) or winter (translucent) growth.

A positive development is seen for haddock age readings showing that the frequency of a different reading (usually ±1 year) has decreased from above 25% in 1996–1997 to about 10% at present. The discrepancies are always discussed and a final agreement on the exchanged cod and haddock otoliths is achieved for all otoliths at present, except ca. 2–5%. For haddock, the overall percentage agreement for recent data (2017–2018) was 88.1% and the precision CV was 3.0%, the same values for cod totalled 87.7% and 3.7% accordingly and considered to be satisfactory.

The workshop on cod and haddock otolith reading planned for May–June of 2021 was delayed and the date for the next workshop in uncertain.

As the EU catches only make up a few percent (<10%) of the total, the German and Spanish length and age data do not have a major impact on the assessment of the relevant stocks. But to use consistent datasets, regular age-reading comparisons should be made. EU age readers could be invited to the NOR-RUS exchanges and workshops.

To determine the effects of changes in age reading protocols between contemporary and historical practices, randomly chosen cod otolith material from each decade for the period 1940s–1980s has been re-read by experts (Zuykova *et al.*, 2009). Although some year-specific differences in age determination were seen between historical and contemporary readers, there was no significant effect on length-at-age for the historical period. A small systematic bias in the number spawning zones detection was observed, demonstrating that the age at first maturation in the historic material as determined by the contemporary readers is younger than that determined by historical readers. The difference was largest in the first sampled years constituting approximately 0.6 years in 1947 and 1957. Then it decreased with time and was found to be within the range of 0.0–0.28 years in the 1970–1980s. The study also shows that cod otoliths could be used for age and growth studies even after long storage.

For capelin otoliths, there is a very good correspondence between the Norwegian and Russian age readings, with a discrepancy in less than 5% of the otoliths. This was confirmed at the Norwegian-Russian age reading workshop on capelin in October 2011 (WD 13, 2012).

For some of the samples, a very high agreement was reached after the initial reading by the different experts. In other cases, some disagreement was evident after the first reading. After the initial reading, the results were analysed. The otoliths that caused disagreement were read again and discussed among the readers. After discussions about the reasons for disagreement, some readers wanted to change their view on some of the otoliths. When the samples were read once more, the agreement was 95%.

It was concluded that experts from all laboratories normally interpret capelin otoliths equally. Difficult otoliths are sometimes interpreted differently, but these samples are few, and should not cause large problems for common work on capelin biology and stock assessment. All participants noted the great value of conducting joint work on otolith reading, and it was decided to continue the programme of capelin otolith exchange and to involve the labs at Iceland and

Newfoundland in the exchange program. Readers from Norway and Russia should continue to meet at Workshops every second year. A capelin age reading Workshop was held in Murmansk in April 2016, and the report from that meeting was presented to the capelin assessment meeting in October 2016. An age reading Workshop for capelin was held in Murmansk in October 2019.

In order to achieve the most accurate age estimates, ICES recommends methods and best practices for age reading of both redfish and Greenland halibut. Still there continue to be differences in opinion between PINRO and IMR regarding age reading methods for these species. It is recommended to start an annual or biannual exchange of otoliths and age reading experts on these species in order to identify the differences in interpretation and to discuss possibilities for a common approach.

The report from the Workshop on Age Reading of Greenland Halibut (WKARGH; ICES CM 2011/ACOM:41) described and evaluated several age reading methods for Greenland Halibut. A second workshop (WKARGH 2) was conducted in August 2016 and worked on further validation on new age reading methods. The workshop recommended that two new methods can be used to provide age estimations for stock assessments. Further, recognizing some bias and low precision in methods, the WKARGH2 recommends that an ageing error matrix or growth curve with error be provided for use in future stock assessments (WKARGH2 report 2016, ICES CM 2016/SSGIEOM:16). WKARGH2 recommends regular inter-lab calibration exercises to improve precision (i.e. exchange of digital images between readers for each method and between methods). The new age readings are not comparable with older data or the Russian age readings, and the new methods show that the species is more slow-growing and vulnerable than the previous age readings suggest. AFWG suggests that Russian and Norwegian scientists and age readers meet to work out issues of disagreements on Greenland halibut aging.

From 2009 onwards, an exchange of *Sebastes mentella* otoliths is conducted annually between the Norwegian and Russian laboratories (see section 6.2.2). In 2011 ICES/PGCCDBS identified differences in the interpretation of age structure by different national laboratories and recommended that international exchanges of otoliths be conducted (ICES C.M. 2011/ACOM:40). The work was conducted during 2011 (Heggebakken, 2011) with participation from Canada, Iceland, Norway, Poland and Spain. Unfortunately, Russia did not respond to the invitation to participate. The agreement in age determination was 79.2% (with allowance for ±1 years) for all ages combined, but 38.6% when only fish older than 20 years were considered. It is recommended that 1) future exchanges be conducted every 3–5 years, 2) that these should primarily focus on 20+-year-old fish and 3) that Russian scientists contribute to future exchanges. A meeting between *S. mentella* age readers from Norway and Russia was held in 2013. Otolith exchanges took place in 2014. It is recommended that such meetings and otolith exchanges be conducted regularly in future.

1.8 Assessment method issues

For coastal cod, the benchmark has resulted in a split into two stocks. For the northern (north of 67 degrees) part there is now a SAM assessment model. There is also a newly adopted HCR to provide target fishing mortality, however there was not sufficient information to provide a reliable Blim. In addition, since this is the first assessment model it is likely that there will be a need for a revision once we accumulate some years' experience running the model. The southern (between 62 and 67 degrees north) now gives advice based on a 2-over-3 rule. A surplus production, based on the reference fleet CPUE, was developed. However, the CPUE time-series was too short to adequately tune the model. This should be investigated further as the time-series is extended, with a view to an eventual benchmark and adoption of the production model for assessment purposes.

Work is in progress on revising the capelin assessment methodologies, with a planned benchmark (in conjunction with Iceland) in 2022. Greenland halibut also has a benchmark (again jointly with Iceland) in 2022, planned to be followed by an HCR evaluation. For Greenland halibut the target F is the key issue, with the previous F_{pa} being rejected by the Advice Drafting Group. A revised F_{pa} has therefore been submitted. Although both capelin and Greenland halibut are being benchmarked through ICES, these are joint Norwegian-Russian stocks, and these models will not be used for ICES advice until the Russian suspension is lifted.

1.9 Environmental information included in the advice of NEA cod

For the fourteenth time, environmental information has been applied in the advice from AFWG. In this year's assessment ecosystem information was directly used in the projection of NEA cod. A combination of regression models, which is based on both climate and stock parameters, were used for the prediction of recruitment-at-age 3, see section 1.11.4.

In addition, the temperature is part of the NEA cod consumption calculations that goes into the historical back-calculations of the number of cod, haddock, and capelin eaten by cod.

1.10 Proposals for status of assessments in 2022–2023

For anglerfish there is currently no advice, however following the benchmark in 2018 we are now able to conduct an assessment and provide advice if requested to do so. Greenland halibut is assessed this year and will be benchmarked in 2022, although following the Russian suspension there will be no ICES advice in 2022. AFWG is providing advice for *Sebastes norvegicus*, but the next advice here will be in 2024, it is to be hoped following a benchmark.

Therefore we anticipate providing ICES assessments in 2022 for northern and southern coastal cod, saithe, and background information for managers on anglerfish. Given an absence of tuning data and the presence of external advice used by managers, there no plans to produce ICES advice for NEA cod, NEA haddock, *Sebastes mentella*, Greenland halibut and capelin until the Russian suspension is lifted.

For saithe the plan is a benchmark in 2024 together with North Sea saithe.

Table 0.1. Age and length sampling by Norway of commercial catches in 2008–2021. Number of samples and average number of fish per sample. Also, number of age samples and aged individuals per 1000 t caught. For comparison, also the EU DCF requirements are shown.

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
NEA-cod + coastal cod												
	2008	336	2526	51263		464	16026	196067	12.9	2.4	81.7	125
	2009	272	2669	53350		417	14170	224816	11.9	1.9	63.0	125
	2010	175	2542	39733		338	7671	263816	9.6	1.3	29.1	125
	2011	273	2305	46227		434	10043	331535	7.0	1.3	30.3	125
	2012	356	3132	57954		618	14710	363207	8.6	1.7	40.5	125
	2013	266	2917	81583	84	1275	13940	464258	6.3	2.7	30.0	125
	2014	556	2063	254627	306	1170	14815	465554	4.4	2.5	31.8	125
	2015	498	1654	130514	89	1392	16500	413741	4.0	3.4	39.9	125
	2016	482	2500	91590	401	1398	17027	403907	6.2	3.5	42.2	125
	2017	413	2615	91366	348	1458	15471	408423	6.4	3.6	37.9	125
	2018	873	3163	122788	346	1545	15535	369897	8.6	4.2	42.0	125
	2019	842	3093	135375	337	1457	12519	322233	9.6	4.5	38.9	125
	2020	389	1869	53587	259	653	12431	334773	5.6	2.0	37.1	125
NEA-haddock												

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2008	285	2177	45038		281	9474	72553	30.0	3.9	130.6	125
	2009	233	2255	41481		206	6010	104882	21.5	2.0	57.3	125
	2010	154	2155	38045		232	5458	123517	17.4	1.9	44.2	125
	2011	227	2028	39663		312	7225	158293	12.8	2.0	45.6	125
	2012	258	2609	47995		386	8191	159008	16.4	2.4	51.5	125
	2013	89	2142	62193	86	965	5718	99127	21.6	9.7	57.7	125
	2014	425	1479	114560	126	825	7297	91333	16.2	9.0	79.9	125
	2015	397	1380	76574	47	967	8394	95086	14.5	10.2	88.3	125
	2016	237	1986	47032	208	391	8202	108718	18.3	3.6	75.4	125
	2017	215	2108	57461	150	1084	8805	113206	18.6	9.6	77.8	125
	2018	536	2435	85303	130	1088	8397	93839	25.9	11.6	89.5	125
	2019	497	2269	83378	123	1003	7652	93860	24.2	10.7	81.5	125
	2020	142	1055	32009	70	342	6589	88108	12.0	3.9	74.8	125
NEA-saithe												
	2008	252	1327	19419		160	5262	165998	8.0	1.0	31.7	125
	2009	182	1337	13354		113	2981	144570	9.2	0.8	20.6	125
	2010	138	1316	15998		151	3667	174544	7.5	0.9	21.0	125

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2011	152	1210	17412		215	4843	143314	8.4	1.5	33.8	125
	2012	209	1474	19191		204	4113	143104	10.3	1.4	28.7	125
	2013	87	1570	69469	69	788	5507	111981	14.0	7.0	49.2	125
	2014	192	697	54365	94	575	5390	115880	6.0	5.0	46.5	125
	2015	206	839	69375	43	614	6484	114830	7.3	5.3	56.5	125
	2016	226	1448	52376	151	737	7278	121710	11.9	6.1	59.8	125
	2017	195	1416	42812	141	788	6348	128651	11.0	6.1	49.3	125
	2018	388	1665	43938	148	823	6937	162454	10.2	5.1	42.7	125
	2019	380	1629	43503	136	817	6552	144133	11.3	5.7	45.5	125
	2020											
Beaked redfish (*S. Norvegicus*)												
	2008	104	1093	18305		98	2281	6180	176.9	15.9	369.1	125
	2009	66	1131	17386		96	2302	6215	182.0	15.4	370.4	125
	2010	49	1050	19339		97	2164	6515	161.2	14.9	332.2	125
	2011	75	1064	16347		106	2310	4645	229.1	22.8	497.3	125
	2012	78	993	12994		76	1297	4250	39.1	3.1	56.7	125
	2013	35	654	627	17	74	1122	4244	154.1	17.4	264.4	125

Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
2014	24	66	919	24	24	365	3053	21.6	7.9	119.6	125
2015	28	121	3497	22	405	1281	2492	48.6	162.5	514.0	125
2016	54	642	2376	36	517	1585	4606	139.4	112.2	344.1	125
2017	69	695	6177	44	571	1633	3354	207.2	170.2	486.9	125
2018	64	778	7354	32	629	1252	4287	181.5	146.7	292.0	125
2019	34	850	10007	34	226	1819	5951	142.8	38.0	305.7	125
2020	37	822	10176	37	193	1537	6503	126.4	29.7	236.3	125
2021	31	916	11069	31	0	0	7701	118.9	0	0	125
Golden redfish (*S. mentella*) **											
2008	13	178	1038		0	0	2214	80.4	0.0	0.0	125
2009	12	319	1841		2	40	2567	124.3	0.8	15.6	125
2010	11	284	3664		11	320	2245	126.5	4.9	142.5	125
2011	9	255	3210		11	298	2690	94.8	4.1	110.8	125
2012	13	166	2187		13	241	2098	79.1	6.2	114.9	125
2013	14	184	383	5	13	390	1361	135.2	9.6	286.6	125
2014	11	36	4664	12	49	5	13402	2.7	3.7	0.4	125
2015	21	166	23794	10	21	184	19700	8.4	1.1	9.3	125

Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
2016	23	285	5470	9	22	169	19083	15.0	1.2	8.9	125
2017	30	256	3196	24	211	24	17280	14.8	12.2	1.4	125
2018	39	409	8782	20	364	25	19287	21.2	18.9	1.3	125
2019	17	352	5897	17	38	329	23844	14.8	1.6	13.8	125
2020	19	494	10963	19	76	694	32950	15.0	2.3	21.1	125
2021	16	627	17161	16	0	0	43797	14.3	0	0	125
Greenland halibut											
2008	53	580	9074		0	0	7394	78.4	0.0	0.0	125
2009	36	922	12853		0	0	8446	109.2	0.0	0.0	125
2010	26	519	8395		0	0	7685	67.5	0.0	0.0	125
2011	29	463	8204		0	0	8273	56.0	0.0	0.0	125
2012	34	610	7716		0	0	10074	60.6	0.0	0.0	125
2013	26	597	4930		0	0	12613	47.3	0.0	0.0	125
2014	33	236	2559	10	0	0	10876	21.7	0.0	0.0	125
2015	31	273	8769	11	0	0	10704	25.5	0.0	0.0	125
2016	83	384	2304	60	0	0	12573	30.5	0.0	0.0	125
2017	67	556	10022	43	317	0	13194	42.1	24.0	0.0	125

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2018	96	582	11720	63	342	0	14876	39.1	23.0	0.0	125
	2019	61	394	9286	47	80	0	14813	26.6	5.4	0.0	125
	2020	80	429	9110	52	80	0	14532	29.5	5.5	0.0	
Anglerfish*****												
	2013	8	55	1551	0	0	0	2988	18	36.5	0.0	125
	2014	8	33	836	0	0	0	1655	19	18.1	24.8	125
	2015	8	74	2054	0	0	0	933	82	35.3	0.0	125
	2016	8	57	1339	0	0	0	1355	41	17.9	0.0	125
	2017	8	88	3604	0	0	0	1473	59	23.8	0.7	125
	2018	8	94	3233	0	0	0	1884	49	24.4	1.1	125
	2019	8	68	3223	0	0	0	2750	24	22.5	0.0	125
	2020	8	89	4129	0	0	0	2258	39	0	0.0	
Capelin												
	2008	4	3	150		0	0	5000	0.6	0.0	0.0	125
	2009	18	97	7039		39	1039	233000	0.4	0.2	4.5	125
	2010	75	230	6191		47	1291	246000	0.9	0.2	5.2	125
	2011	115	315	8346		48	1313	273000	1.2	0.2	4.8	125

Year	No of unique vessels	No of length samples	No of length-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landing tonnes	Length-samples per 1000 t	Age samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison per 1000 t
2012	84	308	9337		29	843	181328	1.7	0.2	4.6	125
2013	12	213	12215	47	47	773	156340	1.4	0.3	4.9	125
2014	27	113	9054	1	8	1086	40021	2.8	0.2	27.1	125
2015	65	722	83776	65	722	5393	71435	10.1	10.1	75.5	125
2016	7	27	1863	7	27	649					125
2017	21	43	2294	14	25	305					125
2018	68	207	15022	33	76	823	123461	1.7	0.6	6.7	125
2019	4	26	260	2	13	0	0				125
2020							0				

****In addition to age the otoliths are also used for identification of coastal cod.**

****Age samples from surveys with commercial trawl come in addition.**

*****From 2013 No. of unique vessels are split by length and age samples.**

******Only from large, meshed gillnets as basis for assessment.**

Table 0.2. Age and length sampling by Russia of commercial catches and age sampling of surveys in 2008–2020. Also length-measured individuals and aged individuals per 1000 t caught. For comparison also the EU DCF requirements are shown.

	Year	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
NEA-cod*										
	2008	380592	3097	7565	10662	190225	2001	16.3	56.0	125
	2009	178038	1075	7426	8501	229291	776	4.7	37.1	125
	2010	126502	1828	7670	9498	267547	473	6.8	35.5	125
	2011	122623	2376	5783	8159	310326	395	7.7	26.3	125
	2012***	140028	2040	7742	9782	329943	424	6.2	29.6	125
	2013	131455	1999	8103	10102	432314	304	4.6	23.4	125
	2014	114538	3110	7154	10264	433479	264	7.2	23.7	125
	2015***	105721	2486	6095	8581	381188	277	6.5	22.5	125
	2016	158006	5090	2704	7794	394107	401	12.9	19.8	125
	2017	161192	4918	6121	11039	396195	407	12.4	27.9	125
	2018	157048	3129	1982	5111	340364	461	9.2	15.0	125
	2019***	83018	2093	3737	5830	316813	262	6.6	18.4	125
	2020***	112950	3105	3858	6963	312683	361	9.9	22.3	125
NEA-haddock										

	Year	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2008	216959	2498	5677	8175	68792	3154	36.3	118.8	125
	2009	43254	489	5421	5910	85514	506	5.7	69.1	125
	2010	85445	834	5060	5894	111372	767	7.5	52.9	125
	2011	61990	1570	3584	5154	139912	443	11.2	36.8	125
	2012***	87880	1545	5034	6579	143886	611	10.7	45.7	125
	2013	42927	1205	4021	5226	85668	501	14.1	61.0	125
	2014	45447	899	3796	4695	78725	577	11.4	59.6	125
	2015***	31009	914	2972	3886	91864	338	9.9	42.3	125
	2016	55598	2691	1884	4575	115710	480	23.3	39.5	125
	2017	74297	3554	2614	6168	106714	696	33.3	57.8	125
	2018	61360	2274	1136	3410	90486	678	25.1	37.7	125
	2019***	44728	1923	1778	3701	76125	588	25.3	48.6	125
	2020***	69301	2356	1575	3931	89030	778	26.5	44.2	125
NEA-saithe										
	2008	8865	479	175	654	11577	766	41.4	56.5	125
	2009	5279	7	68	75	11899	444	0.6	6.3	125
	2010	422	112	249	361	14664	29	7.6	24.6	125

	Year	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2011	88	9	27	36	10007	9	0.9	3.6	125
	2012	4062	145	104	249	13607	299	10.7	18.3	125
	2013	17124	402	76	478	14796	1157	27.2	32.3	125
	2014	2302	278	26	304	12396	186	22.4	24.5	125
	2015	1505	104	131	235	13181	114	7.9	17.8	125
	2016	4233	272	16	288	15203	278	17.9	18.9	125
	2017	1762	228	110	338	14551	121	15.7	23.2	125
	2018	4758	454	9	463	14171	336	32.0	32.7	125
	2019	4528	94	0	94	13990	324	6.7	6.7	125
	2020	83	17	96	113	14082	6	1.2	8.0	125
S. norvegicus										
	2008	1196	45	17	62	749	1597	60.1	82.8	125
	2009	241	2	27	29	698	345	2.9	41.5	125
	2010	486	25	199	224	806	603	31.0	277.9	125
	2011	885	77	62	139	919	963	83.8	151.3	125
	2012	1564	58	54	112	681	2297	85.2	164.5	125
	2013	770	22	142	164	797	966	27.6	205.8	125

	Year	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2014	589	25	33	58	806	731	31.0	72.0	125
	2015	120		20	20	664	181	0.0	30.1	125
	2016	1113	147	34	181	776	1434	189.4	233.2	125
	2017	1426	86	101	187	1131	1261	76.0	165.3	125
	2018	1877	30	21	51	1546	1214	19.4	33.0	125
	2019	1015	150	0	150	1804	563	83.2	83.2	125
	2020	2107	47	31	78	2492	846	18.9	31.3	125
S. mentella										
	2008	21446	471	3379	3850	7117	3013	66.2	541.0	125
	2009	29435	761	1447	2208	3843	7659	198.0	574.6	125
	2010	2776	100	2295	2395	6414	433	15.6	373.4	125
	2011	917	7	640	647	5037	182	1.4	128.4	125
	2012	7802	422	1146	1568	4101	1902	102.9	382.3	125
	2013	19092	1253	1625	2878	3677	5192	340.8	782.7	125
	2014	817	25	1297	1322	1704	479	14.7	775.8	125
	2015	771		1818	1818	1142	675	0.0	1591.9	125
	2016	27765	1076	85	1161	8419	3298	127.8	137.9	125

	Year	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2017	958	99	1000	1099	4952	193	20.0	221.9	125
	2018	21004	845	39	884	10497	2001	80.5	84.2	125
	2019	6881	400	469	869	13164	523	30.4	66.0	125
	2020	8718	340	612	952	13997	623	24.3	68.0	125
Greenland halibut										
	2008	106411	1519	3366	4885	5294	20100	286.9	922.7	125
	2009	77554	819	2282	3101	3335	23255	245.6	929.8	125
	2010	32090	416	2784	3200	6888	4659	60.4	464.6	125
	2011	9892	115	1541	1656	7053	1403	16.3	234.8	125
	2012	82943	2140	2506	4646	10041	8260	213.1	462.7	125
	2013	12608	555	2756	3311	10310	1223	53.8	321.1	125
	2014	24346	633	2106	2739	10061	2420	62.9	272.2	125
	2015	22116	575	2489	3064	12953	1707	44.4	236.5	125
	2016	11818	574	221	795	10576	1117	54.3	75.2	125
	2017	24061	1205	1579	2784	10713	2246	112.5	259.9	125
	2018	21893	954	308	1262	12072	1814	79.0	104.5	125
	2019	861	125	1552	1677	12198	71	10.2	137.5	125

	Year	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2020	1387	165	1853	2018	12266	113	13.5	164.5	125
Capelin										
	2008**	82625	1644	2341	3985	5000	16525	328.8	797.0	125
	2009	94541	900	2511	3411	73000	1295	12.3	46.7	125
	2010	67265	1072	4043	5115	77000	874	13.9	66.4	125
	2011	63784	1273	2271	3544	86531	737	14.7	41.0	125
	2012	20023	1130	1783	2913	68182	294	16.6	42.7	125
	2013	54708	1565	1007	2572	60413	906	25.9	42.6	125
	2014	13206	850	1249	2099	25720	513	33.0	81.6	125
	2015	27200	1000	1004	2004	115				125
	2016	8669	3954	1047	5001	0				125
	2017			4115	4115	6				125
	2018	14491	250	1050	1300	65934	220	3.8	19.7	125
	2019			1498	1498	34				125
	2020			1245	1245	19				125

***In addition also used long-term mean age–length keys.**

****Age samples from surveys with commercial trawl come in addition.**

*****In addition used samples from Russian vessels, sampled by the Norwegian Coast Guard in 2012, 2015, 2019 and 2020.**

Table 0.3. Age and length sampling by Spain[5] of commercial catches and length sampling of surveys in 2008–2021. Also length-measured individuals and aged individuals per 1000 t caught. For comparison also the EU DCF requirements are shown.

Stock	Year	No of vessels	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
NEA-cod											
	2008	2	10108	610		610	9658	1047	63	63	125
	2009	2	8733	1834		1834	12013	727	153	153	125
	2010	2	28297	1735		1735	12657	2236	137	137	125
	2011	2	11633	964		964	13291	875	73	73	125
	2012	2	9849	998		998	12814	769	78	78	125
	2013	2	30295	2381		2381	15041	2014	158	158	125
	2014	2	27828	2306		2306	16479	1689	140	140	125
	2015	2	18568	1445		1445	18772	989	77	77	125

[5] The onshore and the at-sea sampling programs coordinated by the IEO were suspended in most of 2020, due notably to administrative problems and to a lesser extend to COVID-19. This affected all stocks. Both sampling programmes are hired by IEO through call for tenders addressed to specialized companies. The public tender launched in 2019 (to start in 2020) was declared void, having to be re-launched again. This second launch was delayed as a result of the paralysis of public activity during the state of alarm due to the COVID-19 pandemic and could only be reopened in June-July. Given that the process of awarding the contract by public tender takes three-four months under normal conditions, it was finally resolved in December 2020 and signed in January 2021. Since then all activities have been resumed. The sampling to obtain the biological variables of the population (mainly reproduction and growth) is normally carried out in the IEO laboratories. This activity has also faced problems in 2020. On the one hand the administrative and financial difficulties of the IEO prevented the purchasing of samples in the market and on the other hand the three months closure of the labs (15 March to 21 June) due to COVID-19 did not allow for a normal activity.

Stock	Year	No of vessels	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2016	2	27937	1246		1246	14640	1908	85	85	125
	2017	2	33984	2018		2018	14414	2358	140	140	125
	2018	1	25933	911		911	14415	1799	63	63	125
	2019	1	5781	1117		1117	13939	415	80	80	125
	2020						11403				125
	2021	2	23891	1314		1314	11080	2156	119	119	125
NEA-haddock*											
	2009	1	2561				240				
	2010	1	3243				379				
	2011	1	1796				408				
	2012	2	3198				647				
	2013	1	660				413				
	2014	1	2460				370				
	2015	1	702				418				
	2016	2	701				357				
	2017	1	710				156				
	2018	1	154				169				

Stock	Year	No of vessels	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2019						280				
	2020						45				
	2021						131				
NEA-saithe											
	2009	1	123				2				
	2013	1					5				
	2014	1					13				
	2015	1					33				
	2016						25				
	2017						85				
	2018						60				
	2019						199				
	2020						0				
	2021						3				
S. mentella											
	2008**	1	2275	28			987	2304	28	0	125
	2011*	1	86				1237				

Stock	Year	No of vessels	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2012**	2	11579	476			1612	7183	295	0	125
	2014**	1	6177				1146	5390			
	2015**	1	6117				2371	2580			
	2016**	1	11806				3133	3768			
	2017**	1	5015				2624	1911			
	2018**	1	11638				2399	4851			
	2019**	1	11952				1908	6265			
	2020**						737				
	2021**	1	2074	157			280	7396			
Greenland halibut											
	2008	2	11662				112	103826			
	2009	1	3383				210	16143			
	2010	1	5783				182	31800			
	2011	1	8541				169	50600			
	2012	1	4809				186	25907			
	2013	1	11988				190	63019			
	2014	1	12002				206	58262			

Stock	Year	No of vessels	No of length-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total no of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison per 1000 t
	2015	1	17552				111	158126			
	2016	1	15031				218	68837			
	2017										
	2018										
	2019	1					49				
	2020						96				
	2021						125				

***Sampling from bycatch in cod fishery.**

****Sampling from pelagic redfish fishery.**

*****Sampling from Spanish Greenland halibut survey.**

Table 0.4. Age and length sampling by Germany of commercial catches and age sampling of surveys in 2008–2021. Also length-measured individuals and aged individuals per 1000 t caught. For comparison also the EU DCF requirements are shown.

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
NEA cod									
	2008	5	3	65800	2033	4955	13280	410	125
	2009	5	2	43107	2419	8585	5021	282	125
	2010	5	2	51923	3075	8442	6151	364	125

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
	2011	4	1	7318	769	4621	1584	166	125
	2012	4	2	16315	1924	8500	1919	226	125
	2013	4	2	29281	2043	7939	3688	257	125
	2014	4	1	23137	1291	6225	3717	207	125
	2015	4	1	39335	886	6427	6120	138	125
	2016	3	1	22109	1060	6636	3332	160	125
	2017	4	1	19942	785	5969	3341	132	125
	2018	4	2	43371	2283	7774	5579	294	125
	2019	2	1	17954	1444	8535	2104	169	125
	2020	2	1	21716	1021	9786	2219	104	125
	2021	2	1	21548	1393	5470	3939	255	125
NEA haddock									
	2008	5	3	5548	442	535	10370	826	125
	2009	5	2	23348	958	1957	11931	490	125
	2010	5	2	54704	1039	3539	15457	294	125
	2011	4	1	1925	160	1724	1117	93	125
	2012	4	2	4088	502	1111	3680	452	125
	2013	4	1	7040	478	501	14052	954	125

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
	2014	4	1	3113	261	340	9156	768	125
	2015	4	1	616	325	124	4968	2621	125
	2016	3	1	4807	544	170	28276	3200	125
	2017	4	1	3464	527	155	22348	3400	125
	2018	4	2	4345	497	391	11113	1271	125
	2019	2	1	5031	393	208	24188	1889	125
	2020	2	1	2979	356	283	10527	1258	125
	2021	2	1	2808	344	368	7630	935	125
NEA saithe									
	2008	5	3	10210	605	2263	4512	267	125
	2009	6	2	8667	1091	2021	4288	540	125
	2010	7	2	11424	1001	1592	7176	629	125
	2011	4	1	4863	530	1371	3547	387	125
	2012	7	2	14193	1202	1371	10356	877	125
	2013	4	1	1190	414	1212	982	342	125
	2014	3	1	25	0	259	97	0	125
	2015	4	0	0	0	424	0	0	125
	2016	3	1	13981	909	951	14701	956	125

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
	2017	4	1	15734	603	1154	13634	523	125
	2018	4	1	19718	473	1651	11943	286	125
	2019	2	1	9465	1521	1387	6824	1097	125
	2020	2	1	11900	745	1573	7565	474	125
	2021	2	1	3707	784	597	6209	1313	125
Redfish									
	2008	5	3	330	0	46	7174	0	125
	2009	8	2	0	0	100	0	0	125
	2010	6	2	0	0	52	0	0	125
	2011	6	1	7937	0	844	9404	0	125
	2012	9	2	4036	0	584	6911	0	125
	2013	4	1	1315	0	81	16235	0	125
	2014	4	1	571	0	451	1266	0	125
	2015	4	1	76	0	266	286	0	125
	2016	3	1	6095	0	497	12264	0	125
	2017	4	1	977	0	770	1269	0	125
	2018	4	2	3438	0	2508	1371	0	125
	2019	2	1	8958	0	1741	5145	0	125

	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings tonnes	Length-measured individuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
	2020	3	1	4248	0	1998	2126	0	125
	2021	2	1	2261	0	743	3043	0	125
Greenland halibut									
	2008	5	2	0	0	5	0	0	125
	2009	3	2	0	0	19	0	0	125
	2010	2	2	0	0	14	0	0	125
	2011	3	1	0	0	81	0	0	125
	2012	4	2	0	0	40	0	0	125
	2013	3	1	1298	0	49	26544	0	125
	2014	4	1	1076	0	34	31647	0	125
	2015	4	1	658	0	32	20563	0	125
	2016	3	1	365	0	9	40556	0	125
	2017	4	1	0	0	21	0	0	125
	2018	4	1	257	0	52	4942	0	125
	2019	2	1	511	0	45	11356	0	125
	2020	2	1	305	0	74	4122	0	125
	2021	2	1	160	0	72	2222	0	125

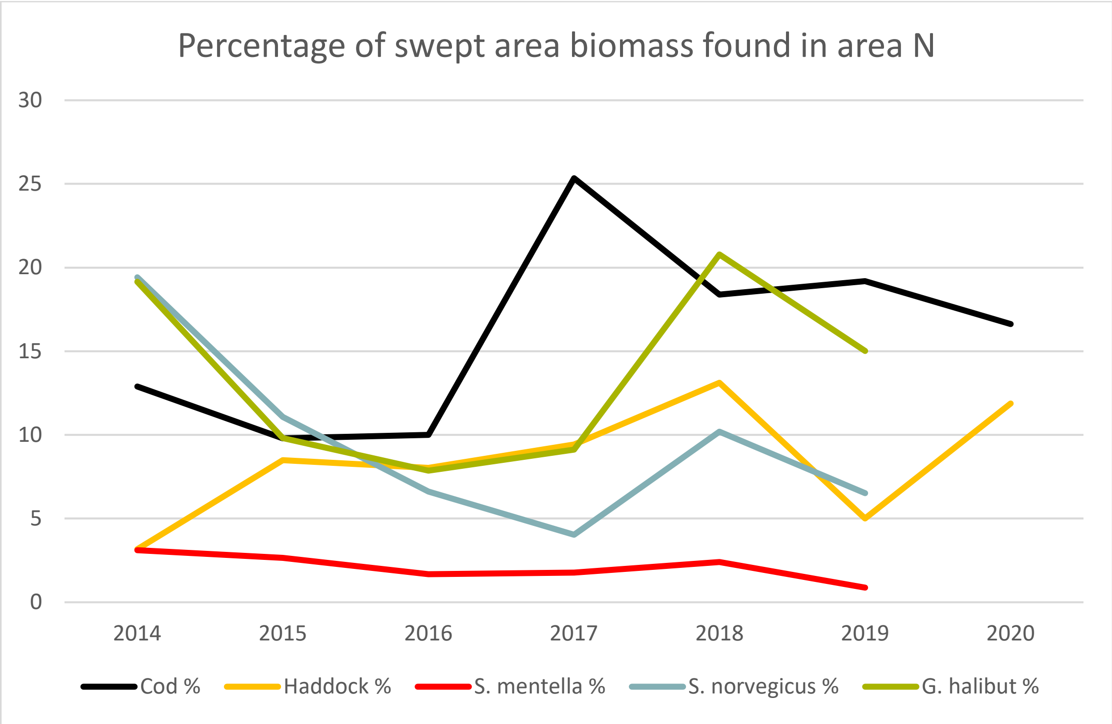


Figure 0.3. Proportion of swept-area biomass in the Joint winter survey found in the new northern area (N), by year and species. For 2020 the indices for redfish and Greenland halibut have not yet been calculated.

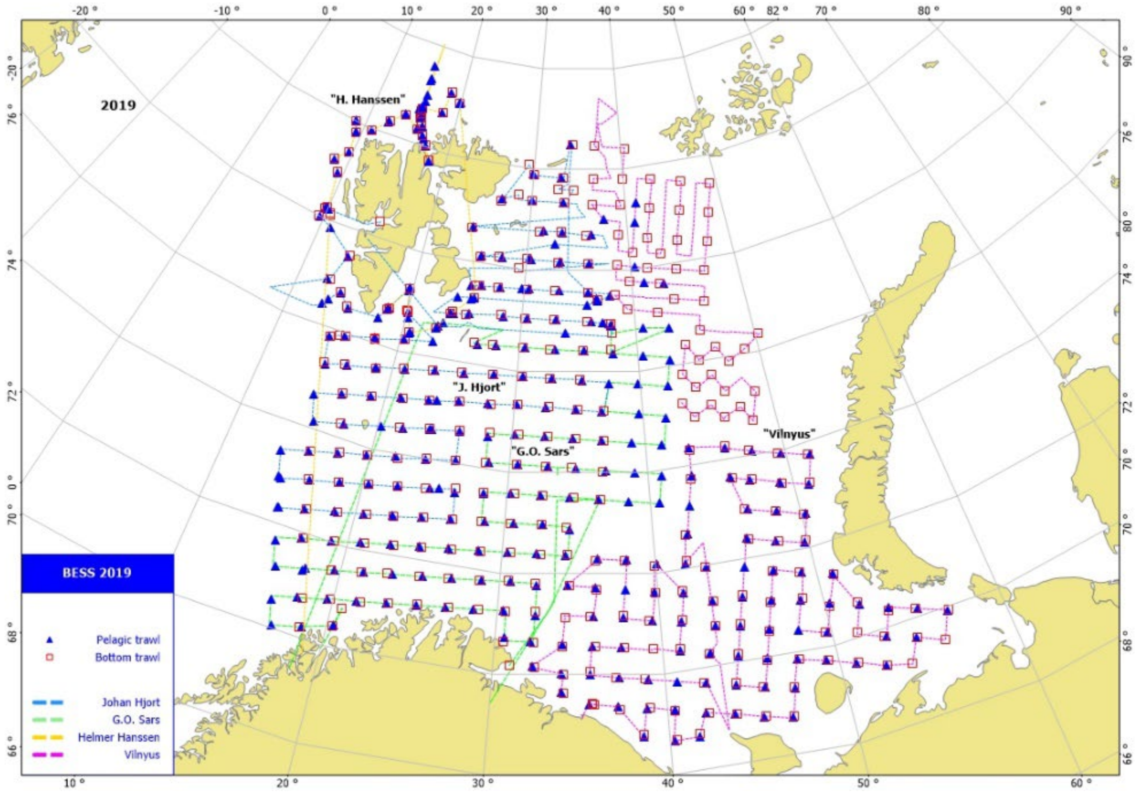


Figure 0.4. Barents Sea Ecosystem survey (BESS) 2019, realized vessel tracks with pelagic and bottom trawl sampling stations.

1.11 Ecosystem information

The aim of this section is to collect important ecosystem information influencing the assessment of fish stocks handled by AFWG. In general, such information is collected and updated by the ICES WGIBAR group, here we only provide information that is directly relevant to the assessment of the AFWG stocks as well as information that is updated after the 2021 WGIBAR report was finished.

1.11.1 0-group abundance

The recruitment of the Barents Sea fish species measured as 0-group has shown a large year-to-year variability. The most important reasons for this variability are variations in the spawning biomass, hydrographic conditions, changes in circulation pattern, food availability and predator abundance, and distribution. In 2018 and 2020, 0-group indices were strongly affected by incomplete area coverage in the Barents Sea, but attempts have been made to correct for this (Prozorkevitch and Van der Meeren, 2021).

1.11.2 Consumption, natural mortality, and growth

Cod is the most important predator among fish species in the Barents Sea. It feeds on a wide range of prey, including larger zooplankton, most available fish species, including own juveniles and shrimp (Tables 1.1–1.2). Cod prefer capelin as a prey, and fluctuations of the capelin stock may have a strong effect on growth, maturation, and fecundity of cod, as well as on cod recruitment because of cannibalism. The role of euphausiids for cod feeding increases in the years when capelin stock is at a low level (Ponomarenko and Yaragina, 1990). Also, according to Ponomarenko (1973; 1984), interannual changes of euphausiid abundance are important for the survival rate of cod during the first year of life.

The food consumption by NEA cod in 1984–2020, based on data from the Joint Russian-Norwegian stomach content database, is presented in Tables 1.1–1.2. The Norwegian (IMR) calculations are based on the method described by Bogstad and Mehl (1997). The main prey items in 2020 were capelin (about 2 million tonnes), followed by krill, amphipods and polar cod of which the consumption was about 500 thousand tonnes of each category. Shrimp, long rough dab, cod, herring, haddock and snow crab were all less important (between 90 and 180 thousand tonnes for each species). The increase in consumption of polar cod from 2019 to 2020 is consistent with the markedly increased abundance of this species. The decrease in consumption of young cod and haddock is consistent with the low abundance of age 0 and 1 of these species in 2020. The consumption calculations made by The consumption per cod by cod age-groups are shown in Tables 1.3–1.4 (IMR and PINRO estimates), while the proportion of cod and haddock in the diet by cod age-group (IMR estimates) is given in Tables 1.5 and Table 1.6. IMR show that the total consumption by age 1 and older cod in 2020 was 5.2 million tonnes. For technical reasons, PINRO estimates (Table 1.2 and 1.4) were not updated this year.

Growth of cod as calculated from weight at age in the winter survey has shown a declining trend in the last years, but this decline has now been halted, and for age 6 and older the trend seems to have been reversed. However, weight at age 3 and 4 was the lowest in this survey series from 1994–present, and for ages 3 and 6–8 it was among the three lowest values in the same period. The trends in consumption per cod by age group in recent years seem consistent with the trends in size at age.

Weight at age in the Lofoten survey was stable from 2019 to 2021, while weight-at-age in catch of cod decreased slightly for ages 3–9 from 2018–2020.

How is the outlook for cod food abundance in 2021? Total abundance of pelagic fish stocks is at an average level, for the most important pelagic species, capelin, the abundance of immature capelin in 2020 was intermediate due to a very strong 2019 year class (the strongest since 2000). Polar cod abundance in 2020 was close to the highest value observed in the 35-year time-series due to the 2019 year class being the strongest ever observed. However, the herring abundance in the Barents Sea is now low as the strong 2016 year class has left the Barents Sea and the following year classes, which still are found in the Barents Sea, are weak. Also, age 1–2 cod and haddock abundance in 2021 is low. On the positive side, shrimp abundance is high, while the abundance of other prey species is around average. Altogether there seems to be reasonable consistency between growth, consumption and feeding data.

One direct application for the management of results from the trophic investigations in the Barents Sea is the inclusion of predator's consumption into fish stock assessment. Predation on cod and haddock by cod has since 1995 been included in the assessment of these two species. These data, summarized in Tables 1.1, 1.3 and 1.5, are used for estimation of cod and haddock consumed by cod and further for estimation of their natural mortality within the SAM model (see sections 3.3.3 and 4.5.5). The average natural mortality for the last years is used as predicted M for the coming years for cod and haddock.

Cod consumption was used in capelin assessment for the first time in 1990, to account for natural mortality due to cod predation on mature capelin in the period January–March (Bogstad and Gjøsæter, 1994). This methodology has been developed further using the Bifrost and CapTool models (Gjøsæter *et al*., 2002; Tjelmeland, 2005; ICES CM 2009/ACOM:34). CapTool is a tool (in Excel with @RISK) for implementing results from Bifrost in the short term (half-year) prognosis used for determining the quota.

In recent years the abundance of large cod and haddock has been very high, and it is still at a high level for cod. There are a limited number of predators on such large fish. As predation is likely to be a major source of natural mortality, it could thus be considered whether the natural mortality in older age groups should be reduced in such a situation. The assumption of reduced natural mortality on older cod was explored by IBPCOD 2017, but no evidence of this was found based on available catch and survey data. To investigate this further, analyses on predator consumption and biomass flow at higher trophic levels like those done by Bogstad *et al.* (2000) should be updated, and such work is ongoing for marine mammals. For cod, in particular, the fishing mortality since 2008 has been so much lower than before that the relative impact of the natural mortality on the survival of older fish has increased considerably.

The amount of commercially important prey consumed by other fish predators (haddock, Greenland halibut, long rough dab, and thorny skate), has also been calculated (Dolgov *et al*., 2007), but these consumption estimates have not been used in assessment for any prey stocks yet. Marine mammals are not included in the current fish stock assessments. However, it has been attempted to extend the stock assessment models of Barents Sea capelin (Bifrost) by including the predatory effects of minke whales, and harp seals (Tjelmeland and Lindstrøm, 2005).

1.11.3 Maturation, condition factor, and fisheries–induced evolution

Data on maturity-at-age are one of the basic components for spawning-stock biomass (SSB) estimates. There have been substantial changes observed in maturity-at-age of NEA cod over a large historical period (since 1946) showing an acceleration in maturity rates, especially in the 1980s. They are thought to be connected both with compensatory density-dependence mechanisms and genetic changes in individuals (Heino *et al.*, 2002; Jørgensen *et al.*, 2008; Kovalev and Yaragina, 2009; Eikeset *et al.*, 2013; Kuparinen *et al.*, 2014) resulted from strong fishing pressure.

Studies on possible evolutionary effects for this stock should be updated with data for recent years to investigate the effects on population dynamics, including growth, maturation, and evolutionary effects, of a prolonged period with low fishing mortality and high stock size.

Recent laboratory and fieldwork have shown that skipped spawning does occur in NEA cod stock (Skjæraasen *et al.*, 2009; Yaragina, 2010). Experimental work on captive fish has demonstrated that skipped spawning is strongly influenced by individual energy reserves (Skjæraasen *et al.*, 2009). This is supported by the field data, which suggest that gamete development could be interrupted by a poor liver condition especially. Fish that will skip spawning seem to remain in the Barents Sea and do not migrate to the spawning grounds. These fish need to be identified and excluded when estimating the stock–recruitment potential as currently they are included in the estimate of SSB. However, more work needs to be undertaken to improve our knowledge of skipped spawning in cod (e.g. comparisons and intercalibration of Norwegian and Russian databases on maturity stages should be done) and other species in order to quantify its influence on the stock reproductive potential.

1.11.4 Recruitment prediction for northeast Arctic cod

Prediction of recruitment in fish stocks is essential to harvest prognosis. Traditionally, prediction methods have been based on spawning-stock biomass and survey indices of juvenile fish and have not included effects of ecosystem drivers. Multiple linear regression models can be used to incorporate both environmental and parental fish stock parameters. In order for such models to give predictions, there need to be a time-lag between the predictor and response variables. In this section, a model for Northeast Arctic cod which is in use in assessment is presented. Note that a recruitment model for Barents Sea capelin with similar features also was presented to the group (WD 13).

1.11.5 Historic overview

Several statistical models, which use multiple linear regressions, have been developed for the recruitment of northeast Arctic cod. All models try to predict recruitment-at-age 3 (at 1 January), as calculated from the assessment model, with cannibalism included. This quantity is denoted as R3. A collection of the most relevant models previously presented to AFWG is described below.

Stiansen *et al.* (2005) developed a model (JES1) with 2-year prediction possibility:

JES1: R3~ Temp(-3) + Age1(-2) + MatBio(-2)

JES2: R3~ Temp(-3) + Age2(-1) + MatBio(-2)

JES3: R3~ Temp(-3) + Age3(0) + MatBio(-2)

Temp is the Kola annual temperature (0–200 m, station 3–7), Age1 is the winter survey bottom trawl index for cod age 1, and MatBio the maturing biomass of capelin on 1 October. The number in parentheses is the time-lag in years. Two other similar models (JES2, JES3) can be made by substituting the winter index term Age1(-2) with Age2(-1) and Age3(0), giving 1 and 0-year predictions, respectively.

Svendsen *et al.* (2007) used a model (SV) based only on data from the ROMS numerical hydrodynamical model, with 3-year prognosis possibility:

SV: R3~ Phyto(-3) + Inflow(-3)

Where Phyto is the modelled phytoplankton production in the whole Barents Sea and Inflow is the modelled inflow through the western entrance to the Barents Sea in autumn. The number in parentheses is the time-lag in years. The model has not been updated since 2007.

The recruitment model (TB) suggested by T. Bulgakova (AFWG 2005, WD14) is a modification of Ricker's model for stock–recruitment defined by:

$$TB: R3 \sim m(-3)\ \exp[-SSB(-3) + N(-3)]$$

Where R3 is the number of age 3 recruits for NEA cod, m is an index of population fecundity, SSB is the spawning-stock biomass and N is equal to the number of months with positive temperature anomalies (TA) on the Kola Section in the birth year for the year class. The number in parentheses is the time-lag in years. For the years before 1998 TA was calculated relative to monthly average for the period 1951–2000. For intervals after 1998, the TA was calculated with relatively linear trend in the temperature for the period 1998–present. The model was run using two-time intervals (using cod year classes 1984–2000 and year classes 1984–2004) for estimating the model coefficients. The models have not been updated since 2009.

Titov (Titov, AFWG 2010, WD 22) and Titov *et al.* (AFWG 2005, WD 16) developed models with 1 to 4-year prediction possibility (TITOV0, TITOV1, TITOV2, TITOV3, TITOV4, respectively), based on the oxygen saturation at bottom layers of the Kola section stations 3–7 (OxSat), air temperature at the Murmansk station (Ta), water temperature: 3–7 stations of the Kola section (layer 0–200 m; Tw), ice coverage in the Barents Sea (I), spawning-stock biomass (SSB), annual values of 0-group cod abundance index, corrected for capture efficiency (CodC0) and the bottom-trawl swept-area abundance of cod at the age 1 and 2, 3 derived from the joint winter Barents Sea acoustic survey (CodB1, CodB2, CodB3). At the 2010 AFWG assessment it was suggested (Dingsør *et al.*, 2010, WD 19, and related discussions in the working group to try to simplify these models).

Hjermann *et al.*, (2007) developed a model with a one-year prognosis, which has been modified by Dingsør *et al.* (AFWG 2010, WD19) to four models with 2-year projection possibility.

$$H1: \log(R3) \sim Temp(-3) + \log(Age0)(-3) + BM_{cod3\text{-}6} / ABM_{capelin}(-2,-1)$$

$$H2: \log(R3) \sim Temp(-2) + I(surv) + Age1(-2) + BM_{cod3\text{-}6} / ABM_{capelin}(-2,-1)$$

$$H3: \log(R3) \sim Temp(-1) + Age2(-1) + BM_{cod3\text{-}6} / ABM_{capelin}(-1)$$

$$H4: \log(R3) \sim Temp(-1) + Age3(0)$$

Temp is the Kola yearly temperature (0–200 m), Age0 is the 0-group index of cod, Age1, Age2 and Age3 are the winter survey bottom trawl index for cod age 1, 2 and 3, respectively, $BM_{cod3\text{-}6}$ is the biomass of cod between age 3 and 6, and ABM is the maturing biomass of capelin. The number in parentheses is the time-lag in years. The models were not updated this year.

At AFWG 2008, Subbey *et al.* presented a comparative study (AFWG 2008, WD27) on the ability of some of the above models in predicting stock–recruitment for NEA cod (Age 3). At the assessment in 2010, a WD by Dingsør *et al.* (AFWG 2010, WD19) was presented, which investigated the performance of some of the mentioned recruitment models. It was strongly recommended by the working group that a Study Group should be appointed to look at criteria for choosing/rejecting recruitment models suitable for use in stock assessment.

The "Study Group on Recruitment Forecasting" (SGRF; ICES CM 2011/ACOM:31, ICES CM 2012/ACOM:24, ICES CM 2013/ACOM:24) have had three meetings (in October 2011 and 2012, and November 2013). Their mandate is to give a "best practice" (Standards and guidelines) for choosing recruitment models after their next meeting, which may be implemented at the next AFWG.

The SGRF 2012 report addressed the problem of combining several model predictions to obtain a recruitment estimate with minimum variance. The method (involving a weighted average of individual model predictions) was proposed as a replacement for the hybrid method of Subbey *et al.* (2008). One major issue not addressed in ICES SGRF (2012) was how to choose the initial ensemble of models, whose weighted average is sought. There are practical constraints (with respect to time and personnel), which stipulates that not all plausible models can be included in the calculation of the hybrid recruitment value. A methodology for choosing models to include in the calculation of a hybrid, representative recruitment forecast was addressed in SGRF 2013. Details can be found in the SGRF 2013 ICES report.

1.11.6 Models used in 2021

The model approach taken in 2021 was the same as in 2018–2020. Some changes were made in 2018, they are described below.

In 2018 at the meeting of the AFWG, the correction and simplification of models were continued. Since in 2017–2018 there was a significant correction of the initial biological data, which caused significant changes in the results of the prognostic models, in 2018 a complete audit of both prognostic models and the hybrid model combining the results of their work was carried out. The main purpose of the model revision was to increase the stability of the models, that is, to reduce the possibility of potential correction of the models due to correction of the biological data included in the model. The solution to the problem was found by increasing the retrospective database backwards in time, that is, from the beginning of the 1980s to the beginning of the 1960s. Accordingly, sets of predictor sets have been revised. The number of models was reduced from 5 to 2 and the names of the models were changed from Titov0(1,2,3,4) to TitovES (environment, short prediction) and TitovEL (environment, long prediction).

This has been conducted and has improved the statistical performance (details are shown in Titov, AFWG 2018, WD23):

TitovES: R32 ~ DOxSat2(t-13) + ITw(t-43) + expIce(t-40) + Ice(t-15)

TitovEL: R34 ~OxSat(t-39)+ ITw(t-43)

Where DOxSat(t-13)~ expOxSat(t-13) + OxSat(t-39), ITw(t-43) ~ I(t-43) +Tw(t–46). The number in parentheses is the time-lag in months, relative to April in the year when the prediction is carried out.

At the 2018 AFWG assessment, a hybrid model (i.e. an average combination) of the best functioning statistical recruitment models were repeated. A statistical analysis of the accuracy of the model's work was carried out, which consisted in estimating the errors in the recovery of data on the number of NEA cod recruitment. Accuracy of the model's work was verified by calculation of standard deviations of the NEA cod recruitment predicted values from the SAM values for the period 2005–2015 when the model was adjusted for data from 1983 to 2004, which consisted in estimating the errors in the recovery of data on the number of NEA cod recruitment.

Figure 1.1 shows the standard deviations of the NEA cod recruitment prediction. The addition of biological parameters (CodB1, CodB2, CodB3, CodC0, SSB) to environmental models (TitovES, TitovEL) substantially increases the error.

Based on these calculations, after comparing the results of constructing independent retrospective forecasts using the methodology previously used in ICES SGRF (ICES CM 2013/ACOM:24), it was decided to abandon the use of biological predictors and to use only environmental data in the NEA cod recruitment forecasting models. It was also found that all models (TitovES, TitovEL, RCT3) satisfy the quality conditions with respect to the forecast for the mean values accepted as the criterion for entering into the calculation of the hybrid model adopted earlier (ICES CM

2013/ACOM:24). It was decided that all biological data will be included in calculations based on the RCT3 model, and the remaining two models (TitovES, TitovEL) will be used only to account for the effect of environmental conditions on NEA cod recruitment.

In AFWG 2021 the procedure for estimating weights for various models (TitovES, TitovEL, RCT3) was repeated using the same method as was made on Study Group on Recruitment Forecasting (SGRF) in 2013. The input data for the models are given below in Tables 1.7 (TitovES, TitovEL) and 1.8 (RCT3).

In summary, the SAM estimate for age 3 from the AFWG 2021 assessment was used as historical R3. The recruitment forecast for 2021–2024 are based on a hybrid model with weighting estimated at AFWG 2021. The weights and forecasts for the 2021 AFWG assessment can be found in Table 1.9.

It was noted that the oceanographic dataset for the Titov ES and EL models cover the year classes from 1959 onwards, while the survey data used in the RCT3 model only cover the year classes from 1991 onwards, although those survey dataseries started in 1981. Further, the area covered in the surveys was extended in 2014, which is accounted for in the cod assessment by splitting the bottom trawl survey series in that year, while no such split was made in the RCT3 model. It should be investigated how this area expansion in the survey best could be accounted for in the recruitment model.

New software in R was presented during AFWG 2021 for predicting cod recruitment using the hybrid model (WD 20) including the automatic procedure for the submodel's weight estimation. A comparison of predicted values with "old" software (WD 21) was done and the results were identical.

Table 1.1. The North-east arctic COD stock's consumption of various prey species in 1984-2020 (1000 tonnes) based on Norwegian consumption calculations

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whiting	Long rough d	Snow crab	Total
1984	494	27	119	447	739	82	16	23	52	374	0	0	25	0	2398
1985	1252	188	64	179	1780	214	3	31	54	244	0	2	48	0	4058
1986	679	1426	133	165	961	162	156	74	110	340	0	0	66	0	4273
1987	813	1372	89	233	295	38	225	26	6	340	1	0	11	0	3449
1988	447	1419	337	151	382	8	99	11	2	259	0	5	6	0	3126
1989	679	823	245	123	589	3	37	8	10	222	0	0	67	0	2805
1990	1149	123	80	162	1409	7	5	16	14	188	0	81	86	0	3320
1991	688	63	71	164	2441	7	10	22	16	264	7	8	240	0	4002
1992	826	97	154	354	2266	275	92	46	88	172	23	2	94	0	4487
1993	709	242	669	305	2873	155	269	261	69	92	2	2	27	0	5674
1994	611	552	693	506	1060	146	599	223	48	76	0	1	43	0	4558
1995	827	972	527	358	607	117	245	367	114	194	2	0	36	0	4366
1996	604	620	1166	345	548	46	101	536	67	95	0	10	37	0	4173
1997	466	404	545	350	978	5	115	350	44	33	0	34	15	0	3340
1998	448	411	513	375	836	104	174	163	36	9	0	14	18	0	3100
1999	422	166	306	300	2047	151	258	67	30	18	1	35	9	0	3808
2000	427	188	492	503	1935	61	218	83	58	8	0	41	21	0	4035
2001	721	176	382	291	1836	76	264	68	51	6	1	157	32	0	4060
2002	376	96	260	241	2004	86	280	108	127	1	0	239	16	0	3834
2003	545	285	545	238	2152	216	275	110	166	3	0	74	53	0	4662
2004	626	560	347	246	1253	216	358	126	198	3	11	56	65	1	4065
2005	781	579	527	274	1399	132	388	118	324	2	5	115	53	0	4697
2006	870	225	1078	353	1737	170	108	80	361	12	2	163	130	0	5287
2007	1259	310	1091	428	2140	285	266	88	378	46	0	44	75	0	6411
2008	1578	160	931	385	2865	105	514	187	293	59	13	18	93	0	7201
2009	1495	243	635	265	3978	123	730	196	252	28	3	5	115	2	8072
2010	1616	415	1049	281	3900	52	334	241	267	142	10	14	133	7	8462
2011	1556	254	902	221	4120	84	424	286	279	115	0	26	122	9	8398
2012	1975	316	842	345	3641	51	519	373	220	51	34	8	125	7	8506
2013	1774	261	566	267	3660	51	137	380	200	111	1	21	167	15	7612
2014	1409	326	475	202	3713	72	31	358	88	31	11	18	106	9	6849
2015	1595	619	637	243	3278	126	147	213	178	140	43	59	85	33	7396
2016	1691	530	745	299	2210	95	346	198	222	57	6	87	120	10	6617
2017	1053	126	582	251	2950	193	88	315	272	45	4	24	139	53	6097
2018	1032	267	644	180	2886	203	246	246	276	34	70	47	52	44	6227
2019	779	212	415	308	2600	181	168	188	212	44	0	2	99	50	5258
2020	919	523	535	172	2021	107	467	115	92	30	14	13	150	90	5247

Table 1.2. The North-east arctic COD stock's consumption of various prey species in 1984-2020 (1000 tonnes) based on Russian consumption calculations (Dolgov, WD 07 AFWG 2020)															
	NOT UPDATED THIS YEAR														
Year	**Other**	**Amphipods**	**Krill**	**Shrimp**	**Capelin**	**Herring**	**Polar cod**	**Cod**	**Haddock**	**Redfish**	**G. halibut**	**Blue whiting**	**Long rough**	**Snow crab**	**Total**
1984	560	31	94	353	593	34	18	14	50	197	0	5	52		2000
1985	767	441	31	211	1041	26	0	89	36	100	0	18	22		2779
1986	615	949	66	159	855	51	169	26	99	166	1	3	26		3186
1987	541	593	79	233	175	9	118	23	2	119	1	10	5		1908
1988	544	196	239	146	348	21	0	21	76	133	0	0	22		1745
1989	496	324	190	117	767	4	37	35	2	178	0	0	64		2213
1990	278	31	105	266	1264	65	8	24	15	237	0	39	79		2409
1991	289	81	55	277	3204	25	45	52	22	141	5	6	46		4248
1992	788	38	211	258	2021	335	196	82	37	117	1	0	42		4125
1993	563	174	184	220	2743	170	170	144	148	40	5	4	47		4611
1994	447	296	359	458	1276	102	486	383	72	55	0	1	40		3976
1995	502	455	396	533	670	192	191	541	130	110	3	0	52		3775
1996	674	346	957	195	469	74	74	451	57	67	0	9	45		3415
1997	463	134	510	257	511	52	111	383	35	29	2	17	17		2520
1998	311	220	645	286	916	73	134	131	23	15	0	24	20		2797
1999	179	81	458	268	1540	80	177	49	16	14	0	27	9		2898
2000	243	122	437	394	1800	53	167	59	32	4	0	28	21		3360
2001	384	75	411	322	1522	93	148	62	52	4	2	145	31		3250
2002	225	45	286	202	2400	55	302	100	80	4	0	110	17		3825
2003	400	171	547	227	1219	153	221	132	331	2	0	28	51		3481
2004	496	393	478	256	1097	129	369	86	144	7	16	48	62		3583
2005	620	163	688	244	1023	168	320	112	271	7	2	67	47		3731
2006	786	86	1547	274	1341	268	125	95	285	17	1	103	148		5076
2007	831	192	1340	420	1881	275	289	68	329	29	1	32	73		5760
2008	1021	51	1005	345	3278	122	664	156	331	60	13	17	121		7184
2009	1048	189	938	284	3360	229	828	142	347	28	0	8	285		7687
2010	973	330	1843	255	4120	143	512	181	246	163	1	16	136		8918
2011	1251	202	831	226	4473	85	422	259	359	143	2	57	170		8479
2012	1771	164	600	273	2986	97	439	291	415	41	7	33	133		7251
2013	1366	210	648	334	3676	45	146	447	272	178	2	40	216		7581
2014	1391	121	744	208	3340	56	98	390	170	20	7	27	154		6726
2015	1122	301	1160	442	2675	69	159	175	180	87	14	39	117		6539
2016	1542	654	775	216	2221	86	248	239	158	48	3	51	328		6568
2017	1042	85	681	316	2709	99	75	271	315	188	3	26	249		6060
2018	1153	146	1541	178	1624	271	117	352	479	41	41	41	121		6105
2019	751	97	498	189	2103	379	131	415	292	47	0	15	159		5075

Table 1.3		**Consumption per cod by cod age group (kg/year), based on Norwegian consumption calculations.**									
Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.247	0.815	1.683	2.521	3.951	5.208	8.009	8.524	9.180	9.912	9.954
1985	0.304	0.761	1.833	3.105	4.675	7.360	11.246	11.972	12.497	13.751	13.869
1986	0.161	0.498	1.343	3.152	5.669	6.884	11.018	11.944	12.749	13.513	13.768
1987	0.219	0.602	1.290	2.051	3.532	5.489	7.077	8.107	8.923	9.343	9.301
1988	0.164	0.702	1.150	2.149	3.743	5.877	10.098	11.222	12.575	13.127	13.373
1989	0.223	0.715	1.606	2.714	3.980	5.611	7.678	8.499	9.597	10.198	10.628
1990	0.363	0.906	1.909	3.058	4.218	5.447	6.527	6.877	7.075	7.455	7.955
1991	0.293	0.972	2.178	3.536	5.318	7.073	9.470	10.238	11.292	12.339	12.037
1992	0.215	0.665	2.100	3.135	4.142	5.093	7.868	9.023	9.402	10.124	10.156
1993	0.112	0.529	1.548	3.045	4.823	6.292	9.413	11.272	11.798	12.288	12.880
1994	0.130	0.406	0.924	2.523	3.508	4.544	6.404	8.844	9.716	9.988	10.232
1995	0.103	0.299	0.918	1.824	3.359	5.261	7.726	10.425	12.300	12.770	13.191
1996	0.108	0.359	0.938	1.855	3.055	4.434	7.409	11.124	14.591	15.048	15.432
1997	0.140	0.327	0.952	1.778	2.717	3.537	5.261	8.128	12.659	13.389	13.205
1998	0.117	0.400	0.991	1.953	2.922	4.188	5.751	8.078	11.375	12.071	12.113
1999	0.163	0.505	1.095	2.720	3.719	5.444	6.975	9.193	10.953	12.063	12.181
2000	0.170	0.499	1.239	2.467	4.262	5.650	7.975	9.405	12.679	13.401	13.542
2001	0.171	0.448	1.308	2.435	3.688	5.305	7.550	11.238	13.477	14.400	14.674
2002	0.199	0.553	1.163	2.443	3.382	4.721	6.366	9.069	10.301	11.513	11.098
2003	0.207	0.648	1.316	2.391	4.002	5.958	8.438	10.435	12.903	13.576	14.443
2004	0.222	0.476	1.298	2.285	3.339	5.568	7.444	11.468	17.366	19.237	18.956
2005	0.203	0.659	1.380	2.746	4.247	6.365	7.670	10.284	13.851	14.895	15.610
2006	0.204	0.626	1.584	2.811	4.241	6.316	7.868	11.626	14.023	15.100	15.929
2007	0.256	0.653	1.738	3.092	4.471	6.237	8.277	10.287	12.786	13.554	13.988
2008	0.204	0.724	1.469	2.877	4.082	7.111	8.407	11.463	15.655	16.348	16.617
2009	0.192	0.618	1.494	2.769	4.434	5.759	8.470	11.487	12.793	13.632	13.821
2010	0.203	0.635	1.357	2.504	3.989	5.709	8.447	12.078	15.363	16.040	16.394
2011	0.219	0.663	1.419	2.627	4.033	5.351	7.272	9.663	15.139	16.314	16.304
2012	0.231	0.763	1.503	2.688	4.103	5.077	7.312	10.038	15.400	16.594	16.518
2013	0.182	0.674	1.447	2.531	3.908	4.999	5.954	7.582	11.489	12.510	13.450
2014	0.224	0.648	1.308	2.549	3.763	4.253	5.837	8.010	10.796	11.514	12.026
2015	0.218	0.662	1.426	2.528	4.254	5.695	7.376	8.628	13.081	13.892	15.034
2016	0.252	0.722	1.578	2.769	3.919	5.514	7.201	8.040	12.056	12.652	14.479
2017	0.248	0.791	1.529	2.653	3.977	5.628	7.031	8.143	11.271	14.168	16.982
2018	0.194	0.775	1.566	2.813	4.391	5.208	6.811	10.602	12.879	17.074	15.980
2019	0.191	0.515	1.343	2.288	3.517	4.417	6.219	8.963	12.186	11.715	12.973
2020	0.175	0.465	1.086	2.461	3.503	4.926	6.796	10.080	11.988	13.655	15.837
Average	**0.201**	**0.613**	**1.406**	**2.590**	**3.969**	**5.500**	**7.639**	**9.785**	**12.275**	**13.221**	**13.647**

Table 1.4		Consumption per cod by cod age group (kg/year), based on Russian consumption calculations.											
		NOT UPDATED THIS YEAR											
Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1984	0.262	0.895	1.611	2.748	3.848	5.486	6.992	8.561	10.572	13.166	13.200	15.547	17.153
1985	0.295	0.753	1.658	2.681	4.264	6.599	8.241	9.745	10.974	14.448	17.327	17.391	19.186
1986	0.179	0.526	1.455	3.455	5.001	5.991	6.458	8.157	9.766	11.457	13.188	14.621	16.134
1987	0.145	0.432	0.852	1.558	3.073	4.380	7.357	9.667	12.705	14.481	15.899	16.616	18.318
1988	0.183	0.704	1.075	1.628	2.391	4.386	8.207	9.978	10.868	16.536	14.639	16.046	17.000
1989	0.282	0.909	1.465	2.207	3.243	4.798	6.578	8.725	11.134	15.798	16.313	18.436	18.041
1990	0.288	1.006	1.694	2.693	3.278	3.833	5.583	6.870	10.715	11.426	13.555	15.964	17.595
1991	0.241	0.936	2.670	4.472	6.037	7.844	9.590	11.543	14.969	19.292	18.590	21.720	23.960
1992	0.178	0.969	2.475	2.866	3.995	5.137	6.723	7.414	8.755	12.303	14.288	15.184	16.745
1993	0.133	0.476	1.512	2.865	3.944	5.108	7.372	8.945	10.343	11.600	14.835	16.536	18.249
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	14.499	17.656	19.469
1995	0.194	0.497	0.962	1.801	3.204	4.847	7.332	9.688	13.835	15.247	16.899	19.273	21.254
1996	0.170	0.498	1.028	1.916	3.059	4.189	6.987	10.212	12.185	13.614	14.529	16.275	17.945
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	16.762	16.710	18.410	20.308
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.404	15.640	17.243
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.268	16.990	18.727
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.090	19.793	21.822
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.341	19.307	21.345
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.836	20.278	22.359
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.480	19.309	21.292
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.607	24.940	27.503
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	20.628	21.448	23.639
2006	0.354	0.925	1.881	2.813	4.019	5.332	7.450	10.328	13.111	17.759	19.488	22.322	24.609
2007	0.234	0.681	1.874	3.128	4.459	5.893	7.563	9.178	12.032	15.919	19.961	21.644	23.863
2008	0.223	0.719	1.697	2.959	4.194	6.073	7.809	10.464	13.627	17.254	21.590	23.373	25.779
2009	0.217	0.624	1.495	2.526	4.304	5.623	7.855	11.490	13.341	15.988	18.770	21.866	24.111
2010	0.235	0.651	1.401	2.577	4.065	5.757	8.312	11.805	16.090	16.844	20.129	23.023	25.387
2011	0.248	0.721	1.497	2.513	3.859	4.963	6.848	9.213	13.799	19.074	20.784	23.791	26.241
2012	0.207	0.588	1.203	2.292	3.266	4.461	5.862	7.629	11.713	16.211	19.345	21.032	23.190
2013	0.190	0.656	1.641	2.552	3.809	4.952	5.791	7.757	10.881	14.989	19.785	22.386	24.691
2014	0.242	0.622	1.321	2.340	3.608	4.387	5.560	7.447	9.017	12.547	16.044	18.854	20.781
2015	0.234	0.745	1.390	2.406	3.915	4.922	5.960	7.505	10.265	12.116	16.245	19.978	22.023
2016	0.307	0.870	1.722	2.813	3.474	4.740	6.754	9.117	10.665	14.810	19.921	24.195	26.683
2017	0.244	0.779	1.582	2.531	3.748	4.943	6.601	9.180	11.302	16.016	20.086	23.464	25.870
2018	0.316	0.867	1.846	2.699	3.736	5.000	6.489	9.170	11.166	14.577	18.672	21.848	24.091
2019	0.269	0.655	1.383	2.204	3.316	4.500	6.415	9.078	13.251	15.509	19.423	22.635	24.958
Average	**0.227**	**0.670**	**1.466**	**2.514**	**3.743**	**5.158**	**7.005**	**9.260**	**11.932**	**15.147**	**17.455**	**19.661**	**21.599**

Table 1.5 Proportion of cod in cod diet, based on Norwegian consumption calculations

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0000	0.0000	0.0032	0.0000	0.0432	0.0262	0.0332	0.0361	0.0371	0.0392	0.0394
1985	0.0015	0.0009	0.0014	0.0017	0.0312	0.0074	0.0822	0.0826	0.0833	0.0835	0.0840
1986	0.0000	0.0022	0.0015	0.0004	0.0130	0.1743	0.1760	0.1761	0.1758	0.1749	0.1745
1987	0.0000	0.0000	0.0007	0.0050	0.0103	0.0244	0.0383	0.0395	0.0412	0.0409	0.0443
1988	0.0000	0.0000	0.0000	0.0002	0.0059	0.0014	0.0037	0.0036	0.0031	0.0035	0.0031
1989	0.0000	0.0006	0.0016	0.0019	0.0027	0.0039	0.0036	0.0036	0.0039	0.0038	0.0040
1990	0.0000	0.0000	0.0000	0.0007	0.0010	0.0010	0.0165	0.0172	0.0181	0.0179	0.0178
1991	0.0000	0.0005	0.0000	0.0003	0.0032	0.0020	0.0222	0.0227	0.0230	0.0231	0.0231
1992	0.0000	0.0021	0.0037	0.0129	0.0248	0.0475	0.0119	0.0160	0.0232	0.0232	0.0231
1993	0.0000	0.0410	0.0370	0.0515	0.0541	0.1135	0.0498	0.0795	0.0797	0.0796	0.0802
1994	0.0000	0.0037	0.0927	0.0349	0.0285	0.0785	0.1248	0.1330	0.2659	0.2674	0.2668
1995	0.0069	0.0812	0.0747	0.0803	0.0923	0.1118	0.1387	0.2526	0.2542	0.2539	0.2545
1996	0.0000	0.1500	0.2566	0.2051	0.1321	0.1263	0.1874	0.2091	0.2436	0.2447	0.2437
1997	0.0000	0.0687	0.0762	0.1137	0.1558	0.1555	0.2315	0.2269	0.2919	0.2850	0.2916
1998	0.0000	0.0134	0.0272	0.0418	0.1037	0.0978	0.1090	0.1498	0.2722	0.2741	0.2718
1999	0.0000	0.0000	0.0048	0.0136	0.0147	0.0338	0.0618	0.1114	0.1902	0.1907	0.1843
2000	0.0000	0.0000	0.0287	0.0148	0.0134	0.0266	0.0497	0.0570	0.2682	0.2699	0.2594
2001	0.0000	0.0160	0.0116	0.0082	0.0131	0.0241	0.0498	0.0375	0.3250	0.3233	0.3268
2002	0.0000	0.0385	0.0597	0.0142	0.0187	0.0284	0.0357	0.0623	0.1582	0.1560	0.1555
2003	0.0000	0.0190	0.0198	0.0199	0.0206	0.0188	0.0451	0.1030	0.2194	0.2219	0.2228
2004	0.0081	0.0234	0.0280	0.0269	0.0296	0.0319	0.0380	0.0663	0.1062	0.1062	0.1077
2005	0.0000	0.0266	0.0230	0.0266	0.0145	0.0277	0.0436	0.0779	0.1484	0.1462	0.1437
2006	0.0000	0.0103	0.0007	0.0128	0.0288	0.0158	0.0392	0.0368	0.0810	0.0821	0.0820
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0304	0.0282	0.0901	0.1407	0.1413	0.1383
2008	0.0000	0.0559	0.0257	0.0101	0.0157	0.0098	0.0764	0.0873	0.0975	0.0959	0.0981
2009	0.0116	0.0225	0.0262	0.0251	0.0152	0.0139	0.0219	0.0945	0.1078	0.1082	0.1076
2010	0.0000	0.0327	0.0580	0.0270	0.0243	0.0243	0.0203	0.0383	0.1367	0.1369	0.1353
2011	0.0129	0.0152	0.0492	0.0170	0.0361	0.0300	0.0238	0.0575	0.1279	0.1279	0.1278
2012	0.0274	0.0608	0.0640	0.0618	0.0274	0.0432	0.0410	0.0373	0.0685	0.0691	0.0681
2013	0.0214	0.0303	0.0459	0.0389	0.0276	0.0224	0.0478	0.0538	0.1166	0.1171	0.1335
2014	0.0824	0.0363	0.0450	0.0342	0.0213	0.0456	0.0661	0.0787	0.0658	0.0658	0.0752
2015	0.0000	0.0088	0.0308	0.0283	0.0266	0.0192	0.0233	0.0281	0.0555	0.0553	0.0539
2016	0.0157	0.0192	0.0063	0.0393	0.0146	0.0172	0.0266	0.0137	0.0906	0.0914	0.0910
2017	0.0419	0.0354	0.0386	0.0470	0.0436	0.0400	0.0560	0.0913	0.0686	0.1015	0.1409
2018	0.0000	0.0186	0.0680	0.0480	0.0351	0.0378	0.0567	0.0310	0.0243	0.0076	0.0252
2019	0.0000	0.0000	0.0328	0.0296	0.0339	0.0228	0.0366	0.0741	0.0934	0.0252	0.0792
2020	0.0000	0.0227	0.0013	0.0041	0.0110	0.0177	0.0311	0.0504	0.0683	0.0649	0.1118

Table 1.6 Proportion of haddock in cod diet, based on Norwegian consumption calculations										
Year/age	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1984	0.0443	0.0175	0.0053	0.0225	0.0455	0.0215	0.0022	0.0020	0.0019	0.0018	0.0017
1985	0.0205	0.0227	0.0052	0.0076	0.0207	0.0109	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0187	0.0015	0.0866	0.0005	0.0530	0.0249	0.0248	0.0257	0.0286	0.0301
1987	0.0000	0.0052	0.0003	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0003	0.0034	0.0034	0.0034	0.0039	0.0035	0.0039
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0339	0.0338	0.0349	0.0347	0.0356
1990	0.0000	0.0000	0.0000	0.0024	0.0021	0.0007	0.0130	0.0124	0.0117	0.0118	0.0119
1991	0.0000	0.0000	0.0098	0.0079	0.0045	0.0051	0.0031	0.0030	0.0029	0.0028	0.0028
1992	0.0000	0.0000	0.0014	0.0683	0.0208	0.0271	0.0278	0.0317	0.0462	0.0462	0.0461
1993	0.0000	0.0000	0.0204	0.0073	0.0149	0.0144	0.0278	0.0261	0.0261	0.0261	0.0263
1994	0.0000	0.0000	0.0065	0.0131	0.0069	0.0141	0.0298	0.0491	0.0456	0.0452	0.0453
1995	0.0000	0.0354	0.0030	0.0429	0.0260	0.0241	0.0393	0.0956	0.1617	0.1615	0.1619
1996	0.0000	0.0000	0.0592	0.0155	0.0098	0.0170	0.0376	0.0485	0.0925	0.1016	0.0981
1997	0.0000	0.0000	0.0242	0.0189	0.0245	0.0158	0.0127	0.0175	0.0561	0.0569	0.0539
1998	0.0000	0.0000	0.0115	0.0120	0.0227	0.0192	0.0106	0.0323	0.0161	0.0166	0.0160
1999	0.0000	0.0000	0.0028	0.0078	0.0158	0.0124	0.0120	0.0139	0.0224	0.0225	0.0217
2000	0.0000	0.0000	0.0233	0.0102	0.0178	0.0116	0.0158	0.0525	0.0286	0.0285	0.0287
2001	0.0000	0.0081	0.0052	0.0163	0.0147	0.0171	0.0194	0.0198	0.0337	0.0330	0.0345
2002	0.0000	0.0000	0.0185	0.0339	0.0353	0.0471	0.0747	0.0761	0.1830	0.1793	0.1785
2003	0.0000	0.0000	0.0145	0.0311	0.0595	0.0436	0.0553	0.1215	0.1079	0.1078	0.1078
2004	0.0044	0.0418	0.0745	0.0388	0.0575	0.0501	0.0564	0.0996	0.0910	0.0911	0.0924
2005	0.0000	0.0853	0.1047	0.0595	0.0621	0.0646	0.1038	0.1082	0.1115	0.1101	0.1085
2006	0.0000	0.0409	0.0829	0.0872	0.0604	0.0897	0.0716	0.1063	0.0962	0.0957	0.0958
2007	0.0000	0.0035	0.0462	0.0415	0.0833	0.0980	0.1335	0.1152	0.1631	0.1627	0.1648
2008	0.0000	0.0045	0.0106	0.0156	0.0383	0.0753	0.1148	0.1327	0.2329	0.2346	0.2321
2009	0.0000	0.0218	0.0241	0.0182	0.0142	0.0362	0.1090	0.0595	0.1881	0.1868	0.1891
2010	0.0000	0.0031	0.0279	0.0182	0.0178	0.0217	0.0362	0.1420	0.1819	0.1806	0.1810
2011	0.0000	0.0049	0.0362	0.0285	0.0087	0.0204	0.0411	0.0924	0.1633	0.1630	0.1625
2012	0.0000	0.0000	0.0113	0.0282	0.0337	0.0271	0.0368	0.0335	0.0859	0.0848	0.0872
2013	0.0000	0.0073	0.0309	0.0112	0.0314	0.0233	0.0147	0.0363	0.0615	0.0615	0.0916
2014	0.0000	0.0089	0.0037	0.0255	0.0080	0.0047	0.0022	0.0340	0.0143	0.0143	0.0194
2015	0.0000	0.0175	0.0409	0.0254	0.0172	0.0166	0.0258	0.0197	0.0384	0.0385	0.0399
2016	0.0000	0.0051	0.0799	0.0771	0.0265	0.0259	0.0323	0.0420	0.0342	0.0343	0.0339
2017	0.0106	0.0429	0.0153	0.0450	0.0462	0.0568	0.0466	0.0528	0.0795	0.0677	0.0867
2018	0.0000	0.0000	0.0434	0.0365	0.0590	0.0661	0.0551	0.0588	0.0821	0.0304	0.1164
2019	0.0000	0.0000	0.0284	0.0564	0.0422	0.0491	0.0513	0.0401	0.0345	0.0644	0.2709
2020	0.0000	0.0000	0.0011	0.0063	0.0037	0.0096	0.0257	0.0707	0.0514	0.0816	0.0287
Average	**0.0022**	**0.0107**	**0.0236**	**0.0277**	**0.0257**	**0.0296**	**0.0378**	**0.0516**	**0.0706**	**0.0706**	**0.0785**

Table 1.7. Parameters of TitovES and TitovEL models (subscripts correspond to the time-lag in months before the start of the year to which the value Cod3 is attributed).

Year	Cod3	$OxSatt_{39}$	$DOxSatt_{13}$	$ITwt_{43}$	$Icet_{15}$	$expIcet_{40}$
1962	1252375	−0.19	−6.6	1.86	0.5	0
1963	900621	−0.94	−2.37	1.59	1.5	0
1964	468028	1.63	1.23	2.47	9	0
1965	870506	0.88	−0.2	3.91	15.7	0
1966	1842715	−1.09	−3.98	7.97	5.3	0
1967	1311586	−0.23	−2.84	8.23	5	9.3
1968	183717	1.5	−0.13	3.78	15.5	0
1969	110450	0.85	0.63	1.77	15.9	0
1970	205641	−0.17	−0.23	3.51	19.8	7.9
1971	402577	0.06	−0.12	−0.13	18.8	2.7
1972	1045979	−3.32	−6.59	14.55	−0.6	428.9
1973	1723668	−2.1	−10.37	19.14	1.8	768.6
1974	568211	1.06	−1.73	2.4	2	0
1975	608710	1.9	0.78	−2.64	−1.2	0
1976	607084	1.33	−1.28	−3.07	−1.9	0
1977	372778	−0.07	−1.84	−2.44	2.5	0
1978	622679	1.19	0.1	1.05	−1	0
1979	202675	0.5	−1.48	−0.12	3.5	0
1980	130292	−0.31	−2.72	1.98	12.9	0
1981	143781	0.76	−0.18	1.94	14.7	0
1982	183737	0.8	0.61	−3.15	8	0.1
1983	141514	0.78	0.22	1.87	12.2	8.5
1984	442251	−2.21	−2.35	−3.08	12.9	0
1985	534310	−0.1	−1.17	3.59	−1.2	0.1
1986	1374917	−2.14	−4.39	1.39	−8.5	2.9
1987	360087	−0.33	−1.69	2.12	0.6	0
1988	335536	0.87	−1.4	−2.34	3.8	0
1989	157635	0.32	−3.42	−5.17	10.5	0

Year	Cod3	$OxSatt_{39}$	$DOxSatt_{13}$	$ITwt_{43}$	$Icet_{15}$	$expIcet_{40}$
1990	130130	1.11	−1.32	−4.21	10.5	0
1991	295846	0.88	0.7	2.42	6.5	0
1992	715916	1.34	0.48	1.37	−0.9	0
1993	988150	−1.98	−3.86	6.12	−0.6	0
1994	752473	−0.5	−2.26	8.25	−4.9	0
1995	539384	0.83	−2.42	4.36	1.8	0
1996	407389	0.86	−0.08	0.55	0.7	0
1997	785420	0.88	0.17	3.11	−7.3	0
1998	1063528	0.3	−6.08	−2.32	−2.5	0
1999	632034	−0.72	−2.4	−6.81	2.9	0
2000	749727	1.86	1.55	−2.29	13.6	0
2001	593152	0.62	0.05	−6.04	2.3	0
2002	374202	−0.88	−0.98	3.63	−9.9	0.8
2003	756675	−0.39	−0.64	8.5	−5.8	0
2004	242069	−2.2	−2.53	−4.62	−1.4	0
2005	693264	−1.65	−1.82	−1.45	4.9	0
2006	536630	−1.18	−1.65	−4	−6	0
2007	1243906	−1.39	−4.42	7.42	−12.3	0
2008	1002761	−1.14	−1.59	3.39	−18	0
2009	581758	0.79	−1.83	−1.61	−17.5	0
2010	201832	−0.38	−2.6	−8.94	−9	0
2011	358117	0.83	−0.07	−5	−4.3	0
2012	503017	0.91	−0.13	−5.05	−4.3	0
2013	464921	0.04	−0.09	1.44	−10.5	0
2014	852202	−0.46	−1	1.43	−17.8	0
2015	452019	−1.26	−1.62	−2.22	−10.5	0
2016	286334	−1.31	−1.92	−7.52	−5.8	0
2017	781901	−0.33	−0.64	−1.69	−14.4	0
2018	508296	−1.24	−1.41	0.1	−20.9	0

Year	Cod3	$OxSatt_{39}$	$DOxSatt_{13}$	$ITwt_{43}$	$Icet_{15}$	$expIcet_{40}$
2019	659091	−0.63	−1.08	−1.71	−13.2	0
2020	572413	−2.02	−2.19	−6.35	−13.6	0
2021	NA	−0.8	−1.08	−1.33	−9.2	0
2022	NA	−1.55	−2.1	−2.47	−12.8	0
2023	NA	−1.52	NA	−4.18	NA	0
2024	NA	−0.31	NA	−5.63	NA	0

Table 1.8 Initial data for RCT3 model.

year class	Recruitment	BST1	BST2	BST3	BSA1	BSA2	BSA3
1982	534	NA	NA	NA	NA	NA	NA
1983	1375	NA	NA	NA	NA	NA	NA
1984	360	NA	NA	NA	NA	NA	NA
1985	336	NA	NA	NA	NA	NA	NA
1986	158	NA	NA	NA	NA	NA	NA
1987	130	NA	NA	NA	NA	NA	NA
1988	296	NA	NA	NA	NA	NA	NA
1989	716	NA	NA	NA	NA	NA	NA
1990	988	NA	NA	NA	NA	NA	NA
1991	752	NA	NA	294	NA	NA	324
1992	539	NA	557	283	NA	624	138
1993	407	1044	541	163	903	212	99
1994	785	5356	792	318	2175	272	159
1995	1064	5899	1423	355	1826	565	391
1996	632	5044	496	188	1699	475	148
1997	750	2491	350	246	2524	232	295
1998	593	473	242	183	365	263	177
1999	374	129	78	118	153	52	61
2000	757	713	419	377	364	209	307
2001	242	34	66	64	19	53	33
2002	693	3022	243	249	1505	117	125

year class	Recruitment	BST1	BST2	BST3	BSA1	BSA2	BSA3
2003	537	323	217	116	161	139	65
2004	1244	853	289	361	500	158	59
2005	1003	674	370	194	411	47	200
2006	582	595	102	126	85	94	108
2007	202	69	36	37	51	26	23
2008	358	389	95	85	205	44	40
2009	503	1028	226	76	620	91	83
2010	465	617	100	69	266	40	61
2011	852	703	143	227	497	89	287
2012	452	436	191	144	313	211	139
2013	286	1246	343	99	1759	211	56
2014	782	1642	306	179	1904	202	112
2015	508	312	129	139	241	73	109
2016	659	645	501	282	439	280	204
2017	572	2714	559	238	2058	362	117
2018	NA	1791	274	115	1437	158	70
2019	NA	165	33	NA	93	17	NA
2020	NA	88	NA	NA	44	NA	NA

Table 1.9. Overview available prognoses of NEA cod recruitment (in million individuals of age 3) from different models.

Model	Parameter	Years of prediction	2021 Prognosis	2022 Prognosis	2023 Prognosis	2024 Prognosis
TitovEL	R at age 3	4	590	614	548	386
	Model weight		0.34	0.47	1	1
TitovES	R at age 3	2	559	627		
	Model weight		0.42	0.53	0	0
RCT3	R at age 3	3	525	301	384	
	Model weight		0.24	0	0	
Hybrid	R at age 3	4	561	621	548	386

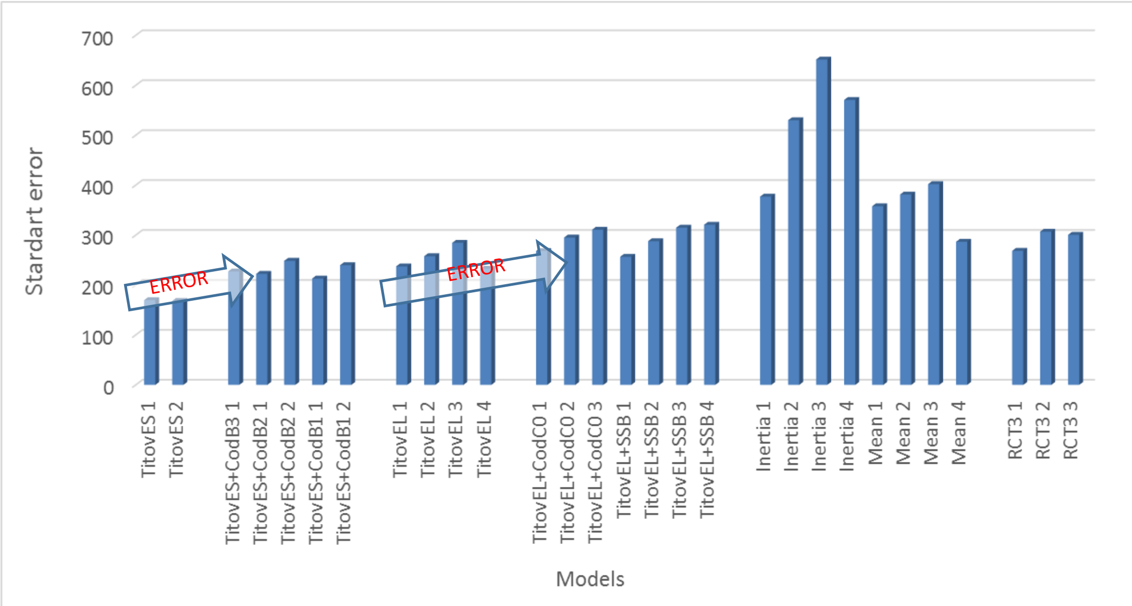


Figure 1.1. Standard errors of the NEA cod recruitment predicted values from the SAM values.

2 Norwegian coastal cod[1]

A benchmark assessment (WKBARFAR) was conducted in February 2021 to address the failure of the current management plan to reduce fishing mortality on Norwegian coastal cod (NCC; ICES, 2021a). The main outcome of the benchmark was that from assessment year 2021 onwards, Norwegian coastal cod (former stock code: cod.27.1-2coast) was split into two stocks/components by 67 degrees latitude (Figure 2.0.1); a data-rich one in the north: cod.27.1-2coastN (northern Norwegian coastal cod); and a data-limited one in the south: cod.27.2coastS (southern Norwegian coastal cod).

The majority (approximately 80–90%) of NCC catches are taken north of 67°N (Table 2.1.1), and this is also where the coastal survey has the best coverage. Genetic studies have revealed a genetic gradient in cod along the Norwegian coast without areas of distinct breaks in population connectivity (Dahle *et al.*, 2018). However, NCC in northern Norway have more genetic material in common with the Northeast Arctic cod (NEAC; cod.27.1-2), compared to Norwegian coastal cod further south (Dahle *et al.*, 2018).

Recent updates of the catch series, a revision of the acoustic survey index and a new swept-area index have improved the data basis for assessment in the northern area. The data for northern Norwegian coastal cod were considered of high enough quality to support an age-based analytical assessment. Southern Norwegian coastal cod (62–67°N) represents the remaining commercial catches of NCC north of 62°N (approximately 10–20%) and is not as consistently covered by the main survey relevant to monitoring cod. Current data availability and quality cannot support a full analytical assessment, and a data-limited approach has therefore been developed to support management of this stock.

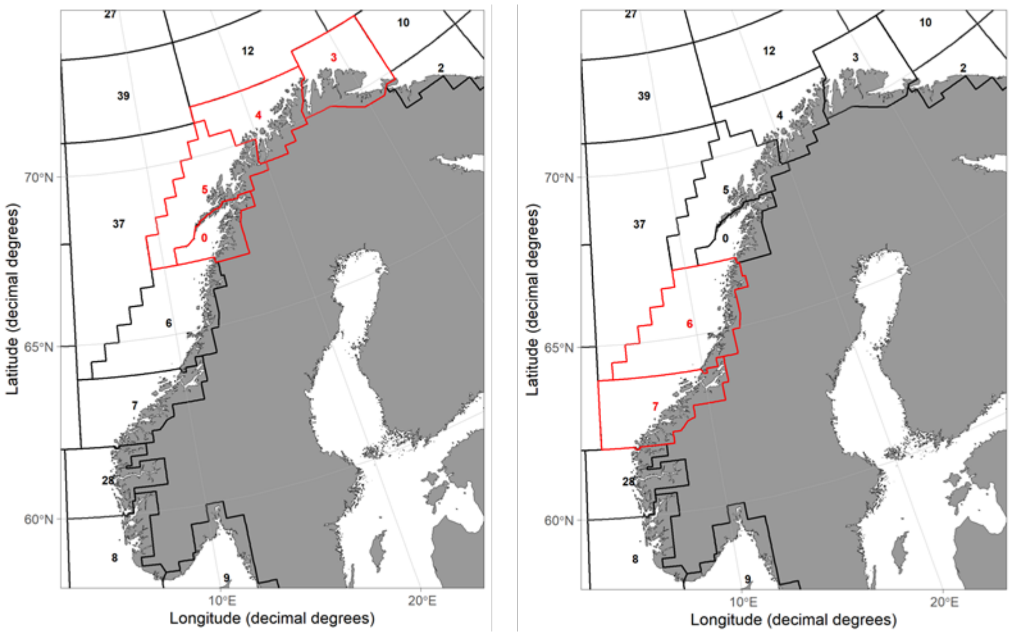


Figure 2.0.1 Norwegian catch reporting areas used to define stock distribution areas for northern Norwegian coastal cod (left) and southern Norwegian coastal cod (right).

[1] Cod (*Gadus morhua*) in subareas 1 and 2, north of 67°N (Norwegian Sea, Barents Sea), northern Norwegian coastal cod: cod.27.1-2.coastN; Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N (Norwegian Sea), southern Norwegian coastal cod: cod.27.2.coastS.

2.1 Fisheries (both stocks)

Coastal cod is fished throughout the year and within nearly all the distribution areas in the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (Figure 2.0.1). Most of the coastal cod catches are taken as a bycatch in fisheries aimed at Northeast Arctic cod during its spawning and feeding migrations to coastal waters. The main fishery for coastal cod, therefore, takes place in the first half of the year. The main fishing areas are along the coast from Varangerfjord to Lofoten (areas 03, 04, 05, 00).

Recreational and tourist fisheries take an important fraction of the total catches in some local areas, especially near the coastal cities, and in some fjords where commercial fishing activity is low. Recreational catches are a much larger proportion of the total for the southern stock than for the northern stock, respectively about 50% vs. 15%. However, there are few reports trying to assess the amount in certain years. In 2010, these reports were used to construct a time-series of recreational catches (ICES 2010). These catch estimates are quite uncertain. No additional information was included during 2010–2019, and the annual recreational catch during this period has been assumed equal to the one estimated for 2009 (12 700 t).

A new project was conducted in the period 2017–2020 by IMR in collaboration with several Norwegian institutions (NINA, Akvaplan-niva, NMBU and Nordland Research), and a number of international partners. Three study areas Troms, Hordaland, and Oslofjord, were chosen because they represent contrasts in recreational fishing. The project is currently being finished and reports will follow, but some preliminary results were presented at the benchmark assessment (WKBARFAR WD13, ICES 2021a), and further used in the present coastal cod assessments.

Historically there has been no reporting system for NCC taken by recreational or tourist fishers in Norway. In 2019, the Norwegian Directorate for Fisheries established a web portal for obligatory catch reporting (both kept and released fish) by all registered fishing businesses. Tourist fishing effort related to tourist fishing businesses has about doubled from 2009 to 2019. The total quantity of cod caught by tourists staying in tourist businesses has also more than doubled from 1586 tonnes in 2009 (Vølstad *et al.*, 2011) to about 3455 tonnes in 2019.

The current (2019) documented estimate of about 9000 tonnes (WKBARFAR WD13, ICES 2021a) is clearly an underestimate as tourists outside registered tourist businesses and residents fishing with fixed gears are not included. In the estimate of 9000 tonnes is also a share of the catch taken by anglers and released again. Based on investigations in other countries, the AFWG anticipates a mortality rate of 100% of fish caught by rod from land, and 20% of released cod caught by rod and handline at sea (e.g. Weltersbach and Strehlow, 2013; Capizzano *et al*., 2016). Until there is a better quantification of the missing recreational segments, the benchmark WK proposed to keep the quantity of 12 700 tonnes recreational catch of Norwegian coastal cod north of 62°N on top of the commercial reported landings, with 7900 tonnes north of 67°N and 4800 tonnes between 62–67°N (Table 2.1.1).

The catches reported (both kept and released fish) by registered fishing businesses to the Norwegian Directorate of Fisheries in the COVID-19 years 2020–2021 were only 23% and 41% of 2019 catches, respectively. In the current assessment, the WG has taken this into account and reduced the rod and line catches from tourist boats accordingly and kept the other, Norwegian resident, recreational catches unchanged at the 2019 level. This results in 10 039 and 10 661 tonnes of recreational NCC catch north of 62°N in 2020 and 2021 (Table 2.1.1). The proportion of the recreational total caught north of 67°N vs. between 62–67°N is assumed to be the same in all years.

The total recreational catch numbers-at-age have been upscaled from the estimated catch-at-age proportions in the commercial landings (Tables 2.2.3c and Table 2.3.3).

It is necessary to update the recreational catch with a better estimate as soon as this is available.

2.1.1 Revision of catch data

The benchmark assessment (WKBARFAR, ICES 2021a) tested and analysed two major catch data revisions: i) using the ECA model to separate the Norwegian coastal cod and the Northeast Arctic cod in the commercial catches by the structure of the otoliths in commercial samples, and ii) revising the catch in tonnes since 1992 using recommended seasonal product-round fish conversion factors instead of fixed factors for the whole year.

Until 1992, Norway used seasonal conversion factors to convert the weight of "headed-and-gutted" cod to round weight (1.6 during winter and 1.4 during the rest of the year). From 1992 onwards, this factor was set to 1.50 for the same product in all Norwegian cod fisheries all year around. From 2000 onwards, this factor was also agreed upon by the Joint Norwegian-Russian Fisheries Commission (JNRFC). From 2000, it hence became constant for all cod fisheries at all times of the year, although there is a larger difference between "headed-and-gutted" weight and round weight in the winter season when at least the Norwegian coastal fisheries for cod are dominated by mature fish with gonads.

Based on a report published by the Norwegian Directorate of Fisheries (Blom, 2015), and summaries of this previously reported to the AFWG as WD 15 in 2017 and as WD 09 in 2020 (Nedreaas, 2017; Fotland and Nedreaas, 2020), ICES advice for NEA cod in 2018 states that "The use of constant conversion factors between round and gutted weight for all seasons and areas introduces a bias to the catch statistics". During the benchmark meeting (WKBARFAR, ICES 2021a) the Norwegian landings of cod by vessels below 28 m in January–April, all gears, were hence corrected by using 1.311 and 1.671 for the products "gutted with head" and "gutted without head", respectively, for each year since 1994.

Catch numbers-at-age are estimated for both stocks of NCC (i.e. northern and southern) by the ECA model. Commercial and recreational total catches have now been calculated back to 1977 for both stocks (Table 2.1.1, WD 03). In addition, catch-at-age in the years 1977–1993 have been estimated for the northern stock (WD 03), though it is not yet included in the assessment model.

2.1.2 Catch sampling

The basis for estimating Norwegian coastal cod catches is the total landings of cod from fisheries operating within the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (ref. Figure 2.0.1), combined with the catch samplings of these fisheries. Commercial catches of cod are separated into types of cod by the structure of the otoliths in the commercial catch samples. Figure 2.1.2 illustrates the main difference between the two types: The figure and the following text is from Berg *et al*. (2005):

> **Coastal cod has a smaller and more circular first translucent zone than northeast Arctic cod, and the distance between the first and the second translucent zone is larger. The shape of the first translucent zone in northeast Arctic cod is similar to the outer edge of the broken otolith and to the subsequent established translucent zones. This pattern is established at an age of 2 years, and error in differentiating between the two major types does not increase with age since the established growth zones do not change with age.**

The precision and accuracy of the separation method for categorizing cod-type was investigated by comparing the results of different otolith reads to the results of genetic analyses, and the investigation determined that the results from the otolith method are high in accuracy (Berg *et al*., 2005). Nevertheless, in cases with a low percentage misclassification of large catches of pure NEA cod, the catches of coastal cod could be severely overestimated.

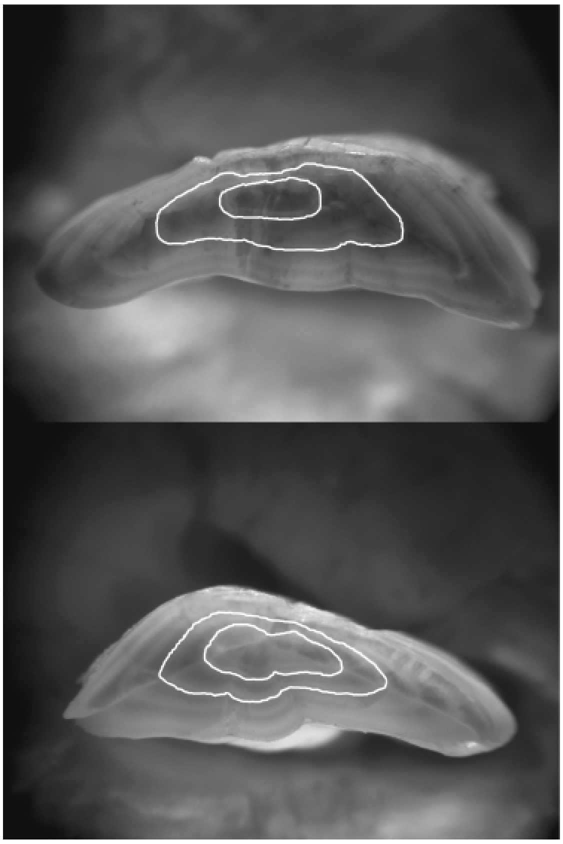


Figure 2.1.2. An image of a Norwegian coastal cod otolith (top) and a Northeast Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al.*, 2005).

Since the catches are separated by type of cod by the structure of the otoliths, the numbers of age samples are critical for the estimated catch of coastal cod. Table 2.1.2 shows the sampling of the cod fisheries by quarters, split by NCC and NEAC. The Norwegian sampling program changed in 2010, which led to poor sampling in that year. The sampling in later years gradually improved, and the number of samples (but not the number of otoliths) is now well above the level prior to 2010.

The number of otoliths sampled in 2020 was lower than previous recent years due to reduced access to fish landing sites because of COVID-19, but the proportion of NCC in samples was similar. In 2021, the number of otoliths were nearly back to pre-pandemic levels; a total of 10 612 fish were aged in 2021, whereof 35% were classified as Norwegian coastal cod (Table 2.1.2).

2.1.3 Regulations

The Norwegian cod TAC is a combined TAC for both the NEAC stock and NCC stocks. Landings of cod are counted against the overall cod TAC for Norway, where the expected catch of NCC (North and South) is in the order of 10%. The NCC part of this combined quota was set 40 000 t in 2003 and earlier years. In 2004, it was set to 20 000 t, and in the following years to 21 000 t. There are no separate quotas given for the coastal cod for the different groups within the fishing fleet. Catches of coastal cod are thereby not effectively restricted by quotas.

Since the coastal cod is fished under a merged Norwegian coastal cod/Northeast Arctic cod quota, the main objective of these regulations is to move the traditional coastal fishery from areas with high fractions of NCC to areas where the proportion of NEAC is higher. Most regulation measures for NEAC also applies to NCC; minimum catch size, minimum mesh size, maximum bycatch of undersized fish, closure of areas having high densities of juveniles, and some seasonal and area restrictions. A number of regulations contribute to some protection of NCC, e.g. a ban on trawl fishing inside 6 nautical miles from the baseline and "fjord-lines" that were drawn along the coast to close the fjords for direct cod fishing with vessels larger than 15 metres. For more details about the technical regulations, see ICES (2020).

Table 2.1.1. Left: estimated commercial catches of Norwegian coastal cod North of 67˚N (NCC North) and between 62–67˚N (NCC South), and Northeast Arctic cod between 62–67˚N (NEAC South). Middle: estimated recreational catches of cod north of 67˚N and between 62–67˚N, all assumed to be coastal cod. Right: Recreational catches of NCC North and South that were sold and included in the commercial catch statistics. Note that an initial unlikely low share of NCC vs. NEAC in the 2001 commercial landings compared to years before/after was replaced by an average of the 2000 and 2002 NCC values.

Year	Commercial catch (tonnes)			Recreational catch (tonnes)			Sold recreational catch included in commercial catch (tonnes)*		
	NCC North	NCC South	NEAC South	NCC North	NCC South	Total	NCC North	NCC South	Total
1977	33735	9776	13831	7789	4774	12563			
1978	36413	6272	8982	7855	4814	12669			
1979	31929	8194	10745	7921	4855	12776			
1980	29792	8923	12948	8003	4905	12909			
1981	36161	10117	16551	8054	4936	12990			
1982	33361	5883	19361	8121	4977	13098			
1983	46297	5562	10616	8188	5019	13207			
1984	63305	5621	9442	8256	5060	13316			
1985	56944	7424	5786	8324	5102	13425			
1986	37359	3319	10742	8392	5143	13535			
1987	39630	5147	7731	8424	5163	13588			
1988	55602	5153	4069	8457	5183	13640			
1989	38174	6993	4277	8551	5241	13792			
1990	16707	3687	8055	9035	5538	14573			
1991	22863	3823	12331	9524	5837	15361			
1992	30110	3923	20156	10018	6140	16157			
1993	39681	6202	22814	9181	5627	14809			
1994	52579	6381	23430	9144	5556	14700			
1995	56907	8936	16981	9144	5556	14700			
1996	41820	6207	13250	9020	5480	14500			
1997	46605	4746	12695	9020	5480	14500			

Year	Commercial catch (tonnes)			Recreational catch (tonnes)			Sold recreational catch included in commercial catch (tonnes)*		
	NCC North	NCC South	NEAC South	NCC North	NCC South	Total	NCC North	NCC South	Total
1998	45462	6200	9389	9082	5518	14600			
1999	38743	5522	7101	8646	5254	13900			
2000	33081	5838	4329	8460	5140	13600			
2001	24470	5250	3499	8335	5065	13400			
2002	32188	6937	4266	8460	5140	13600			
2003	29253	8905	3943	8646	5254	13900			
2004	31198	6866	3941	8335	5065	13400			
2005	30097	8005	1462	8211	4989	13200			
2006	36884	8612	1175	8087	4913	13000			
2007	26200	7695	2250	8087	4913	13000			
2008	27711	9889	1376	7962	4838	12800			
2009	22988	7145	2474	7900	4800	12700			
2010	34804	7634	2685	7900	4800	12700			
2011	27982	7128	7474	7900	4800	12700			
2012	26778	8187	4942	7900	4800	12700	1425	239	1665
2013	21376	5131	8395	7900	4800	12700	450	167	617
2014	22750	6244	6682	7900	4800	12700	774	229	1003
2015	34483	5004	5424	7900	4800	12700	618	226	844
2016	49503	5962	2006	7900	4800	12700	810	332	1142
2017	54273	4159	1242	7900	4800	12700	772	307	1078
2018	34532	4436	1822	7900	4800	12700	889	326	1215
2019	35861	2965	1677	7900	4800	12700	1603	339	1943
2020	43133	3481	987	6233	3806	10039	1789	347	2136
2021	38347	3696	578	6623	4039	10661	565	321	885

***Source: Norwegian Directorate of Fisheries. All reported recreational cod assumed to be coastal cod.**

Table 2.1.2. Number of otoliths sampled by quarter from commercial catches. NCC: Norwegian coastal cod. NEAC: Northeast Arctic cod. The table includes all otoliths from the Norwegian catch sampling areas 0 and 3–7 (covering both Norwegian coastal cod stocks).

Year	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total		
	NCC	NEAC	NCC	NEAC	NCC	NEAC	NCC	NEAC	NCC	NEAC	%NCC
1985	1451	3852	777	1540	1277	1767	1966	730	5471	7889	41
1986	940	1594	1656	2579	0	0	669	966	3265	5139	39
1987	1195	2322	937	3051	638	1108	1122	1137	3892	7618	34
1988	257	546	160	619	87	135	55	44	559	1344	29
1989	556	1387	72	374	65	501	97	663	790	2925	21
1990	731	2974	61	689	252	97	265	674	1309	4434	23
1991	285	1168	92	561	77	96	279	718	733	2543	22
1992	152	619	281	788	79	82	272	672	784	2161	27
1993	314	1098	172	1046	0	0	310	541	796	2685	23
1994	317	1605	179	923	21	31	126	674	643	3233	17
1995	188	1591	232	1682	2095	1057	752	1330	3267	5660	37
1996	861	5486	591	1958	1784	1076	958	2256	4194	10776	28
1997	1106	5429	367	2494	1940	894	1690	1755	5103	10572	33
1998	608	4930	552	1342	489	1094	2999	2217	4648	9583	33
1999	1277	4702	493	2379	202	717	961	1987	2933	9785	23
2000	1283	4918	365	2112	386	1295	472	668	2506	9993	20
2001	1102	5091	352	2295	126	786	432	983	2012	9155	18
2002	823	5818	321	1656	503	831	897	1355	2544	9660	21
2003	821	4197	445	2850	790	936	1112	1286	3168	9269	25
2004	1511	7539	758	2565	532	685	531	1317	3332	12106	22
2005	1583	6219	767	4383	473	258	877	1258	3700	12188	23
2006	2244	5087	1329	2819	590	271	119	71	4282	8248	34
2007	1867	5895	944	2496	503	648	637	1163	3951	10202	28
2008	1450	4162	1116	3122	626	515	693	999	3885	8798	31
2009	1114	5109	558	2592	126	253	842	465	2640	8419	24
2010	736	2000	572	992	464	195	325	270	2097	3457	38
2011	643	2271	789	2548	412	296	732	443	2576	5558	32

Year	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total		
	NCC	NEAC	NCC	NEAC	NCC	NEAC	NCC	NEAC	NCC	NEAC	%NCC
2012	1294	6283	749	1864	379	85	324	185	2746	8417	25
2013	966	5389	832	3155	216	88	1115	385	3129	9017	26
2014	1019	4470	869	3312	338	29	1060	524	3286	8335	28
2015	746	7770	618	3619	327	354	511	547	2202	12290	15
2016	2465	5581	1073	2445	616	207	1501	727	5655	8960	39
2017	2276	4568	879	2742	810	151	1231	475	5196	7936	40
2018	2007	4927	924	1882	498	104	1143	435	4572	7348	40
2019	1830	4594	759	1969	838	260	1284	445	4711	7268	39
2020	1926	3551	587	1688	424	85	434	317	3371	5641	37
2021	1731	4060	956	2219	459	291	580	316	3726	6886	35
µ85–21	1126	4022	627	2091	525	467	794	838	3054	7446	29

2.2 Northern Norwegian coastal cod

2.2.1 Stock status summary

The assessment is based on the decisions of the 2021 WKBARFAR benchmark (ICES 2021a), with updates from the 2022 WKNCCHCR workshop on evaluation of Norwegian coastal cod harvest control rules (ICES 2022). The latter included changes to the assessment model as a follow-up to the benchmark in addition to reference point and HCR evaluations based on a request from the Norwegian managers.

The changes to the model included replacing the acoustic survey index by age with an aggregated biomass index due to uncertain age information, and a change to the Fbar from ages 4–7 to 4–8 to better reflect fishing pressure on the stock.

The evaluation of reference points led to the conclusion that it was not possible to set a B_{lim} with the certainty required to use it as a basis for estimating reference points in the ICES AR. Therefore, the requested HCRs (based on B_{lim}) could not be considered precautionary. As an alternative, the workshop proposed a constant fishing mortality HCR without a B_{lim}. In this HCR, target F was set to $F_{0.1}$, a conservative proxy for F_{msy}. This HCR was evaluated as precautionary for all stock sizes above B_{loss} (lowest SSB observed in last c. 20 years) at WKNCCHCR.

The HCR advice was released on 7 June 2022 and the $F_{0.1}$ HCR was adopted by the managers shortly thereafter. The revised model and new HCR were used as basis for the advice released on 15 June 2022.

The 2022 assessment shows that SSB declined from a relatively high level at the start of the assessment period (1994) to a low level in 1999. Between 1999–2002, SSB increased, but to a level lower than the one observed at the start of the assessment period. After 2002, SSB stayed at a similar level until 2010, after which it increased to approximately 50 000 t lower than the 1994 level. After 2016, there has been a declining trend back towards the level estimated in 2003–2010, followed by an increase from 2019 to 2020 of approximately 10 000 t and a slight decrease from 2020 to 2021 (3500 t). Fishing mortality mainly follows the trend in SSB, with highest F in the period with lowest estimated SSB. However, F increased from 2019 to 2020 despite increasing SSB, and decreased from 2020 to 2021 despite a small decrease in SSB. Recruitment-at-age 3 has been relatively stable over time, with somewhat higher values in the early period. There is a weak relationship between SSB and recruitment-at-age 3 despite low fishing pressure on this age.

Stock numbers-at-age 2 in 2020 were the lowest observed in the time-series, and the estimate of this cohort in 2021 is also one of the lowest in the time-series. TSB in 2021 is about 30 000 t lower than in 2020 and the lowest observed since 2006–2007. This is mainly driven by the low age 3 numbers, which were also seen in 2006–2007.

The 2021 advice for this stock was revised two times due to errors in data input, with the final quota advice released 15 June 2022 advising that 2022 catches should not exceed 12 143 t (commercial and recreational catches combined). Total landings in 2021 were ~ 45 000 t, and it is likely that 2022 landings will be at a similar level, exceeding the quota advice.

Further details on the stock assessment procedure can be found in the Stock Annex.

2.2.2 The fishery (Table 2.2.1–Table 2.2.4)

Commercial landings of northern Norwegian coastal cod in 2021 were 38 347 t, down c. 5000 t from 2020. Of the total landings, 22% were taken in ICES Division 1.b and the rest in Division 2.a (Table 2.2.1). The highest landings were made in the Norwegian catch reporting area 05, using Danish seine and gillnet (Table 2.2.2). Compared to 2020, catch proportions were higher in area 05 and lower in areas 03, 04 and 00. In total, 40% of the landings were taken in gillnet fisheries and 32% in Danish seine, while longline/jig made up 16% of the landings and trawl 12%.

The estimate of recreational catch (fixed at 7900 t) was adjusted in 2020 and 2021 based on reports from tourist businesses to reflect reduced fishing tourism due to the COVID-19 pandemic.

Catch-at-age (commercial + recreational) of ages 3, 4 and 6–10+ were lower compared to 2020, while catches of ages 2 and 5 increased. The total catch in tonnes decreased by 4400 t compared to 2020.

The level of discarding and misreporting from coastal vessels has been investigated for three periods: 2000 and 2002–2003 (WD 14 at 2002 WG), and 2012–2018 (Berg and Nedreaas 2021). The report from the 2000-investigation concluded that there was both discarding and misreporting by species in 2000. In the gillnet fishery for cod, discarding and misreporting represented approximately 8–10% relative to reported catch, and 1/3 of this was probably coastal cod. Data from 2002–2003 showed that misreporting in the coastal gillnet fisheries had been reduced significantly since 2000. A recent work by Berg and Nedreaas (2021) estimating discards of cod in the coastal gillnet fisheries during 2012–2018 showed that discarding (as percentage of total catch in weight including discards) decreased from less than 1% at the beginning of the period to less than 0.5% during 2016–2018. In weight, this corresponds to a decrease from more than 500 tonnes-per-year to about 180 tonnes-per-year. The reason for discarding seems to be highgrading by size (and price) during the first half of the year, and damaged fish (same size as landed fish) in the second half of the year.

Tourist fishing businesses reporting to the Norwegian Directorate of Fisheries in 2019 showed that about 42% of the reported rod and line catch was released, and with an assumed mortality of 20% of the released cod from the boat (see section 2.1), this corresponds to about 8% discards (dead fish) in the rod and line sector of the recreational fishery.

In the stock assessment, discarding is not included in the commercial landings, i.e. commercial catches are assumed equal to landings, but discarding in the rod and line (from boat) sector of the recreational fishery is included in the recreational catch estimate.

2.2.3 Survey results

A trawl-acoustic survey for coastal cod along the Norwegian coast from the Russian border to 62°N was started in autumn 1995. In 2003, this survey was combined with a saithe survey conducted at the coastal banks and moved from September to October–November (ICES acronym for the combined survey: A6335). Since 2003, the survey therefore covered an extended area and had a more consistent design with fixed bottom trawl stations in addition to trawl hauls set out on acoustic registrations. The seabed along the Norwegian coast is rugged, with sharp drops and peaks over short distances. This makes it difficult to get reliable survey indices both with acoustics and bottom trawl sampling. Acoustics can reach areas where the seabed is too uneven to perform bottom trawling, but species detection and discrimination can be hindered by dead zones and acoustic shadows. Acoustics and bottom trawl data therefore contain both independent and overlapping information.

For the 2021 benchmark, one acoustic and one swept-area index was prepared (WD 06 to AFWG 2021), and it was decided to include them both in the assessment. At the WKNCCHCR 2022 workshop, further quality control of the survey indices were done, resulting in a decision to change the acoustic index from an index by age to an aggregated biomass index (ICES, 2022). This was due to the index by age poorly tracking age classes, particularly after the coastal cod survey merged with the saithe survey, and that the uncertain age 2 estimates from this index had a large influence on model estimates (particularly the shape of the stock–recruit relationship). The swept-area index has generally higher internal consistency and is still included in the model as an age disaggregated index. It should be noted that the uncertainties associated with these indices are rather large and increasing with age.

The survey indices are calculated with the software StoX (Johnsen *et al*., 2019), developed at the Institute of Marine Research in Norway. Instead of conventional age–length keys, StoX uses an imputation algorithm to assign age information to individuals that have been length measured but not aged. Crucial to coastal cod, the software also imputes other biological information, particularly otolith type, which is used to split the index on NEAC and NCC. The underlying assumption is that the proportion of NCC in length samples are representative of the proportion in the environment. StoX also estimates coefficients of variation using a bootstrap routine. The bootstrapping consists of two parts; resampling of primary sampling units (trawl stations or acoustic transects) with replacement, and the imputation of missing ages by random draw from individuals in the same length group. Primarily, age information is drawn from individuals in the same length group sampled in the same trawl haul. Should there be none, the draw extends to all trawl hauls within the same survey strata, and lastly, to the entire survey area. The CV is the variability resulting from both parts of the bootstrap routine.

The results of the 2021 survey north of 67°N are presented in Tables 2.2.5–2.2.12. Box 2.1 below details a decision that was made at AFWG to exclude the acoustic index data point from 2021 (last survey year) due to an inconsistently high value. This decision must be revisited next year when another data point is available.

Box 2.1. Decision to exclude the acoustic 2021 survey index from the 2022 stock assessment.

The 2021 acoustic survey index came in very high in relation to most previous years and compared to the 2021 swept-area index. To evaluate whether the high index reflected an actual increase in the stock or was due to an error, several checks were made before and during AFWG.

These are summarized below, and further details can be found in the presentation "Survey_data_acoustics_NCCNorth" on the AFWG 2022 SharePoint.

High acoustic values compared to trawl catches were evident both when the acoustic index was expressed as total abundance and as total biomass (Figure B2.1.1), and were seen for all age groups. Looking at internal consistency, the 2021 data point fell outside or on the very edge of the "cloud" of points for nearly all age groups. This was not the case in the swept-area index, where the 2021 data point were more consistent with previous observations.

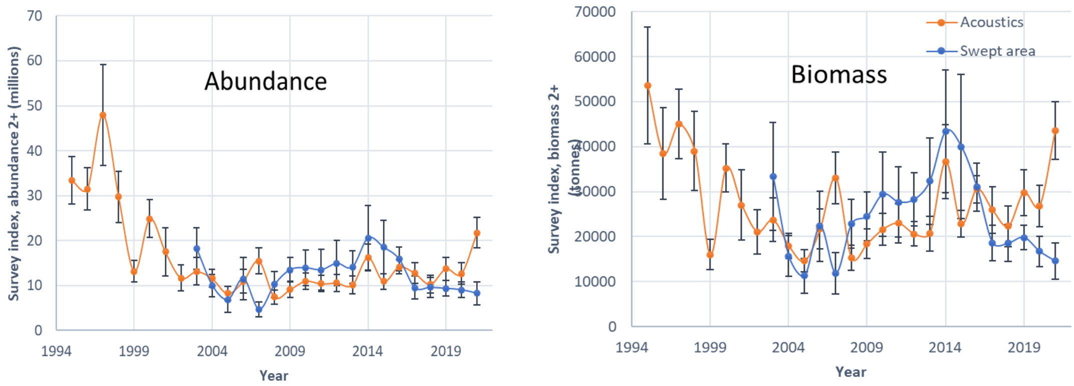


Figure B2.1.1. Swept-area (blue) and acoustic (orange) abundance indices (left, in millions) and biomass indices (right, in tonnes) for northern coastal cod. The error bars represent 95% confidence intervals around the mean. The figures show the indices after correction of stock discrimination and rescrutinization of the acoustics.

It was mainly two strata in the northeast that contributed the high acoustic values, called "Østhavet" and "Hjelmsøy Loppa". While the acoustic values were high in these strata, catch rates in the trawl were not particularly high compared to other areas. Østhavet is the strata with the largest proportion of Northeast Arctic cod in the survey, increasing the risk of misclassification between the two stocks. The area also have high abundances of other demersal fish such as saithe and haddock, increasing the risk of misclassification in the acoustic scrutinization process. Therefore, both the stock discrimination by otolith typing and the acoustic scrutinization in this area were closely examined.

In the rescrutinization, some obvious scrutinization errors were found and corrected. These mainly concerned situations where saithe had been misclassified as cod, or too large proportions of cod had been assigned to mixed demersal fish aggregations. This correction reduced the acoustic index somewhat (c. -20% for age 3, c. -10% on average).

To examine possible misclassification of stock types, a subsample of the otoliths was reread. This resulted in approximately 9% of otoliths in the sample being reclassified from coastal cod to Northeast Arctic cod. Coastal cod otoliths come in many variations (some specific to local fjords), and this level of misclassification is not unexpected even among experienced readers. Correcting the stock discrimination further reduced the survey index for some ages, but the total change compared to pre-rescrutinization of the acoustics and pre-rereading of otoliths did not exceed c. -20% for any age and the acoustic index was still unusually high compared to the swept-area index.

Next, commercial catches from the approximate time and area with high acoustic survey registrations were examined. While cod catches in October-November 2021 were actually lower than in the previous four years, catches of saithe were higher, particularly in November (Figure B2.1.2). The survey covered the area in October, not November, but the catch statistics nevertheless indicate that saithe abundance rather than cod abundance was high in the area within few weeks of the survey.

In summary, the acoustic survey index in 2021 fell outside the internal consistency “cloud” for several ages, also compared to the one other year (2007) when the acoustic index was much higher than the swept-area index. Two strata with high saithe abundances contributed the most to the coastal cod index. The high coastal cod index was caused by large acoustic registrations classified as cod that were not reflected in large survey trawl catches, or in higher commercial catches around the time of the survey. However, commercial catches of saithe were relatively high in the area at the time of the survey and some weeks after. In conclusion, some degree of misclassification between cod and saithe was strongly suspected and the expert group was not confident enough in the data to include the 2021 cod index in the assessment. Excluding it and re-evaluating this decision again when another data point is available next year was considered to be more appropriate, and a precautionary decision given that the high acoustic index had a large influence on model results (20% increase in terminal year SSB when including the 2021 acoustic data point).

Figure B2.1.2. Commercial catch (kilograms) of cod (left panels), saithe (middle panels) and haddock (right panels) in Norwegian statistical fishing area 03 by month in the years 2017–2021. The survey for coastal cod and saithe takes place in months 10 and 11 (October-November). High saithe catches in this period in 2021 are circled in red.

2.2.3.1 Indices of abundance and survey mortality (Tables 2.2.5–2.2.8, Figures 2.2.2–2.2.5)

As detailed in Box 2.1, the acoustic survey index in 2021 were much higher than the swept-area index, for all age groups, and the total acoustic biomass index was nearly three times higher than the total swept-area biomass index (Tables 2.2.5 and 2.2.7).

The 2020 age 1 and 2 swept-area abundance indices were particularly low. In 2021, age 2 indices were higher than expected from the low 2020 estimate of the same year class, while the age 3 estimate were consistent with the low index for this year class in the previous year (Table 2.2.7). The age 1 index in 2021 was higher than in 2021, but still among the lowest in the time-series. Note, however, that age 1 cod are too small to be representatively sampled in the survey and that their distribution extends to shallow habitats not accessible to the research vessels. Indices for the oldest fish (age 10+) were slightly higher in 2021 than in 2020, but the 2020–2021 indices are nevertheless much lower than those seen in 2009–2019 (Table 2.2.7).

The coefficients of variation (CVs) in both indices are generally higher for ages 8 and above where there is less data (Tables 2.2.6 and 2.2.8).

Survey mortality for age 1–2 decreased sharply in 2021 relative to 2020 as a result of the unexpectedly high estimate of age 2 in 2021 relative to age 1 in 2020 (Figure 2.2.5). Survey mortality for age 9–10 showed an opposite trend with a sharp increase. All other ages in the acoustic index had lower survey Z this year due to the high acoustic estimates, while in the swept-area index, the trends were more variable. Generally, internal consistencies are rather low in both survey indices, and consequently, the survey mortality is highly variable between years (Figure 2.2.5).

2.2.3.2 Age reading and stock separation (Table 2.2.9)

About 2400 cod otoliths were sampled north of 67°N during the 2021 survey, which slightly down from 2500 in 2020 but well above the long-term average (Table 2.2.9). The proportions of NCC at age among those otoliths were higher for older fish (age 6+) compared to the long-term average and the previous year, but within ranges previously observed (Table 2.2.9).

2.2.3.3 Length and weights-at-age (Tables 2.2.10–2.2.11, Figure 2.2.6)

There has been a trend of increasing mean length and, particularly, weight at age over the time-series for most ages, though the trend has levelled off or even reversed in the last few years. Mean lengths-at-age in 2021 were similar to previous years (Table 2.2.10), while mean weights at age decreased compared to 2020 for all ages except age 6 where it was similar (Table 2.2.11). For ages 8 and older the mean lengths and weights show larger variations, probably caused by few fish sampled in some years (Figure 2.2.6).

2.2.3.4 Maturity-at-age (Table 2.2.12, Figure 2.2.7)

The fraction of mature fish in the autumn survey (Table 2.2.12) show rather large variation between years. While some of the variation is likely related to variation in stock size and size at age, it may also be partly caused by the difficulty of distinguishing mature and immature cod in autumn. Coastal cod spawn in February–June and many mature individuals are therefore in a resting state at the time of the survey in October–November. The maturity ogive therefor includes spent/resting individuals, which gives an ogive similar to that estimated from a smaller fishery-dependent dataset, collected during the spawning season (ICES 2021a). No large changes in maturity-at-age were observed between 2020 and 2021 (Figure 2.2.7).

2.2.4 Data used in the assessment

2.2.4.1 Catch numbers-at-age (Table 2.2.3c)

The estimated total catch-at-age (2–10+) for the period 1994–2021, including both commercial and recreational catches, is used in the assessment (Table 2.2.3c). Tables 2.2.3a and 2.2.3b show the commercial and recreational catches separately.

2.2.4.2 Catch weight-at-age (Table 2.2.4)

Weight-at-age in catches is derived from the commercial sampling and is shown in Table 2.2.4. The same weight-at-age is assumed for recreational and tourist catches. Weight of the plus group is an average for the ages included in the plus group, weighted by abundance-at-age.

2.2.4.3 Tuning data (Table 2.2.13)

The acoustic total biomass index (ages 2+) and the swept-area survey index by age (2–10+) are used in the assessment (Table 2.2.13). The acoustic index is split in two parts; 1995–2002 and

2003- due to a change in catchability when the saithe and coastal cod surveys were combined in 2003.

2.2.4.4 Stock weight-at-age (Table 2.2.14)

The weight-at-age for ages 2–7 in the stock (Table 2.2.14) is obtained from the Norwegian coastal survey (Table 2.2.11), while catch weight-at-age (Table 2.2.4) is used for ages 8–10+ due to large uncertainty for these ages in survey data (Figure 2.2.6). The survey weights are assumed to be relevant to the weight-at-age in the stock at survey time (October). These weights will, however, overestimate the stock biomass at the start of the year, and in the assessment model, SSB is therefore calculated after applying 80% of the year's fishing and natural mortality, corresponding to the survey timing.

2.2.4.5 Maturity-at-age (Table 2.2.12, Figure 2.2.7)

Annual maturity-at-age observed in the survey is used in the assessment (Table 2.2.12). Maturity of the plus group is an average for the ages included in the plus group, weighted by abundance-at-age.

2.2.4.6 Natural mortality (Table 2.2.15, Figure 2.2.8)

In Northeast Arctic cod, cannibalism has been documented to be a significant source of mortality that varies in relation to alternative food and in relation to the abundance of large cod. This might also be the case for the coastal cod (Pedersen and Pope 2003a and b). In the 2005 coastal cod survey 1125 cod stomachs were analysed (Mortensen 2007). The observed average frequency of occurrence of cod in cod stomachs was around 4%. Other important predators on cod in coastal waters are cormorants, harbour porpoises and otters (Anfinsen 2002; Pedersen *et al.*, 2007; Mortensen 2007). Young saithe (ages 2–4) has also been observed to consume post-larvae and 0-group cod during summer/autumn (Aas 2007). As detailed data on consumption of coastal cod is lacking, natural mortality in the assessment is assumed dependent on cod size; M is calculated based on stock weight-at-age, following the method by Lorenzen (1996). With this method, M ranges from approximately 0.6 for age 2 to 0.2 for the plus group (Table 2.2.15).

2.2.5 Final assessment run

The 2022 assessment was run with the configuration decided upon at the 2021 benchmark (Table 2.2.16), with the necessary updates following decisions from WKNCCHCR (ICES, 2022). These decisions included replacing the acoustic index by age with a total biomass index, including age 8 in the Fbar range (previously F4–7, now F4–8), and reporting recruitment-at-age 3 (model starts at age 2).

The main features of the configuration are: 1) Coupling of fishing mortality states for ages 7–9, 2) Coupling of survey catchability parameters for ages 5–9 in the swept-area index, 3) Separate variance parameter for age 2 in the catch, 4) AR(1)-correlation between ages in the swept-area index, and 5) Recruitment modelled as random walk.

The log-likelihood, number of parameters and AIC of the final run are presented in the table below. There were no problems with model convergence. The "base" model presented below refers to last year's model, which differed from the current model in using acoustic indices by age instead of aggregated biomass indices.

Model	Log(L)	#par	AIC
Current	−185.44	19	408.88
base	−180.17	37	434.33

The estimated survey catchabilities at age are presented in Table 2.2.17.

2.2.5.1 Model diagnostics (Figure 2.2.9–Figure 2.2.11)

A 5-year retrospective peel indicated no large problems with the estimates of SSB and Fbar, while the model have a low precision in the recruitment (age 2) estimate from 2013 onwards (Figure 2.2.9). The second half of the model period has larger uncertainty as there is an additional survey index (from bottom trawl) that gives generally higher abundance estimates compared to the acoustic index, though this pattern was inversed in the last years. Mohn's rho (average 5-year retrospective bias) was 0.2 for SSB, −0.15 for Fbar, and 0.32 for recruitment. Thus, the model would have overestimated recruitment, particularly from 2013 and onwards, had it been run in previous years.

The process residuals were improved at the benchmark by splitting the acoustic index in two parts and show no concerning patterns (Figure 2.2.10). The one-step-ahead residuals (Figure 2.2.11) were also improved by introducing correlations between ages in the survey indices. Evaluation of this correlation structure should be done at the next benchmark to see if the residuals can be further improved, particularly since the correlation structure has recently been removed from the acoustic index due to the removal of age information.

2.2.5.2 Model results (Table 2.2.18–2.2.20, Figure 2.2.1)

Stock numbers-at-age 2 in 2020 were the lowest observed in the time-series, and the estimate of this cohort (age 3 recruits) in 2021 was also one of the lowest in the time-series (Table 2.2.18). SSB decreased with 3500 t from 2020 to 2021, but Fbar also decreased somewhat reflecting the decreased catches of most ages included in the 4–8 Fbar range (Table 2.2.18 and Table 2.2.3c). Fishing mortality for ages 2–5 in 2021 were slightly higher than in 2019 and 2020, while Fs for ages 6 and above were lower (Table 2.2.19). Abundances of ages 9 and 10+ in 2021 were low and slightly down from last year (Table 2.2.20). Abundances of ages 2, 5 and 8 increased compared to 2020.

2.2.6 Reference points

Reference points were evaluated at the 2021 benchmark (ICES 2021a). The estimated stock–recruitment (age 2) relationship showed increasing recruitment with increasing SSB throughout the model period, and the same pattern resulted from adding 2020 data in the assessment (ICES, 2021d). At the benchmark, B_{lim} was therefore set near the highest SSB observed, based on the reasoning that the lack of plateau in the SSB-recruit relationship indicated that the stock was below full reproductive capacity.

At the 2022 evaluation of reference points and harvest control rules, this decision was re-evaluated by looking closer at assessment data input and historical catch data. An extension of the assessment model back in time indicated that the stock had not experienced severe recruitment failure in the period examined. The stock also appeared to swiftly respond to decreased F, which would not be expected from a severely depleted stock. At the same time, simulations demonstrated a high sensitivity of the stock–recruit relationship, and therefore also B_{lim}, to small changes in the assessment model, though the estimates of SSB and F were rather consistent. The workshop therefore concluded that it was not possible to set a B_{lim} with the certainty required to use it as a basis for estimating reference points in the ICES AR. Lacking such reference points, the managers adopted a constant fishing mortality HCR (see below) in 2022.

2.2.6.1 Management plan

The Norwegian management plan was implemented in June 2022 and forms the basis for the 2022 advice (ICES, 2022). The target F in the plan is set to $F_{0.1}$, a conservative proxy for F_{msy} that is expected to drive the stock towards and above B_{msy}. This HCR was evaluated as precautionary for all stock sizes above $SSB_{lowerbound}$ (lowest SSB observed in last c. 20 years) at WKNCCHCR (ICES, 2022). No adjustment of target F is thus applied as long as SSB is above this value. The HCR requires re-evaluation should the stock fall below $SSB_{lowerbound}$.

2.2.7 Predictions

2.2.7.1 Input data (Tables 2.2.21a–b)

The built-in forecast option in SAM is used for short-term prediction. Since the fishery is not quota regulated, status quo fishing is assumed for the interim year, i.e. same F as in the final year of assessment (Table 2.2.21a). Process noise is included in the prediction (i.e. process-NoiseF=FALSE). Averages from the last 5 years of the assessment are used for stock weights, catch weights, maturity, and natural mortality-at-age (Table 2.2.21b). Recruitment is the median resampled from the last 10 years (Table 2.2.21a).

2.2.7.2 Catch options for 2021 (Table 2.2.22, Figure 2.2.12)

The ICES advice basis for northern Norwegian coastal cod is the Norwegian management plan. This leads to catch advice of no more than 29 347 tonnes in 2023. This catch level is expected to lead to an 8% increase in SSB relative to SSB estimated for 2022, while the same level of fishing in 2023 as in 2021 is expected to give a 1.5% decrease in SSB. Zero catch in 2023 is expected to give a 26% increase in SSB (Table 2.2.21, Figure 2.2.12).

2.2.7.3 Comparison of the present and last year's assessments

Due to the updates to the assessment model following WKNCCHCR (ICES, 2022), last year's assessment is not directly comparable to this year's assessment. However, for exploratory reasons both the old and new models were run with 1994–2020 and 1994–2021 data and the results indicated a downwards revision of SSB (and corresponding increase in F) approximately five years back in time when adding 2021 data. For 2020, the downwards revision was approximately 7000 t.

2.2.8 Comments to the assessment and the forecast

The assessment model performs rather well despite uncertainties in survey data. However, as both the stock and model are new, the assessment has so far been tested in a limited number of situations. Both the data input and configuration should be improved leading up to the next benchmark. Some areas of research that can potentially reduce uncertainty in the assessment include:

- Examining whether survey index uncertainty can be improved, e.g. by adjusting the survey design or the post-stratification applied to calculate indices.
- Rereading subsamples of otoliths from the first part of the survey (1995–2002) as these readings are expected to be less precise.
- Extending the swept-area index back to 1995.
- Re-examining the coupling of ages applied in the swept-area index observation correlation in SAM.
- Consider the new option of modelling natural mortality, stock weights, proportion mature and catch weights as processes with error (as opposed to fixed values) in SAM

2.2.9 Tables and figures

Table 2.2.1. Northern Norwegian coastal cod. Total commercial catch (t) by fishing areas in the last two years.

Year	03	04	05	00	Total in Division 1.b (NOR area 03)	Total in Division 2.a (NOR areas 04+00+05)	Total
2020	12245	12393	10832	7652	12245	30877	43122
2021	8244	6548	18542	4640	8244	29730	37974

Table 2.2.2. Commercial catch of northern Norwegian coastal cod (t) in 2021 by gear and Norwegian statistical fishing area.

Year	2021					
Area	03	04	05	00	Total north of 67°N	% by gear
Gillnet	1007	2985	7667	3352	15011	40
L.line/Jig	3578	621	1436	382	6017	16
Danish seine	2568	1633	7178	892	12272	32
Trawl	1083	1303	2258	14	4658	12
Others*	7.2	6.1	2.8	-	16	<0.1
Total	8244	6548	18542	4640	37974	

Table 2.2.3a. Northern Norwegian coastal cod. Estimated commercial landings in numbers ('000) at-age and total tonnes by year.

	Age									Tonnes
Year	2	3	4	5	6	7	8	9	10+	Landed
1994	11	98	978	4394	3760	2756	1119	304	675	52579
1995	21	228	814	2743	4796	3164	1815	943	612	56907
1996	41	768	1415	2035	3130	3086	1210	542	584	41820
1997	57	1111	2106	1956	2344	2721	1856	565	746	46605
1998	436	1631	6433	4391	2784	835	779	377	393	45462
1999	79	912	3395	4938	2037	783	527	394	425	38743
2000	30	534	2549	3925	2240	826	376	112	273	33081
2001	10	330	1863	2242	1641	961	305	104	493	24470
2002	42	308	1551	2585	2391	1057	630	183	363	32188
2003	120	350	952	1859	2173	1206	582	308	252	29253

	Age									Tonnes
Year	2	3	4	5	6	7	8	9	10+	Landed
2004	23	179	1067	1520	2189	1570	784	328	371	31198
2005	13	241	924	1984	2003	1463	716	255	345	30097
2006	23	222	1276	1977	2619	1735	1017	402	396	36884
2007	36	376	1198	1667	1327	1088	477	277	279	26200
2008	63	387	997	1909	1549	1005	576	278	287	27711
2009	21	456	667	1177	1194	812	419	431	211	22988
2010	29	530	754	2832	1947	1055	528	283	857	34804
2011	65	465	1209	1318	1239	1081	568	343	583	27982
2012	374	1017	1126	1118	1287	760	364	177	596	26778
2013	131	503	1024	1038	909	704	478	219	340	21376
2014	88	505	824	1258	839	676	523	297	397	22750
2015	331	1106	1411	1251	1700	1040	639	437	873	34483
2016	75	937	1988	1582	1723	2119	1174	640	1073	49503
2017	846	1577	2071	2323	2087	1491	1331	700	903	54273
2018	171	563	1465	1634	1525	1416	747	518	497	34532
2019	49	953	1299	1776	1585	1260	985	318	519	35861
2020	40	534	2205	2116	2538	1615	906	354	309	43133
2021	162	408	1914	3023	1801	1270	644	177	251	38347

Table 2.2.3b. Northern Norwegian coastal cod. Estimated catch number (’000) at-age in recreational and tourist catches.

	Age									Tonnes
Year	2	3	4	5	6	7	8	9	10+	landed
1994	2	17	170	764	654	479	195	53	117	9144
1995	3	37	131	441	771	508	292	151	98	9144
1996	9	166	305	439	675	666	261	117	126	9020
1997	11	215	408	378	454	527	359	109	144	9020
1998	87	326	1285	877	556	167	156	75	78	9082
1999	18	204	758	1102	455	175	118	88	95	8646
2000	8	136	652	1004	573	211	96	29	70	8460

Year	Age 2	3	4	5	6	7	8	9	10+	Tonnes landed
2001	3	112	635	764	559	327	104	36	168	8335
2002	11	81	408	679	628	278	166	48	95	8460
2003	36	104	281	549	642	356	172	91	74	8646
2004	6	48	285	406	585	419	209	88	99	8335
2005	4	66	252	541	546	399	195	69	94	8211
2006	5	49	280	433	574	380	223	88	87	8087
2007	11	116	370	514	410	336	147	85	86	8087
2008	18	111	287	549	445	289	165	80	82	7962
2009	7	157	229	405	410	279	144	148	73	7900
2010	7	120	171	643	442	240	120	64	194	7900
2011	18	131	341	372	350	305	160	97	165	7900
2012	110	300	332	330	380	224	107	52	176	7900
2013	48	186	379	383	336	260	177	81	126	7900
2014	31	175	286	437	291	235	181	103	138	7900
2015	76	253	323	287	389	238	146	100	200	7900
2016	12	150	317	253	275	338	187	102	171	7900
2017	123	230	301	338	304	217	194	102	131	7900
2018	39	129	335	374	349	324	171	119	114	7900
2019	11	210	286	391	349	278	217	70	114	7900
2020	6	77	319	306	367	233	131	51	45	6233
2021	28	71	331	522	311	219	111	31	43	6623

Table 2.2.3c. Northern Norwegian coastal cod. Total estimated catch number ('000) at age, including recreational and tourist catches.

Year	Age 2	3	4	5	6	7	8	9	10+	Tonnes landed
1994	13	115	1148	5158	4414	3235	1313	356	793	61723
1995	24	264	945	3183	5567	3672	2106	1094	711	66051
1996	50	934	1720	2473	3805	3752	1471	659	709	50840
1997	68	1326	2514	2334	2797	3248	2215	674	890	55624

	Age									Tonnes
Year	2	3	4	5	6	7	8	9	10+	landed
1998	523	1957	7718	5268	3341	1002	935	452	471	54544
1999	97	1116	4152	6040	2492	957	644	482	520	47390
2000	38	670	3201	4929	2812	1037	472	141	342	41541
2001	13	442	2497	3006	2199	1288	409	140	661	32806
2002	53	389	1959	3265	3019	1335	796	231	459	40648
2003	156	454	1234	2408	2815	1562	754	399	326	37900
2004	30	227	1352	1926	2774	1989	993	415	470	39533
2005	17	307	1176	2525	2550	1862	911	324	440	38308
2006	28	271	1556	2410	3193	2115	1240	490	482	44970
2007	47	492	1567	2181	1737	1423	624	362	365	34287
2008	81	498	1284	2458	1994	1294	741	358	369	35674
2009	28	612	896	1582	1605	1091	563	579	284	30888
2010	35	651	925	3474	2388	1295	647	347	1051	42704
2011	83	597	1550	1690	1588	1386	728	440	747	35882
2012	484	1317	1458	1447	1666	984	471	229	772	34678
2013	179	689	1403	1421	1245	965	655	300	466	29276
2014	119	680	1110	1695	1130	911	704	400	534	30650
2015	407	1360	1734	1537	2089	1278	785	537	1072	42383
2016	86	1086	2305	1835	1998	2458	1362	743	1244	57403
2017	969	1806	2373	2661	2391	1707	1525	802	1035	62173
2018	210	691	1800	2007	1873	1740	918	637	611	42432
2019	60	1163	1585	2167	1934	1537	1202	387	633	43761
2020	45	612	2524	2422	2905	1849	1037	405	353	49366
2021	190	479	2245	3545	2112	1490	755	207	294	44970

Table 2.2.4. Northern Norwegian coastal cod. Mean catch weight at age (kg).

	Age								
Year	2	3	4	5	6	7	8	9	10+
1994	0.910	1.422	1.987	2.649	3.479	4.343	5.245	6.487	8.825

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1995	0.784	1.272	1.708	2.236	3.073	4.203	5.228	6.121	9.469
1996	0.874	1.269	1.722	2.385	2.968	3.660	4.544	5.462	7.814
1997	1.115	1.490	1.902	2.497	3.219	3.930	4.738	5.616	7.768
1998	0.719	1.212	1.654	2.343	3.346	3.969	4.786	5.389	9.584
1999	0.989	1.512	1.975	2.501	3.331	4.032	4.923	5.415	8.339
2000	1.019	1.452	2.057	2.598	3.447	4.449	5.553	5.834	9.781
2001	1.014	1.448	1.905	2.593	3.266	3.756	4.498	4.794	7.711
2002	0.929	1.470	2.059	2.760	3.590	4.467	5.268	6.236	9.943
2003	1.082	1.687	2.180	2.944	3.754	4.672	5.417	5.713	9.070
2004	1.145	1.604	2.186	2.848	3.640	4.555	5.367	5.930	7.991
2005	1.112	1.622	2.249	3.017	3.539	4.371	5.233	5.981	8.320
2006	1.522	2.020	2.491	3.284	4.075	4.887	5.806	6.638	9.710
2007	1.072	1.546	2.168	2.968	3.987	4.925	5.781	6.871	9.771
2008	1.153	1.663	2.355	3.043	3.970	4.902	5.844	6.279	9.239
2009	1.331	1.761	2.502	3.328	4.196	5.218	6.178	6.516	9.248
2010	1.252	1.770	2.375	3.103	3.834	4.483	5.437	6.185	7.599
2011	1.080	1.689	2.310	3.031	3.906	4.681	5.941	6.422	8.346
2012	1.010	1.653	2.328	3.232	4.246	5.111	6.448	6.914	9.446
2013	1.107	1.674	2.295	3.122	3.997	4.873	5.892	6.800	10.104
2014	1.187	1.788	2.410	3.222	4.118	5.165	5.791	6.461	9.643
2015	1.055	1.545	2.192	3.030	3.745	4.724	5.601	6.482	9.044
2016	1.279	1.774	2.363	3.171	3.972	4.868	5.893	6.850	8.928
2017	1.316	1.785	2.468	3.225	4.077	5.014	5.977	6.933	9.356
2018	1.141	1.700	2.307	3.090	3.878	4.770	5.711	6.581	9.333
2019	1.431	1.904	2.615	3.254	4.116	4.868	5.748	6.562	8.561
2020	1.487	2.147	2.823	3.514	4.218	4.932	5.655	6.387	9.024
2021	1.189	1.847	2.513	3.360	4.387	5.442	6.391	7.285	8.998

Table 2.2.5. Northern Norwegian coastal cod. Acoustic abundance indices by age (in thousands) and total biomass (t) from the Coastal survey (A6335). The split between coastal cod and Northeast Arctic cod is uncertain for age 1.

	Age											
Year	1	2	3	4	5	6	7	8	9	10+	Sum	Biomass
1995	26495	8774	4974	6382	6440	4373	1309	532	319	132	59729	55126
1996	17580	9025	8592	4576	5306	2723	1022	213	32	24	49093	39263
1997	16567	15358	16930	7710	4484	2316	716	328	59	33	64502	45756
1998	8360	6757	8524	8261	3717	1530	700	102	122	45	38118	39474
1999	2494	3486	3387	2788	2498	751	172	30	22	20	15648	16167
2000	5028	7439	5831	3939	3853	2825	622	258	71	32	29899	35602
2001	2711	4551	4246	3776	2184	1499	974	149	29	93	20211	27250
2002	1188	2071	2532	2926	2075	970	596	293	106	124	12882	21203
2003	3276	2168	3026	3303	1838	1519	651	364	190	69	16403	23978
2004	3046	2643	2819	2589	1686	1094	371	213	104	72	14639	18237
2005	904	1201	2228	1816	1490	843	234	233	127	79	9156	14690
2006	4981	1836	2587	2210	1453	1612	1046	130	89	27	15970	22116
2007	2458	3037	2778	3794	2437	1632	1215	441	120	41	17952	33314
2008	2344	1739	1684	1511	985	761	399	225	97	74	9821	15491
2009	3907	1502	2084	2596	1373	605	386	378	140	64	13035	18716
2010	5509	2503	2853	2240	1679	583	309	432	229	195	16531	21966
2011	2104	2542	1869	2372	1469	1215	394	278	137	150	12529	23115
2012	3561	2170	3546	1832	1154	791	503	254	107	224	14142	20913
2013	4694	3084	1597	1770	1287	838	657	430	216	252	14825	21105
2014	6030	4171	3066	2137	2904	1609	1151	429	462	326	22286	37127
2015	3421	3122	2465	1802	1017	1128	477	363	303	265	14362	23144
2016	2921	3341	3667	2349	2308	841	669	452	222	308	17078	30763
2017	1018	3289	3202	2335	1764	1122	450	256	181	183	13800	25998
2018	4977	2847	1837	2376	1246	946	494	246	136	169	15274	22602
2019	2607	2992	3724	2221	2149	1272	656	212	262	266	16360	29992
2020	481	1618	3378	3739	2025	890	522	319	85	125	12701	26878
2021	3735	4806	3597	4923	3935	2102	1143	747	231	243	21727	43863

Table 2.2.6. Northern Norwegian coastal cod. Acoustic abundance index coefficient of variation (CV, in %) by age.

	Age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1995	17	13	9	12	14	21	19	40	51	41
1996	20	11	15	17	14	26	54	39	52	156
1997	24	25	16	16	14	25	26	47	90	81
1998	26	19	12	16	16	31	69	40	87	104
1999	24	10	11	20	17	23	19	47	40	92
2000	14	16	12	10	9	10	15	29	49	89
2001	18	31	18	16	19	18	21	41	72	69
2002	25	17	21	16	14	15	23	36	72	67
2003	27	26	14	14	14	16	18	22	26	35
2004	17	15	14	12	13	17	17	25	69	33
2005	18	23	18	10	14	20	23	30	40	61
2006	108	68	15	14	15	27	22	23	31	
2007	21	20	19	15	16	16	21	31	45	97
2008	24	19	14	13	12	14	20	24	39	37
2009	22	20	15	12	17	14	18	19	31	25
2010	41	18	16	13	12	22	22	22	21	21
2011	22	17	16	15	15	15	27	21	19	35
2012	20	20	13	14	15	11	19	16	24	18
2013	14	16	14	15	14	13	17	20	31	37
2014	16	19	12	15	15	13	15	14	23	43
2015	21	16	11	10	12	12	16	16	16	27
2016	29	15	10	8	11	16	17	21	39	31
2017	34	16	12	16	14	18	23	28	43	25
2018	18	17	17	16	18	9	18	60	20	35
2019	18	20	15	13	12	15	18	28	33	35
2020	28	16	16	12	14	14	19	27	39	57
2021	18	16	13	12	13	13	16	19	32	45

Table 2.2.7. Northern Norwegian coastal cod. Swept-area abundance indices by age (in thousands) and total biomass (t) from the Coastal survey (A6335). The split between coastal cod and Northeast Arctic cod is uncertain for age 1.

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum	Biomass
2003	5254	3268	3763	4521	2700	2319	863	489	220	69	23467	33861
2004	2837	2201	2396	2602	1463	722	359	181	46	63	12868	15980
2005	665	1042	1988	1478	1268	746	157	107	68	54	7574	11379
2006	1802	2156	2623	2946	1554	1026	941	171	107	23	13349	22526
2007	446	911	853	1071	789	465	394	114	75	29	5146	11943
2008	2463	1822	2795	1883	1419	1145	580	348	161	94	12710	23090
2009	6642	2251	3570	3716	1584	868	712	466	204	160	20172	24986
2010	7412	2353	3268	3385	2397	784	383	733	317	328	21360	29875
2011	2322	3471	2498	2866	2095	1445	292	315	213	310	15827	27845
2012	4299	3218	4485	2784	1537	1042	930	411	200	346	19251	28587
2013	6382	4101	1706	2666	1887	1575	890	578	297	419	20502	32875
2014	5696	5448	4026	3034	3521	2016	1388	465	364	337	26296	43823
2015	4298	4733	4154	3727	2068	1818	902	506	397	222	22827	40385
2016	3944	4433	4522	2610	1995	746	735	413	203	210	19810	31320
2017	768	2891	2407	1563	1151	715	308	200	147	157	10308	18682
2018	4070	3197	1916	1879	1049	748	323	183	128	168	13661	18815
2019	2234	2114	2470	1508	1460	839	490	148	129	211	11601	19974
2020	560	1670	2599	2416	1188	611	291	177	49	72	9072	16780
2021	1412	2531	1367	1589	1367	732	289	239	82	81	8277	14699

Table 2.2.8. Northern Norwegian coastal cod. Swept-area abundance index coefficient of variation (CV, in %).

	Age								
Year	1	2	3	4	5	6	7	8	9	10
2003	23	23	16	14	12	12	24	32	25	69
2004	27	16	16	16	21	21	23	34	40	37
2005	21	28	30	22	16	25	24	25	45	58
2006	20	34	24	26	17	13	24	30	34	
2007	23	28	30	18	17	15	24	31	44	87

	Age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2008	15	26	21	13	11	17	15	20	37	36
2009	16	16	18	14	14	18	15	21	24	27
2010	9	16	19	21	16	18	26	27	21	16
2011	20	24	27	19	23	17	25	23	23	35
2012	9	37	24	13	12	13	16	17	23	20
2013	14	17	15	23	20	21	16	17	31	38
2014	17	30	17	16	17	26	14	15	22	39
2015	19	17	18	27	29	22	30	19	19	23
2016	20	13	13	10	9	13	16	24	20	20
2017	30	20	17	15	9	17	18	39	30	27
2018	15	19	16	15	12	11	15	27	19	19
2019	15	16	16	13	10	9	12	17	25	30
2020	28	14	16	13	13	16	15	19	31	41
2021	19	19	21	16	21	18	13	16	25	35

Table 2.2.9. Proportion Norwegian coastal cod by age among all aged cod in the Norwegian coastal survey north of 67°N. The split between coastal cod and Northeast Arctic cod is uncertain for age 1.

	Age									**Total number aged**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1995	0.92	0.98	0.94	0.86	0.60	0.54	0.60	0.56	0.90	1.00	2236
1996	0.87	0.96	0.89	0.81	0.68	0.60	0.41	0.42	0.27	0.25	2289
1997	0.88	0.91	0.86	0.79	0.71	0.64	0.43	0.26	0.14	0.75	1774
1998	0.89	0.85	0.80	0.74	0.80	0.69	0.50	0.34	0.32	0.60	2639
1999	0.88	0.90	0.81	0.64	0.58	0.62	0.52	0.20	0.22	0.13	2911
2000	0.97	0.91	0.85	0.76	0.65	0.57	0.42	0.46	0.18	0.08	4325
2001	0.88	0.84	0.74	0.71	0.65	0.55	0.45	0.41	0.21	0.31	3282
2002	0.84	0.86	0.78	0.68	0.54	0.34	0.32	0.29	0.10	0.18	2265
2003	0.90	0.94	0.87	0.88	0.85	0.75	0.65	0.59	0.52	0.57	2953
2004	0.86	0.76	0.77	0.59	0.67	0.57	0.60	0.49	0.41	0.63	2287
2005	0.65	0.81	0.76	0.76	0.65	0.59	0.48	0.56	0.50	0.44	1209

Year	Age 1	2	3	4	5	6	7	8	9	10	**Total number aged**
2006	0.98	0.93	0.94	0.83	0.75	0.71	0.68	0.68	0.57	0.00	1419
2007	0.73	0.81	0.76	0.82	0.73	0.61	0.69	0.43	0.83	0.50	1021
2008	0.99	0.99	0.99	0.83	0.89	0.84	0.78	0.67	0.94	0.75	1448
2009	0.94	0.94	0.83	0.69	0.55	0.58	0.75	0.76	0.73	0.72	1944
2010	0.94	0.94	0.89	0.75	0.66	0.49	0.60	0.86	0.90	0.97	2093
2011	0.90	0.93	0.91	0.89	0.77	0.66	0.52	0.73	0.80	0.83	1577
2012	0.94	0.89	0.90	0.82	0.83	0.73	0.71	0.61	0.88	0.84	1831
2013	0.93	0.94	0.88	0.77	0.79	0.83	0.74	0.79	0.73	1.00	1920
2014	0.99	0.99	0.99	0.96	0.93	0.90	0.93	0.87	0.87	0.88	2361
2015	0.89	0.93	0.89	0.86	0.75	0.73	0.65	0.73	0.82	0.96	1859
2016	0.99	0.98	0.99	0.90	0.84	0.69	0.75	0.80	0.71	0.83	2041
2017	1.00	0.98	0.95	0.93	0.86	0.74	0.78	0.68	0.84	1.00	1732
2018	0.99	0.97	0.91	0.86	0.88	0.82	0.72	0.68	0.87	0.90	2395
2019	0.95	0.99	0.97	0.88	0.84	0.83	0.84	0.76	0.82	0.91	2107
2020	1.00	0.84	0.85	0.81	0.71	0.70	0.75	0.83	0.78	0.64	2504
2021	0.97	0.93	0.85	0.84	0.76	0.79	0.81	0.83	0.84	0.83	2405
Average 95–21	0.91	0.91	0.87	0.80	0.74	0.67	0.63	0.60	0.62	0.65	2179

Table 2.2.10. Northern Norwegian coastal cod. Mean length (cm) at-age from Coastal survey data (A6335). Mean lengths of ages > 7 have higher uncertainty due to few samples. The split between coastal cod and Northeast Arctic cod is uncertain for age 1. For the plus group, mean length is the average mean length for ages 10+, weighted by abundance-at-age.

Year	**Age** **1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1995	18.9	31.4	42.1	51.8	58.8	64.3	77.5	82.4	87.1	105.7
1996	16.7	28.3	41.3	51.9	58.1	65.2	74.8	86.7	99.6	115.0
1997	16.6	29.6	40.7	52.0	58.1	66.9	66.8	68.6	102.0	92.0
1998	17.8	30.3	44.0	52.0	60.3	67.8	74.9	82.2	83.8	107.8
1999	19.4	31.2	44.1	54.1	58.7	65.4	74.0	89.0	88.2	72.7
2000	20.0	32.5	44.0	54.0	61.4	64.5	73.8	81.9	80.3	90.3
2001	20.0	33.7	45.7	55.4	61.1	65.2	67.6	76.1	87.2	109.7

Year	Age 1	2	3	4	5	6	7	8	9	10+
2002	21.6	32.6	45.0	54.5	62.0	68.8	72.4	70.5	66.7	91.8
2003	19.3	33.3	43.8	52.6	60.9	67.7	73.7	78.8	81.9	107.9
2004	21.1	32.7	44.0	54.5	59.2	67.7	70.5	75.5	74.2	79.5
2005	21.6	35.7	44.7	55.4	60.5	62.6	71.4	71.7	80.3	105.9
2006	20.6	34.1	46.2	55.0	60.0	68.8	71.4	74.6	89.0	117.6
2007	21.2	35.9	47.2	56.8	62.7	67.3	73.7	83.4	100.5	99.3
2008	22.1	35.4	48.3	57.9	68.5	69.1	75.8	75.8	71.7	82.3
2009	19.8	32.9	46.7	57.1	64.7	71.4	76.6	76.9	81.2	76.7
2010	18.9	36.9	47.8	56.9	64.1	71.2	76.4	75.5	82.1	83.1
2011	19.1	34.6	48.7	61.0	67.6	71.2	78.1	80.8	80.5	81.6
2012	20.3	32.9	48.3	59.3	65.5	71.4	76.4	80.7	82.2	83.5
2013	21.2	34.3	45.6	56.9	67.7	70.9	73.3	77.3	82.4	88.4
2014	21.1	33.7	48.8	58.0	66.9	72.8	77.5	81.7	80.8	91.4
2015	19.9	34.6	48.3	60.3	67.8	72.6	77.9	79.9	82.2	84.8
2016	20.3	33.1	48.2	58.0	69.5	73.5	76.9	82.5	87.5	87.7
2017	20.3	37.0	47.6	58.7	66.7	74.0	79.5	86.0	84.0	92.8
2018	17.0	37.6	48.0	60.1	68.7	71.5	81.1	84.7	92.1	84.1
2019	19.6	33.7	49.0	59.0	68.2	73.5	80.4	84.4	84.1	95.4
2020	20.8	33.2	46.9	58.3	66.5	72.3	77.4	83.9	93.2	85.3
2021	20.9	33.2	44.5	56.5	65.3	73.3	76.2	82.4	80.0	91.9

Table 2.2.11. Northern Norwegian coastal cod. Mean weight (g) at-age from Coastal survey data (A6335). Mean weights of ages > 7 have higher uncertainty due to few samples. The split between coastal cod and Northeast Arctic cod is uncertain for age 1. For the plus group, mean weight is the average mean weight for ages 10+, weighted by abundance-at-age.

Year	Age 1	2	3	4	5	6	7	8	9	10+
1995	58	282	719	1395	2091	2767	4693	5905	7211	13022
1996	41	216	672	1349	1939	2779	4223	6638	11146	20000
1997	41	244	655	1393	1914	2921	2988	3768	9600	7779
1998	49	259	840	1406	2261	3173	4320	5275	5896	15476

	Age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1999	63	272	793	1508	1964	2759	4257	7262	6561	5934
2000	69	322	826	1561	2363	2811	4260	5977	6061	7553
2001	74	377	933	1660	2320	2998	3338	4478	7193	13677
2002	88	357	918	1595	2377	3468	4415	3868	3588	10135
2003	68	361	820	1427	2269	3127	4114	5493	6350	13767
2004	88	338	877	1646	2153	3197	3810	4656	4184	5457
2005	99	436	878	1727	2205	2542	3666	3520	5562	14216
2006	83	400	989	1649	2231	3502	3992	4445	8004	21921
2007	97	486	1066	1865	2579	3168	4520	6363	11111	13111
2008	97	427	1109	1971	3327	3393	4543	4921	4270	6451
2009	74	357	1032	1878	2695	3803	4599	5146	5349	5205
2010	63	502	1088	1872	2745	3586	4684	5096	6263	6698
2011	59	401	1165	2279	3109	3702	5163	5593	6174	5963
2012	73	355	1141	2026	2907	3690	4688	5549	6118	6504
2013	85	384	918	1817	3041	3438	3963	4926	5662	8265
2014	80	359	1122	1894	2929	3690	4646	5562	5550	8639
2015	73	406	1115	2145	2987	3774	4839	5299	5869	6708
2016	73	347	1101	1904	3327	3928	4689	5885	7273	8108
2017	83	504	1058	1969	2943	3997	4676	6985	6306	8472
2018	52	522	1109	2094	3206	3763	5391	5818	8438	6378
2019	62	372	1131	1984	2983	3815	5141	5908	6420	9215
2020	95	380	1012	1932	2963	3741	4908	6307	9287	7126
2021	79	348	853	1704	2542	3756	4421	5840	5231	7967

Table 2.2.12. Northern Norwegian coastal cod. Maturity-at-age as determined from maturity stages observed in the coastal survey (A6335). Maturity for age 10+ is the average proportion mature for ages 10 and above, weighted by abundance-at-age. The split between coastal cod and Northeast Arctic cod is uncertain for age 1.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1995	0.00	0.00	0.13	0.51	0.60	0.78	0.86	0.99	1.00	1.00

	Age								
Year	1	2	3	4	5	6	7	8	9	10+
1996	0.00	0.02	0.14	0.38	0.74	0.84	0.92	1.00	1.00	1.00
1997	0.03	0.06	0.25	0.36	0.64	0.93	0.92	0.86	1.00	1.00
1998	0.01	0.03	0.13	0.24	0.56	0.70	0.98	0.93	0.88	1.00
1999	0.00	0.02	0.06	0.27	0.52	0.69	0.74	1.00	0.57	1.00
2000	0.00	0.00	0.06	0.20	0.51	0.68	0.80	0.92	1.00	1.00
2001	0.00	0.00	0.04	0.27	0.76	0.96	0.97	0.97	1.00	1.00
2002	0.00	0.01	0.11	0.30	0.78	0.89	0.98	0.94	1.00	1.00
2003	0.00	0.00	0.03	0.28	0.55	0.88	0.95	0.93	1.00	1.00
2004	0.00	0.01	0.11	0.30	0.78	0.92	0.94	1.00	1.00	1.00
2005	0.00	0.00	0.11	0.37	0.56	0.83	0.94	0.97	1.00	1.00
2006	0.00	0.01	0.19	0.53	0.72	0.93	0.90	0.96	1.00	1.00
2007	0.00	0.00	0.16	0.54	0.72	0.93	0.96	1.00	1.00	1.00
2008	0.00	0.02	0.10	0.30	0.73	0.88	0.97	1.00	1.00	1.00
2009	0.00	0.00	0.05	0.21	0.39	0.64	0.77	0.90	0.97	0.94
2010	0.00	0.00	0.03	0.27	0.57	0.78	0.92	0.99	0.98	1.00
2011	0.02	0.00	0.05	0.31	0.63	0.74	0.89	0.90	0.88	1.00
2012	0.00	0.01	0.04	0.28	0.57	0.86	0.89	1.00	0.96	1.00
2013	0.00	0.00	0.02	0.22	0.57	0.86	0.99	0.94	0.96	1.00
2014	0.00	0.00	0.03	0.15	0.56	0.78	0.90	0.98	1.00	1.00
2015	0.00	0.01	0.04	0.19	0.48	0.74	0.78	0.93	0.95	1.00
2016	0.00	0.00	0.06	0.28	0.61	0.85	0.91	0.98	1.00	1.00
2017	0.00	0.00	0.05	0.29	0.60	0.83	0.95	1.00	0.91	1.00
2018	0.00	0.00	0.07	0.24	0.60	0.79	0.94	1.00	1.00	1.00
2019	0.00	0.00	0.05	0.23	0.50	0.73	0.89	1.00	0.97	1.00
2020	0.00	0.02	0.07	0.33	0.60	0.88	0.97	0.98	1.00	1.00
2021	0.00	0.00	0.07	0.29	0.58	0.88	0.89	0.96	1.00	1.00

Table 2.2.13. Northern Norwegian coastal cod. Tuning data used in the final SAM run.

Norwegian Coastal cod									
101									
Norw-Coast-Ac-Q4-1995 (Aco)									
1995	2002								
1	1	0.75	0.85						
-2									
1	53586								
1	38553								
1	45079								
1	39064								
1	16012								
1	35255								
1	27051								
1	21098								
Norw-Coast-Ac-Q4-2003 (Aco)									
2003	2020								
1	1	0.75	0.85						
-2									
1	23749								
1	17968								
1	14601								
1	21748								
1	33075								
1	15266								
1	18428								
1	21637								
1	22991								
1	20654								
1	20705								
1	36710								
1	22892								
1	30551								
1	25918								
1	22347								
1	29829								
1	26833								
Norw-Coast-Ac-Q4 (BTr)									
2003	2021								
1	1	0.75	0.85						
2	10								
1	3.268	3.763	4.521	2.700	2.319	0.863	0.489	0.220	0.069
1	2.201	2.396	2.602	1.463	0.722	0.359	0.181	0.046	0.063
1	1.042	1.988	1.478	1.268	0.746	0.157	0.107	0.068	0.054

1	2.156	2.623	2.946	1.554	1.026	0.941	0.171	0.107	0.023
1	0.911	0.853	1.071	0.789	0.465	0.394	0.114	0.075	0.029
1	1.822	2.795	1.883	1.419	1.145	0.580	0.348	0.161	0.094
1	2.251	3.570	3.716	1.584	0.868	0.712	0.466	0.204	0.160
1	2.353	3.268	3.385	2.397	0.784	0.383	0.733	0.317	0.328
1	3.471	2.498	2.866	2.095	1.445	0.292	0.315	0.213	0.310
1	3.218	4.485	2.784	1.537	1.042	0.930	0.411	0.200	0.346
1	4.101	1.706	2.666	1.887	1.575	0.890	0.578	0.297	0.419
1	5.448	4.026	3.034	3.521	2.016	1.388	0.465	0.364	0.337
1	4.733	4.154	3.727	2.068	1.818	0.902	0.506	0.397	0.222
1	4.433	4.522	2.610	1.995	0.746	0.735	0.413	0.203	0.210
1	2.891	2.407	1.563	1.151	0.715	0.308	0.2	0.147	0.157
1	3.197	1.916	1.879	1.049	0.748	0.323	0.183	0.128	0.168
1	2.114	2.470	1.508	1.460	0.839	0.490	0.148	0.129	0.211
1	1.670	2.599	2.416	1.188	0.611	0.291	0.177	0.049	0.072
1	2.531	1.367	1.589	1.367	0.732	0.289	0.239	0.082	0.081

Table 2.2.14. Northern Norwegian coastal cod. Stock mean weight-at-age (kg) was used in the assessment model. Mean weights at age in the catch are used in place of stock weights for ages 8–10+. Mean weights in 1994, when the survey had not yet started, are means of stock weights in the years 1995–1997 for ages 2–7 and set to weight in catch for ages 8–10+.

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1994	0.247	0.682	1.379	1.981	2.822	3.968	5.245	6.487	8.825
1995	0.282	0.719	1.395	2.091	2.767	4.693	5.228	6.121	9.469
1996	0.216	0.672	1.349	1.939	2.779	4.223	4.544	5.462	7.814
1997	0.244	0.655	1.393	1.914	2.921	2.988	4.738	5.616	7.768
1998	0.259	0.840	1.406	2.261	3.173	4.320	4.786	5.389	9.584
1999	0.272	0.793	1.508	1.964	2.759	4.257	4.923	5.415	8.339
2000	0.322	0.826	1.561	2.363	2.811	4.260	5.553	5.834	9.781
2001	0.377	0.933	1.660	2.320	2.998	3.338	4.498	4.794	7.711
2002	0.357	0.918	1.595	2.377	3.468	4.415	5.268	6.236	9.943
2003	0.361	0.820	1.427	2.269	3.127	4.114	5.417	5.713	9.07
2004	0.338	0.877	1.646	2.153	3.197	3.810	5.367	5.93	7.991
2005	0.436	0.878	1.727	2.205	2.542	3.666	5.233	5.981	8.32
2006	0.400	0.989	1.649	2.231	3.502	3.992	5.806	6.638	9.71
2007	0.486	1.066	1.865	2.579	3.168	4.520	5.781	6.871	9.771
2008	0.427	1.109	1.971	3.327	3.393	4.543	5.844	6.279	9.239

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2009	0.357	1.032	1.878	2.695	3.803	4.599	6.178	6.516	9.248
2010	0.502	1.088	1.872	2.745	3.586	4.684	5.437	6.185	7.599
2011	0.401	1.165	2.279	3.109	3.702	5.163	5.941	6.422	8.346
2012	0.355	1.141	2.026	2.907	3.690	4.688	6.448	6.914	9.446
2013	0.384	0.918	1.817	3.041	3.438	3.963	5.892	6.800	10.104
2014	0.359	1.122	1.894	2.929	3.690	4.646	5.791	6.461	9.643
2015	0.406	1.115	2.145	2.987	3.774	4.839	5.601	6.482	9.044
2016	0.347	1.101	1.904	3.327	3.928	4.689	5.893	6.850	8.928
2017	0.504	1.058	1.969	2.943	3.997	4.676	5.977	6.933	9.356
2018	0.522	1.109	2.094	3.206	3.763	5.391	5.711	6.581	9.333
2019	0.372	1.131	1.984	2.983	3.815	5.141	5.748	6.562	8.561
2020	0.380	1.012	1.932	2.963	3.741	4.908	5.655	6.387	9.024
2021	0.348	0.853	1.704	2.542	3.756	4.421	6.391	7.285	8.998

Table 2.2.15. Northern Norwegian coastal cod. Natural mortality-at-age is used in the assessment model. Estimated from mean weights at age (Table 2.2.14) by the Lorenzen (1996) method.

	Age								
Year	2	3	4	5	6	7	8	9	10+
1994	0.687	0.504	0.407	0.364	0.327	0.295	0.271	0.254	0.231
1995	0.661	0.496	0.405	0.358	0.329	0.280	0.271	0.258	0.226
1996	0.716	0.507	0.410	0.367	0.329	0.289	0.283	0.267	0.240
1997	0.690	0.511	0.406	0.368	0.324	0.321	0.279	0.265	0.240
1998	0.677	0.473	0.404	0.350	0.316	0.287	0.278	0.268	0.225
1999	0.668	0.482	0.396	0.365	0.329	0.288	0.276	0.268	0.235
2000	0.634	0.476	0.392	0.345	0.327	0.288	0.266	0.262	0.224
2001	0.604	0.458	0.384	0.347	0.321	0.311	0.284	0.278	0.241
2002	0.615	0.461	0.389	0.345	0.307	0.285	0.270	0.257	0.223
2003	0.612	0.477	0.403	0.350	0.317	0.292	0.268	0.264	0.229
2004	0.625	0.467	0.386	0.355	0.315	0.298	0.269	0.261	0.238
2005	0.578	0.467	0.380	0.353	0.338	0.302	0.271	0.260	0.235

Year	Age 2	3	4	5	6	7	8	9	10+
2006	0.594	0.450	0.385	0.351	0.306	0.294	0.262	0.252	0.224
2007	0.559	0.440	0.371	0.336	0.316	0.283	0.263	0.249	0.224
2008	0.582	0.435	0.365	0.311	0.309	0.283	0.262	0.256	0.228
2009	0.614	0.444	0.370	0.332	0.299	0.282	0.258	0.253	0.228
2010	0.554	0.437	0.371	0.330	0.304	0.280	0.268	0.257	0.242
2011	0.593	0.428	0.349	0.318	0.301	0.272	0.261	0.255	0.235
2012	0.615	0.431	0.362	0.324	0.301	0.280	0.254	0.249	0.226
2013	0.601	0.461	0.374	0.320	0.308	0.295	0.261	0.250	0.222
2014	0.613	0.433	0.369	0.323	0.301	0.281	0.263	0.254	0.225
2015	0.591	0.434	0.356	0.321	0.299	0.277	0.265	0.254	0.229
2016	0.620	0.436	0.369	0.311	0.296	0.280	0.261	0.250	0.230
2017	0.553	0.441	0.365	0.323	0.294	0.280	0.260	0.249	0.227
2018	0.547	0.435	0.358	0.315	0.300	0.268	0.264	0.253	0.227
2019	0.607	0.432	0.364	0.322	0.298	0.272	0.263	0.253	0.233
2020	0.603	0.447	0.367	0.322	0.300	0.276	0.265	0.255	0.229
2021	0.619	0.471	0.381	0.338	0.300	0.285	0.255	0.245	0.230

Table 2.2.16. Northern Norwegian coastal cod. SAM configuration.

Model used: SAM (State–space assessment model; https://www.stockassessment.org; Nielsen and Berg 2014).

Software used: Template Model Builder (TMB) and R.

Age range of assessment: 2–10, where 10 is a plus group.

Start year of assessment: 1994

Last change of configuration: WKNCCHCR 2022

The assessment is available at www.stockassessment.org under the name NCCN67_acotsb_2022_Excl2021acou

```
# Configuration saved: Thu Oct 21 15:33:05 2021

# Where a matrix is specified rows corresponds to fleets and columns to ages. Same number indicates same parameter
# used. Numbers (integers) starts from zero and must be consecutive. Negative numbers indicate that the parameter is not
# included in the model
$minAge
# The minimium age class in the assessment
 2

$maxAge
# The maximum age class in the assessment
```

```
 10

$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 0 0 1

$keyLogFsta
# Coupling of the fishing mortality states processes for each age (normally only the first row (= fleet) is used). Sequential
# numbers indicate that the fishing mortality is estimated individually for those ages; if the same number is used for two or
# more ages, F is bound for those ages (assumed to be the same). Binding fully selected ages will result in a flat selection
# pattern for those ages.
  0  1  2  3  4  5  5  5  6
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1

$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, 2 AR(1), 3 separable AR(1).
# 0: independent means there is no correlation between F across age 1: compound symmetry means that all ages are equally
# correlated; 2: AR(1) first order autoregressive - similar ages are more highly correlated than ages that are further apart,
# so similar ages have similar F patterns over time. if the estimated correlation is high, then the F pattern over time for each
# age varies in a similar way. E.g if almost one, then they are parallel (like a separable model) and if almost zero then they
# are independent. 3: Separable AR - Included for historic reasons . . .  more later
 2

$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1 -1
  0 -1 -1 -1 -1 -1 -1 -1 -1
  1 -1 -1 -1 -1 -1 -1 -1 -1
  2  3  4  5  5  5  5  5  6

$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarF
# Coupling of process variance parameters for log(F)-process (Fishing mortality normally applies to the first (fishing) fleet;
# therefore only first row is used)
  0  0  0  0  0  0  0  0  0
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarLogN
# Coupling of the recruitment and survival process variance parameters for the log(N)-process at the different ages. It is
# advisable to have at least the first age class (recruitment) separate, because recruitment is a different process than
# survival.
 0 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations. First row refers to the coupling of the variance parameters for
# the catch data observations by age. Second and further rows refers to coupling of the variance parameters for the index
# data observations by age
  0  0  0  0  0  0  0  0  0
```

```
  1 -1 -1 -1 -1 -1 -1 -1 -1
  2 -1 -1 -1 -1 -1 -1 -1 -1
  3  3  3  3  3  3  3  3  3

$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID",
# "AR", "US"
"ID" "ID" "ID" "AR"

$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above. NA's indicate where
# correlation parameters can be specified (-1 where they cannot).
#2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
 NA  NA  NA  NA  NA  NA  NA  NA
 -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
  0   1   1   1   2   3   3   3

$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, 2 for Beverton–Holt, and 3 piece-wise constant).
 0

$noScaledYears
# Number of years where catch scaling is applied.
 0

$keyScaledYears
# A vector of the years where catch scaling is applied.

$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange
# lowest and higest age included in Fbar
 4 8

$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index, 3 total catch, 4 total landings and
# 5 TSB index).
 -1 5 5 -1

$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN"

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0

$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0
$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0

$fracMixObs
# A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the
```

```
# distribution of that fleet
 0 0 0 0

$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year is included in the left interval. (This
# option is only used in combination with stock–recruitment code 3)

$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations.
  -1  -1  -1  -1  -1  -1  -1  -1  -1
  NA  NA  NA  NA  NA  NA  NA  NA  NA
  NA  NA  NA  NA  NA  NA  NA  NA  NA
  -1  -1  -1  -1  -1  -1  -1  -1  -1

$hockeyStickCurve
#
 20

$stockWeightModel
# Integer code describing the treatment of stock weights in the model (0 use as known, 1 use as observations to inform
# stock weight process (GMRF with cohort and within year correlations))
 0

$keyStockWeightMean
# Coupling of stock-weight process mean parameters (not used if stockWeightModel==0)
 NA NA NA NA NA NA NA NA NA

$keyStockWeightObsVar
# Coupling of stock-weight observation variance parameters (not used if stockWeightModel==0)
 NA NA NA NA NA NA NA NA NA

$catchWeightModel
# Integer code describing the treatment of catch weights in the model (0 use as known, 1 use as observations to inform
# catch weight process (GMRF with cohort and within year correlations))
 0

$keyCatchWeightMean
# Coupling of catch-weight process mean parameters (not used if catchWeightModel==0)
 NA NA NA NA NA NA NA NA NA

$keyCatchWeightObsVar
# Coupling of catch-weight observation variance parameters (not used if catchWeightModel==0)
 NA NA NA NA NA NA NA NA NA

$matureModel
# Integer code describing the treatment of proportion mature in the model (0 use as known, 1 use as observations to inform
# proportion mature process (GMRF with cohort and within year correlations on logit(proportion mature)))
 0

$keyMatureMean
# Coupling of mature process mean parameters (not used if matureModel==0)
 NA NA NA NA NA NA NA NA NA
$mortalityModel
# Integer code describing the treatment of natural mortality in the model (0 use as known, 1 use as observations to inform
# natural mortality process (GMRF with cohort and within year correlations))
 0

$keyMortalityMean
```

#
 NA NA NA NA NA NA NA NA NA

$keyMortalityObsVar
Coupling of natural mortality observation variance parameters (not used if mortalityModel==0)
 NA NA NA NA NA NA NA NA NA

$keyXtraSd
An integer matrix with 4 columns (fleet year age coupling), which allows additional uncertainty to be estimated for the specified observations

Table 2.2.17. Northern Norwegian coastal cod. SAM output. Estimated catchability at age for each fleet. The two parts of the acoustic biomass index have one catchability parameter each as the biomass index is not split by age. In the swept-area index, catchabilities are coupled (set equal) in the SAM configuration for ages 5–9.

Fleet/Age	2	3	4	5	6	7	8	9	10+	2+
Acoustic biomass index pt. 1	-	-	-	-	-	-	-	-	-	0.131
Acoustic biomass index pt. 2	-	-	-	-	-	-	-	-	-	0.084
Swept-area index	0.000059	0.000099	0.000141	0.000155	0.000155	0.000155	0.000155	0.000155	0.000206	-

Table 2.2.18. Northern Norwegian coastal cod. SAM output. Estimated recruitment (1000's), Spawning-stock biomass (SSB, t), average fishing mortalities for ages 4–8 (Fbar(4–8)), and Total-stock biomass (TSB, t).

Year/Age	R (age 3)	Low	High	SSB	Low	High	Fbar (4–8)	Low	High	TSB	Low	High
1994	34992	27728	44159	130993	96944	177001	0.28	0.22	0.35	319804	274928	372005
1995	41348	33622	50850	111126	83352	148154	0.37	0.30	0.45	304438	265793	348702
1996	50989	42740	60829	88896	71071	111192	0.36	0.30	0.45	250491	223931	280201
1997	61719	51220	74369	68453	55548	84356	0.46	0.38	0.56	225985	203998	250343
1998	53189	45264	62500	57631	46109	72033	0.47	0.39	0.57	239763	217051	264852
1999	54709	46415	64485	46563	38713	56004	0.43	0.35	0.53	218210	198852	239451
2000	53310	45246	62810	51115	43978	59411	0.33	0.27	0.41	229435	209257	251560
2001	45938	39048	54044	66803	59523	74974	0.27	0.22	0.33	234635	214160	257068
2002	46742	39710	55019	80746	71999	90555	0.31	0.25	0.37	252166	229999	276470
2003	47784	40608	56228	67357	59689	76011	0.30	0.25	0.36	235077	214066	258152
2004	42553	36652	49404	76698	67828	86727	0.33	0.27	0.40	237280	215168	261663
2005	43888	37773	50993	68735	60330	78311	0.29	0.24	0.35	229863	208034	253982
2006	35580	30541	41451	86978	75614	100050	0.34	0.27	0.41	239023	215690	264880
2007	33123	28438	38579	93704	80558	108995	0.24	0.189	0.29	247700	222464	275799
2008	42627	36580	49673	93726	79841	110026	0.22	0.180	0.28	264965	237448	295670
2009	40757	35217	47169	72516	60529	86876	0.19	0.149	0.23	258190	230778	288857
2010	37846	32781	43693	83864	70567	99665	0.23	0.185	0.28	270820	243344	301398

Year/Age	R (age 3)	Low	High	SSB	Low	High	Fbar (4–8)	Low	High	TSB	Low	High
2011	36999	31855	42973	94782	80225	111980	0.21	0.167	0.26	292032	262578	324790
2012	45225	39106	52300	99826	84178	118383	0.166	0.135	0.21	286213	257303	318372
2013	34861	30026	40475	100983	85441	119352	0.143	0.116	0.176	275339	247640	306137
2014	40524	35046	46858	105791	90454	123730	0.139	0.114	0.170	295707	267055	327433
2015	40680	35009	47270	97679	83546	114202	0.20	0.164	0.24	315537	285400	348856
2016	42547	35926	50387	102587	88477	118947	0.28	0.24	0.34	308133	276832	342974
2017	42932	35446	52000	86205	73511	101091	0.37	0.31	0.44	299472	264379	339224
2018	41939	33397	52665	82113	68806	97994	0.32	0.26	0.39	297859	254656	348391
2019	52186	39653	68680	71717	57570	89341	0.34	0.27	0.43	284703	235074	344811
2020	42704	30808	59193	83705	62620	111890	0.36	0.26	0.49	273050	215481	346000
2021	34086	22950	50628	80421	55386	116771	0.28	0.185	0.41	245947	182979	330584

Table 2.2.19. Northern Norwegian coastal cod. SAM output. Estimated fishing mortalities at age. F for ages 7–9 are coupled (set equal) in the SAM configuration.

Year/Age	2	3	4	5	6	7	8	9	10+
1994	0.000	0.005	0.038	0.162	0.327	0.432	0.432	0.432	0.330
1995	0.000	0.008	0.055	0.181	0.388	0.602	0.602	0.602	0.424
1996	0.001	0.018	0.091	0.227	0.396	0.551	0.551	0.551	0.424
1997	0.001	0.025	0.119	0.274	0.535	0.680	0.680	0.680	0.559
1998	0.004	0.054	0.243	0.470	0.631	0.502	0.502	0.502	0.425
1999	0.001	0.027	0.169	0.382	0.540	0.535	0.535	0.535	0.463
2000	0.001	0.016	0.127	0.323	0.403	0.403	0.403	0.403	0.414
2001	0.000	0.010	0.085	0.223	0.342	0.359	0.359	0.359	0.660
2002	0.001	0.012	0.082	0.211	0.379	0.428	0.428	0.428	0.870
2003	0.001	0.013	0.066	0.177	0.329	0.456	0.456	0.456	0.869
2004	0.001	0.008	0.050	0.144	0.326	0.555	0.555	0.555	1.001
2005	0.000	0.008	0.054	0.150	0.279	0.481	0.481	0.481	1.121
2006	0.001	0.011	0.068	0.190	0.328	0.550	0.550	0.550	1.634
2007	0.001	0.016	0.077	0.181	0.248	0.334	0.334	0.334	0.981
2008	0.001	0.018	0.073	0.205	0.259	0.287	0.287	0.287	0.650
2009	0.001	0.015	0.046	0.153	0.240	0.244	0.244	0.244	0.413
2010	0.001	0.018	0.055	0.185	0.303	0.299	0.299	0.299	0.576
2011	0.002	0.021	0.063	0.141	0.221	0.306	0.306	0.306	0.543
2012	0.006	0.038	0.078	0.129	0.184	0.220	0.220	0.220	0.449
2013	0.003	0.026	0.061	0.106	0.149	0.200	0.200	0.200	0.366
2014	0.003	0.022	0.061	0.101	0.141	0.196	0.196	0.196	0.386
2015	0.005	0.040	0.095	0.142	0.206	0.273	0.273	0.273	0.592
2016	0.003	0.030	0.097	0.155	0.282	0.443	0.443	0.443	0.810
2017	0.009	0.057	0.145	0.215	0.352	0.560	0.560	0.560	0.856
2018	0.003	0.025	0.085	0.160	0.271	0.536	0.536	0.536	0.678
2019	0.001	0.020	0.082	0.164	0.289	0.583	0.583	0.583	0.703
2020	0.001	0.017	0.090	0.192	0.357	0.579	0.579	0.579	0.598
2021	0.002	0.021	0.104	0.203	0.281	0.397	0.397	0.397	0.477

Table 2.2.20. Northern Norwegian coastal cod. SAM output. Estimated stock numbers-at-age (1000's).

Year/Age	2	3	4	5	6	7	8	9	10+
1994	83306	34992	39108	35936	17710	10156	4859	1124	3081
1995	99046	41348	21156	25103	21136	9196	4904	2426	2391
1996	122445	50989	24666	13420	14705	10279	3800	2040	2278
1997	106813	61719	29781	14775	7417	7169	4422	1665	2104
1998	109788	53189	37075	17441	7753	3140	2647	1673	1590
1999	102990	54709	31344	19796	7616	2989	1429	1217	1595
2000	87319	53310	32472	17792	9540	3182	1313	631	1351
2001	84360	45938	32944	19070	9052	4668	1581	661	1043
2002	87770	46742	28354	20764	10684	4636	2421	840	787
2003	80865	47784	29702	17439	12024	5330	2266	1202	671
2004	79982	42553	30041	18718	10327	6229	2509	1083	819
2005	63046	43888	25902	19644	11604	5441	2650	1088	718
2006	60940	35580	27501	16663	12008	6298	2525	1254	696
2007	72916	33123	22655	17391	9725	6490	2681	1128	661
2008	72708	42627	20802	14229	10443	5543	3553	1480	827
2009	68818	40757	27790	13391	8383	5924	3135	2090	1208
2010	64863	37846	25556	18703	8278	4860	3508	1883	1938
2011	79524	36999	24213	16582	11184	4537	2725	2004	1967
2012	67552	45225	23859	15880	10497	6602	2574	1518	2049
2013	74721	34861	28813	15504	10251	6472	3989	1602	1965
2014	75747	40524	21186	18945	10261	6479	3964	2525	2094
2015	78329	40680	25643	13703	12444	6653	3986	2523	2721
2016	78398	42547	25151	16357	8609	7530	3883	2323	2673
2017	76621	42932	25648	15970	10107	4889	3645	1921	2091
2018	89067	41939	26384	15213	9415	5216	2140	1603	1555
2019	77253	52186	25915	16956	9522	5308	2320	971	1358
2020	63412	42704	33048	16728	10302	5326	2260	989	947
2021	79169	34086	26829	20881	10098	5286	2294	960	842

Table 2.2.21a. Northern Norwegian coastal cod. Assumptions for the interim year and in the forecast: Fbar, recruitment, SSB and catch.

Variable	Value	Notes
$F_{ages\ 4–7}$ (2022)	0.280	F_{sq} = median fishing mortality in 2021.
SSB (2022)	86 899	Short-term forecast fishing at *status quo* (F_{sq}); Tonnes.
$R_{age\ 2}$ (2022 and 2023)	77 253	Median resampled recruitment (2012–2021). The youngest age in the model is age 2. Other reported recruitments are at age 3 when the fish enter the fishery; thousands.
Total catch (2022)	43 688	Short-term forecast fishing at F_{sq}; Tonnes.

Table 2.2.21b. Northern Norwegian coastal cod. Assumptions for the interim year and in the forecast: mean weights in catch and stock, maturity-at-age, and natural mortality-at-age (last 5 year averages).

Age	Weight in catch (kg)	Weight in stock (kg)	Proportion mature	Natural mortality
2	1.313	0.425	0.005	0.586
3	1.877	1.032	0.060	0.445
4	2.545	1.936	0.275	0.367
5	3.289	2.927	0.576	0.324
6	4.135	3.815	0.822	0.298
7	5.005	4.907	0.929	0.276
8	5.896	5.896	0.987	0.261
9	6.749	6.749	0.976	0.250
10+	9.054	9.054	1.000	0.229

Table 2.2.22. Northern Norwegian coastal cod. Catch scenarios.

Basis	Total catch (2023)	F_{total} (2023)	SSB (2023)*	% SSB change**	% advice change***	% probability of SSB falling below $SSB_{lower\ bound}$ in 2023
ICES advice basis						
Management plan^	29 347	0.176	93 809	8.0	142	8.8
Other scenarios						
F = 0	0	0	109 399	26	−100	0.9
$F = F_{2021}$	44 278	0.28	85 568	−1.5	265	18.5

*** For this stock, SSB is calculated at the time of survey (October) as maturity ogives and stock weights are from the survey. Thus SSB is influenced by fisheries between 1 January and 1 October. The actual spawning time is March–June.**

**** SSB in October 2023 relative to SSB in October 2022 (86 899 tonnes).**

***** Advice for 2023 relative to advice for 2022 (12 146 tonnes).**

^According to the harvest control rule (HCR) in the MP (ICES, 2022a). The advice basis has changed compared to last year following the adoption of the harvest control rule (HCR) evaluated in ICES (2022a) by the managing body.

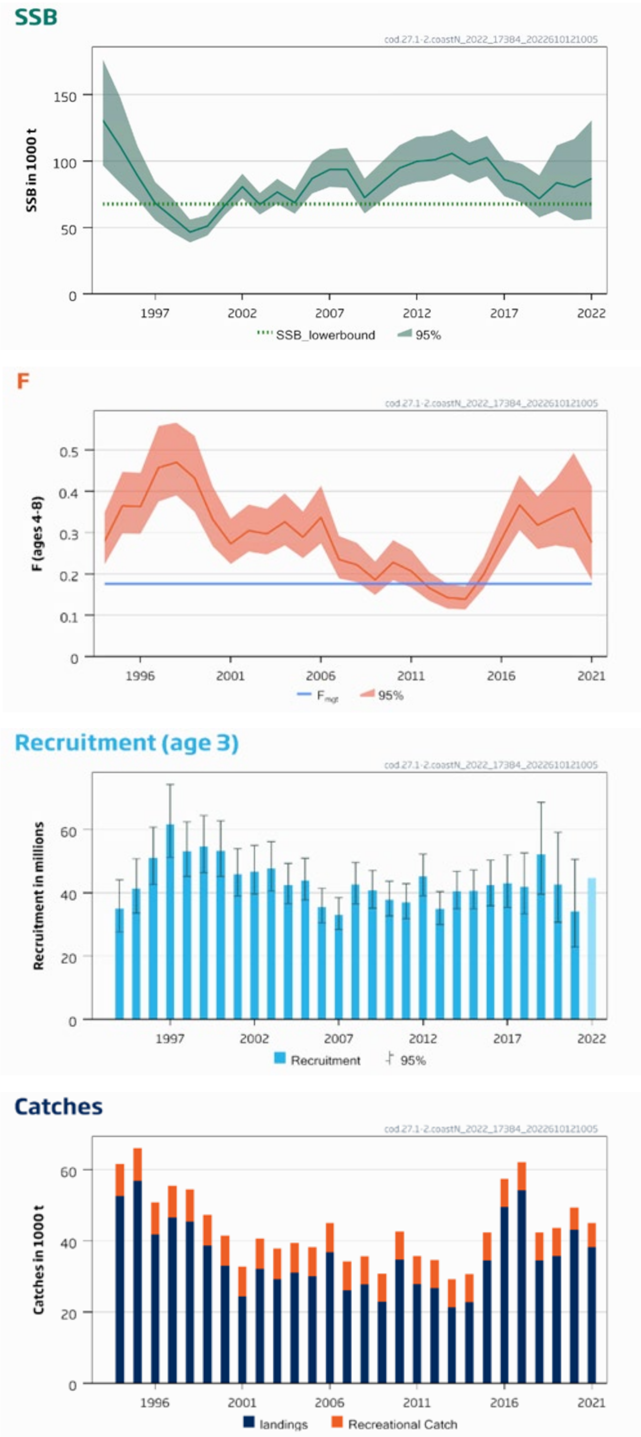


Figure 2.2.1. Northern Norwegian coastal cod. Standard figures. SAM estimates of a) SSB, b) Fbar(4–8), c) recruitment (age 2,), and d) catch input data.

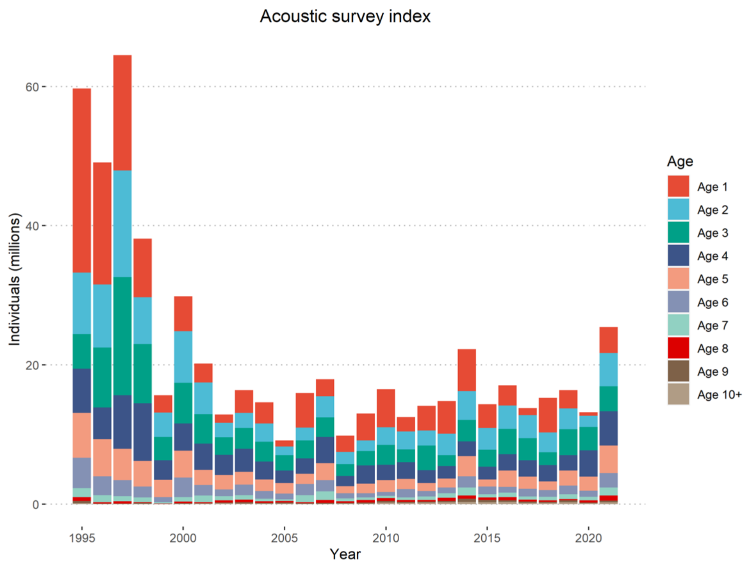


Figure 2.2.2. Northern Norwegian coastal cod. Acoustic abundance index by age (colours) from the Coastal survey in October–November (survey code A6335). Note that starting in 2022, the acoustic index is included in the assessment model as a total biomass index rather than numbers-at-age.

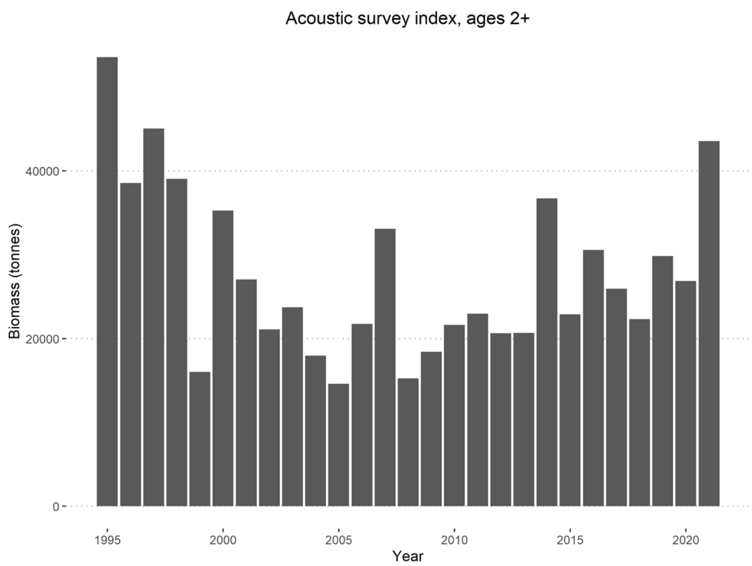


Figure 2.2.3. Northern Norwegian coastal cod. Acoustic biomass index (ages 2+) from the Coastal survey in October-November. Biomass for ages 1+ are reported in Table 2.2.5, but it is biomass for ages 2+ that goes into the assessment model due to the difficulty of distinguishing between coastal and Northeast Arctic cod for age 1. Note that the final data point (2021) was excluded from this year's assessment (see Box 2.1).

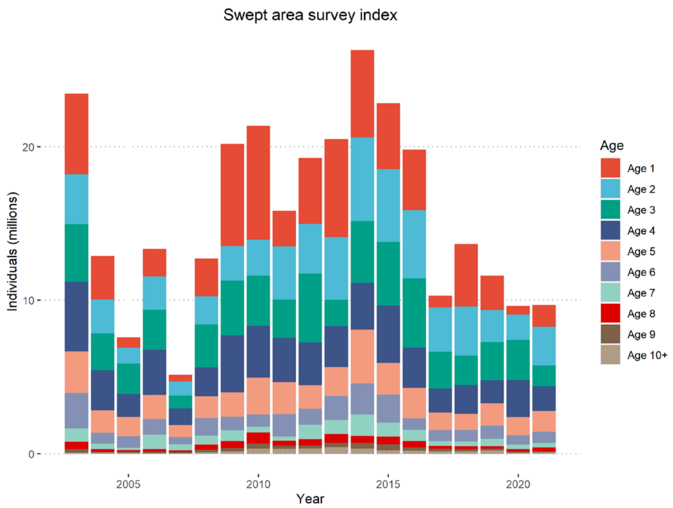


Figure 2.2.4. Northern Norwegian coastal cod. Swept-area abundance index by age (colours) from the coastal survey in October–November (survey code A6335).

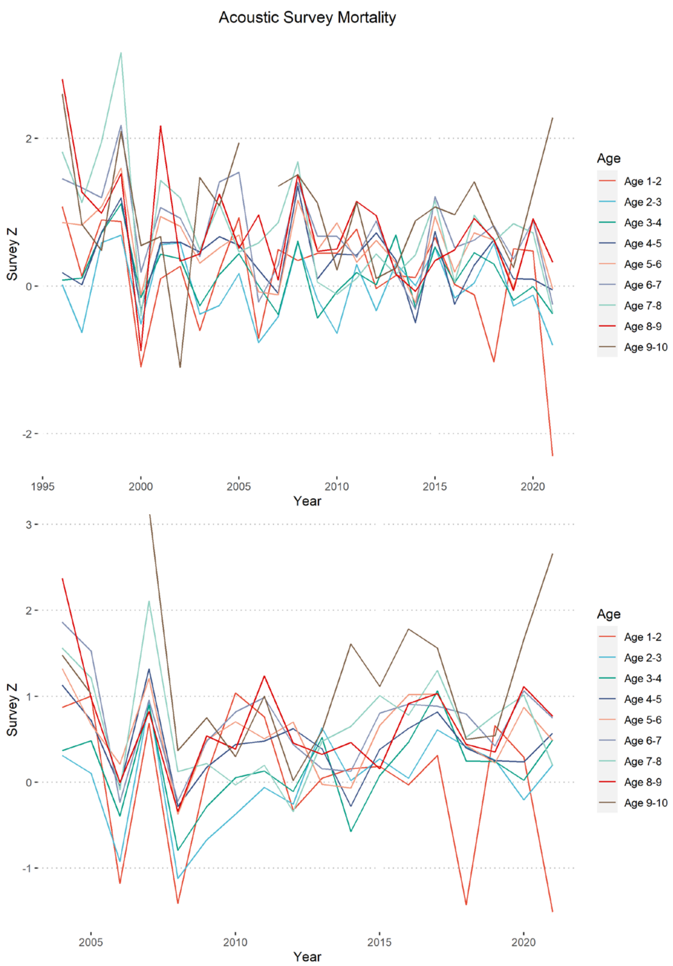


Figure 2.2.5. Northern Norwegian coastal cod. Survey mortality (Z) at age (colours) in the acoustic index (top) and swept-area index (bottom). Z was estimated as $-\log(A_{a+1,y+a}/A_{a,y})$, where $A_{a,y}$ is abundance of age *a* in year *y*.

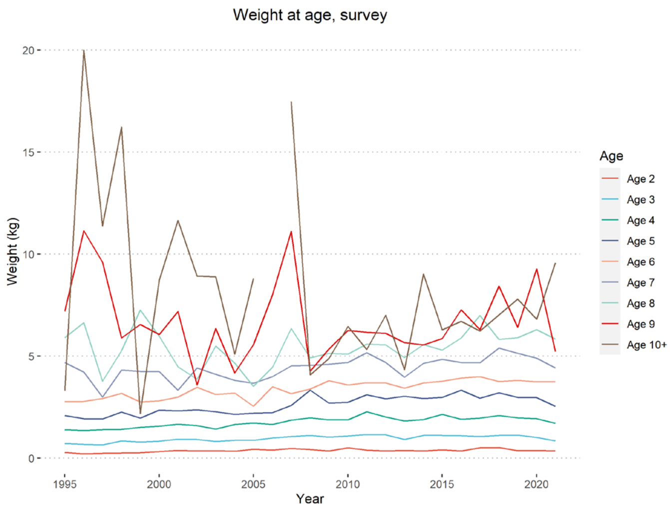


Figure 2.2.6. Northern Norwegian coastal cod. Mean weight-at-age in the coastal survey. Few individuals of ages 10+ were sampled at the beginning of the time-series, leading to extremely large variation in mean weights. In the stock assessment model, stock weights for ages 8–10+ are set equal to mean weight of these ages in the catch.

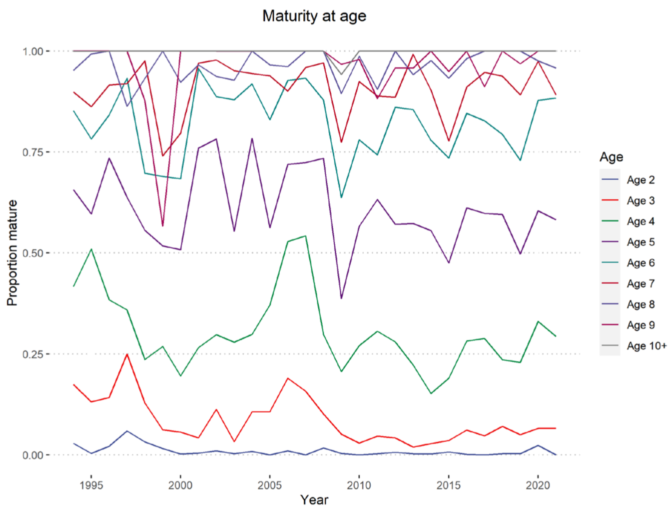


Figure 2.2.7. Northern Norwegian coastal cod. Proportions mature-at-age as observed in the Coastal survey. Since the survey takes place in October-November and the main spawning season is in March-April, spent/resting individuals are included as mature when calculating these proportions.

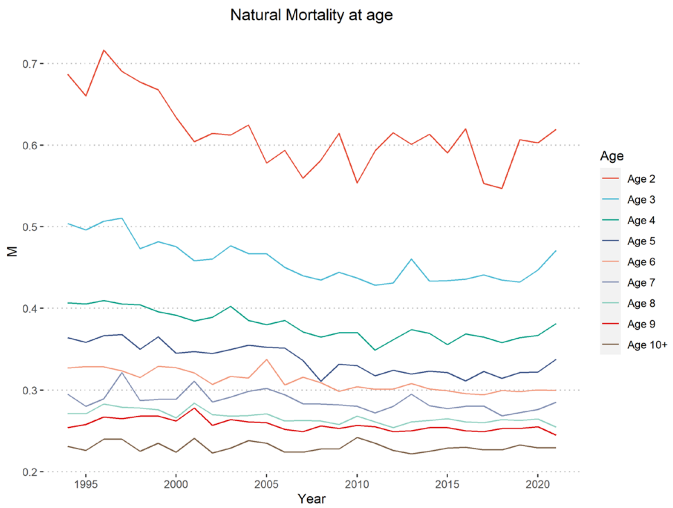


Figure 2.2.8. Northern Norwegian coastal cod. Natural mortality-at-age estimated from stock weights-at-age by the Lorenzen (1996) method.

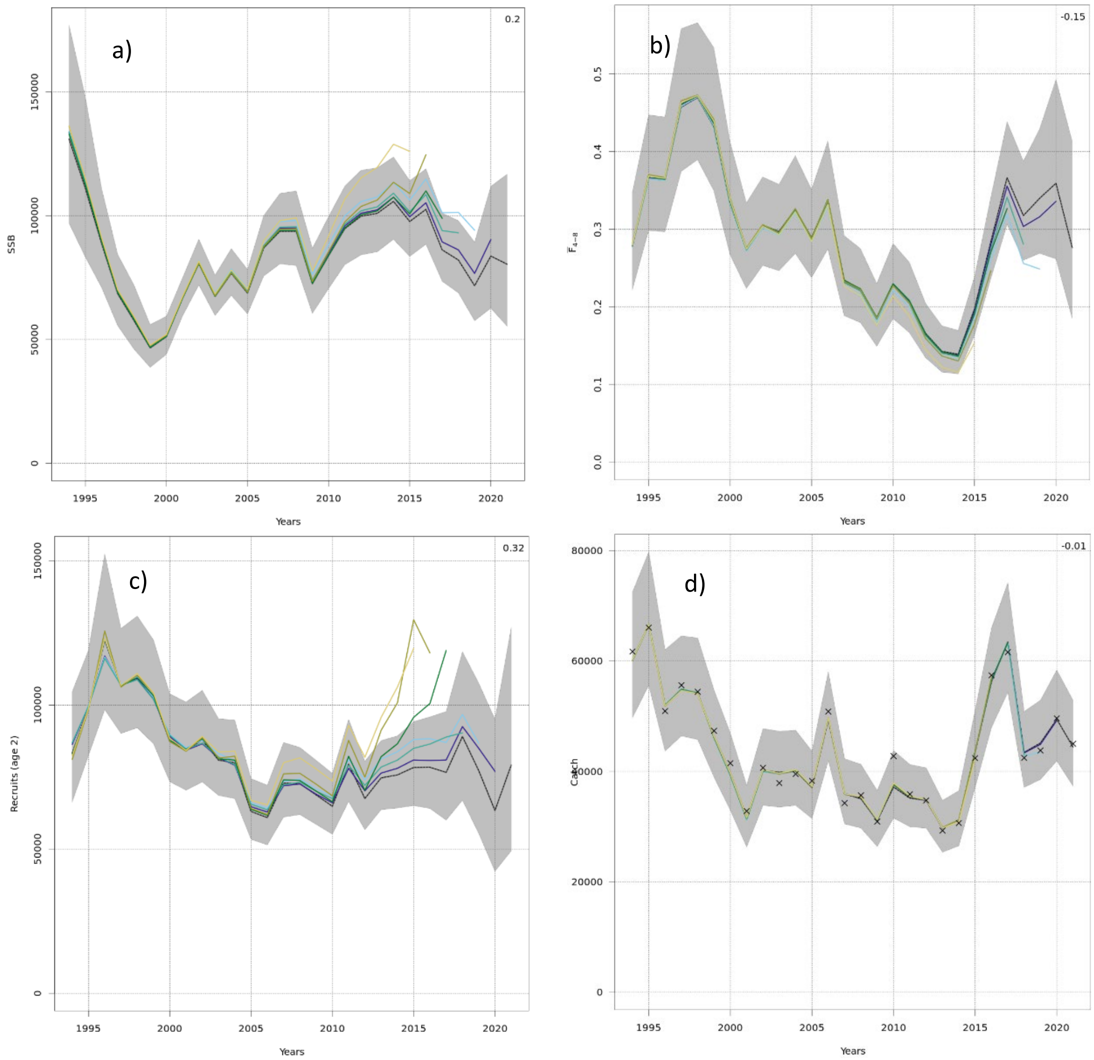


Figure 2.2.9. Northern Norwegian coastal cod. Northern Norwegian coastal cod. 5-year retrospective peel: a) SSB, b) Fbar, c) recruitment, and d) catch. The Mohn's rho value (5-year average retrospective bias) is indicated in the upper right corner of each panel.

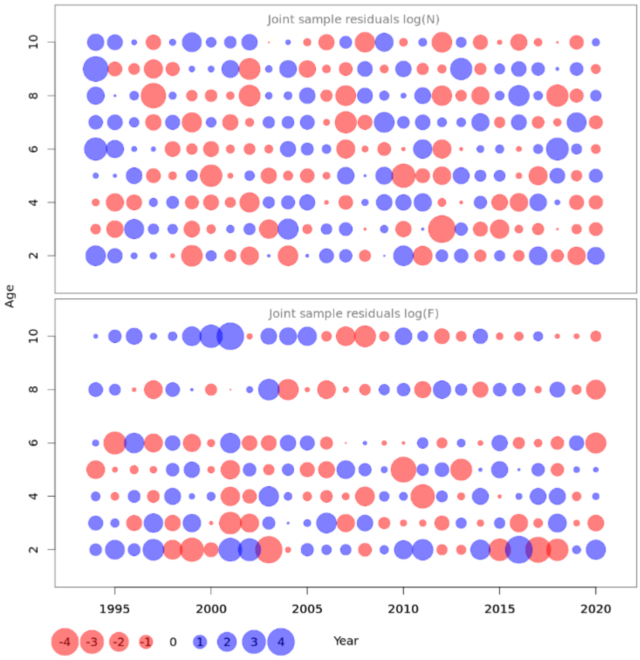


Figure 2.2.10. Northern Norwegian coastal cod. Residuals for the log(N) (top) and log(F) (bottom) process from the final SAM run.

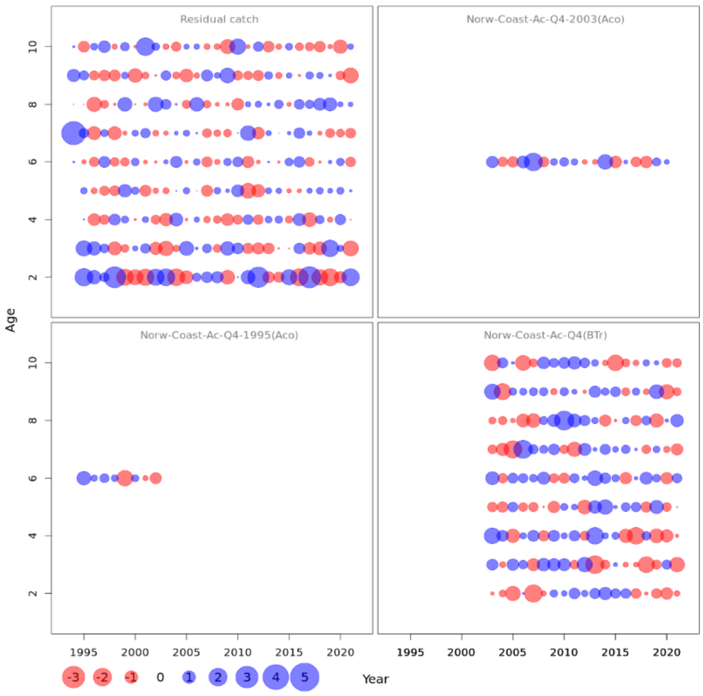


Figure 2.2.11. Northern Norwegian coastal cod. One-step-ahead residuals by fleet from the final SAM run. Blue circles indicate positive residuals and red circles indicate negative residuals. Top left: catch, top right: acoustic index pt. 2, bottom left: acoustic index pt. 1, bottom right: swept-area index.

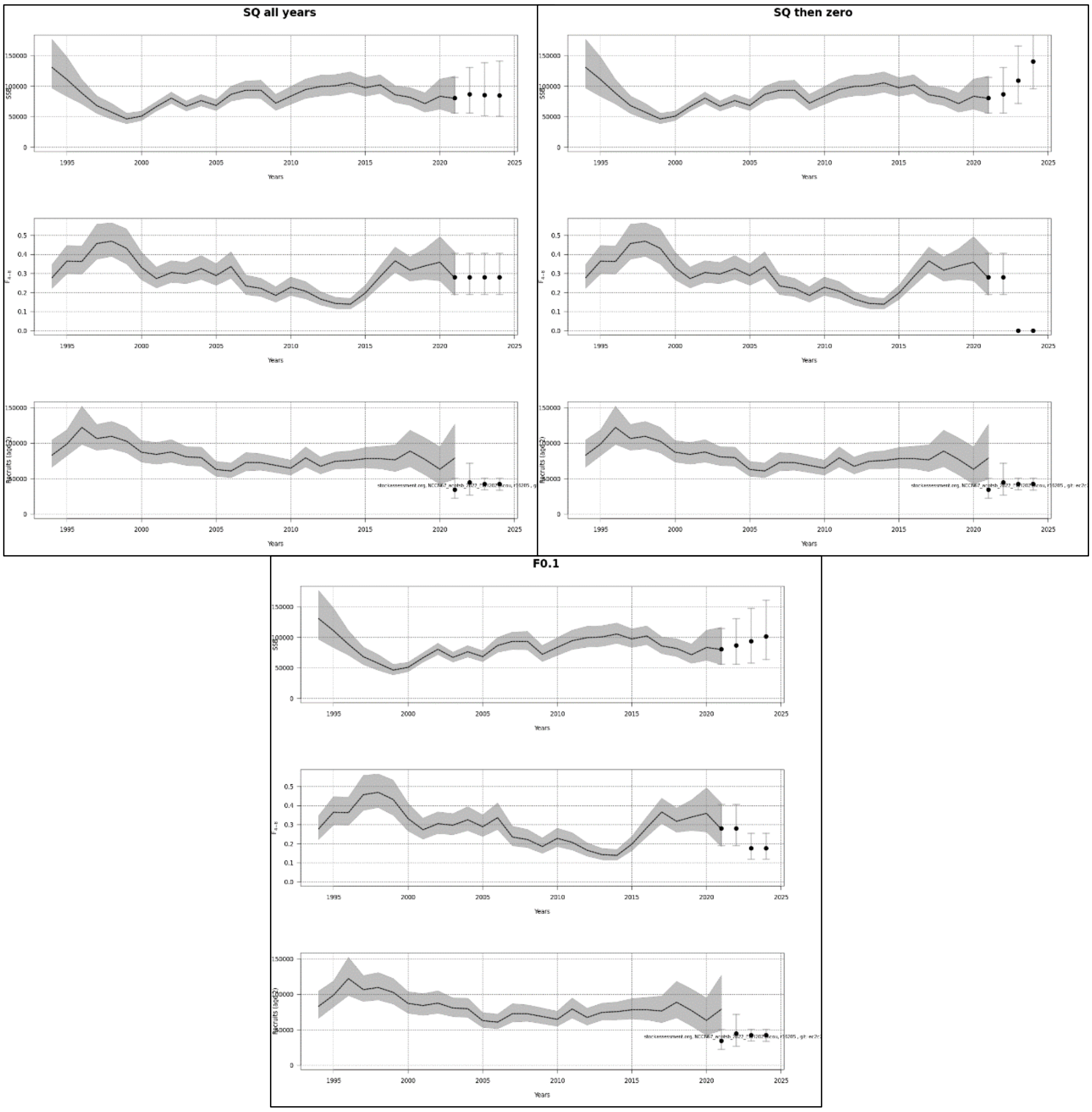


Figure 2.2.12. Northern Norwegian coastal cod. Short-term prediction. Predicted SSB (top panels), Fbar (middle panels) and recruitment (bottom panels) at status quo fishing (top left), status quo then zero fishing (top right), and fishing according to the management plan ($F_{0.1}$ = 0.176). In the forecast, recruitment is the same for all scenarios (resampled from the period 2012–2021).

2.3 Southern Norwegian coastal cod

2.3.1 Stock status summary

An assessment based on the decisions of the 2021 WKBARFAR benchmark (ICES 2021b) is presented for this stock.

Commercial catches have decreased since 2010–2012 (Figure 2.3.1). To some extent this is explained by decreasing effort until 2013, but catches have continued to decrease after 2013 when the effort has been stable or increasing (Figures 2.3.8 and 2.3.9). The recreational fishery by tourists and Norwegian residents is assumed to catch similar amounts as the commercial fishery (Figure 2.3.1 and Table 2.3.3), and a prerequisite for more accurate future assessments is a better estimation of the recreational catches.

Catch advice for southern Norwegian coastal cod (62–67°N) follows the "rfb" rule for category 3 stocks (ICES, 2020, 2022). The "rfb" rule is primarily driven by the trend in the coastal reference fleet gillnet CPUE index (more controlled than a full fleet CPUE, Section 2.3.3). Thus, the advice depends heavily on the representativeness of the CPUE index (Fischer *et al*., 2020). The CPUE index has increased enough that the +20% stability cap was reached (Section 2.3.9, Figure 2.3.7, and Table 2.3.7).

A stochastic length-based spawning potential ratio (LBSPR) model and other length-based indicators are presented as additional information. In the previous assessment, the LBSPR was used to assess the need for a 20% precautionary buffer in the "2 over 3" rule, although ICES lacks a framework for using the LBSPR directly as a basis for catch advice. ICES recommends the use of the surplus production model SPiCT for category 3 stocks, but the SPiCT fit was determined to be unsatisfactory in the 2021 benchmark and has not been updated here (ICES 2021b).

The LBSPR model estimates that stock size is below, and fishing pressure is above, possible MSY reference points (Figures 2.3.10 and 2.3.11). From 2010–2021, the "spawning potential ratio" (SPR), i.e. the ratio between the spawning potential of the current stock and the theoretical spawning potential without fishing, fluctuated between 20–35% with an overall downward trend. SPR in 2021 was estimated as 25% (95% CI: 21–29%), which places the stock below generally accepted target values (30–40% SPR).

Additional length-based indicators depict a somewhat depleted and worsening stock status. For example, mean length and the mean length of the largest 5% of caught fish have decreased over the past decade (Figure 2.3.12). The length at 50% selectivity, i.e. first capture, has decreased from ca. 57.6 to 48.4 cm (Figure 2.3.13). About half of the catch is immature, and this proportion has increased in the last decade (Figure 2.3.14). The minimum legal size (44 cm) is well below the length at 50% maturity (62.8 cm).

Priorities for more accurate future assessments are 1) better estimation of recreational catches, and 2) re-evaluation of available survey data that could be used as indices. Possible model improvements include 1) accounting for uncertainty in the index, and 2) combining index and length data in one model.

The catch advice for 2022 was 7613 tonnes. The advice for 2023 is that catches should be no more than 9136 tonnes. Assuming recreational catches of 4420 tonnes, this implies a commercial catch of no more than 4716 tonnes.

2.3.2 Fisheries (Table 2.3.2–Table 2.3.4)

Coastal cod is fished throughout the year but the main (about 70%) commercial fishery for coastal cod in the area between 62°N and 67°N takes place during February–April. The main fishing areas are along the coast of Helgeland including Træna and Lovund, Vikna, Halten bank, and further along the coast of Trøndelag and Møre and Romsdal counties. Except for the Borgundfjord at Møre, the quantities fished inside fjords are quite low.

In the 1990s the average percentage share between gear types in the estimated coastal cod commercial landings was around 65% gillnet, 26% longline/handline, 8% Danish seine, and 1% bottom trawl. In 2021 this share was 50% gillnet, 15% longline/handline, 27% Danish seine, and 5% bottom trawl (Table 2.3.4).

Recreational and tourist fisheries take an important fraction of the total catches in some local areas, especially near the coastal cities, and in some fjords where commercial fishing activity is low. However, there are a few reports trying to assess the amount in certain years (see section 2.1). The current split of the recreational catches between the area north of 67˚N and between 62–67°˚N in 2019–2021 is done based on the tourist fishing businesses' reporting to the Norwegian Directorate of Fisheries by county. Since the 67˚N latitude goes through the Nordland county, the splitting north and south of 67˚N for this county is done proportional to the number of tourist fishing businesses north and south of this latitude. The same area proportion (37.8% south and 62.2% north) of the recreational fishery is used for the whole time-series back to 1994, and this is a very rough assumption that should be further investigated and better documented. In 2021, the recreational cod catches between 62–67°N are estimated to about 52% of total cod catches in this region (Table 2.3.3).

Discarding is known to take place. There have previously been conducted two investigations trying to estimate the level of discarding and misreporting from coastal fishing vessels in two periods (2000 and 2002–2003, WD 14 at 2002 WG). The amount of discards was calculated, and the report from the 2000-investigation concluded there was both discard and misreporting by species in 2000, in the gillnet fishery approximately 8–10% relative to reported catch. One-third of this was probably coastal cod. The last report concluded that misreporting in the Norwegian coastal gillnet fisheries have been reduced significantly since 2000.

According to Berg and Nedreaas (2021), between 2–5% was discarded in the commercial gillnet fishery in the area 62–67°N during 2012–2018, and about 7% in the rod and line sector of the recreational fishery. The latter estimate is based on reporting to the Directorate of Fisheries in 2019 showing that about 35% of the reported rod and line catch was released with an assumed mortality of 20% of the released cod (Section 2.1). Discarding is not included in the commercial catch in this report but discarding in the rod and line (from boat) sector of the recreational fishery is included in the recreational catch estimate.

2.3.2.1 Estimated catches and catch-at-age (Table 2.3.2–Table 2.3.4, and Figure 2.1.1 and Figure 2.3.1–Figure 2.3.2)

The current coastal cod assessments include all coastal cod caught within the coastal statistical areas 600, 601, 700 and 701 which extend beyond the 12 nautical mile zone (see Figure 2.1.1). Estimated commercial and recreational catches of coastal cod and Northeast Arctic (NEA) cod in these statistical areas between 62–67°˚N are shown in Table 2.1.1 and Figures 2.3.1–2.3.2.

The estimated commercial catch-at-age (2–10+) for the period 1994–2021 is given in Table 2.3.2. Table 2.3.3 shows the total catch numbers-at-age when recreational and tourist fishing is included, where the proportions-at-age for the recreational catch are assumed equal to those from the commercial catch. The commercial catch in 2021 by gear and Norwegian statistical fishing areas is presented in Table 2.3.4.

2.3.2.2 Catch weights-at-age (Table 2.3.5)

Mean weight-at-age in catches is derived from the commercial sampling and is shown in Table 2.3.5. The same weight-at-age is assumed for the recreational and tourist catches.

2.3.2.3 Recreational catches in 2023

To split the 2023 catch advice into commercial and recreational components, we assume continued recovery of the tourist/recreational catch towards the pre-Covid level. The assumed recreational catch in 2021 was 4039 t, and for 2022 we assume halfway between this and the pre-Covid level (4800 t), which is 4420 t.

2.3.3 Reference fleet

The Norwegian Reference Fleet is a group of active fishing vessels paid and tasked with providing information about catches (self-sampling) and general fishing activity to the Institute of Marine Research. The fleet consists of both high seas and coastal vessels that cover most of the Norwegian waters. The Highseas Reference Fleet began in 2000 and was expanded to include coastal vessels in 2005 (Clegg and Williams, 2020). The Coastal reference fleet has reported catch-per-gillnet soaking time (CPUE) from their daily catch operations (WD 07 in ICES 2021b).

These fleets catch cod from both coastal and NEA populations, which can be discriminated based on their otolith shape (Section 2.1.2). Size distribution of individuals is sampled from a subset of fishing events and, within the size samples, individuals are sampled for otolith in a presumably random way.

To determine the origin of the cod, we use all reference fleet data from north of 62°N (i.e. ICES Subarea 2.a.2; Norwegian statistical areas 3, 4, 5, 0, 6, 7) with information on otolith type. In this update assessment, we used the models selected in the benchmark (ICES 2021b), after confirming that model diagnostics were satisfactory (Figures 2.3.3 and 2.3.5). To calculate the CPUE index between 62–67°N we only use quarters 3–4 because at that time of year there are fewer issues with mixing coastal and NEA cod (Figure 2.3.4).

2.3.4 Standardized CPUE index (Table 2.3.6 and Figures 2.3.3–2.3.7)

Raw CPUE data are seldom proportional to population abundance as many factors (e.g. changes in fish distribution, catch efficiency, effort, etc) potentially affect its value. Therefore, CPUE standardization is an important step that attempts to derive an index that tracks relative population dynamics.

The first step in the CPUE standardization is to estimate the proportion of Norwegian coastal vs. Northeast Arctic (NEA) cod in the catch, as these two cod stocks (ecotypes) mix in the Norwegian Sea. Our goal is to derive an index of only coastal cod abundance. We follow these steps:

1. Fit a binomial GLM to estimate the probability that cod caught between 62–67°N are coastal vs. NEA cod during the time frame of interest (quarters 3–4).
2. Fit a lognormal GLM to standardize total cod CPUE, taking into account year, gear, area, and quarter.
3. Combine the output from the previous two steps to create an index of abundance for only coastal cod.

Here we define important terms used in the CPUE standardization:

Standardized effort (gillnet day) = gear count x soaking time (hours) / 24 hours

CPUE (per gillnet day) = catch weight / standardized effort

Step 1: Proportion coastal vs. NEA cod

We used all data from above 62⁰N (i.e. areas 3, 4, 5, 0, 6, 7) with information on otolith type. The latter is the source of identification that helps separate coastal vs. NEA cod (Section 2.1.2). Otolith types 1 and 2 were categorized as coastal cod and types 3–5 as NEA cod. Around 2500 otolith samples have been read per year since 2010. A total of 30 828 samples between 2007–2021 were included in the binomial GLM, after removing covariates that had less than three observations to ensure estimability.

We then fit a binomial model with logit link using four categorical explanatory variables: year, area, quarter, and gear, with an area-year interaction effect. In other words, the probability that individual cod i is classified as coastal, π_i, is given by:

$$Z_i \sim \text{Bernoulli}(\pi_i), \qquad \text{(eq 1)}$$

$$\text{logit}(\pi_i) = \alpha + \sum_a \beta_a \,\text{Area}_i + \sum_y \beta_y \,\text{Year}_i + \sum_g \beta_g \,\text{Gear}_i + \sum_q \beta_q \,\text{Quarter}_i + \sum_y \sum_a \beta_{a,y} \,\text{Area}_i\text{Year}_i$$

where Z_i is a binary variable that equals 1 if cod i was coastal and 0 if not. Likewise, Area_i, Year_i, Gear_i, and Quarter_i are 1 if cod i was caught in that area, year, gear, and quarter and 0 if not.

There were no issues with the diagnostics (Figure 2.3.3). We then predicted the proportion of coastal cod that would be expected in areas 6 and 7, during quarters 3 and 4, between 2007–2021 (Figure 2.3.4).

Step 2: Total cod CPUE standardization

The final lognormal GLMM selected in the benchmark was fitted on all cod CPUE data (no distinction between coastal and NEA cod) in areas 6–7 and quarters 3–4 between 2007–2021 (ICES 2021b). As in the benchmark, data were filtered to remove gears with less than 3 observations or only used in one year. There were only three zero catch observations out of 747, and these were removed, resulting in a final sample size of N = 744. We fit the model:

$$\log(Y_j) \sim N(\mu_j = \alpha + \textstyle\sum_a \beta_a \,\text{Area}_j + \sum_y \beta_y \,\text{Year}_j + \sum_g \beta_g \,\text{Gear}_j + \sum_q \beta_q \,\text{Quarter}_j + b_{AreaYear_j} AreaYear_j + b_{QuarterYear_j} QuarterYear_j),$$

$$b_{AreaYear_j} \sim N(0, \sigma^2_{AreaYear}), \qquad \text{(eq 2)}$$

$$b_{QuarterYear_j} \sim N(0, \sigma^2_{QuarterYear}).$$

where Y_j is the CPUE of gillnet set j, β are categorical fixed effect terms for each area, year, gear, and quarter (as in equation 1), and b are random effect intercept terms for area-year and quarter-year interactions. The $AreaYear_j$ indicates that the area and year variables were concatenated into a single variable and considered as a random effect acting on the intercept, and likewise for $QuarterYear_j$. The total cod CPUE model showed reasonable diagnostics (Figure 2.3.5).

Step 3: Joining steps 1–2 to create a standardized coastal cod CPUE

The predicted proportion coastal cod, $\hat{\pi}_{y,q,a}$, and total cod CPUE, $\hat{Y}_{y,q,a}$, for each year y, quarter q, and area a combination were calculated from the two models above and combined to estimate the standardized coastal cod CPUE index, $I_{y,q,a}$:

$$I_{y,q,a} = \hat{\pi}_{y,q,a} * \hat{Y}_{y,q,a} \qquad \text{(eq 3)}$$

The variance of $I_{y,q,a}$ was calculated as:

$$V(I_{y,q,a}) = (\hat{\pi}_{y,q,a})^2 V(Y_{y,q,a}) + (\hat{Y}_{y,q,a})^2 V(\pi_{y,q,a}) \qquad \text{(eq 4)}$$

The resulting standardized coastal cod CPUE indices for areas 6 and 7 are shown in Figure 2.3.6, where quarters 3 and 4 are weighted equally. To combine the indices for areas 6 and 7, we weighted the indices in proportion to the surface area within 12 nm (0.587 for area 6, 0.413 for area 7). The composite standardized CPUE index for coastal cod in the entire area between 62–67°N , is shown in Figure 2.3.7 and Table 2.3.6.

2.3.5 Stochastic LBSPR (Table 2.3.1)

Given the uncertainty in parameters and the demonstrated sensitivity of the length-based spawning potential ratio (LBSPR) model to input parameters (Hordyk *et al*., 2015b, 2015a), the AFWG developed a stochastic LBSPR approach at the last benchmark (ICES 2021b), similar to the one developed for anglerfish (Section 9). While the LBSPR assumes that key life history parameters (growth, natural mortality, and maturity; described below) are known, our approach includes uncertainty and correlation in these parameters by fitting the LBSPR model 1000 times using randomly sampled values from their estimated distributions. Observation uncertainty of the annual length distributions is also included by random resampling (bootstrapping) the length data.

Most of the parameters estimated during the benchmark do not need to be re-evaluated on an annual basis and could be randomly generated using the reported mean and standard deviation values. However, we re-estimated each of the life history parameter models selected in the benchmark with data updated through 2021 (Table 2.3.1). All parameter estimates and residual diagnostics were very similar to those from the benchmark.

2.3.5.1 Growth (k, L_{inf})

The von Bertalanffy growth model parameters L_{inf} (asymptotic length) and k (growth coefficient) were estimated using non-least-squares fit to length and decimal age data from the reference fleet. The value for the theoretical age when size is zero, t_0 = -0.0387, was borrowed from northern coastal cod (north of 67°N). To account for biases from size selective sampling, we used composite weights based on the product of 1) calibrated weights (size-selective ageing among individuals sampled for size; Perreault *et al*., 2020) and 2) weights correcting for size selectivity-at-age in the catch (loosely based on model 1 in Taylor *et al*., 2005), using selectivity parameters estimated using LBSPR and parameters borrowed from northern coastal cod.

2.3.5.2 Natural mortality (M)

One of the most critical parameters for the performance of LBSPR is M/k. For southern coastal cod we had a reasonable estimate of k but no *a priori* information on M/k. The benchmark evaluated four methods of estimating M based on life history and selected the size-varying M following Lorenzen (1996) due to its consistency with cannibalism-driven mortality in the partially sympatric NEA cod and that it estimated similar SPR and F/M to assuming M = 0.2.

2.3.5.3 Maturity (LM_{50}, LM_{95})

The maturity parameters LM_{50} and LM_{95} (length at 50% and 95% maturity) were estimated by fitting a binomial GLM with covariate length to yearly bootstrapped maturity data from the autumn coastal survey. All data north of 62°N were used because biological samples from the area between 62–67°N were scarce. For consistency with the choices made for the northern stock, resting individuals (stage 4) were considered mature.

Table 2.3.1. Life history parameter distributions estimated using data through 2021, used as inputs in the LBSPR model. Other required LBSPR parameter values not included here were left at their default values.

Parameter	Mean (sd)	Description
M	0.230 (0.001)	Natural mortality (year^{-1}) at asymptotic length (L_{inf}). Size-varying M following Lorenzen (1996) fit to resampled reference fleet commercial sampling data.
M_{pow}	0.959 (0.005)	aka exponent c, eqn. 17 in Hordyk *et al.* (2016): parameterization of the size-varying M in LBSPR, following Lorenzen (1996) fit to resampled reference fleet commercial sampling data.
k	0.255 (0.003)*	von Bertalanffy growth coefficient
M/k	0.900 (0.007)	M/k at L_{inf}, derived from the above estimates
L_{inf}	94.1 (0.455)*	Asymptotic length (cm) as defined in the von Bertalanffy growth function
t_0	-0.0388	Theoretical age when length = 0 in the von Bertalanffy growth function. Not used in the LBSPR model, but used in the estimation of k and L_{inf} (above). Borrowed from northern coastal cod.
CVL_{inf}	0.155 (0.001)	Coefficient of variation of L_{inf}, encompasses all inter-individual growth variability of LBSPR. The values used are borrowed from northern coastal cod, estimated and randomly generated on the log scale (mean = -1.862; s.d. = 0.0039).
LM_{50}	62.8 (1.842)†	Length (cm) at 50% maturity. Estimated from resampled coastal survey data (2010–2021, all data north of 67°N) using a binomial glm.
LM_{95}	79.6 (3.816)†	Length (cm) at 95% maturity. Estimated from resampled coastal survey data (2010–2021, all data north of 67°N) using a binomial glm.

***randomly generated preserving the correlation structure between k and Linf using a multinormal distribution.**
†pairs (*LM*50, *LM*95) estimated from a same bootstrapped dataset and year drawn together to preserve the correlation between the two parameters and avoid using a parameterization based on the distribution of $\Delta LM = LM_{95} - LM_{50}$.

2.3.5.4 Length distribution resampling

The LBSPR model is fitted to 1000 bootstrapped length data and parameter sets. While input parameters were randomly generated/drawn as per Table 2.3.1, the generation of the randomized datasets is twofold:

1. random attribution of unclassified individuals as coastal and NEA cod, using a binomial random generator based on the GAM,

```
gam(is_coastal ~ s(length) + factor(area) * factor(year) + factor(quarter) +
                 factor(gear), family=binomial(link = "logit"))
```

2. bootstrap of the length composition within each year, i.e. draw the number of individuals sampled within each year of data from step 1, with replacement.

For each of the 1000 randomized data and parameter sets, the LBSPR model estimates SPR, F/M, and the lengths at 50% and 95% selectivity, SL_{50} and SL_{95}.

2.3.6 Results of the assessment (Figure 2.3.6–Figure 2.3.13)

2.3.6.1 Standardized CPUE index

In recent years, the standardized CPUE index for coastal cod based on the reference fleet gillnet data has generally increased in area 6 (northern subarea, 64–67°N) and decreased in area 7 (southern subarea, 62–64°N; Figure 2.3.6). The composite CPUE index combining areas 6 and 7 decreased from 2007–2013 and has increased since 2013, with large uncertainty (95% CIs extend to 0 in all years; Figure 2.3.7). The composite CPUE index in 2020–2021 was higher than from 2017–2019, and so the "2 over 3" ratio that largely determines the catch advice increased from last year's assessment (red lines in Figure 2.3.7). CPUE in 2020–2021 was similar to 2007–2008, the beginning of the time-series.

2.3.6.2 Effort and CPUE from official landings statistics

We have also calculated CPUE from the full fleet, although this is less controlled for fishing behaviour and uses a less precise measure of effort than the reference fleet CPUE. Still, it is valuable to consider because it covers the entire commercial fleet instead of just a few boats in the reference fleet.

Calculating fishing effort for the full fleet is much less precise than for the reference fleet, where we can calculate kg cod caught per gillnet per day. The number of sales notes has been shown to give an overestimation of the fishing effort, since a trip can give several sales notes by splitting the entire trip catch into several sales, each with its own sales note. We therefore consider a "trip" by combining the vessel's "Registration mark" in the sales note statistics with "Last catch date", and define effort as the number of sales note trips.

	2018		2019		2020	
Vessel size group	Number of trips	Landed round weight (t)	Number of trips	Landed round weight (t)	Number of trips	Landed round weight (t)
LG1: (blank)	680	29	605	30	603	33
LG2: < 11 m	4203	229	3814	191	4311	298
LG3: 11–14.99 m	1107	129	1221	145	1125	114
LG4: 15–20.99 m	89	24	99	20	71	19
LG5: 21–27.99 m	3	2	1	1	32	15
LG6: >= 28 m	1	3	1	0	8	1

The table above shows the number of trips and cod landings (round weight in tonnes) from inside 12 nautical miles during the second half-year during 2018–2020, per vessel size group, all gears. This shows that the vessel size groups < 11 and 11–14.99 m, represented by the coastal reference fleet (Section 2.3.3), are responsible for most of the effort and cod landings. The 9–15 m vessels in the reference fleet represent the gear and vessel size group responsible for about 60% of the total annual cod commercial catches in the stock area, and 88% of the effort (fishing trips) and 86% of cod catches in the second half of the year.

Figures 2.3.8 and 2.3.9 show the effort and CPUE from official landings statistics from 2007–2020. The recent gillnet CPUE trends differ by vessel size group, with some increasing and some decreasing (Figure 2.3.9).

2.3.6.3 Stochastic LBSPR outputs and interpretation

Between 2010–2021, the mean SPR fluctuated between 20 and 35%, with an overall downward trend (Figure 2.3.10). In most years SPR was estimated below common target values (30–40%) and in 2019–2020 SPR was near the limit reference point (generally accepted to be 20% in the absence of further information on the stock dynamics; ICES 2018; Prince *et al.*, 2020; Mace and Sissenwine, 1993). SPR in 2021 was estimated as 0.25 (95% CI: 0.21–0.29). In all years 2010–2021, the relative fishing mortality F/M was estimated above the value which achieve long-term SPR = 40%, or the more usual proxy F/M = 1 (Figure 2.3.11). F/M in 2021 was estimated as 1.28 (95% CI: 1.07–1.52). Concomitant with the decrease in SPR, the size-based indicators $L_{max5\%}$ (mean length of the largest 5% of individuals) and $\bar{L}$ (mean length) also declined from 2010–2021 (Figure 2.3.12). These all together depict a somewhat depleted and worsening stock status.

In the absence of clear information on the stock–recruitment relationship, a more legitimate reference point cannot be estimated and even a SPR of 30% should be considered as a potentially non-precautionary level, with SPR = 40% preferred as B_{MSY} proxy (Clark, 2002; Hordyk *et al.*, 2015a). In conformity with ICES guidelines (ICES, 2018) and commonly used SPR-based proxies (Prince *et al.*, 2020; Mace and Sissenwine, 1993), the corresponding limit reference point (proxy for $B_{lim} = B_{MSY}/2$) should be SPR = 20%. A simulation function in the LBSPR package also allowed us to estimate $F_{SPR40\%}/M = 0.81$ (95% CI: 0.74–0.88), which is the F/M that leads to SPR = 40% given equilibrium and the parameter values (Figure 2.3.11). This also produces the expected mean length at SPR = 40%, $\bar{L}_{SPR=40\%}$, which could be evaluated for use as a target/reference length in the fishing pressure proxy part of the ICES 'rfb' rule (Figure 2.3.12).

2.3.6.4 Catch lengths in relation to maturity

Averaged across all years, the length at which 50% of southern coastal cod are mature, LM_{50}, was estimated as 62.8 cm (95% CI: 59.4–66.9). This is substantially higher than the minimum legal size (44 cm) or the estimated length at 50% selectivity (S_{50}; Figure 2.3.13). In addition, S_{50} has decreased in the last decade, i.e. the fishery is catching smaller fish, closer to the minimum size. This has led the proportion of immature fish in the catch to increase from about 25% in 2010 to about 50% in 2021 (Figure 2.3.14).

2.3.6.5 Total mortality (*Z*) from catch curves

Since catch numbers-at-age data are available for this stock for a longer period (1994–2021; Tables 2.3.2 and 2.3.3) it is possible to estimate the total mortality from catch-curve analyses. The assumptions usually made for catch-curve analysis are that (1) there are no errors in the estimation of age composition, (2) recruitment is constant or at least varies without trend over time, (3) Z is constant over time and across ages, and (4) above some determined age, all animals are equally available and vulnerable to the fishery and the sampling process. The catch-curve estimates a single total mortality rate for all years/ages that compose its synthetic cohort, and this total mortality estimate is generally similar to the average of the true total mortality rate.

We estimated the average total mortality of ages 5–14 for the years 1994–2020, not updated with 2021 data. Note that Tables 2.3.2 and 2.3.3 only present data up to age group 10+ but catch-at-age data were available to the AFWG up to age group 15+. Figure 2.3.15 shows a very stable level of the total mortality during the entire time-series, varying without trend around the long-term average of $Z = 0.75$. With $M = 0.23$ (Table 2.3.1), this implies fishing mortality around 0.5.

2.3.6.6 Additional indices: coastal survey

The last benchmark considered and rejected indices calculated from the main survey covering coastal cod, the autumn coastal survey (Nocoast-Aco-4Q), due to concerns about poor and inconsistent coverage south of 67°N (WD33 in ICES 2021b). The reference fleet CPUE index was used instead. The reviewers commented that it was “not entirely clear that this was justified” (ICES 2021b). Given the high uncertainty in the CPUE index (95% CIs extend to 0 in all years; Figure 2.3.7), we calculated swept-area indices from the coastal survey trawl data between 62°N and 67°N for comparison (methods described for northern coastal cod in Section 2.2.3). It is possible that the coastal survey data may not provide reliable abundance-at-age indices, yet still produce a useable aggregate (across ages) biomass index.

Three alternative swept-area indices from the coastal survey are shown in Figure 2.3.16: total age-2+ biomass, total numbers age-2+, and spawning-stock biomass. There are several notable differences from the reference fleet CPUE index: 1) the survey indices extend back to 2003, whereas the CPUE index starts in 2007; 2) the 95% CIs are much smaller for the survey indices; and 3) the survey indices are relatively stable from 2003–2013 and then decline from 2013–2021, whereas the CPUE index declines from 2007–2013 and then increases. The coefficient of variation (CV) of the CPUE index is 0.7–0.85 in most years, and the survey indices CV is 0.2–0.4 (Figure 2.3.17). The correlations between the CPUE and survey indices are negative, whereas the correlations between the survey indices and SPR estimated from the LBSPR model are positive (Figure 2.3.18). In contrast to the age-aggregated swept-area indices, the index-at-age probably is too uncertain to be useful (CVs > 0.3–0.4 for most ages and years; Figure 2.3.19).

Further exploration of how to produce indices from the coastal survey data is warranted. The survey index CVs reported here may not be reliable as they do not take into account variable spatial coverage by year. Still, the consistency between the survey indices and SPR, and the lower CV of the survey indices, indicates that an age-aggregated swept-area index calculated from the coastal survey may be useful for assessing southern coastal cod.

2.3.6.7 Additional indices: shallow water survey

IMR established a shallow water survey using small, passive meshed gear in 2013 in the hope that it would provide information on fish abundance in nearshore habitat not sampled by the main coastal survey, especially for young cod ages 1–3 (Eidset 2019; WD 13).

The shallow water survey appears to provide precise enough estimates of abundance-at-ages 1–3 to generate useful indices, with CVs between 0.15–0.20 (Figure 2.3.19). CVs for ages 0 and 4 were about 0.30, and the CV for age 5 was 0.40. The survey can reasonably track cohorts—the correlations from one age/year to the next were about 0.45–0.60 for ages 0–5, with the exception of age-2 to age-3, which was about 0.15 (Figure 2.3.20). Indices for ages 2 and 3 were somewhat consistent between the coastal survey swept-area and the shallow water survey ($r = 0.82$ and 0.32, respectively), but not for other ages.

Both surveys estimate declining trends for all ages 1–5 over the period 2013–2021, with the coastal survey estimating steeper declines for all ages (Figure 2.3.21). The coastal survey swept-area indices-at-age were stable or increasing for all ages in the decade before the shallow water survey was initiated, 2003–2012 (Figure 2.3.21). For further details, see WD 13.

2.3.7 Comments to the assessment

The assessment remains rather uncertain. The reasons for this include highly uncertain data for the recreational catch and uncertainty in the catch split between Northeast Arctic cod and coastal cod, although the CPUE series is calculated for the second half of the year to minimize the mixing of the two stocks in the dataseries. The assessment also depends on the representativeness of the coastal reference fleet gillnet CPUE index. Gillnets are responsible for most of the catches, and the 9–15 m vessels in the reference fleet represent the gear and vessel size category responsible for about 60% of the total annual cod commercial catches in the area, and 88% of the effort (fishing trips) and 86% of cod catches in the second half of the year. Still, the reference fleet CPUE increasing trend in recent years is not consistent with decreases in the SPR, coastal survey swept-area index, or shallow water survey index.

ICES catch advice is based on the "rfb" rule for Category 3 stocks, which relies primarily on the reference fleet CPUE. While the reference fleet CPUE has increased since 2013, the SPR, coastal survey swept-area index, and shallow water survey index have decreased and are presented as additional information.

Priorities for more accurate future assessments are 1) better estimation of recreational catches, and 2) re-evaluation of available survey data that could be used as indices. Possible model improvements include 1) accounting for index uncertainty in the 'rfb' rule, and 2) combining index and length data in one model.

2.3.8 Reference points

No biological reference points are established except the SPR and F/M reference levels often referred to in literature. See section 2.3.6.1 above.

2.3.9 Catch scenarios for 2023

The ICES Guidance for completing single-stock advice for category 3 stocks was applied (ICES, 2020, 2022). A standardized CPUE index from the coastal reference fleet (9–15 m vessel length) in coastal waters between 62°N and 67°N during quarters 3 and 4, between 2007–2021, is used as the stock biomass index (Table 2.3.6). The advice is the previous year's catch advice multiplied by four modifiers: 1) ratio of the two latest index values (Index A) to the three preceding values (Index B), 2) length-based proxy of fishing pressure (f), 3) biomass safeguard (not applicable here), and 4) life history multiplier (m). The advice is estimated to have increased by more than 20% and thus the stability cap was applied. Discarding (of dead fish) is known to take place (2–5% in the commercial fishery and about 7% in the rod and line sector of the recreational fishery; Berg and Nedreaas, 2021), but ICES cannot quantify the corresponding catch.

The catch advice for 2023 is estimated to 9136 tonnes (Table 2.3.7). Assuming recreational catches at 4420 tonnes, this implies a commercial catch of no more than 4716 tonnes.

2.3.10 Management considerations

Applying the official ICES Guidance for catch advice results in an increase of 20%. Several caveats should be considered:

- Uncertainty of the CPUE index used in the 'rfb' rule is high, with 95% confidence intervals extending to 0 in all years (Figure 2.3.7). This is not taken into account when calculating the advice.
- The CPUE index increase is driven by area 6. The index is lower and has decreased in area 7 (Figure 2.3.6).
- The LBSPR results indicate fairly poor status: SPR = 0.25 (95% CI: 0.21–0.29) and F/M = 1.28 (95% CI: 1.07–1.52; Figures 2.3.10 and 2.3.11).
- Length-based indicators in the reference fleet data have declined over the past decade (Figures 2.3.12 and 2.3.13). Mean length has decreased from ca. 70.9 to 63.2 cm and the

length at 50% selectivity, i.e. first capture, has decreased from ca. 57.6 to 48.4 cm (averages 2010–2013 vs. 2018–2021).

- The minimum legal size (44 cm) is well below the length at 50% maturity (62.8 cm). About half of the catch is immature, and this proportion has increased in the last decade (Figure 2.3.14).
- Commercial catches have decreased over the last 10–15 years while effort has probably remained stable or increased since 2013 (Figures 2.3.1, 2.3.8, and 2.3.9).
- The coastal survey swept-area and shallow water survey indices decreased from 2013–2021, the opposite trend as in the CPUE index (Figure 2.3.21).

ICES finds it difficult to give precise catch advice when the recreational catches, likely contributing more than 50% of total catches, are poorly estimated. A prerequisite for more accurate future assessments is a better estimation of the recreational catches.

The substantial and increasing proportion of immature fish in the catch is concerning, as well as the length at 50% selectivity being below the length at 50% maturity (Figures 2.3.13 and 2.3.14). Increasing the size of first capture closer to or above the size of maturity is worth considering, especially given the current difficulties of estimating catch and controlling fishing pressure with a quota (Prince and Hordyk, 2018).

Norwegian coastal cod is taken as part of a mixed fishery with Northeast Arctic cod (cod.27.1-2), from which it cannot be visually distinguished. Without the option of setting a direct TAC, the coastal cod stocks are managed by technical regulatory measures. Despite management actions, the previous management plan has not led to significantly reduced fishing mortality. A new plan is therefore required, with regulations better targeted to areas and seasons where catches of coastal cod are high. The split of the coastal cod stock in two units – one data rich in the north and one data poor in the south – combined with improved genetic stock identification techniques improves the spatial resolution of the assessment and allows development of more targeted management measures.

2.3.11 Rebuilding plan for coastal cod

The Norwegian Ministry of Fisheries is working on a new rebuilding plan. Fisheries scientists need to discuss with managers, how to facilitate rebuilding of the stock, evaluate rebuilding targets and measures to avoid high fishing pressure in areas with high fractions of coastal cod. Stronger restrictions are required in all areas where coastal cod is distributed.

2.3.12 Recent ICES advice

For the years 2004–2011, the advice was; No catch should be taken from this stock and a recovery plan should be developed and implemented.

For 2012, and later the advice has been to follow the rebuilding plan. The latest ICES advice strongly recommends a new rebuilding plan.

The catch advice for 2022 was 7613 tonnes (ICES, 2021a).

2.3.13 Figures and tables

Table 2.3.2. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Estimated commercial landings in numbers ('000) at-age, and total tonnes by year.

	Age								Tonnes
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Landed**
1994	1	7	111	288	361	279	158	71	112	6381
1995	3	32	210	399	491	467	267	114	96	8936
1996	2	64	242	384	304	253	130	36	44	6207
1997	2	117	171	212	189	185	131	44	33	4746
1998	20	177	446	496	332	109	82	22	23	6200
1999	3	116	313	308	255	123	53	66	26	5522
2000	2	242	697	411	159	57	51	17	37	5838
2001	2	94	423	457	304	149	52	17	86	5250
2002	9	88	360	409	441	138	52	12	16	6937
2003	23	204	237	571	398	380	112	22	53	8905
2004	5	112	334	260	400	232	139	35	26	6866
2005	2	65	381	522	445	262	122	37	19	8005
2006	10	48	308	617	565	179	99	54	50	8612
2007	11	154	364	497	379	113	51	23	29	7695
2008	31	103	893	665	195	265	69	38	47	9889
2009	1	224	663	259	311	107	74	42	20	7145
2010	5	115	400	434	245	260	50	36	45	7634
2011	3	59	310	484	267	194	65	36	35	7128
2012	28	113	268	501	317	279	73	36	36	8187
2013	5	54	239	214	248	169	80	27	16	5131
2014	1	56	166	390	265	226	79	43	38	6244
2015	21	149	257	229	263	120	69	37	41	5004
2016	1	83	248	313	206	200	121	66	83	5962
2017	13	73	275	279	157	97	70	24	34	4159
2018	9	57	131	298	255	141	90	36	32	4436
2019	4	34	85	101	128	121	77	21	24	2965

	Age									Tonnes
	2	3	4	5	6	7	8	9	10+	Landed
2020	1	46	164	140	144	79	84	37	16	3481
2021	34	173	198	228	114	78	50	27	33	3696

Table 2.3.3. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Total estimated catch number ('000) at age, including recreational and tourist catches.

	Age									Tonnes	Hereof
	2	3	4	5	6	7	8	9	10+	landed	rec. (t)
1994	2	14	207	538	676	523	296	132	210	11937	5556
1995	4	51	341	647	797	757	433	184	155	14492	5556
1996	3	120	455	723	572	476	245	68	82	11687	5480
1997	5	253	369	456	407	399	283	95	72	10226	5480
1998	38	334	842	937	628	207	155	42	43	11718	5518
1999	5	226	610	600	497	240	103	128	51	10776	5254
2000	3	456	1311	773	299	107	96	32	69	10979	5140
2001	3	184	832	897	598	293	101	34	169	10315	5065
2002	15	153	627	711	768	240	91	22	28	12077	5140
2003	36	325	377	907	633	605	178	35	85	14159	5254
2004	9	194	581	451	695	403	242	60	45	11931	5065
2005	3	105	619	848	722	426	197	61	31	12994	4989
2006	16	76	484	968	888	282	156	84	79	13525	4913
2007	18	252	597	814	620	185	83	38	47	12609	4913
2008	46	153	1330	990	290	395	103	56	71	14727	4838
2009	1	375	1109	433	519	178	124	70	34	11945	4800
2010	7	187	651	706	398	423	81	58	74	12434	4800
2011	5	98	518	811	447	325	109	59	58	11928	4800
2012	45	179	425	795	502	442	115	57	58	12987	4800
2013	9	105	463	414	480	327	154	52	31	9931	4800
2014	1	100	293	690	469	400	140	76	68	11044	4800
2015	41	293	503	449	515	234	135	72	80	9804	4800
2016	2	151	448	566	371	360	218	120	150	10762	4800

	Age									Tonnes	Hereof
	2	3	4	5	6	7	8	9	10+	landed	rec. (t)
2017	28	158	592	600	337	208	152	51	73	8959	4800
2018	19	118	272	620	532	293	187	75	66	9236	4800
2019	12	88	223	265	336	316	201	54	63	7765	4800
2020	1	97	342	293	301	166	177	78	34	7287	3806
2021	72	361	414	477	239	163	104	56	70	7735	4039

Table 2.3.4. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Commercial catch in 2021 by gear and Norwegian statistical fishing area. Both fishing areas lie within ICES Division 2.a.

Gear	Area 06	Area 07	Total 62–67°N	% by gear
Gillnet	996.0	835.6	1831.6	49.8
Longline/Handline	291.9	248.1	540.0	14.7
Danish seine	0.1	1004.6	1004.7	27.3
Trawl	85.7	109.7	195.4	5.3
Others	1.2	103.2	104.4	2.8
Total	1374.9	2301.2	3676.1	

Table 2.3.5. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Mean weight at age in the catch.

CWT	2	3	4	5	6	7	8	9	10+
1994	1.028	1.537	2.206	2.985	3.822	4.908	5.954	7.468	9.571
1995	0.845	1.392	1.950	2.603	3.649	4.811	6.076	7.404	10.566
1996	1.177	1.975	2.554	3.392	4.186	5.242	6.429	7.283	11.591
1997	1.348	2.004	2.611	3.439	4.282	5.387	6.563	7.467	10.828
1998	1.007	1.737	2.454	3.373	4.483	5.484	6.914	7.825	14.092
1999	1.459	2.231	2.927	3.800	4.854	6.032	7.009	8.257	12.088
2000	1.344	1.971	2.811	3.568	4.610	5.588	6.860	7.815	11.806
2001	0.565	0.981	1.533	2.250	3.129	4.160	5.375	6.722	16.118
2002	1.372	2.330	3.302	4.199	5.225	6.290	7.226	9.768	13.031
2003	1.312	2.143	2.962	3.899	4.702	5.648	6.616	7.425	11.376
2004	1.368	2.124	2.758	3.684	4.705	5.858	6.874	7.901	11.117
2005	1.488	2.332	2.990	3.701	4.562	5.637	6.699	7.703	10.364

CWT	2	3	4	5	6	7	8	9	10+
2006	1.526	2.158	2.866	3.790	4.703	5.769	6.725	7.876	10.103
2007	1.613	2.295	3.285	4.337	5.744	7.105	8.397	9.991	12.359
2008	1.455	2.221	3.179	3.932	5.443	6.533	7.990	8.341	11.107
2009	1.667	2.135	3.234	4.207	5.279	6.527	7.568	7.606	11.305
2010	1.480	2.262	3.325	4.431	5.534	6.335	7.598	9.048	9.543
2011	1.381	2.127	3.172	4.263	5.511	6.510	8.012	9.032	11.065
2012	1.214	2.012	3.011	4.302	5.520	6.686	8.188	9.569	11.635
2013	1.269	2.027	3.092	4.024	5.268	6.370	7.524	8.918	12.241
2014	1.304	2.194	3.047	3.998	4.959	6.115	7.181	8.234	11.537
2015	1.219	1.832	2.726	3.797	4.627	5.845	7.009	8.195	10.981
2016	1.339	1.930	2.617	3.578	4.471	5.421	6.429	7.445	9.132
2017	1.529	2.022	2.750	3.663	4.543	5.612	6.542	7.489	9.678
2018	1.190	1.848	2.547	3.434	4.265	5.301	6.375	7.333	9.393
2019	1.662	2.283	3.120	3.895	4.840	5.796	6.743	7.737	9.548
2020	1.660	2.395	3.150	3.922	4.707	5.505	6.313	7.130	8.993
2021	1.325	2.049	2.827	3.696	4.692	5.835	6.755	7.672	11.064

Table 2.3.6. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Composite standardized CPUE index from the coastal reference fleet during quarters 3 and 4, between 2007–2021. SE = standard error. 95% confidence intervals (CI) calculated using the approximation CPUE +/- 1.96 SE.

Year	CPUE index	SE	CI low (2.5%)	CI high (97.5%)
2007	0.30	0.27	0	0.84
2008	0.39	0.28	0	0.93
2009	0.25	0.17	0	0.57
2010	0.16	0.11	0	0.37
2011	0.24	0.18	0	0.60
2012	0.24	0.21	0	0.65
2013	0.06	0.04	0	0.13
2014	0.13	0.09	0	0.30
2015	0.26	0.18	0	0.62
2016	0.29	0.20	0	0.68

Year	CPUE index	SE	CI low (2.5%)	CI high (97.5%)
2017	0.37	0.32	0	0.99
2018	0.14	0.11	0	0.36
2019	0.17	0.13	0	0.42
2020	0.39	0.31	0	1.00
2021	0.30	0.25	0	0.79

Table 2.3.7. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Values used for calculating catch advice under the ICES "rfb" rule (ICES, 2022a).*

Quantity	Value
A_y: Previous year catch advice	7613 t
Stock biomass trend	
Index A (average CPUE 2020–2021)	0.342
Index B (average CPUE 2017–2019)	0.225
r: Stock biomass trend (ratio A/B)	1.52
Fishing pressure proxy	
Mean catch length (L_{mean}= L_{2021})**	67.7 cm
MSY proxy length ($L_{F=M}$)***	66.2 cm
f: Fishing pressure proxy relative to MSY proxy ($L_{2021}/L_{F=M}$)	1.02
Biomass safeguard	
Last index value (I_{2021})	0.297
Index trigger value ($I_{trigger}=I_{loss}\times1.4$)	0.058
b: index relative to trigger value, min{$I_{2021}/I_{trigger}$, 1}	1
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability	
m: multiplier (generic multiplier based on life history)	0.9
rfb rule catch advice****	10 643 t
Stability cap (+20%/-30% compared to A_y, only applied if b≥1)	Applied
Discard rate	Not quantified
Catch advice for 2023	**9136 t**
% advice change^	+20%

*** The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the table.**

**** Calculated as per ICES (2022a), only using lengths greater than L_c.**

***** Equation A.3 in Jardim *et al.* (2015).**

****** [$A_y \times r \times f \times b \times m$]**

^ Advice value for 2023 relative to the advice value for 2022.

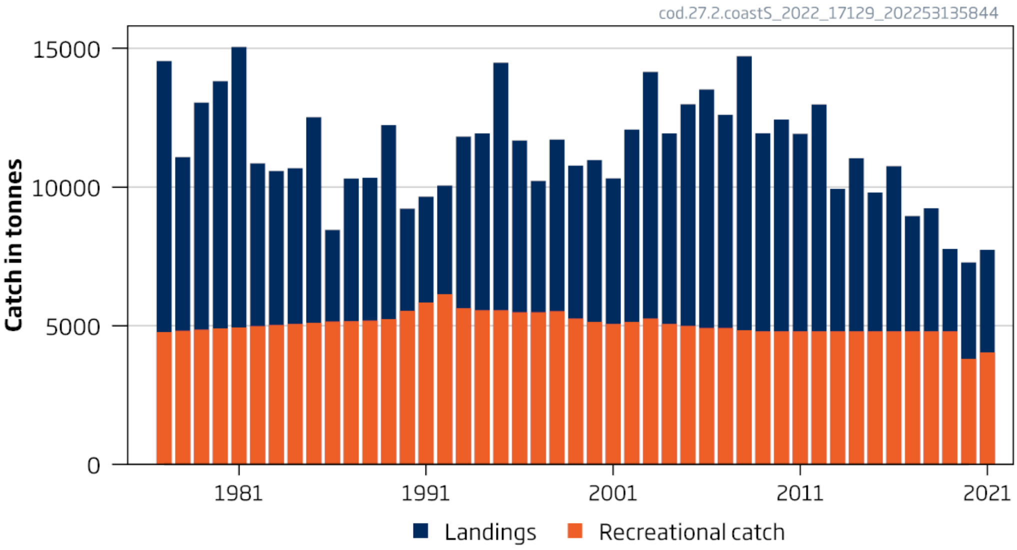


Figure 2.3.1. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Commercial landings and recreational catches. Recreational catches are fixed from 2009–2019 at 4800 tonnes and then reduced from 2020–2021 due to Covid-19 impacts on tourist fishing.

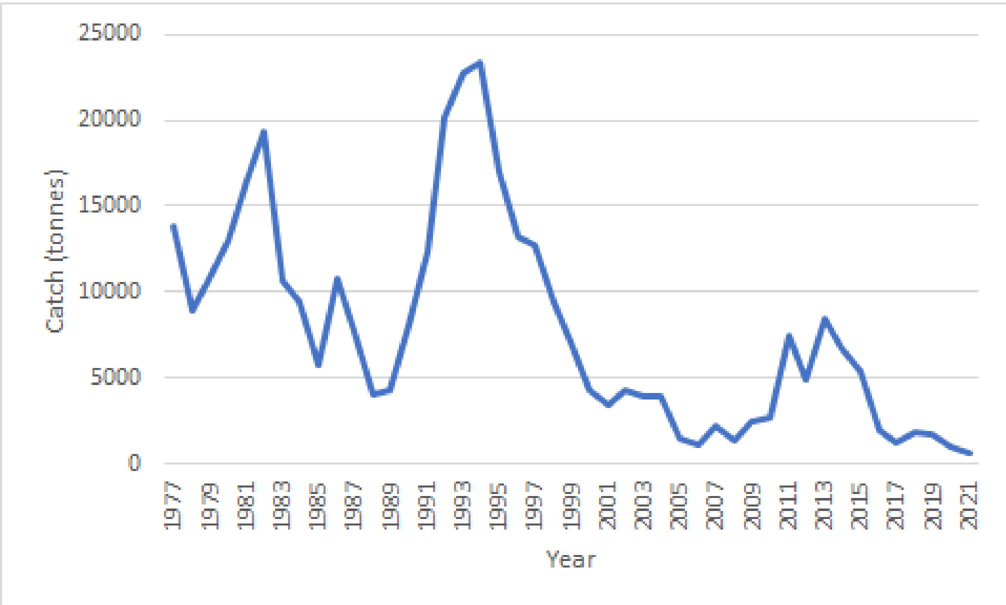


Figure 2.3.2. Estimated commercial landings of Northeast Arctic cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N.

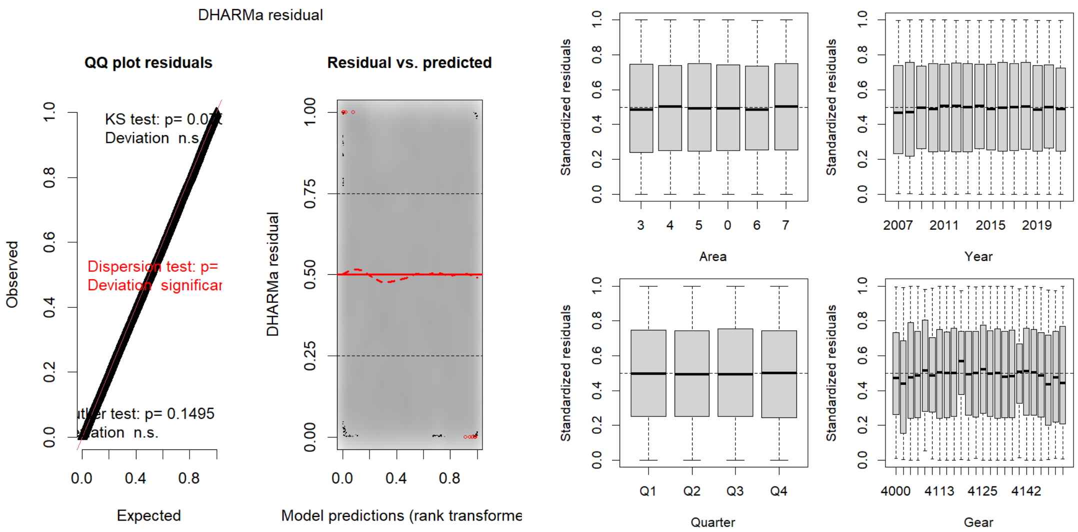


Figure 2.3.3. Residual diagnostic plots for the final binomial model to differentiate coastal cod vs. NEAC. The panel on the left is a standard output from the residual diagnostics using the R package DHARMa. The panel on the right plots the model standardized residuals against available covariates. Both panels indicate no significant issues with the final model.

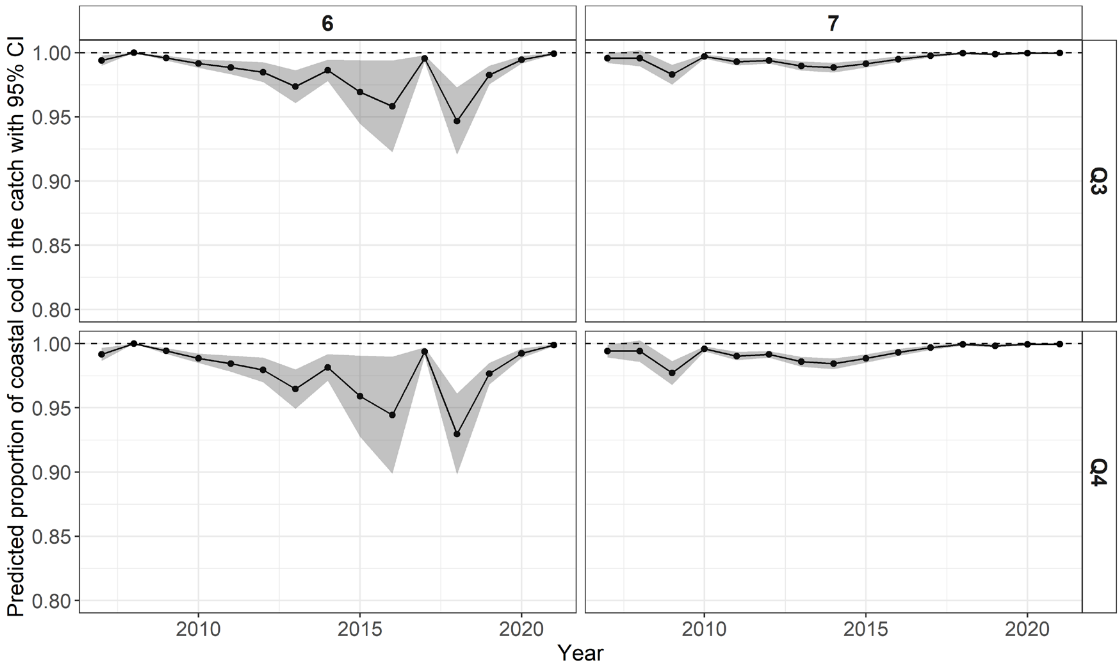


Figure 2.3.4. Predicted probability of cod being classified as coastal instead of Northeast Arctic, based on the quarter (vertical panels), area (horizontal panels), and year (x-axis within each panel). The grey shaded polygon represents the 95% confidence interval.

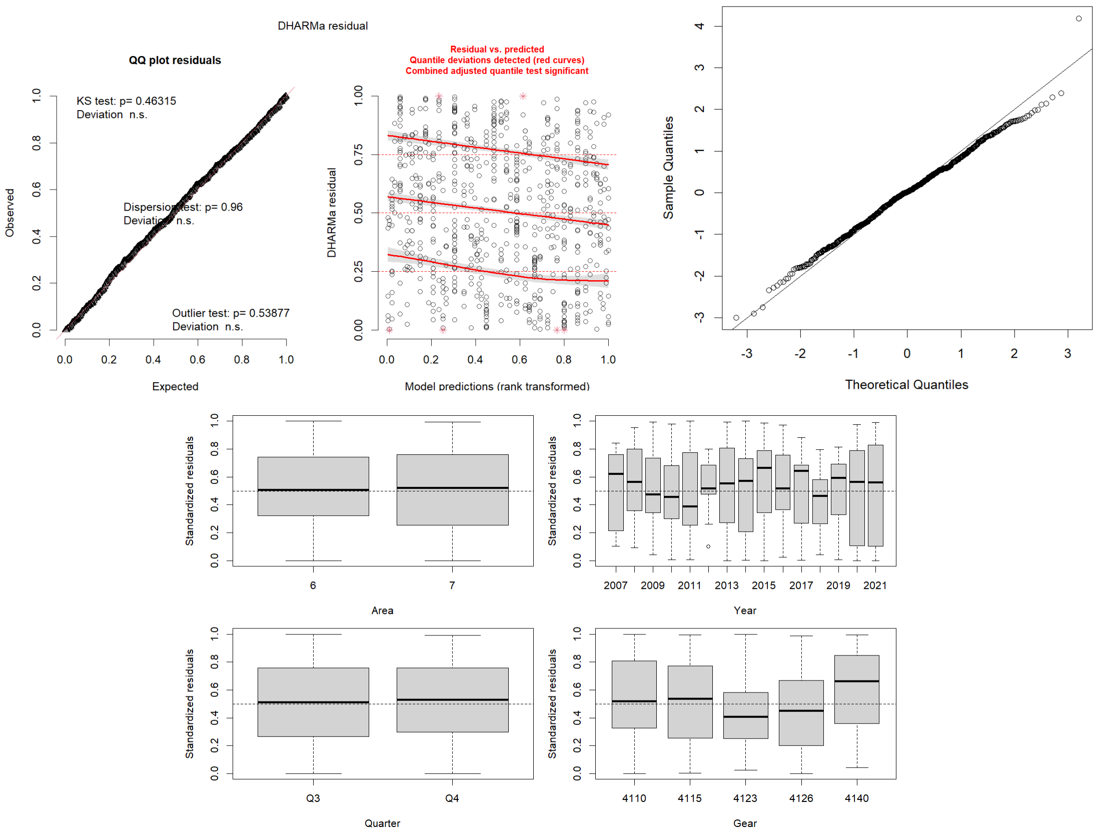


Figure 2.3.5. Residual diagnostic plots for the final CPUE model fitted to cod data in area 6 and 7, and quarters 3 and 4. Top panel left: standard output from the residual diagnostics using the R package DHARMa. Top panel right: normal QQ-plot. Bottom panel: model standardized residuals vs. available covariates. All panels indicate no significant (though some) issues with the final model.

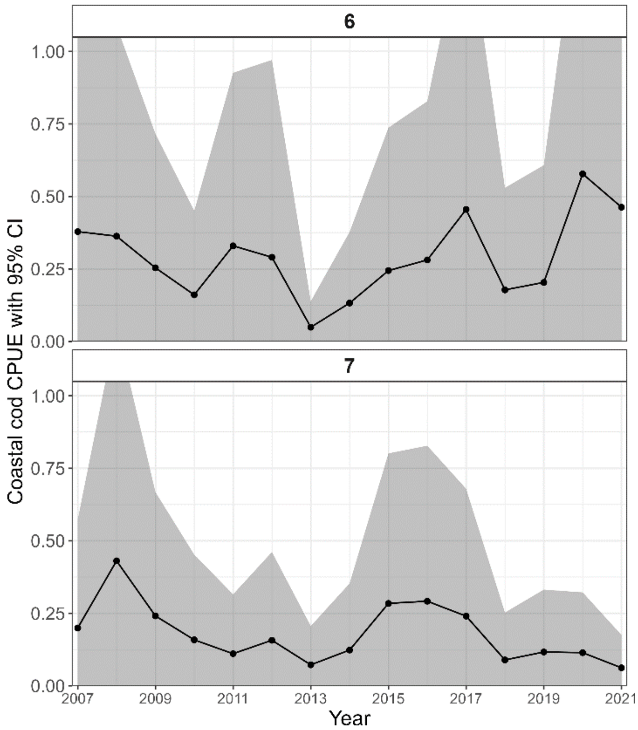


Figure 2.3.6. Standardized reference fleet CPUE (kg per gillnet per day) index for coastal cod in areas 6 and 7 during quarters 3 and 4, between 2007–2021. The grey shaded polygon represents the 95% confidence interval (calculated using the approximation: mean +/- 1.96 SE).

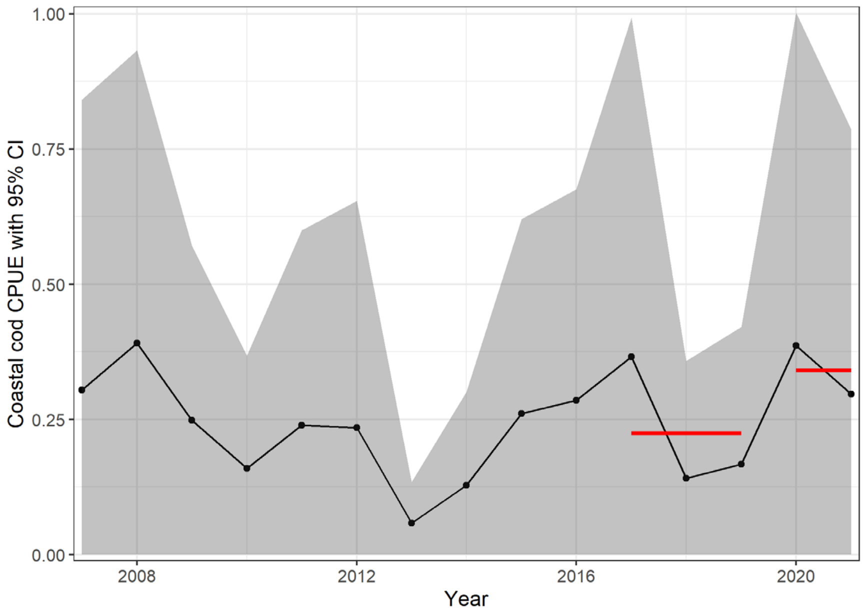


Figure 2.3.7. Composite reference fleet CPUE (kg cod per gillnet per day) index for southern Norwegian coastal cod, areas 6 and 7 combined. 95% confidence intervals are calculated using the approximation: mean +/- 1.96 SE. Red horizontal lines indicate the averages for the last 2 years (2020–2021) and previous 3 (2017–2019) used in the 'rfb' rule for catch advice (Table 2.3.7).

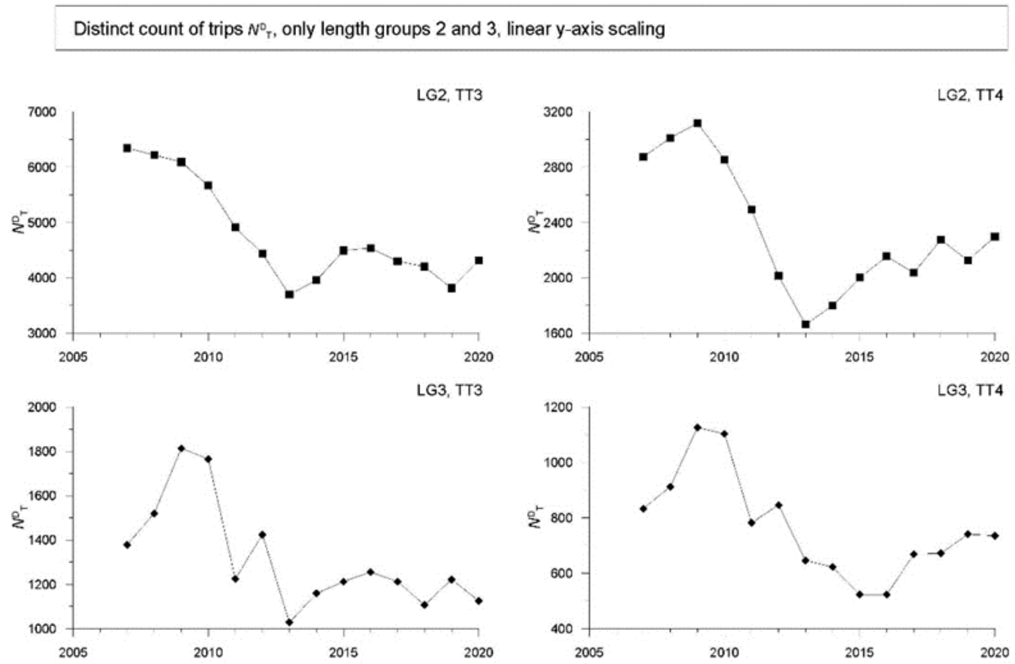


Figure 2.3.8. Full commercial fleet fishing effort presented as the number of sales note trips for two boat sizes, LG2 = <11 m and LG3 = 11–14.99 m, for areas 62–67°°N in the second half of the year. Left panel: all gears; right panel: gillnet only. Note different y-axes.

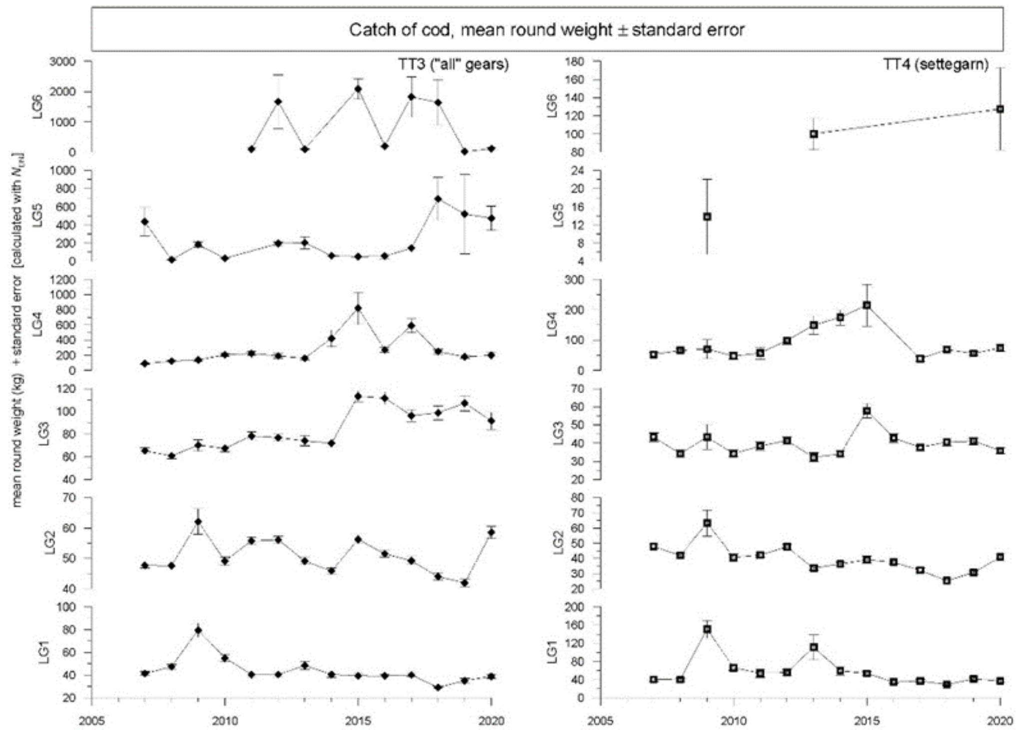


Figure 2.3.9. Full commercial fleet CPUE (kg cod per sales note trip) per boat size (LG1-LG6) for area 62–67°N in the second half of the year. Left panel: all gears; right panel: gillnet only.

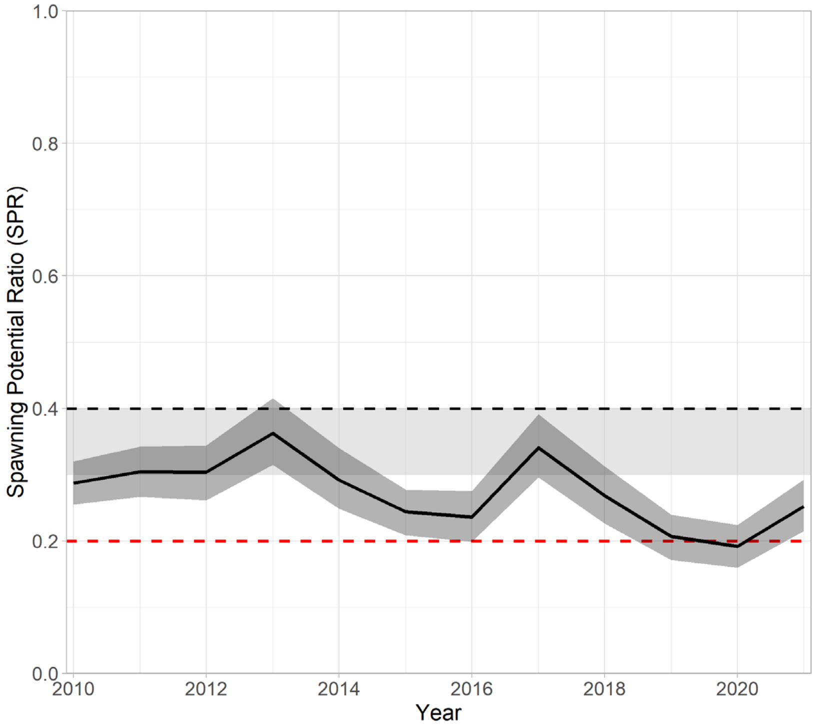


Figure 2.3.10. Spawning potential ratio (SPR) per year estimated by the length based spawning potential ratio (LBSPR) model. Mean (black line) and confidence intervals (dark shaded area, 95% interquartile range [IQR]), based on the stochastic LBSPR. The light shaded area delimits the $SPR_{30\%-40\%}$ zone (common targets) and the red dashed horizontal line the $SPR_{20\%}$ limit reference point.

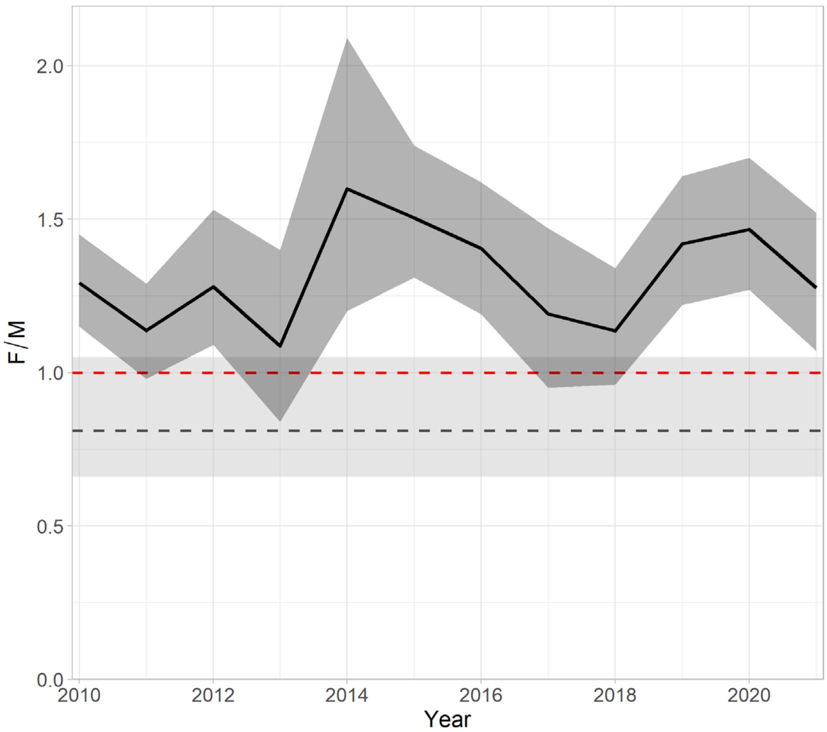


Figure 2.3.11. Estimated fishing mortality relative to natural mortality (F/M) per year estimated by the length based spawning potential ratio (LBSPR) model. Mean (black line) and confidence intervals (dark shaded area, 95% IQR), based on the stochastic LBSPR. Red dashed line indicates F/M = 1, and grey dashed line indicates $F_{40\%SPR}$/M (with 95% IQR, light shaded area), common target reference points.

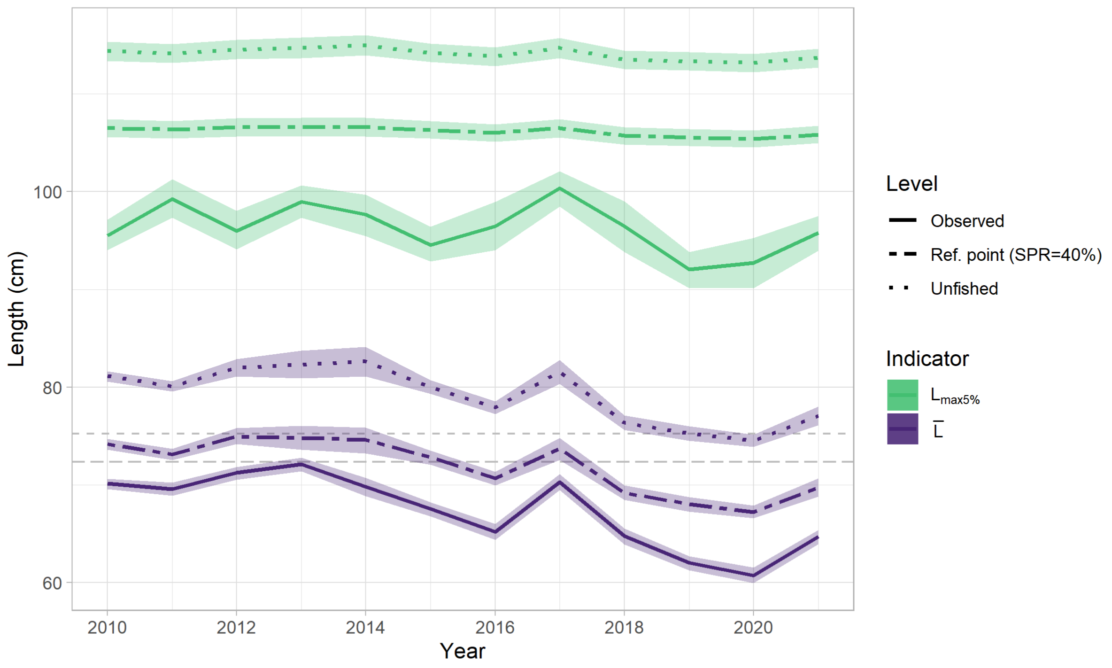


Figure 2.3.12. Length-based indicators $L_{max5\%}$ and mean catch length ($\bar{L}$) in relation to their reference points (mean and 95%CI). The reference points were estimated using the LBSPR simulation model together with the stochastic parameters detailed in Table 2.3.1 (mortality scenario following Lorenzen, 1996) and SPRs of 40% and 100% (unfished).

Figure 2.3.13. Length-based indicators, mean catch length ($\bar{L}$) and length at 50% selectivity (S_{50}), in relation to the minimum legal size (44 cm) and length at 50% maturity (M_{50}). M_{50} is estimated with uncertainty by bootstrapping data from the coastal survey. S_{50} is estimated by the length based spawning potential ratio (LBSPR) model, independently by year. $\bar{L}$ is calculated from the coastal reference fleet biological samples.

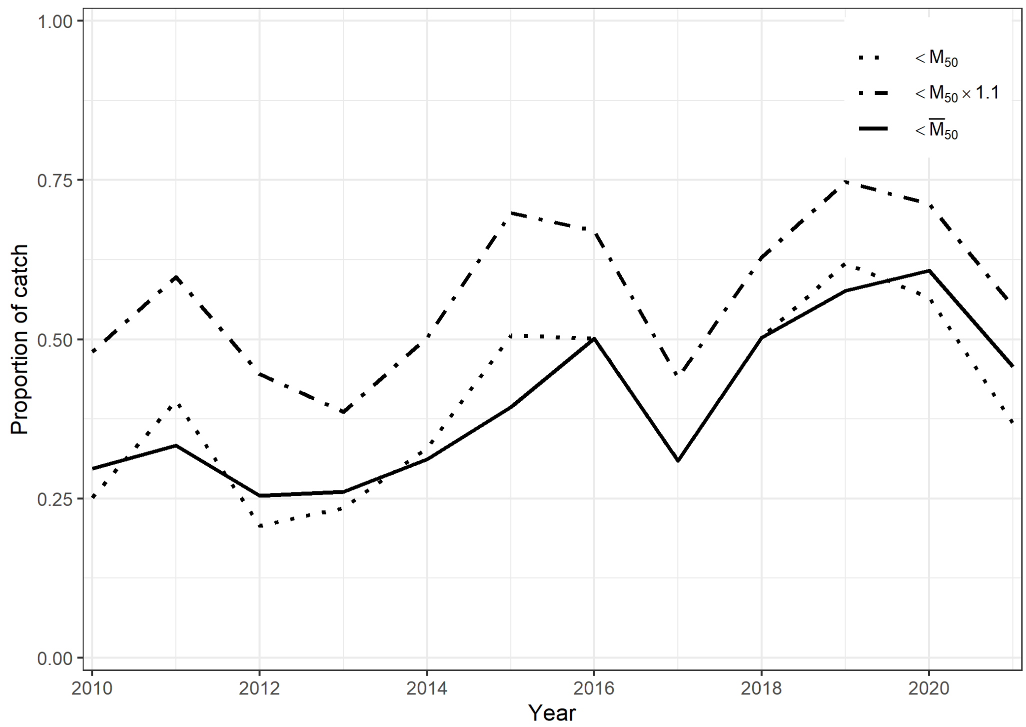


Figure 2.3.14. Proportion of the catch that is immature, southern Norwegian coastal cod. Linetype shows the proportion of cod in each year that are smaller than the yearly length at 50% maturity (M_{50}, dotted line), yearly M_{50} times 1.1 (dashed line), and average M_{50} ($\bar{M}_{50}$ = 62.8 cm, solid line).

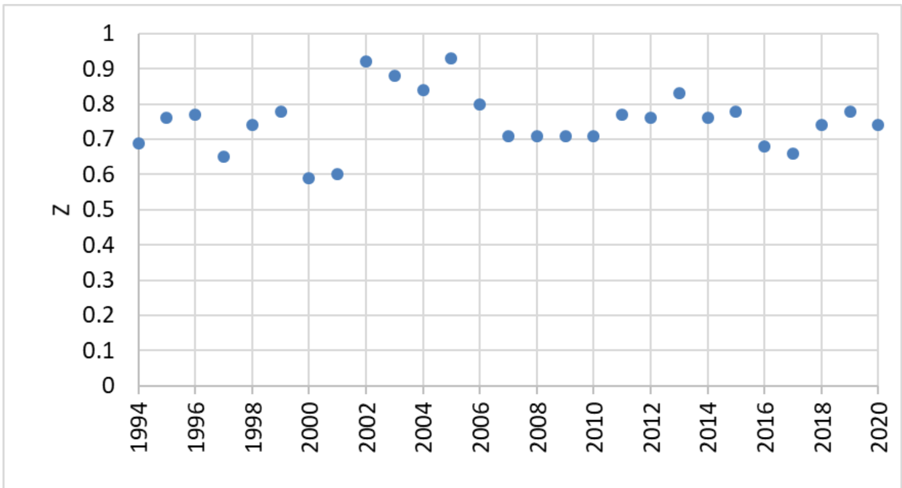


Figure 2.3.15. Total mortality (Z) estimated from catch curves (average over ages 5–14 in commercial and recreational catches) 1994–2020.

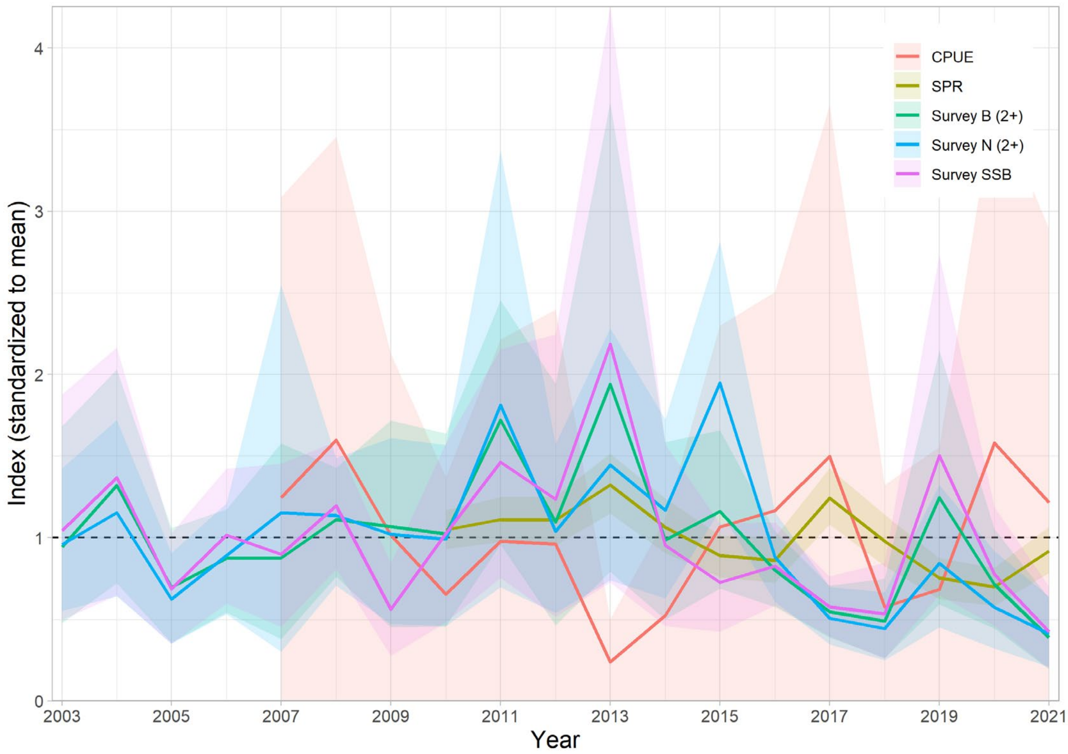


Figure 2.3.16. Coastal survey trawl swept-area indices in relation to the reference fleet CPUE index and SPR, each standardized to its mean. Three alternative indices are calculated from the coastal survey: total age-2+ biomass (Survey B 2+), numbers age-2+ (Survey N 2+), and spawning-stock biomass (Survey SSB). Shading depicts 95% confidence intervals.

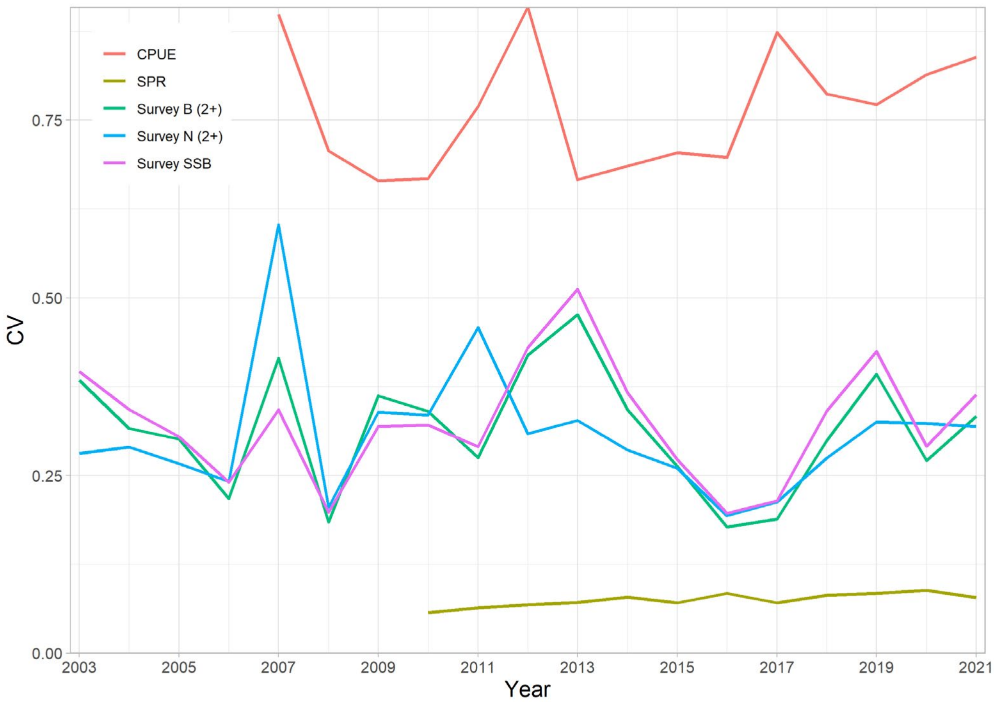


Figure 2.3.17. Coefficient of variation (CV) from the coastal survey trawl swept-area indices, reference fleet CPUE index, and SPR. Three alternative indices are calculated from the coastal survey: total age-2+ biomass (Survey B 2+), numbers age-2+ (Survey N 2+), and spawning-stock biomass (Survey SSB).

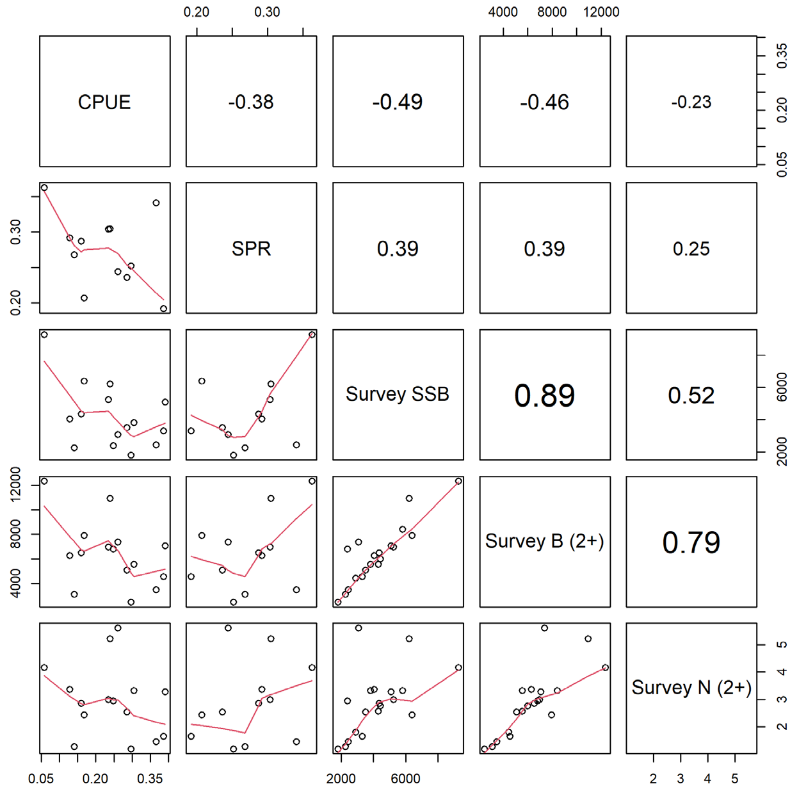


Figure 2.3.18. Correlation between the coastal survey trawl swept-area indices, reference fleet CPUE index, and SPR. Three alternative indices are calculated from the coastal survey: total age-2+ biomass (Survey B 2+), numbers age-2+ (Survey N 2+), and spawning-stock biomass (Survey SSB).

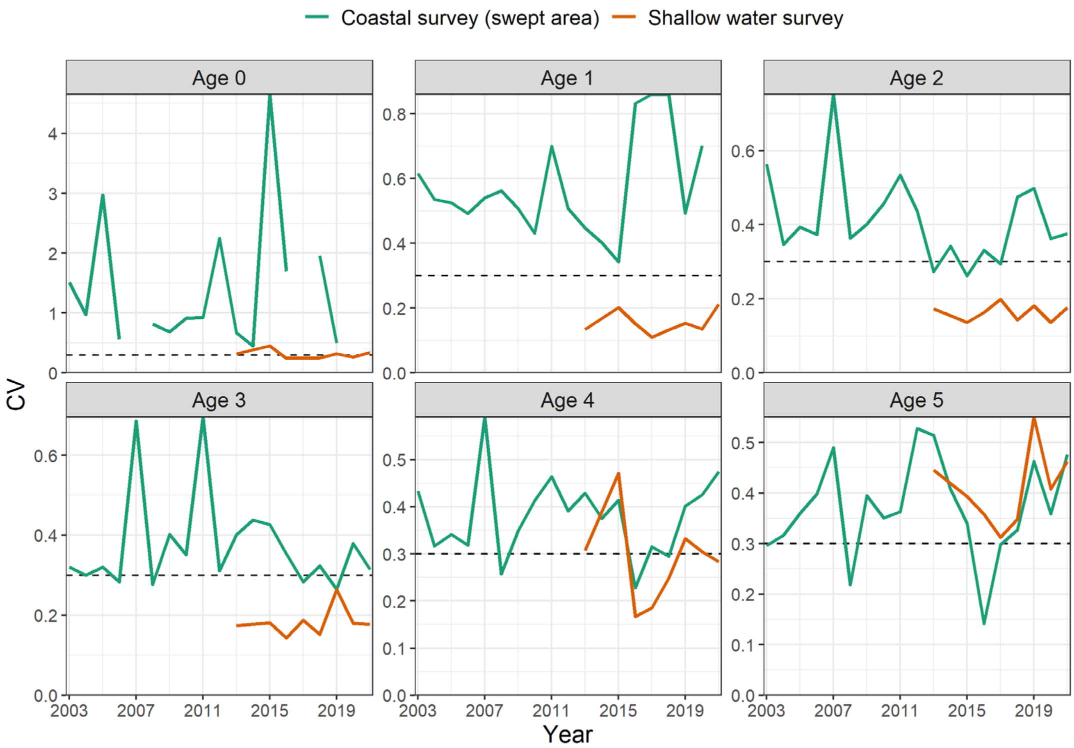


Figure 2.3.19. Coefficient of variation (CV) for additional survey indices-at-age, by year. Green: coastal survey swept-area (trawl). Orange: shallow water (garn ruse) survey. Dashed horizontal line indicates CV = 0.3, a commonly used upper threshold for considering indices to be informative on stock trends. See WD 13 for more details.

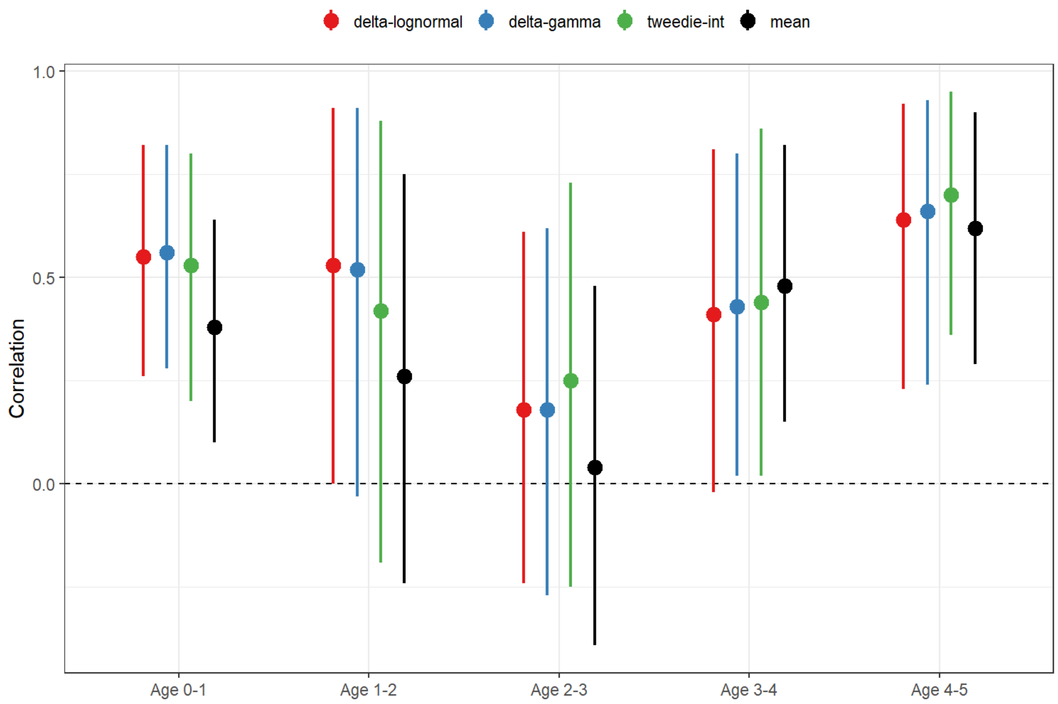


Figure 2.3.20. Correlation between the shallow water survey index-at-age in the previous age/year to the next, i.e. consistency, or the ability to track cohorts. Error bars indicate bootstrapped 95% confidence intervals. The delta-lognormal model was selected. See WD 13 for more details.

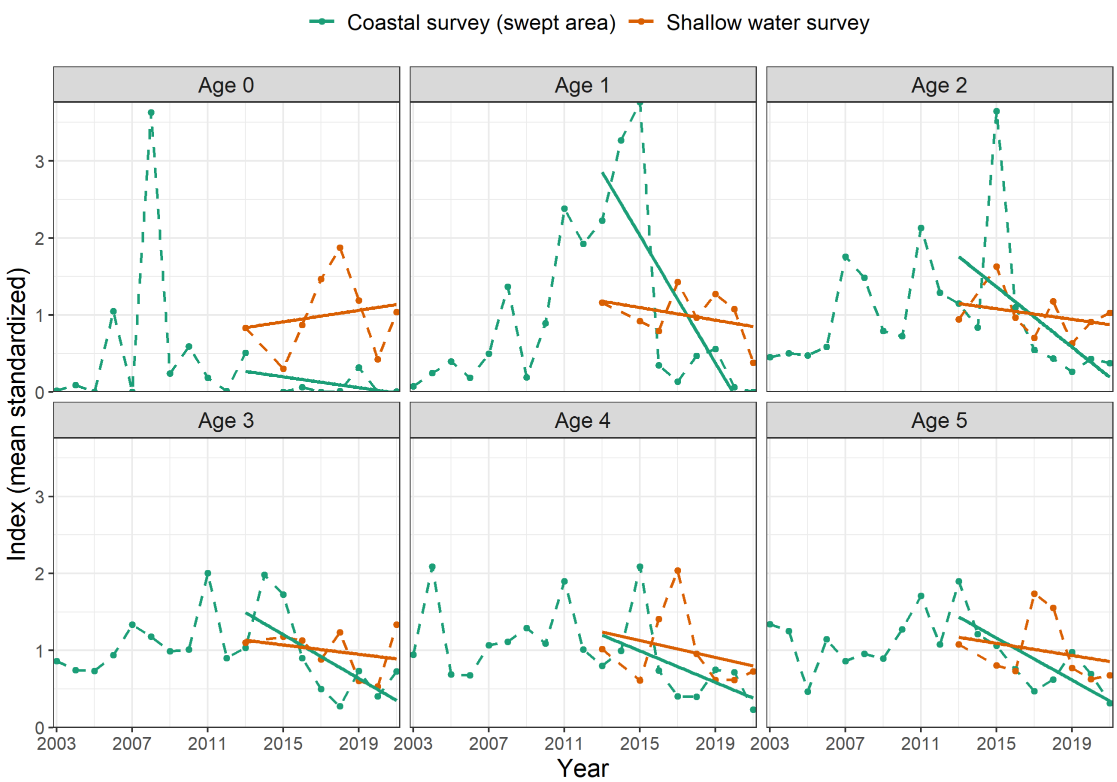


Figure 2.3.21. Southern Norwegian coastal cod indices-at-age from two available surveys, standardized to their means (horizontal dashed lines). Green: coastal survey swept-area (trawl). Orange: shallow water (garn ruse) survey. Lines are linear model fits from 2013–2021. See WD 13 for more details.

3 Northeast Arctic cod[1]

On 30 March 2022, all Russian participation in ICES was suspended. As a result of this decision, it is not possible to run ICES stock assessments or provide ICES advice for the Barents Sea stocks of NEA cod, NEA haddock, *Sebastes mentella* or Greenland Halibut, as management and data collection for these stocks are shared between Norway and Russia. There is therefore no stock assessment for NEA cod this year, but input data to the assessment are updated as far as possible.

The tables and figures updated are the following: Tables 3.1–3.5, 3.7, 3.13, Tables A1–A8, A13–A15 and Figure 3.6b. The numbering of tables and figures is unchanged from AFWG 2021 so there are some 'holes' in the numbering.

Figures and tables can be found in the Data/NEA cod folder. Tables A9–A12 are not updated and will not be included in the report, but for completeness, they are also uploaded in the AFWG SharePoint folder.

3.1 Status of the fisheries

3.1.1 Historical development of the fisheries (Table 3.1)

From a level of about 900 000 t in the mid-1970s, the total catch declined steadily to around 300 000 t in 1983–1985 (Table 3.1). Catches increased to above 500 000 t in 1987 before dropping to 212 000 t in 1990, the lowest level recorded in the post-war period. The catches increased rapidly from 1991 onwards, stabilized around 750 000 t in 1994–1997 but decreased to about 414 000 t in 2000. From 2000–2009, the reported catches were between 400 000 and 520 000 t, in addition, there were unreported catches (see below). Catches have been above the long-term average since 2011 and have decreased from a peak of 986 449 tonnes in 2014 to 693 000 tonnes in 2019–2020 before increasing to 758 000 tonnes in 2021. The fishery is conducted both with an international trawler fleet and with coastal vessels using traditional fishing gears. Quotas were introduced in 1978 for the trawler fleets and in 1989 for the coastal fleets. In addition to quotas, the fishery is regulated by a minimum catch size, a minimum mesh size in trawls and Danish seines, a maximum bycatch of undersized fish, closure of areas having high densities of juveniles and seasonal and area restrictions.

3.1.2 Reported catches prior to 2021 (Tables 3.1–3.4, Figure 3.1)

The provisional catch of cod in Subarea 1 and divisions 2.a and 2.b for 2021 reported to the working group is 800 427 t (including both NEA cod and NCC catches).

Reported catch figures used for the assessment of Northeast Arctic cod:

The historical practice (considering catches between 62°N and 67°N for the whole year and catches between 67°N and 69°N for the second half of the year to be Norwegian coastal cod) has been used for estimating the Norwegian landings of Northeast Arctic cod up to and including 2011 (Table 3.2). The catches of coastal cod subtracted from total cod catches in Subarea 1 and divisions 2.a and 2.b for the period 1960–2021 are given in Table 3.2. For 2012–2021 the

[1] Cod (*Gadus morhua*) in subareas 1 and 2 (Northeast Arctic); cod.27.1-2.

Norwegian catches have been analysed by an ECA-version designed for simultaneously providing estimates of catch numbers-at-age for each of the two stocks.

Coastal cod catches in 2021 for the southern and northern areas combined were 42 044 tonnes using the current conversion factors between round and gutted weight, and this amount was as in previous years subtracted from the total cod catch north of 62° N to get the figure for NEA cod used in that assessment (Table 3.1 and 3.2). The figure for the total coastal cod catch in 2021 using the revised conversion factors, as decided at WKBARFAR 2021 and used in the coastal cod assessment was 32 043 tonnes (Table 2.1a), which is 3.9% above the value using the current conversion factors.

These values for coastal cod are now inconsistent with the coastal cod catches presented in Chapter 2, as the coastal cod catch time-series were revised at WKBARFAR, but not the NEA cod time-series. At WKBARFAR, the proposal for revision of NEA cod catch dataseries was rejected, as Norwegian data for many years and age groups (especially ages 12+ in years prior to 2013) were changed considerably and the reason for this was not sufficiently explained. WKBARFAR recommended that when the revision of the historical Norwegian catch data are ready it should be submitted to ICES for review, ideally by a review attached to the AFWG.

The catch by area is shown in Table 3.1, and further split into trawl and other gears in Table 3.3. The distribution of catches by areas and gears in 2021 was similar to 2020. The nominal landings by country are given in Table 3.4.

There is information on cod discards (see section 0.4) but it was not included in the assessment because these data are fragmented and different estimates are in contradiction with each other. Moreover, the level of discards is relatively small in the recent period and the inclusion of these estimates in the assessment should not change our perception on NEA cod stock size.

In summer/autumn 2018, a Norwegian vessel caught 441 t of cod in the Jan Mayen EEZ, which is a part of ICES area 2a, mostly by longline. Cod is known to occasionally occur in this area, but rarely in densities which are suitable for commercial fisheries. The cod caught in this area in 2018 was large (65–110 cm), and otolith readings and genetics both showed this cod to be a mix of Northeast Arctic and Icelandic cod. Norway did in 2019–2020 carry out an experimental longline fishery during four different periods each year in order to investigate further the occurrence of cod in this area in space and time as well as stock identity. The size distribution and genetic composition of the cod caught in this area in 2019–2021 were similar to that in 2018, although there was somewhat smaller cod (< 65 cm) in 2020–2021 than in 2019. Most of the cod caught in April-May 2019 was spawning or spent, while most cod caught in March 2020 had not started spawning. Cod spawning in this area has not been observed prior to 2019. Total catches in 2019 amounted to 628 t, in 2020 to 522 t and in 2021 to 146 t. The 2018 catches in this area were partly counted against the Norwegian TAC for cod north of 62° N, while the 2019 and 2020 TAC for this area comes in addition to the Norwegian TAC for cod as agreed by JNRFC. There have been varying practice considering including those catches in the assessment, they were included in 2020 but the plan is to exclude them for all years in future assessments. Regulations for the fishery in this area for 2022 have not yet been decided upon.

3.1.3 Unreported catches of Northeast Arctic cod (Table 3.1)

In the years 2002–2008, certain quantities of unreported catches (IUU catches) have been added to the reported landings. More details on this issue are given in the Working group reports for that period.

There are no reliable data on the level of IUU catches outside the periods 1990–1994 and 2002–2008, but it is believed that their level was not substantial enough to influence historical stock assessment.

According to reports from the Norwegian-Russian analysis group on estimation of total catches the total catches of cod since 2009 were very close to officially reported landings.

3.1.4 TACs and advised catches for 2021 and 2022

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 885 600 t for 2020 and in addition 21 000 t Norwegian coastal cod. The total reported catch of 800 427 t in 2021 was 106 173 t below the agreed TAC. Since 2015 JNRFC has decided that Norway and Russia can transfer to next year or borrow from last year 10% of the cod country's quota. That may lead to some deviation between agreed TAC and reported catch. As an extraordinary measure due to expected underfishing of the TAC in 2021, JNRFC decided that it should be possible to transfer 15% of the TAC between 2021 and 2022.

The advice for 2022 given by ACOM in 2021 was 708 480 t based on the agreed harvest control rule. The quota established by JNRFC for 2022 was set equal to the advice. In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2022 as for 2021: 21 000 t.

ICES will not give advice for this stock for 2023.

3.2 Status of research

3.2.1 Fishing effort and CPUE (Table A1, Figure 3.6a-c)

CPUE series of the Norwegian and Russian trawl fisheries are given in Table A1. Russian CPUE data for 2021 were not available. The data reflect the total trawl effort (Figure 3.6a), both for Norway and Russia. The Norwegian series is given as a total for all areas. Norwegian data for 2011–2021 are not necessarily compatible with data for 2007 and previous years. Norwegian CPUE declined from 2020 to 2021 and reached the lowest level in the 2011–2021 time-series (Figure 3.6b).

3.2.2 Survey results - abundance and size at age (Tables 3.5, A2–A14)

Some survey results for 2021 were revised since AFWG 2021, for a summary of this, see section 3.2.3.

3.2.2.1 Joint Barents Sea winter survey (bottom trawl and acoustics) Acronyms: BS-NoRu-Q1 (BTr) and BS-NoRu-Q1 (Aco)

Results from this survey were not available as Russian data have not been exchanged, but the survey was carried out as planned with good spatial coverage.

Before 2000 this survey was made without participation from Russian vessels, while in 2001–2005, 2008–2016 and 2018–2022 Russian vessels have covered important parts of the Russian zone. In 2006–2007 the survey was carried out only by Norwegian vessels. In 2007, 2016, 2021 and 2022 the Norwegian vessels were not allowed to cover the Russian EEZ. The method for adjustment for incomplete area coverage in 2007 is described in the 2007 report. The same method was used to adjust the 1997–1998 survey indices in the 2016 revision (Mehl *et al*. 2016). Table 3.5 shows areas covered in the time-series and the additional areas implied in the method used to adjust for missing coverage in the Russian Economic Zone. In 5 of the 8 adjusted years (including 2021) the adjustments were not based on area ratios, but the "index ratio by age" was used. This means that the index by age for the covered area was scaled by the observed ratio between total index and the index for the same area observed in the years prior to the survey. The adjustments for 2017 were based on average index rations by age for 2014–2016. Adjustments were also made in 2020–2021 using the average index ratios by age for 2018–2019 and 2019–2020, respectively.

Regarding the older part of this time-series it should be noted that the survey prior to 1993 covered a smaller area (Jakobsen *et al*. 1997), and the number of young cod (particularly 1- and 2-year old fish) was probably underestimated. Other changes in the survey methodology through time are described by Jakobsen *et al.* (1997), while the surveys for the years 2007–2012 and 2013–2018 are reported in Mehl *et al.* (2013, 2014, 2015, 2016, 2017a). Note that the change from 35 to 22 mm mesh size in the codend in 1994 is not corrected for in the time-series. This mainly affects the age 1 indices.

With the recent expansion of the cod distribution it is likely that in recent years the coverage in the February survey (BS-NoRu-Q1 (BTr) and BS-NoRu-Q1 (Aco)) has been incomplete, in particular for the younger ages. This could cause a bias in the assessment, but the magnitude is unknown. The 2014–2021 surveys covered considerably larger areas than earlier winter surveys, and showed that most age groups of cod (particularly ages 1 and 2) were distributed far outside the standard survey area. The bottom trawl survey estimates including the extended area for 2014–2021 were used in the tuning data separately from the same index before 2014, as decided at WKBARFAR 2021.

3.2.2.2 Lofoten acoustic survey on spawners Acronym: Lof-Aco-Q1

The estimated abundance indices from the Norwegian acoustic survey off Lofoten and Vesterålen (the main spawning area for this stock) in March/April are given in Table A4. A description of the survey, sampling effort and details of the estimation procedure can be found in Korsbrekke (1997). The 2022 survey results in biomass terms was 182 thousand tonnes, this is 21 % below the 2021 level and the lowest since 2006.

3.2.2.3 Russian autumn survey Acronym: RU-BTr-Q4

Abundance estimates from the Russian autumn survey (November-December) are given in Table A9 (acoustic estimates) and Table A10 (bottom trawl estimates). The entire bottom trawl time-series was in 2007 revised backwards to 1982 (Golovanov *et al.,* 2007, WD3), using the same method as in the revision presented in 2006, which went back to 1994. The new swept-area indices reflect Northeast Arctic cod stock dynamics more precisely compared to the previous one - catch per hour trawling. The Russian autumn survey in 2006 was carried out with reduced area coverage. Divisions 2a and 2b were adequately investigated in the survey in contrast to Subarea 1, where the survey covered approximately 40% of the long-term average area coverage. The Subarea 1 survey indices were calculated based on actual covered area (40 541 sq. miles). The 2007 AFWG decided to use the "final" year-class indices without any correction because of satisfactory internal correspondence between year-class abundances at age 2–9 years according to the 2006 survey and ones due to the previous surveys.

This survey was not conducted in 2016, but was carried out in 2017, when 79% of the standard survey area was covered (Sokolov *et al* 2018, WD 11). The index shows a reliable internal consistence and it was decided to use it in the assessment. This survey was not carried out in 2018–2021 and will likely be discontinued.

3.2.2.4 Joint Ecosystem survey Acronym: Eco-NoRu-Q3 (Btr)

Swept-area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey in August-September for the period 2004–2021 are given in Table A14. This survey normally covers the entire distribution area of cod at that time of the year.

In 2014 this survey had an essential problem with area coverage in the northwest region because of difficult ice conditions. In the area covered by ice in 2014 a substantial part of population was distributed during 2013 survey. So, based on those observations AFWG decided in 2015 to exclude 2014 year from that tuning series in current assessment. In 2016 there was incomplete coverage in the international waters and close to the Murmansk coast. An adjustment for this incomplete coverage was made based on interpolation from adjacent areas (Kovalev *et al* 2017, WD 12). At this time of the year, usually a relatively small part of the cod stock is found in the area which was not covered in 2016. In 2017 and 2019 the coverage was close to complete, although the far northeastern part of the survey area (west of the north island of Novaya Zemlya) was not covered due to military restrictions. In 2018, a large area in the eastern part of the Barents Sea was not covered Thus it was decided not to include 2018 data from this survey in the assessment.

The coverage in 2020 was less synoptic than usual, as explained in Section 0.6. As the survey indices from the BESS 2020 showed an unexplainable large decline compared to the 2019 indices, it was considered to exclude 2020 indices from this survey, but it was decided to keep them in and re-evaluate next year whether they should still be included in the assessment. The 2021 coverage was good, although as in several previous years, most of the international waters in the Barents Sea was not covered. The mentioned re-evaluation has not been carried out.

The survey indices are calculated both the BioFox and StoX calculation methods, and as in earlier years, the Biofox series was used in the tuning. A research recommendation from WKBARFAR was to unify these two methods for estimating indices from ecosystem survey. However, the benchmark decided to use weight at age from the StoX in calculations of weight at age used in the assessment.

3.2.2.5 Survey results - length and weight-at-age (Tables A5–A8, A11–A12, A15)

Length-at-age is shown in Table A5 for the Norwegian survey in the Barents Sea in winter, in Table A7 for the Lofoten survey and in Table A11 for the Russian survey in October-December. Weight-at-age is shown in Table A6 for the Norwegian survey in the Barents Sea in winter, in Table A8 for the Lofoten survey, Table A12 for the Russian survey in October-December and Table A15 for the BESS survey (calculated using StoX).

Length and weight at age in the Lofoten survey increased from 2021 to 2022 for age groups 5–6 and 8–11. The size at age in the BESS survey was about the same in 2021 as in 2020.

3.2.3 Revision of 2021 survey results

Some errors in StoX software were found in summer 2021, affecting the 2021 winter survey results (bottom trawl and acoustic) for cod and haddock and thus a revised assessment was carried out in September 2021 for both stocks (as described in the AFWG 2021 report executive summary). Also an error in calculating the 12+ group for the bottom trawl survey for use in the tuning was corrected. After that some additional errors in StoX software have been found and corrected, final estimates for 2021 are in the survey report which is now published (Fall et al. 2022). In addition, the 2020 ecosystem survey indices and weight at age as well as the 2021 Lofoten survey indices and weight at age have been revised.

3.2.4 Age reading

The joint Norwegian-Russian work on cod otolith reading has continued, with regular exchanges of otoliths and age readers (see chapter 0.7). The results of fifteen years of annual comparative age readings are described in Yaragina *et al.* (2009). Zuykova *et al.* (2009) re-read old otoliths and found no significant difference in contemporary and historical age determination and subsequent length-at-age. However, age at first maturation in the historical material as determined by contemporary readers is younger than that determined by historical readers. Taking this difference into account would thus have effect on the spawning stock–recruitment relationship and thus on the biological reference points. The overall percentage agreement for the 2017–2018 exchange was 87.7% (WD 8, AFWG 2020). The main reason for cod ageing discrepancies between Russian and Norwegian specialists remains the same, representing the latest summer growth zone, and different interpretations of the false zones. The general trend is that the Russian readers assign slightly lower ages than the Norwegian readers compared to the modal age for all age groups. This is opposite of what we have seen in previous readings, where the Russian readers has tended to be slightly overestimating the age compared to the Norwegian readers. More details can be found in section 0.7.

The trend with bias in NEA cod age determination registered for some years of the period 1992–2018 between experts of both countries is a solid argument to continue comparative cod age reading between PINRO and IMR to monitor the situation. The German participant has expressed an intention to join the age reading cooperation in future.

3.3 Data available for use in assessment

Data for the period 1946–1983 are taken from the AFWG 2001 report (ICES CM 2001/ACFM:19) and were not revised at the WKBARFAR benchmark in 2021.

3.3.1 Catch-at-age (Table 3.6)

For 2021, age compositions from all areas were available from Norway, Spain and Germany. Russian data were not available and thus total catch-at-age was not calculated.

There is still a concern about the biological sampling from parts of the Norwegian fishery that may be too low. Also the split between NEA cod and coastal cod may be affected by the sampling coverage.

3.3.2 Survey indices available for use in assessment (Table 3.13, A13)

The following survey dataseries were available:

Fleet code	Name	Place	Season	Age	Years
Fleet 15*	Joint bottom trawl survey	Barents Sea	Feb-Mar	3–12+	1981–2013, 2014–2021
Fleet 16	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	3–12+	1985–2021
Fleet 18	Russian bottom trawl surv.	Total area	Oct-Dec	3–12+	1982–2017
Fleet 007	Ecosystem surv.	Total area	Aug-Sep	3–12+	2004–2021

***Survey indices for Fleet 15 were divided by two series (before and after 2014) in model tuning as decided at WKBARFAR 2021.**

The tuning fleet file is shown in Table 3.13. Note that the joint acoustic survey (sum of Barents Sea and Lofoten acoustic survey indices) is given in Table A13.

Survey indices for Fleet 15 have been multiplied by a factor 100, while survey indices for Fleets 007, 16 and 18 have been multiplied by a factor 10. This is done to keep the dynamics of the surveys even for very low indices, because some models (e.g. XSA) adds 1.0 to the indices before the logarithm is taken.

3.3.3 Weight-at-age (Tables 3.7–3.9, A2, A4, A6, A8, A12).

3.3.3.1 Catch weights

For 2021, weight-at-age in the catch for areas 1, 2a and 2b was provided by Norway, Spain and Germany (Table 3.7). Russian data were not available and thus total weight at age was not calculated. For ages up to and including 11, observations are used. Following the WKBARFAR 2021 decision, weight at age in catch for the years 1983–present for ages 12–15+ are calculated by a cohort-based von Bertalanffy approach used to replace previous fixed values.

3.3.3.2 Stock weights

Weight at age in the stock for 2022 were not calculated as winter survey data were not available.

For ages 1–11 stock weights-at-age at the start of year y ($W_{a,y}$) for 1983–2021 are calculated combining, when available, weight at age from the Winter, Lofoten, Russian autumn and ecosystem surveys. The details are given in the stock annex. For ages 12–15+ a similar approach as for weight at age in the catch was used.

3.3.4 Natural mortality including cannibalism (Table 3.12, Table 3.17)

A natural mortality (M) of 0.2 + cannibalism was used. Cannibalism is assumed to only affect natural mortality of ages 3–6.

2021 data are available and 2020 data have been updated, but tables with results based on these data are not included (Tables 3.12 and 3.17 in the 2021 AFWG report) as no assessment was done.

The method used for calculation of the prey consumption by cod described by Bogstad and Mehl (1997) is used to calculate the consumption of cod by cod for use in cod stock assessment. The consumption is calculated based on cod stomach content data taken from the joint PINRO-IMR stomach content database (methods described in Mehl and Yaragina 1992). On average about 9000 cod stomachs from the Barents Sea have been analysed annually in the period 1984–2021.

These data are used to calculate the per capita consumption of cod by cod for each half-year (by prey age groups 0–6 and predator age groups 1–11+). It was assumed that the mature part of the cod stock is found outside the Barents Sea for three months during the first half of the year. Thus, consumption by cod in the spawning period was omitted from the calculations.

An iterative procedure was applied to include the per capita consumption data in the SAM run. It is described in detail in Stock Annex.

For the cod assessment data from annual sampling of cod stomachs has been used for estimating cannibalism, since the 1995 assessment. The argument has been raised that the uncertainty in such calculations are so large that they introduce too much noise in the assessment. A rather comprehensive analysis of the usefulness of this was presented in Appendix 1 in the 2004 AFWG report. The conclusion was that it improves the assessment.

The data on cod cannibalism for the historical period (1946–1983) was included in assessment during the benchmark to make the time-series consistent (ICES 2015, WKARCT 2015). These estimates were based on hindcasted values of NEA cod natural mortality-at-ages 3–5 using PINRO database on food composition from cod stomach for the historical period (Yaragina *et al*. 2018).

3.3.5 Maturity-at-age (Tables 3.10–3.11, Tables 3.10–3.11)

Since data from the winter survey 2022 were not available, ogives for 2022 could not be calculated.

Historical (pre–1982) Norwegian and Russian time-series on maturity ogives were reconstructed by the 2001 AFWG meeting (ICES CM 2001/ACFM:19). The Norwegian maturity ogives were constructed using the Gulland method for individual cohorts, based on information on age at first spawning from otoliths. For the period 1946–1958 only the Norwegian data were available. The Russian proportions mature-at-age, based on visual examinations of gonads, were available from 1959.

Since 1982 Russian and Norwegian survey data have been used (Table 3.10). For the years 1985–2021, Norwegian maturity-at-age ogives have been obtained by combining the Barents Sea winter survey and the Lofoten survey. Russian maturity ogives from the autumn survey as well as from commercial fishery for November-February are available from 1984 until present. The Norwegian maturity ogives tend to give a higher percent mature-at-age compared to the Russian ogives, which is consistent with the generally higher growth rates observed in cod sampled by the Norwegian surveys. The percent mature-at-age for the Russian and Norwegian surveys have been arithmetically averaged for all years, except 1982–1983 when only Norwegian observations were used and 1984 when only Russian observations were used.

Russian data for the autumn survey for 2018 and later years were not available as the survey was not conducted. In WD15, 2019, updated correction factors to allow for this when calculating the combined maturity-at-age in 2019 were calculated, based on historical differences between Norwegian and Russian data. These correction factors were then applied to the Norwegian data for 2020–2021.

The approach used for calculating maturity-at-age is the same as previously used and consistent with the approach used to estimate the weight-at-age in the stock, except that no data from the BESS survey are used. However, since survey data, both abundance indices and proportion mature, have been revised, the entire time-series of ogives back to 1994 was revised at the benchmark. The proportions of mature cod for age 13–15 are set to 1 for the period 1984–present.

Maturity-at-age for cod has been variable the last five years, particularly for ages 6–9. According to the combined data, maturity-at-age decreased in 2015–2016, then increased, but decreased again from 2019 to 2021 (Table 3.11).

4 Northeast Arctic haddock[1]

4.1 Introductory note

On 30 March 2022 all Russian participation in ICES was suspended. As a result of this decision, it is not possible to run ICES stock assessments or provide ICES advice for the Barents Sea stocks of NEA cod, NEA haddock, *Sebastes mentella* or Greenland Halibut, as management and data collection for these stocks are shared between Norway and Russia. There is therefore no stock assessment for NEA haddock this year.

The following tables were updated: Tables 4.1–4.5. Except for these tables, the text, tables and figures are unchanged from last year's report.

The data folder at the SharePoint will be updated when more data becomes available.

4.2 Status of the fisheries

4.2.1 Historical development of the fisheries

Haddock is mainly fished by trawl as bycatch in the fishery for cod. Also, a directed trawl fishery for haddock is conducted. The proportion of the total catches taken by direct fishery varies between years. On average approximately 30% of the catch is with conventional gears, mostly longline, which in the past was used almost exclusively by Norway. Some of the longline catches are from a directed fishery, which is restricted by national quotas. In the Norwegian management, the quotas are set separately for trawl and other gears. The fishery is also regulated by a minimum landing size, a minimum mesh size in trawls and Danish seine, a maximum bycatch of undersized fish, closure of areas with high density/catches of juveniles and other seasonal and area restrictions.

The exploitation rate of haddock has been variable. The highest fishing mortalities for haddock have occurred at low to intermediate stock levels and historically show little relationship with the exploitation rate of cod, despite haddock being primarily caught as bycatch in the cod fishery. However, the more restrictive quota regulations introduced around 1990 have resulted in a more stable pattern in the exploitation rate.

The exceptionally strong year classes 2005–2006 contributed to the strong increase to all-time high stock levels and high levels in the last decade. Their importance in the catches is currently minimal.

4.2.2 Catches prior to 2021 (Table 4.1–Table 4.3, Figure 4.1)

The highest landings of haddock historically were 322 kt in 1973. Since 1973 the highest catches observed were about 316 kt in 2012. In 2013–2015 the stock biomass started to decline and the landings in 2018, 2019 and 2020 were below 200 kt (Figure 4.1).

In 2006 it was decided to include reported Norwegian landings of haddock from the Norwegian statistical areas 06 and 07 (i.e. between 62°N and Lofoten Islands). These areas were not

[1] Haddock (*Melanogrammus aeglefinus*) in subareas 1 and 2 (Northeast Arctic); had.27.1-2.

previously included in the total landings of NEA haddock as input for this stock assessment (ICES CM 2006/ACFM:19; ICES CM 2006/ACFM:25).

Provisional official landings for 2020 are about 183 kt, which is 15% below agreed TAC (215 kt).

Estimates of unreported catches (IUU catches) of haddock have been added to reported landings for the years from 2002 to 2008. Two estimates of IUU catches were available, one Norwegian and one Russian. At the benchmark in 2011 it was decided to base the final assessment on the Norwegian IUU estimates (ICES CM 2011/ACOM:38; Table 4.1).

We continue to include the estimates of IUU catches 2002–2008, but the IUU are assumed to be negligible for 2009–2020 and therefore set to zero.

4.2.3 Catch advice and TAC for 2021

The catch advice for 2021 was 233 kt and the Joint Norwegian-Russian Fisheries Commission set the TAC in accordance with the HCR. Furthermore, Russia and Norway can transfer the unused part of their own quota, restricted to a maximum of 10% of own quotas from 2020 to 2021.

4.3 Status of research

4.3.1 Survey results

Russia provided indices for 1982–2015 and 2017 for the Barents Sea trawl and acoustic survey (TAS) which was carried out in October–December (FLT01, RU-BTr-Q4). The survey was discontinued in 2018.

The Joint Barents Sea winter survey provides two index series used for tuning and recruitment forecast (bottom trawl: FLT02, NoRu-BTr-Q1 and acoustics: FLT04, NoRu-Aco-Q1). The survey area has been extended from 2014 with additional northern areas (N) covered. The extended area is now included in total and standard survey index calculations for haddock (WKDEM 2020). Overall, this survey tracks both strong and poor year classes well. The indices from the Joint winter survey of cod and haddock in the Barents Sea 1994–2021 are given in WD 2. The spatial survey coverage in 2021 was relatively good. Note that since the AFWG was conducted, minor errors were discovered in the winter survey index for 2021 (both acoustic and bottom trawl). These had minimal (< 1%) impact on the assessment of SSB for NEA haddock. This report is not updated to account for correcting these errors.

Both the acoustic and swept indices of all ages were lower in 2021 compared to 2020.

The Joint Barents Sea ecosystem survey provides indices by age from bottom-trawl data (FLT007, Eco-NoRu-Q3 Btr) used for tuning and recruitment forecast. At the benchmark in 2011 it was decided to include this survey as tuning series. Tuning indices by age from the joint ecosystem survey are presented in WD 1 (2004–2020 except 2018). The survey coverage in 2020 was good, but the survey covered the eastern Barents Sea much later than the western Barents Sea (almost three months), which might have influenced the results in an unknown way. The distribution of haddock was reduced in 2020 compared 2019, especially on the Novaya Zemlya bank, where haddock was almost absent. The indices were much lower for the youngest and oldest haddock in 2020 compared to 2019.

4.4 Data used in the assessment

4.4.1 Catch-at-age (Table 4.4)

Age and length composition of the landings in 2020 were available from Norway and Russia in Subarea 1 and Division 2.b, and from Norway, Russia, and Germany in Division 2.a. The biological sampling of NEA haddock catches is considered good for the most important ages in the fisheries (see section 1).

Relevant data of estimated catch-at-age obtained from InterCatch for the period 2008–2020 and historical values from 1950–2007 is listed in Table 4.4.

4.4.2 Catch-weight-at-age (Table 4.5)

The mean weight-at-age in the catch was obtained from InterCatch as a weighted average of the weight-at-age in the catch for Norway, Russia, and Germany.

4.4.3 Stock-weight-at-age (Table 4.6)

Since 1983 the stock weights-at-age (Table 4.6) are calculated using the average of the weight-at-age estimate from the Joint Barents Sea winter survey and the Russian bottom trawl survey. These averages are assumed to give representative values for the beginning of the year (see stock annex for details). However, the Russian bottom trawl survey has been discontinued and therefor stock weights-at-age were calculated using a correction factor (WKDEM 2020). Since the benchmark in 2006 stock weight at age has been smoothed (ICES 2006, see stock annex for details).

4.4.4 Maturity-at-age (Table 4.7)

Since the benchmark 2006, smoothed estimates were produced separately for the Russian autumn survey and the joint winter survey and then combined using arithmetic average. These averages are assumed to give representative values for the beginning of the year. However, the Russian bottom trawl survey has been discontinued and therefore stock weights-at-age were calculated using a correction factor (see WKDEM 2020 and stock annex).

4.4.5 Natural mortality (Table 4.8)

Natural mortality used in the assessment was 0.2. For ages 3–6 mortality predation by cod are added (see stock annex). For the period from 1984 and onwards actual estimates of predation by cod was used. For the years 1950–1983 the average natural mortality for 1984–2020 was used (age groups 3–6). Estimated mortality from predation by cod in this year's assessment is based on the 'final run' cod assessment. The proportion of F and M before spawning was set to zero.

4.4.6 Data for tuning (Table 4.9)

The following survey series are included in the data for tuning for SAM, the last age for all surveys is the plus group. Data are lacking (no survey) for FLT01 in 2016, and for FLT007 in 2018 (not included due to poor coverage).

Name	ICES Acronym	Place	Season	Age	Year	prior weight
FLT01: Russian bottom trawl	RU-BTr-Q4	Barents Sea	October–December	3–8	1991–2017	1
FLT02: Joint Barents Sea survey–acoustic	BS-NoRU-Q1(Aco)	Barents Sea	February–March	3–9	1993–2021	1
FLT04: Joint Barents Sea survey–bottom trawl	BS-NoRu-Q1 (BTr)	Barents Sea	February–March	3–10	1994–2021	1
FLT007: Joint Russian-Norwegian ecosystem autumn survey in the Barents Sea–bottom trawl	Eco-NoRu-Q3 (Btr)	Barents Sea	August–September	3–9	2004–2020	1

4.4.7 Changes in data from last year (Table 4.6–Table 4.7, Table 4.9)

At the benchmark (WKDEM 2020) it was decided that historic values (1950–1993) of stock weight and maturity should not be updated in the following years. Due to the smoothing procedure (see stock annex) the stock weight and maturity ate at age back to 1994 are updated every year.

Natural mortality includes cod predation for the ages 3–6. The data from 1984 and onwards are updated every year after the update of the cod assessment. This year, the change in consumption estimates back to 1984 were larger than usual due to the revision of the cod stock undertaken at the cod benchmark held in early 2021. The averages used for the historic period (1950–1983) were updated and used in the assessment.

4.5 Assessment models and settings (Table 4.10)

At the benchmark in 2020 it was decided to continue using the SAM model as the main model and XSA, with revised settings, will be used as additional model for comparison. This year the TISVPA model is also used as an additional model for comparison.

The SAM configuration was revised during the benchmark in 2020. The main changes were 1) to include age group 3 in the winter survey indices (Fleet 02 and 04), 2) include a plus group in all survey series (new option in SAM), 3) include a prediction variance link for the observation variances (new option in SAM, Breivik *et al.,* in prep) 4) correlation structure in observation variance for the surveys (Berg and Nielsen, 2016).

The configuration, settings and tuning of SAM that were decided on during the benchmark (WKDEM 2020) were used in the current assessment. The configuration file is given in Table 4.10 and in the stock annex.

4.6 Results of the assessment (Table 4.11–Table 4.14 and Figure 4.1–Figure 4.3)

The dominating feature of the assessment is that the stock reached an all-time high level around 2011 due to the strong 2004–2006 year classes, and since declined (Table 4.11; Figure 4.1)

Fishing mortality has increased since 2013 (Table 4.12). The estimate of fishing mortality of main ages (4–7) in 2020 was 0.43 and above F_{MSY} = 0.35.

The SSB has decreased since the peak in 2013, and the estimate for 2021 201 kt and is still well above MSY $B_{trigger}$ = 80 kt (Figure 4.1).

Most of last year residuals are negative while catch observation close to predicted values, which means survey tends to underestimate stock. Retrospective estimates confirms that stock going down only based on last year surveys data (Figure 4.2 and Figure 4.3)

4.7 Comparison with last year's assessment (Figure 4.4)

The text table below compares this year's estimates with last year's estimates. Compared to last year's assessment the current estimates by SAM model of the total stock (TSB) and spawning stock (SSB) are lower for 2020. The F in 2019 is estimated a higher. Estimates for all ages except ages 4 and 5 (2015 and 2016 year classes) were reduced.

Year of assessment , model	F (2019)	Numbers 2020 (ages)											SSB (2020)	TSB (2020)
		3	4	5	6	7	8	9	10	11	12	13+		
2020 SAM	0.38	497	532	171	60	29	11	10	4	4	2	5	243	798
2021 SAM	0.43	442	530	164	48	24	9	8	3	3	2	3	205	723
Ratio 2021/2020	1.1	0.9	1.0	1.0	0.8	0.8	0.8	0.8	0.9	0.7	1.0	0.7	0.8	0.9

4.8 Additional assessment methods (Table 4.15, Figure 4.5–Figure 4.6)

4.8.1 XSA (Figure 4.5)

The Extended Survivors Analysis (XSA) was used to tune the VPA by available index series. As last years, FLR was used for the assessment of haddock (see stock annex), and thus all results concerning XSA are obtained using FLR. The settings used were the same as set in the benchmark in 2015 (WKARCT 2015). The biomass estimates of XSA with these settings significantly deviated from estimates of main model SAM. During the WKDEM 2020 it was found that changing S.E. of the mean survivor estimates shrinkage F from 1.5 to 0.5 gives estimates of biomass dynamics close to SAM estimates. Furthermore, this change improved XSA retrospective pattern. At AFWG 2021 this comparison was also done and confirmed that usage of survivor estimates shrinkage 0.5 gave the similar result with SAM estimates.

The estimated consumption of NEA haddock by NEA cod is incorporated into the XSA analysis by first constructing a catch number-at-age matrix, adding the numbers of haddock eaten by cod to the catches for the years where such data are available (1984–2020). The summary of XSA stock estimates with shrinkage value 0.5 are presented in Table 4.15. A retrospective estimate for XSA gave same signals as for main model SAM (Figure 4.5).

4.8.2 TISVPA (Figure 4.6)

The TISVPA (Triple Instantaneous Separable VPA) model (Vasilyev, 2005; 2006) represents fishing mortality coefficients (more precisely, exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). The generation-dependent parameters, which are estimated within the model, are intended to adapt traditional separable representation of fishing mortality to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishers, or by some other reasons. To NEA haddock stock the TISVPA model was at benchmark group for arctic stocks (WKARCT) in 2015 and this year it was decided to apply to NEA haddock using the same data as SAM except that natural mortality values from cannibalism were taken from the SAM runs. All the input data, including catch-at-age, weight-at-age in stock and in catches, maturity-at-age were taken the same as for stock assessment by means of SAM. During AFWG 2021 the results of runs using the TISVPA model were presented in WD#22. Generally biomass estimates of this model were higher than SAM estimates, which can be explained by different assumptions about indices catchability. A retrospective assessment for TISVPA shows same trends as for both another models (Figure 4.6).

4.8.3 Model comparisons (Figure 4.7)

Results from SAM, XSA and TISVPA are compared in Figure 4.7. Comparison of results of SAM, TISVPA and XSA with previous year settings shows that the models estimate similar trends. The TSVPA model is more flexible for settings than the others and considering a possible decrease in survey data consistency, it was attempted to do tuning of surveys not at abundance but to age proportions because the probable change in effective survey catchability.

4.9 Predictions, reference points and harvest control rules (Table 4.16–Table 4.21)

4.9.1 Recruitment (Table 4.16–Table 4.17)

SAM was used to estimate the recruitment-at-age 3 of the 2018 year class in 2021. The RCT3 program translation in R was used to estimate the recruiting year classes 2019–2020 in 2022 and 2023 with survey data from the ecosystem survey and winter survey. Input data and results are shown in Tables 4.16 and 4.17, respectively.

The text table below shows the recruitment estimates for the year classes 2000–2018 from assessments and RCT3 (shaded cells). Overall, there is a good agreement with the year-class strength estimate from RCT3 and the assessments, for the year classes 2014–2018, the correlation between the initial estimate from RCT3 and the estimate in SAM is 98%. For the 2004–2017 year classes the estimate from SAM was on average 80% of the initial estimate, whereas the SAM estimate of the recruitment-at-age 3 of the 2018 year class was less than 50% from the initial estimate from RCT3 calculated in 2019.

Year	Year of assessment, base model (XSA 2005-2014)									XSA	SAM	SAM	SAM	SAM	SAM	SAM	SAM
Class	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2015	2016	2017	2018	2019	2020	2021
2000	197	237	236	249	246	222	232	232	232	229	237	179	231	247	244	247	352	340
2001	176	219	224	257	245	237	241	239	239	236	247	184	239	222	218	220	268	260
2002	295	313	339	367	365	371	352	359	359	352	368	275	352	351	349	353	377	366
2003	156	183	135	161	171	185	189	183	186	181	197	169	208	165	161	164	161	158
2004	462	755	672	665	668	610	765	743	725	698	768	687	930	898	869	879	557	543
2005		521	731	943	975	1029	1193	1301	1317	1303	1415	996	1456	1330	1241	1251	1149	1113
2006			463	832	1036	811	1057	1187	1264	1267	1366	827	1254	1083	1027	1030	1063	1025
2007				202	208	212	284	330	370	384	411	211	355	307	305	308	249	241
2008					149	101	120	151	155	169	178	89	157	107	109	110	122	117
2009						303	315	320	345	357	363	230	351	294	291	293	356	340
2010							188	146	137	146	150	100	133	105	105	106	124	119
2011								483	513	482	398	298	397	340	329	332	425	411
2012									124	145	104	78	73	79	70	68	75	72
2013										394	290	197	235	184	174	177	219	213
2014											279	198	247	189	145.96	148	202	194
2015													422	398	333	336	384	368
2016														1067	933	930	875	822
2017															577	629	497	442
2018																344	294	154
2019																	39	31
2020																		95

4.9.2 Prediction data (Table 4.18, Figure 4.8)

The input data for the prediction are presented in Table 4.18.

Stock numbers for 2021–2022 at age 3 are taken from RCT3, and abundance-at-ages 3–13+ in 2020 from the SAM assessment. The average fishing pattern observed in 2018–2020 scaled to F in 2020 was used for distribution of fishing mortality-at-age for 2021–2023 (Figure 4.8). The proportion of M and F before spawning was set to 0.

Input data to projection of weight at age in the stock, weight at age in the catch, maturity and mortality followed the stock annex.

4.9.3 Biomass reference points (Figure 4.1)

Biological and fisheries reference points for NEA haddock were last set following a thorough analysis as part of the WKNEAMP-2 (ICES, 2016) Harvest Control Rule evaluation in 2016. The revised model developed during the 2020 benchmark produced better fits to the data but only a small change in the reconstructed stock (WKDEM 2020). A brief analysis at WKDEM 2020 indicated that the reference points from the current model are very similar to the previously estimated values. Given the more thorough analysis at WKNEAMP-2 (ICES, 2016), this is taken as indicating that there was no evidence to deviate from the reference points set in 2016.

At the last benchmark (WKDEM 2020) it was proposed to keep B_{lim} = 50 000 t and B_{pa} = 80 000 t with the rationale that B_{lim} is equal to B_{loss}, and $B_{pa} = B_{lim}*\exp(1.645*\sigma)$, where $\sigma = 0.3$. This gives a 95% probability of maintaining SSB above B_{lim} considering the uncertainty in the assessments and stock dynamics. B_{MSY} trigger was proposed equal B_{pa}, $B_{trigger}$ was then selected as a biomass that is encountered with low probability if F_{MSY} is implemented, as recommended by WKFRAME2 (ICES CM 2011/ACOM:33). Values of reference points compared with current stock values are reflected in Figure 4.1.

4.9.4 Fishing mortality reference points (Figure 4.1)

Biological and fisheries reference points for NEA haddock were last set following a thorough analysis as part of the WKNEAMP-2 (ICES, 2016) Harvest Control Rule evaluation in 2016. The revised model developed during the 2020 benchmark produced better fits to the data but only a small change in the reconstructed stock (WKDEM 2020). A brief analysis at WKDEM 2020 indicated that the reference points from the current model are very similar to the previously estimated values. Given the more thorough analysis at WKNEAMP-2 (ICES, 2016), this is taken as indicating that there was no evidence to deviate from the reference points set in 2016.

There is no standard method of estimating F_{lim} nor F_{pa}, and ACOM accepted to use geometric mean recruitment (146 million) and B_{lim} as basis for the F_{lim} estimate. F_{lim} is then based on the slope of line from origin at SSB = 0 to the geometric mean recruitment (146 million) and SSB = B_{lim}. The SPR value of this slope give F_{lim} value on SPR curve; F_{lim} = 0.77 (found using Pasoft). Using the same approach as for B_{pa}; $F_{pa} = F_{lim}*\exp(-1.645*\sigma) = 0.47$.

F_{MSY} = 0.35 has been estimated by long-term stochastic simulations. Values of reference points compared with current stock values are reflected in Figure 4.1.

The estimates of cod's consumption of haddock were revised following the cod benchmark in early 2021. At the AFWG 2021 meeting, the haddock F_{MSY} was checked with the new updated mortality estimates and found to still be valid and precautionary.

4.9.5 Harvest control rule

The harvest control rule (HCR) was evaluated by ICES in 2007 (ICES CM 2007/ACFM:16) and found to be in agreement with the precautionary approach. The agreed HCR for haddock with last modifications is as follows (Protocol of the 40th Session of The Joint Norwegian Russian Fisheries Commission (JNRFC), 14 October 2011):

- TAC for the next year will be set at level corresponding to F_{MSY}.
- The TAC should not be changed by more than +/- 25% compared with the previous year TAC.
- If the spawning stock falls below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{MSY} at B_{pa} to F = 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year and a year ahead) there should be no limitations on the year-to-year variations in TAC.

As mentioned above F_{lim} and F_{pa} were revised in 2011. The new values of F_{lim} = 0.77 and F_{pa} = 0.47 are higher than the previous values (0.49 and 0.35, respectively). In the 2012 meeting of the JNRFC the proposals of ICES were accepted, and the current HCR management is based on F_{MSY} instead of F_{pa}. This corresponds to the goal of the management strategy for this stock and should provide maximum sustainable yield.

In 2014, JNRFC decided that from 2015 onwards, Norway and Russia can transfer to next year or borrow from last year maximum 10% of the country's quota. At its 45th session in October 2015, the Joint Norwegian-Russian Fisheries Commission (JNRFC) decided that a number of alternative harvest control rules (HCRs) for Northeast Arctic haddock should be evaluated by ICES. This was done by WKNEAMP (ICES 2015/ACOM:60, ICES C. M. 2016/ACOM:47). Six HCRs for NEA haddock including the existing one were tested. At its 46th session in October 2016, the JNRFC decided not to change the HCR.

4.9.6 Prediction results and catch options for 2021 (Table 4.19–Table 4.21)

The projection shows a slight increase in SSB from 203 kt in 2021 to 205 kt in 2022 (Table 4.19). TAC constraint F is used for 2021. The TAC for 2022 is established using the current one-year HCR, in accordance of the management plan. F_{MSY} = 0.35 would give a quota for 2022 of 180 kt, this is a 23% decrease from the TAC and advice for 2021. Yield-per-recruit is given in Table 4.21.

Catch options for 2021 are shown in the text table below (weights in tonnes).

Basis	Total catch (2022)	F ages 4–7 (2022)	SSB (2023)	% SSB change *	% TAC change **	% Advice change ***
ICES advice basis						
Management plan	180003	0.35	201485	−1.6	−22.6	−22.6
Other scenarios						
MSY approach: F_{MSY}	180003	0.35	201485	−1.6	−22.6	−22.6
F = 0	0	0	309362	51.1	−100.0	−100.0
F = F2021	214185	0.44	181739	−11.2	−7.9	−7.9
F_{pa}	227071	0.47	174372	−14.8	−2.4	−2.4
F_{lim}	320921	0.77	122248	−40.3	38.0	38.0

*** SSB 2023 relative to SSB 2022.**

**** Catch in 2022 relative to TAC in 2021**

***** Catch value for 2022 relative to advice value for 2021**

Detailed information about expected catches by following HCR in 2022 and 2023 is given in Table 4.20. This catch forecast covers all catches. It is then implied that all types of catches are to be counted against this TAC. It also means that if any overfishing is expected to take place, the above calculated TAC should be reduced by the expected amount of overfishing.

4.9.7 Comments to the assessment and predictions (Figure 4.2–Figure 4.4 and Figure 4.9)

Haddock was benchmarked prior to last year's assessment (WKDEM 2020). The motivation for the benchmark was the poor retrospective (text table below).

Retrospective bias (Mohn's Rho), 5-year peel	R	SSB	F	TSB
AFWG 2018	−3%	24%	−7%	14%
AFWG 2019	−5%	18%	−7%	7%
WKDEM 2020	−2%	3%	−3%	1%
AFWG 2020	−4%	−3%	0%	−5%
AFWG 2021	1%	6%	−7%	3%

The one step ahead residuals showed no clear pattern (Figure 4.2). This year, we also used model simulations and jitter analysis, as diagnostics of SAM model performance. No problems were detected.

By adding a new year of data, the analytical retrospective bias increased for SSB and F and decreased for R and TSB (Figure 4.3). The increased bias was mainly due to the low survey indices from the ecosystem survey 2020 and winter survey 2021, pulling the stock estimate down. Compared to last year's assessment, except for the ages 4 and 5, estimates of all ages in 2020 was estimated lower at this year's assessment. This is mainly due to the low survey indices from the ecosystem survey of 2020 and winter survey 2021, but also due to update of the data, especially of the predation from cod, following the benchmark of the cod stock in 2021.

According to this year's assessment, the 2016 year class is the sixth strongest year class in the time-series back to 1950 and the 2017 year class is also above average, whereas the 2018 year class is weak. The 2019–2020 year classes are predicted to be well below average, the 2019 year class as the weakest since 1990.

As for the last two assessments F was above F_{MSY} in 2020 (Figure 4.4). This appears to be due to a too optimistic estimate of the stock in the assessment in 2019, and consequently too high TAC set for 2020. There was less fishing on youngest fish than initially assumed. Also, the weight in the catch in 2020 was considerably lower than was assumed in the forecast, especially for the 4-year olds (Figure 4.9).

The retrospective trend indicates that the catch advice given in 2020 for 2021 is likely biased high. The catch in 2020 was 15% lower than TAC and the catch is expected to be below the TAC also in 2021, especially since the TAC in 2021 was higher than the 2020 TAC.

Table 4.1. Northeast Arctic haddock. Total nominal catch (t) by fishing areas.

Year	Subarea 1	Division 2.a	Division 2.b	un-reported[2)]	Total[3)]	Norwegian statistical areas 06 & 07[4]
1960	125026	27781	1844	-	154651	6000
1961	165156	25641	2427	-	193224	4000
1962	160561	25125	1723	-	187409	3000
1963	124332	20956	936	-	146224	4000
1964	79262	18784	1112	-	99158	6000
1965	98921	18719	943	-	118583	6000
1966	125009	35143	1626	-	161778	5000
1967	107996	27962	440	-	136398	3000
1968	140970	40031	725	-	181726	3000
1969	89948	40306	566	-	130820	2000
1970	60631	27120	507	-	88258	-
1971	56989	21453	463	-	78905	-
1972	221880	42111	2162	-	266153	-
1973	285644	23506	13077	-	322227	-
1974	159051	47037	15069	-	221157	10000
1975	121692	44337	9729	-	175758	6000

Year	Subarea 1	Division 2.a	Division 2.b	un-reported[2)]	Total[3)]	Norwegian statistical areas 06 & 07[4]
1976	94054	37562	5648	-	137264	2000
1977	72159	28452	9547	-	110158	2000
1978	63965	30478	979	-	95422	2000
1979	63841	39167	615	-	103623	6000
1980	54205	33616	68	-	87889	5098
1981	36834	39864	455	-	77153	4767
1982	17948	29005	2	-	46955	3335
1983	5837	16859	1904	-	24600	3112
1984	2934	16683	1328	-	20945	3803
1985	27982	14340	2730	-	45052	3583
1986	61729	29771	9063	-	100563	4021
1987	97091	41084	16741	-	154916	3194
1988	45060	49564	631	-	95255	3756
1989	29723	28478	317	-	58518	4701
1990	13306	13275	601	-	27182	2912
1991	17985	17801	430	-	36216	3045
1992	30884	28064	974	-	59922	5634
1993	46918	32433	3028	-	82379	5559
1994	76748	50388	8050	-	135186	6311
1995	75860	53460	13128	-	142448	5444
1996	112749	61722	3657	-	178128	5126
1997	78128	73475	2756	-	154359	5987
1998	45640	53936	1054	-	100630	6338
1999	38291	40819	4085	-	83195	5743
2000	25931	39169	3844	-	68944	4536
2001	35072	47245	7323	-	89640	4542
2002	40721	42774	12567	18736/5310	114798/101372	6898
2003	53653	43564	8483	33226/9417	138926/115117	4279

Year	Subarea 1	Division 2.a	Division 2.b	un-reported[2)]	Total[3)]	Norwegian statistical areas 06 & 07[4]
2004	64873	47483	12146	33777/8661	158279/133163	3743
2005	53518	48081	16416	40283/9949	158298/127964	5538
2006	51124	47291	33291	21451/8949	153157/140655	5410
2007	62904	58141	25927	14553/3102	161525/150074	7110
2008	58379	60178	31219	5828/-	155604/149776	6629
2009	57723	66045	76293	0	200061	4498
2010	62604	86279	100318	0	249200	3661
2011	86931	99307	123546	0	309785	4169
2012	90141	96807	128679	0	315627	3869
2013	68416	64810	60520	0	193744	4000
2014	61537	58320	57665	0	177522	3433
2015	75195	61567	57993	0	194756	3902
2016	78714	95140	59561	0	233416	3233
2017	94772	75455	57362	0	227589	2987
2018	80902	58522	51853	0	191276	4437
2019	87446	50967	36989	0	175402	2812
2020[1)]	98341	57397	26730	0	182468	3196
2021[1)]	107907	58097	37025	0	203118	2363

1) Provisional figures

2) Figures based on Norwegian/Russian IUU estimates. From 2009, IUU estimates are made by a Joint Russian-Norwegian analysis group under the Russian-Norwegian Fisheries Commission.

3) In 2002–2008, the Norwegian IUU estimates were used in final assessment.

4) Included in total landings and in landings in region 2.a.

Table 4.2. Northeast Arctic haddock. Total nominal catch ('000 t) by trawl and other gear for each area.

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1967	73.7	34.3	20.5	7.5	0.4	-	-
1968	98.1	42.9	31.4	8.6	0.7	-	-
1969	41.4	47.8	33.2	7.1	1.3	-	-

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1970	37.4	23.2	20.6	6.5	0.5	-	-
1971	27.5	29.2	15.1	6.7	0.4	-	-
1972	193.9	27.9	34.5	7.6	2.2	-	-
1973	242.9	42.8	14	9.5	13.1	-	-
1974	133.1	25.9	39.9	7.1	15.1	-	-
1975	103.5	18.2	34.6	9.7	9.7	-	-
1976	77.7	16.4	28.1	9.5	5.6	-	-
1977	57.6	14.6	19.9	8.6	9.5	-	-
1978	53.9	10.1	15.7	14.8	1	-	-
1979	47.8	16	20.3	18.9	0.6	-	-
1980	30.5	23.7	14.8	18.9	0.1	-	-
1981	18.8	17.7	21.6	18.5	0.5	-	-
1982	11.6	11.5	23.9	13.5	-	-	-
1983	3.6	2.2	8.7	8.2	0.2	1.7	-
1984	1.6	1.3	7.6	9.1	0.1	1.2	-
1985	24.4	3.5	6.2	8.1	0.1	2.6	-
1986	51.7	10.1	14	15.8	0.8	8.3	-
1987	79	18.1	23	18.1	3	13.8	-
1988	28.7	16.4	34.3	15.3	0.6	0	-
1989	20	9.7	13.5	15	0.3	0	-
1990	4.4	8.9	5.1	8.2	0.6	0	-
1991	9	8.9	8.9	8.9	0.2	0.2	-
1992	21.3	9.6	11.9	16.1	1	0	-
1993	35.3	11.6	14.5	17.9	3	0	-
1994	58.6	18.2	26.1	24.3	7.9	0.2	-
1995	63.9	12	29.6	23.8	12.1	1	-
1996	98.3	14.4	36.5	25.2	3.4	0.3	-
1997	57.4	20.7	44.9	28.6	2.5	0.3	-

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1998	26	19.6	27.1	26.9	0.7	0.3	-
1999	29.4	8.9	19.1	21.8	4	0.1	-
2000	20.1	5.9	18.8	20.4	3.7	0.1	-
2001	28.4	6.7	23.4	23.8	7	0.3	-
2002	30.5	10.2	19.5	23.3	12.5	0.1	18.7/5.3
2003	42.7	10.9	21.9	21.7	8.1	0.4	33.2/9.4
2004	52.4	12.5	27	20.5	11.5	0.6	33.8/8.7
2005	38.5	15	24.9	20.9	13	1.6	40.3/9.9
2006	40.1	11	22	25.3	30.1	3.2	21.5/8.9
2007	51.8	11.1	30.5	27.7	20.4	5.5	14.6/3.1
2008	46.8	11.6	30.9	29.3	24.9	6.3	5.8/-
2009	49	8.8	40.1	25.3	67.1	7.8	0
2010	43.6	19	50	35.7	87	10.4	0
2011	55.8	31.1	61.1	38.9	107.7	14.3	0
2012	58.8	31.3	57.5	39.2	103.2	24.8	0
2013	40.1	28.3	37.7	26.9	52.1	8.1	0
2014	35.2	26.3	32.5	25.8	49	8.6	0
2015	49.1	26.1	34.6	27	48.5	9.4	0
2016	56.4	22.3	62.5	32.5	45.4	14.1	0
2017	65	29.8	50.7	24.7	47.1	10.3	0
2018	51.7	29.2	36.9	21.6	43.2	8.6	0
2019	53.9	33.5	30.4	20.4	31.0	5.9	0
2020	66.7	31.6	35.1	22.3	23.2	3.5	0
2021[1)]	80.5	27.4	41.4	16.7	31.5.2	5.5	0

1) Provisional

2) Figures based on Norwegian/Russian IUU estimates.

Table 4.3 Northeast Arctic haddock. Nominal catch (t) by countries. Subarea 1 and divisions 2.a and 2.b combined. (Data provided by Working Group members).

Year	Faroe Islands	France	GDR (–1990) and Greenland (1992–)	Germany	Norway[4]	Poland	UK	Russia[2]	Others	Total[3]
1960	172	-	-	5597	46263	-	45469	57025	125	154651
1961	285	220	-	6304	60862	-	39650	85345	558	193224
1962	83	409	-	2895	54567	-	37486	91910	58	187408
1963	17	363	-	2554	59955	-	19809	63526	-	146224
1964	-	208	-	1482	38695	-	14653	43870	250	99158
1965	-	226	-	1568	60447	-	14345	41750	242	118578
1966	-	1072	11	2098	82090	-	27723	48710	74	161778
1967	-	1208	3	1705	51954	-	24158	57346	23	136397
1968	-	-	-	1867	64076	-	40129	75654	-	181726
1969	2	-	309	1490	67549	-	37234	24211	25	130820
1970	541	-	656	2119	37716	-	20423	26802	-	88257
1971	81	-	16	896	45715	43	16373	15778	3	78905
1972	137	-	829	1433	46700	1433	17166	196224	2231	266153
1973	1212	3214	22	9534	86767	34	32408	186534	2501	322226
1974	925	3601	454	23409	66164	3045	37663	78548	7348	221157
1975	299	5191	437	15930	55966	1080	28677	65015	3163	175758
1976	536	4459	348	16660	49492	986	16940	42485	5358	137264
1977	213	1510	144	4798	40118	-	10878	52210	287	110158
1978	466	1411	369	1521	39955	1	5766	45895	38	95422
1979	343	1198	10	1948	66849	2	6454	26365	454	103623
1980	497	226	15	1365	66501	-	2948	20706	246	92504
1981	381	414	22	2402	63435	Spain	1682	13400	-	81736
1982	496	53	-	1258	43702	-	827	2900	-	49236
1983	428	-	1	729	22364	139	259	680	-	24600
1984	297	15	4	400	18813	37	276	1103	-	20945
1985	424	21	20	395	21272	77	153	22690	-	45052

Year	Faroe Islands	France	GDR (–1990) and Greenland (1992–)	Germany	Norway[4]	Poland	UK	Russia[2]	Others	Total[3]
1986	893	12	75	1079	52313	22	431	45738	-	100563
1987	464	7	83	3105	72419	59	563	78211	5	154916
1988	1113	116	78	1323	60823	72	435	31293	2	95255
1989	1217	-	26	171	36451	1	590	20062	-	58518
1990	705	-	5	167	20621	-	494	5190	-	27182
1991	1117	-	**Greenland**	213	22178	-	514	12177	17	36216
1992	1093	151	1719	387	36238	38	596	19699	1	59922
1993	546	1215	880	1165	40978	76	1802	35071	646	82379
1994	2761	678	770	2412	71171	22	4673	51822	877	135186
1995	2833	598	1097	2675	76886	14	3111	54516	718	142448
1996	3743	6	1510	942	94527	669	2275	74239	217	178128
1997	3327	540	1877	972	103407	364	2340	41228	304	154359
1998	1903	241	854	385	75108	257	1229	20559	94	100630
1999	1913	64	437	641	48182	652	694	30520	92	83195
2000	631	178	432	880	42009	502	747	22738	827	68944
2001	1210	324	553	554	49067	1497	1068	34307	1060	89640
2002	1564	297	858	627	52247	1505	1125	37157	682	114798
2003	1959	382	1363	918	56485	1330	1018	41142	1103	138926
2004	2484	103	1680	823	62192	54	1250	54347	1569	158279
2005	2138	333	15	996	60850	963	1899	50012	1262	158298
2006	2390	883	1830	989	69272	703	1164	53313	1162	153157
2007	2307	277	1464	1123	71244	125	1351	66569	2511	161525
2008	2687	311	1659	535	72779	283	971	68792	1759	155604
2009	2820	529	1410	1957	104354	317	1315	85514	1845	200061
2010	3173	764	1970	3539	123384	379	1758	111372	2862	249201
2011	1759	268	2110	1724	158202	502	1379	139912	4763	310619
2012	2055	322	3984	1111	159602	441	833	143886	3393	315627

Year	Faroe Islands	France	GDR (–1990) and Greenland (1992–)	Germany	Norway[4]	Poland	UK	Russia[2]	Others	Total[3]
2013	1886	342	1795	500	99215	439	639	85668	3260	193744
2014	1470	198	1150	340	91306	187	355	78725	3791	177522
2015	2459	145	1047	124	95094	246	450	91864	3327	194756
2016	2460	340	1401	170	108718	200	575	115710	3838	233412
2017	2776	108	1810	170	113132	228	372	106714	2279	227588
2018	2333	183	1317	385	93839	169	453	90486	2111	191276
2019	1515	143	1208	204	93860	280	456	76125	1611	175402
2020	1392	96	910	282	88108	45	320	89030	2286	182468
2021[1)]	1722	102	1101	365	100673	13	78	98282	705	203041

1) Provisional figures.

2) USSR prior to 1991.

3) Figures based on Norwegian IUU estimates in 2002–2008 (see table 4.1)

4) Included landings in Norwegian statistical areas 06 and 07 (from 1983)

Table 4.4. Northeast Arctic haddock. Catch numbers-at-age (numbers, ´000).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0	4446	3189	37949	35344	18849	28868	9199	1979	1093	853	867	1257
1951	4069	222	65643	9178	18014	13551	6808	6850	3322	1182	734	178	436
1952	0	13674	6012	151996	13634	9850	4693	3237	2434	606	534	185	161
1953	392	8031	64528	13013	70781	5431	2867	1080	424	315	393	202	410
1954	1726	493	6563	154696	5885	27590	3233	1302	712	319	126	68	349
1955	0	989	1154	10689	176678	4993	28273	1445	271	100	50	30	20
1956	97	3012	16437	5922	14713	127879	3182	8003	450	200	80	60	45
1957	828	243	2074	24704	7942	12535	46619	1087	1971	356	17	40	119
1958	153	2312	1727	5914	31438	5820	12748	17565	822	1072	226	79	296
1959	169	2425	20318	7826	7243	14040	3154	2237	5918	285	316	71	113
1960	2319	3613	39910	70912	13647	7101	6236	1579	2340	2005	497	70	42
1961	362	5531	15429	56855	63351	8706	3578	4407	788	527	1287	67	80
1962	0	4524	39503	30868	48903	33836	3201	1341	1773	242	247	483	28

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1963	3	2143	28466	72736	18969	13579	9257	1239	559	409	80	84	212
1964	149	834	22363	49290	30672	5815	3527	2716	833	104	206	235	190
1965	0	3498	5936	46356	40201	12631	1679	974	897	123	204	123	471
1966	0	2577	26345	22631	63176	29048	5752	582	438	189	186	25	30
1967	0	53	15907	41346	13496	25719	8872	1616	218	175	155	75	41
1968	0	33	657	67632	41267	7748	15599	5292	655	182	101	115	70
1969	0	1061	1524	1968	44634	19002	3620	4937	1628	316	43	43	23
1970	480	281	23444	2454	1906	22417	8100	2012	2016	740	166	26	96
1971	15	3535	1978	24358	1257	918	9279	3056	826	1043	369	130	35
1972	133	9399	230942	22315	42981	3206	1611	6758	2638	900	989	538	120
1973	0	5956	70679	260520	24180	6919	422	426	1692	529	147	339	95
1974	281	3713	9685	41706	88120	5829	4138	382	618	2043	935	276	659
1975	1321	4355	10037	14088	33871	49711	2135	1236	92	131	500	147	287
1976	3475	7499	13994	13454	6810	20796	40057	1247	1350	193	280	652	671
1977	184	18456	55967	22043	7368	2586	7781	11043	311	388	96	101	182
1978	46	2033	47311	18812	4076	1389	1626	2596	6215	162	258	3	139
1979	0	48	17540	35290	10645	1429	812	546	1466	2310	181	87	55
1980	0	0	627	22878	21794	2971	250	504	230	842	1299	111	50
1981	1	68	486	2561	22124	10685	1034	162	162	72	330	564	69
1982	2	29	883	900	3372	12203	2625	344	75	80	91	321	238
1983	3	351	1173	2636	1360	2394	2506	1799	267	37	60	100	132
1984	7	754	1271	1019	1899	657	950	2619	352	87	2	22	53
1985	4	2952	29624	1695	564	1009	943	886	1763	588	124	64	93
1986	506	650	23113	68429	1565	783	896	393	702	1144	443	130	414
1987	9	83	5031	87170	64556	960	597	376	212	230	419	245	73
1988	7	139	1439	12478	47890	20429	397	178	74	88	168	198	80
1989	611	221	2157	4986	16071	25313	3198	147	1	28	28	53	96
1990	2	446	1015	2580	2142	4046	6221	840	134	42	14	13	44
1991	23	533	4421	3564	2416	3299	4633	3953	461	83	9	18	27

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1992	49	2793	11571	11567	4099	2642	2894	3327	3498	486	35	32	18
1993	498	272	13487	19457	13704	4103	1747	1886	2105	1965	201	96	25
1994	95	187	3374	47821	36333	13264	2057	903	1453	2769	1802	259	49
1995	2	85	2003	16109	72644	19145	6417	746	361	770	655	804	116
1996	35	478	1662	6818	36473	73579	13426	2944	573	365	533	598	767
1997	70	94	2280	5633	12603	32832	49478	5636	778	245	126	158	463
1998	547	1476	1701	11304	9258	8633	13801	19469	2113	330	59	54	377
1999	104	568	16839	8039	15365	6073	4466	6355	6204	647	117	109	220
2000	46	692	1520	29986	6496	5149	2406	1657	1570	1744	183	70	184
2001	374	1758	12971	5230	32049	5279	2941	1137	1161	1169	747	169	288
2002	59	603	7132	46335	11084	21985	2602	1602	482	448	581	349	98
2003	123	611	6803	31448	56480	11736	14541	1637	2178	858	411	413	395
2004	58	1295	7993	21116	41310	41226	4939	4914	598	1252	296	139	465
2005	102	865	11452	19369	22887	37067	24461	2393	2997	990	201	263	1059
2006	271	2496	4539	35040	27571	15033	16023	8567	1259	1298	222	175	321
2007	575	3914	30707	15213	45992	18516	10642	7889	2570	678	605	197	185
2008	440	2089	14536	44192	15926	31173	9145	4520	2846	1181	274	214	166
2009	483	1364	15379	55013	52498	13679	15382	3800	1669	887	285	353	321
2010	457	620	6545	52006	80622	50306	9273	5324	1954	1114	533	242	621
2011	909	806	1277	8501	90394	100522	39496	4397	2340	668	437	269	708
2012	268	611	7814	4206	18007	93055	82721	14445	1325	448	217	216	568
2013	402	904	1778	12780	3805	12297	58024	29930	4976	957	331	212	535
2014	528	649	6948	4503	14563	6833	16304	39620	16439	2431	619	440	545
2015	303	1334	1645	27317	8526	16624	7950	20538	25534	6677	1556	295	312
2016	294	655	5774	3482	33177	9563	18045	12030	21875	13492	4757	876	248
2017	724	1898	30744	46463	16895	48927	10518	14992	9 485	8447	6640	1872	317
2018	679	1438	9424	16291	34060	8466	18882	5123	8902	4125	3564	4504	1040
2019	797	968	13908	28572	24171	32555	6278	6803	2601	3618	1225	1715	1400
2020	122	1298	10797	62206	46715	18137	10773	3051	2839	1445	996	915	1092

Table 4.5. Northeast Arctic haddock. Catch weights-at-age (kg).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1951	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1952	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1953	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1954	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1955	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1956	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1957	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1958	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1959	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1960	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1961	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1962	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1963	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1964	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1965	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1966	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1967	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1968	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1969	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1970	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1971	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1972	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1973	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1974	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1975	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1976	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1977	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1978	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1979	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1980	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1981	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1982	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1983	0.188	0.689	1.033	1.408	1.71	2.149	2.469	2.748	3.069	3.687	4.516	3.094	3.461
1984	0.408	0.805	1.218	1.632	2.038	2.852	2.845	3.218	3.605	4.065	4.407	4.734	5.099
1985	0.319	0.383	0.835	1.29	1.816	2.174	2.301	2.835	3.253	3.721	4.084	4.137	4.926
1986	0.218	0.325	0.612	1.064	1.539	1.944	2.362	2.794	3.25	3.643	4.14	4.559	5.927
1987	0.143	0.221	0.497	0.765	1.179	1.724	2.135	2.551	3.009	3.414	3.84	4.415	5.195
1988	0.279	0.551	0.55	0.908	1.097	1.357	1.537	1.704	2.403	2.403	2.486	2.531	2.834
1989	0.258	0.55	0.684	0.84	0.998	1.176	1.546	1.713	1.949	2.14	2.389	2.522	2.797
1990	0.319	0.601	0.793	1.172	1.397	1.624	1.885	2.112	2.653	3.102	3.18	3.438	3.319
1991	0.216	0.616	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.408	2.896	3.274
1992	0.055	0.458	0.906	1.263	1.535	1.747	2.043	2.2	2.298	2.494	2.49	2.673	2.923
1993	0.381	0.64	0.94	1.204	1.487	1.748	1.994	2.237	2.417	2.654	2.906	3.184	3.363
1994	0.278	0.521	0.614	0.906	1.287	1.602	1.968	2.059	2.39	2.545	2.881	2.918	3.222
1995	0.258	0.446	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	2.965	3.163	3.786
1996	0.287	0.427	0.683	0.868	1.045	1.363	1.71	1.886	2.214	2.37	2.438	2.707	2.896
1997	0.408	0.575	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.5	2.279	2.532	2.609
1998	0.409	0.593	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.511	2.8	2.849
1999	0.435	0.695	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.339	2.611	2.865
2000	0.378	0.577	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.587	2.647	3.098
2001	0.391	0.647	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.757	3.376	3.338
2002	0.159	0.407	0.687	1.001	1.363	1.643	1.975	2.086	2.294	2.487	2.612	2.847	3.501
2003	0.198	0.384	0.594	0.875	1.113	1.364	1.361	1.972	1.636	1.877	2.088	2.351	2.842
2004	0.328	0.429	0.636	0.886	1.183	1.508	1.821	2.075	2.339	2.58	2.527	3.153	3.197
2005	0.285	0.492	0.722	0.906	1.121	1.343	1.619	2.036	2.177	2.382	2.527	2.496	2.81
2006	0.311	0.567	0.745	1.041	1.287	1.504	1.72	2.082	2.377	2.738	3.082	3.02	3.43
2007	0.329	0.431	0.652	0.899	1.197	1.435	1.722	1.99	2.309	2.715	2.987	2.947	3.591

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
2008	0.383	0.484	0.658	0.901	1.242	1.515	1.781	2.18	2.33	2.664	3.019	3.326	3.829
2009	0.378	0.508	0.707	1.024	1.28	1.538	1.806	2.107	2.398	2.531	2.606	3.089	3.541
2010	0.317	0.499	0.642	0.887	1.137	1.396	1.702	1.907	2.095	2.404	2.534	3.064	3.249
2011	0.423	0.513	0.811	0.953	1.093	1.254	1.462	1.715	1.978	2.328	2.305	2.55	2.76
2012	0.271	0.506	0.756	1.004	1.174	1.371	1.514	1.715	2.051	2.444	2.414	2.615	2.932
2013	0.469	0.542	0.821	1.014	1.217	1.401	1.571	1.714	1.914	2.168	2.24	2.516	2.807
2014	0.469	0.645	0.792	1.033	1.253	1.417	1.625	1.793	1.941	2.081	2.479	2.703	3.011
2015	0.473	0.647	0.876	1.054	1.327	1.571	1.777	1.934	2.025	2.216	2.481	2.99	3.455
2016	0.497	0.743	0.882	1.115	1.369	1.662	1.917	2.089	2.301	2.567	3.076	3.286	3.331
2017	0.449	0.608	0.874	1.088	1.378	1.666	1.879	2.146	2.258	2.476	2.72	2.98	3.713
2018	0.443	0.663	0.820	1.051	1.339	1.629	1.927	2.156	2.372	2.588	2.728	2.773	3.175
2019	0.341	0.508	0.729	0.955	1.275	1.581	1.834	2.151	2.378	2.607	2.868	2.934	3.382
2020	0.364	0.523	0.629	0.788	1.131	1.489	1.821	2.126	2.426	2.651	2.771	3.147	3.359

Table 4.6. Northeast Arctic haddock. Stock weights-at-age (kg). The data from 1950–1993 is unchanged AFWG 2019, the data from 1994 and onward have been updated this year. The ages 3–13 are adjusted to account for the lack of the Russian survey as described in the stock annex, age 1–2 are unadjusted smoothed estimates based on winter survey data.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1950	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1951	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1952	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1953	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1954	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1955	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1956	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1957	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1958	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1959	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1960	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1961	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1962	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1963	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1964	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1965	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1966	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1967	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1968	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1969	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1970	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1971	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1972	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1973	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1974	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1975	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1976	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1977	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1978	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1979	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597	3.597	3.597
1980	0.063	0.262	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792	3.792	3.792
1981	0.051	0.274	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904	3.904	3.904
1982	0.036	0.224	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016	4.016	4.016
1983	0.035	0.164	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165	4.165	4.165
1984	0.028	0.158	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878	3.878	3.878
1985	0.03	0.127	0.379	0.700	1.394	2.195	2.626	2.572	3.158	3.261	3.728	3.728	3.728
1986	0.035	0.136	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632	3.632	3.632
1987	0.042	0.161	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946	3.946	3.946
1988	0.039	0.189	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787	3.787	3.787
1989	0.037	0.175	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449	4.449	4.449
1990	0.031	0.169	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73	4.73	4.73
1991	0.025	0.141	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256	4.256	4.256

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1992	0.023	0.114	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491	3.491	3.491
1993	0.025	0.107	0.279	0.616	1.100	1.537	2.08	2.308	2.54	2.831	3.531	3.531	3.531
1994	13.8	22.1	0.25	0.502	0.936	1.646	2.17	2.713	2.866	2.817	2.978	3.64	4.181
1995	14.9	22.6	0.261	0.465	0.795	1.311	2.113	2.633	3.166	3.295	3.228	3.163	3.955
1996	14.9	24.3	0.278	0.485	0.744	1.132	1.714	2.568	3.092	3.61	3.719	3.419	3.481
1997	15.2	24.3	0.343	0.512	0.766	1.06	1.49	2.122	3.021	3.546	4.044	3.887	3.738
1998	14	24.8	0.343	0.622	0.813	1.096	1.412	1.873	2.546	3.466	3.957	4.181	4.199
1999	14.2	23	0.363	0.627	0.97	1.154	1.447	1.772	2.263	2.956	3.888	4.111	4.49
2000	13.7	23.3	0.293	0.657	0.976	1.36	1.517	1.822	2.147	2.655	3.365	4.059	4.416
2001	13.2	22.5	0.301	0.538	1.023	1.36	1.774	1.905	2.205	2.539	3.05	3.56	4.361
2002	13.9	21.8	0.273	0.556	0.848	1.428	1.774	2.191	2.299	2.603	2.921	3.252	3.871
2003	13.9	22.8	0.248	0.502	0.873	1.2	1.844	2.191	2.61	2.695	2.993	3.119	3.56
2004	14.1	22.8	0.283	0.461	0.795	1.238	1.572	2.284	2.623	3.043	3.093	3.178	3.434
2005	12.7	23.1	0.283	0.528	0.732	1.132	1.618	1.968	2.702	3.043	3.444	3.282	3.497
2006	12.6	20.9	0.293	0.524	0.831	1.053	1.49	2.023	2.371	3.145	3.46	3.624	3.608
2007	13.2	20.9	0.219	0.542	0.831	1.177	1.395	1.873	2.432	2.776	3.555	3.64	3.938
2008	14	21.7	0.219	0.415	0.855	1.177	1.553	1.761	2.263	2.845	3.168	3.738	3.955
2009	14.1	22.9	0.248	0.411	0.664	1.207	1.544	1.936	2.135	2.669	3.242	3.373	4.041
2010	15.3	23.1	0.286	0.461	0.664	0.957	1.581	1.936	2.335	2.526	3.05	3.434	3.689
2011	14.8	24.9	0.295	0.528	0.732	0.951	1.279	1.979	2.335	2.749	2.908	3.252	3.754
2012	15.7	24.3	0.366	0.546	0.836	1.053	1.271	1.626	2.383	2.735	3.137	3.105	3.56
2013	15.1	25.5	0.339	0.667	0.861	1.184	1.395	1.617	1.981	2.79	3.137	3.327	3.419
2014	15.2	24.6	0.391	0.617	1.03	1.215	1.563	1.761	1.97	2.352	3.183	3.327	3.64
2015	14.9	24.8	0.353	0.704	0.962	1.437	1.59	1.946	2.135	2.34	2.728	3.373	3.64
2016	14.2	24.3	0.363	0.642	1.087	1.351	1.865	1.99	2.346	2.513	2.715	2.921	3.689
2017	13.8	23.2	0.343	0.662	0.996	1.516	1.763	2.296	2.395	2.749	2.908	2.907	3.237
2018	13.6	22.7	0.298	0.622	1.023	1.394	1.948	2.179	2.729	2.803	3.153	3.105	3.222
2019	13.4	22.3	0.278	0.55	0.97	1.428	1.804	2.393	2.597	3.159	3.197	3.342	3.419
2020	NA	22.1	0.266	0.516	0.866	1.36	1.854	2.238	2.838	3.028	3.572	3.388	3.656

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
2021	NA	NA	0.259	0.494	0.813	1.222	1.774	2.284	2.663	3.279	3.444	3.754	3.705

Table 4.7. Northeast Arctic haddock. Proportion mature-at-age. The data from 1950–1993 is unchanged since AFWG 2019, the data from 1994 and onward have been updated this year, ages 11–13+ is set to 1 (not shown)

Year	1	2	3	4	5	6	7	8	9	10
1950	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1951	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1952	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1953	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1954	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1955	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1956	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1957	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1958	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1959	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1960	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1961	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1962	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1963	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1964	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1965	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1966	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1967	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1968	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1969	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1970	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1971	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1972	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1973	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1974	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1975	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994

Year	1	2	3	4	5	6	7	8	9	10
1976	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1977	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1978	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1979	0	0	0.027	0.101	0.311	0.622	0.845	0.944	0.982	0.994
1980	0	0	0.026	0.076	0.243	0.649	0.86	0.95	0.984	0.995
1981	0	0	0.056	0.104	0.303	0.549	0.857	0.948	0.984	0.995
1982	0	0	0.053	0.161	0.332	0.577	0.77	0.947	0.983	0.995
1983	0	0	0.057	0.183	0.472	0.665	0.8	0.906	0.983	0.995
1984	0	0	0.044	0.196	0.51	0.801	0.862	0.921	0.967	0.995
1985	0	0	0.027	0.149	0.522	0.796	0.928	0.953	0.973	0.989
1986	0	0	0.021	0.103	0.454	0.758	0.928	0.977	0.984	0.991
1987	0	0	0.021	0.076	0.294	0.713	0.918	0.976	0.993	0.994
1988	0	0	0.025	0.074	0.24	0.576	0.898	0.975	0.993	0.998
1989	0	0	0.032	0.09	0.25	0.534	0.822	0.966	0.993	0.998
1990	0	0	0.046	0.127	0.305	0.578	0.798	0.937	0.99	0.997
1991	0	0	0.041	0.164	0.358	0.623	0.82	0.925	0.98	0.997
1992	0	0	0.03	0.147	0.449	0.704	0.855	0.936	0.976	0.994
1993	0	0	0.018	0.113	0.396	0.741	0.878	0.95	0.979	0.992
1994	0	0	0.028	0.083	0.263	0.627	0.838	0.941	0.958	0.957
1995	0	0	0.029	0.074	0.204	0.49	0.825	0.932	0.975	0.98
1996	0	0	0.031	0.079	0.184	0.408	0.716	0.925	0.972	0.99
1997	0	0	0.042	0.086	0.192	0.373	0.634	0.858	0.968	0.988
1998	0	0	0.042	0.117	0.211	0.391	0.602	0.803	0.931	0.986
1999	0	0	0.046	0.119	0.277	0.418	0.616	0.776	0.898	0.964
2000	0	0	0.033	0.128	0.279	0.512	0.645	0.789	0.88	0.946
2001	0	0	0.035	0.092	0.3	0.512	0.735	0.81	0.889	0.937
2002	0	0	0.03	0.097	0.225	0.542	0.735	0.871	0.902	0.942
2003	0	0	0.027	0.083	0.235	0.44	0.757	0.871	0.937	0.949
2004	0	0	0.032	0.073	0.204	0.457	0.666	0.886	0.938	0.969

Year	1	2	3	4	5	6	7	8	9	10
2005	0	0	0.032	0.09	0.179	0.408	0.683	0.826	0.945	0.969
2006	0	0	0.033	0.089	0.218	0.37	0.634	0.837	0.911	0.973
2007	0	0	0.023	0.094	0.218	0.429	0.594	0.803	0.919	0.954
2008	0	0	0.023	0.063	0.228	0.429	0.659	0.772	0.898	0.958
2009	0	0	0.027	0.062	0.154	0.443	0.655	0.818	0.878	0.947
2010	0	0	0.032	0.073	0.154	0.325	0.67	0.818	0.907	0.936
2011	0	0	0.035	0.09	0.179	0.322	0.543	0.828	0.907	0.952
2012	0	0	0.046	0.095	0.22	0.37	0.54	0.731	0.913	0.951
2013	0	0	0.041	0.131	0.23	0.433	0.594	0.728	0.851	0.955
2014	0	0	0.051	0.116	0.303	0.447	0.662	0.772	0.848	0.918
2015	0	0	0.043	0.142	0.274	0.545	0.673	0.82	0.878	0.917
2016	0	0	0.046	0.123	0.327	0.509	0.762	0.831	0.908	0.935
2017	0	0	0.042	0.129	0.288	0.578	0.732	0.888	0.914	0.952
2018	0	0	0.035	0.117	0.3	0.527	0.785	0.868	0.947	0.956
2019	0	0	0.031	0.096	0.277	0.542	0.744	0.903	0.936	0.974
2020	0	0	0.03	0.087	0.233	0.512	0.76	0.879	0.956	0.968
2021			0.029	0.081	0.211	0.45	0.735	0.886	0.942	0.979

Table 4.8. Northeast Arctic haddock. Consumption of Haddock by NEA Cod (mln. spec) age 0–6, and total biomass ages 0–6 consumed.

Age	0	1	2	3	4	5	6	Biomass
1984	1975.1	990.1	15.3	0.1	0.0	0.0	0.0	51.7
1985	2027.1	1378.0	5.1	0.0	0.0	0.0	0.0	53.5
1986	92.8	624.2	224.5	168.5	0.0	0.0	0.0	109.8
1987	0.0	1058.2	0.0	0.0	0.0	0.0	0.0	5.8
1988	0.0	16.8	0.5	8.7	0.0	0.2	0.0	2.5
1989	21.3	221.3	0.0	0.0	0.0	0.0	0.0	9.9
1990	47.9	135.9	33.9	3.3	0.0	0.0	0.0	13.9
1991	0.0	352.4	12.9	0.0	0.0	0.0	0.0	15.5
1992	132.1	1737.1	123.0	0.9	0.0	0.0	0.0	87.7
1993	824.9	1441.6	143.6	32.2	3.1	2.6	0.0	69.3

Age	0	1	2	3	4	5	6	Biomass
1994	1348.5	1483.4	73.6	23.9	6.9	0.8	0.0	48.4
1995	181.8	2868.8	167.3	12.4	28.2	27.8	0.3	113.6
1996	359.6	1549.9	154.2	38.2	5.2	2.5	3.2	66.6
1997	0.0	947.0	38.9	26.4	1.7	0.8	0.5	44.0
1998	0.0	1739.4	27.5	1.7	2.6	0.4	0.0	36.0
1999	0.0	1041.9	25.3	0.4	0.0	0.0	0.0	29.6
2000	813.4	1412.0	71.6	2.2	1.1	0.2	0.1	58.3
2001	1047.9	593.6	53.3	4.7	0.1	0.0	0.0	51.2
2002	456.0	2437.4	240.6	39.5	2.3	0.4	0.2	127.0
2003	1140.2	3568.0	214.3	39.3	12.7	1.2	0.0	165.8
2004	5395.1	2862.8	303.7	39.8	9.9	2.5	0.0	198.1
2005	7703.0	6674.7	276.3	55.4	9.3	2.3	0.9	324.5
2006	12706.3	8410.2	375.2	5.5	4.4	1.2	0.5	360.5
2007	1204.2	10143.7	660.2	71.9	3.9	2.2	0.2	377.6
2008	1354.5	964.7	894.3	227.7	44.3	5.7	3.3	293.3
2009	5607.2	1854.7	274.1	262.0	69.0	22.3	1.5	252.4
2010	1968.7	5687.7	180.0	66.9	68.5	62.2	11.6	266.8
2011	2316.3	2622.4	451.4	56.1	75.1	86.7	19.4	279.0
2012	231.9	7132.1	134.3	107.3	15.0	6.7	4.3	219.5
2013	2172.4	1581.6	376.4	31.6	22.4	5.5	4.2	200.4
2014	1195.0	1991.3	140.6	27.5	1.8	0.6	0.0	87.6
2015	4931.7	2579.5	131.3	13.6	44.5	1.5	0.2	177.8
2016	8067.8	2654.8	276.8	22.6	2.5	7.7	1.8	222.0
2017	4421.9	7602.9	229.3	22.9	12.7	6.2	13.7	271.8
2018	2348.7	7041.1	583.6	65.0	6.9	0.6	0.0	276.1
2019	542.7	4542.6	411.3	119.2	8.1	0.3	0.0	211.8
2020	2008.8	450.9	72.5	63.7	80.4	4.2	0.1	91.7
Av.1984–2020	**2017.4**	**2713.4**	**199.9**	**44.9**	**14.7**	**6.9**	**1.8**	**142.5**

Table 4.9. Northeast Arctic haddock. Survey indices for SAM tuning (see section 4.4.6). The last age is a plus group.

Northeast Arctic haddock

104

RU-BTr-Q4 #Russian trawl and acoustic survey bottom trawl index

1991 2020

1 1 0.9 1.00

3 8

1	62	9	3	6	18	17
1	346	50	4	6	9	9
1	1985	356	48	8	4	4
1	442	1014	116	15	1	6
1	31	123	370	40	5	4
1	28	49	362	334	29	6
1	32	32	10	27	10	8
1	38	46	8	5	15	5
1	196	39	37	8	3	14
1	60	109	26	11	2	5
1	334	40	65	11	4	4
1	399	450	47	24	4	3
1	221	299	231	34	16	3
1	113	94	107	87	5	6
1	240	86	48	57	24	3
1	113	119	57	26	24	13
1	838	73	137	38	14	15
1	2557	1051	124	111	17	11
1	1647	1704	631	57	32	9
1	299	1697	1589	466	34	17
1	47	268	1087	783	165	13
1	209	49	160	720	480	70
1	61	175	50	104	374	272
1	250	46	175	56	142	416
1	22	199	40	74	28	171
1	-1	-1	-1	-1	-1	-1
1	71	99	9	38	6	27
1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1

BS-NoRU-Q1(Aco) # Joint Barents Sea winter survey acoustic index

1994 2021

1 1 0.077 0.189

3 9

1	348.7	626.6	121.4	8.55	0.7	0.33	2.71
1	41.5	121.5	395.4	47.6	2.8	0.05	0.83
1	30	22.1	68.7	143.7	5.67	0.94	0.07
1	57.3	22.2	15.5	56.1	62.8	4.68	0.19

1	33.8	58.8	24.2	7.7	14.1	20.7	1.62
1	83.7	21.6	22.1	6.17	1.55	3.88	2.77
1	36.4	75.5	14	12.6	1.57	0.53	3.02
1	233.5	40.2	41.4	2.2	1.61	0.16	0.71
1	255.2	201.8	18.5	11.7	1.59	0.29	0.56
1	203.7	184.6	136	12.3	6.01	0.26	0.9
1	151	101.8	107.8	57.7	7.62	1.15	0.55
1	221.3	115.7	57.4	56.7	12.7	0.38	0.33
1	56.3	123.8	47.4	19.3	13.6	3.23	0.35
1	209.3	46.1	80.6	28.9	10	5.05	2.79
1	812.4	303	90	74.1	7.41	12.8	2.11
1	883.7	630	266.6	38.9	14.6	1.26	1.71
1	128.1	631	604	167	12.1	2.94	2.11
1	54.2	84.2	313	292.2	54.9	1.72	1.47
1	191.6	48.8	88.1	310.6	172.5	30.1	1.01
1	67.3	146.8	35.4	53	223.8	102.7	14.35
1	334.8	39.12	108.71	23.2	34.76	86.34	38.8
1	24.31	189.4	26.6	46.17	9.22	22.41	31.97
1	71.82	12.06	59.67	12.5	17.31	7.48	33.27
1	81.13	65.08	4.8	34.8	6.24	7.93	17.73
1	170.4	62.87	64.18	6.88	15.77	2.75	14.52
1	507.61	146.22	31.73	21.88	4.9	3.27	4.11
1	290.483	302.908	81.912	23.057	11.49	1.804	6.219
1	43.1	114.3	173.8	17.1	6.28	0.48	1.12

BS-NoRu-Q1 (BTr) # Joint Barents Sea winter survey bottom trawl index

1994 2021

1 1 0.077 0.189

3 10

1	314.533	436.251	46.176	3.54	0.163	0.13	0.2	0.651
1	54.857	167.104	343.38	29.623	1.441	0.025	0.043	0.404
1	55.843	31.334	150.768	238.108	16.131	1.15	0	0.069
1	79.632	39.855	18.255	61.566	88.411	3.277	0.082	0.043
1	21.681	36.749	11.844	1.294	9.203	7.212	0.648	0.092
1	56.92	15.874	9.418	2.831	0.807	1.282	0.771	0.034
1	24.08	35.241	6.789	4.134	0.684	0.083	0.802	0.288
1	293.996	26.252	22.997	1.634	0.752	0.058	0.06	0.329
1	312.87	185.453	12.417	8.04	0.846	0.218	0.009	0.325
1	352.236	174.452	72.708	5.104	1.682	0.119	0.104	0.217
1	173.132	100.516	77.021	51.281	7.409	0.912	0.133	0.228
1	317.889	141.058	50.664	61.191	10.082	0.249	0.08	0.009
1	78.798	130.76	46.048	20.874	16.208	3.184	0.094	0.265
1	443.266	81.784	84.667	26.279	5.411	2.197	1.376	0.896
1	1591.031	583.606	53.079	54.732	6.794	10.248	0.23	0.167
1	1230.426	751.012	368.33	25.414	12.437	0.851	0.09	0.363
1	102.451	510.449	443.759	139.316	7.988	1.016	0.386	0.574
1	52.883	123.634	469.482	290.036	65.236	1.416	1.121	0.184

1	316.077	28.785	74.714	267.945	154.601	24.766	3.115	0.391
1	57.444	143.984	22.019	33.624	191.145	69.385	6.114	0.076
1	381.173	32.729	104.397	23.257	50.035	97.536	38.692	2.425
1	30.615	187.035	43.601	39.44	14.668	18.735	30.744	10.2
1	163.385	34.342	115.597	22.406	41.948	12.437	32.396	33.161
1	134.9	105.5	7.553	55.338	9.692	15.6	2.527	23.861
1	336.307	86.656	65.764	7.771	15.59	3.621	2.564	11.931
1	1075.552	187.224	49.399	16.996	4.038	2.948	0.736	1.91
1	424.225	586.985	99.123	22.08	6.057	2.605	1.042	2.827
1	118.428	194.033	302.978	20.677	4.628	0.848	0.204	0.93

FLT007: Eco-NoRu-Q3 (Btr) # Joint Barents Sea ecosystem survey bottom trawl index

2004 2020

1 1 0.65 0.75

3 9

1	123.368	70.303	69.118	31.482	2.989	1.721	0.22
1	324.56	89.531	30.44	32.246	15.035	0.472	1.116
1	107.467	124.64	41.597	18.98	17.482	7.289	1.384
1	1282.94	88.498	90.369	19.227	5.881	7.102	3.209
1	1154.869	405.999	43.133	35.517	4.94	2.514	2.539
1	650.742	619.088	305.883	21.045	6.549	0.87	0.576
1	184.001	865.318	666.439	147.72	15.84	2.73	0.589
1	40.446	73.802	392.93	301.368	37.357	2.972	0.514
1	92.468	20.348	67.607	214.052	152.03	12.739	2.003
1	25.779	65.228	19.575	50.846	150.131	76.427	7.561
1	261.631	40.768	70.161	25.781	60.452	85.771	19.646
1	42.148	213.636	25.132	37.111	20.577	47.868	42.903
1	209.303	34.43	184.09	47.965	56.787	40.367	125.907
1	70.313	70.306	11.47	20.537	3.963	4.025	15.265
1	-1	-1	-1	-1	-1	-1	-1
1	896.982	160.736	38.067	15.133	5.303	5.037	11.56
1	204.059	341.372	58.813	4.918	1.959	0.802	1.483

Table 4.10 Northeast Arctic haddock. SAM model configuration used. Updated at WKDEM 2020

```
#Configuration saved: Wed Feb 12 12:57:09 2020
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
$minAge
# The minimum age class in the assessment
 3
$maxAge
# The maximum age class in the assessment
 13
$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 1 1 1 1
```

```
$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  4  5  5  5  5  5  5
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, 2 AR(1), 3
separable AR(1).
 2
$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered
by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
  0  1  1  1  1  1 -1 -1 -1 -1 -1
  2  3  3  3  3  4  4 -1 -1 -1 -1
  5  6  6  6  6  7  7  7 -1 -1 -1
  8  9  9  9  9  9  9 -1 -1 -1 -1
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
  0  0  0  0  0  0 -1 -1 -1 -1 -1
  1  1  1  1  1  2  2 -1 -1 -1 -1
  3  3  3  3  3  4  4  4 -1 -1 -1
  5  5  5  5  5  5  5 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
  0  1  1  1  1  1  1  1  1  1  1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1 1
$keyVarObs
# Coupling of the variance parameters for the observations.
  0  1  2  2  2  2  2  2  2  2  2
  3  3  3  3  3  3 -1 -1 -1 -1 -1
  4  4  4  4  4  4  4 -1 -1 -1 -1
  5  5  5  5  5  5  5  5 -1 -1 -1
  6  6  6  6  6  6  6 -1 -1 -1 -1
$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). |
Possible values are: "ID" "AR" "US"
 "ID" "AR" "AR" "AR" "AR"
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
```

```
 NA  NA  NA  NA  NA  NA  NA  NA  NA  NA
  0   1   1   1   2  -1  -1  -1  -1  -1
  3   3   3   3   3   4  -1  -1  -1  -1
  5   5   5   5   5   6   6  -1  -1  -1
  7   7   7   7   7   7  -1  -1  -1  -1
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, 2 for Beverton–Holt, and 3 piece-wise constant).
 0
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.
 $keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
$fbarRange
# lowest and higest age included in Fbar
 4 7
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index, 3 total catch, 4 total landings and 5 TSB index).
 -1 -1 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN"
$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0
$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0
$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0
$fracMixObs
# A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet
 0 0 0 0 0
$constRecBreaks
# This option is only used in combination with stock-recruitment code 3)
 $predVarObsLink
# Coupling of parameters used in a mean-variance link for observations.
  0   1   2   2   2   2   2   2   2   2   2
  3   3   3   3   3   3  -1  -1  -1  -1  -1
  4   4   4   4   4   4   4  -1  -1  -1  -1
  5   5   5   5   5   5   5   5  -1  -1  -1
  6   6   6   6   6   6   6  -1  -1  -1  -1
```

Table 4.11. Northeast Arctic haddock. SAM model. Estimated recruitment, spawning-stock biomass (SSB), and average fishing mortality.

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4–7)	Low	High	TSB	Low	High
1950	72387	46062	113757	214451	191896	239657	0.755	0.637	0.894	387984	347732	432897
1951	657549	421933	1024740	126198	111962	142244	0.683	0.574	0.812	433412	338704	554603
1952	88651	56447	139228	101722	88677	116687	0.712	0.595	0.851	425163	337716	535254
1953	1235085	805743	1893203	120624	103993	139915	0.536	0.443	0.650	733145	558302	962743
1954	133361	85029	209168	174452	147488	206344	0.430	0.353	0.524	826557	650141	1050844
1955	58610	36972	92912	313927	267217	368803	0.445	0.368	0.537	849059	713766	1009997
1956	229244	145866	360280	368382	313148	433358	0.470	0.390	0.567	690111	591624	804993
1957	60266	38168	95158	253706	217108	296473	0.425	0.353	0.512	435085	377199	501855
1958	72860	46450	114287	182036	157918	209837	0.517	0.428	0.623	315294	277030	358844
1959	389171	254295	595585	125360	108680	144599	0.445	0.366	0.540	333166	273423	405963
1960	320748	208438	493573	112847	99388	128128	0.540	0.450	0.648	418829	348061	503987
1961	145185	94620	222773	124852	111078	140333	0.663	0.560	0.786	402474	349320	463715
1962	294861	192640	451325	125250	111167	141117	0.791	0.670	0.933	376991	323928	438745
1963	315359	207593	479068	94365	82948	107352	0.757	0.634	0.905	353624	295169	423655
1964	353500	231399	540029	84511	74143	96329	0.632	0.523	0.763	386037	318642	467687
1965	126853	81897	196486	103153	89857	118418	0.524	0.432	0.635	386407	325823	458256
1966	313477	203773	482241	145776	126683	167746	0.557	0.463	0.671	451214	384496	529509

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4–7)	Low	High	TSB	Low	High
1967	341190	221107	526492	151263	130129	175829	0.441	0.363	0.535	464389	389441	553759
1968	18013	11107	29212	168174	145329	194610	0.482	0.397	0.586	426984	361320	504581
1969	20599	12799	33151	167949	143974	195917	0.411	0.335	0.504	316968	270836	370956
1970	209787	134801	326485	155435	131552	183655	0.383	0.309	0.474	286902	241277	341154
1971	109545	69787	171952	127588	107314	151692	0.327	0.261	0.409	263556	223617	310629
1972	1052876	667948	1659631	128490	111420	148176	0.653	0.533	0.799	601810	452127	801049
1973	310449	202458	476042	125203	107368	146001	0.534	0.435	0.655	637223	507838	799570
1974	66135	42760	102289	153690	133714	176650	0.504	0.415	0.612	462911	398743	537405
1975	59421	38424	91892	194817	166555	227875	0.497	0.414	0.597	378920	328264	437393
1976	61869	39371	97225	196331	168410	228881	0.721	0.606	0.857	296386	259233	338863
1977	120514	75884	191393	118795	99987	141140	0.735	0.606	0.893	201315	172466	234989
1978	214589	140083	328722	81208	67119	98254	0.623	0.505	0.768	199556	164222	242492
1979	161504	105201	247938	62610	52588	74542	0.580	0.466	0.722	206831	171527	249400
1980	22094	13599	35894	62985	53381	74317	0.471	0.377	0.589	213487	177892	256205
1981	10280	6095	17337	73069	61627	86634	0.432	0.345	0.540	168620	141915	200351
1982	16749	10277	27298	68801	56759	83398	0.379	0.301	0.479	122917	102645	147193
1983	8656	5087	14729	58364	47816	71239	0.351	0.275	0.449	87932	73504	105192
1984	13271	8149	21611	53199	43258	65423	0.315	0.244	0.406	71822	59820	86232

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4–7)	Low	High	TSB	Low	High
1985	358813	233153	552199	49169	40822	59223	0.395	0.309	0.504	191524	140182	261671
1986	478572	311663	734868	54924	46468	64919	0.535	0.425	0.675	374796	293890	477975
1987	90214	57751	140923	77959	66517	91369	0.628	0.504	0.783	356744	297363	427982
1988	38984	24377	62344	80099	67250	95402	0.509	0.407	0.637	253948	214793	300241
1989	28853	17865	46599	84610	69520	102976	0.372	0.294	0.470	193201	161348	231341
1990	37125	23767	57992	85901	69709	105854	0.211	0.165	0.270	153622	127998	184377
1991	111048	77956	158188	100647	84303	120159	0.239	0.190	0.300	186699	159043	219165
1992	328727	233077	463631	111090	95809	128808	0.294	0.237	0.365	291322	243904	347959
1993	848769	613008	1175203	125741	110626	142922	0.316	0.257	0.389	526073	433781	638001
1994	396614	318970	493159	153834	137161	172532	0.371	0.306	0.451	650312	566914	745978
1995	100060	77811	128671	186134	165514	209324	0.298	0.250	0.356	643113	566516	730065
1996	99507	77719	127404	215730	192019	242370	0.366	0.310	0.431	557155	495314	626717
1997	119084	93193	152169	186891	166282	210055	0.445	0.376	0.527	400459	358952	446765
1998	63240	48775	81995	130850	115668	148025	0.452	0.378	0.541	266478	238448	297802
1999	151245	120741	189455	94816	83809	107270	0.462	0.383	0.557	233978	208477	262597
2000	83258	65021	106611	78075	68910	88460	0.341	0.279	0.417	214801	189585	243371
2001	367666	300041	450533	91259	81229	102526	0.366	0.303	0.442	318048	280668	360407
2002	395448	321892	485812	108683	96817	122003	0.351	0.292	0.423	436563	384807	495280

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4–7)	Low	High	TSB	Low	High
2003	340113	272564	424403	136879	122623	152791	0.424	0.358	0.503	506909	450642	570201
2004	260359	212216	319424	155689	139461	173805	0.387	0.328	0.456	493539	441891	551224
2005	366492	300172	447466	166962	149621	186313	0.404	0.344	0.476	510380	457657	569177
2006	157564	127155	195244	151329	135466	169050	0.369	0.312	0.437	439168	393891	489649
2007	543223	441281	668715	153562	137718	171230	0.384	0.323	0.455	504466	450324	565117
2008	1112513	913961	1354200	163092	145133	183272	0.314	0.262	0.377	738154	647137	841971
2009	1025284	845638	1243094	183533	163348	206213	0.260	0.216	0.311	996702	871947	1139306
2010	240955	195431	297083	248053	220499	279050	0.244	0.206	0.291	1130768	991062	1290169
2011	117224	92480	148588	355613	315855	400375	0.255	0.217	0.301	1178847	1040816	1335183
2012	340386	276667	418780	475908	419566	539815	0.220	0.186	0.260	1175999	1040560	1329067
2013	119057	94420	150121	523943	460492	596137	0.148	0.124	0.177	1005601	890548	1135517
2014	411335	336043	503497	523619	463357	591718	0.154	0.128	0.185	983944	880258	1099843
2015	72464	56494	92950	497402	444871	556135	0.190	0.159	0.227	874947	787488	972120
2016	212760	170769	265075	489847	438583	547104	0.261	0.219	0.310	803199	722937	892372
2017	194179	156196	241399	410620	369903	455820	0.351	0.296	0.416	702033	634303	776994
2018	367841	295751	457503	303265	271126	339214	0.404	0.339	0.481	617524	553251	689263
2019	821773	668831	1009689	234446	206986	265549	0.433	0.355	0.527	695945	612581	790655
2020	441844	354723	550361	204484	175372	238429	0.438	0.347	0.554	722596	623367	837621

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4–7)	Low	High	TSB	Low	High
2021	153680	110687	213373	200849	162390	248417				648860	532298	790945

Table 4.12. Northeast Arctic haddock. SAM model estimated fishing mortality-at-age. SAM model.

Year age	3	4	5	6	7	8	9	10	11	12	13
1950	0.096	0.412	0.706	0.849	1.052	0.886	0.886	0.886	0.886	0.886	0.886
1951	0.086	0.359	0.617	0.773	0.981	0.884	0.884	0.884	0.884	0.884	0.884
1952	0.092	0.380	0.641	0.797	1.029	0.933	0.933	0.933	0.933	0.933	0.933
1953	0.067	0.282	0.473	0.588	0.802	0.737	0.737	0.737	0.737	0.737	0.737
1954	0.048	0.207	0.357	0.468	0.689	0.648	0.648	0.648	0.648	0.648	0.648
1955	0.046	0.199	0.368	0.502	0.710	0.600	0.600	0.600	0.600	0.600	0.600
1956	0.050	0.210	0.389	0.549	0.733	0.621	0.621	0.621	0.621	0.621	0.621
1957	0.047	0.198	0.367	0.492	0.643	0.547	0.547	0.547	0.547	0.547	0.547
1958	0.058	0.235	0.450	0.601	0.781	0.690	0.690	0.690	0.690	0.690	0.690
1959	0.059	0.228	0.409	0.521	0.620	0.566	0.566	0.566	0.566	0.566	0.566
1960	0.089	0.317	0.537	0.633	0.672	0.616	0.616	0.616	0.616	0.616	0.616
1961	0.117	0.406	0.682	0.782	0.783	0.694	0.694	0.694	0.694	0.694	0.694
1962	0.147	0.502	0.853	0.941	0.867	0.722	0.722	0.722	0.722	0.722	0.722
1963	0.133	0.471	0.805	0.909	0.845	0.681	0.681	0.681	0.681	0.681	0.681
1964	0.097	0.360	0.634	0.769	0.765	0.647	0.647	0.647	0.647	0.647	0.647

Year age	3	4	5	6	7	8	9	10	11	12	13
1965	0.077	0.292	0.513	0.635	0.656	0.566	0.566	0.566	0.566	0.566	0.566
1966	0.090	0.328	0.563	0.667	0.670	0.555	0.555	0.555	0.555	0.555	0.555
1967	0.072	0.268	0.446	0.515	0.535	0.465	0.465	0.465	0.465	0.465	0.465
1968	0.084	0.297	0.490	0.554	0.588	0.513	0.513	0.513	0.513	0.513	0.513
1969	0.079	0.267	0.428	0.469	0.481	0.416	0.416	0.416	0.416	0.416	0.416
1970	0.082	0.262	0.402	0.428	0.439	0.381	0.381	0.381	0.381	0.381	0.381
1971	0.073	0.233	0.351	0.355	0.366	0.324	0.324	0.324	0.324	0.324	0.324
1972	0.193	0.503	0.759	0.696	0.654	0.545	0.545	0.545	0.545	0.545	0.545
1973	0.199	0.486	0.641	0.530	0.477	0.381	0.381	0.381	0.381	0.381	0.381
1974	0.179	0.431	0.547	0.515	0.522	0.460	0.460	0.460	0.460	0.460	0.460
1975	0.195	0.459	0.548	0.494	0.487	0.417	0.417	0.417	0.417	0.417	0.417
1976	0.289	0.647	0.785	0.723	0.728	0.640	0.640	0.640	0.640	0.640	0.640
1977	0.322	0.713	0.852	0.719	0.658	0.559	0.559	0.559	0.559	0.559	0.559
1978	0.223	0.546	0.726	0.644	0.576	0.505	0.505	0.505	0.505	0.505	0.505
1979	0.160	0.443	0.670	0.652	0.557	0.502	0.502	0.502	0.502	0.502	0.502
1980	0.101	0.316	0.525	0.563	0.481	0.459	0.459	0.459	0.459	0.459	0.459
1981	0.085	0.273	0.472	0.538	0.444	0.428	0.428	0.428	0.428	0.428	0.428
1982	0.075	0.244	0.411	0.477	0.385	0.380	0.380	0.380	0.380	0.380	0.380

Year age	3	4	5	6	7	8	9	10	11	12	13
1983	0.077	0.247	0.388	0.428	0.342	0.341	0.341	0.341	0.341	0.341	0.341
1984	0.069	0.226	0.347	0.376	0.308	0.293	0.293	0.293	0.293	0.293	0.293
1985	0.075	0.257	0.412	0.481	0.429	0.412	0.412	0.412	0.412	0.412	0.412
1986	0.088	0.315	0.541	0.666	0.619	0.588	0.588	0.588	0.588	0.588	0.588
1987	0.097	0.359	0.644	0.786	0.724	0.658	0.658	0.658	0.658	0.658	0.658
1988	0.071	0.278	0.511	0.655	0.592	0.537	0.537	0.537	0.537	0.537	0.537
1989	0.055	0.219	0.388	0.466	0.414	0.362	0.362	0.362	0.362	0.362	0.362
1990	0.029	0.126	0.214	0.255	0.248	0.231	0.231	0.231	0.231	0.231	0.231
1991	0.031	0.136	0.243	0.291	0.285	0.262	0.262	0.262	0.262	0.262	0.262
1992	0.032	0.146	0.291	0.367	0.372	0.341	0.341	0.341	0.341	0.341	0.341
1993	0.026	0.128	0.291	0.407	0.439	0.398	0.398	0.398	0.398	0.398	0.398
1994	0.024	0.124	0.305	0.476	0.579	0.544	0.544	0.544	0.544	0.544	0.544
1995	0.019	0.099	0.231	0.366	0.497	0.489	0.489	0.489	0.489	0.489	0.489
1996	0.024	0.123	0.286	0.439	0.614	0.620	0.620	0.620	0.620	0.620	0.620
1997	0.032	0.158	0.374	0.534	0.716	0.683	0.683	0.683	0.683	0.683	0.683
1998	0.038	0.178	0.402	0.552	0.677	0.676	0.676	0.676	0.676	0.676	0.676
1999	0.045	0.203	0.432	0.560	0.652	0.624	0.624	0.624	0.624	0.624	0.624
2000	0.033	0.159	0.325	0.412	0.468	0.438	0.438	0.438	0.438	0.438	0.438

Year age	3	4	5	6	7	8	9	10	11	12	13
2001	0.034	0.162	0.355	0.455	0.491	0.449	0.449	0.449	0.449	0.449	0.449
2002	0.031	0.151	0.321	0.453	0.481	0.423	0.423	0.423	0.423	0.423	0.423
2003	0.036	0.169	0.366	0.531	0.629	0.570	0.570	0.570	0.570	0.570	0.570
2004	0.034	0.158	0.329	0.483	0.578	0.547	0.547	0.547	0.547	0.547	0.547
2005	0.037	0.163	0.336	0.494	0.624	0.603	0.603	0.603	0.603	0.603	0.603
2006	0.036	0.159	0.316	0.443	0.558	0.549	0.549	0.549	0.549	0.549	0.549
2007	0.037	0.158	0.319	0.465	0.592	0.572	0.572	0.572	0.572	0.572	0.572
2008	0.025	0.112	0.230	0.383	0.532	0.524	0.524	0.524	0.524	0.524	0.524
2009	0.020	0.088	0.178	0.307	0.465	0.479	0.479	0.479	0.479	0.479	0.479
2010	0.020	0.084	0.168	0.287	0.438	0.489	0.489	0.489	0.489	0.489	0.489
2011	0.021	0.088	0.184	0.303	0.446	0.489	0.489	0.489	0.489	0.489	0.489
2012	0.020	0.082	0.159	0.264	0.373	0.400	0.400	0.400	0.400	0.400	0.400
2013	0.015	0.061	0.108	0.171	0.252	0.311	0.311	0.311	0.311	0.311	0.311
2014	0.017	0.069	0.121	0.178	0.249	0.345	0.345	0.345	0.345	0.345	0.345
2015	0.022	0.089	0.160	0.223	0.288	0.396	0.396	0.396	0.396	0.396	0.396
2016	0.029	0.115	0.224	0.312	0.392	0.509	0.509	0.509	0.509	0.509	0.509
2017	0.037	0.150	0.305	0.439	0.511	0.590	0.590	0.590	0.590	0.590	0.590
2018	0.037	0.155	0.348	0.523	0.590	0.640	0.640	0.640	0.640	0.640	0.640

Year age	3	4	5	6	7	8	9	10	11	12	13
2019	0.035	0.155	0.374	0.596	0.604	0.600	0.600	0.600	0.600	0.600	0.600
2020	0.035	0.156	0.385	0.598	0.615	0.579	0.579	0.579	0.579	0.579	0.579
2021											

Table 4.13. Northeast Arctic haddock. SAM model. Estimated stock numbers-at-age.

Year age	3	4	5	6	7	8	9	10	11	12	13
1950	72387	101009	76017	37150	46935	16676	4880	2688	1381	1458	2057
1951	657549	47705	46081	27475	12803	12509	5437	1943	1014	446	1091
1952	88651	438929	30695	19192	9000	4349	3848	1638	740	358	506
1953	1235085	52138	209525	14008	6354	2642	1334	1051	533	255	309
1954	133361	913544	26058	91355	6875	2330	1091	550	387	198	228
1955	58610	84501	631189	14601	52376	3092	919	454	237	160	168
1956	229244	40701	55883	324913	7240	17802	1441	402	215	114	153
1957	60266	151466	27728	36033	111034	3106	6150	704	168	100	131
1958	72860	39770	92930	15488	20893	40149	1644	2509	354	84	120
1959	389171	51295	26037	40026	7337	7294	14884	731	899	148	88
1960	320748	266359	35741	15664	16981	3484	3678	6151	365	369	109
1961	145185	192859	145259	17681	6976	8042	1598	1508	2792	158	204
1962	294861	86481	92421	59752	6747	2709	3285	659	610	1159	139

Year age	3	4	5	6	7	8	9	10	11	12	13
1963	315359	177692	37947	26417	17576	2650	1088	1226	273	244	536
1964	353500	199644	75558	12273	7678	5842	1227	440	508	123	346
1965	126853	240169	115011	30342	4168	2789	2265	536	199	218	212
1966	313477	82668	159195	62307	12375	1706	1278	942	273	92	187
1967	341190	201060	43604	72639	24821	4868	791	602	450	133	132
1968	18013	248132	118431	21878	36202	12529	2349	410	314	233	138
1969	20599	11699	142453	55382	10694	15788	5755	1164	197	157	175
1970	209787	12601	7442	70596	25187	5928	8046	3010	645	106	186
1971	109545	135078	7121	4480	33447	12303	3367	4542	1695	372	163
1972	1052876	80012	82395	4549	3103	17570	6739	2020	2777	1031	316
1973	310449	611103	46689	23226	1698	1550	7634	2898	926	1381	612
1974	66135	168872	250030	16572	10670	885	1018	4471	1685	549	1231
1975	59421	37507	90353	140384	6794	4948	449	564	2145	815	939
1976	61869	33814	16493	44274	79181	3147	2774	247	336	1149	973
1977	120514	31955	13774	6432	17629	30320	1281	1184	103	150	807
1978	214589	55473	9805	4432	2903	7738	15125	627	564	45	431
1979	161504	118148	23372	3261	2038	1408	4103	7088	338	273	226
1980	22094	103045	58844	8328	1152	1050	718	2169	3494	175	240

Year age	3	4	5	6	7	8	9	10	11	12	13
1981	10280	15556	63778	26434	3456	551	560	381	1144	1721	215
1982	16749	6731	11059	31900	10551	1721	278	308	219	627	960
1983	8656	11414	4623	6826	13527	5614	984	146	178	128	805
1984	13271	5143	6723	2738	3892	8834	2874	577	80	105	519
1985	358813	8928	2896	3609	1787	2574	5370	1840	369	51	399
1986	478572	277557	5190	1600	1853	994	1477	2795	1027	206	263
1987	90214	251326	157099	2536	656	793	470	680	1205	471	209
1988	38984	69536	135665	46741	1070	233	319	205	302	507	280
1989	28853	25825	49166	71076	12181	553	95	152	99	146	365
1990	37125	21055	17098	26048	32816	5474	358	59	87	57	277
1991	111048	25165	13652	14116	20258	20295	3130	252	40	57	205
1992	328727	84057	16045	10130	10434	12634	12657	1883	167	26	158
1993	848769	223913	57735	10760	5933	6253	7669	7276	1047	103	107
1994	396614	587436	154930	31942	4717	3143	3765	4809	4340	594	117
1995	100060	226590	435698	78166	14754	2118	1430	1880	2211	2156	341
1996	99507	61789	169995	248671	32136	7295	1100	713	945	1113	1277
1997	119084	55471	38253	96439	103120	13962	2515	500	315	419	1105
1998	63240	80491	34945	18197	36788	39134	5215	991	213	133	718

Year age	3	4	5	6	7	8	9	10	11	12	13
1999	151245	48598	47807	17437	8943	15880	13968	1913	411	95	395
2000	83258	120846	31027	21381	6915	4355	6581	5478	813	189	237
2001	367666	68635	94932	16897	10167	3556	2621	3527	2687	439	242
2002	395448	300091	52067	48539	9168	5544	1920	1468	1939	1411	359
2003	340113	261408	196328	34543	25078	4620	3530	1249	843	1100	1007
2004	260359	172273	166036	112867	16305	11103	2162	1680	629	400	1083
2005	366492	171572	94829	110334	51502	6674	5666	1165	744	318	809
2006	157564	219442	109811	52161	45104	21091	3242	2875	569	352	551
2007	543223	121375	168189	61734	26885	19538	8239	1776	1508	293	455
2008	1112513	468268	98184	105061	22152	14209	7305	3341	914	737	371
2009	1025284	728429	383448	62880	40729	10451	5495	3239	1485	513	620
2010	240955	691017	611521	237174	32624	15444	4886	2807	1654	800	679
2011	117224	194409	563046	432721	124025	14466	6299	2164	1383	855	862
2012	340386	73679	139426	404212	273255	55692	6248	2614	1060	724	988
2013	119057	202072	58279	96150	278419	130583	24094	3248	1443	609	1036
2014	411335	74058	147167	50176	89044	149208	62995	11011	1919	910	1046
2015	72464	289943	66054	93229	40823	70958	75588	26121	5433	1045	1069
2016	212760	49328	170881	46203	62182	33887	50649	38657	13022	2602	1031

Year age	3	4	5	6	7	8	9	10	11	12	13
2017	194179	178302	34064	111000	28140	36803	19145	22167	18206	5675	1498
2018	367841	136644	126603	24863	44110	14515	18040	9062	9354	8647	3170
2019	821773	245167	89266	64306	16672	17748	6762	7639	3760	3946	4324
2020	441844	529584	163506	48047	23575	8750	7624	3230	3185	1816	3452
2021	153680	259641	362981	65434	24257	9282	3972	3483	1479	1459	2410

Table 4.14. Northeast Arctic haddock. SAM model. Natural mortality estimated.

Year	3	4	5	6	7	8	9	10	11	12	13
1950	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1951	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1952	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1953	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1954	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1955	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1956	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1957	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1958	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1959	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1960	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Year	3	4	5	6	7	8	9	10	11	12	13
1961	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1962	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1963	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1964	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1965	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1966	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1967	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1968	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1969	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1970	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1971	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1972	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1973	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1974	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1975	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1976	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1977	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1978	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Year	3	4	5	6	7	8	9	10	11	12	13
1979	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1980	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1981	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1982	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1983	0.347	0.258	0.245	0.242	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1984	0.216	0.224	0.214	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1985	0.209	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1986	0.640	0.262	0.200	0.210	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1987	0.200	0.207	0.421	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1988	0.379	0.200	0.200	0.393	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1989	0.200	0.200	0.200	0.232	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1990	0.328	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1991	0.202	0.216	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1992	0.216	0.205	0.203	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1993	0.253	0.248	0.274	0.260	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1994	0.289	0.216	0.295	0.227	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1995	0.379	0.341	0.319	0.291	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1996	0.724	0.319	0.253	0.283	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Year	3	4	5	6	7	8	9	10	11	12	13
1997	0.503	0.267	0.255	0.284	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1998	0.230	0.291	0.265	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
1999	0.200	0.207	0.278	0.260	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2000	0.214	0.200	0.215	0.245	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2001	0.210	0.200	0.226	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2002	0.323	0.213	0.200	0.204	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2003	0.417	0.250	0.208	0.203	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2004	0.414	0.301	0.201	0.228	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2005	0.396	0.302	0.231	0.270	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2006	0.223	0.214	0.275	0.211	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2007	0.297	0.200	0.239	0.320	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2008	0.371	0.279	0.266	0.338	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2009	0.402	0.248	0.284	0.256	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2010	0.358	0.249	0.273	0.285	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2011	0.529	0.468	0.310	0.227	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2012	0.593	0.313	0.204	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2013	0.460	0.340	0.248	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2014	0.283	0.206	0.219	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Year	3	4	5	6	7	8	9	10	11	12	13
2015	0.344	0.402	0.211	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2016	0.305	0.200	0.248	0.229	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2017	0.330	0.296	0.233	0.412	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2018	0.442	0.250	0.265	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2019	0.361	0.269	0.200	0.276	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2020	0.412	0.360	0.323	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
2021	0.412	0.360	0.323	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200

Table 4.15. Northeast Arctic haddock. Summary XSA (p-shrinkage not applied, F shrinkage= 0.5). Thu Apr 23 16:16:08 2020.

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4–7
1950	82517	242696	134602	132125	0.9816	1.5897	0.8305
1951	669592	356206	101130	120077	1.1874	1.2272	0.6238
1952	76993	235716	57527	127660	2.2191	1.7404	0.7243
1953	1276811	512541	82624	123920	1.4998	1.4279	0.5157
1954	152912	538732	117456	156788	1.3349	1.474	0.3802
1955	68791	486182	178951	202286	1.1304	1.536	0.5112
1956	208993	475286	243778	213924	0.8775	1.2623	0.4328
1957	66305	326559	186324	123583	0.6633	1.2455	0.4322
1958	87212	277194	157018	112672	0.7176	1.1252	0.5185

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4–7
1959	398937	365304	133348	88211	0.6615	0.9405	0.3672
1960	289884	401516	114703	154651	1.3483	1.0411	0.484
1961	130882	391762	130068	193224	1.4856	0.9942	0.6362
1962	291125	346736	118945	187408	1.5756	1.0518	0.8
1963	341475	311066	82694	146224	1.7683	1.1458	0.8645
1964	398845	302301	63902	99158	1.5517	1.3572	0.6522
1965	124503	358459	95547	118578	1.241	1.1507	0.4935
1966	294241	388088	127654	161778	1.2673	1.1621	0.583
1967	362769	468419	154643	136397	0.882	0.9984	0.4147
1968	23990	421753	169593	181726	1.0715	0.9976	0.503
1969	21471	342797	184231	130820	0.7101	0.882	0.3972
1970	202641	286838	156150	88257	0.5652	0.9762	0.3575
1971	122645	345853	168613	78905	0.468	0.7638	0.2465
1972	1252757	619817	123068	266153	2.1626	1.0883	0.6918
1973	342252	604302	114785	322226	2.8072	1.1656	0.5362
1974	69287	604427	200945	221157	1.1006	0.8946	0.4315
1975	60222	493447	256440	175758	0.6854	0.8957	0.4268
1976	66905	307480	206755	137264	0.6639	1.12	0.5705

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4–7
1977	134417	229040	141828	110158	0.7767	1.09	0.6832
1978	213614	256138	130603	95422	0.7306	0.9219	0.5112
1979	176286	318567	129566	103623	0.7998	0.7684	0.5515
1980	34826	343544	133268	87889	0.6595	0.7568	0.3978
1981	13441	293155	148313	77153	0.5202	0.7174	0.4012
1982	17394	212027	127285	46955	0.3689	0.7224	0.3093
1983	9563	104393	71491	24600	0.3441	1.0373	0.2715
1984	13434	83502	64118	20945	0.3267	1.0547	0.2498
1985	288300	182799	62012	45052	0.7265	0.9761	0.32
1986	529936	343817	62309	100563	1.6139	1.0484	0.4388
1987	109761	333920	75055	154916	2.064	0.992	0.5958
1988	54817	260029	78423	95255	1.2146	0.9955	0.499
1989	26591	212726	91989	58518	0.6361	0.9774	0.3892
1990	36885	170781	95306	27182	0.2852	1.0159	0.1562
1991	104289	195374	110525	36216	0.3277	1.0374	0.2082
1992	207573	269180	125749	59922	0.4765	0.9797	0.2838
1993	661827	442193	130412	82379	0.6317	1.0031	0.359
1994	292252	542649	144884	135186	0.9331	1.0056	0.425

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4–7
1995	97799	538481	158892	142448	0.8965	1.0247	0.3825
1996	102077	472118	184556	178128	0.9652	1.0175	0.4235
1997	115566	349254	162754	154359	0.9484	1.0519	0.4862
1998	58271	249707	124288	100630	0.8097	1.0113	0.4235
1999	230876	252735	93038	83195	0.8942	1.021	0.4212
2000	89446	250625	85299	68944	0.8083	1.026	0.2802
2001	366245	356725	110567	89640	0.8107	0.9903	0.2795
2002	342709	443325	128727	114798	0.8918	1.011	0.3173
2003	224429	474128	150713	138926	0.9218	1.019	0.4292
2004	225230	455037	157794	158279	1.0031	1.0192	0.3795
2005	347443	471039	168020	158298	0.9421	1.0029	0.49
2006	157072	415213	142651	153157	1.0736	0.9938	0.405
2007	668942	496479	140120	161525	1.1528	0.9916	0.4228
2008	1339631	738745	146275	155604	1.0638	0.9928	0.3902
2009	1454218	1075831	168600	200061	1.1866	1.0019	0.3525
2010	526318	1253906	233140	249200	1.0689	0.9994	0.293
2011	245890	1275393	336181	309785	0.9215	0.9978	0.3175
2012	381957	1158133	419440	315627	0.7525	0.9994	0.266

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4–7
2013	156234	988402	465852	193744	0.4159	0.9967	0.134
2014	389701	993569	511632	177522	0.347	0.9968	0.111
2015	103379	934929	524799	194756	0.3711	0.9953	0.1558
2016	260916	846474	496913	233183	0.4693	1.0006	0.2208
2017	200597	729410	417225	227588	0.5455	0.994	0.3318
2018	368406	618897	307333	191276	0.6224	0.9943	0.3915
2019	871151	709103	236928	175402	0.7403	0.9963	0.4545
2020	415726	760305	214036	182468	0.8525	0.9962	0.4345

Table 4.16. Northeast Arctic haddock. Input data for recruitment prediction (RCT3)- recruits as 3 year-olds. Recr: recruitment estimate from SAM 2020 NT1: Norwegian Russian winter bottom trawl survey age 1 NT2: Norwegian Russian winter bottom trawl survey age 2 NT3: Norwegian Russian winter bottom trawl survey age 3 NAK1: Norwegian Russian winter acoustic survey age 1 NAK2: Norwegian Russian winter acoustic survey age 2 NAK3: Norwegian Russian winter acoustic survey age 3 ECO1: Ecosystem survey age 1. ECO2: Ecosystem survey age 2. The Russian survey (RT) was discontinued in 2017 and has not been used for recruitment.

Year class	Recr.	NT1	NT2	NT3	NAK1	NAK2	NAK3	EC01	ECO2
1990	848769	NA	NA	NA	NA	NA	NA	NA	NA
1991	396614	NA	NA	315	NA	NA	349	NA	NA
1992	100060	NA	225	55	NA	188	42	NA	NA
1993	99507	604	200	56	888	89	30	NA	NA
1994	119084	1429	265	80	1198	95	57	NA	NA
1995	63240	301	91	22	133	27	34	NA	NA
1996	151245	1118	197	57	509	151	84	NA	NA

Year class	Recr.	NT1	NT2	NT3	NAK1	NAK2	NAK3	EC01	ECO2
1997	83258	248	83	24	211	30	36	NA	NA
1998	367666	1208	437	294	653	405	234	NA	NA
1999	395448	832	447	313	1063	266	255	NA	NA
2000	340113	1231	475	352	753	268	204	NA	NA
2001	260359	1700	472	173	1315	362	151	NA	NA
2002	366492	3327	707	318	2744	467	221	NA	268
2003	157564	701	386	79	529	144	56	189	114
2004	543223	4473	1310	443	2277	625	209	604	929
2005	1112513	4945	1685	1591	2091	954	812	2270	1819
2006	1025284	3731	2042	1230	2016	1754	884	988	1292
2007	240955	853	317	103	778	209	128	322	144
2008	117224	563	80	53	444	86	54	135	65
2009	340386	1635	354	316	1559	288	192	274	114
2010	119057	676	137	57	429	95	67	105	42
2011	411335	1867	490	381	1583	407	335	591	223
2012	72464	345	124	31	293	110	24	156	75
2013	212760	1281	342	163	1839	247	72	265	145
2014	194179	1134	562	135	1593	107	81	320	145

Year class	Recr.	NT1	NT2	NT3	NAK1	NAK2	NAK3	EC01	ECO2
2015	367841	2299	770	336	1276	331	170	794	189
2016	821773	5065	1676	1076	3344	806	508	936	NA
2017	441844	3823	1125	424	2931	688	286	NA	585
2018	153680	1898	268	118	1545	261	43	379	58
2019	NA	111	31	NA	273	32	NA	27	NA
2020	NA	462	NA	NA	435	NA	NA	NA	NA

Table 4.17. Northeast Arctic haddock Analysis by RCT3 ver3.1 - R translation

Analysis by RCT3 ver3.1 - R translation

Data for 8 surveys over 31 year classes : 1990 - 2020
Regression type = C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as 0.2
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2018

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred
NT1	0.9691	5.441	0.2604	0.9137	20	7.549	12.76	0.2972
NT2	0.8716	7.198	0.3445	0.8606	20	5.594	12.07	0.3981
NT3	0.6869	8.867	0.1120	0.9830	20	4.783	12.15	0.1292
NAK1	1.1972	4.034	0.5124	0.7322	20	7.343	12.83	0.5854
NAK2	0.9353	7.276	0.3050	0.8873	20	5.568	12.48	0.3476
NAK3	0.8015	8.550	0.1825	0.9560	20	3.786	11.59	0.2206
EC01	1.0586	6.267	0.3663	0.8532	14	5.941	12.56	0.4250
ECO2	0.8087	8.248	0.3967	0.8071	15	4.074	11.54	0.4843
VPA Mean	NA	NA	NA	NA	28	NA	12.58	0.8028

WAP.weights
0.13206
0.07360
0.29163
0.03404
0.09653
0.23972

```
    0.06460
    0.04973
    0.01810

yearclass:2019
   index  slope intercept     se rsquare  n indices prediction se.pred
     NT1 1.0341     4.886 0.3606  0.8393 20   4.715      9.762  0.5627
     NT2 0.8802     7.128 0.3358  0.8594 20   3.455     10.170  0.4915
     NT3     NA        NA     NA      NA NA      NA         NA      NA
    NAK1 1.2736     3.396 0.5859  0.6643 20   5.612     10.543  0.7771
    NAK2 0.9857     6.947 0.3531  0.8468 20   3.490     10.388  0.4971
    NAK3     NA        NA     NA      NA NA      NA         NA      NA
    EC01 1.1232     5.823 0.4206  0.8056 15   3.326      9.558  0.6831
    ECO2     NA        NA     NA      NA NA      NA         NA      NA
 VPA Mean     NA        NA     NA      NA 29      NA     12.518  0.7822
 WAP.weights
    0.18821
    0.24677
         NA
    0.09871
    0.24116
         NA
    0.12772
         NA
    0.09743

yearclass:2020
   index slope intercept     se rsquare  n indices prediction se.pred
     NT1 1.031     4.895 0.3624  0.8374 19   6.137      11.22  0.4597
     NT2    NA        NA     NA      NA NA      NA         NA      NA
     NT3    NA        NA     NA      NA NA      NA         NA      NA
    NAK1 1.257     3.489 0.5814  0.6667 19   6.078      11.13  0.7321
    NAK2    NA        NA     NA      NA NA      NA         NA      NA
```

```
   NAK3    NA       NA     NA      NA NA      NA        NA      NA
   EC01    NA       NA     NA      NA NA      NA        NA      NA
   ECO2    NA       NA     NA      NA NA      NA        NA      NA
VPA Mean    NA       NA     NA      NA 29      NA      12.51  0.7770
WAP.weights
    0.5733
       NA
       NA
    0.2260
       NA
       NA
       NA
       NA
    0.2006

                 WAP logWAP  int.se
yearclass:2018 188877  12.15 0.09103
yearclass:2019  30736  10.33 0.24414
yearclass:2020  94702  11.46 0.34806
```

Table 4.18. Northeast Arctic haddock. Prediction with management option table: Input data (based on SAM estimates

"MFDP version 1a"

"Run: 2021"

"Time and date: 22:28 19.04.2021"

"Fbar age range: 4-7"

""

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	153680	0.405	0.029	0	0	0.259	0.0368	0.693
4	259641	0.293	0.081	0	0	0.494	0.1603	0.919
5	362981	0.263	0.211	0	0	0.813	0.3808	1.180
6	65434	0.225	0.45	0	0	1.222	0.5906	1.475
7	24257	0.2	0.735	0	0	1.774	0.6223	1.843
8	9282	0.2	0.886	0	0	2.284	0.6257	1.920
9	3972	0.2	0.942	0	0	2.663	0.6257	2.150
10	3483	0.2	0.979	0	0	3.279	0.6257	2.413
11	1479	0.2	1	0	0	3.444	0.6257	2.489
12	1459	0.2	1	0	0	3.754	0.6257	2.863
13	2410	0.2	1	0	0	3.705	0.6257	3.453

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	30736	0.405	0.03	0	0	0.273	0.0368	0.708
4	.	0.293	0.078	0	0	0.481	0.160	0.905
5	.	0.263	0.199	0	0	0.784	0.3808	1.154
6	.	0.225	0.418	0	0	1.154	0.5906	1.414
7	.	0.2	0.679	0	0	1.609	0.6223	1.745
8	.	0.2	0.871	0	0	2.191	0.6257	1.931

9	.	0.2	0.946	0	0	2.716	0.6257	2.066
10	.	0.2	0.971	0	0	3.085	0.6257	2.314
11	.	0.2	1	0	0	3.686	0.6257	2.379
12	.	0.2	1	0	0	3.624	0.6257	2.799
13	.	0.2	1	0	0	4.059	0.6257	3.468

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	94702	0.405	0.03	0	0	0.315	0.0368	0.753
4	.	0.293	0.082	0	0	0.497	0.160	0.922
5	.	0.263	0.192	0	0	0.766	0.3808	1.138
6	.	0.225	0.401	0	0	1.117	0.5906	1.380
7	.	0.2	0.649	0	0	1.526	0.6223	1.696
8	.	0.2	0.833	0	0	2.000	0.6257	1.884
9	.	0.2	0.937	0	0	2.610	0.6257	2.070
10	.	0.2	0.973	0	0	3.145	0.6257	2.283
11	.	0.2	1	0	0	3.507	0.6257	2.334
12	.	0.2	1	0	0	3.854	0.6257	2.775
13	.	0.2	1	0	0	3.938	0.6257	3.471

Table 4.19. Northeast Arctic haddock. Prediction with management option table for 2021–2023 (TAC constraint applied for intermediate year

MFDP version 1a

Run: 2021

2021MFDP Index file 19.04.2021

Time and date: 22:28 19.04.2021

Fbar age range: 4-7

202
1

Biomass	SSB	FMult	FBar	Landings

648860	200849	0.9932	0.4355	232537

2022					2023	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
507632	204751	0	0	0	569679	309362
.	204751	0.1	0.0439	26690	544131	293022
.	204751	0.2	0.0877	52064	519923	277586
.	204751	0.3	0.1316	76192	496979	263004
.	204751	0.4	0.1754	99141	475232	249226
.	204751	0.5	0.2193	120972	454615	236208
.	204751	0.6	0.2631	141745	435068	223906
.	204751	0.7	0.307	161515	416531	212280
.	204751	0.8	0.3508	180334	398951	201292
.	204751	0.9	0.3947	198253	382274	190906
.	204751	1	0.4385	215319	366452	181089
.	204751	1.1	0.4824	231576	351439	171807
.	204751	1.2	0.5262	247065	337192	163032
.	204751	1.3	0.5701	261828	323667	154734
.	204751	1.4	0.6139	275901	310828	146888
.	204751	1.5	0.6578	289320	298636	139467
.	204751	1.6	0.7016	302119	287058	132448
.	204751	1.7	0.7455	314329	276060	125808
.	204751	1.8	0.7893	325981	265612	119527
.	204751	1.9	0.8332	337103	255683	113583
.	204751	2	0.877	347723	246247	107960

Table 4.20. Northeast Arctic haddock. Prediction single option table for 2020–2022 based on HCR

MFDP version 1a

Run: Fhcr

Time and date: 22:38 19.04.2021

Fbar age range: 4-7

Year:	2021	F multiplier:	0.9932	Fbar:	0.4355				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0366	4541	3147	153680	39803	4457	1154	4457	1154
4	0.1592	33255	30561	259641	128263	21031	10389	21031	10389
5	0.3782	101347	119589	362981	295104	76589	62267	76589	62267
6	0.5866	26289	38776	65434	79960	29445	35982	29445	35982
7	0.6181	10240	18872	24257	43032	17829	31628	17829	31628
8	0.6215	3934	7553	9282	21200	8224	18783	8224	18783
9	0.6215	1683	3619	3972	10577	3742	9964	3742	9964
10	0.6215	1476	3562	3483	11421	3410	11181	3410	11181
11	0.6215	627	1560	1479	5094	1479	5094	1479	5094
12	0.6215	618	1770	1459	5477	1459	5477	1459	5477
13	0.6215	1021	3527	2410	8929	2410	8929	2410	8929
Total		185031	232537	888078	648860	170074	200849	170074	200849

Year:	2022	F multiplier:	0.7982	Fbar:	0.35				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0294	732	518	30736	8391	922	252	922	252
4	0.128	10320	9340	98822	47533	7708	3708	7708	3708
5	0.304	38324	44226	165188	129507	32872	25772	32872	25772
6	0.4714	64912	91785	191163	220602	79906	92212	79906	92212

7	0.4967	10397	18142	29062	46761	19733	31751	19733	31751
8	0.4994	3846	7426	10704	23452	9323	20427	9323	20427
9	0.4994	1467	3030	4082	11087	3862	10488	3862	10488
10	0.4994	628	1452	1747	5389	1696	5233	1696	5233
11	0.4994	550	1309	1532	5646	1532	5646	1532	5646
12	0.4994	234	654	650	2357	650	2357	650	2357
13	0.4994	611	2120	1702	6906	1702	6906	1702	6906
Total		132021	180003	535387	507632	159906	204751	159906	204751

Year:	2023	F multiplier:	0.7982	Fbar:	0.35				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0294	2256	1699	94702	29831	2841	895	2841	895
4	0.128	2079	1917	19907	9894	1632	811	1632	811
5	0.304	15050	17127	64869	49690	12455	9540	12455	9540
6	0.4714	31818	43909	93703	104666	37575	41971	37575	41971
7	0.4967	34082	57803	95269	145381	61830	94352	61830	94352
8	0.4994	5202	9800	14479	28958	12061	24122	12061	24122
9	0.4994	1911	3955	5318	13881	4983	13007	4983	13007
10	0.4994	729	1664	2028	6379	1973	6207	1973	6207
11	0.4994	312	728	868	3044	868	3044	868	3044
12	0.4994	273	759	761	2933	761	2933	761	2933
13	0.4994	420	1457	1169	4602	1169	4602	1169	4602
Total		94131	140817	393074	399259	138149	201485	138149	201485

Table 4.21. Northeast Arctic haddock. Yield-per-recruit. Input data and results.

MFYPR version 2a

Run: 2021YPR

Time and date: 22:25 19.04.2021

Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	4.2321	6.4432	1.9203	5.0608	1.9203	5.0608
0.1	0.0495	0.1087	0.2095	3.7039	4.7588	1.4293	3.4316	1.4293	3.4316
0.2	0.099	0.1778	0.3169	3.3732	3.7718	1.1326	2.4938	1.1326	2.4938
0.3	0.1485	0.2264	0.3785	3.1444	3.1343	0.9353	1.9004	0.9353	1.9004
0.4	0.198	0.2629	0.417	2.9753	2.6943	0.7954	1.5002	0.7954	1.5002
0.5	0.2475	0.2917	0.4427	2.8442	2.3754	0.6914	1.2172	0.6914	1.2172
0.6	0.297	0.3153	0.4607	2.7389	2.1352	0.6114	1.0098	0.6114	1.0098
0.7	0.3465	0.3351	0.4739	2.6519	1.9487	0.5482	0.8532	0.5482	0.8532
0.8	0.396	0.3521	0.4839	2.5784	1.8001	0.497	0.7322	0.497	0.7322
0.9	0.4455	0.367	0.4917	2.5152	1.6793	0.4549	0.6367	0.4549	0.6367
1	0.495	0.3802	0.4979	2.4601	1.5791	0.4196	0.56	0.4196	0.56
1.1	0.5445	0.392	0.5029	2.4114	1.4948	0.3897	0.4974	0.3897	0.4974
1.2	0.594	0.4028	0.5071	2.3679	1.4229	0.3641	0.4458	0.3641	0.4458
1.3	0.6435	0.4126	0.5105	2.3287	1.3608	0.3419	0.4026	0.3419	0.4026
1.4	0.693	0.4216	0.5135	2.2931	1.3066	0.3226	0.3661	0.3226	0.3661
1.5	0.7425	0.4299	0.516	2.2605	1.2588	0.3055	0.3349	0.3055	0.3349
1.6	0.792	0.4377	0.5182	2.2306	1.2164	0.2903	0.3081	0.2903	0.3081
1.7	0.8415	0.445	0.5201	2.2029	1.1784	0.2768	0.2849	0.2768	0.2849
1.8	0.891	0.4519	0.5218	2.1771	1.1442	0.2647	0.2646	0.2647	0.2646
1.9	0.9405	0.4583	0.5234	2.1531	1.1131	0.2538	0.2468	0.2538	0.2468
2	0.99	0.4644	0.5247	2.1306	1.0848	0.2439	0.2311	0.2439	0.2311

	F multiplier	Absolute F

Reference point

Fbar(3-13)	1	0.495
FMax	>=1000000	
F0.1	0.4082	0.2021
F35%SPR	0.3284	0.1626

Weights in kilograms

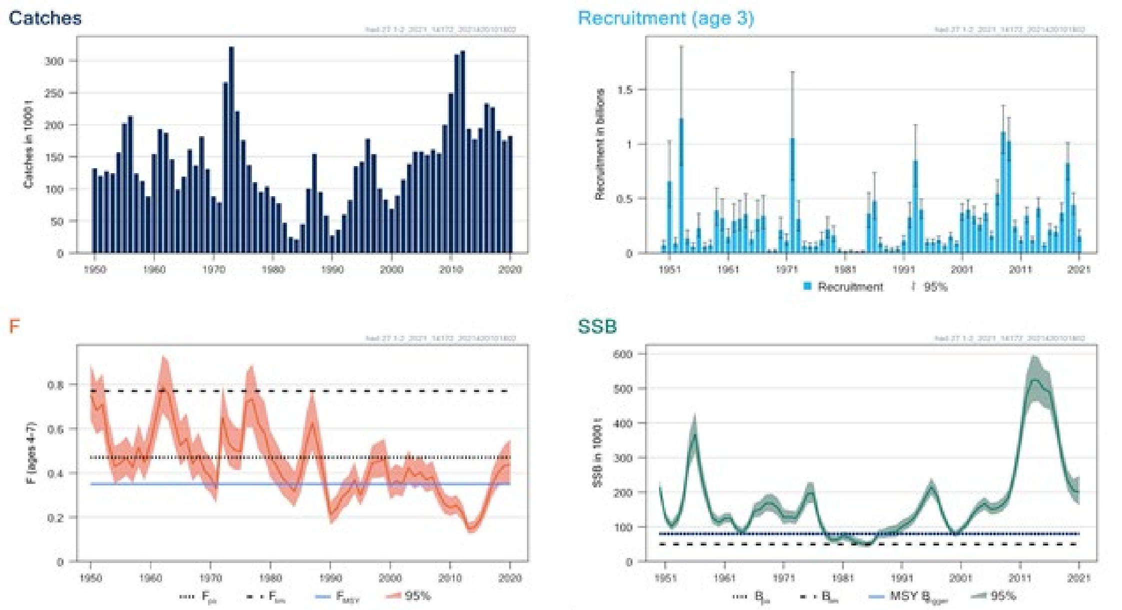


Figure 4.1 Landings, fishing mortality, recruitment, and spawning-stock biomass of Northeast Arctic haddock 1950–2021. Fishing mortality and spawning-stock biomass are given with point wise 95% confidence intervals (shaded areas).

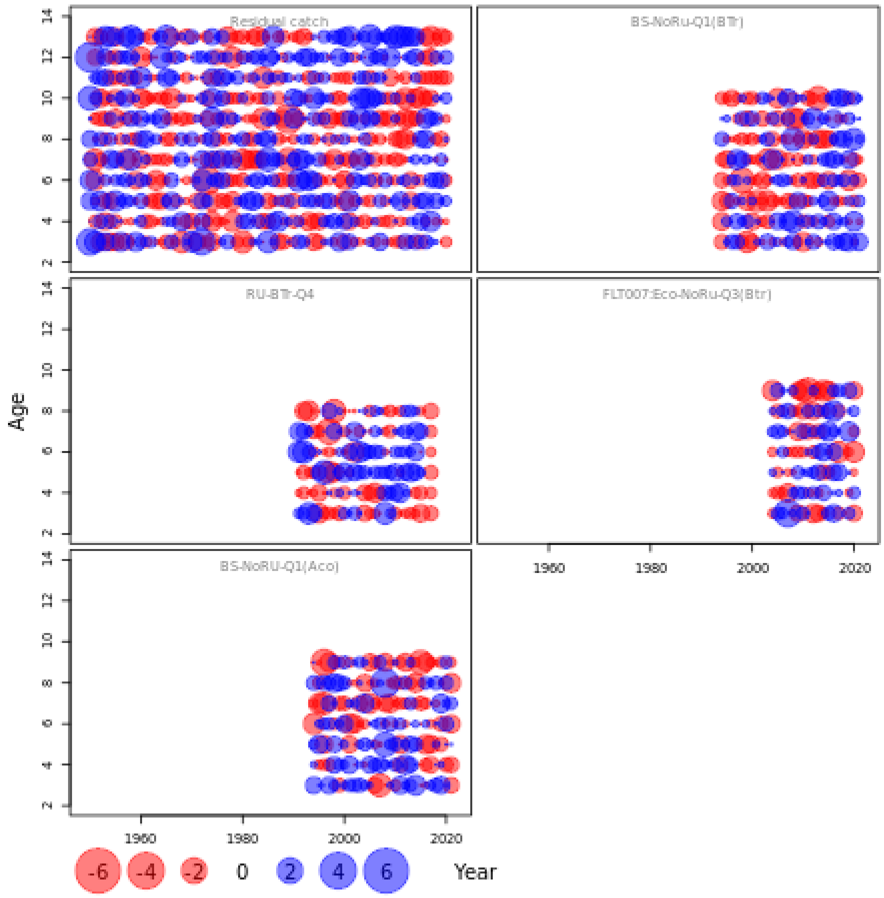


Figure 4.2. Northeast Arctic haddock; on step ahead residuals for the final SAM run. Blue circles indicate positive residuals (observations larger than predicted) and red circles indicate negative residuals.

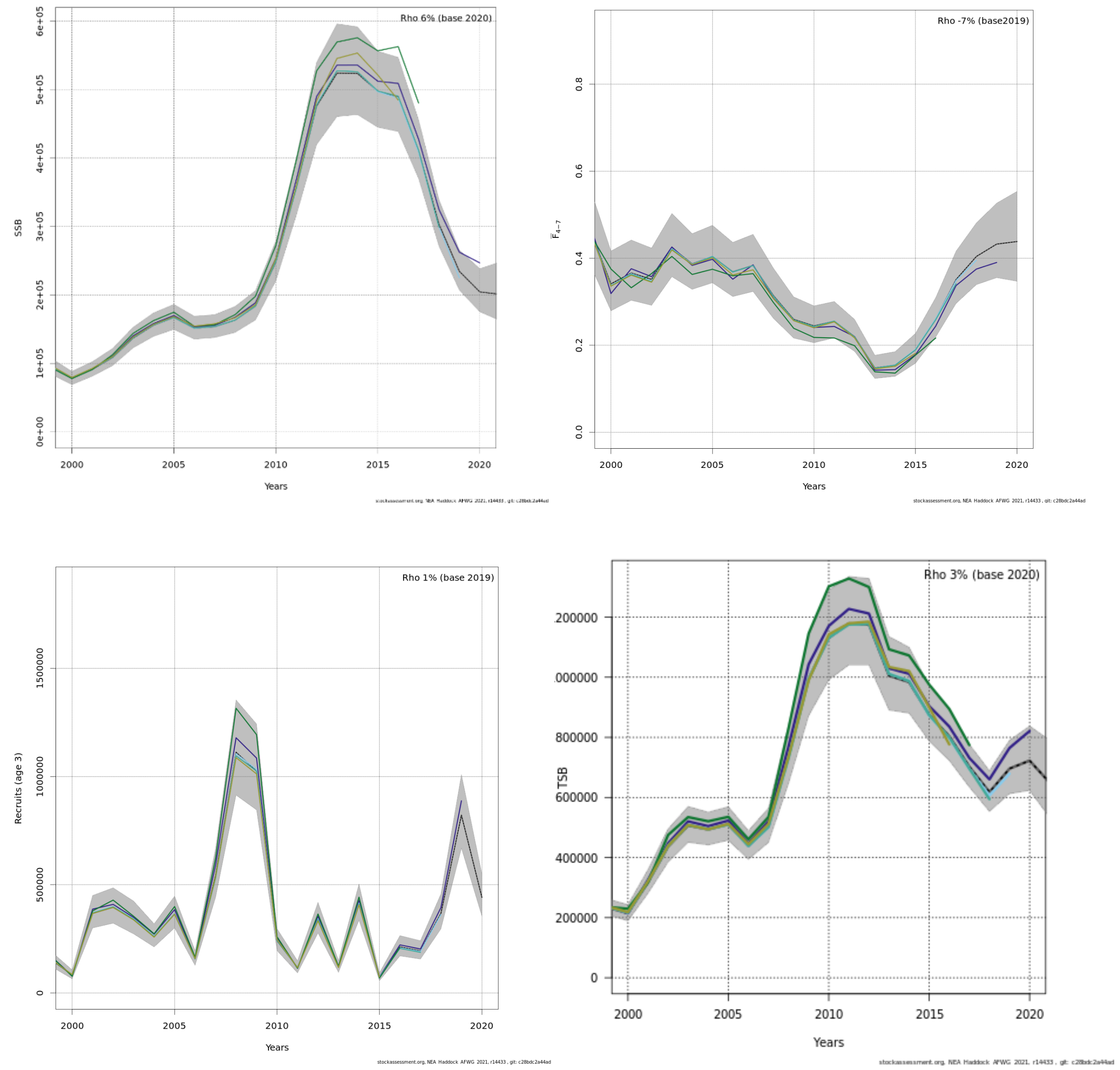


Figure 4.3. Northeast Arctic haddock. 5 year retrospective plots of SSB (top right), fishing mortality (top left), TSB (bottom left), and recruitment (bottom right) for years 2000–2021 (SAM with 95% confidence intervals).

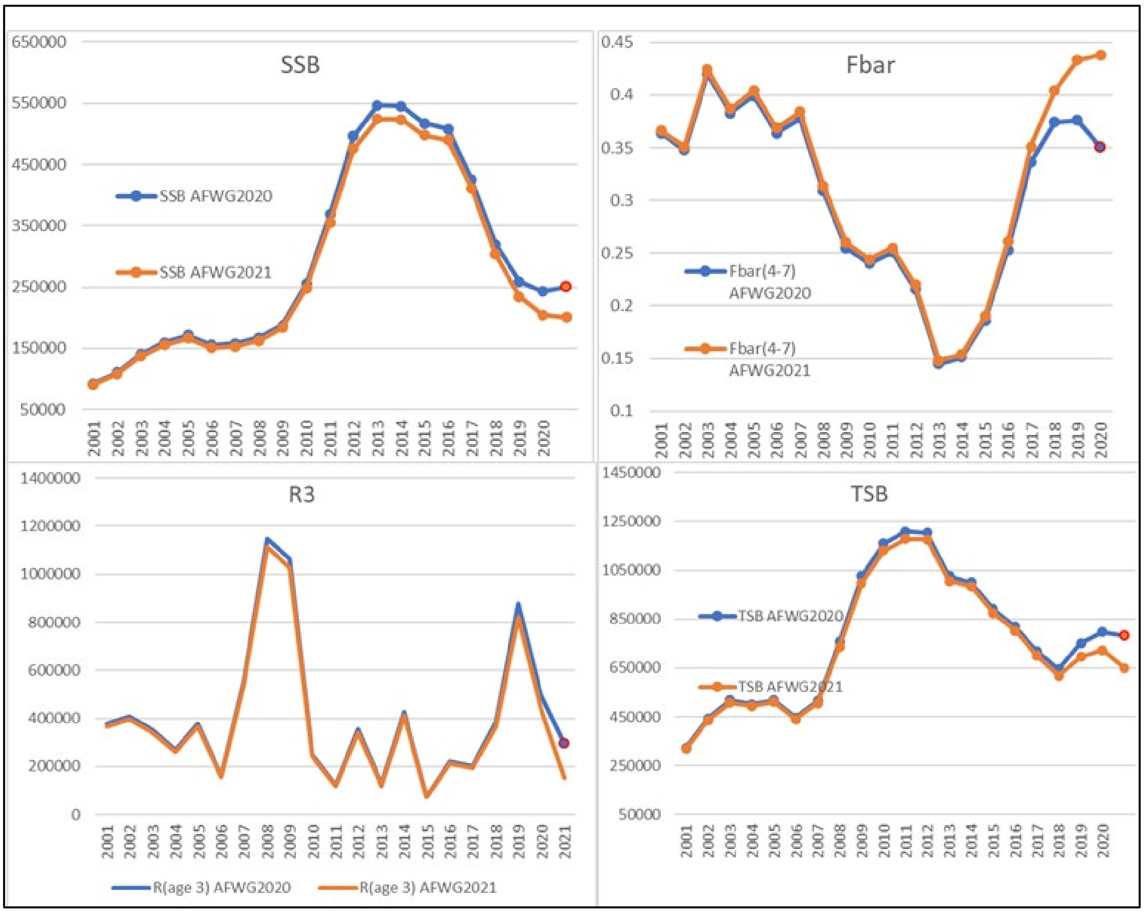


Figure 4.4. Results of assessment of NEA haddock. Fbar, TSB, recruits and SSB from AFWG 2020 (last year) and AFWG 2021 from 2001 and onwards. The last red points on the blue lines are forecasts from last year.

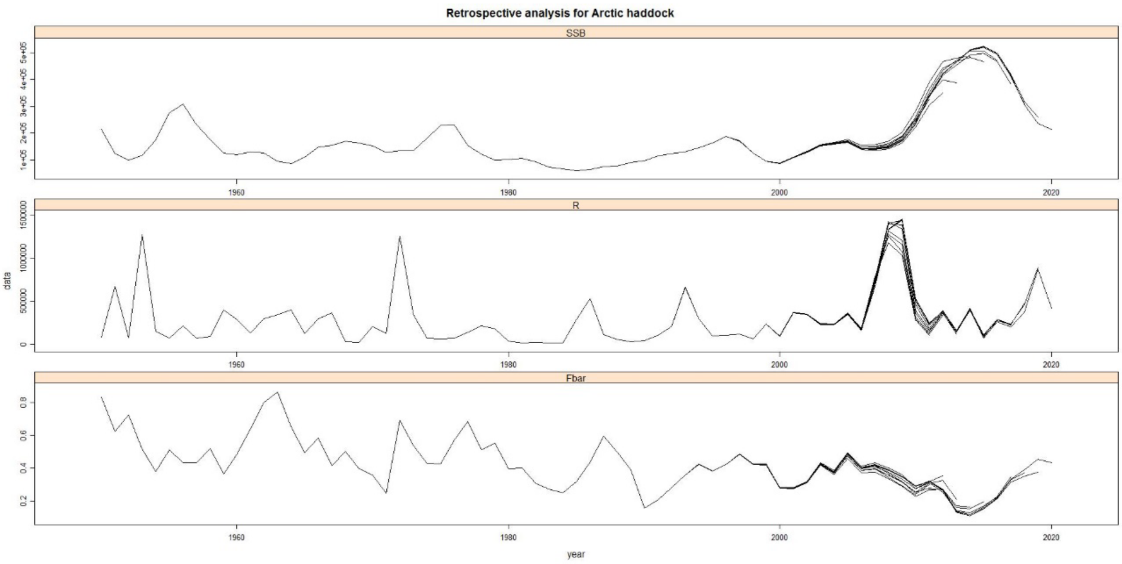


Figure 4.5. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1950–2020 (XSA without P shrinkage, F shrinkage= 0.5)

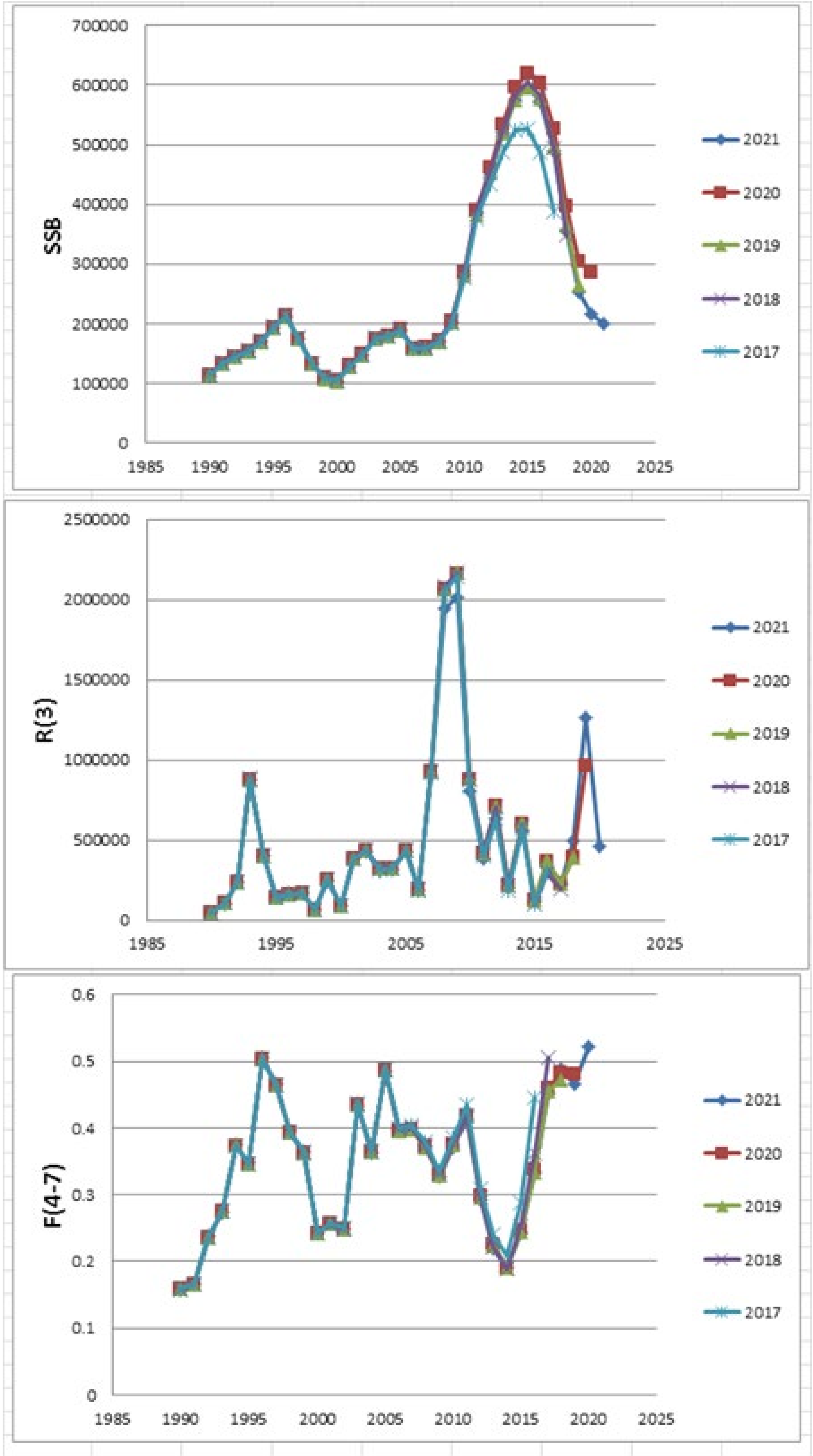


Figure 4.6. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1990–2020 from TSVPA model (see WD 22).

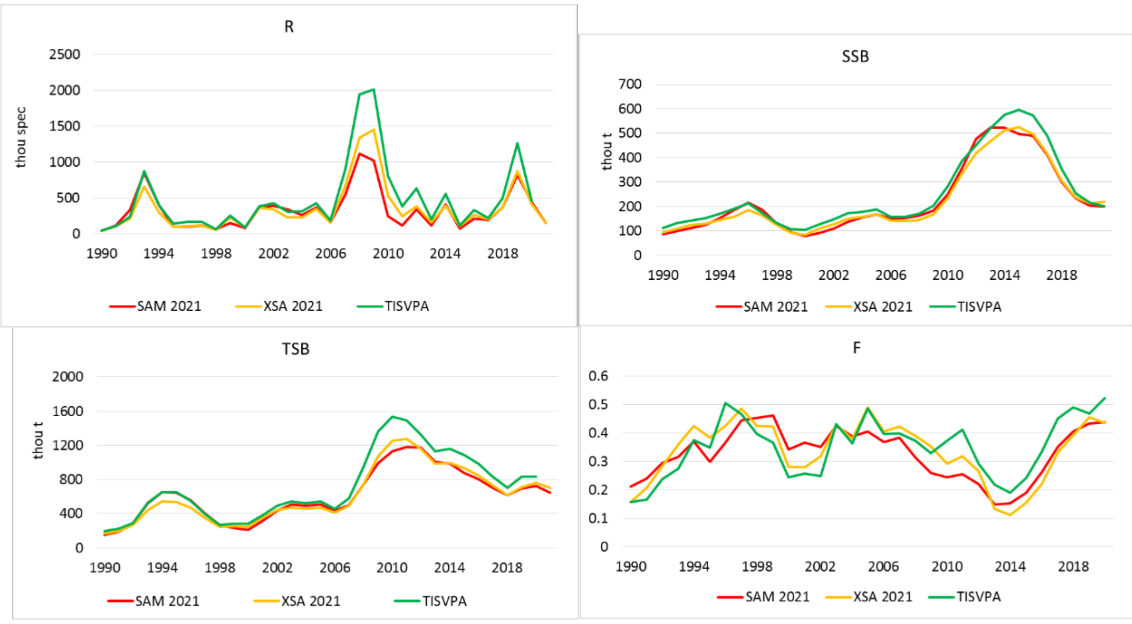


Figure 4.7. Comparison of results of assessment of NEA haddock. Recruits, biomass, spawning biomass and F in 1990–2020 by different models: medium SAM estimates, XSA with setting mentioned at section 4.9 and TISVPA with settings as mentioned at WDXX.

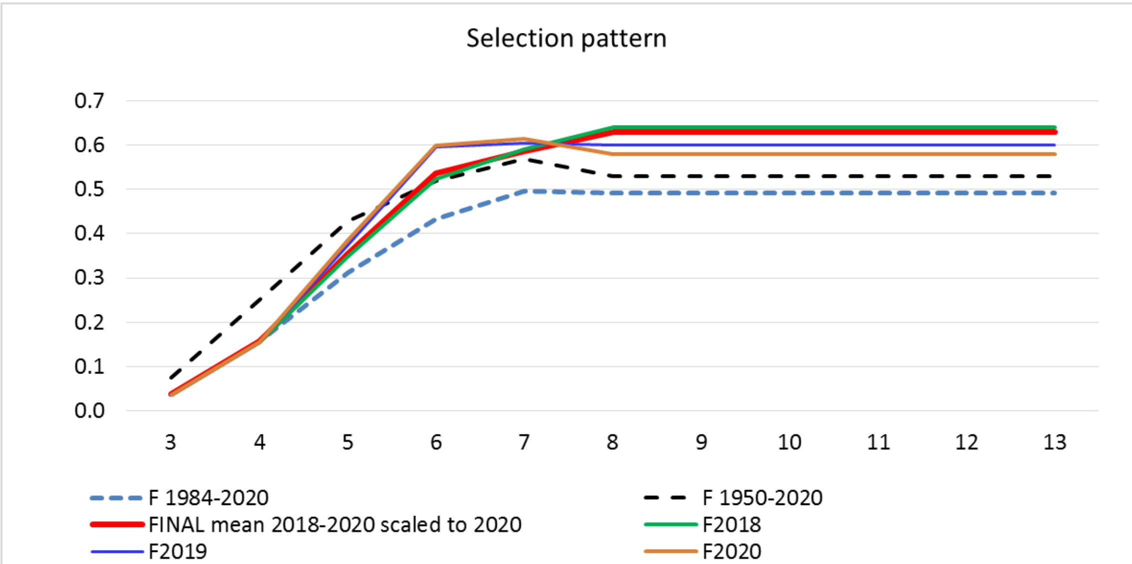


Figure 4. 8. Standard selection pattern model (red) used for short-term forecasts at AFWG 2021.

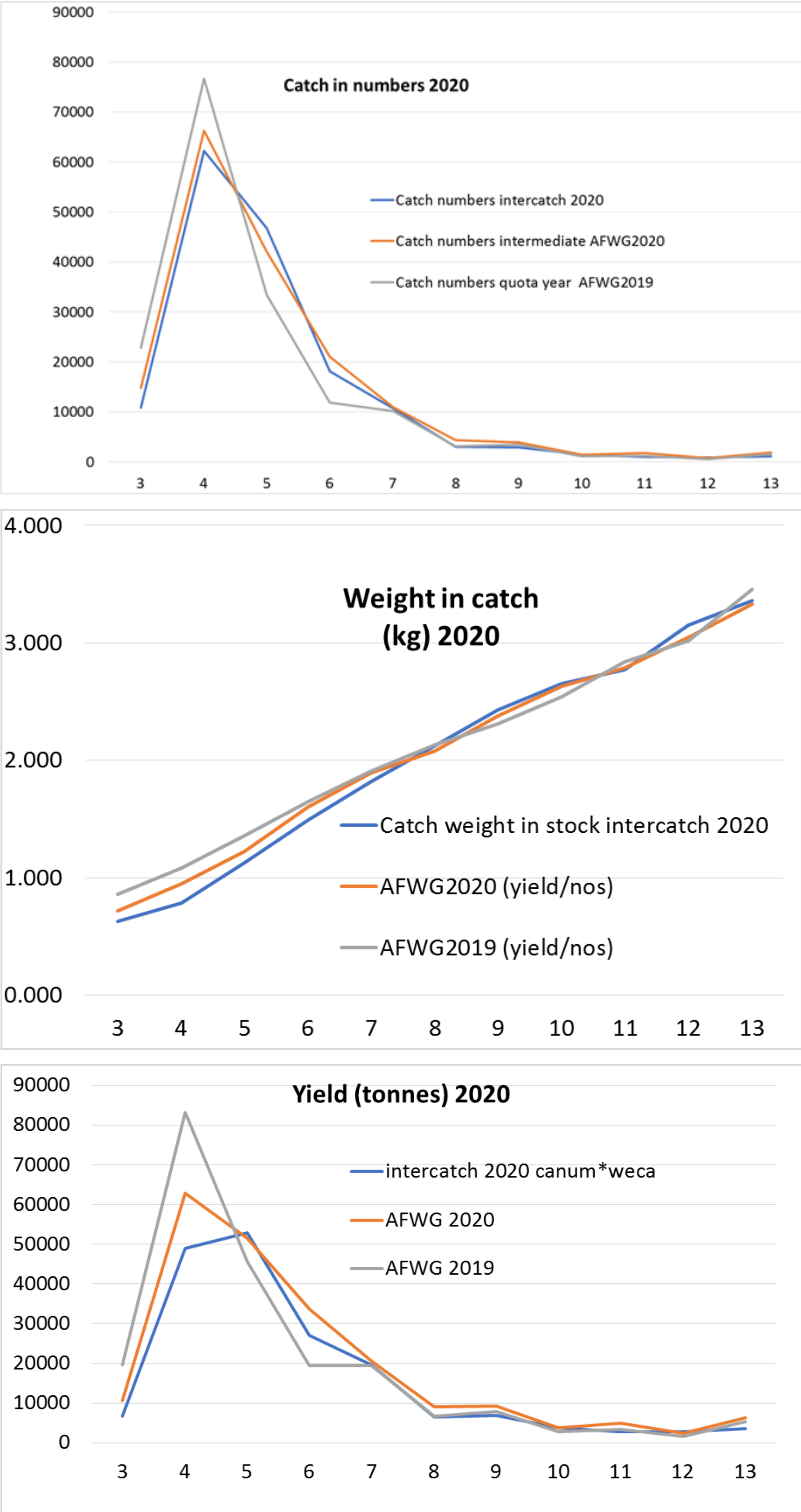


Figure 4.9. Comparisons of catch data by age 2020 from InterCatch with forecasts from AFWG 2019 and 2020. Top: catch number of individuals, middle: catch weights, bottom: yield.

5 Northeast Arctic saithe[1]

5.1 The fishery (Table 5.1 and Table 5.2, Figure 5.1)

Currently, the main fleets targeting saithe are trawl, purse-seine, gillnet, handline, and Danish seine. Landings of saithe were highest in 1970–1976 with an average of 239 000 t and a maximum of 265 000 t in 1970. This period was followed by a sharp decline to a level of about 160 000 t in the years 1978–1984, while in 1985 to 1991 the landings ranged from 67 000–123 000 t. After 1991 landings increased, ranging between 136 000 t (in 2000) and 212 000 t (in 2006), followed by a decline to 132 000 t in 2015. In 2020 landings were 169 405 t and 188 176 t in 2020.

Discarding, although illegal, occurs in the saithe fishery, but is not considered a major problem in the assessment. Due to its nearshore distribution saithe is virtually inaccessible for commercial gears during the first couple of years of life and there are no reports indicating overall high discard rates in the Norwegian fisheries. There are reported incidents of slipping in the purse-seine fishery, mainly related to minimum landing size. Observations from non-Norwegian commercial trawlers indicate that discarding may occur when vessels targeting other species catch saithe, for which they may not have a quota or have filled it. However, there are no quantitative estimates of the level of discarding available.

5.1.1 ICES advice applicable to 2021 and 2022

The advice from ICES for 2021 was as follows:

- ICES advised that catches in 2021 should be no more than 197 779 t.

The advice from ICES for 2022 was as follows:

- ICES advised that catches in 2022 should be no more than 197 212 t.

5.1.2 Management applicable in 2021 and 2022

Management of Saithe in subareas 1 and 2 is by TAC and technical measures. For 2021, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 197 779 t.

For 2022, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 197 212 t.

5.1.3 The fishery in 2021 and expected landings in 2022

Provisional figures show that the landings in 2021 were approximately 188 176 t, which is 9603 t lower than the TAC of 197 779 t.

Since the WG does not have any prognosis of total landings in 2022 available, the TAC of 197 212 t is used in the projections.

[1] Saithe (*Pollachius virens*) in subareas 1 and 2 (Northeast Arctic); pok.27.1-2.

5.2 Commercial catch-effort data and research vessel surveys

5.2.1 Catch-per-unit-effort

The NEA saithe interbenchmark protocol (IBP; ICES CM 2014/ACOM: 53) recommended leaving out the CPUE time-series in the model tuning (see section 5.3.5). A detailed description of the Norwegian trawl CPUE and its previous use is given in the stock annex.

5.2.2 Survey results (Figure 5.1–5.2)

An *ad hoc* subgroup of the AFWG was held to review proposed changes to several survey series using the new "StoX" survey computation methodology on 16 and 17 April 2017 at the JRC, Italy. The survey series reviewed included the coastal survey for saithe for the period 2003 to 2017. StoX is a new program developed at IMR Norway, to produce a more robust, transparent, and automated method of computing survey series. The method is currently used in ICES assessments (for example for NSS herring). For the saithe survey series, a WD was presented to the group (Mehl *et al.*, 2018a), examining the differences between the previous survey series and those resulting from StoX in survey indices by age, as well as mean weight and mean length. During the meeting consistency plots were produced for each survey and showed to have a better fit with the StoX series compared to the old series. The meeting concluded that the new StoX survey series should be used to replace the previous survey series in AFWG stock assessment, but that once the assessment model is run the residuals and fits to the data should be examined to check for unexpected detrimental effects on model performance. The resulting SAM model fits using the old and the StoX survey series (using data for both survey series up to 2016, but excluding the 2003 StoX estimate, as this was considered abnormally high) were practically the same, without any detrimental effects on model performance.

The echo abundance observed in 2021 (Staby *et al.*, in press) increased by 30% compared to 2020 and was about 20% higher than the average for 2003–2020. The abundance estimated with StoX increased with 8% compared to 2020. This increase is the result of higher estimates of 5–9-year-old saithe, which were between 24–33% higher than in 2020. Only estimates of 3-year old saithe were below the 2020 estimate. The proportion of saithe in the southern part of the survey area (south of the Lofoten islands between 62^0–67^0N) increased from about 20% in 1997 to above 60% in 2008, decreased in later years and was 20% in 2021, similar to the 2020 proportion.

5.2.3 Recruitment indices

Owing to the nearshore distribution of juvenile saithe, obtaining early estimates of recruitment for ages 0–2 has not been possible so far. The survey recruitment indices are strongly dependent on the extent to which 2–4 year old saithe have migrated from the coastal areas and become available to the acoustic saithe survey on the banks, and this varies between years. Also, observations from an observer programme, established in 2000 to start a 0-group index series (Borge and Mehl, WD 21 2002) did not seem to reflect the dynamics in year-class strength very well. (Mehl, WD 6 2007; Mehl, WD 7 to WKROUND 2010). The programme was consequently terminated in 2010.

5.3 Data used in the assessment

5.3.1 Catch numbers-at-age (Table 5.3)

Total Norwegian landings by gear and landings data for all other countries from 2021 were updated based on the official total catch (preliminary) reported to ICES or to Norwegian authorities.

Age composition data for 2021 were available for Norwegian landings. The biological sampling of all gear groups, areas, and quarters was sufficient to produce a reliable catch-at-age matrix for 2021. As in previous years age data from the Danish seine and bottom-trawl fishery were combined to increase the number of samples by area and quarter, thereby improving the estimate of catch-at-age numbers.

Catch-at-age estimates (numbers and mean weight and length-at-age) were produced with StoX-Reca (version 3.4) for the 2021 assessment[2]. Comparative runs with the older ECA program were not possible for the 2021 data since data in the required format is not available anymore. This is the second year that catch-at-age estimates are produced with StoX-Reca for input in the SAM assessment. In previous years catch-at-age was estimated manually, and until 2020 with ECA.

5.3.2 Weight-at-age (Table 5.4)

Constant weights-at-age values for age groups 3–11 are used for the period 1960–1979, whereas estimated values for the 12+ group vary during this period. For subsequent years, annual estimates of weight-at-age in the catches are used. Weight-at-age in the stock is assumed to be the same as weight-at-age in the catch. Compared to 2020, estimated weight-at-age for age groups 3–12+ differed only slightly in 2021.

5.3.3 Natural mortality

A fixed natural mortality of 0.2 for all age groups was used both in the assessment and the forecast.

5.3.4 Maturity-at-age (Table 5.5)

A 3-year running average is used for the period from 1985 and onwards (2-year average for the first and last year). Inconsistencies between proportion mature fish and trends in SSB and recruitment since 2008 resulted in the NEA saithe IBP to recommend the use of a constant maturity ogive for the years from 2007 and onwards based on the average 2005–2007 (ICES CM 2014/ACOM: 53). Analysis are currently being done to investigate which method, i.e. macroscopic determination, otolith spawning rings or histological analysis, is the most reliable to determine the maturity stage.

5.3.5 Tuning data (Table 5.6)

Until the 2005 WG, the XSA tuning was based on three dataseries: CPUE from Norwegian purse-seine and Norwegian trawl and indices from a Norwegian acoustic survey. The 2005 WG found rather large and variable log q residuals and large S.E. log q for the purse-seine fleet, as well as strong year effects, and in the combined tuning the fleet got low scaled weights. The WG decided

[2] https://github.com/StoXProject/RstoxFDA/

not to include the purse-seine tuning fleet in the analysis. This was confirmed by new analyses at the 2010 benchmark assessment (ICES CM 2010/ACOM:36). The trawl CPUE series on the other hand did not show the trends in stock size abundance of NEA saithe in later years. In the more recent years there were signs of changes in fishing strategy, with fewer and shorter fishing periods and a smaller proportion of directed saithe fishery (Mehl and Fotland, WD 20 2013).

Analyses of the two remaining tuning series done at the 2010 benchmark assessment indicated that there had been a shift in catchability around year 2002. The survey was redesigned in 2003, and the fishery to a larger degree targeted older ages. Permanent breaks were made in both tuning series in 2002. The acoustic survey, compared with the trawl CPUE time-series, seemed to track the stock changes better, both in abundance and distribution.

The sensitivity runs presented to the IBP (Fotland WD 30 2014 IBP NEA saithe) clearly showed that the residual pattern got worse (strong year effects) when using both tuning series in SAM. It became obvious that SAM tries to fit something in between both contradicting data sources. Therefore, it had to be decided whether one data source was more reliable or whether both data sources should be considered leading to a fit in between both extremes. Given that CPUE series should not be used when larger changes in fishing patterns occur (selectivity, spatial distribution of the fleet, change between targeted and bycatch fishery) it was recommended to leave out the CPUE time-series in its current form for now (ICES CM 2014/ACOM: 53). Another reason was that the proportion of catches covered by the index had decreased steadily between 2002 and 2011, further questioning the representativeness of the CPUE index. However, it may be worth trying alternative CPUE indices (e.g. one index for the targeted fishery only and one index for the fishery with saithe bycatches) until the next benchmark.
The following two tuning fleets are thus used in the present assessment (by the time this report was written the new ICES name for this survey was not available)

- NOcoast-Aco-4Q: Indices from the Norwegian acoustic survey 1994–2001, age groups 3 to 7.
- NOcoast-Aco-4Q: Indices from the Norwegian acoustic survey 2002–2021, age groups 3 to 7.

5.4 SAM runs and settings (Table 5.7)

In connection with the NEA saithe IBP a number of exploratory SAM runs were performed. Model settings and results are presented in working documents included in the IBP report (ICES CM 2014/ACOM: 53).

SAM model settings and configuration in 2021 were the same as in previous simulations.

- Tuning data: Acoustic survey series (age 3–7) only, time-series split (1994–2001 and 2002–present);
- Maturity data: Ogives for the years 2007 and later based on the average of the 2005–2007 data;
- Flat exploitation pattern for age groups 8+;
- Correlated Fs between age groups and time;
- Beverton–Holt stock–recruitment relationship used to estimate recent recruitment.

5.5 Final assessment run (Table 5.8 to Table 5.11, Figure 5.3–5.6)

The state–space assessment model (SAM) was used for the final run. SAM catchabilities and negative log likelihood values are given in Table 5.8.

Figure 5.3 presents normalized residuals for the total catches and the two parts of the acoustic tuning series. There are both year- and age effects and the second part of the series seems to perform better than the first part. Figure 5.4 shows plots of the stock numbers from the SAM vs. tuning indices.

5.5.1 SAM F, N, and SSB results (Tables 5.9–5.11, Figures 5.5–5.6)

The estimated fishing mortality (F_{4-7}) in 2020 was 0.219 (AFWG 2021), which is higher than 0.187 from this year's assessment and below the F_{pa} of 0.35. The fishing mortality (F_{4-7}) in 2021 was estimated at 0.186. From 1997 to 2009 fishing mortality was below F_{pa}, but started to increase in 2005 and was above F_{pa} in 2010–2012.

Fishing mortality and stock size have in the last decade generally been considerably over- and underestimated respectively. Due to the changes made to the assessment following the benchmark assessment workshop in 2010 (ICES CM 2010/ACOM: 36) and later the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the retrospective patterns have improved considerably, as is illustrated in Figure 5.7. Based on the 2021 assessment the SSB has in recent years been both slightly over and underestimated while F_{4-7} has been generally overestimated.

The SAM-estimate of the 2014 year class was considered to be reliable enough to be used in the projections. In previous assessments the value of the 3-year olds in the last data year has been set to the long-term geometrical mean, and the value of the year class at age 4 were obtained by applying Pope's approximation. Since 2007 the 2007, 2010, 2013, and 2016 year classes have been above the long-term geometric mean, while in the other years, year-class strength has been considered average or below.

The total biomass (ages 3+) was above the long-term (1960–2021) average from 1997 to 2008, reached a local maximum in 2005, and declined below the average level between 2011 and 2015. Since 2016 it has been above the long-term average, and in 2021 was estimated at > 1 140 000 tonnes, the highest estimate in the time-series. The SSB was above the long-term mean from 2000 to 2009, decreased below the average between 2010 to 2013, and has been above the long-term average since 2014. SSB has been above B_{pa} (220 000 t) since 1996 (Figure 5.5).

5.5.2 Recruitment (Table 5.10, Figure 5.5)

Catches of age group 3 have varied considerably during the period 2004−2017 (Table 5.10). Until the 2005 WG, RCT3-runs were conducted to estimate the corresponding year classes, with 2 and 3 year olds from the acoustic survey as input together with XSA numbers. However, it was stated several times in the ACOM Technical Minutes that it would be more transparent to use the long-term geometric mean (GM) recruitment. GM values were therefore used in the 2005–2014 since the issue was not discussed at the IBP when SAM was adopted as assessment model. During the 2015 AFWG assessment, analyses were performed to investigate if the last year recruitment value from SAM could be used instead of the long-term GM (for method description refer to Stock Annex). Results from this analysis showed that the retrospective runs of SAM gave better estimates of recruitment than the geometric mean and consequently estimates of the recruiting year class (3 year olds in the last data year) from the SAM were accepted for the last year.

5.6 Reference points (Figure 5.5)

In 2010 the age span was expanded from 11+ to 15+ and important XSA parameter settings were changed (ICES CM 2010/ACOM: 36). LIM reference points were re-estimated at the 2010 WG according to the methodology outlined in ICES CM 2003/ACFM: 15, while the PA reference point estimation was based on the old procedure (ICES CM 1998/ACFM: 10). The results were not very much different from the previous analyses performed in 2005 (ICES CM 2005/ACFM: 20), and it was decided not to change the existing LIM and PA reference points. The shift from XSA to SAM resulted in only minor changes in estimated fishing mortality, spawning-stock-biomass and recruitment and no new reference points were estimated. Reference points were estimated as: B_{lim} 136 000 t, B_{pa} 220 000 t, F_{MP} 0.32 F_{lim} 0.58, and F_{pa} 0.35.

5.6.1 Harvest control rule

In 2007 ICES evaluated the harvest control rule for setting the annual fishing quota (TAC) for Northeast Arctic saithe. ICES concluded that the HCR was consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also held true when an implementation error (difference between TAC and catch) equal to the historic level was included. The HCR was implemented the same year. It contains the following elements:

- Estimate the average TAC level for the coming 3 years based on F_{mp}. TAC for the next year will be set to this level as a starting value for the 3-year period.
- The year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development. However, the TAC should not be changed by more than 15% compared with the previous year's TAC.
- If the spawning-stock-biomass (SSB) at the beginning of the year for which the quota is set (first year of prediction), is below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{mp} at SSB = B_{pa} to 0 at SSB equal to zero. At SSB levels below B_{pa} in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.

In 2011 the evaluation was repeated taking into account the changes made to the assessment after the 2010 benchmark assessment (ICES CM 2010/ACOM: 36). The analyses indicate that the HCR still is in agreement with the precautionary approach (Mehl and Fotland, WD 11 2011).

The fishing mortality used in the harvest control rule (F_{mp}) was in 2007 set to F_{pa} = 0.35. In June 2013, after the ICES advice for 2014 for this stock had been given, F_{mp} was reduced to 0.32.

5.7 Predictions

5.7.1 Input data (Table 5.12)

The input data to the predictions based on results from the final model run are given in Table 5.12. The estimates for stock number-at-age in 2022 were taken from the final SAM run for ages 4+. The geometric mean (GM) for recruitment (age 3) of 161 659 thousand was used in 2022 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of the 2019–2021 fishing mortalities estimated in the final SAM run for ages 3 to 12 was used, with mortalities for 8+ being constant. For weight-at-age in stock and catch the average of the last three years (2019–2021) from SAM input file was used. For maturity-at-age the average of the 2005–2007 annual ogives was applied.

5.7.2 Catch options for 2022 (short-term predictions; Tables 5.13–14)

The management option table (Table 5.13) shows that the expected landings of 197 212 t in 2022 will result in a fishing an adjusted mortality F_{bar} of 0.207, which is lower compared to 2021 of 0.265, but well below the F_{pa} of 0.35. A catch in 2023 corresponding to the $F_{status\ quo}$ level of 0.207 will be 189 690 t, while a catch in 2023 corresponding to the evaluated and implemented HCR of 226 794 t will result in F of 0.254 (Table 5.14).

For a catch in 2022 corresponding to the TAC of 197 212 t, the SSB is expected to decrease from about 745 913 t at the beginning of 2022 to 686 937 t at the beginning of 2023. At $F_{status\ quo}$ in 2023 SSB is estimated to decrease to 633 154 t at the beginning of 2024 and for a catch corresponding to the HCR it will decrease to about 597 899 in 2024.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2022 to be 20% higher and the SSB 26% higher compared to the previous assessment. The F in 2020 from the current assessment is higher than the F from the previous assessment, and the realized F in 2021 is lower compared to the predicted one in 2021 based on the TAC.

	Total stock (3+) by 1 January 2021 (tonnes)	SSB by 1 January 2021 (tonnes)	F4–7 in 2021	F4–7 in 2020
WG 2021	954114	568972	0.23	0.22
WG 2022	1140302	715674	0.186	0.187

5.8 Comments to the assessment and the forecast (Figure 5.6)

A statistical model is less sensitive to +group setting than XSA. In addition, the results from XSA were more dependent on the input data (use or no use of CPUE, split of the tuning survey time-series), the shrinkage parameter and whether the number of iterations is capped or not. XSA only converged at a large number of iterations. In contrast, results from SAM are much more robust and depend to a lesser degree on subjective choice of model settings (such as shrinkage). In addition, SAM as a stochastic model is not treating catches as known without error. The fishing mortality rates could be considered correlated in time, and to reflect that neighbouring age groups have more similar fishing mortalities.

The retrospective pattern has been a major concern in the assessment, but due to the changes done at the benchmark assessment in 2010 (ICES CM 2010/ACOM: 36) and later at the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the assessment has become stable (Figure 5.6)

The biological sampling from the fishery got critically low after the termination of the original Norwegian port-sampling program in 2009. In 2015 this was in particular the case for samples from trawl in quarter two and three in ICES area 1 and age samples from purse-seine fishery south of Lofoten (ICES area 2.a). In 2021 biological sampling from the saithe purse-seine fishery catches in Norwegian waters was adequate.

Lack of reliable recruitment estimates is a major problem. Prediction of catches will still, to a large extent, be dependent on assumptions of average recruitment in the intermediate year and the forecast period, since fish from age four to seven constitute major parts of the catches. Since the saithe HCR is a three-year-rule, the estimation of average F_{mp} catch in the HCR will affect stock numbers up to age five, and thereby affect the total prognosis of the fishable stock and the quotas derived from it. The recruitment-at-age 3 estimated by the SAM has on average been at about the long-term geometric mean level since 2005

.

5.9 Tables and figures

Table 5.1. Saithe in subareas 1 and 2 (Northeast Arctic). Nominal catch (t) by countries as officially reported to ICES.

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
1960	23	1700		25 948		96050					9780	14	133515
1961	61	3625		19757		77875					4615	18	105951
1962	2	544		12651		101895			912		4699	4	120707
1963		1110		8108		135297					4112		148627
1964		1525		4420		184700			84		6511	186	197426
1965		1618		11387		165531			137		6746	181	185600
1966		2987	813	11269		175037			563		13078	41	203788
1967		9472	304	11822		150860			441		8379	48	181326
1968			1248	4753		96641					8782		111424
1969	20	193	6744	4355		115140					13585	23	140060
1970	1097		29200	23466		151759			43550		15690		264924
1971	215	14536	16840	12204		128499	6017		39397	13097	10467		241272
1972	109	14519	7474	24595		143775	1111		1278	9247	8348		210456
1973	7	11320	12015	30338		148789	23		2411	2115	6841		213859
1974	46	7119	29466	33155		152699	2521		28931	7075	3104	5	264121

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
1975	28	3156	28517	41260		122598	3860	6430	13389	11397	2763	55	233453
1976	20	5609	10266	49056		131675	3164	7233	9013	21661	4724	65	242486
1977	270	5658	7164	19985		139705	1	783	989	1327	6935		182817
1978	809	4345	6484	19190		121069	35	203	381	121	2827		155464
1979	1117	2601	2435	15323		141346			3	685	1170		164680
1980	532	1016		12511		128878			43	780	794		144554
1981	236	218		8431		166139			121		395		175540
1982	339	82		7224		159643			14		732		168034
1983	539	418		4933		149556			206	33	1251		156936
1984	503	431	6	4532		152818			161		335		158786
1985	490	657	11	1873		103899			51		202		107183
1986	426	308		3470		63090			27		75		67396
1987	712	576		4909		85710			426		57	1	92391
1988	441	411		4574		108244			130		442		114242
1989	388	460[2]		606		119625			506	506	726		122817
1990	1207	340[2]		1143		92397			52		709		95848
1991	963	77[2]	**Greenland**	2003		103283			504 [4]		492	5	107327
1992	165	1980	734	3451		119763			964	6	541		127604

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
1993	31	566	78	3687	3	140604		1	9509	4 [2]	415	5	154903
1994	67 [2]	557	15	1863	4 [2]	141589		1 [2]	1640 [2]	655 [2]	557	2	146950
1995	172 [2]	358	53	935		165001		5	1148		688	18	168378
1996	248 [2]	346	165	2615		166045		24	1159	6	707	33	171348
1997	193[2]	560	363[2]	2915		136927		12	1774	41	799	45	143629
1998	366	932	437[2]	2936		144103		47	3836	275	355	40	153327
1999	181	638 [2]	655[2]	2473	146	141941		17	3929	24	339	32	150375
2000	224[2]	1438	651[2]	2573	33	125932		46	4452	117	454	8 [2]	135928
2001	537	1279	701[2]	2690	57	124928		75	4951	119	514	2	135853
2002	788	1048	1393	2642	78	142941		118	5402	37	420	3	154870
2003	2056	1022	929[2]	2763	80 [2]	150400		147	3894	18	265	18 [2]	161592
2004	3071	255	891[2]	2161	319	147975		127	9192	87	544	14	164636
2005	3152	447	817[2]	2048	395	162338		354	8362	25	630		178568
2006	1795	899.7	779[2]	2780	255	195462	88.9	101	9823	0	532	42	212557
2007	2048	965.6	801[2]	3019	219	178644	99.3	412	12168	22	557	11.8	198967
2008	2405	1008.6	513[2]	2264	113	165998	65.8	348	11577	33	506	9.7	184840
2009	1611	378.6	697	2021	69	144570	30.6	184.01	11899	2	379	24	161865
2010	1632	677.2	954	1592	124	175246	278.9	93	14664	8	283	2.5	195554

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
2011	306	504.2	445	1371	66	143314	0	45.34	10007	2	972	15.14	157048
2012	146	780.55	658	1371	126	143174	0	7.65	13607	4	1087	0	160960
2013	80	1900.92	972	1212	245	111961	2.21	17.24	14796	5	415	21.93	131629
2014	273	1674	407	259	659	115864	0.86	8.25	12396	12	518	0	132070
2015	766	515	393	424	248	115157	1143	10.42	13181	34	403	0	132275
2016	1148	526	613	952	702	121705	530	52	15203	26	301	10	141768
2017 [1]	639	680	407	865	589	126947	504	86	14551	88	439	24	145819
2018	626	937	448	1642		162460	404	51	14171	60	464	17	181280
2019	618	1472	424	1371		144076	46	131	13990	199	419	434	163180
2020		530	410	1544		151697	1.2	132	14082	0	517	118	169405
2021	573	684	449	600	148	171836	0.3	21	13836	3	2	23	188176

1 Provisional figures.

2 As reported to Norwegian authorities.

3 USSR prior to 1991.

4 Includes Estonia.

5 Includes Denmark. Netherlands. Ireland. and Sweden.

6 As reported by Working Group member.

Table 5.2 Saithe in subareas 1 and 2 (Northeast Arctic). Catch (´000) by fishing gear.

Year	Purse-seine	Trawl	Gillnet	Others	Total
1977	75.2	69.5	19.3	12.7	176.7
1978	62.9	57.6	21.1	13.9	155.5
1979	74.7	52.5	21.6	15.9	164.7
1980	61.3	46.8	21.1	15.4	144.6
1981	64.3	72.4	24.0	14.8	175.5
1982	76.4	59.4	16.7	15.5	168.0
1983	54.1	68.2	19.6	15.0	156.9
1984	36.4	85.6	23.7	13.1	158.8
1985	31.1	49.9	14.6	11.6	107.2
1986	7.9	36.2	12.3	8.2	64.6
1987	34.9	27.7	19.0	10.8	92.4
1988	43.5	45.4	15.3	10.0	114.2
1989	49.5	45.0	16.9	11.4	122.8
1990	24.6	44.0	19.3	7.9	95.8
1991	38.9	40.1	18.9	9.4	107.3
1992	27.1	67.0	22.3	11.2	127.6
1993	33.1	84.9	21.2	15.7	154.9
1994	30.2	82.2	21.1	13.5	147.0
1995	21.8	103.5	26.9	16.1	168.4
1996	46.9	72.5	31.6	20.3	171.3
1997	44.4	55.9	24.4	19.0	143.6
1998	44.4	57.7	27.6	23.6	153.3
1999	39.2	57.9	29.7	23.6	150.4
2000	28.3	54.5	29.6	23.5	135.9
2001	28.1	58.1	28.2	21.5	135.9
2002	27.4	75.5	30.4	21.5	154.8
2003	43.3	73.8	25.2	19.3	161.6
2004	41.8	74.6	26.9	21.3	164.6
2005	42.1	91.8	25.6	19.1	178.6

Year	Purse-seine	Trawl	Gillnet	Others	Total
2006	73.5	87.1	29.7	22.5	212.8
2007	41.8	100.7	33.3	23.2	199.0
2008	39.4	91.2	37.0	17.1	184.7
2009	35.5	81.1	33.2	12.1	161.9
2010	54.9	89.8	36.9	13.2	194.8
2011	45.3	67.1	32.1	12.2	156.7
2012	44.2	73.9	28.3	14.5	160.9
2013	34.7	65.2	19.2	12.7	131.8
2014	29.3	54.8	26.7	21.2	132.0
2015	30.4	55.4	23.5	22.5	131.8
2016	28.9	64.1	21.4	26.9	141.3
2017[1]	32.4	65.0	21.4	27.3	146.1
2018	36.0	83.6	28.8	33.2	181.5
2019	28.7	68.6	29.4	36.6	163.1
2020	26.8	74	30.3	38.3	169.4
2021	30.9	81.6	29.5	46	188

[1] Provisional figures.

[2] Unresolved discrepancies between Norwegian catch by gear figures and the total reported to ICES for these years.

[3] Includes 4300 tonnes not categorized by gear. proportionally adjusted.

[4] Reduced by 1200 tonnes not categorized by gear. proportionally adjusted.

Table 5.3 Catch numbers-at-age ('000) of northeast Arctic saithe.

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1960	13517	16828	17422	6514	6281	3088	1691	956	481	1481
1961	25237	12929	17707	5379	1886	1371	736	573	538	1202
1962	45932	13720	5449	10218	2991	1262	1156	556	611	1518
1963	51171	35199	7165	5659	4699	1337	1308	848	550	1612
1964	10925	72344	15966	3299	4214	3223	1518	1482	1282	3038
1965	42578	5737	30171	11635	3282	2421	3135	802	1136	2986
1966	25127	61199	14727	14475	5220	1542	1047	1083	530	2724

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1967	28457	23826	34493	3957	5388	2797	1356	1340	814	2536
1968	29955	21856	6065	9846	936	2274	1070	686	465	922
1969	76011	11745	16650	4666	4716	1107	1682	663	199	303
1970	43834	63270	14081	16298	5157	8004	2521	3722	1103	1714
1971	61743	47522	21614	7661	7690	2326	3489	1760	2514	1888
1972	55351	44490	24752	8650	4769	3012	1584	1817	1044	1631
1973	62938	20793	22199	13224	5868	3246	2368	2153	1291	1947
1974	36884	44149	15714	20476	12182	4815	3267	2512	1440	2392
1975	70255	13502	18901	5123	9018	7841	3365	2714	2237	2544
1976	135592	33159	8618	9448	3725	3483	2905	1870	1183	1940
1977	105935	36703	10845	2205	4633	1557	1718	1030	495	718
1978	56505	31946	14396	5232	1694	2132	1082	1126	756	1726
1979	75819	28545	17280	5384	3550	1178	1659	536	373	1086
1980	40303	36202	9100	6302	3161	1322	145	721	406	1204
1981	85966	22345	22044	3706	2611	2056	378	286	258	385
1982	35853	67150	13481	8477	1088	1291	476	271	124	338
1983	18216	25108	34543	3408	3178	1243	803	261	215	587
1984	43579	34927	12679	11775	1193	1862	589	585	407	537
1985	48989	11992	7200	5287	3746	776	879	134	274	427
1986	21322	12433	5845	4363	2704	1349	338	438	123	152
1987	18555	51742	4506	3238	3624	784	644	267	263	565
1988	8144	35928	32901	4570	2333	1222	968	321	73	30
1989	12607	19400	33343	18578	1762	352	177	189	1	205
1990	23792	16930	9054	10238	7341	1076	160	112	150	118
1991	68682	13630	5752	4883	3877	2381	383	61	90	89
1992	44627	33294	5987	5412	4751	3176	1462	286	93	350
1993	22812	61931	31102	3747	1759	1378	1027	797	76	71
1994	7063	32671	49410	19058	2058	724	421	278	528	129

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1995	17178	52109	40145	30451	4177	483	125	259	31	263
1996	10510	54886	18499	18357	17834	2849	485	214	148	325
1997	11789	11698	35011	13567	13452	7058	812	55	48	98
1998	3091	16215	11946	31818	8376	5539	2873	727	111	282
1999	9655	12236	22872	10347	18930	3374	3343	2290	419	170
2000	9175	22768	7747	10676	6123	8303	2530	2652	1022	197
2001	3816	7946	26960	8769	7120	3146	4687	1935	1406	528
2002	6582	17492	11573	25671	5312	4276	2382	3431	965	1420
2003	2345	50653	13600	7123	9594	5494	3545	2519	2327	1813
2004	1002	6129	33840	10613	7494	8307	2792	3088	2377	3072
2005	26093	12543	9841	23141	10799	5659	7852	2674	713	1588
2006	1590	68137	12328	10098	16757	8080	5671	5127	1815	2529
2007	3144	4115	39889	15301	7963	11302	7749	4138	2157	849
2008	25259	18953	5969	24363	9712	5624	7697	4705	1606	1572
2009	9050	34311	9954	6628	15930	4766	3021	4224	2471	1426
2010	26382	43436	28514	7988	3129	12444	2749	1314	1212	1431
2011	6239	45213	13307	15157	6622	2901	5934	1730	647	1115
2012	30742	17841	33911	10496	7058	3522	1570	2586	557	890
2013	17151	15491	15946	21980	5512	3298	1149	729	885	653
2014	7650	24769	13822	9343	12331	3284	2130	904	378	763
2015	13185	15459	30159	9271	7324	7133	1697	723	433	620
2016	8278	20955	13044	15532	6621	4774	4363	1053	718	1382
2017	5421	34736	12901	7324	9032	3885	2562	1924	376	1999
2018	5260	19260	41425	12618	5903	5667	2843	1956	1112	1567
2019	12421	15078	15388	25177	8327	3243	2848	1357	619	1171
2020	6216	27602	13466	14054	17767	5031	2034	1469	564	1236
2021	5732	7938	26311	12418	11357	12295	3544	1580	954	1939

Table 5.4 Catch weight-at-age (kg) northeast Arctic saithe.

	Age groups								
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1960	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.55
1961	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.75
1962	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.52
1963	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.33
1964	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.35
1965	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.54
1966	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.43
1967	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.49
1968	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.36
1969	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.16
1970	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.03
1971	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.87
1972	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.14
1973	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.01
1974	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.69
1975	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.73
1976	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	7.86
1977	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.05
1978	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.00
1979	0.71	1.11	1.63	2.33	3.16	4.03	4.87	5.63	6.44	8.28
1980	0.79	1.27	2.03	2.55	3.29	4.34	5.15	5.75	6.11	7.22
1981	0.73	1.40	2.05	2.76	3.30	4.38	5.95	6.39	6.61	7.00
1982	0.77	1.12	2.02	2.61	3.27	3.91	4.69	5.63	7.18	7.69
1983	1.05	1.33	1.86	2.80	4.00	4.18	5.33	5.68	7.31	9.16
1984	0.71	1.26	2.02	2.70	3.88	4.47	5.36	6.06	6.28	7.88
1985	0.75	1.33	2.07	2.63	3.28	3.96	4.54	5.55	6.88	8.74
1986	0.59	1.22	1.97	2.30	2.87	3.72	4.30	4.69	5.84	7.21
1987	0.53	0.84	1.66	2.32	2.97	4.00	4.72	5.44	5.79	7.42

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1988	0.62	0.87	1.31	2.43	3.87	5.38	5.83	5.36	6.92	8.82
1989	0.74	0.95	1.40	1.78	2.96	3.73	4.62	4.66	8.34	7.69
1990	0.71	1.00	1.45	2.09	2.49	3.75	3.90	6.74	4.94	7.34
1991	0.68	1.05	1.85	2.39	3.08	3.35	4.48	4.66	5.62	7.31
1992	0.67	1.01	1.92	2.28	2.77	3.20	3.73	6.35	6.90	7.83
1993	0.61	0.99	1.65	2.46	2.85	3.03	3.71	4.49	5.56	7.13
1994	0.52	0.76	1.24	2.12	3.22	3.83	4.69	5.31	5.66	7.29
1995	0.56	0.79	1.19	1.71	2.87	3.78	4.06	5.30	6.86	7.65
1996	0.59	0.82	1.33	1.84	2.48	3.73	4.32	5.34	5.98	7.58
1997	0.62	0.95	1.24	1.72	2.35	3.10	4.19	5.79	6.77	7.75
1998	0.68	1.00	1.48	1.87	2.58	3.07	4.13	5.44	6.70	8.59
1999	0.67	1.05	1.45	1.93	2.27	2.97	3.61	4.10	4.93	6.97
2000	0.60	1.03	1.63	2.10	2.67	3.14	3.81	4.41	5.76	8.07
2001	0.75	1.12	1.54	2.04	2.60	3.14	3.63	4.54	5.05	6.17
2002	0.69	1.01	1.50	1.97	2.54	3.25	3.77	4.31	4.91	6.11
2003	0.66	0.91	1.42	1.89	2.54	2.58	3.49	3.75	4.12	5.90
2004	0.70	1.03	1.37	1.90	2.41	2.98	3.44	3.73	4.14	5.47
2005	0.59	0.89	1.49	2.09	2.16	2.99	3.24	3.82	3.92	6.19
2006	0.63	0.83	1.43	1.78	2.27	2.73	3.02	3.90	4.06	5.82
2007	0.73	1.08	1.41	1.86	2.43	2.94	3.35	3.66	4.17	5.54
2008	0.63	0.98	1.38	1.92	2.31	2.83	3.16	3.43	3.82	4.75
2009	0.73	1.03	1.65	2.00	2.37	2.69	3.23	3.38	3.46	4.67
2010	0.70	0.99	1.45	2.14	2.50	3.13	3.34	3.81	3.99	5.17
2011	0.70	0.82	1.42	2.07	2.68	3.25	3.62	3.97	4.52	5.84
2012	0.59	1.07	1.35	2.15	2.82	3.20	3.67	4.16	4.60	5.70
2013	0.57	1.01	1.50	1.83	2.74	3.33	3.91	4.61	4.50	6.13
2014	0.66	0.92	1.58	2.12	2.54	3.49	4.01	4.22	4.71	5.80
2015	0.61	0.85	1.24	1.91	2.45	3.02	3.97	4.74	4.51	6.05

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
2016	0.84	1.04	1.46	2.02	2.36	3.12	3.53	4.14	4.65	6.03
2017	0.89	1.12	1.68	2.18	2.63	3.13	3.63	4.16	4.5	5.9
2018	0.91	1.21	1.56	2.02	2.51	3.04	3.44	3.89	4.50	5.60
2019	0.83	1.17	1.64	2.06	2.62	3.18	3.71	4.13	4.88	6.14
2020	0.74	1.06	1.57	2.01	2.53	3.13	3.75	4.36	5.05	6.80
2021	0.77	1.16	1.61	2.14	2.68	3.15	3.65	4.14	4.7	6.3

Table 5.5. 3-year running average maturity ogive 1985–2006. Values for 2007–2020 average of 2005–2007.

Year	3	4	5	6	7	8	9	10	11	12+
1985	0	0.02	0.5	0.92	0.99	1	1	1	1	1
1986	0	0.02	0.51	0.94	0.99	1	1	1	1	1
1987	0	0	0.35	0.98	1	1	1	1	1	1
1988	0	0	0.25	0.96	1	1	1	1	1	1
1989	0	0	0.15	0.92	1	1	1	1	1	1
1990	0	0	0.2	0.85	0.99	1	1	1	1	1
1991	0	0.02	0.25	0.84	0.98	1	1	1	1	1
1992	0	0.02	0.3	0.83	0.93	0.92	0.9	0.95	1	1
1993	0	0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.99
1994	0	0.02	0.26	0.84	0.9	0.82	0.87	0.89	1	0.99
1995	0	0.02	0.22	0.8	0.92	0.9	0.97	0.94	1	0.99
1996	0	0.03	0.21	0.65	0.91	0.93	1	1	1	1.00
1997	0	0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1.00
1998	0	0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1.00
1999	0	0	0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.98
2000	0	0	0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.95
2001	0	0	0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.94
2002	0	0	0.13	0.78	0.95	0.98	0.98	0.99	0.98	0.97
2003	0	0	0.14	0.82	0.96	0.98	0.98	0.99	1	0.99
2004	0	0	0.21	0.8	0.97	0.99	0.99	1	1	0.98

Year	3	4	5	6	7	8	9	10	11	12+
2005	0	0.03	0.3	0.82	0.97	0.99	0.99	1	1	1.00
2006	0	0.04	0.4	0.86	0.98	0.99	1	1	1	1.00
2007	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2008	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2009	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2010	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	0.99
2011	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2012	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2013	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2014	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2015	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2016	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2017	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2018	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2019	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2020	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00
2021	0	0.05	0.42	0.87	0.97	0.98	0.98	0.97	0.97	1.00

Table 5.6 Northeast Arctic saithe. Tuning datasets applied in final SAM run

```
North-East Arctic saithe (Sub-areas I and II)
102
FLT13: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
19942001
1 1 0.75 0.85
3  7
   1    87.1   108.9    41.4     8.1     0.7
   1   166.1    86.5    46.5    16.5     2.4
   1   122.6   207.4    31.7    15.1     4.0
   1    38.0   184.8    79.8    50.6     9.6
   1    96.7   202.6    69.3    84.3     6.6
   1   233.8    72.9    62.2    21.0    19.2
   1   142.5   176.3    11.6    11.5     8.0
   1   275.9    45.9    53.8     5.6     6.1
FLT14: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
20022021
1 1 0.75 0.85
3  7
   1   230.2    92.6    18.9    10.6     2.2
   1    87.5   151.7    26.1     6.2     6.4
   1   191.2   107.6    44.3    15.2     4.25
   1   198.5    51.9    17.6    13.2     7.68
   1    40.9   129.9    14.4     4.62     9.49
   1   93.5    23.9    58.5     6.51     3.95
   1    55.9    15.9    7.84    9.99     3.06
   1   96.9    61.4     6.99     4.01     7.62
   1   143.0    22.5    17.1     3.95     1.68
   1    42.7    59.6     4.61     4.23     1.07
   1    69    29.7    18.8     3.48     2.83
   1   77.1    16.5    13.3    11.6     2.19
   1    40.1    70.8    8.73     5.6     5.44
   1    72.4    22.7    30.1     6.08     4.22
   1        145.7        32.0        10.5        11.2        4.15
   1        91.1         63.9        13.3        2.76        5.35
   1        30.6         61.1        45.4        12.3        4.2

   1        84.4         50.6        24.2        17.75       3.54
   1        48.23        90.45       28.85       12.33       6.52
   1        64.9         33.6        59.3        15.3        8.3
```

Table 5.7 SAM parameter settings

Model used: State-space assessment model SAM (https://www.stockassessment.org).

Software used: Template Model Builder (TMB) and R.

Visible stock on (https://www.stockassessment.org) "afwg_saithe_ 2018_001".

Model Options agreed upon at IBP saithe winter 2014.

$minAge

The minimium age class in the assessment

3

$maxAge

The maximum age class in the assessment

12

$maxAgePlusGroup

Is last age group considered a plus group (1 yes, or 0 no).

1

$keyLogFsta

Coupling of the fishing mortality states (nomally only first row is used).

0 1 2 3 4 5 5 5 5 5

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

$corFlag

Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)

2

$keyLogFpar

Coupling of the survey catchability parameters (nomally first row is not used, as that is covered by fishing mortality).

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

0 1 2 3 3 -1 -1 -1 -1 -1

4 5 6 7 7 -1 -1 -1 -1 -1

$keyQpow

Density dependent catchability power parameters (if any).

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

-1 -1 -1 -1 -1 -1 -1 -1 -1 -1

$keyVarF

Coupling of process variance parameters for log(F)-process (nomally only first row is used)

0 0 0 0 0 0 0 0 0 0

```
 -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1  -1  -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
  0   0   0   0   0   0   0   0   0   0
  1   1   1   1   1  -1  -1  -1  -1  -1
  2   2   2   2   2  -1  -1  -1  -1  -1
```

Table 5.7 SAM parameter settings continued

$obsCorStruct

Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"

"ID" "ID" "ID"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

#3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-11 11-12

NA NA NA NA NA NA NA NA NA

NA NA NA NA -1 -1 -1 -1 -1

NA NA NA NA -1 -1 -1 -1 -1

$stockRecruitmentModelCode

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton–Holt).

2

$noScaledYears

Number of years where catch scaling is applied.

0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange

lowest and higest age included in Fbar

4 7

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1

Table 5.8 SAM catchabilities, negative log likelihood values and number of parameters.

Index	Fleet number	Age	Catchability	Low	High
1	2	3	0.87	0.592	1.279
2	2	4	1.171	0.798	1.718
3	2	5	0.606	0.413	0.89
4	2	6	0.374	0.278	0.504
5	2	7	0.374	0.278	0.504
6	3	3	0.585	0.48	0.713
7	3	4	0.486	0.399	0.592
8	3	5	0.283	0.232	0.346
9	3	6	0.184	0.155	0.22
10	3	7	0.184	0.155	0.22

Model fitting.

Model	log(L)	#par	AIC
Current	-567.30	17	1168.61
base	-560.41	17	1154.81

Table 5.9 Estimated fishing mortalities.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	0.236	0.284	0.321	0.278	0.222	0.164	0.164	0.164	0.164	0.164
1961	0.222	0.260	0.273	0.226	0.173	0.126	0.126	0.126	0.126	0.126
1962	0.222	0.261	0.267	0.225	0.177	0.132	0.132	0.132	0.132	0.132
1963	0.224	0.272	0.281	0.238	0.194	0.153	0.153	0.153	0.153	0.153
1964	0.237	0.298	0.318	0.277	0.240	0.207	0.207	0.207	0.207	0.207
1965	0.234	0.291	0.325	0.288	0.253	0.230	0.230	0.230	0.230	0.230
1966	0.260	0.320	0.344	0.289	0.244	0.223	0.223	0.223	0.223	0.223
1967	0.261	0.310	0.319	0.265	0.225	0.216	0.216	0.216	0.216	0.216
1968	0.222	0.241	0.230	0.185	0.152	0.147	0.147	0.147	0.147	0.147
1969	0.231	0.241	0.222	0.175	0.143	0.131	0.131	0.131	0.131	0.131
1970	0.330	0.362	0.342	0.285	0.251	0.240	0.240	0.240	0.240	0.240

Year Age	3	4	5	6	7	8	9	10	11	12
1971	0.360	0.385	0.357	0.295	0.270	0.259	0.259	0.259	0.259	0.259
1972	0.382	0.391	0.351	0.283	0.259	0.244	0.244	0.244	0.244	0.244
1973	0.421	0.428	0.386	0.317	0.299	0.284	0.284	0.284	0.284	0.284
1974	0.544	0.561	0.513	0.429	0.417	0.395	0.395	0.395	0.395	0.395
1975	0.597	0.620	0.567	0.478	0.489	0.478	0.478	0.478	0.478	0.478
1976	0.653	0.683	0.612	0.499	0.497	0.471	0.471	0.471	0.471	0.471
1977	0.578	0.614	0.541	0.430	0.417	0.378	0.378	0.378	0.378	0.378
1978	0.575	0.651	0.597	0.488	0.476	0.432	0.432	0.432	0.432	0.432
1979	0.554	0.677	0.639	0.529	0.509	0.454	0.454	0.454	0.454	0.454
1980	0.493	0.637	0.620	0.519	0.481	0.422	0.422	0.422	0.422	0.422
1981	0.456	0.629	0.622	0.521	0.460	0.393	0.393	0.393	0.393	0.393
1982	0.422	0.620	0.623	0.527	0.449	0.375	0.375	0.375	0.375	0.375
1983	0.402	0.629	0.655	0.595	0.531	0.453	0.453	0.453	0.453	0.453
1984	0.444	0.715	0.733	0.722	0.682	0.594	0.594	0.594	0.594	0.594
1985	0.351	0.589	0.611	0.648	0.679	0.592	0.592	0.592	0.592	0.592
1986	0.241	0.448	0.496	0.571	0.649	0.594	0.594	0.594	0.594	0.594
1987	0.224	0.454	0.530	0.664	0.809	0.756	0.756	0.756	0.756	0.756
1988	0.214	0.456	0.537	0.660	0.772	0.663	0.663	0.663	0.663	0.663
1989	0.201	0.423	0.471	0.525	0.534	0.402	0.402	0.402	0.402	0.402
1990	0.223	0.477	0.523	0.592	0.602	0.453	0.453	0.453	0.453	0.453
1991	0.191	0.426	0.477	0.551	0.568	0.43	0.43	0.43	0.43	0.43
1992	0.172	0.429	0.54	0.689	0.754	0.605	0.605	0.605	0.605	0.605
1993	0.13	0.354	0.475	0.62	0.679	0.542	0.542	0.542	0.542	0.542
1994	0.1	0.297	0.419	0.568	0.629	0.505	0.505	0.505	0.505	0.505
1995	0.081	0.249	0.339	0.438	0.471	0.372	0.372	0.372	0.372	0.372
1996	0.073	0.227	0.315	0.421	0.488	0.418	0.418	0.418	0.418	0.418
1997	0.053	0.163	0.226	0.297	0.338	0.291	0.291	0.291	0.291	0.291
1998	0.046	0.153	0.221	0.297	0.347	0.322	0.322	0.322	0.322	0.322
1999	0.045	0.157	0.228	0.298	0.338	0.321	0.321	0.321	0.321	0.321

Year Age	3	4	5	6	7	8	9	10	11	12
2000	0.038	0.139	0.205	0.267	0.295	0.29	0.29	0.29	0.29	0.29
2001	0.029	0.115	0.177	0.237	0.264	0.272	0.272	0.272	0.272	0.272
2002	0.026	0.108	0.168	0.228	0.261	0.289	0.289	0.289	0.289	0.289
2003	0.024	0.102	0.157	0.216	0.261	0.323	0.323	0.323	0.323	0.323
2004	0.022	0.095	0.148	0.206	0.261	0.348	0.348	0.348	0.348	0.348
2005	0.032	0.126	0.181	0.241	0.29	0.377	0.377	0.377	0.377	0.377
2006	0.039	0.154	0.214	0.285	0.344	0.455	0.455	0.455	0.455	0.455
2007	0.046	0.171	0.229	0.299	0.356	0.463	0.463	0.463	0.463	0.463
2008	0.07	0.248	0.299	0.365	0.42	0.531	0.531	0.531	0.531	0.531
2009	0.08	0.275	0.322	0.372	0.418	0.52	0.52	0.52	0.52	0.52
2010	0.097	0.328	0.373	0.405	0.431	0.505	0.505	0.505	0.505	0.505
2011	0.096	0.313	0.369	0.409	0.439	0.49	0.49	0.49	0.49	0.49
2012	0.101	0.303	0.353	0.384	0.408	0.437	0.437	0.437	0.437	0.437
2013	0.084	0.249	0.293	0.317	0.338	0.351	0.351	0.351	0.351	0.351
2014	0.074	0.219	0.265	0.288	0.313	0.325	0.325	0.325	0.325	0.325
2015	0.068	0.206	0.252	0.273	0.298	0.305	0.305	0.305	0.305	0.305
2016	0.058	0.185	0.239	0.273	0.311	0.331	0.331	0.331	0.331	0.331
2017	0.05	0.159	0.209	0.249	0.294	0.319	0.319	0.319	0.319	0.319
2018	0.051	0.156	0.206	0.251	0.304	0.333	0.333	0.333	0.333	0.333
2019	0.048	0.139	0.18	0.221	0.271	0.291	0.291	0.291	0.291	0.291
2020	0.045	0.129	0.164	0.203	0.254	0.274	0.274	0.274	0.274	0.274
2021	0.044	0.124	0.16	0.201	0.259	0.291	0.291	0.291	0.291	0.291

Table 5.10 Estimated stock numbers.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	84026	103212	54063	28175	26072	14377	10474	7296	3627	12068
1961	116162	56676	68814	30180	17272	15941	8956	6995	5128	11294
1962	206835	67972	36513	44590	18691	12606	11345	6190	5188	12543
1963	273837	133053	38589	25467	28675	11916	9860	8217	4491	13419
1964	80835	192878	77533	22463	17668	18939	8050	7502	6155	13840

Year Age	3	4	5	6	7	8	9	10	11	12
1965	254979	49841	112584	45181	14490	11634	12341	5023	5213	13956
1966	134273	182245	34470	63060	26337	9323	7542	7296	3184	12731
1967	174211	83249	111131	20133	36539	16005	6325	5254	4560	10163
1968	143787	116727	47168	64268	12956	23786	10028	4120	3369	8278
1969	267366	88097	80560	31720	42494	10731	17821	6985	2677	6823
1970	220408	169181	58085	54888	22485	29924	9254	14125	5140	7175
1971	229850	143772	87223	35346	32832	14314	17677	6588	9316	7926
1972	154265	138705	86049	46349	22941	19544	9605	10385	4330	10127
1973	201294	80094	79530	52478	27745	15439	12675	6829	6372	8956
1974	100846	110892	41709	46327	32933	16776	10303	8264	4297	9026
1975	168309	44068	52917	19820	23857	17932	9298	6058	4796	7160
1976	220420	75068	19305	25739	10487	11393	8684	4696	3080	5760
1977	202624	90088	30935	8391	13327	5454	5692	4260	2303	4198
1978	136704	89616	38553	15022	4590	7301	3202	3088	2395	3966
1979	195867	60076	38732	17165	7704	2359	4023	1756	1536	3421
1980	118880	94852	23529	16838	8555	3654	1123	2060	963	2671
1981	232133	57025	43586	9993	8254	4418	1830	686	1062	1820
1982	127952	125404	24407	19554	4695	4369	2237	1031	397	1629
1983	100879	68200	54301	9874	9348	2589	2500	1240	604	1293
1984	94848	58223	30631	20737	4285	4557	1300	1334	710	1061
1985	104305	42143	23127	12843	7080	1920	2089	553	608	830
1986	178608	49257	17676	11011	5982	2441	945	954	268	630
1987	144151	132580	22527	8341	5503	2777	854	481	424	466
1988	80501	101647	76524	11120	3458	2046	1327	228	201	292
1989	78046	54928	56075	39182	4874	1188	817	616	51	290
1990	87261	47774	29573	26563	18844	2441	593	458	369	216
1991	226767	48317	22071	15097	11249	8480	1237	296	263	324
1992	281942	142737	22449	10926	7827	5050	4674	646	168	376
1993	211259	213473	76372	10118	4266	3120	1966	2308	279	238

Year Age	3	4	5	6	7	8	9	10	11	12
1994	150273	162581	132562	37440	4346	1719	1484	755	1243	269
1995	274143	132666	112259	75546	15576	1848	794	777	300	828
1996	158412	244059	88297	68551	40422	7966	1036	484	447	705
1997	164614	120139	178524	58072	40148	21591	4151	503	259	629
1998	104290	135570	83800	128048	32888	24116	12886	2554	332	632
1999	241011	78990	95788	53536	73974	18368	15028	7672	1477	581
2000	159210	193027	51166	55833	31213	40670	11326	9626	4373	1130
2001	212316	106590	140257	35446	33157	18987	24144	7251	6082	3184
2002	357911	178223	78274	93953	23958	20586	12629	15001	4495	5918
2003	150915	317001	123912	51622	56760	17215	12746	8645	9148	6508
2004	153670	121325	209984	86127	35543	36407	10979	7448	5520	9153
2005	436325	119168	79064	125579	56566	23815	22286	6916	3815	7598
2006	73821	345200	79938	48535	73946	34788	14872	12596	3933	6097
2007	113108	53944	216276	52597	29793	39911	19826	8324	6281	4403
2008	200409	76125	37793	114916	30173	16518	19969	10815	4207	5099
2009	145999	154224	46054	25005	62623	15713	7883	9287	5323	4258
2010	269620	98774	91079	28578	14178	33189	7780	3771	4152	4392
2011	113082	199262	50578	46919	15677	8135	15981	3933	1849	3951
2012	153896	91823	123730	31155	24749	9056	4398	7733	1916	2866
2013	209004	92107	63809	77806	18423	13253	5007	2445	3911	2504
2014	108650	170558	60363	42747	46061	11056	7654	3138	1446	3686
2015	165109	80832	121163	41909	28657	27070	6462	4433	1956	3238
2016	252926	119916	54779	73849	27556	17665	15680	3768	2878	3794
2017	178636	220533	82076	34542	41960	16410	10391	8671	2096	4721
2018	130677	151127	179261	60196	24652	23598	9822	6206	4995	4402
2019	257000	124197	112305	120744	36398	15055	12994	5636	3480	5550
2020	122722	233796	104193	82456	74786	23057	9465	7550	3336	5780
2021	147428	91131	190540	79694	56869	48629	14558	6074	4587	6134
pred		115519	65936	132944	53373	35935	29775	8914	3719	6565

Table 5.11 Estimated recruitment, total-stock biomass (TBS), spawning-stock biomass (SSB), and average fishing mortality for ages 4 to 7 (F4–7).

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
1960	84026	52561	134326	462688	338674	632112	0.276	0.198	0.387	686916	533851	883869
1961	116162	76540	176295	454708	335633	616028	0.233	0.170	0.319	661579	517022	846553
1962	206835	137011	312245	460869	343520	618305	0.233	0.172	0.315	725964	576883	913571
1963	273837	181598	412927	458340	345386	608234	0.246	0.184	0.330	837994	675845	1039045
1964	80835	53177	122880	483760	370183	632184	0.283	0.213	0.377	818944	659137	1017496
1965	254979	169260	384110	523809	405297	676974	0.289	0.218	0.384	858901	696125	1059738
1966	134273	89365	201748	482581	370844	627985	0.299	0.225	0.398	827172	670337	1020701
1967	174211	115695	262323	494141	382863	637762	0.280	0.210	0.373	800174	649854	985264
1968	143787	95615	216229	469782	362951	608057	0.202	0.151	0.270	758020	616216	932456
1969	267366	177243	403313	509859	402401	646012	0.195	0.147	0.259	869361	717880	1052806
1970	220408	146917	330662	568159	457854	705038	0.310	0.238	0.403	973772	817707	1159623
1971	229850	153927	343220	554682	452021	680661	0.327	0.253	0.422	954274	806359	1129321
1972	154265	103449	230043	535848	440342	652069	0.321	0.250	0.413	878566	745483	1035406
1973	201294	135058	300013	537224	446847	645881	0.358	0.280	0.457	846588	723212	991011
1974	100846	67415	150854	493712	412902	590337	0.480	0.380	0.606	736039	632146	857006
1975	168309	112918	250872	398963	334802	475420	0.539	0.429	0.677	614139	527453	715071
1976	220420	147490	329412	281331	234555	337436	0.573	0.457	0.718	544141	461430	641678
1977	202624	135938	302023	208941	173586	251498	0.500	0.398	0.630	478268	402502	568295
1978	136704	91625	203960	189086	158224	225968	0.553	0.442	0.692	418443	354574	493817
1979	195867	131462	291824	170439	142582	203739	0.588	0.471	0.735	410417	343590	490243
1980	118880	79764	177178	150189	125504	179728	0.564	0.451	0.706	391858	328104	468000
1981	232133	155017	347614	154449	128375	185819	0.558	0.446	0.698	447833	368831	543756
1982	127952	85652	191143	135715	112885	163162	0.555	0.442	0.696	403434	333787	487614
1983	100879	67291	151234	164048	135411	198741	0.603	0.483	0.752	410114	342736	490739
1984	94848	63020	142751	146889	121652	177361	0.713	0.575	0.885	323432	272348	384098
1985	104305	69193	157235	110715	92052	133162	0.632	0.507	0.788	270744	226156	324123
1986	178608	118543	269107	83490	69335	100536	0.541	0.432	0.677	266515	217251	326950
1987	144151	96320	215734	72061	59969	86591	0.614	0.495	0.761	284521	232275	348519

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
1988	80501	53240	121721	88318	72923	106963	0.606	0.488	0.753	302927	249183	368263
1989	78046	51493	118292	104092	80609	134415	0.488	0.388	0.615	286337	236432	346777
1990	87261	57160	133215	120178	95890	150620	0.549	0.437	0.689	273010	228545	326126
1991	226767	149759	343375	114661	93974	139901	0.506	0.402	0.636	355669	288542	438413
1992	281942	186702	425764	95211	80072	113212	0.603	0.483	0.753	464558	373132	578385
1993	211259	141268	315927	97293	80974	116900	0.532	0.425	0.666	533627	431635	659720
1994	150273	102344	220647	148467	120525	182887	0.478	0.379	0.603	485997	402285	587130
1995	274143	185154	405903	197554	158396	246391	0.374	0.294	0.476	588527	488899	708456
1996	158412	107589	233241	246590	200772	302864	0.363	0.284	0.463	682201	569882	816657
1997	164614	111990	241966	246211	200966	301643	0.256	0.198	0.331	725654	604353	871300
1998	104290	71230	152695	294713	240842	360634	0.254	0.196	0.329	803607	669600	964433
1999	241011	164532	353040	309916	250154	383956	0.255	0.196	0.332	806148	677769	958842
2000	159210	108688	233216	368993	298161	456652	0.226	0.174	0.295	825951	697965	977407
2001	212316	146303	308116	374833	307242	457293	0.198	0.153	0.257	883686	751264	1039450
2002	357911	251930	508475	450424	375437	540388	0.191	0.148	0.247	1027724	880623	1199397
2003	150915	106003	214855	437861	368459	520334	0.184	0.143	0.237	1003187	858533	1172213
2004	153670	106851	221003	518880	441074	610410	0.178	0.137	0.230	1016491	870454	1187028
2005	436325	305892	622375	602367	509925	711569	0.209	0.162	0.270	1097718	941847	1279385
2006	73821	52104	104591	535304	456254	628049	0.249	0.194	0.320	942032	809282	1096558
2007	113108	80112	159694	545628	466743	637846	0.264	0.206	0.338	880826	754665	1028077
2008	200409	142439	281971	468492	394737	556028	0.333	0.262	0.424	730583	629841	847439
2009	145999	103996	204967	361785	304858	429342	0.347	0.275	0.439	677268	585513	783402
2010	269620	192575	377489	327806	277143	387730	0.384	0.304	0.486	698709	600271	813290
2011	113082	80132	159583	292358	246890	346200	0.382	0.301	0.485	584827	501895	681463
2012	153896	109359	216571	301256	254999	355904	0.362	0.285	0.459	595305	510906	693647
2013	209004	148918	293333	323389	270270	386947	0.299	0.235	0.382	608668	520886	711244
2014	108650	77223	152865	348814	291208	417817	0.271	0.212	0.347	642313	549371	750979
2015	165109	117480	232047	357938	298395	429363	0.257	0.200	0.330	626740	534207	735301
2016	252926	178613	358158	391741	323101	474963	0.252	0.195	0.326	794025	671466	938953

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
2017	178636	126300	252660	401931	329879	489720	0.228	0.175	0.297	891948	751182	1059092
2018	130677	90890	187881	464929	378166	571597	0.229	0.175	0.300	940084	786349	1123876
2019	257000	179210	368558	560109	445368	704413	0.203	0.152	0.270	1055975	875840	1273157
2020	122722	83756	179818	616956	480534	792107	0.187	0.138	0.255	1069119	871949	1310875
2021	147428	92304	235474	715674	542678	943818	0.186	0.131	0.264	1140302	899686	1445270

Table 5.12 Northeast Arctic saithe. Prediction input data

rMFDP version
Run: r
F_{bar} age range: 4–7

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161659	0.2	0	0	0	0.78	0.046	0.78
4	115519	0.2	0.05	0	0	1.128	0.131	1.128
5	65936	0.2	0.42	0	0	1.605	0.168	1.605
6	132944	0.2	0.87	0	0	2.088	0.208	2.088
7	53373	0.2	0.97	0	0	2.651	0.261	2.651
8	35935	0.2	0.98	0	0	3.192	0.285	3.192
9	29775	0.2	0.98	0	0	3.715	0.285	3.715
10	8914	0.2	0.97	0	0	4.16	0.285	4.16
11	3719	0.2	0.97	0	0	4.833	0.285	4.833
12	6565	0.2	0.99	0	0	6.434	0.285	6.434

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161659	0.2	0	0	0	0.78	0.046	0.78
4	.	0.2	0.05	0	0	1.128	0.131	1.128
5	.	0.2	0.42	0	0	1.605	0.168	1.605
6	.	0.2	0.87	0	0	2.088	0.208	2.088
7	.	0.2	0.97	0	0	2.651	0.261	2.651
8	.	0.2	0.98	0	0	3.192	0.285	3.192

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
9	.	0.2	0.98	0	0	3.715	0.285	3.715
10	.	0.2	0.97	0	0	4.16	0.285	4.16
11	.	0.2	0.97	0	0	4.833	0.285	4.833
12	.	0.2	0.99	0	0	6.434	0.285	6.434

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161659	0.2	0	0	0	0.78	0.046	0.78
4	.	0.2	0.05	0	0	1.128	0.131	1.128
5	.	0.2	0.42	0	0	1.605	0.168	1.605
6	.	0.2	0.87	0	0	2.088	0.208	2.088
7	.	0.2	0.97	0	0	2.651	0.261	2.651
8	.	0.2	0.98	0	0	3.192	0.285	3.192
9	.	0.2	0.98	0	0	3.715	0.285	3.715
10	.	0.2	0.97	0	0	4.16	0.285	4.16
11	.	0.2	0.97	0	0	4.833	0.285	4.833
12	.	0.2	0.99	0	0	6.434	0.285	6.434

Input units are thousands and kg - output in tonnes

Table 5.13 Northeast Arctic saithe. Short-term prediction

rMFDP version
Run: r
F_{bar} age range: 4–7

2022

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1103920	745913	1.0786	0.2071	197212

2023–2024

2023					2024	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
1050549	686937	0	0	0	1212129	815773
.	686937	0.1	0.0192	19638	1190491	796705

2023					2024	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
.	686937	0.2	0.0384	38826	1169356	778107
.	686937	0.3	0.0576	57575	1148713	759967
.	686937	0.4	0.0768	75895	1128549	742273
.	686937	0.5	0.096	93798	1108852	725014
.	686937	0.6	0.1152	111294	1089611	708179
.	686937	0.7	0.1344	128393	1070814	691758
.	686937	0.8	0.1536	145104	1052450	675738
.	686937	0.9	0.1728	161438	1034509	660112
.	686937	1	0.192	177402	1016980	644867
.	686937	1.1	0.2112	193007	999852	629995
.	686937	1.2	0.2304	208262	983117	615487
.	686937	1.3	0.2496	223174	966763	601332
.	686937	1.4	0.2688	237752	950783	587523
.	686937	1.5	0.288	252005	935166	574049
.	686937	1.6	0.3072	265940	919904	560904
.	686937	1.7	0.3264	279566	904988	548078
.	686937	1.8	0.3456	292888	890410	535564
.	686937	1.9	0.3648	305916	876161	523353
.	686937	2	0.384	318656	862233	511438

Input units are thousands and kg - output in tonnes

Table 5.14 Northeast arctic saithe. Short-term projection output HCR landings

rMFDP version
Run: r
F_{bar} age range: 4–7

2022

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1103920	745913	1.0786	0.2071	197212

2023

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1050549	686937	1.3246	0.254	226794

2024

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
962796	597899	1.667	0.32	246332

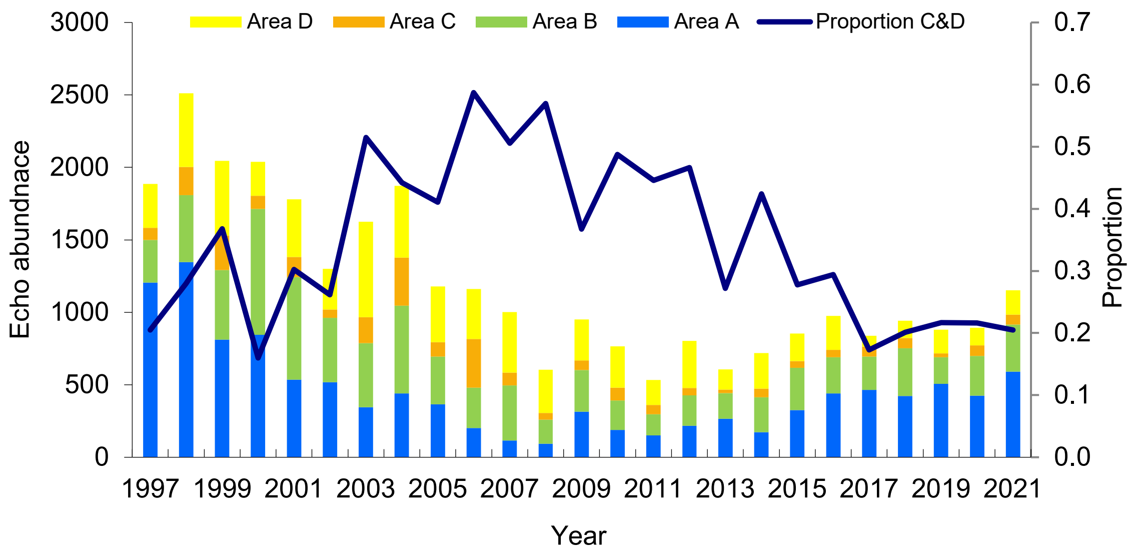


Figure 5.1. Northeast Arctic saithe. Echo abundance and proportion of saithe in the southern half of the survey area (subarea C+D).

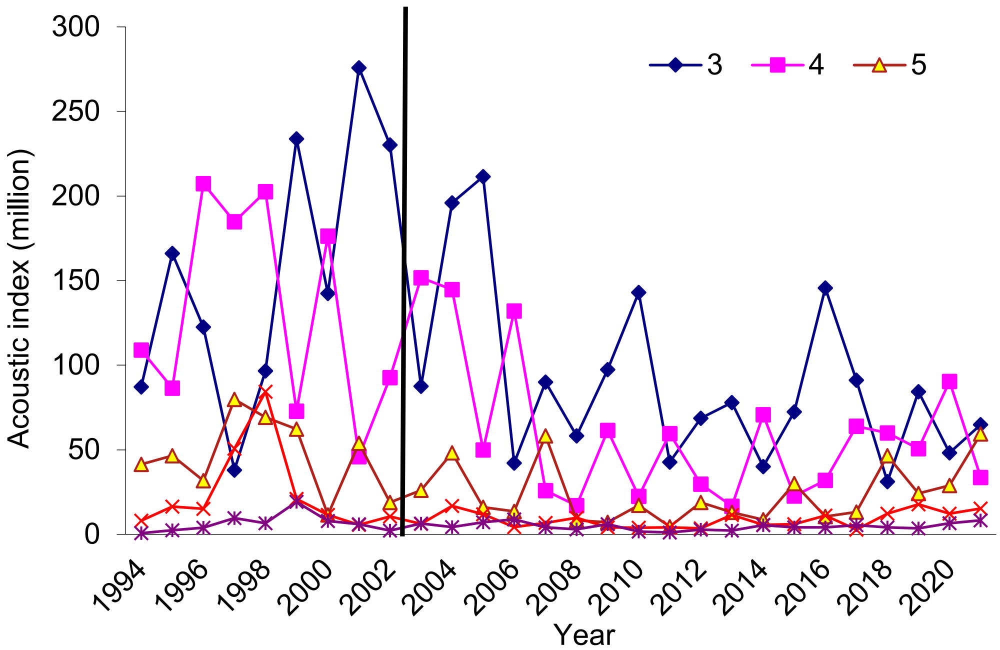


Figure 5.2. Northeast Arctic saithe. acoustic survey tuning indices by age class (3–7). break in 2002 black line.

Figure 5.3. Northeast Arctic saithe. Final run normalized residuals. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals. The top figure shows residuals for the total catch series. the figure in the middle the residuals for the first survey series and the bottom figure the residuals for the survey series from 2002.

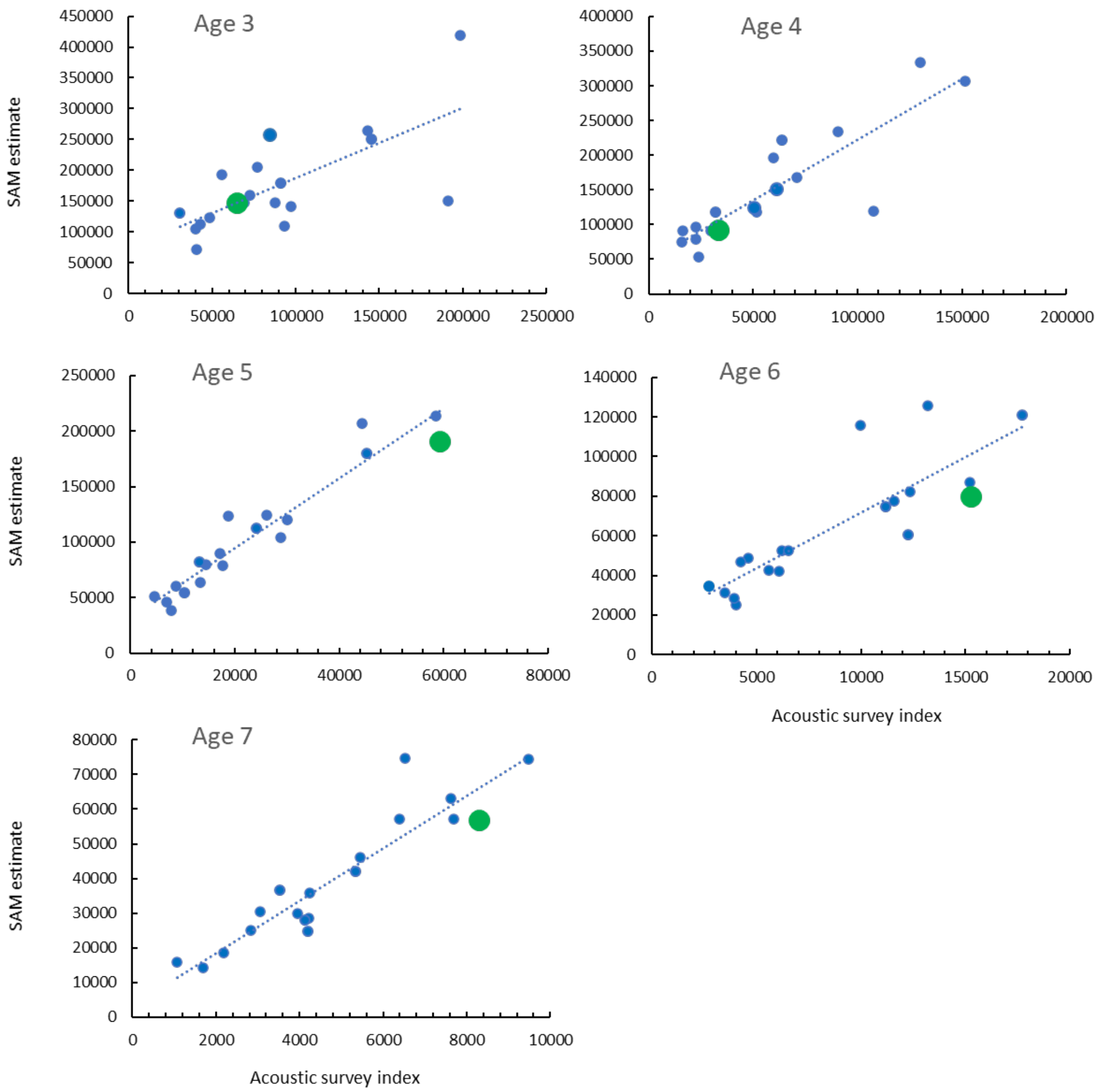


Figure 5.4. NEA saithe - Acoustic survey vs. SAM. Green point 2021 data.

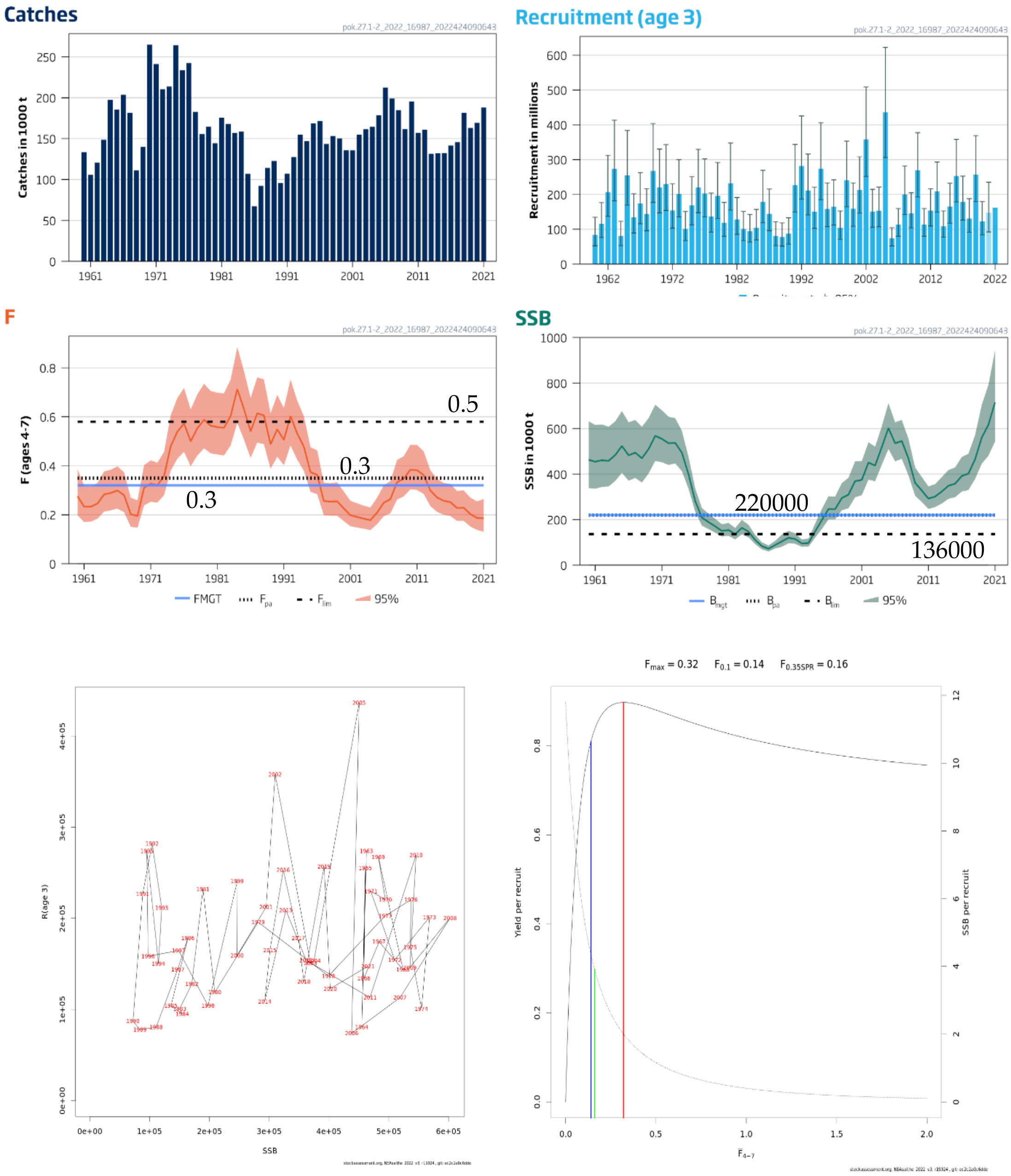


Figure 5.5. Northeast Arctic saithe (subareas 1 and 2).

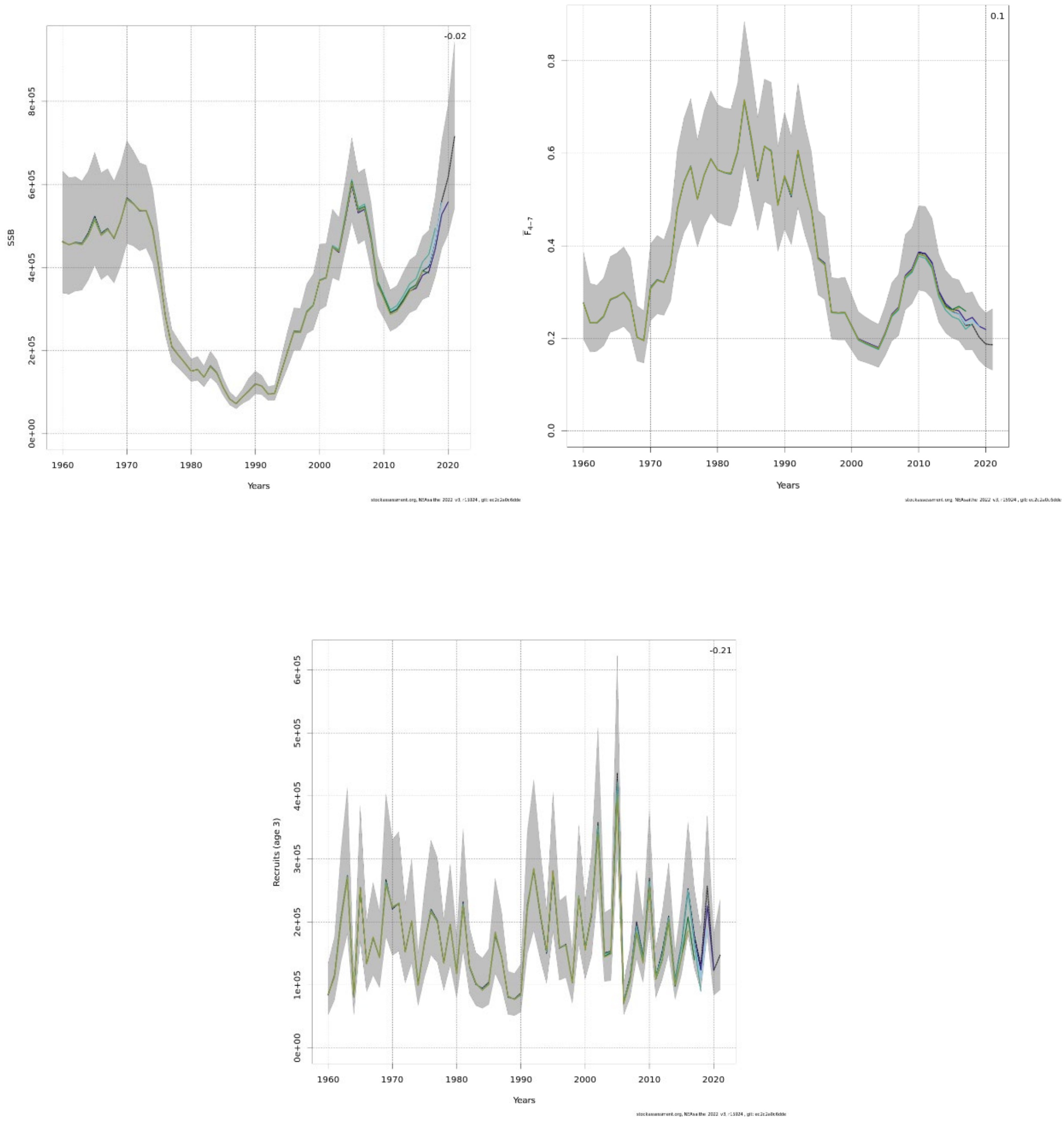


Figure 5.6. Saithe in subareas 1 and 2 (Northeast Arctic) RETROSPECTIVE SAM SSB. F4–7. and recruits.

6 Northeast Arctic beaked redfish[1]

On 30 March 2022 all Russian participation in ICES was suspended. As a result of this decision, it is not possible to run ICES stock assessments or provide ICES advice for the Barents Sea stocks of NEA cod, NEA haddock, *Sebastes mentella* or Greenland Halibut, as management and data collection for these stocks are shared between Norway and Russia. There is therefore no stock assessment for NEA cod this year, but input data to the assessment are updated as far as possible.

The chapter was therefore updated as in a non-assessment year. This comprises tables 6.1 through to 6.7 and tables 6.12, to 6.19. Updated figures comprise figures 6.1, 6.2, 6.6, 6.7 (upper panel), 6.8, 6.10, 6.12, 6.15 and 6.16.

6.1 Status of the fisheries

6.1.1 Development of the fishery

A description of the historical development of the fishery in subareas 1 and 2 is found in the stock annex for this stock.

An international pelagic fishery for *S. mentella* in the Norwegian Sea outside EEZs has developed since 2004 (Figure 6.1). This pelagic fishery, which is further described in the stock annex, is managed by the Northeast Atlantic Fisheries Commission (NEAFC). Since 2014 the directed demersal and pelagic fisheries are reopened in the Norwegian Economic Zone, the Fisheries Protection Zone around Svalbard and, for pelagic fisheries only, in the Fishing Zone around Jan Mayen. The spatial regulation for this fishery is illustrated in Figures 6.2 and 6.3. In 2021, most of the catches of *S. mentella* from the Russian and Norwegian fisheries were taken in the Norwegian Exclusive Economic Zone or as bycatch in the Fisheries Protection Zone around Svalbard. Catches in international waters were mainly taken by EU nations.

Figure 6.2 shows the distribution of catch among national fishing fleets for 2018 to 2021 and the location of Norwegian *S. mentella* catches in the Norwegian EEZ in 2021 as well as bycatch in other areas. The 44th Session of the Joint Norwegian-Russian Fisheries Commission decided to split the total TAC among countries as follows: Norway: 72%, Russia: 18%, Third countries: 10% (as bycatch in the fishery protection zone at Svalbard (Spitsbergen): 4.1%, and international waters of the Norwegian Sea (NEAFC-area): 5.9%). This split was reconducted at the 51st session of the commission in 2021.

6.1.2 Bycatch in other fisheries

During 2003–2013, all catches of *S. mentella*, except the pelagic fishery in the Norwegian Sea outside EEZ, were taken as bycatches in other fisheries. Some of the pelagic catches are taken as bycatches in the blue whiting and herring fisheries. From 2014 onwards most of the catch is taken as targeted catch and no longer as bycatch, following the opening of a targeted fishery in the Norwegian EEZ, Svalbard Fisheries Protection Zone and around Jan Mayen. When fishing for other species it has since 2013 been allowed to have up to 20% redfish (both species together) in round weight as bycatch outside 12 nautical miles and only 10% bycatch inside 12 nautical miles to better protect *S. norvegicus*.

[1] Beaked redfish (*Sebastes mentella*) in subareas 1 and 2 (Northeast Arctic); reb.27.1-2.

6.1.3 Landings prior to 2021 (Tables 6.1–6.7, Figure 6.1)

Nominal catches of *S. mentella* by country for subareas 1 and 2 combined are presented in Table 6.1, while they are presented for Subarea 1 and divisions 2.a and 2.b in Tables 6.2–6.4. The pelagic catch of *S. mentella* in the Norwegian Sea outside EEZs reported to NEAFC and/or ICES amounted to 7739 t in 2018, 6060 t in 2019, 5469 t in 2020 and 2872 t in 2021, and is shown by country in Table 6.5. Nominal catches for both redfish species combined (i.e. *S. mentella* and *S. norvegicus*) by country are presented in Table 6.6. The sources of information used are catches reported to ICES, NEAFC, Norwegian and Russian authorities (foreign vessels fishing in the Norwegian and Russian economic zones) or direct reporting to the AFWG. Where catches are reported as *Sebastes sp*., they are split into *S. norvegicus* and *S. mentella* by AFWG experts based on available correlation between official catches of these two species in the considered areas. All tables have been updated for 2020, and new figures presented for 2021. Total international landings in 1952–2021 are also shown in Figure 6.1.

In 2014, ICES advised that the annual catch in 2015, 2016, and 2017 should be set at no more than 30 000 t and in 2017, ICES advised that the annual catch in 2018 should not exceed 32 658 t. Following the benchmark (WKREDFISH, ICES 2018a) and the subsequent evaluation of a management plan for the stock (WKREBMSE, ICES 2018b) ICES advised an annual catch of no more than 53 757 t for 2019 and 55 860 t in 2020, corresponding to a fishing mortality of F = 0.06. This was continued in 2020, when ICES advised an annual catch of no more than 66 158 t in 2021 and 67 210 t in 2022, still corresponding to F = 0.06. No advice was given in 2022.

Because of the novelty of the situation, related with reopening fisheries after 10 years of its ban, the total landings of *S. mentella* in subareas 1 and 2 in 2014, demersal and pelagic catches, amounted to only 18 426 t. The total landings of the demersal and pelagic fishery increased to 34 754 t in 2016, 30 783 t in 2017, 38 046 t in 2018, 45 640 t in 2019, 53 631 t in 2020 and 63 482 t in 2021. Of this, 2872 t were reported from the pelagic fishery in international waters of the Norwegian Sea. The total landings in 2017 and 2018 were respectively 783 t and 5388 t above the TAC advised by ICES, but were 8117 t, 2229 t and 2676 t below TAC in 2019, 2020 and 2021, respectively. Norway caught the major share of the demersal catches, but Russian demersal catches increased substantially after 2017, particularly in ICES Division 2.b.

The redfish population in Subarea 4 (North Sea) is believed to belong to the Northeast Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are not included in the assessment. The total redfish landings (golden and beaked redfish combined) from Subarea 4 have up to 2003 been 1000–3000 t per year. Since 2005 the annual landings from this area have varied between 90 and 333 t (Table 6.7).

6.1.4 Expected landings in 2022

ICES has advised on the basis of precautionary considerations that the annual catch should be set at no more than 67 210 t in 2022. The 51st sessions of the Joint Norwegian-Russian Fisheries Commission decided to follow this advice.

In 2022 Norwegian fishing vessels, can catch and land up to 44 291 t of redfish in the Norwegian economic zone (NEZ) in a limited area north of 65°20’N (see map in Figure 6.3), in international waters and the fisheries zone around Jan Mayen. Of this quantity, 100 t are allocated to cover bycatch in other fisheries and 52 t for research/surveillance and education purposes, while the remaining 43 139 t can be taken in a directed fishery. Only vessels with cod and saithe trawl permits can participate in the directed fishery for redfish. Each vessel which has the right to participate is assigned a maximum quota, which can be adjusted during the year, per how much of the national quota is exploited. The fishery may be stopped if the total quota is reached. This quota must also cover catches of redfish (both species) in other fisheries. It is prohibited to fish for redfish with bottom trawls in the period from 1 March until 10 May. Investigations were conducted in 2015–2016 to see if the protection of females during the main time of larvae release should be improved by extending the period of prohibited fishing until later in May, and to see if the area south of Bear Island (Area 20 in Figure 6.3) can be opened for directed fishing, either with or without sorting grid, and permissions were granted to a small number of vessels of the Norwegian reference fleet for an earlier onset of fishing to gain further data. The hitherto conclusion is that males dominated the catches (more than 70%) in the main fishing areas south and southwest of Bear Island during the investigations from late April until the directed fishery started on 10 May, and that the area south of Bear Island should stay closed during January–February due to smaller *S. mentella* inhabiting this area at the beginning of the year.

Since 2015, Russia has had access to the NEZ when fishing their quota share. In 2021 Russia may fish 11 908 t (18%) plus 2000 t transferred from Norway to Russia. Apart from this an additional 2100 t were transferred from Norway to Russia to cover bycatch of redfish (both species) in Russian fisheries targeting other species. The remaining 6616 t are divided between third countries in the NEZ and Svalbard Zone (2713 t) and the NEAFC areas (3903 t). Catch in the NEAFC areas in 2021 amounted to 2872 t while the catch in the national economic zones of Norway and Russia as well as the fisheries protection zone around Svalbard was 60 610 t. The total catch in 2021 was 2676 t lower than the advised TAC. It is assumed that the total catch in 2022 should not exceed the TAC of 67 210 t set by ICES.

6.2 Data used in the assessment

Analytical assessment was conducted for this stock following recommendation from the benchmark assessment working group (WKREDFISH, ICES 2018a). Input datasets were updated with the most recently available data. The analytical assessment, based on a statistical catch-at-age model (SCAA), covers the period 1992–2020. The input data consists of the following tables:

- Total catch in tonnes (Table 6.1)
- Catch in tonnes in the pelagic fishery Norwegian Sea outside EEZs (Table 6.5)
- Total catch numbers-at-age 6–19+ (Table 6.8)
- Catch numbers-at-age 7–19+ in the pelagic fishery (Table 6.9)
- Weight-at-age 2–19+ in the population (Table 6.12)
- Maturity-at-age 2–19+ in the population (Table 6.14)
- Russian autumn survey numbers-at-age 0–11 (Table 6.15)
- Ecosystem survey numbers-at-age 2–15 (Table 6.17)
- Winter survey numbers-at-age 2–15 (Table 6.18b)
- Deep pelagic ecosystem survey proportions-at-age (Table 6.19)

There was no direct observation of catch numbers-at-age for the pelagic fishery in the Norwegian Sea outside EEZs in 2012–2021. Instead, numbers-at-age were estimated based on catch-at-age from previous or following year, and weight-at-age and fleet selectivities (section 6.2.2 in AFWG report 2013). In 2013, 2016 and 2019, observations from the scientific survey in the Norwegian Sea were used to derive numbers-at-age in the pelagic fishery. This was considered appropriate given that the survey operates in the area of the fishery, with a commercial pelagic trawl and at the time of the start of the fishery.

6.2.1 Length- composition from the fishery (Figure 6.4)

Comparison of length distributions of the Norwegian and Russian catches of *S. mentella* in 2019–2020 are shown in Figure 6.4. In 2020, the Russian and Norwegian fleets fished smaller fish than in 2019, reflecting good year classes due to enter the fishable stock. In 2020 length of beaked redfish in Norwegian catches was larger than in Russian catches. This is probably due to differences in the fishing areas. The Russian fleet largely operated in area 2b, and the Norwegian fleet in area 2a.

6.2.2 Catch-at-age (Tables 6.8–6.11, Figure 6.5)

Catch-at-age in the Norwegian fishery was estimated using ECA for 2014. For 2015, 2016 and 2018, it was not possible to run ECA and the catch-at-age for the Norwegian Fishery was estimated using the older Biomass program in SAS (Table 6.8). Not enough age readings were available to estimate catch-at-age in 2017, 2019 and 2020. For the demersal fisheries 2017, 2019 and 2020 as well as the pelagic fisheries 2017, 2018 and 2020 (Table 6.9) proportions-at-age in the catch were derived from proportions at-age in earlier years, weight-at-age and fleet selectivity (section 6.2.2 in AFWG report 2013).

The procedure for estimating catch-at-age for recent years in which age data are not available is somewhat problematic. This is because the last year of observation has a large effect on the estimated catch-at-age for several years. At the assessment working group in 2017 and at the benchmark assessment in January 2018, the last year of observations for the catch-at-age was 2014 and the values for the years 2015 and 2016 were extrapolated. Once available, the data for 2015 (demersal) and 2016 (pelagic) were substantially different from these earlier extrapolations.

Age composition of the Russian and Norwegian catches in 2020 was calculated using the age–length key, based on Russian age readings. The joint age–length key for the last three years (2018–2020) was applied. In general, the age distribution in the Norwegian fishery was shifted towards older fish compared to the Russian fishery. In the Russian catches fish at age 15–16 dominated, while in the Norwegian catches 16–17 years old. (Figure 6.5). The proportion (by numbers) of individuals at age 18 and older in the Norwegian catches was almost twice as large as in the Russian ones.

Age–length-keys for *S. mentella* are uncertain because of the slow growth rate of individuals and therefore these data should be used with caution. They were not used in the current assessment but may be considered in future assessments. Given that age is difficult to derive from length it is important that age readings are available for the most recent years, at the time of the working group.

6.2.3 Weight-at-age (Tables 6.12, 6.13, Figures 6.6, 6.7)

In earlier assessment, weight-at-age in the stock was set equal to the weight-at-age in the catch. This turned out to be problematic because of important fluctuations in reported weight-at-age in the catch that cannot be explained biologically (i.e. these are noisy data). In 2015, it was advised to either use a fixed weight-at-age for the 19+ group, or use a modelled weight-at-age based on catch and survey records (Planque, 2015). The second option was chosen. Weight-at-age in the population was modelled for each year using mixed-effect models of a von Bertalanffy growth function (in weight). In 2018 an attempt was made to model weight-at-age for each cohort (rather than each year of observation). This showed that the growth function is nearly invariant between cohorts. Therefore, it was decided to use a fixed (i.e. common to all years) weight-at-age as input to the Statistical Catch-at-age model. The observed and modelled weight-at-age are presented in Table 6.12 as well as Figures 6.6 and 6.7.

6.2.4 Maturity-at-age (Table 6.14, Figure 6.8)

The proportion maturity-at-age was estimated for individual years using a mixed-effect statistical model (Table 6.14, Figure 6.8). The modelled values of maturity-at-age for individual years are used in the analytical assessment models, except in 2008, 2011 and 2016–2020 when the fixed effects only were considered, at least in the two latest years due to a lack of age data.

6.2.5 Natural mortality

In previous years, natural mortality for *S. mentella* was set to 0.05 for all ages and all years. This was based on life-history correlates presented in Hoenig (1983). Thirty-nine alternative mortality estimates were explored during the benchmark workshop, based on the review work by Kenchington (2014) and several additional recent papers (Then *et al*., 2014; Hamel, 2014; Charnov *et al*., 2013). Overall, the mode of these natural mortality estimates is 0.058 which departs only slightly from the original estimate of 0.050 (Figure 6.9). WKREDFISH 2018 decided to continue using 0.050 as the value of M in the assessment model. These estimates were updated for a peer-reviewed paper submitted in 2022 (Höffle and Planque, in revision) with 44 estimators resulting in a mode of the distribution of 0.07.

Figure 6.10 shows cod's predation on juvenile (5–14 cm) redfish during 1984–2020. This time-series confirms the presence of redfish juveniles and may be used as an indicator of redfish abundance. A clear difference is seen between the abundance/consumption ratio in the 1980s and at present. A change in survey trawl catchability (smaller meshes) from 1993 onwards (Jakobsen *et al*., 1997) and/or a change in the cod's prey preference may cause this difference. As long as the trawl survey time-series has not been corrected for the change in catchability, the abundance index of juvenile redfish less than 15 cm during the 1980s might have been considerably higher, if this change in catchability had been corrected for. The decrease in the abundance of young redfish in the surveys during the 1990s is consistent with the decline in the consumption of redfish by cod. It is important that the estimation of the consumption of redfish by cod is being continued.

6.2.6 Scientific surveys

Following a dedicated review, AFWG approved the use of the new StoX versions of winter and ecosystem surveys for use in the *S.s mentella* assessment (WD 17 and WD 18 in AFWG 2020). The group recommended that the data be monitored annually to identify if a significant portion of the mentella stock moves east of the strata system. The group further recommended that work continues to investigate redfish-specific strata systems for the winter survey.

The results from the following research vessel survey series were evaluated by the Working Group:

6.2.6.1 Surveys in the Barents Sea and Svalbard area (Tables 1.1, 1.2, 6.15–6.18, Figures 6.11, 6.12)

Russian bottom trawl survey in the Svalbard and Barents Sea areas in October-December for 1978–2015 in fishing depths of 100–900 m (Table 6.15, Figure 6.11). ICES acronym: RU-BTr-Q4.

Russian-Norwegian Barents Sea 'Ecosystem survey' (bottom trawl survey, August-September) from 1986–2019 in fishing depths of 100–500 m (Figures 6.11–6.12). Data disaggregated by age for the period 1992–2019 (Tables 6.16b-6.17). ICES acronym: Since 2003 part of Eco-NoRu-Q3 (BTr), survey code: A5216.

Winter Barents Seabed-trawl survey (February) from 1986–2014 (jointly with Russia since 2000, except 2006 and 2007) in fishing depths of 100–500 m (Figures 6.11–6.12). Data disaggregated by age for the period 1992–2011 and 2013 (Table 6.18b). ICES acronym: BS-NoRu-Q1 (BTr), survey code: A6996.

The Norwegian survey initially designed for redfish and Greenland halibut is now part of the ecosystem survey and covers the Norwegian Economic Zone (NEZ) and Svalbard Fisheries Protection Zone incl. north and east of Spitsbergen during August 1996–2012 from less than 100 m to 800 m depth. This survey includes survey no. 2 above, and has been a joint survey with Russia since 2003, and since then called the Ecosystem survey. ICES acronym: Eco-NoRu-Q3 (Btr), survey code: A5216.

6.2.6.2 Pelagic survey in the Norwegian Sea (Table 6.19, Figures 6.13, 6.14)

The international deep pelagic ecosystem survey in the Norwegian Sea (WGIDEEPS, ICES 2016, survey code: A3357) monitors deep pelagic ecosystems, focusing on beaked redfish (*S. mentella*). The latest survey was conducted in the open Norwegian Sea from 11 August until 28 August 2019, following similar surveys in 2008, 2009, 2013 and 2016. The spatial coverage of the survey and the catch rates of beaked redfish in the trawl are presented in Figure 6.13. The survey is scheduled every third year. Estimated numbers-at-age from this survey were presented at the benchmark assessment in 2018 and used in the SCAA model. Data for 2016 was updated in 2019, using additional age readings and numbers-at-age for the 2019 survey were presented during AFWG 2020, used in the assessment and updated for AFWG 2021. The details of the data preparation, using StoX, are available from WD7 of AFWG 2018 (Planque *et al.,* 2018). The data used as input to the analytical assessment consists of proportions-at-age from age 2 to 75 years (Figure 6.14).

6.2.6.3 Additional surveys (Figures 6.15–6.17)

The international 0-group survey in the Svalbard and Barents Sea areas in August-September 1980–2021, is now part of the Ecosystem survey (Figures 6.15 and 6.16). ICES acronym: Eco-NoRu-Q3 (Btr), survey code: A5216.

A slope survey "Egga-sør survey" was carried out by IMR from 07 March to 07 April 2020, following similar surveys in 2009, 2012, 2014, 2016 and 2018. The spatial coverage of the 2022 survey and the distribution of beaked redfish registered by acoustic is presented in Figure 6.17. Egga-Sør and Egga-Nord surveys operate on a biennial basis. The length and age distributions of beaked redfish from these surveys show consistent ageing in the population and gradual incoming of new cohorts after the recruitment failure period. These surveys are considered as candidates for data input to the analytical assessment of *S. mentella* (see also Planque, 2016).

6.3 Assessment

The group performed the analytical assessment using the statistical catch-at-age (SCAA) model reviewed at the benchmark in January 2018 (WKREDFISH, ICES 2018a). The model was configured as the benchmark baseline model which includes 53 parameters to be estimated and the model converged correctly.

6.3.1 Results of the assessment (Tables 6.20, 6.21, Figures 6.18–6.24)

6.3.1.1 Stock trends

The temporal patterns in recruitment-at-age 2 (Figures 6.18, 6.21) confirm the previously reported recruitment failure for the year classes 1996 to 2003 and indicate a return to high levels of recruitment. The estimates of year-class strength for recent years are uncertain due to limited age data from winter and ecosystem surveys. Modelled spawning-stock biomass (SSB) has increased from 1992 to 2007 (Table 6.21). In the late 2000s the total-stock biomass (TSB) consisted of a larger proportion of mature fish than in the 1990s. This is reversing as individuals from new successful year classes, but still immature, are growing. TSB has increased from about 1.0 to above 1.4 million tonnes in the last 10 years (Table 6.21 and Figures 6.21–6.22). The concurrent decline in SSB from 2007 to 2014 can be attributed to the weak year classes (1996–2003) entering the mature stock. This trend has levelled off and SSB increases again. SSB at the start of 2021 is estimated at 900 221 t.

6.3.1.2 Fishing mortality (Tables 6.20a,b–6.21, Figure 6.19)

The patterns of fleet selectivity-at-age indicate that most of the fish captured by the demersal fleet in 2020 are of age 8 years and older, while the pelagic fleet mostly captures fish of age 14 and older (Tables 6.20a,b and Figure 6.19). While model results at the benchmark workshop showed a gradual shift in the demersal selectivity towards older ages in recent years, this is no longer observed after the 2015 catch-at-age data were incorporated in the model. The demersal fleet selectivity appears shifted towards later ages only in 2014. In 2020 F_{19+} is estimated at 0.05 (Table 6.21), with 0.04 for the demersal and 0.008 for the pelagic fleets (Table 6.20a), respectively.

6.3.1.3 Survey selectivity patterns (Figure 6.20)

Winter and ecosystem surveys selectivity at age are very similar and show reduced selectivity for age 8 years and older, which is consistent with the known geographical distribution of different life stages of *S. mentella* (Figure 6.20). Conversely, the Russian survey shows a reduced selectivity for age 7 years and younger. This is believed to result from gear selectivity.

6.3.1.4 Residual patterns (Figure 6.23)

Residual patterns in catch and survey indices are presented in Figure 6.23a-e. There is generally no visible trend in the residuals for the Russian groundfish survey neither by age nor by year. Trends in residuals are visible in recent years for winter and ecosystem surveys and will need to be investigated further. Alternative methods for the estimation of the survey selectivity patterns will be investigated in the benchmark assessment planned for 2024 and could resolve the issue. Residual patterns for the demersal fleet indicate a similar fit of the model compared to AFWG 2018, when a time varying selectivity-at-age for this fleet was introduced.

6.3.1.5 Retrospective patterns (Figure 6.24)

The historical retrospective patterns for the years 2007 to 2016 are presented in Figure 6.24. All model parameters were estimated in each individual run. The most recent model run (last year of data 2020) is consistent with previous runs. As in 2018 the SSB time-series is smoother than before, due to fixed weight-at-age for every year. The new estimates for winter and Ecosystem surveys in 2020 led to an increase in estimated SSB, up to 19% in the early years and around 7% to 9% in later years. Contrarily, the 2021 update revised SSB moderately down, by about 5% to 6%. Retrospective bias (Mohn's rho) over the last 5 assessments was -48% for recruitment, -2% for F(19+) and +7% for SSB. The benchmark run stands out and this is due to the unavailability of recent catch-at-age data during the benchmark assessment (see section 6.2.2).

6.3.1.6 Projections

F_{MSY} at age 19+ is approximated using $F_{0.1}$ and estimated at 0.084 (section 1.4 of the WKREBMSE report 2018b).

The estimated fishing mortality in 2020 is: $F_{19+} = 0.05$.

If the fishing mortality is maintained, this is expected to lead to a catch of 57 743 t in 2021, well below the advised TAC of 66 158 t. This would lead to an SSB of 925 932 t in early 2022, catches of 59 466 t in 2022 and SSB of 955 688 t in 2023.

Raising F_{19+} to the precautionary approach (F_{19+} = 0.06), recommended in the latest advice, in 2022–2024 would lead to average catches of 72 263 t during that period and a SSB of 999 340 t by 2025 (SSB at the start of 2020 is estimated at 874 727 t).

These projections assume that the selectivity patterns of the demersal and pelagic fleets are identical with those estimated for 2019. It is also assumed that the ratio of fishing mortality between these two fleets remains unchanged.

6.3.1.7 Additional considerations

Historical fluctuations in the recruitment-at-age 2 (Figures 6.18 and 6.21) are consistent with the 0-group survey index (Figure 6.16), although the 0-group survey index is not used as an input to the SCAA.

The population age structure derived from the model outputs for the old individuals (beyond 19+, Figure 6.22) is consistent with the age structure reported from the slopes surveys although these are not yet used as input to the model.

Recent recruitment levels estimated with SCAA are highly uncertain since they rely on only few years of observations and since the age readings from winter survey were not available for years 2014–2021. The use of the autoregressive model for recruitment (random effects in the SCAA) which was introduced in this assessment allows for a projection of the recruitment in recent years, despite the current lack of age data.

6.3.1.8 Assessment summary (Table 6.21, Figure 6.21)

The history of the stock as described by the SCAA model for the period 1992–2019 is summarized in Table 6.21 and Figure 6.21. The key elements are as follows:

- upward trend in Total-stock biomass from 1992 to 2006 followed by stabilization until 2011 and a new upward trend until the present,
- upward trend in spawning-stock biomass from 1992 to 2007 followed by stabilization (or slight decline) until 2014 and subsequent increase,
- recruitment failure for year classes 1996–2003 (2y old fish in 1998–2005),
- good (although uncertain) recruitment for year classes born after 2005. Age data for recruits (at age 2y) after 2014 is limited.
- Annual fishing mortality for the 19+ group throughout the assessment period varied between 0.003 and 0.05.

6.4 Comments to the assessment

Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. Data from the pelagic survey in the Norwegian Sea has been reviewed in the last benchmark and is now included in the assessment model. Priority should be given to including additional data from the slope surveys that include older age groups, in the analytical assessment in future (WD 5 in 2016).

The SCAA model relies on the availability of reliable age data in surveys and in the catch. Although additional age reading since the last assessment has improved reliability, it requires a continuous effort to keep these data at an appropriate level.

6.5 Biological reference points

The proposed reference points estimated during the workshop on the management plan for *S. mentella* in (ICES 2018b) were:

Reference point	Value
B_{lim}	227000 t
B_{pa}	315000 t
$F_{MSY19+}= F_{0.1}$	0.084

Which are revised from those set during the benchmark in the same year (ICES 2018a) which were B_{pa} = 450 kt, B_{lim} = 324 kt and F_{MSY19+} = $F_{0.1}$ = 0.08.

6.6 Management advice

The present report neither assesses the stock nor does it give advice.

6.7 Possible future development of the assessment

Many developments suggested in earlier years were presented and evaluated at the benchmark in January 2018. These include integrating a stochastic process model i) for recruitment-at-age 2, ii) for the annual component of fishing mortalities, and iii) to account for annual changes in fleet selectivities-at-age. In addition, iv) a right trapezoid population matrix, v) coding of older ages into flexible predefined age-blocks, and vi) integrating of data from pelagic surveys in the Norwegian Sea were implemented. The purpose of these new features was to reduce the number of parameters to estimate (i, ii), include new data on the older age fraction of the population (iv, v, vi) and account for possible temporal changes in selectivity linked to changes in the national and international fisheries and their regulations (iii).

Recommendations that have been followed since comprise:

- An increase in the number of age readings from surveys and from the fishery, particularly for recent years.
- Use of a standardized method (StoX) for the determination of numbers-at-age in the surveys. The use of StoX for survey indices was evaluated at the beginning of AFWG 2020.

Future developments for the assessment of *S. mentella* may possibly include:

- Use of a standardized method (ECA) for the determination of numbers-at-age in the catch.
- A genetic-based method for rapidly identifying Sebastes species (*S. norvegicus*, *S. mentella*, *S. viviparus*);
- Direct use of length information (as in GADGET);
- Development of a joint age–length key for calculation of age composition of all *S. mentella* catches.
- Development of a joint model for *S. mentella* and *S. norvegicus* which can include uncertainty in species identification and reporting of catch of *Sebastes sp*.

Implementing the current model in a more generic framework (SAM or XSAM) would provide a set of diagnostic tools and the wider expertise shared by the groups developing these models. The new version of GADGET, running the currently used TMB-package in the background, may provide an opportunity to put both species on the same platform.

Further studies of redfish mortality at young age, including a scientific publication, should be carried out. These studies should also take account of historic estimates of bycatch. Variable M by age and possibly time period could then be incorporated in the assessment.

6.8 Tables and figures

Table 6.1. *S. mentella* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1, divisions 2.a and 2.b combined.

Year		Estonia	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998		-	20	73	100	14	-	9	-	-	-	9733	13	125	3646	177	134	14045
1999		-	73	26	202	50	-	3	-	-	-	7884	6	65	2731	29	140	11209
2000		-	50	12	62	29	48	1	-	-	-	6020	2	115	3519	87	130	10075
2001		-	74	16	198	17	3	4	-	-	-	13937	5	179	3775	90	120	18418
2002		15	75	58	99	18	41	4	-	-	-	2152	8	242	3904	190	188	6993
2003		-	64	22	32	8	5	5	-	-	-	1210	7	44	952	47	124	2520
2004	Sweden - 1	-	588	13	10	4	10	3	-	-	-	1375	42	235	2879	257	76	5493
2005		5	1147	46	33	39	4	4	-	-	7	1760	-	140	5023	163	95	8465
2006	Canada - 433	396	3808	215	2483	63	2513	4	341	845	-	4710	2496	1804	11413	710	1027	33261
2007		684	2197	234	520	29	1587	17	349	785	-	3209	1081	1483	5660	2181	202	20219
2008		-	1849	187	16	25	9	9	267	117	13	2220	8	713	7117	463	83	13096
2009	EU - 889	-	1343	15	42	-	33	-	-	-	3	2677	338	806	3843	177	80	10246
2010		-	979	175	21	12	2	-	243	457	-	2065	-	293	6414	1184	79	11924
2011		-	984	175	835	-	2	-	536	565	-	2471	11	613	5037	1678	55	12962

Year	Estonia	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
2012	-	259	-	517	-	36	-	447	449	-	2114	318	1038	4101	1780	-	11059
2013	-	697	-	80	21	1	-	280	262	-	1750	84	1078	3677	1459	-	9389
2014	-	743	215	446	15	-	-	215	167	3	13149	103	505	1704	1162	-	18426
2015	-	657	49	242	48	3	-	537	192	3	19433	5	678	1142	2529	52	25570
2016	-	502	134	493	74	24	0	1243	1065	-	18191	208	1066	8419	3213	122	34754
2017	4	443	45	763	66	3	-	562	790	-	17 077	102	1060	6593	2838	436	30783
2018	-	425	67	2473	82	10	-	1020	1010	374	18594	275	699	10497	2457	63	38 046
2019	-	156	370	1599	615	10	-	-	653	244	23844	471	1422	13444	2222	590	45640
2020	-	149	163	1807	62	5	-	2	1081	1483	32950	4	870	13874	744	437	53631
2021[1]	-	290	218	1166	85	6	-	-	1379	-	43797	2	381	14887	615	655	63482

1 - Provisional figures.

Table 6.2. *S. mentella* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	20	-	-	-	-	-	26	-	-	378	-	-	424
1999	69	-	-	-	-	-	69	-	-	489	-	-	627
2000	-	-	-	-	48	-	47	-	-	406	-	-	501

Year	Faroe Islands	France	Germany	Greenland	Iceland	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2001	-	-	-	-	3	-	8	-	-	296	-	-	307
2002	-	-	-	-	-	-	4	-	-	587	-	-	591
2003	-	-	-	-	-	-	6	-	-	292	-	-	298
2004	-	-	-	-	-	-	2	-	-	355	-	-	357
2005	-	-	-	-	-	-	3	-	-	327	-	-	330
2006	2	-	-	-	-	-	12	-	-	460	-	2	476
2007	-	-	-	-	8	-	11	-	-	210	-	20	249
2008	-	-	-	-	-	-	5	-	-	155	-	2	162
2009	-	-	-	-	8	-	3	-	-	80	-	-	91
2010	-	-	-	-	-	-	20	-	-	10	-	-	30
2011	-	-	-	-	-	-	48	-	-	13	-	-	61
2012	-	-	-	-	-	-	34	-	-	17	-	-	51
2013	-	-	-	-	-	-	64	-	-	27	-	-	91
2014	-	-	-	-	-	-	159	-	-	63	-	-	222
2015	-	-	-	18	-	-	138	1	-	125	-	-	282
2016	-	-	-	-	-	-	225	1	-	229	342	-	797
2017	-	-	-	12	-	-	207	3	-	196	-	-	418

Year	Faroe Islands	France	Germany	Greenland	Iceland	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2018	-	-	19	26	3	-	255	-	-	376	-	-	679
2019	83	4	-	13	-	1	369	16	1	206	19	4	715
2020	35	12	6	18	1	-	335	3	2	118	1	-	532
2021[1]	87	31	-	14	-	-	195	-	4	367	1	-	699

1 - Provisional figures.

Table 6.3. *S. mentella* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.a (including landings from the pelagic trawl fishery in the international waters).

Year		Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
1998		-	73	58	14	-	6	-	-	9186	118	-	2626	55	106	12242
1999		-	16	160	50	-	3	-	-	7358	56	-	1340	14	120	9117
2000		50	11	35	29	-	-	-	-	5892	98	-	2167	18	103	8403
2001		63	12	161	17	-	4	-	-	13636	105	-	2716	18	95	16827
2002		37	54	59	18	41	4	-	-	1937	124	-	2615	8	157	5054
2003		58	18	17	8	5	5	-	-	1014	17	-	448	8	102	1700
2004	**Sweden** - 1	555	8	4	4	10	3	-	-	987	86	-	2081	7	18	3764
2005		1101	36	17	38	2	4	-	-	1083	71	-	3307	20	15	5694

Year		Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
2006	**Estonia** - 396 **Canada** – 433	3793	199	2475	52	2513	3	845	-	4010	1731	2467	10110	589	958	30574
2007	**Estonia** - 684	2157	226	519	29	1579	16	785	349	3043	1395	1079	5061	2159	120	19201
2008	**Netherlands** - 13	1821	179	9	24	9	9	117	267	1952	666	1	6442	430	62	12001
2009	**EU** – 889	1316	7	23	-	25	-	-	-	2208	764	338	3305	137	62	9074
2010		961	175	13	12	2	-	457	243	1705	246	-	5903	1183	55	10955
2011		932	175	697	-	2	-	561	536	1682	599	-	4326	1656	19	11185
2012		259	-	469	-	32	-	449	447	1500	1038	311	3478	1770	-	9753
2013	**NL**	675	-	24	21	1	-	262	280	871	1055	68	3293	1435	-	7985
2014	2	728	209	411	15	-	-	167	215	4089	505	100	1334	1159	-	8934
2015	3	657	49	236	25	3	-	192	537	11410	678	3	480	2508	47	16828
2016		495	107	493	61	-	24	1065	1243	8887	1052	183	3949	2862	71	20492
2017		425	38	763	44	3	-	790	562	7348	1059	94	3922	2813	429	18287
2018	374	400	47	2440	51	7	-	1010	876	14057	699	272	4721	2435	62	27451
2019	244	73	363	1599	59	10	-	652	-	17741	1421	455	7366	2184	569	32736
2020	1483	112	146	1797	41	4	-	1081	-	22854	868	-	6085	737	403	35613
2021[1]	-	151	182	1128	70	6	-	1379	-	35799	377	-	6008	535	552	46187

1 - Provisional figures.

Table 6.4. *S. mentella* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.b.

Year		Netherlands	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Poland	Portugal	Russia	Spain	Denmark	UK	Total
1998		-	-	-	42	-	3	521	13	7	642	122	-	29	1379
1999		-	4	10	42	-	-	457	6	9	902	15	-	20	1465
2000		-	-	1	27	-	1	82	2	17	946	69	-	27	1172
2001		-	11	4	37	-	-	293	5	74	763	72	**Estonia**	25	1284
2002		-	38	4	40	-	-	210	8	118	702	182	15	31	1348
2003		-	6	4	15	-	-	190	7	27	212	39	-	22	522
2004		-	33	5	6	-	-	386	42	149	443	250	-	58	1372
2005	**Iceland** - 2	7	46	10	17	1	-	673	-	69	1389	143	5	80	2442
2006		-	13	16	8	11	1	688	29	73	843	121	-	67	1870
2007		-	40	8	1	-	1	155	2	88	389	22	-	62	768
2008		-	28	8	7	1	-	263	6	47	520	33	-	19	932
2009	**Canada** - 3	3	27	8	19	-	-	466	1	42	458	41	-	17	1085
2010		-	18	-	8	-	-	339	-	47	501	1	-	24	938
2011	**LT** - 4	-	52	-	139	-	-	741	11	14	698	23	-	36	1717
2012	**Iceland** - 4	-	-	-	48	-	-	581	7	-	606	10	-	-	1256
2013		-	22	-	56	-	-	815	16	23	357	23	-	-	1312

Year		Netherlands	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Poland	Portugal	Russia	Spain	Denmark	UK	Total
2014		1	15	6	34	-	-	8901	3	-	307	3	-	-	9270
2015		-	-	-	6	5	-	7885	1	-	536	21	-	5	8459
2016		-	7	27	-	14	-	9078	24	14	4241	9	-	50	13464
2017		-	18	7	1	10	-	9522	5	1	2476	25	4	7	12075
2018	**LT** - 144	-	25	20	14	6	-	4281	3	-	5400	22	-	1	9915
2019		-	-	4	-	543	-	5734	-	-	5873	19	-	17	12190
2020[1]	**LV** - 2	-	2	5	4	2	-	9760	-	-	7671	6	-	34	17486
2021[1]		-	52	6	38	1		7803	2	-	8512	79	1	103	16596

1 - Provisional figures.

Table 6.5. *S. mentella* in subareas 1 and 2. Nominal catch (t) by countries of the pelagic fishery in international waters of the Norwegian Sea (see text for further details).

Year		Estonia	Faroe Islands	France	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2002		-	-	-	9	-	-	-	-	-	-	-	-	-	9
2003		-	-	-	40	-	-	-	-	-	-	-	-	-	40
2004		-	500	-	2	-	-	-	-	-	-	1510	-	-	2012
2005		-	1083	-	20	-	-	-	-	-	-	3299	-	-	4402
2006	**CAN -** 433	396	3766	192	2475	2510	341	845	2862	2447	1697	9390	575	841	28770

Year		Estonia	Faroe Islands	France	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2007		684	1968	226	497	1579	349	785	1813	1079	1377	3645	2155	-	16157
2008		-	1797	-	-	-	267	117	330	-	641	4901	390	-	8443
2009	**EU** - 889	-	1253	-	-	-	-	-	-	337	701	1975	135	-	5290
2010		-	912	-	-	-	243	457	450	-	244	5103	820	-	8229
2011		-	740	175	693	-	536	561	342	-	595	3621	1648	-	8911
2012		-	259	-	469	31	447	449	-	311	1038	2714	1768	-	7486
2013		8	675	-	-	-	280	262	1	68	1078	2720	1435	-	6527
2014		-	697	-	409	-	215	167	-	100	505	795	1146	-	4034
2015		-	606	-	231	-	537	192	-	-	678	-	2508	-	4752
2016		-	393	-	493	-	1243	1065	9	-	821	512	2862	-	7398
2017	**NL**	-	296	-	761	-	562	790	-	14	791	1014	2624	-	6852
2018	374	-	400	-	2192	-	876	1010	-	116	372	-	2399	-	7739
2019	244	**Greenland**	-	298	1157	-	-	652	1	364	1096	117	1908	223	6060
2020	1366	3	-	73	1380	-	-	1081	-	-	480	25	737	324	5469
2021[1]	-	-	-	117	514	-	-	1379	-	-	84	498	280	-	2872

1 - Provisional figures.

Table 6.6. REDFISH in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1, divisions 2.a and 2.b combined for both *S. mentella* and *S. norvegicus*.

Year	Latvia	Lithuania	Estonia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	-	2970	7457	-	-	-	-	18650	-	1806	69689	25	716	-	101313
1985	-	-	-	-	3326	6566	-	-	-	-	20456	-	2056	59943	38	167	-	92552
1986	-	**DK**	-	29	2719	4884	-	-	-	-	23255	-	1591	20694	-	129	14	53315
1987	-	+	-	450[3]	1611	5829	-	-	-	-	18051	-	1175	7215	25	230	9	34595
1988	-	-	-	973	3349	2355	-	-	-	-	24662	-	500	9139	26	468	2	41494
1989	-	-	-	338	1849	4245	-	-	-	-	25295	-	340	14344	5[2]	271	1	46688
1990	-	37[3]	-	386	1821	6741	-	-	-	-	34090	-	830	18918	-	333	-	63156
1991	-	23	-	639	791	981	-	-	-	-	49463	-	166	15354	1	336	13	67768
1992	**CAN**	9	-	58	1301	530	614	-	-	-	23451	-	977	4335	16	479	3	31773
1993	8[3]	4	-	152	921	685	15	-	-	-	18319	-	1040	7573	13	734	1	29465
1994	-	28	-	26	771	1026	6	4	3	-	21466	-	985	6220	34	259	13	30841
1995	-	-	-	30	748	693	7	1	5	1	16162	-	936	6985	67	252	13	25900
1996	-	-	-	42[3]	746	618	37	-	2	-	21675	-	522	1641	409	305	121	26118
1997	-	-	-	7	1011	538	39[2]	-	11	-	18839	1	535	4556	308	235	29	26109
1998	-	-	-	98	567	231	47[3]	-	28	-	26273	13	131	5278	228	211	94	33200
1999	-	-	-	108	61[3]	430	97	14	10	-	24634	6	68	4422	36	247	62	30195

Year	Latvia	Lithuania	Estonia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
2000	-	-	-	67[3]	25	222	51	65	1	-	19052	2	131	4631	87	-	203[6]	24536
2001	-	-	-	111[3]	46	436	34	3	5	-	23071	5	186	4738	91	-	239[6]	28965
2002	-	-	15	135[3]	89	141	49	44	4	-	10713	8[3]	276	4736	193[2]	-	234[6]	16636
2003	**S**	-	-	173[3]	30	154	44[3]	9	5[3]	89	8063	7	50	1431	47[2]	-	258[6]	10360
2004	1	-	-	607	17[3]	78	24[3]	40	3	33	7608[1,2]	42	240	3601[2]	260[2]	-	145[6]	12699
2005	**CAN**	**LT**	5	1194	56	105	75[3]	12[2]	4[3]	55[2]	7845[1,2]	-	196	5637	171[3]	-	147[6]	15502
2006	433	845	396	3919	223	2518	107[3]	2544[3]	12[3]	21	11015	2496[2]	1873	12126	719[2]	-	1066[6]	40649
2007	**LV**	785	684	2343	249	587	84[3]	1655[2]	7[3]	20	8993[2]	1081[2]	1708	6550	2186[2]	-	257[6]	27591
2008	267	117	-	2123[3]	250	46	96[3]	36[3]	15[3]	15	7436[1]	8	785	7866	467[2]	**EU[7]**	168[6]	19695
2009	-	-	-	1413	16	100	81	99	-	4	8128	338	836	4541	177	889	111[6]	16733
2010	243[3]	457[3]	-	1150	226	52	84[3]	24[3]	-	-	8059	1[3]	321	6979	1187	-	123[6]	18906
2011	536	565	-	1008[2]	228	844	51	24	-	1	7152	59	638	5956	1684[2]	-	68[6]	18814
2012	447	449	-	346	182	588	58	59	12	5	6361	352	1055	4782	1780[2]	**DK**	100[6]	16576
2013	280	262	-	780	353	81	66	9	1	-	5606	103	1114	4474	1459	1	493[6]	15082
2014	215	167	-	810	434	452	35	29	-	4	16556	124	510	2510	1162	-	211[6]	23219
2015	537	192	-	733	102	266	259	38	-	3	22208	22	678	1806	2531	1	109[6]	29485
2016	1243	1065	-	685	164	497	161	79	-	-	22322	234	1066	9283	32013	7	198[6]	40217

Year	Latvia	Lithuania	Estonia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
2017	562	790	4	566	62	782	127	68	-	2	20581	129	1150	7890	2882	-	596[6]	36192
2018	1020	1010	-	571	104	2539	159	77	-	374	23563	311	766	12331	2469	1	100[6]	45395
2019	-	656	-	392	395	1692	671	93	-	244	29795	491	1495	15373	2287	-	615[6]	54199
2020	2	1081	-	315	164	1895	161	57	-	1483	39453	13	956	16489	750		456[6]	63277
2021[1]	-	1379	-	613	224	1242	177	78	-	-	51498	22	441	16624	623		751[6]	73675

1 - Provisional figures.

2 - Working Group figure.

3 - As reported to Norwegian authorities or NEAFC.

4 - Includes former GDR prior to 1991.

5 - USSR prior to 1991.

6 - UK(E&W) + UK(Scot.)

7 - EU not split on countries.

Table 6.7. REDFISH in Subarea 4 (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Norway	Poland	Portugal	Sweden	UK (Scot.)	Total
1998	2	27	12	570	370	4	21	1113		-	-	749	2868
1999	3	52	1	-	58	39	16	862		-	-	532	1563

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Norway	Poland	Portugal	Sweden	UK (Scot.)	Total
2000	5	41	-	224	19	28	19	443		-	-	618	1397
2001	4	96	-	272	13	19	+	421		-	-	538	1363
2002	2	40	2	98	11	7	+	241		-	-	524	925
2003	1	71	2	26	2	-	-	474		-	-	463	1039
2004	+	42	3	26	1	-	-	287		-	-	214	578
2005	2	34	-	10	1	-	-	84		-	-	28	159
2006	1	49	1	12	3	-	-	163	-	33	-	79	341
2007	+	27	-	8	1	-	-	116	1	-	-	77	230
2008	+	3	-	8	1	-	-	77	-	-	1	54	144
2009	+	4	1	38	+	-	-	119	-	-	+	86	248
2010	-	5	-	3	-	-	-	62	-	-	+	150	220
2011	-	9	-	90	1	-	-	66	-	-	+	71	237
2012	-	10	-	19	+	-	-	71	-	-	+	87	187
2013	-	7	-	40	+	-	-	54	-	-	-	176	277
2014	-	-	-	32	1	-	-	146	-	-	+	93	272
2015	+	1	-	14	1	-	-	157	-	-	+	61	234
2016	-	3	-	11	+	-	-	180	-	-	+	22	216

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Netherlands	Norway	Poland	Portugal	Sweden	UK (Scot.)	Total
2017	-	3	-	10	+	-	-	168	-	-	+	38	21
2018	-	10	-	4	-	-	-	71	-	-	+	29	114
2019[1]	-	7	+	10	+	-	+	62	-	-	+	10	89
2020	-	10	-	4	+	-	+	54	-	-	+	27	95
2021[1]	-	4	-	11	+	-	+	30	-	-	+	123	168

1 - Provisional figures.

+ denotes less than 0.5 tonnes.

Table 6.8. *S. mentella* in subareas 1 and 2. Catch numbers-at-age 6 to 18 and 19+ (in thousands) and total landings (in tonnes). For the period 2012–2016 age data are missing from the pelagic fishery. For the period 2015–2018, age data are missing from all fisheries. The numbers-at-age have been estimated following the method outlined in section 6.2.2.

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tonnes Land.
1992	1873	2498	1898	1622	1780	1531	2108	2288	2258	2506	2137	1512	677	9258	33946	15590
1993	159	159	174	512	2094	3139	2631	2308	2987	1875	1514	1053	527	6022	25154	12814
1994	738	730	722	992	2561	2734	3060	1535	2253	2182	3336	1284	734	3257	26118	12721
1995	662	941	1279	719	740	1230	2013	4297	3300	2162	1454	757	794	2404	22752	10284
1996	223	634	1699	1554	1236	1078	1146	1413	1865	880	621	498	700	2247	15794	8075
1997	125	533	1287	1247	1297	1244	876	1416	1784	1217	537	1177	342	3568	16650	8598
1998	37	882	2904	4236	3995	2741	1877	1373	1277	1595	1117	784	786	6241	29845	14045

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tonnes Land.
1999	9	83	441	1511	2250	3262	1867	1454	1447	1557	1418	1317	658	3919	21193	11209
2000	1	24	390	1235	2460	2149	1816	1205	1001	993	932	505	596	5705	19012	10075
2001	117	372	542	976	925	1712	2651	2660	1911	1773	1220	714	814	16234	32621	18418
2002	2	40	252	572	709	532	1382	1893	1617	855	629	163	237	4082	12965	6993
2003	6	37	103	93	132	220	384	391	434	466	513	199	231	1193	4402	2520
2004	7	16	70	96	278	429	611	433	1063	813	830	841	607	3076	9170	5493
2005	2	20	57	155	244	262	295	754	783	1896	817	1087	1023	6065	13460	8465
2006	0	4	3	38	64	121	423	1461	1356	2835	4271	3487	3969	32084	50116	33261
2007	0	1	3	22	33	86	235	631	2194	2825	3657	4359	3540	15824	33410	20219
2008	0	0	1	10	46	100	197	469	612	1502	1384	894	1886	11906	19007	13095
2009	0	1	16	22	42	39	254	258	577	364	823	692	1856	11706	16650	10246
2010	10	4	6	19	34	55	61	241	267	390	566	655	667	13879	16854	11924
2011	4	4	4	25	55	114	11	103	286	394	408	479	567	15223	17677	12962
2012	4	24	29	24	26	66	69	78	80	279	387	365	409	13332	15172	11056
2013	0	3	19	92	88	41	42	42	10	167	144	174	299	11726	12847	9474
2014	14	28	346	97	124	96	152	55	111	69	252	293	197	23744	25578	18780
2015	43	41	135	569	849	1362	1254	721	388	952	291	599	877	29612	37693	25856
2016	42	0	1015	687	3469	2670	3089	2067	2037	1314	1385	1288	1143	37744	57950	35646

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tonnes Land.
2017	0	84	0	4479	2823	11454	5380	4385	2451	2235	1396	1437	1290	20897	58311	30934
2018	1173	4126	4511	4873	7166	4872	2339	2925	3570	6944	1973	2330	2677	30661	80140	38739
2019	0	4106	14968	14423	12882	15533	8137	2059	3499	4599	10818	2992	3576	11058	108650	45954
2020	0	0	8772	23581	18571	15195	17516	9091	2319	3883	5056	11870	3273	9248	128375	54686

Table 6.9. Pelagic *S. mentella* in the Norwegian Sea (outside the EEZ). Catch numbers-at-age.

	Numbers 10^3					Age							
YEAR	7	8	9	10	11	12	13	14	15	16	17	18	19+
2006	0	0	0	0	23	93	1083	323	1563	3628	2514	3756	29704
2007	0	0	9	18	25	154	444	1642	2302	3021	3394	3156	12684
2008	0	0	0	0	28	146	115	143	214	594	752	753	13258
2009	0	0	0	0	9	1314	294	471	889	999	869	1150	2981
2010	0	0	0	0	0	0	130	336	254	466	467	508	11510
2011	0	0	0	0	0	223	83	83	168	136	166	136	13182
2012[1]	0	0	0	22	29	19	294	146	132	217	288	126	8939
2013[2]	11	137	98	465	123	158	96	169	246	196	238	598	7968
2014[3]	0	10	125	88	406	103	125	70	113	151	112	130	4398
2015[3]	0	0	0	0	169	54	51	0	0	0	85	22	6345
2016[3]	0	0	154	307	271	276	134	90	107	239	445	229	10499

	Numbers 10^3						Age						
YEAR	7	8	9	10	11	12	13	14	15	16	17	18	19+
2017[3]	0	0	0	237	461	389	370	165	100	109	226	402	8351
2018[3]	0	0	0	0	687	1274	1004	873	352	195	199	393	12673
2019	25	5	200	400	220	242	197	279	183	155	135	161	6696
2020[4]	0	44	8	344	670	352	361	270	345	207	163	136	5500

1 - No age data in 2012, catch numbers-at-age are estimated from proportions at age in 2011 and in 2013.

2 - No age data from the catches in 2013. Age readings from the research survey conducted in September 2013 are used to derive catch numbers-at-age.

3 - No age data in 2014 – 2018, catch numbers-at-age are estimated from previous year according to protocol described in section 6.2.2.

4 - No age data in 2020, catch numbers-at-age are estimated from previous year according to protocol described in section 6.2.2.

Table 6.10. *S. mentella* in subareas 1 and 2. Total catch numbers-at-length, in thousands, for 2011–2020.

Year	Length group																
	18–20	20–22	22–24	24–26	26–28	28–30	30–32	32–34	34–36	36–38	38–40	40–42	42–44	44–46	46–48	48–50	50–52
2011	0	12	0	0	1	8	249	2544	6481	6528	3620	829	95	18	1	0	0
2012	0	0	23	19	26	28	41	287	1898	5030	5385	1911	451	197	43	23	0
2013	0	0	4	32	154	137	90	69	1382	4214	4480	1633	497	197	0	0	0
2014	0	5	0	25	29	235	660	697	3358	7667	8544	3808	787	34	0	0	0
2015	*Data not available at the time of the working group*																
2016	*Data not available at the time of the working group*																

Year	Length group																
	18–20	20–22	22–24	24–26	26–28	28–30	30–32	32–34	34–36	36–38	38–40	40–42	42–44	44–46	46–48	48–50	50–52
2017	*Data not available at the time of the working group*																
2018	*Data not available at the time of the working group*																
2019	*Data not available at the time of the working group*																
2020	*Data not available at the time of the working group*																
2021	*Data not available at the time of the working group*																

Table 6.11. *S. mentella* in subareas 1 and 2. Catch numbers-at-length, in thousands, in the pelagic fishery for 2011–2020.

Year	Length group																
	18–20	20–22	22–24	24–26	26–28	28–30	30–32	32–34	34–36	36–38	38–40	40–42	42–44	44–46	46–48	48–50	50–52
2011	0	0	0	0	1	8	244	2562	5887	4425	1537	287	13	0	1	0	0
2012	0	0	0	0	0	0	106	2014	5092	3681	952	48	0	0	0	0	0
2013	0	0	0	0	0	0	75	1352	4791	2967	730	87	6	0	0	0	0
2014	0	0	0	0	0	3	14	349	2408	2454	827	80	6	1	0	0	0
2015	*Data not available at the time of the working group*																
2016	*Data not available at the time of the working group*																
2017	*Data not available at the time of the working group*																

Year	Length group																
	18–20	20–22	22–24	24–26	26–28	28–30	30–32	32–34	34–36	36–38	38–40	40–42	42–44	44–46	46–48	48–50	50–52
2018	*Data not available at the time of the working group*																
2019	*Data not available at the time of the working group*																
2020	*Data not available at the time of the working group*																
2021	*Data not available at the time of the working group*																

Table 6.12. *S. mentella* in subareas 1 and 2. Observed mean weights-at-age (kg) from the Norwegian data (Catches and surveys combined). Weights-at-age used in the statistical catch-at-age model are identical for every year and given at the bottom line of the table.

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.167	0.164	0.211	0.241	0.309	0.324	0.378	0.366	0.428	0.454	0.487	0.529	0.571	0.805
1993	0.141	0.181	0.217	0.254	0.306	0.357	0.349	0.4	0.45	0.436	0.46	0.499	0.462	0.846
1994	0.174	0.188	0.235	0.298	0.361	0.396	0.415	0.48	0.492	0.562	0.642	0.636	0.72	0.846
1995	0.158	0.185	0.226	0.261	0.324	0.36	0.432	0.468	0.496	0.519	0.566	0.573	0.621	0.758
1996	0.175	0.189	0.224	0.272	0.323	0.337	0.377	0.518	0.536	0.603	0.69	0.8	0.683	0.958
1997	0.152	0.191	0.228	0.28	0.324	0.367	0.435	0.492	0.521	0.615	0.601	0.611	0.671	0.911
1998	0.12	0.148	0.192	0.261	0.326	0.373	0.427	0.496	0.537	0.566	0.587	0.625	0.658	0.809
1999	0.133	0.17	0.226	0.286	0.343	0.382	0.441	0.483	0.537	0.565	0.62	0.644	0.672	0.757
2000	0.109	0.144	0.199	0.276	0.332	0.392	0.437	0.49	0.54	0.585	0.631	0.65	0.671	0.872

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2001	0.115	0.137	0.183	0.262	0.31	0.356	0.4	0.434	0.484	0.534	0.581	0.615	0.624	0.819
2002	0.114	0.139	0.182	0.253	0.329	0.372	0.392	0.434	0.476	0.52	0.545	0.587	0.601	0.833
2003	0.109	0.124	0.196	0.245	0.312	0.371	0.422	0.434	0.477	0.516	0.551	0.591	0.623	0.817
2004	0.104	0.129	0.18	0.264	0.308	0.376	0.413	0.444	0.478	0.521	0.579	0.614	0.688	0.835
2005	0.104	0.136	0.196	0.263	0.322	0.37	0.408	0.451	0.478	0.523	0.55	0.551	0.64	0.797
2006	0.107	0.143	0.2	0.266	0.314	0.374	0.419	0.462	0.489	0.527	0.57	0.602	0.59	0.796
2007	0.115	0.131	0.18	0.252	0.305	0.364	0.409	0.449	0.485	0.513	0.523	0.554	0.569	0.737
2008	0	0.158	0.177	0.242	0.304	0.402	0.465	0.486	0.511	0.546	0.6	0.596	0.635	0.803
2009	0.129	0.179	0.206	0.249	0.326	0.394	0.51	0.55	0.542	0.583	0.609	0.594	0.595	0.809
2010	0.129	0.128	0.175	0.263	0.375	0.447	0.501	0.541	0.582	0.602	0.593	0.608	0.592	0.706
2011	0.136	0.156	0.183	0.261	0.316	0.435	0.512	0.604	0.655	0.609	0.671	0.647	0.677	0.795
2012	0.135	0.178	0.225	0.246	0.249	0.356	0.474	0.582	0.53	0.626	0.654	0.73	0.699	0.833
2013	0.129	0.145	0.189	0.23	0.27	0.282	0.345	0.384	0.534	0.559	0.634	0.627	0.661	0.72
2014	0.193	0.172	0.221	0.167	0.192	0.239	0.333	0.277	0.364	0.516	0.713	0.78	0.797	0.882
2015	0.167	0.168	0.232	0.294	0.346	0.383	0.457	0.436	0.474	0.538	0.665	0.69	0.724	0.824
2016[1]	0.11	0	0.331	0.356	0.401	0.392	0.434	0.486	0.543	0.579	0.74	0.591	0.598	0.776
2017	0.154	0.196	0.254	0.27	0.306	0.413	0.425	0.458	0.533	0.472	0.562	0.65	0.692	0.796
2018[1]	0	0.233	0.135	0.371	0.323	0.28	0.379	0.452	0.524	0.633	0.483	0.589	0.457	0.821

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2019[1]	0.118	0.38	0.341	0.47	0.538	0.523	0.539	0.565	0.572	0.62	0.656	0.601	0.633	0.744
Modelled	0.141	0.188	0.237	0.286	0.334	0.381	0.424	0.465	0.503	0.537	0.569	0.597	0.623	0.755

1 - Provisional figures.

Table 6.13. Pelagic *S. mentella* in the Norwegian Sea (outside the EEZ). Catch weights-at-age (kg).

Year/ Age	11	12	13	14	15	16	17	18	19+
2006	0.44	0.44	0.52	0.44	0.49	0.55	0.53	0.56	0.61
2007	0.39	0.43	0.41	0.48	0.50	0.52	0.55	0.57	0.64
2008	0.36	0.47	0.56	0.50	0.56	0.54	0.56	0.55	0.64
2009	0.38	0.44	0.45	0.48	0.54	0.59	0.64	0.58	0.69
2010	-	-	0.62	0.56	0.54	0.59	0.59	0.56	0.61
2011	-	0.48	0.54	0.54	0.64	0.59	0.54	0.59	0.59
2012	*No data*	-	-	-	-	-	-	-	-
2013[2]	0.31	-	-	-	0.56	0.62	0.60	0.62	0.68
2014	*No data*	-	-	-	-	-	-	-	-
2015	*No data*	-	-	-	-	-	-	-	-
2016	*No data*	-	-	-	-	-	-	-	-
2017	*No data*	-	-	-	-	-	-	-	-
2018	*No data*	-	-	-	-	-	-	-	-
2019	*No data*	-	-	-	-	-	-	-	-

2020	*No data*	-	-	-	-	-	-	-	-
2021[1]	*No data*	-	-	-	-	-	-	-	-

1 - Provisional figures.

2 - As observed in the research survey in the Norwegian Sea in September 2013.

Table 6.14. Proportion of maturity-at-age 6–19+ in *S. mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data. The proportions were derived from samples with at least 5 individuals. a50 w1 and w2 are the annual coefficients for modelled maturity ogives using a double half sigmoid of the form 0.5 ((1+tanh(age- a50)/w1)) for age < a50 and 0.5 (1+tanh((age- a50)/w2) for age > a50. a50 equals the age at 50% maturity.

year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.00	0.01	0.02	0.04	0.07	0.14	0.26	0.42	0.53	0.59	0.65	0.70	0.75	1.00
1993	0.01	0.02	0.04	0.08	0.15	0.28	0.44	0.55	0.61	0.67	0.72	0.77	0.82	1.00
1994	0.02	0.04	0.08	0.15	0.28	0.44	0.59	0.72	0.81	0.88	0.93	0.96	0.98	1.00
1995	0.03	0.07	0.13	0.24	0.39	0.57	0.71	0.83	0.90	0.95	0.97	0.98	0.99	1.00
1996	0.01	0.01	0.02	0.05	0.10	0.19	0.33	0.50	0.59	0.66	0.73	0.79	0.84	1.00
1997	0.02	0.04	0.08	0.16	0.29	0.46	0.55	0.61	0.66	0.71	0.76	0.80	0.84	1.00
1998	0.02	0.04	0.08	0.15	0.26	0.43	0.56	0.65	0.73	0.80	0.85	0.90	0.93	1.00
1999	0.03	0.05	0.10	0.20	0.34	0.51	0.57	0.64	0.70	0.75	0.80	0.84	0.87	1.00
2000	0.03	0.06	0.11	0.21	0.36	0.52	0.63	0.73	0.81	0.87	0.91	0.94	0.96	1.00
2001	0.01	0.02	0.04	0.09	0.17	0.30	0.47	0.56	0.62	0.68	0.74	0.79	0.83	1.00
2002	0.02	0.05	0.10	0.19	0.33	0.50	0.54	0.59	0.63	0.67	0.70	0.74	0.77	1.00
2003	0.03	0.06	0.12	0.21	0.36	0.51	0.57	0.63	0.69	0.73	0.78	0.82	0.85	1.00
2004	0.03	0.06	0.12	0.22	0.37	0.51	0.55	0.59	0.63	0.67	0.70	0.73	0.76	1.00

year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2005	0.02	0.05	0.09	0.18	0.31	0.49	0.55	0.61	0.66	0.71	0.75	0.79	0.83	1.00
2006	0.01	0.02	0.03	0.07	0.13	0.24	0.39	0.53	0.59	0.64	0.70	0.75	0.79	1.00
2007	0.02	0.04	0.09	0.17	0.30	0.47	0.64	0.77	0.87	0.93	0.96	0.98	0.99	1.00
2008[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00
2009	0.02	0.04	0.09	0.17	0.30	0.47	0.60	0.71	0.80	0.87	0.92	0.95	0.97	1.00
2010	0.02	0.04	0.08	0.16	0.28	0.45	0.54	0.60	0.66	0.71	0.76	0.80	0.83	1.00
2011[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00
2012	0.02	0.05	0.10	0.19	0.32	0.50	0.59	0.68	0.75	0.81	0.86	0.90	0.93	1.00
2013	0.00	0.01	0.02	0.04	0.08	0.15	0.28	0.45	0.62	0.77	0.87	0.93	0.97	1.00
2014	0.00	0.00	0.01	0.02	0.03	0.06	0.12	0.23	0.38	0.53	0.61	0.68	0.74	1.00
2015	0.01	0.02	0.05	0.09	0.17	0.31	0.48	0.54	0.58	0.63	0.67	0.71	0.74	1.00
2016	0.03	0.06	0.12	0.22	0.38	0.52	0.56	0.61	0.66	0.70	0.74	0.77	0.81	1.00
2017[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00
2018[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00
2019[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00
2020[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00
2021[1]	0.02	0.04	0.08	0.15	0.27	0.43	0.55	0.62	0.68	0.74	0.79	0.83	0.87	1.00

1 - Model parameter estimates were unrealistic and replaced by average parameter values.

Table 6.15. *S. mentella*. Average catch (numbers of specimens) per hour trawling of different ages of *S. mentella* in the Russian groundfish survey in the Barents Sea and Svalbard areas (1976–1983 published in *Annales Biologiques*). The survey was not conducted in 2016 took place in 2017 with insufficient coverage and was terminated after that year.

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1974	-	-	4.8	-	4.9	22.8	4.8	4.8	-	-	-	3
1975	-	7.4	-	1.7	6.4	2.4	3.5	5	-	-	4	-
1976	7	-	8.1	1.2	2.5	6.8	4.9	5	1	13	-	-
1977	-	0.2	0.2	0.2	0.9	5.1	3.7	1	19	2	-	-
1978	0.8	0.02	0.9	1	5	3.8	2	20	6	-	-	-
1979	-	1.9	1.4	3.6	2.3	9	11	16	1	-	-	0.1
1980	0.3	0.4	2	2.5	16	6	11	25	2	-	1.5	2
1981	-	2.2	3.9	20	6	12	47	18	6.3	1.6	0.5	1
1982	19.8	13.2	13	15	34	44	39	32.6	4.3	3.1	4.9	+
1983	12.5	3	5	6	31	34	32.3	13.3	4	4.2	0.6	1.1
1984	-	10	2	-	5	18.3	19	2.2	2.4	0.2	1.7	2.4
1985	107	7	-	1	5.2	16.2	1.7	1.7	0.6	2.8	3.8	0.3
1986	2	-	1	1.8	8.4	3.6	2.1	1.2	5.6	8.2	0.9	0.7
1987	-	3	37.9	1.3	8	4.1	2	10.6	9.6	1.4	2	1.3
1988	4	58.1	4.3	13.3	25.8	3.9	8.6	11.2	2.8	4.2	3	4.7
1989	8.7	9	17	23.4	4.6	5.4	4	6.6	6.6	4.1	7.7	5.3
1990	2.5	6.3	6.1	1	4.3	1.7	11.5	6.5	5.5	6.7	7.4	3.6

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1991	0.3	1	0.5	1.5	1.2	11.3	3.9	3.3	4.6	5.8	2.7	1.9
1992	0.6	+	0.2	0.1	4.3	1.3	2	2.3	4.9	2.3	1	4.1
1993[1]	-	+	1.5	1.8	1	1.2	3	4.2	2.6	2	3.2	2.1
1994	0.3	3.5	1.7	1.7	0.9	3.6	5.2	4.3	3.1	3.3	1.8	1.2
1995	2.8	1	1.1	0.4	2.2	2.6	3.5	3.4	2.9	1.2	1	8.5
1996[2]	+	0.1	0.1	0.4	0.7	1.1	1	1.4	1	0.8	3.7	0.6
1997	-	-	+	0.4	0.5	0.3	0.9	0.6	1	1.1	0.5	0.4
1998	-	0.1	0.2	0.3	0.2	1.1	0.5	0.7	1	0.4	0.4	0.7
1999	0.1	-	0.1	+	0.1	0.3	0.5	0.8	0.5	0.2	0.4	0.6
2000	-	0.6	0.1	0.5	0.3	0.3	0.6	0.4	0.1	0.1	0.7	0.3
2001	-	0.1	0.4	-	0.1	0.2	0.2	0.3	0.2	0.8	0.1	1
2002[3]	0.1	0.5	0.1	-	-	0.1	0.5	0.4	1.5	0.5	1	1.1
2003	-	-	0.1	-	0.3	1.0	0.5	4.8	2.1	3.7	1.3	1.9
2004	-	0.2	0.3	0.5	1.5	0.9	4.4	3.7	7.5	4.1	3.1	3.3
2005	-	-	1.4	1.9	1.4	2.3	3.9	7.2	6.1	6.8	3.1	
2006[4]	0.1	1.8	1.2	1.1	0.8	2.1	4.1	3.0	6.1	5.9		
2007	2.5	0.4	0.1	1.2	1.7	2.4	3.6	4.3	7.4			
2008	0.1	0.1	1.6	1.8	4.1	2.9	5.8	5.5				

Year class	0	1	2	3	4	5	6	7	8	9	10	11
2009	1.6	1.9	1.1	4.4	4.8	2.9	4.8					
2010	7.5	0.7	1.2	1.5	1.9	1.6						
2011	0.1	0.3	0.6	1.6	1.6							
2012	0.2	0.7	0.5	0.3								
2013	0.1	0.1	0.4									
2014	3.6	1.0										
2015	6.6											

1 - Not complete area coverage of Division 2.b.

2 - Area surveyed restricted to Subarea 1 and Division 2.a only.

3 - Area surveyed restricted to Subarea 1 and Division 2.b only.

4 - Area surveyed restricted to divisions 2.a and 2.b only.

Table 6.16a. *S. mentella*[1] in Division 2.b. Abundance indices (on length) from the bottom trawl survey in the Svalbard area (Division 2.b) in summer/autumn 1986–2021 (numbers in millions).

Year	Length group (cm)									
	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	**Total**
1986[2]	6	101	192	17	10	5	2	4	0	337
1987[2]	20	14	140	19	6	2	1	2	0	204
1988[2]	33	23	82	77	7	3	2	2	0	229
1989	556	225	24	72	17	2	2	8	4	910
1990	184	820	59	65	111	23	15	7	3	1287

Year	Length group (cm)									
	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	**Total**
1991	1533	1426	563	55	138	38	30	7	1	3791
1992	149	446	268	43	22	15	4	7	4	958
1993	9	320	272	89	16	13	3	1	0	723
1994	4	284	613	242	10	9	2	2	1	1167
1995	33	33	417	349	77	18	5	1	0	933
1996	56	69	139	310	97	8	4	1	1	685
1997	3	44	13	65	57	9	5	0	0	195
1998	0	37	35	28	132	73	45	2	0	352
1999	3	3	124	62	260	169	42	1	0	664
2000	0	10	30	59	126	143	21	1	0	391
2001	1	5	3	32	57	227	50	3	0	378
2002	1	4	6	21	62	266	47	4	0	410
2003	1	5	7	11	51	244	45	1	0	364
2004	0	2	8	6	14	78	49	2	0	160
2005	22	1	4	4	10	70	47	1	0	158
2006	85	6	5	7	43	200	108	3	0	457
2007	97	68	1	5	11	102	119	3	0	406

Year	Length group (cm)									
	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	**Total**
2008	124	47	22	3	8	22	70	3	0	299
2009	9	122	88	14	3	27	219	5	0	486
2010	96	18	44	37	2	20	91	7	0	315
2011	126	91	81	48	10	7	67	5	1	436
2012	29	71	65	77	47	8	94	10	0	400
2013	33	43	127	106	67	19	89	13	0	497
2014[3]	3	10	59	49	38	24	66	20	0	268
2015	85	7	28	157	115	65	69	25	0	552
2016	244	33	44	205	138	139	142	48	0	993
2017	41	39	8	20	59	76	57	17	0	317
2018	66	62	55	35	100	65	80	26	0	489
2019	3	25	84	31	59	82	72	25	1	381
2020	97	8	57	39	40	115	97	16	0	470
2021	492	135	15	39	16	58	88	18	0	860

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Old trawl equipment (bobbins gear and 80 m sweep length).

3 - Poor survey coverage in 2014.

Table 6.16b. ***S. mentella*[1] in Division 2.b. Norwegian bottom trawl survey indices (on age) in the Svalbard area (Division 2.b) in summer/autumn 1992–2019 (numbers in millions).**

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	283	419	484	131	58	45	14	8	5	2	7	2	1	3	1462
1993	2	527	117	202	142	8	23	6	13	1	7	1	1	0	1050
1994	7	280	290	202	235	42	94	1	1	3	4	1	1	0	1161
1995	4	50	365	237	132	61	19	17	11	0	1	3	0	0	900
1996	13	32	10	36	103	135	78	16	50	28	32	8	21	2	565
1997	8	43	6	7	38	18	29	19	6	2	0	2	1	1	181
1998	0	25	27	13	10	12	61	52	41	15	0	5	13	0	276
1999	3	16	108	25	28	39	106	59	54	26	35	14	18	12	543
2000	4	6	5	13	30	21	28	44	66	48	21	19	9	6	321
2001	1	4	2	0	12	15	18	36	28	46	45	80	53	14	354
2002	3	2	4	1	5	22	34	23	90	35	54	65	17	22	377
2003	0	4	3	3	5	3	29	25	25	25	11	164	55	23	376
2004	1	1	4	4	1	4	2	9	4	15	14	17	15	15	108
2005	15	1	1	3	1	2	2	8	4	5	14	7	30	21	115
2006	35	1	3	3	2	6	5	37	3	20	46	69	8	22	258
2007	28	39	0	0	4	1	5	5	7	5	3	7	28	17	150
2008	6	24	19	11	3	2	2	4	3	3	3	3	6	8	96
2009	9	69	50	29	26	25	7	1	1	1	4	20	11	8	260

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
2010	*No age readings available*														
2011	125	42	61	42	12	49	31	4	1	0	2	0	0	1	369
2012	27	54	32	27	34	43	26	34	18	9	0	1	0	0	305
2013	30	4	29	36	7	93	72	43	40	7	8	3	3	3	377
2014[2,3]	0	3	2	7	21	40	13	27	5	30	13	11	3	2	176
2015	63	1	10	56	36	54	33	95	28	21	12	4	5	3	421
2016	*No age readings available*														
2017	39	26	10	13	14	20	39	16	29	8	6	19	1	28	269
2018	*No age readings available*														
2019	0	32	53	0	24	21	21	46	52	76	0	0	0	0	324
2020	No age readings available														
2021	No age readings available														

1 - Includes some unidentified *Sebastes* specimens mostly less than 15 cm.

2 - Old trawl equipment (bobbins gear and 80 m sweep length).

3 - Poor survey coverage in 2014.

Table 6.17. *S. mentella* in subareas 1 and 2. Abundance indices (on age) from the Ecosystem survey in August-September 1996–2021 covering the Norwegian Economic Zone (NEZ) and Svalbard incl. the area north and east of Spitsbergen (numbers in thousands and total biomass in thousand tonnes) and the continental slope down to 1000 m.

Year/ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
1996	146198	112742	22353	53507	165531	181980	108738	43328	65310	40546	38254	19843	29446	10931	17414	1056120	171

Year/ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
1997	62682	130816	12492	23452	74342	55880	76607	82503	17640	14274	675	2238	1723	633	8765	564723	73
1998	313	78767	85715	39849	25805	23413	84825	100332	54287	24329	11334	7457	15250	576	25212	577464	105
1999	5359	23240	117170	47851	41608	76797	128677	73306	58018	64781	49890	13565	18458	12171	24672	755562	155
2000	5964	23169	14336	19960	52666	68081	83857	77513	100442	72294	71148	36599	17183	20590	26501	690304	178
2001	5026	6541	10957	1093	19766	25591	36594	51644	44407	61704	50083	86122	53952	15699	31877	501057	162
2002	9112	6646	7379	3821	8635	28215	47456	63903	103368	49964	76133	71970	25241	36765	34957	573565	181
2003	4086	8218	7368	3140	7885	7983	43821	62360	52015	34782	61735	168703	107298	39760	26882	636036	257[2]
2004	8554	15793	11443	7399	3554	7560	6164	11686	8566	22973	25920	23199	20392	19472	50960	243635	91[2]
2005	32526	6856	5546	5616	3772	5980	6985	13151	5803	5700	16554	34393	34987	34336	53165	265370	101[2]
2006	125437	4833	6844	6602	4255	8486	7424	38309	3983	24756	48733	71491	13957	37991	159909	563010	199[2]
2007	411738	213851	15844	5121	11830	3234	8884	10298	14652	7217	4200	7925	53657	19308	237861	1025620	199[2]
2008	58894	206727	142254	29386	7745	3182	2895	6352	6132	3538	3445	5380	7018	9717	95279	587944	84[2]
2009	122459	176405	231265	82701	109509	45607	15812	2775	5807	2950	3929	22097	12431	9299	331974	1175019	260[2]
2010	*No age reading*																
2011	422533	390888	227693	61575	56025	78022	47213	12153	3176	2049	2607	856	85	2948	103653	1411479	120[2]
2012	353610	256305	351327	173183	130446	70403	58164	40645	21408	12671	3553	1044	1568	3374	139887	1617588	184[2]
2013	299841	203094	189851	194068	164206	178236	112427	103262	92160	13848	13956	8579	2784	2857	144033	1723202	271[2]
2014[1]	2247	20884	33295	82052	52428	94324	93771	68765	35193	56728	40647	19047	16518	3335	163869	783104	239[2]

Year/ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
2015	404973	86648	53046	95737	53022	109686	46714	126156	73141	25441	19583	6569	5284	3335	119261	1228596	207[2]
2016	*No age reading*																
2017	534647	244469	213984	215852	33595	45809	61428	62449	37597	33901	39670	37492	10364	40052	85250	1696557	213[2]
2018	*No age reading*																
2019[3]	93518	77195	125457	81499	62447	38668	61615	91672	178887	124876	0	0	0	0	60931	996765	211[2]
2020	*No age reading*																
2021	*No age reading*																

1 - Poor survey coverage in 2014.

2 – Calculated using modelled weight-at-age.

3 – Provisional figures.

Table 6.18a. *S. mentella*[1]. Abundance indices (on length) from the bottom trawl survey in the Barents Sea in winter 1986–2021 (numbers in millions). The area coverage was extended from 1993 onwards. Numbers from 1994 onwards were recalculated while numbers for 1986–1993 are as in previous reports.

Year	Length group (cm)								
	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
1986	81	152	205	88	169	130	88	24	14	950
1987	72	25	227	56	35	11	5	1	0	433
1988	587	25	133	182	40	50	48	4	0	1068
1989	623	55	28	177	58	9	8	2	0	961
1990	324	305	36	56	80	13	13	2	0	828

Year	Length group (cm)									
	5.0–9.9	**10.0–14.9**	**15.0–19.9**	**20.0–24.9**	**25.0–29.9**	**30.0–34.9**	**35.0–39.9**	**40.0–44.9**	**> 45.0**	**Total**
1991	395	449	86	39	96	35	24	3	0	1127
1992	139	367	227	35	55	34	8	2	1	867
1993	31	593	320	116	24	25	6	1	0	1117
1994	8	296	479	488	74	74	17	3	0	1440
1995	310	84	571	390	83	58	24	3	0	1522
1996	215	101	198	343	136	42	17	1	0	1054
1997[2]	38	83	19	198	266	82	39	3	0	728
1998[2]	1	87	62	101	202	40	13	2	0	507
1999	2	7	70	37	172	73	22	3	0	386
2000	9	13	40	78	143	97	27	7	2	415
2001	10	23	7	57	79	75	10	1	0	260
2002	17	7	19	36	96	116	24	1	0	317
2003	4	4	10	13	70	198	46	6	0	351
2004	2	3	7	19	33	86	32	2	0	183
2005	0	6	7	11	28	154	86	4	0	296
2006	100	2	10	15	23	104	83	3	1	339
2007	382	121	3	7	12	121	121	7	0	773
2008	858	359	27	5	12	104	165	5	0	1533

Year	Length group (cm)									
	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
2009	95	325	136	5	9	67	163	6	0	806
2010	652	276	215	64	7	74	191	6	0	1485
2011	501	230	212	149	14	47	157	5	0	1315
2012	129	280	86	125	47	14	154	18	0	855
2013	249	227	245	159	143	35	193	27	0	1279
2014	91	174	250	114	125	51	115	14	0	933
2015	175	110	215	302	290	215	171	18	0	1495
2016	615	105	149	332	213	163	124	14	1	1714
2017	568	185	68	197	286	310	231	11	0	1855
2018	189	250	83	109	192	270	214	22	1	1329
2019	42	288	263	92	158	255	211	20	0	1330
2020	196	122	207	92	118	231	209	25	1	1200
2021	887	132	142	124	81	186	172	23	1	1749
2022[3]	640	1025	45	104	76	87	153	20	0	2149

1 - Includes some unidentified *Sebastes* specimens mostly less than 15 cm.

2 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1.

3- Russian data not provided in time for AFWG 2022.

Table 6.18b. *S. mentella*[1] in subareas 1 and 2. Preliminary Norwegian bottom trawl indices (on age) from the annual Barents Sea survey in February 1992–2020 (numbers in millions). The area coverage was extended from 1993 onwards. Numbers recalculated.

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992															
1993															
1994	5	96	315	160	342	269	97	55	4	28	13	14	26	5	1430
1995	315	49	148	251	343	238	67	25	7	19	21	9	11	10	1512
1996	189	107	85	111	140	132	128	60	21	24	14	6	9	4	1029
1997[2]	41	65	30	33	92	83	103	100	30	67	29	13	7	3	697
1998[2]	1	72	45	25	11	50	108	112	36	17	7	6	3	2	496
1999	0	1	38	40	29	28	52	62	55	32	16	4	7	1	364
2000	19	1	4	33	37	21	30	69	72	49	22	14	10	4	385
2001	1	17	8	2	7	25	36	30	41	18	22	28	5	3	243
2002	18	4	11	8	2	9	43	56	23	14	34	19	38	14	293
2003	0	3	2	4	6	6	15	36	24	24	43	36	62	33	293
2004	2	1	4	2	4	10	11	16	14	12	14	25	24	13	152
2005	0	4	3	2	6	6	7	14	18	8	18	27	40	57	208
2006	74	26	4	4	6	8	9	12	6	14	16	10	41	28	259
2007	237	75	4	1	2	2	5	8	9	6	8	21	33	72	485
2008	699	166	101	14	0	2	4	6	4	6	4	20	22	30	1079

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
2009	104	108	100	87	64	32	19	14	4	6	21	1	22	7	589
2010	160	264	176	166	93	72	24	23	3	11	5	8	10	17	1031
2011	348	228	128	127	99	67	42	20	2	6	1	1	2	25	1095
2012	*No age readings*														
2013	0	179	268	136	154	108	126	14	31	8	7	20	41	112	1105
2014	*No age readings*														
2015	*No age readings*														
2016	*No age readings*														
2017	*No age readings*														
2018	*No age readings*														
2019	*No age readings*														
2020	*No age readings*														
2021	*No age reading*														
2022	*No age reading*														

1 - Includes some unidentified *Sebastes* specimens mostly less than 15 cm.

2 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1.

Table 6.19. Comparison of results on *S. mentella* from the Norwegian Sea pelagic surveys in 2008, 2009, 2013, 2016, and 2019. Acoustic results for the 2019 survey were not available at the time of AFWG 2021.

	2008	2009	2013	2016	2019
mean length (cm) All/M/F[1]	37.0/36.4/37.5	36.6/36.0/37.1	37.5/37.0/38.1	37.7/37.0/38.3	37.6/37.2/38.0
mean length (cm) S/DSL/D[2]	37.2/36.8/39.1	37.2/36.5/38.3	37.1/37.4/38.9	38.1/37.6/38.4	37.4/37.6/37.7
mean weight (g) All/M/F	619/585/648	625/609/666	659/625/706	656/619/694	683/644/724
Mean age (y) All/M/F	25 / 25 / 25	25 / 25 / 24	28 / 29 / 28	27 / 27 / 26	- / - / -
Sex ratio (M/F)	45% / 55%	45% / 55%	59% / 41%	50% / 50%	51% / 49%
Occurrence	96%	100%	95%	80%	99%
Catch rates	3.80 t/NM2	3.94 t/NM2	3.47 t/NM2	1.01 t/NM2	3.40 t/NM2
mean s_A	33 m^2/NM2	34 m^2/NM2	19 m^2/NM2	5.2 m^2/NM2	-
Total Area	53720 NM2	69520 NM2	69520 NM2	67150 NM2	73364 NM2
Abundance (Acoustics)[3]	395000 t	532000 t	297000 t	136000 t	-
Abundance (Trawl)[4]	406000 t	548000 t	482000 t	116000 t	499000 t

1 - M = males only, F = females only.

2 - S = shallower than DSL, DSL = deep scattering layer, D = deeper than DSL.

3 - The abundance derived from hydroacoustics is calculated assuming a Length-dependent target strength equation of TS=20log(L)-68.0. In 2016 the TS equation used was TS=20log(L)-69.6 following recommendation from ICES-WKTAR (2010).

4 - Trawls: Gloria 2048 in 2008 and 2009 Gloria 2560 HO helix in 2013 and Gloria 1024 in 2016. Trawl catchability for redfish set to 0.5 for all trawls based on results from Bethke *et al.* (2010).

Table 6.20a. *S. mentella* in subareas 1 and 2. Population matrix with numbers-at-age (in thousands) for each year and separable fishing mortality coefficients for the demersal and pelagic fleet by year (Fy) and selectivity at age for the pelagic fleet (Sa). Numbers are estimated from the statistical catch-at-age model.

sa (demersal)	Varies over time																	
sa (pelagic)	0.000	0.000	0.000	0.000	0.000	0.011	0.021	0.040	0.072	0.128	0.218	0.345	0.500	0.654	0.781	0.871	0.927	1.00

Fy (demseral)	Fy (pelagic)	Year/ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.047	0	1992	400482	389741	353230	226347	135488	92234	89791	93917	117663	81823	93165	68973	70343	61008	44144	28865	19263	189594
0.033	0	1993	269635	381031	370812	336074	212616	127026	86296	83827	87482	109349	75866	86189	63671	64803	56096	40520	26454	189790
0.029	0	1994	186684	256540	362525	352802	319693	202185	120684	81795	79052	81844	101509	70092	79457	58648	59674	51651	37307	199095
0.022	0	1995	176880	177618	244080	344918	335435	303663	191638	113922	76744	73703	75960	93978	64817	73442	54197	55140	47725	218431
0.015	0	1996	141619	168289	168991	232226	327949	318662	287967	181152	107206	71896	68826	70808	87530	60347	68366	50448	51324	247731
0.015	0	1997	100331	134741	160116	160783	220890	311790	302573	272671	170835	100747	67437	64508	66347	82008	56538	64050	47263	280175
0.021	0	1998	51116	95458	128197	152339	152942	210033	296148	286703	257391	160684	94563	63242	60476	62193	76869	52995	60036	306917
0.016	0	1999	44153	48634	90822	121971	144924	145441	199419	279828	268898	240322	149816	88137	58940	56361	57961	71639	49389	341983
0.013	0	2000	34755	42009	46272	86411	116045	137872	138314	189354	264491	252692	225223	140303	82528	55187	52772	54269	67077	366448

Fy (dem-seral)	Fy (pe-lagic)	Year/ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.022	0	2001	37339	33067	39968	44024	82214	110407	131155	131410	178898	248725	237429	211600	131815	77535	51848	49579	50986	407298
0.008	0	2002	38941	35525	31461	38027	41864	78123	104749	124064	123750	167666	232279	221283	197021	122681	72149	48243	46130	426398
0.003	0	2003	43637	37050	33800	29933	36180	39827	74299	99503	117532	116952	158314	219274	208884	185979	115805	68106	45540	446046
0.006	0	2004	57553	41518	35251	32158	28476	34415	37875	70629	94536	111603	111009	150233	208056	198187	176450	109871	64615	466389
0.009	0	2005	132682	54758	39501	33539	30594	27087	32725	35992	67041	89612	105673	105043	142115	196789	187444	166882	103912	502203
0.005	0.037	2006	232450	126238	52099	37583	31908	29103	25760	31100	34148	63456	84646	99708	99070	134014	185561	176746	157357	571518
0.005	0.02	2007	334514	221160	120107	49568	35757	30357	27676	24483	29525	32351	59910	79557	93210	92061	123811	170622	161976	665175
0.005	0.014	2008	329290	318267	210419	114274	47161	34020	28875	26317	23268	28028	30647	56583	74873	87407	86043	115411	158754	767828
0.003	0.01	2009	347731	313297	302809	200199	108723	44870	32362	27463	25018	22092	26541	28937	53298	70366	81967	80545	107903	864910
0.004	0.011	2010	499621	330843	298081	288103	190475	103441	42683	30778	26103	23751	20941	25123	27351	50295	66297	77127	75720	913426
0.006	0.01	2011	564854	475356	314774	283604	274107	181219	98398	40592	29255	24786	22518	19820	23735	25792	47347	62323	72432	927686
0.005	0.01	2012	430519	537420	452269	299486	269829	260792	172392	93587	38590	27780	23486	21284	18693	22343	24238	44435	58434	936507

Fy (demseral)	Fy (pelagic)	Year/ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.004	0.009	2013	266964	409610	511319	430303	284938	256719	248087	163968	88987	36672	26371	22258	20126	17635	21037	22787	41732	933205
0.016	0.01	2014	258560	253998	389716	486485	409404	271099	244224	235990	155943	84602	34842	25026	21082	19016	16625	19798	21423	915423
0.027	0.009	2015	365166	246002	241662	370788	462844	389498	257876	232267	224355	148158	80286	33001	23636	19836	17820	15521	18433	868602
0.038	0.009	2016	451107	347430	234054	229925	352769	440331	370468	245175	220605	212602	139754	75203	30686	21858	18283	16392	14262	813967
0.029	0.009	2017	511012	429198	330556	222687	218746	335582	418701	351919	232291	207772	198260	128990	68930	28016	19909	16628	14894	751597
0.031	0.009	2018	450559	486193	408353	314502	211868	208105	319130	397615	332524	217203	192586	183085	118896	63437	25746	18275	15250	702184
0.035	0.008	2019	430622	428676	462580	388520	298434	200557	196202	299251	370679	308459	200755	177539	168427	109172	58153	23572	16717	655482
0.042	0.008	2020	430544	409708	407856	440113	368806	282178	188135	182261	276059	340792	283133	184067	162594	154051	99729	53069	21495	612355

Table 6.20b. *S. mentella* in subareas 1 and 2. Fisheries selectivity at age for the demersal fleet by age (Sa). Numbers are estimated from the statistical catch-at-age model.

Year/ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1992	0.000	0.000	0.000	0.274	0.315	0.359	0.406	0.454	0.503	0.553	0.601	0.647	0.691	0.731	0.768	0.802	0.831	1.000
1993	0.000	0.000	0.000	0.006	0.016	0.044	0.115	0.270	0.512	0.749	0.895	0.960	0.986	0.995	0.998	0.999	1.000	1.000
1994	0.000	0.000	0.000	0.024	0.057	0.129	0.269	0.477	0.693	0.848	0.933	0.972	0.988	0.995	0.998	0.999	1.000	1.000

Year/ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1995	0.000	0.000	0.000	0.030	0.069	0.150	0.296	0.500	0.704	0.850	0.931	0.970	0.987	0.995	0.998	0.999	1.000	1.000
1996	0.000	0.000	0.000	0.017	0.048	0.131	0.311	0.574	0.801	0.923	0.973	0.991	0.997	0.999	1.000	1.000	1.000	1.000
1997	0.000	0.000	0.000	0.014	0.041	0.113	0.274	0.528	0.768	0.908	0.967	0.989	0.996	0.999	1.000	1.000	1.000	1.000
1998	0.000	0.000	0.000	0.005	0.024	0.100	0.334	0.693	0.910	0.979	0.995	0.999	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.000	0.000	0.000	0.001	0.006	0.029	0.125	0.411	0.773	0.943	0.988	0.997	0.999	1.000	1.000	1.000	1.000	1.000
2000	0.000	0.000	0.000	0.000	0.001	0.013	0.112	0.556	0.925	0.992	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.000	0.000	0.000	0.024	0.056	0.126	0.260	0.460	0.674	0.834	0.924	0.967	0.986	0.994	0.998	0.999	1.000	1.000
2002	0.000	0.000	0.000	0.002	0.011	0.050	0.201	0.545	0.851	0.964	0.992	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.000	0.000	0.000	0.037	0.081	0.165	0.309	0.503	0.696	0.838	0.921	0.964	0.984	0.993	0.997	0.999	0.999	1.000
2004	0.000	0.000	0.000	0.016	0.038	0.092	0.203	0.392	0.620	0.805	0.912	0.963	0.985	0.994	0.998	0.999	1.000	1.000
2005	0.000	0.000	0.000	0.005	0.016	0.047	0.130	0.310	0.576	0.804	0.925	0.974	0.991	0.997	0.999	1.000	1.000	1.000
2006	0.000	0.000	0.000	0.002	0.007	0.018	0.051	0.134	0.306	0.558	0.783	0.912	0.967	0.988	0.996	0.999	0.999	1.000
2007	0.000	0.000	0.000	0.001	0.003	0.008	0.024	0.065	0.166	0.363	0.620	0.824	0.930	0.975	0.991	0.997	0.999	1.000
2008	0.000	0.000	0.000	0.000	0.001	0.003	0.012	0.053	0.204	0.540	0.844	0.961	0.991	0.998	1.000	1.000	1.000	1.000
2009	0.000	0.000	0.000	0.001	0.005	0.017	0.060	0.190	0.461	0.757	0.919	0.976	0.993	0.998	1.000	1.000	1.000	1.000
2010	0.000	0.000	0.000	0.003	0.008	0.022	0.060	0.154	0.343	0.600	0.812	0.925	0.973	0.990	0.997	0.999	1.000	1.000
2011	0.000	0.000	0.000	0.000	0.002	0.006	0.020	0.069	0.210	0.487	0.773	0.924	0.978	0.994	0.998	0.999	1.000	1.000
2012	0.000	0.000	0.000	0.002	0.004	0.010	0.022	0.050	0.108	0.217	0.389	0.594	0.771	0.885	0.947	0.976	0.989	1.000

Year/ Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2013	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.007	0.020	0.056	0.144	0.326	0.581	0.799	0.919	0.970	0.989	1.000
2014	0.000	0.000	0.000	0.002	0.003	0.007	0.013	0.024	0.045	0.083	0.147	0.248	0.387	0.548	0.699	0.816	0.895	1.000
2015	0.000	0.000	0.000	0.001	0.003	0.007	0.020	0.050	0.124	0.273	0.500	0.727	0.876	0.950	0.980	0.993	0.997	1.000
2016	0.000	0.000	0.000	0.001	0.004	0.013	0.036	0.100	0.249	0.496	0.745	0.896	0.962	0.987	0.996	0.999	0.999	1.000
2017	0.000	0.000	0.000	0.001	0.003	0.013	0.059	0.228	0.581	0.867	0.969	0.993	0.999	1.000	1.000	1.000	1.000	1.000
2018	0.000	0.000	0.000	0.084	0.161	0.287	0.456	0.636	0.785	0.884	0.941	0.971	0.986	0.993	0.997	0.998	0.999	1.000
2019	0.000	0.000	0.000	0.064	0.176	0.397	0.670	0.863	0.951	0.984	0.995	0.998	0.999	1.000	1.000	1.000	1.000	1.000
2020	0.000	0.000	0.000	0.061	0.185	0.441	0.733	0.905	0.971	0.991	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000

Table 6.21. Stock summary for *S. mentella* in subareas 1 and 2 as estimated by the statistical catch-at-age model. Stock biomass is for age 2 y+.

Year	Rec (age 2) in millions	Rec (age 6) in millions	Stock Biomass (tonnes)	SSB (tonnes)	F (12–18)	F(19+)
1992	400	135	529902	251287	0.034	0.047
1993	270	213	572073	296819	0.032	0.033
1994	187	320	625480	372504	0.029	0.029
1995	177	335	685167	427268	0.022	0.022
1996	142	328	745628	353633	0.015	0.015
1997	100	221	804167	434166	0.015	0.015
1998	51	153	857764	490259	0.021	0.021
1999	44	145	900559	552753	0.016	0.016
2000	35	116	936871	640611	0.013	0.013
2001	37	82	966732	593973	0.022	0.022
2002	39	42	978051	669920	0.008	0.008
2003	44	36	992518	739317	0.003	0.003
2004	58	28	1004779	744162	0.006	0.006
2005	133	31	1010390	794940	0.009	0.009
2006	232	32	1012716	782416	0.028	0.042
2007	335	36	992659	911254	0.017	0.025
2008	329	47	987952	853677	0.014	0.019
2009	348	109	992652	886130	0.009	0.013
2010	500	190	1006686	844048	0.01	0.014
2011	565	274	1025073	833040	0.012	0.016
2012	431	270	1052231	827546	0.01	0.014
2013	267	285	1095856	782106	0.008	0.013
2014	259	409	1152683	733907	0.015	0.026
2015	365	463	1202973	757372	0.029	0.036
2016	451	353	1244958	787325	0.041	0.047
2017	511	219	1280146	790415	0.034	0.038
2018	451	212	1327151	811748	0.037	0.041

Year	Rec (age 2) in millions	Rec (age 6) in millions	Stock Biomass (tonnes)	SSB (tonnes)	F (12–18)	F(19+)
2019	431	298	1373398	842086	0.04	0.043
2020	431	369	1418249	874727	0.047	0.05

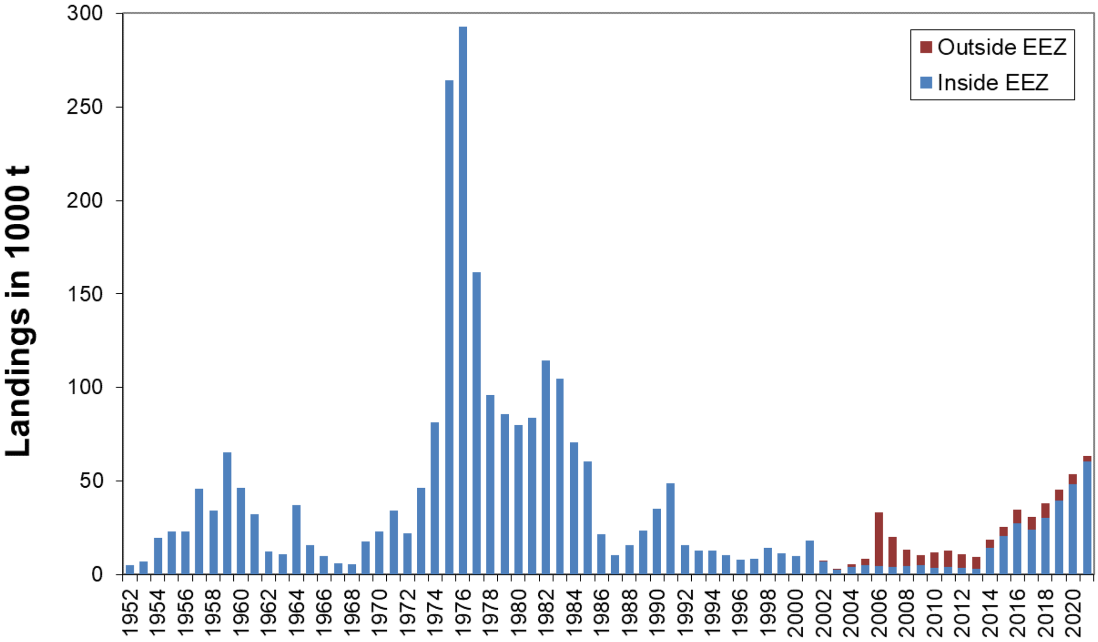


Figure 6.1. ***S. mentella*** **in subareas 1 and 2. Total international landings 1952–2020 (thousand tonnes).**

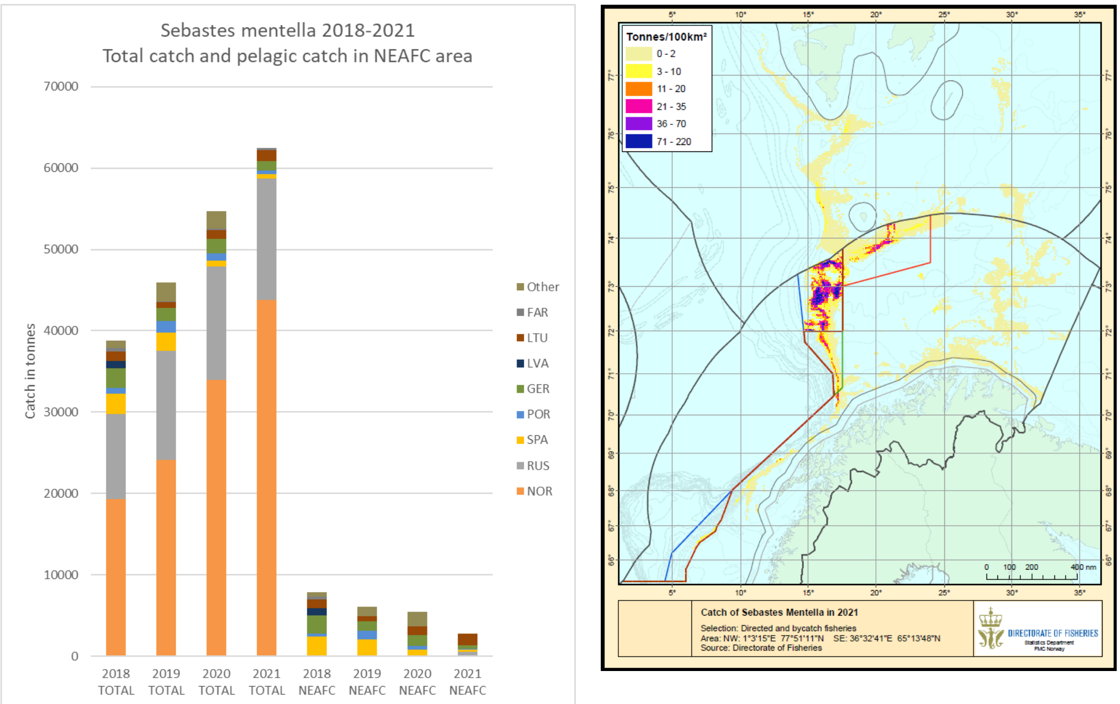


Figure 6.2. ***S. mentella*** **in subareas 1 and 2. Left panel: Catch in tonnes reported by national fleets for the subareas 27.1 and 27.2 and in the NEACF regulatory area. Right panel: Geographical location of the directed Norwegian fishery in 2021 within the Norwegian Exclusive Economic Zone and bycatches by Norwegian vessels in all areas. Directed fishing with bottom trawl is not permitted to the east of the red line. Directed fishing with pelagic trawl is not permitted to the east of the blue line. Directed fishing is not permitted in the Fishery Protection Zone around Svalbard.**

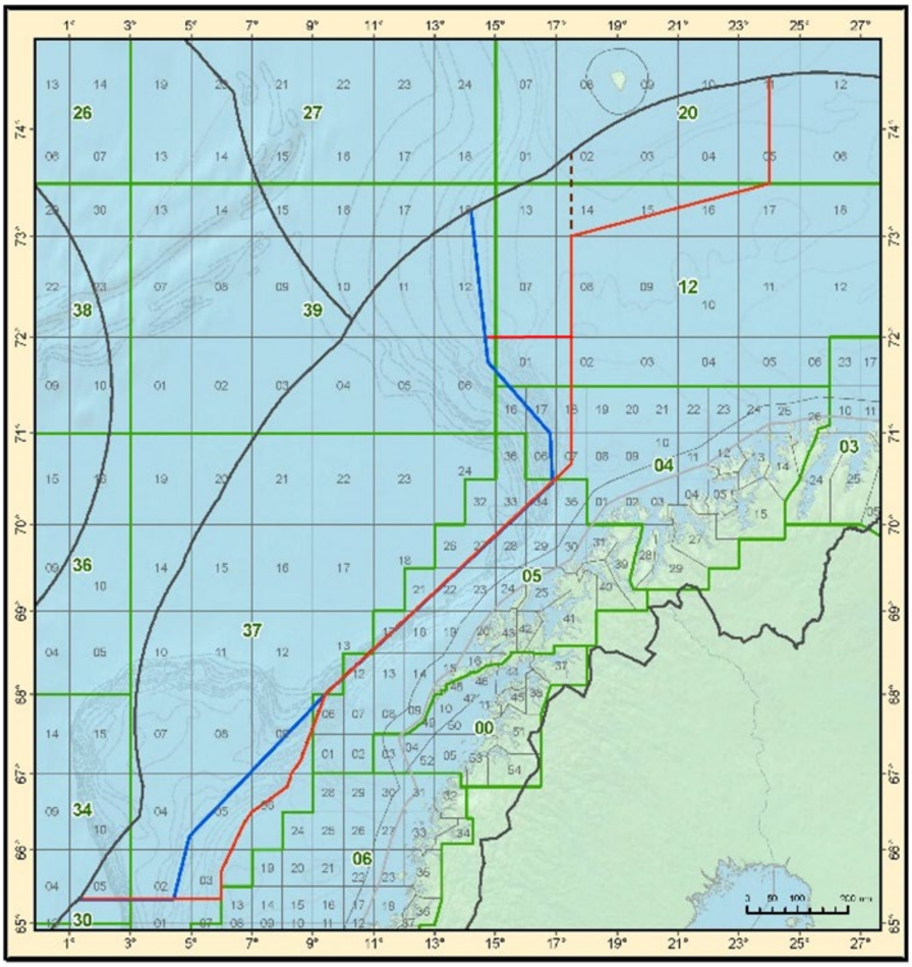


Figure 6.3. Delineation of the geographical limits for directed fishing in the Norwegian Economic Zone in 2014–2021. Directed pelagic trawling is only allowed west of the blue line. Directed demersal trawling is only allowed between the blue and the red line. The area east of the stippled line inside NEZ south of Bear Island is only open for directed demersal trawling after 10 May. The other areas for directed fishing are also open during 1 January to last February. Due to high bycatch ratios of golden redfish 72°N was suggested as southern limit for directed demersal fishing marked by the red line along that latitude to the Norwegian directorate of fisheries in November 2018.

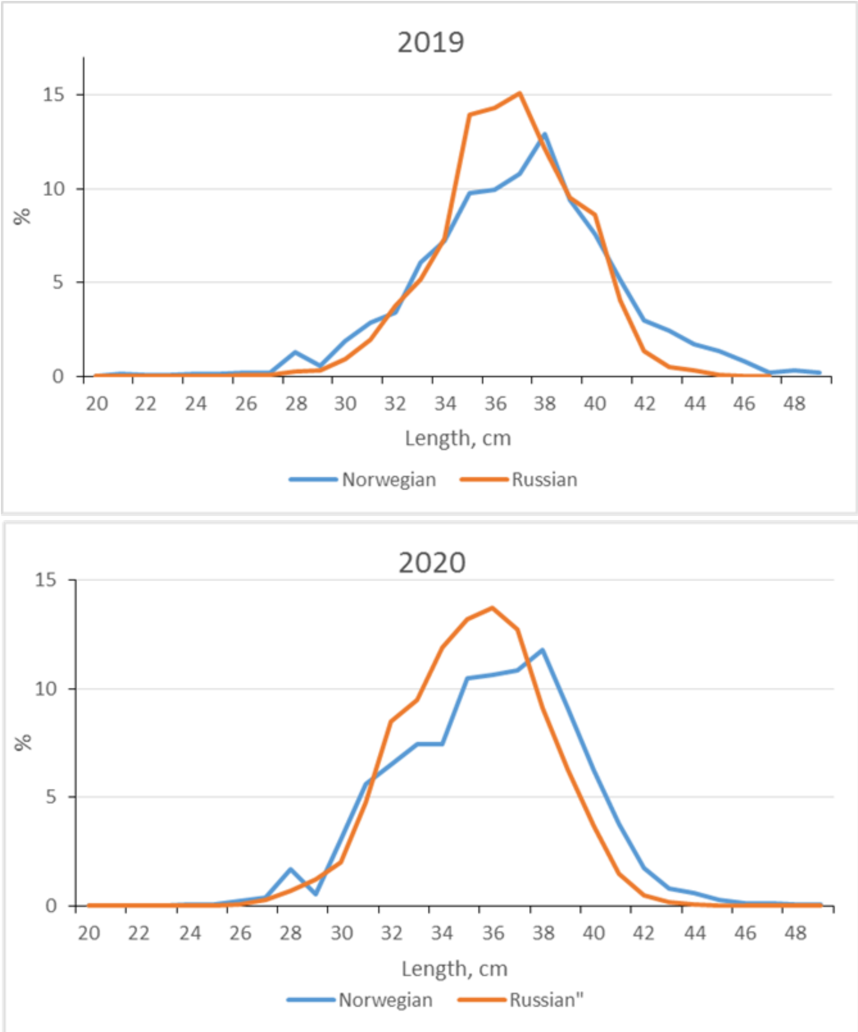


Figure 6.4. *S. mentella* in subareas 1 and 2. Length-distributions of the commercial demersal catches by Norway and Russia in 2019–2020.

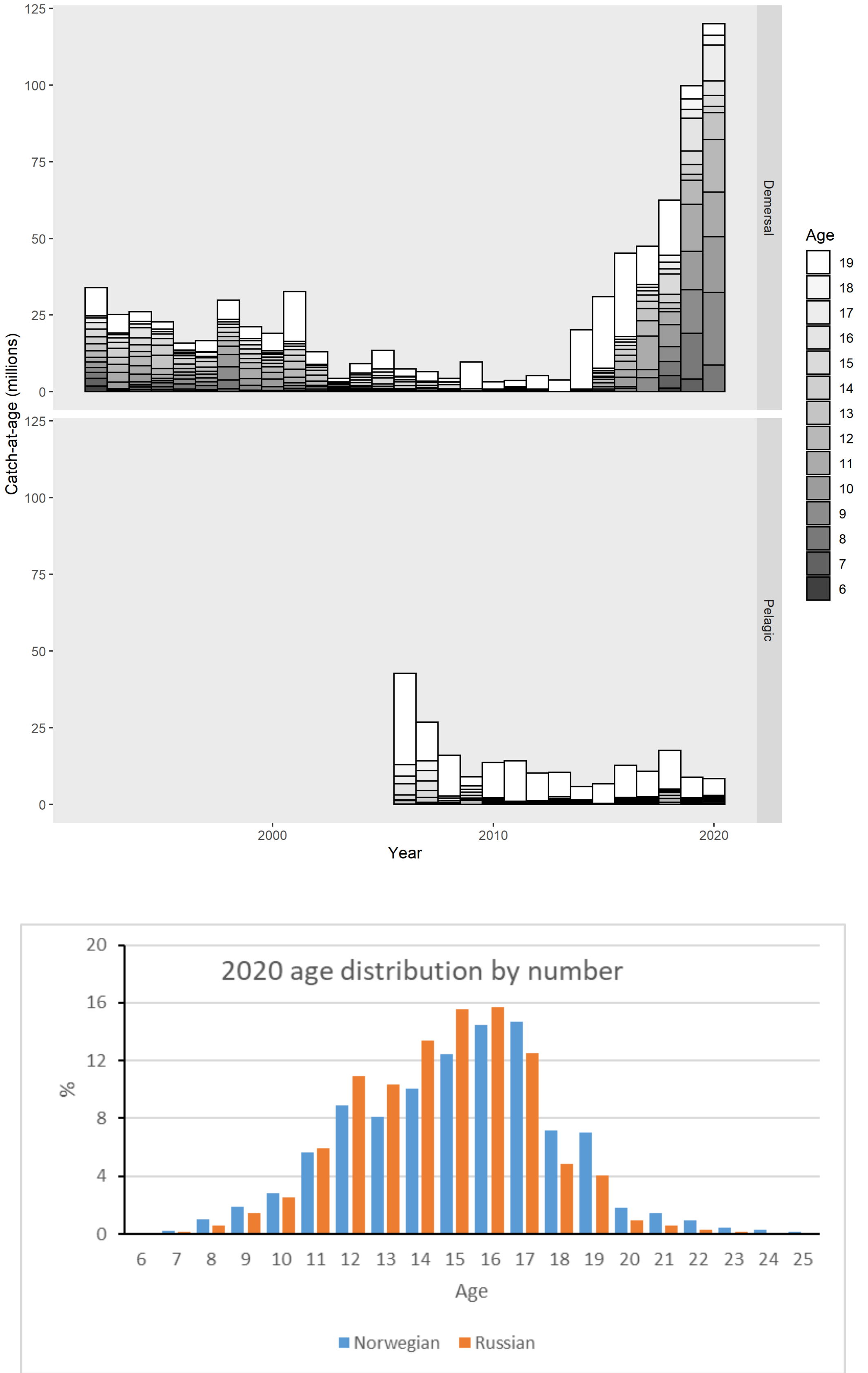


Figure 6.5. ***S. mentella*** **in subareas 1 and 2. Upper panels: Catch numbers-at-age for the demersal and pelagic fleets 1992–2020. Lower panel: Age composition of the commercial demersal catches by Norway and Russia in 2020 (calculated using ALK).**

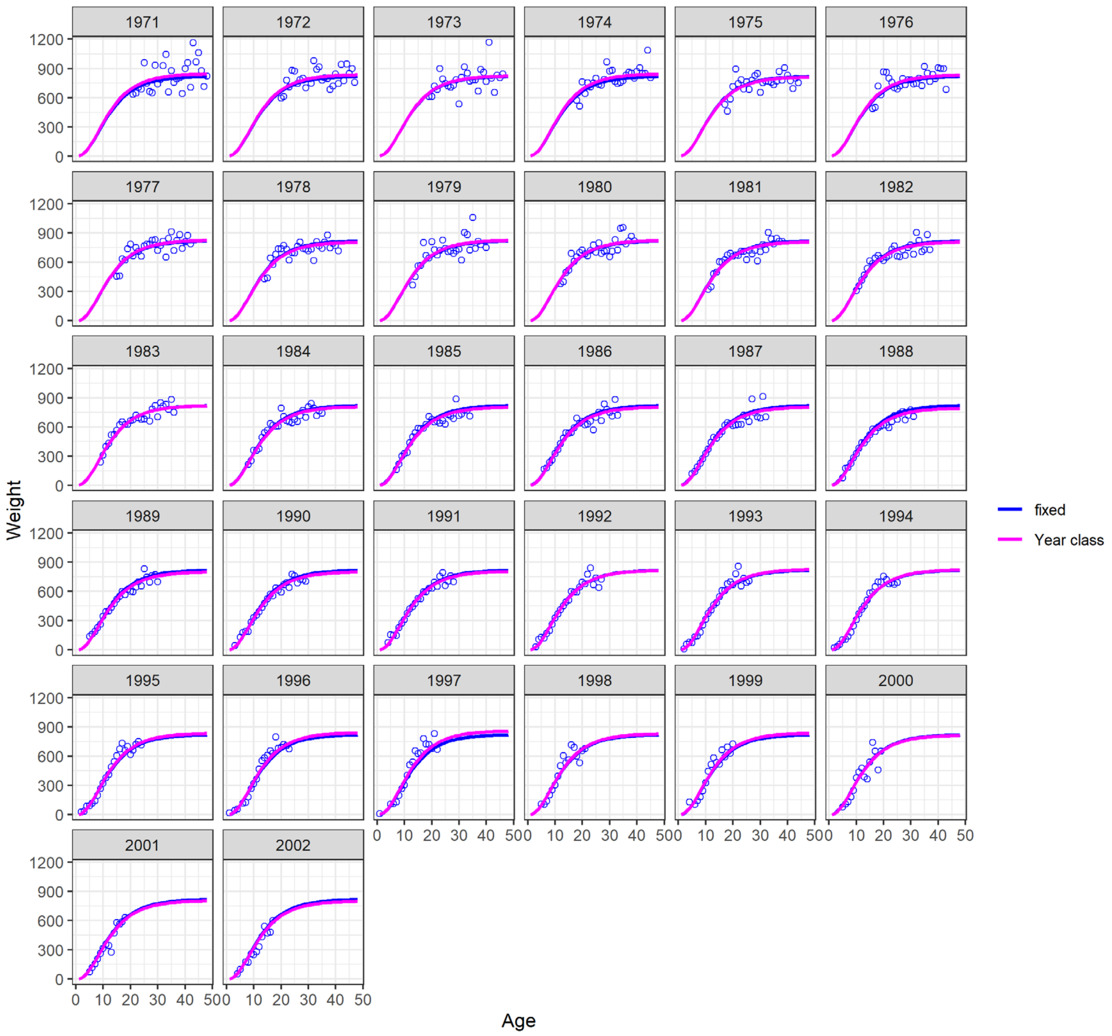


Figure 6.6. Weight-at-age of *S. mentella* per year class in subareas 1 and 2 derived from Norwegian commercial and survey data (Table 6.7). The weights were derived from samples with at least five individuals and are expressed in grammes. The blue and purple lines show the fitted mixed-effect models.

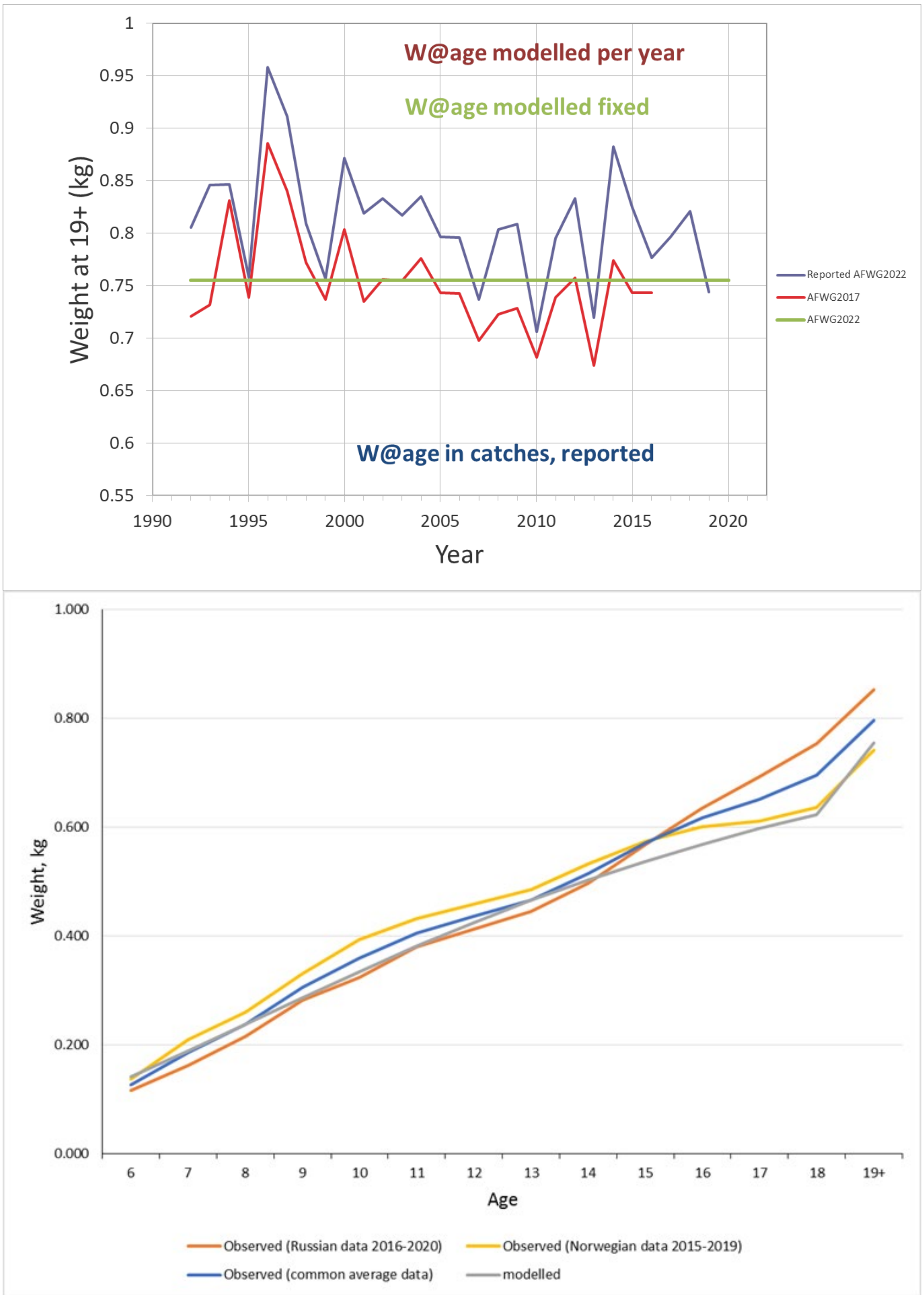


Figure 6.7. *S. mentella* in subareas 1 and 2. The upper panel shows weight-at-age 19+ as reported from catches (blue) or modelled from catches and survey observations (red) using a mixed effect model (Figure 6.5). AFWG 2017 was the last working group using the annual mixed effect model. The weights-at-age used in the assessment were based on the fixed effects model and are therefore the same for every year. These weights were updated in 2022 and differ only slightly from those estimated in the assessments since 2018. The bottom panel shows comparison of the observed Norwegian and Russian weight by age with the modelled one.

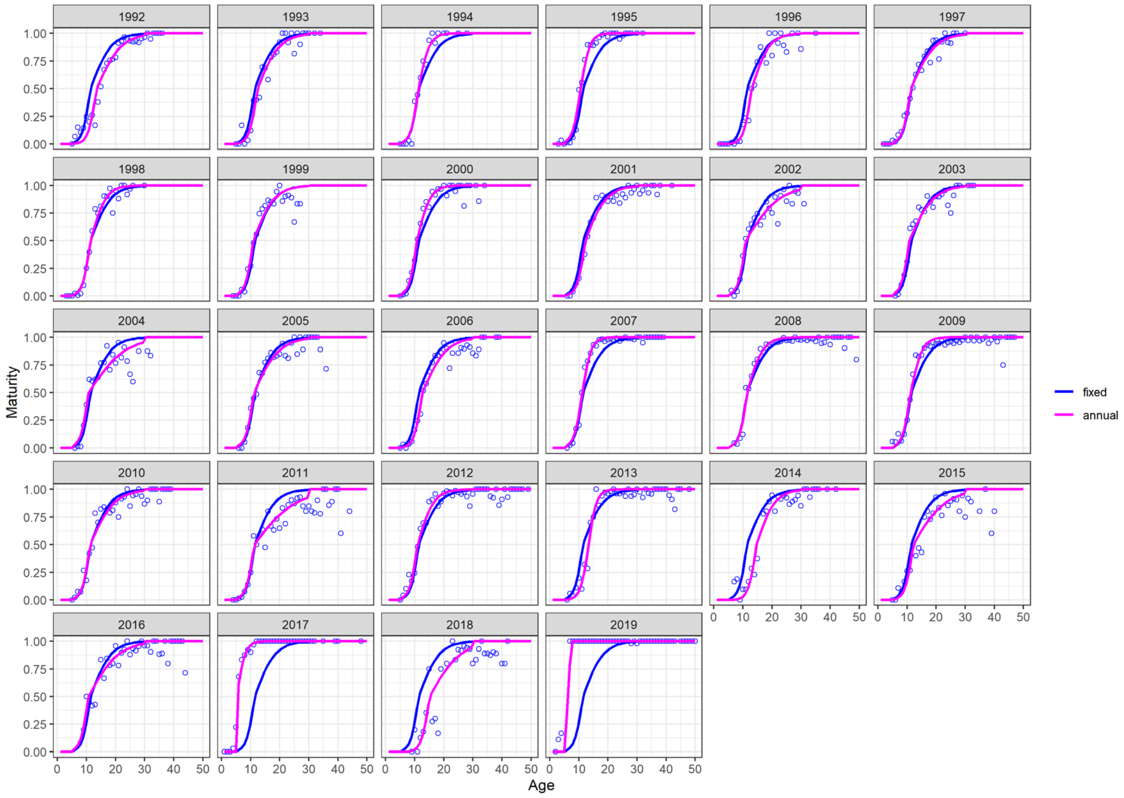


Figure 6.8. Proportion maturity-at-age of *S. mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table D7). The proportions were derived from samples with at least five individuals. The blue and purple lines show the fitted mixed-effect models. For 2008, 2011 and 2016–2019 the common model (fixed effects blue) was used for other years the annual models (random effects purple) were used. Available data for 2019 was insufficient at the time of the meeting and the fixed effect model was used and there was no age data available for 2020 or 2021.

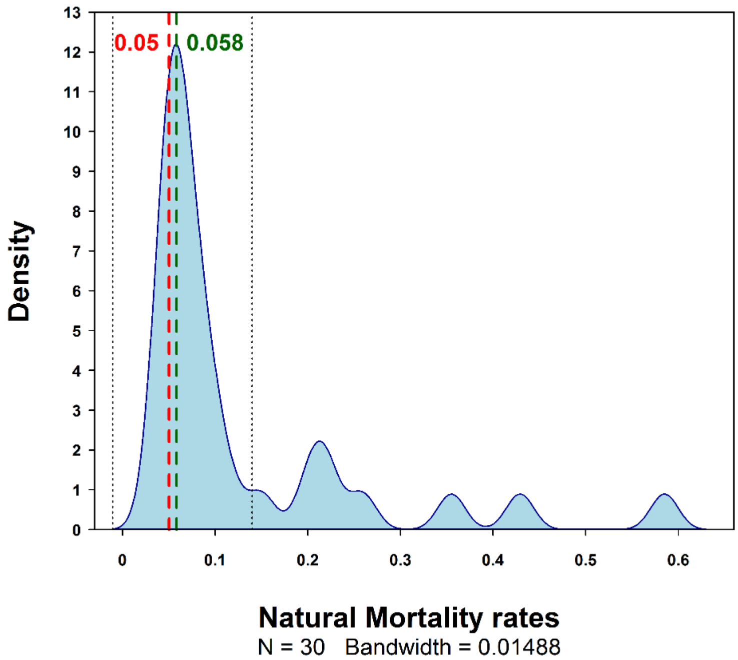


Figure 6.9. Density distribution of natural mortality rates calculated with 30 of the 39 compared methods. The excluded methods are those based on certain taxa or areas. The broken red line indicates the currently used value; the broken green line the most frequent one and the black dotted lines indicate the beginning and end of the distribution's peak.

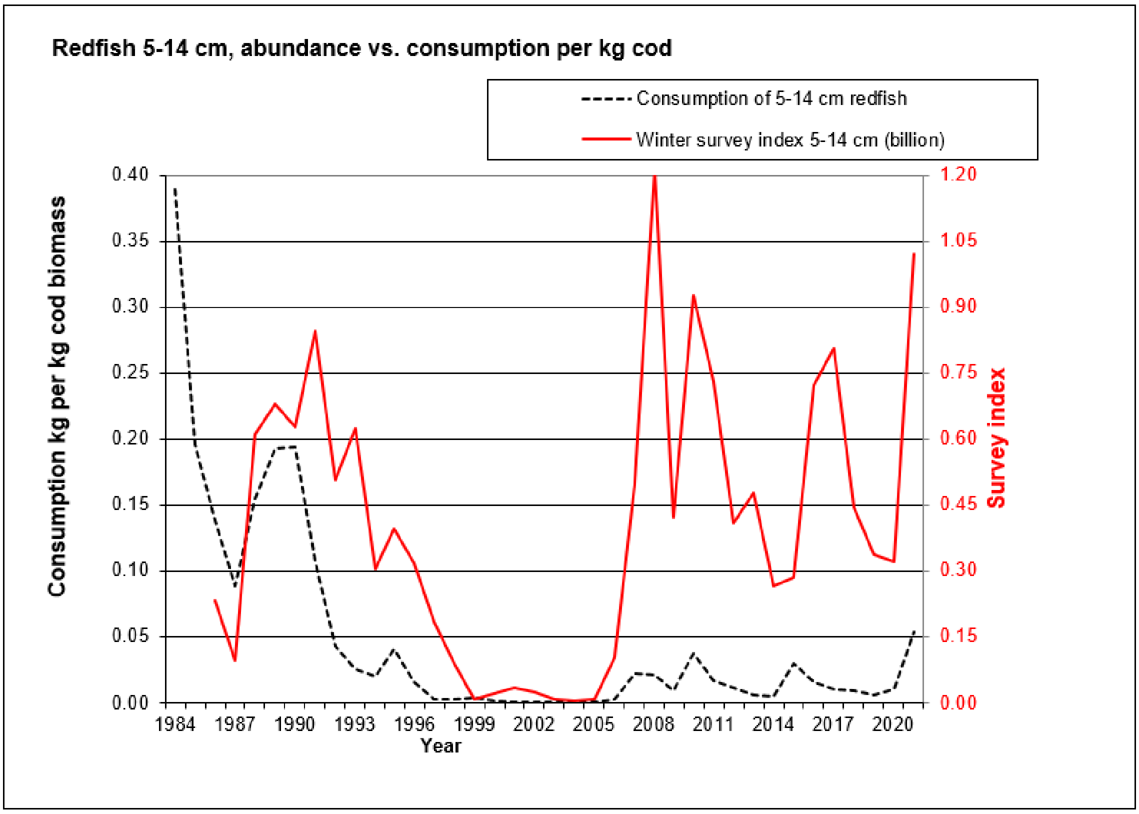


Figure 6.10. Abundance of *S. mentella* (5–14 cm) during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod (See Section 1 Table 1.1).

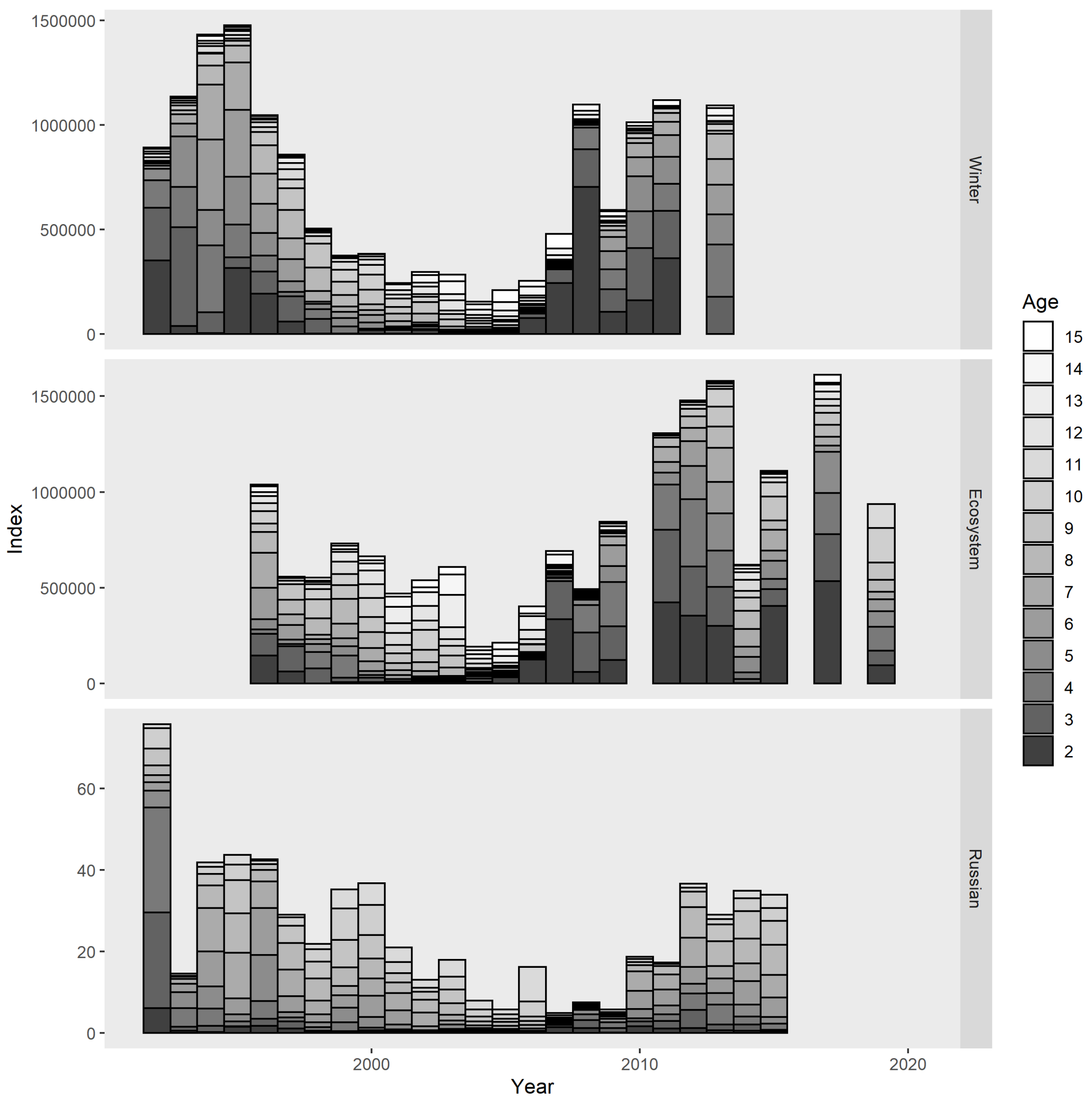
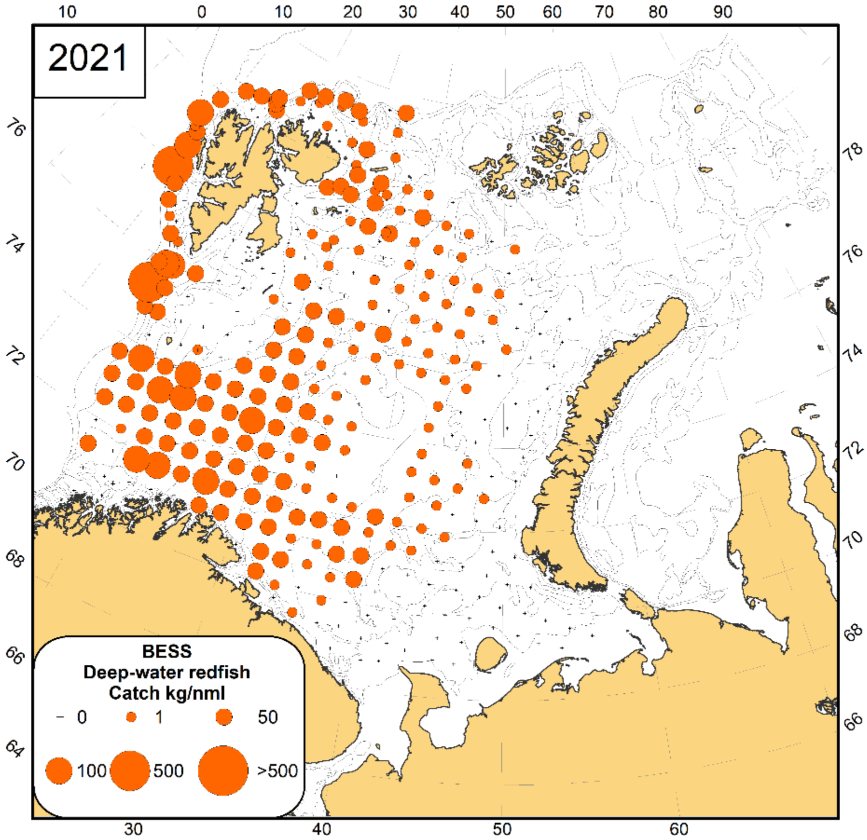


Figure 6.11. ***S. mentella*** **in subareas 1 and 2. Age disaggregated abundance indices for bottom trawl surveys 1992–2020 in the Barents Sea in winter (winter survey top) in summer (Ecosystem survey middle) and in autumn (Russian groundfish survey bottom).**



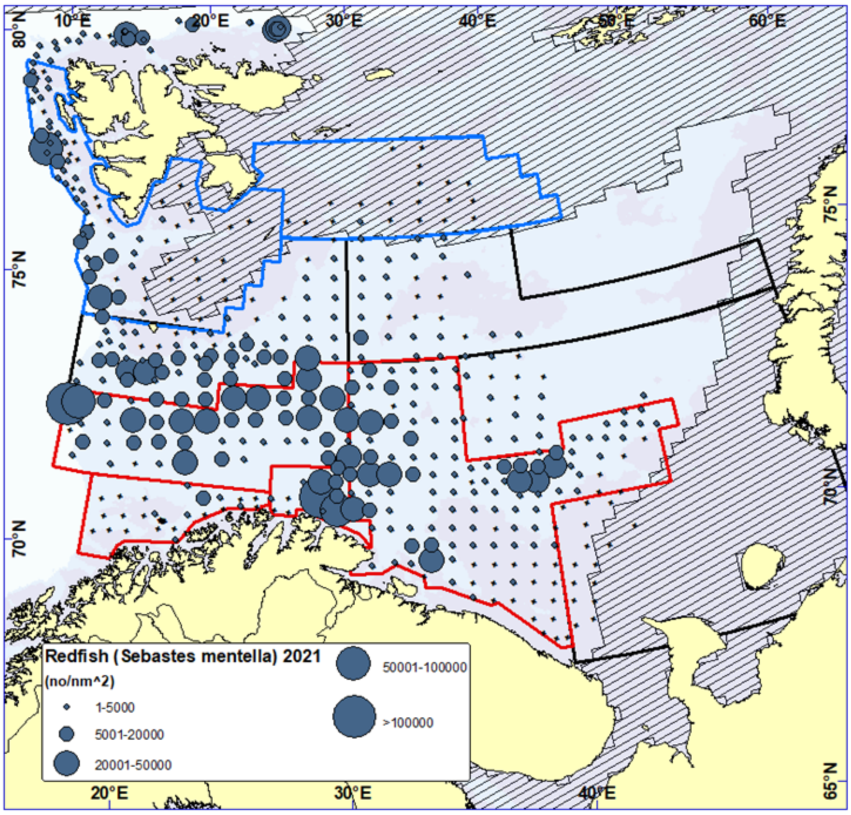


Figure 6.12. ***S. mentella*** **in subareas 1 and 2. Abundance indices for individual trawl stations during the ecosystem survey in autumn 2021 (top) and winter survey 2021 (bottom).**

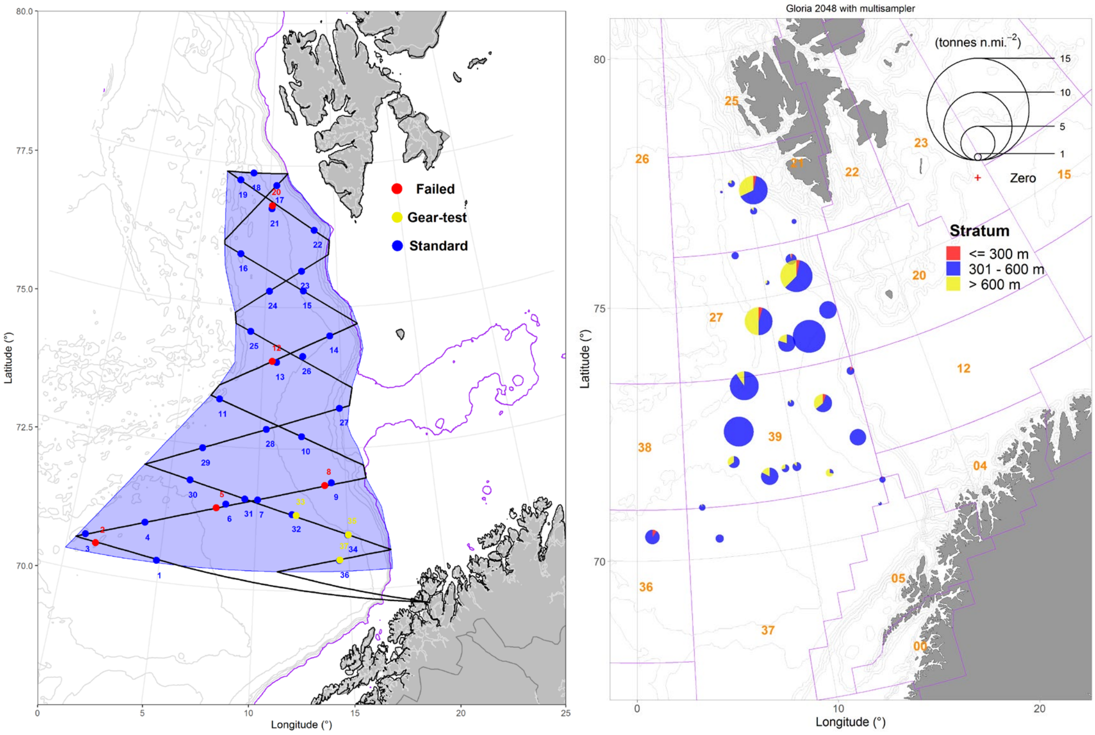


Figure 6.13. ***S. mentella*** **in subareas 1 and 2. Left panel: Survey track of the Deep Pelagic Ecosystem Survey in 2019 and categorized trawls. Only trawls in the category "Standard" served as input for the survey index. Right panel: Catch rates in tonnes per square nautical mile for the surveyed depth layers (< = 300 m, 301–600 m and > 600 m).**

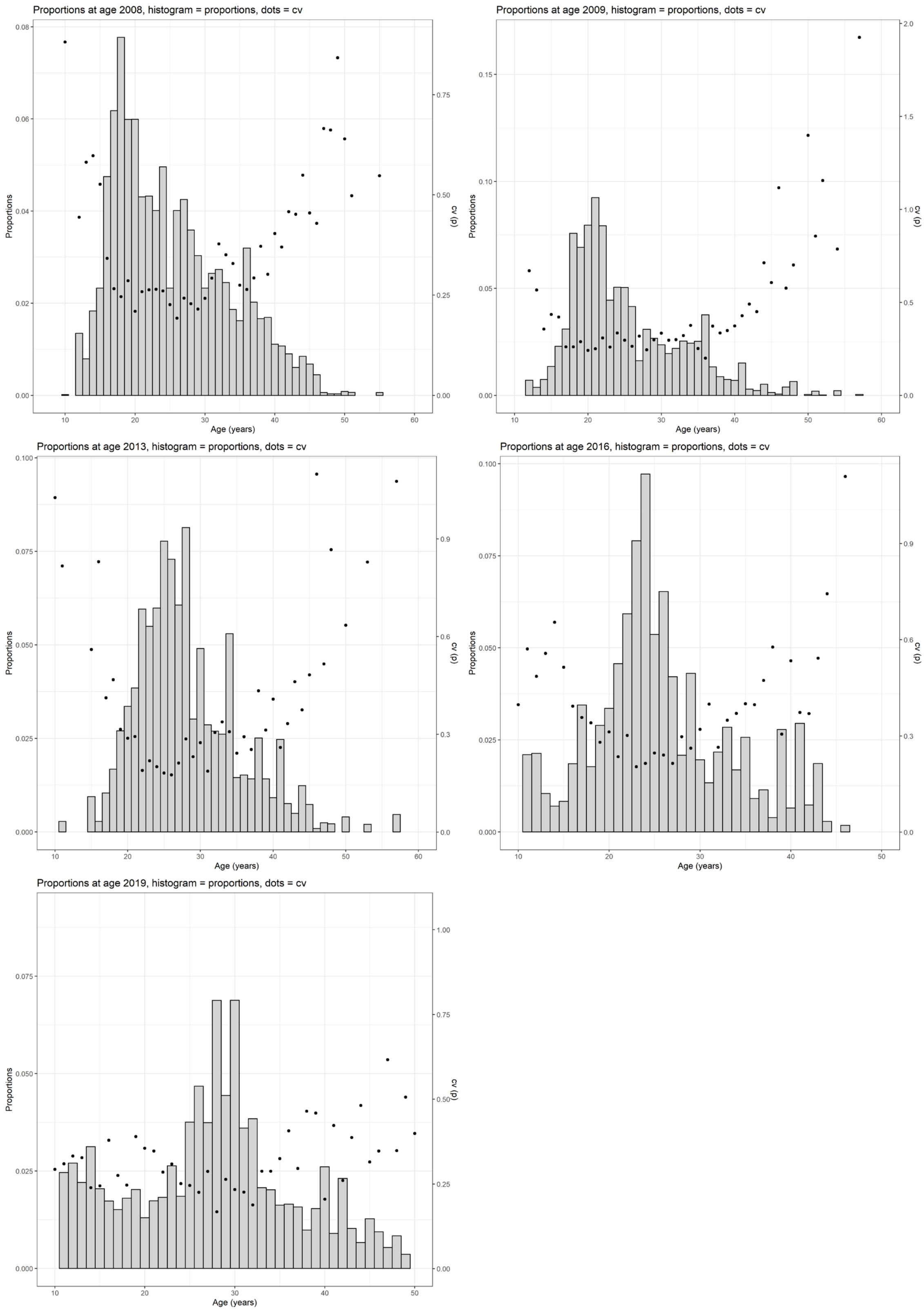


Figure 6.14. ***S. mentella*** **in subareas 1 and 2. Proportions at age during the International Deep Pelagic Ecosystem Survey (WGIDEEPS) in the Norwegian Sea. Bars show proportions at age and dots shows the coefficient of variation for each age. Estimated with RStoX.**

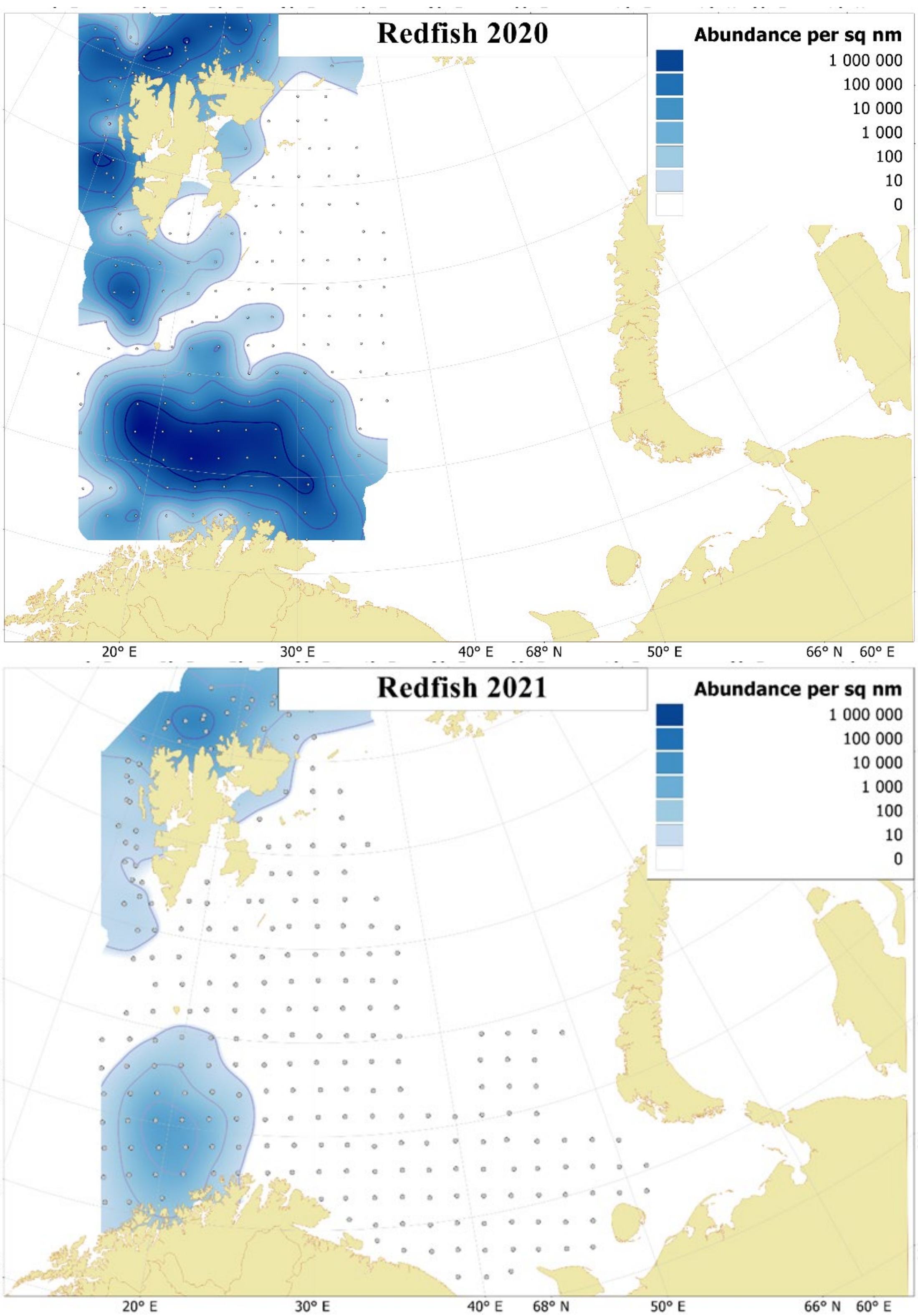


Figure 6.15. Map showing the specific pelagic 0-group trawl stations and the abundance of 0-group *S. mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard in 2020 (upper panel) and 2021 (lower panel).

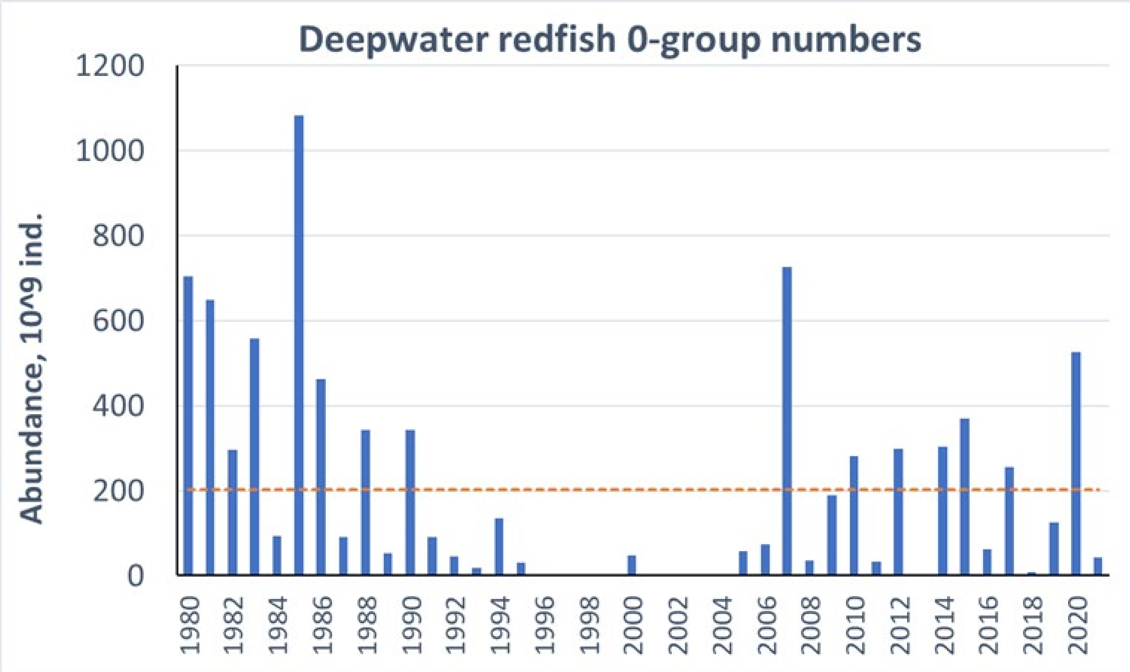


Figure 6.16. *S. mentella* in subareas 1 and 2. Abundance indices (in billions) of 0-group redfish (believed to be mostly *S. mentella*) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980–2021.

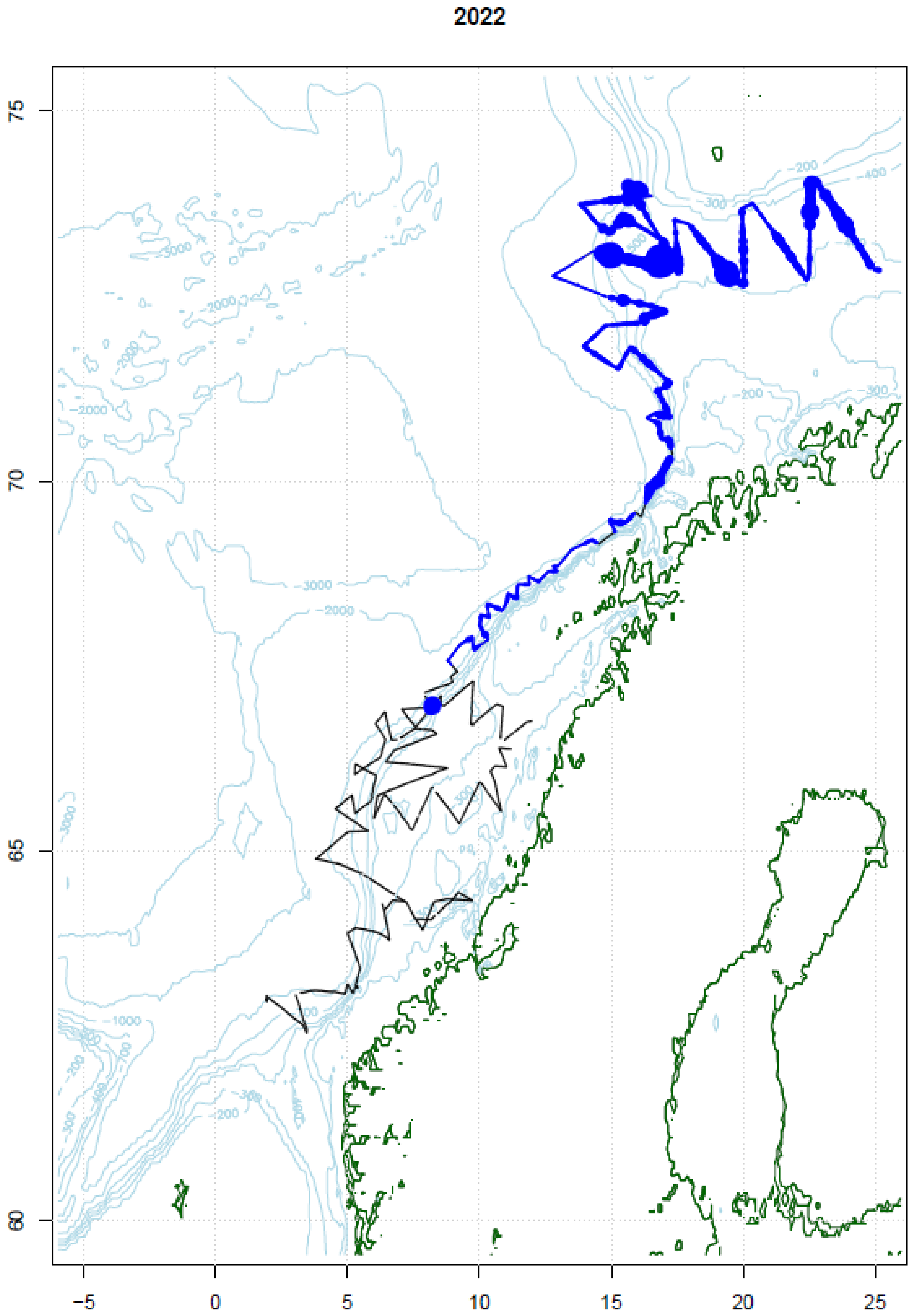
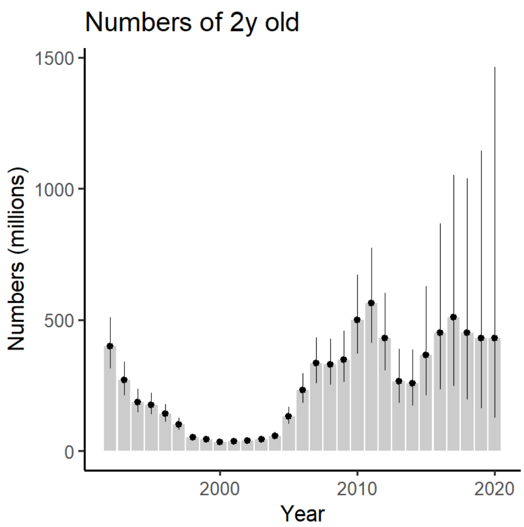
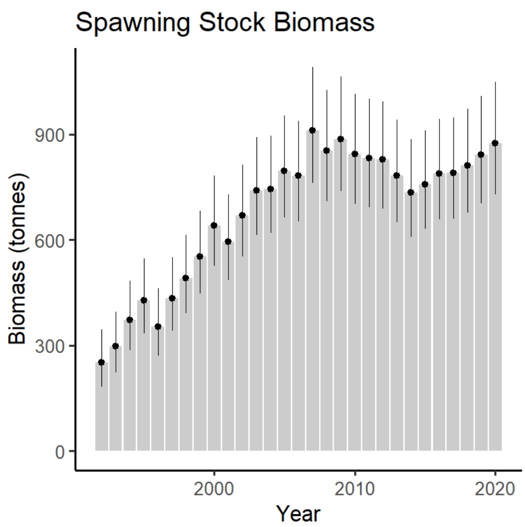


Figure 6.17. ***S. mentella*** **in subareas 1 and 2. Horizontal distribution of** ***S. mentella*** **hydroacoustic backscattering (sA) during the Norwegian slope survey in spring 2020. The circles are proportional to the sA assigned to redfish along the vessel track.**

Recruitment-at-age 2	**Spawning-stock biomass**
	

Fishing mortality – year component

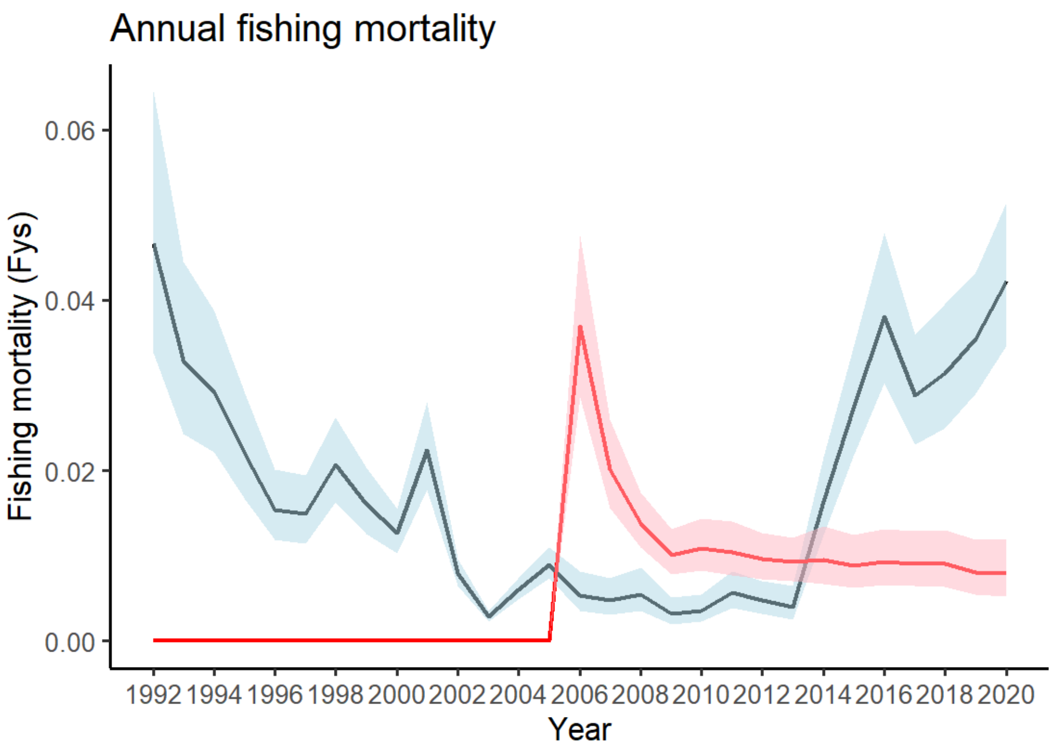


Figure 6.18. *S. mentella* in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated recruitment-at-age 2 spawning-stock biomass from 1992 to 2020 and annual fishing mortality coefficients by year (Fy) from the demersal (blue) and pelagic (red) fleets. Error bars (top) and the coloured envelope (bottom) indicate 95% confidence limits.

Fleet selectivity – age component

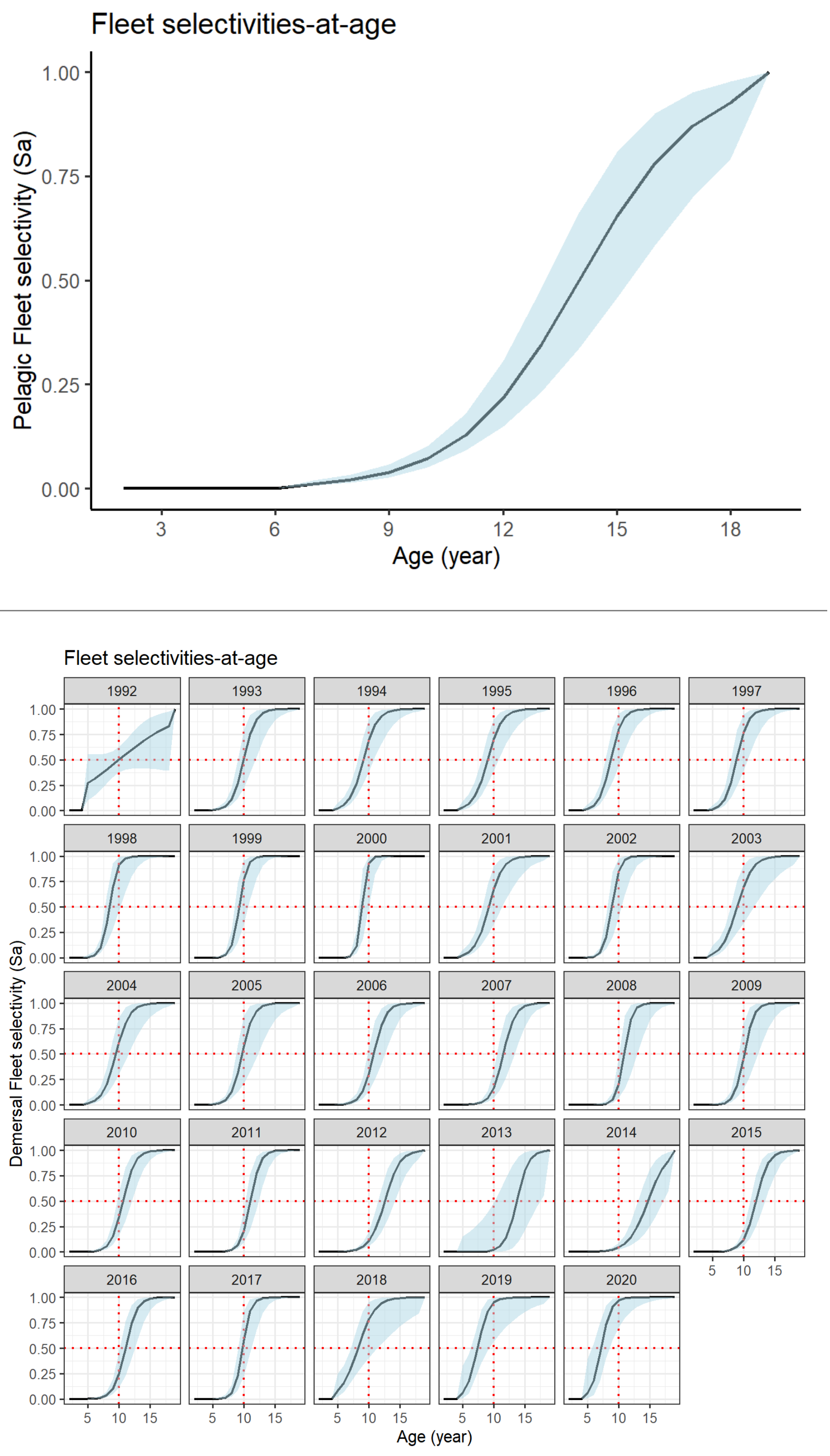


Figure 6.19. ***S. mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated annual fleet selectivity by age (Fa) from the pelagic (top panel) and demersal (lower panels) fleets. Colored envelopes indicate 95% confidence limits.**

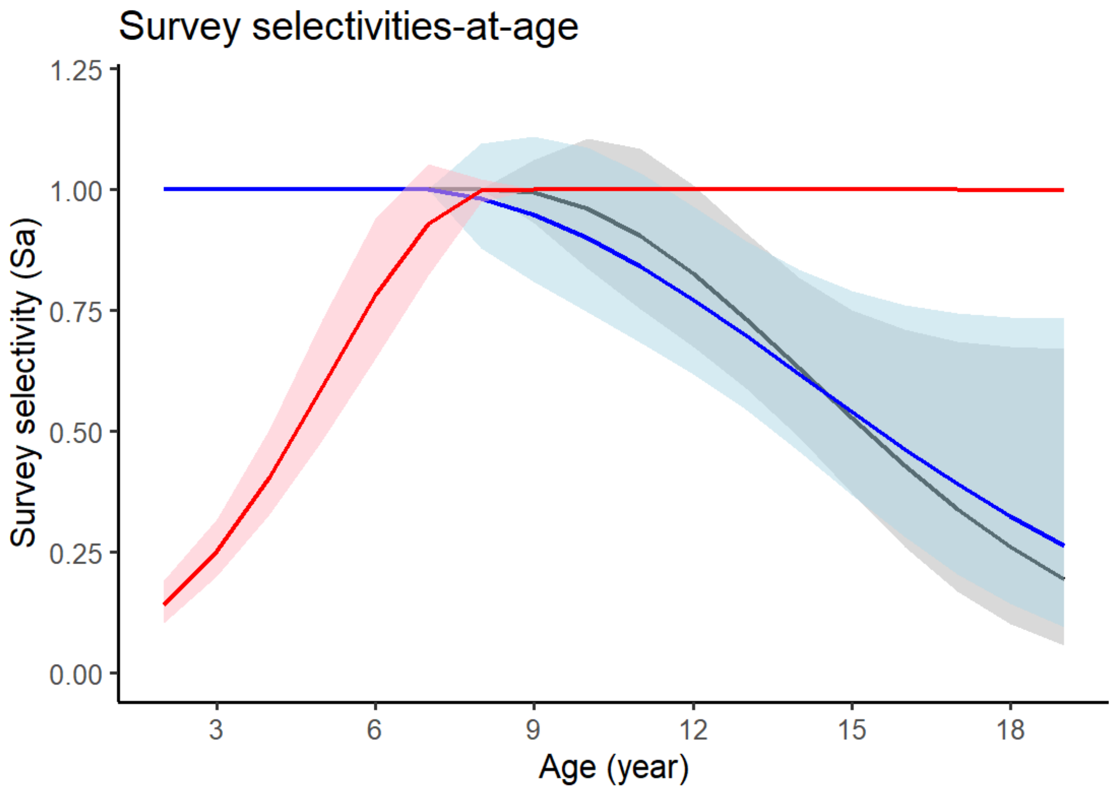


Figure 6.20. ***S. mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the selectivity-at-age for winter (blue) ecosystem (grey) and Russian groundfish (red) surveys.**

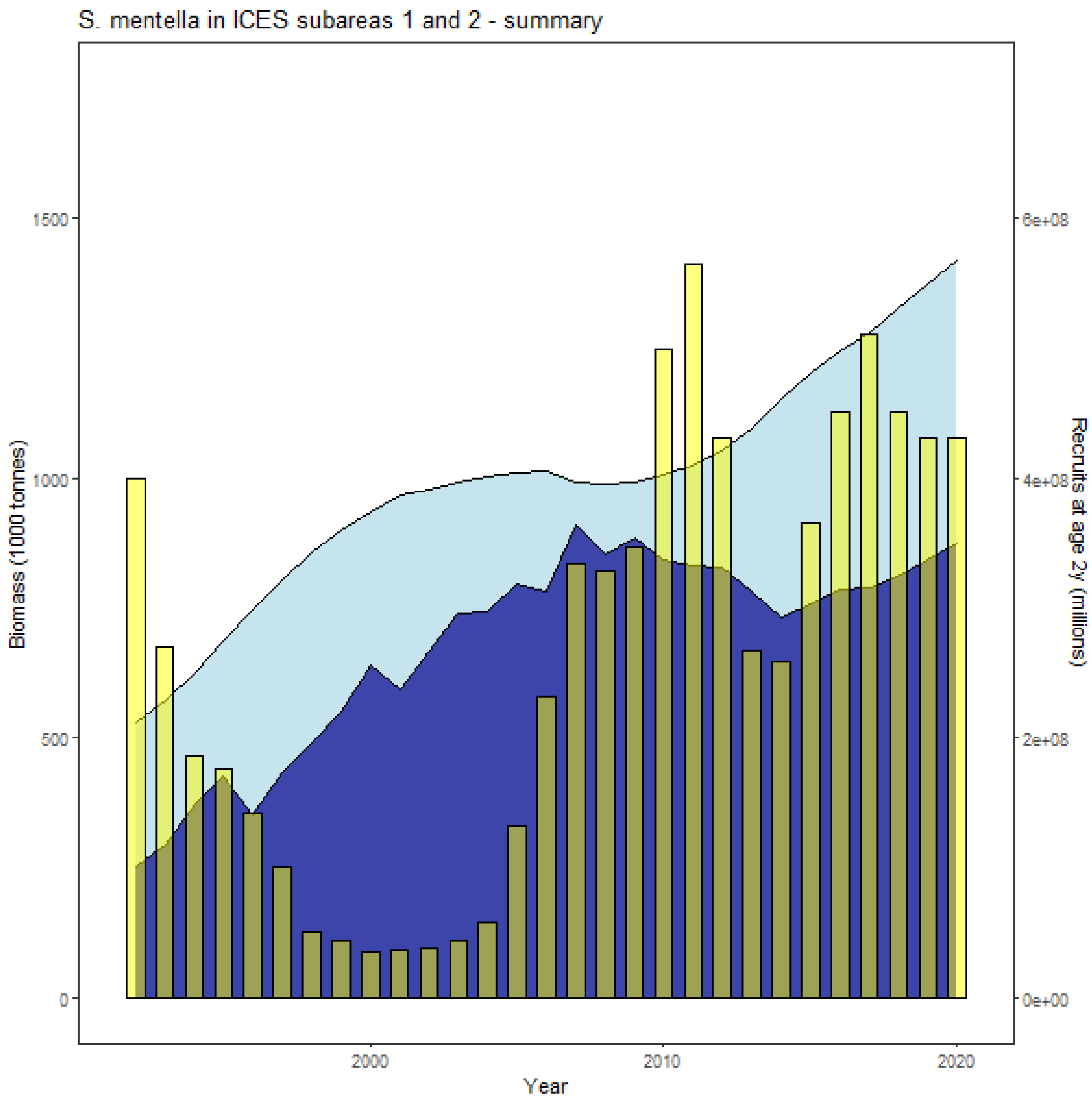


Figure 6.21. ***S. mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age model showing the evolution of total biomass (in tonnes light blue left axis) spawning-stock-biomass (in tonnes dark blue, left axis) and recruitment-at-age 2 (in numbers yellow, right axis) for the period 1992–2020 for *S. mentella* in subareas 1 and 2.**

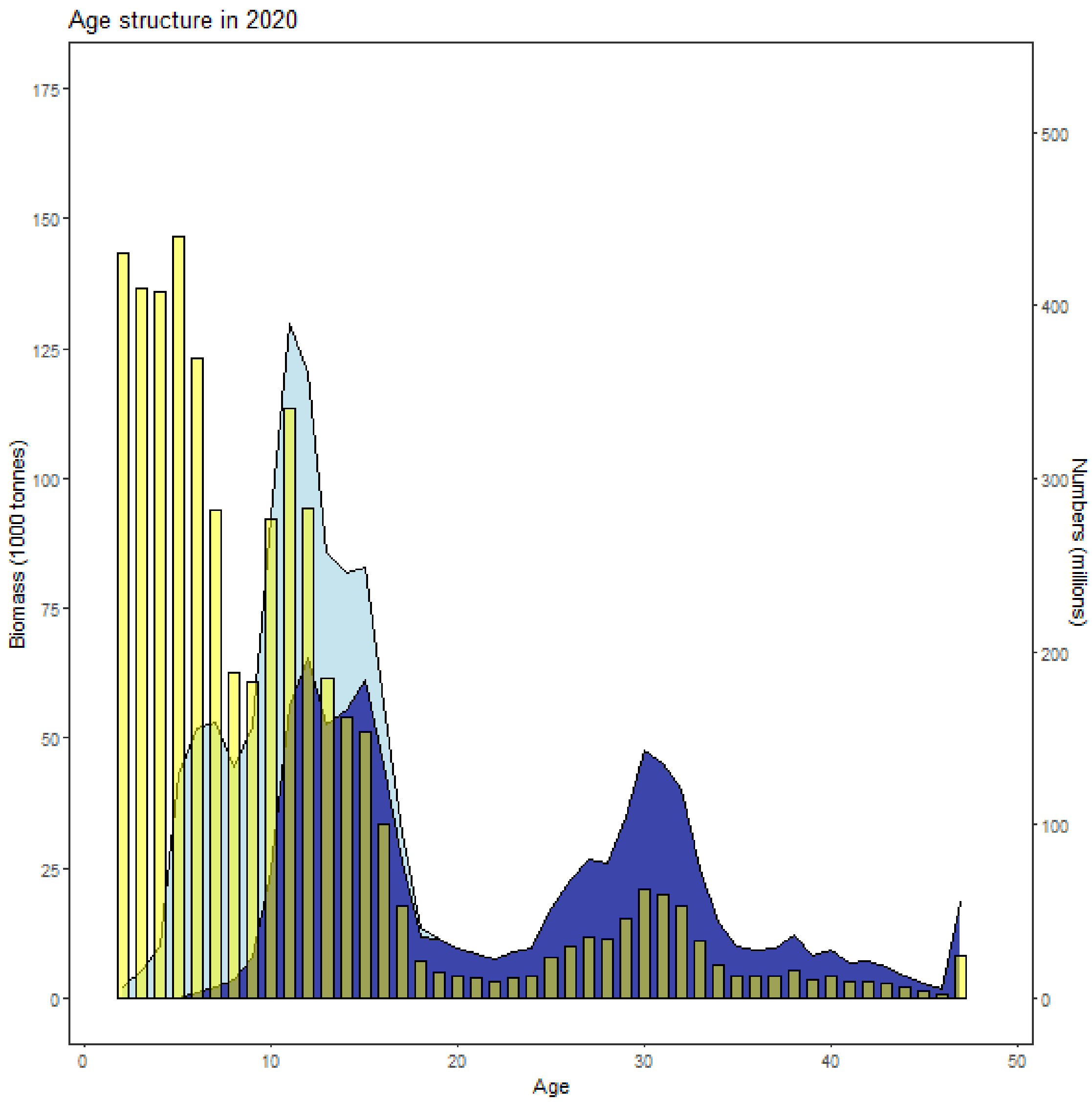


Figure 6.22. *S. mentella* in subareas 1 and 2. Modelled distribution of numbers (yellow bars right *y*-axis) biomass (light blue left *y*-axis) and spawning-stock-biomass (dark blue left *y*-axis) at age 2–45+ in 2020.

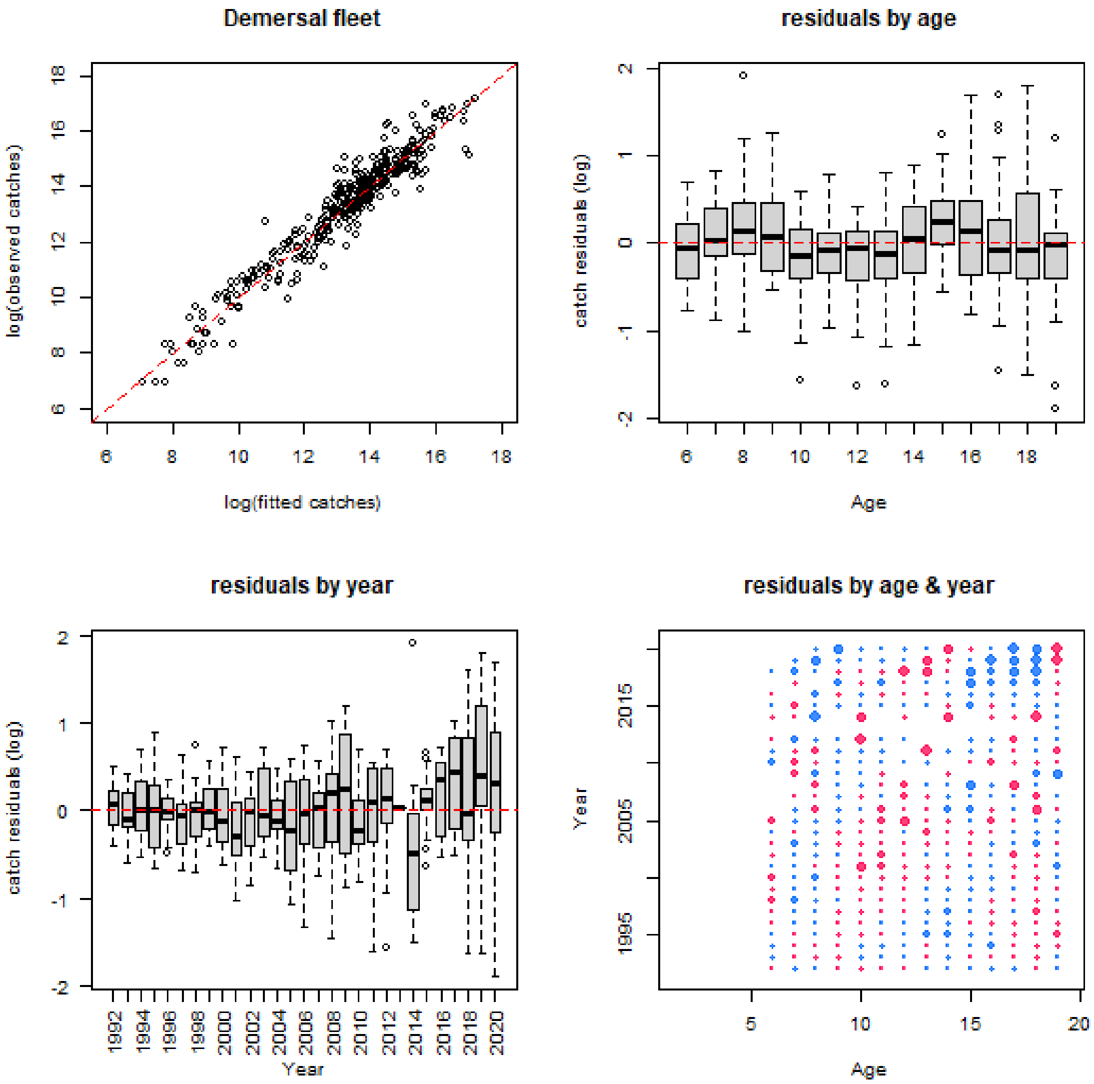


Figure 6.23a. Diagnostic plots for the demersal fleet catch-at-age data. Top-left: scatterplot of observed vs. fitted indices the dotted red line indicates 1:1 relationship. Top right: boxplot of residuals (observed-fitted) for each age. Bottom left: boxplot of residuals for each year. Bottom right: bubble plot of residuals for each age/year combination bubble size is proportional to mean residuals blue are positive and red are negative residuals.

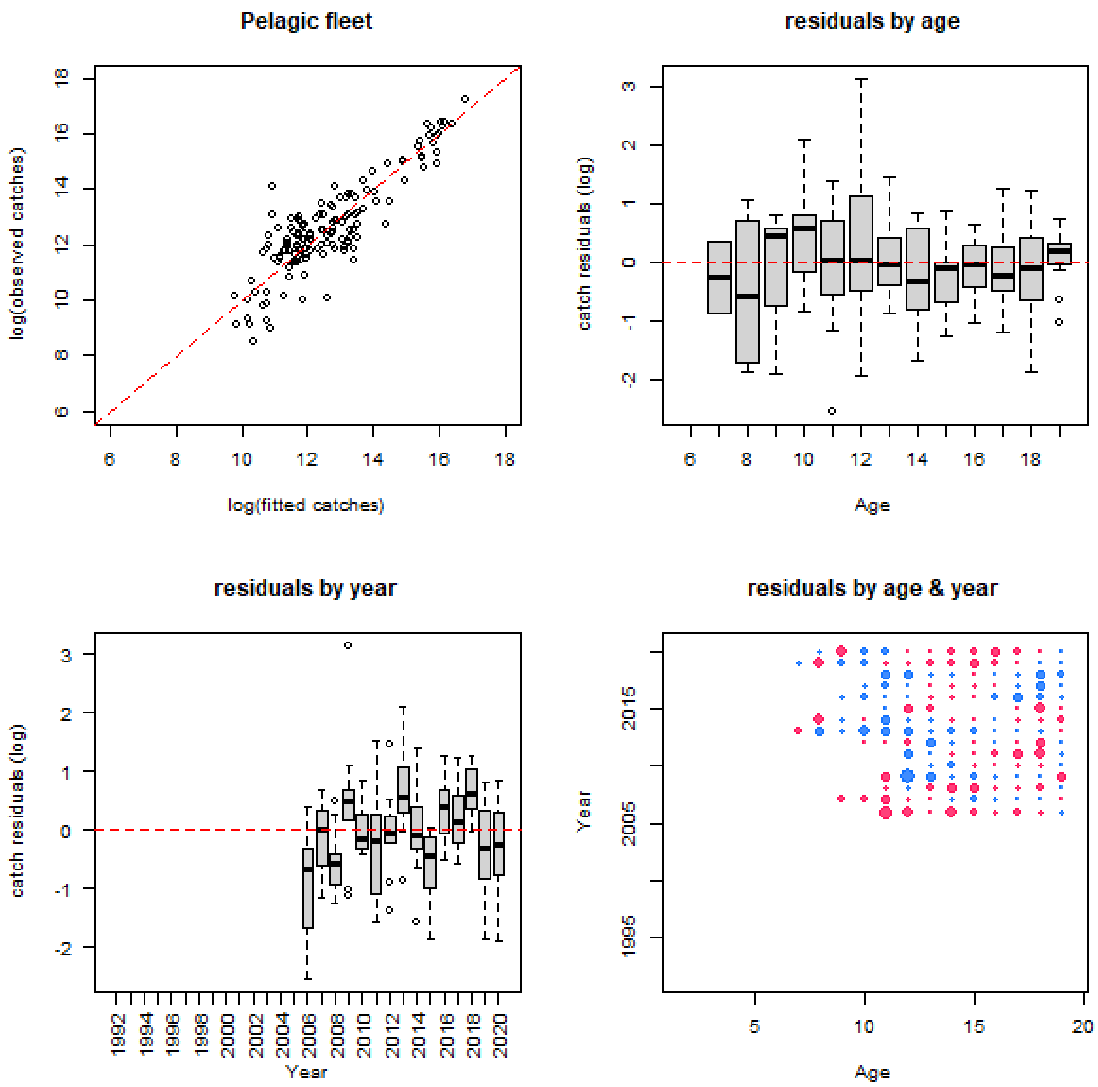


Figure 6.23b. Diagnostic plots for the pelagic fleet catch-at-age data. See legend from Figure 6.23a.

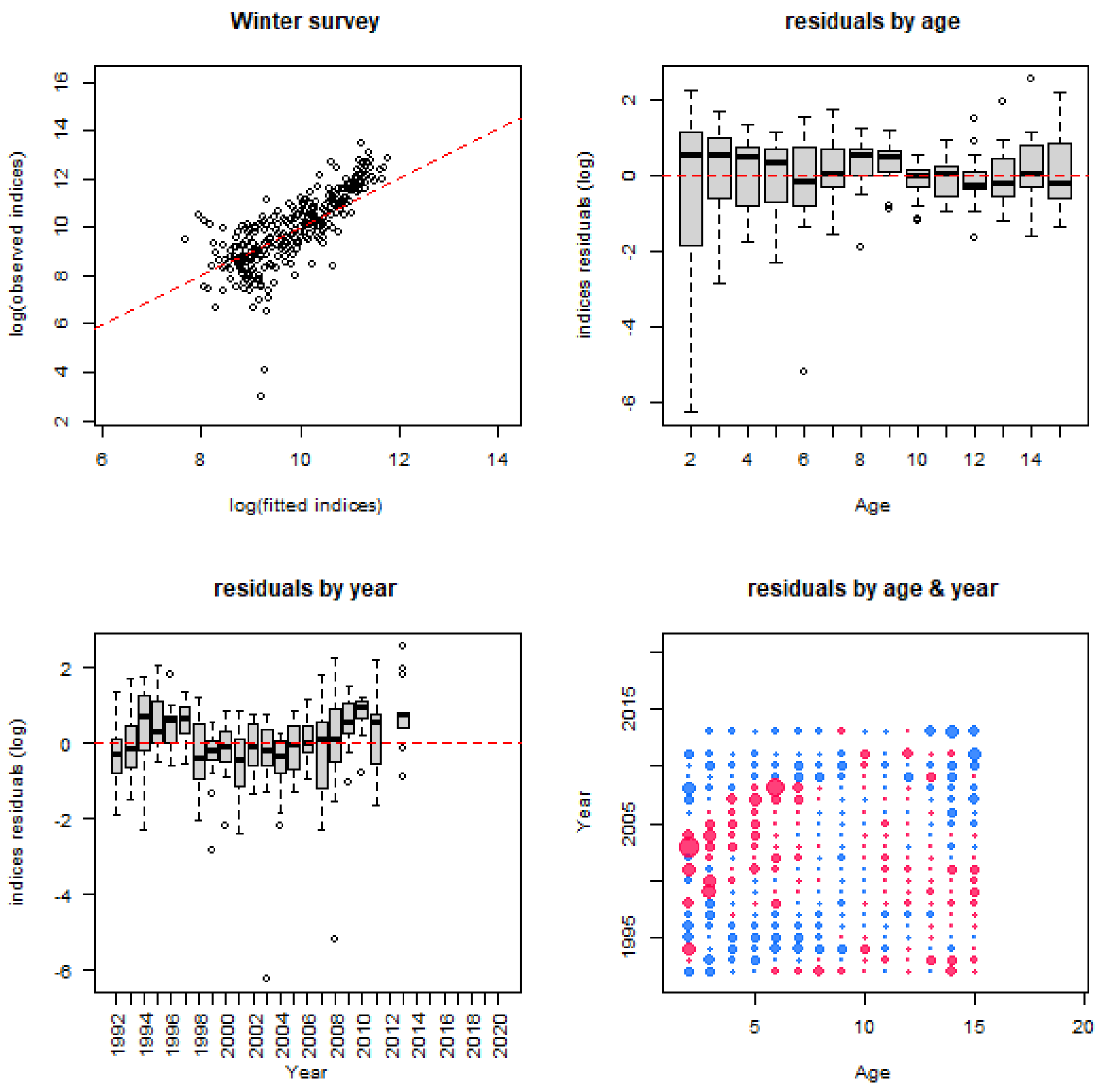


Figure 6.23c. Diagnostic plots for winter survey data. See legend from Figure 6.23a.

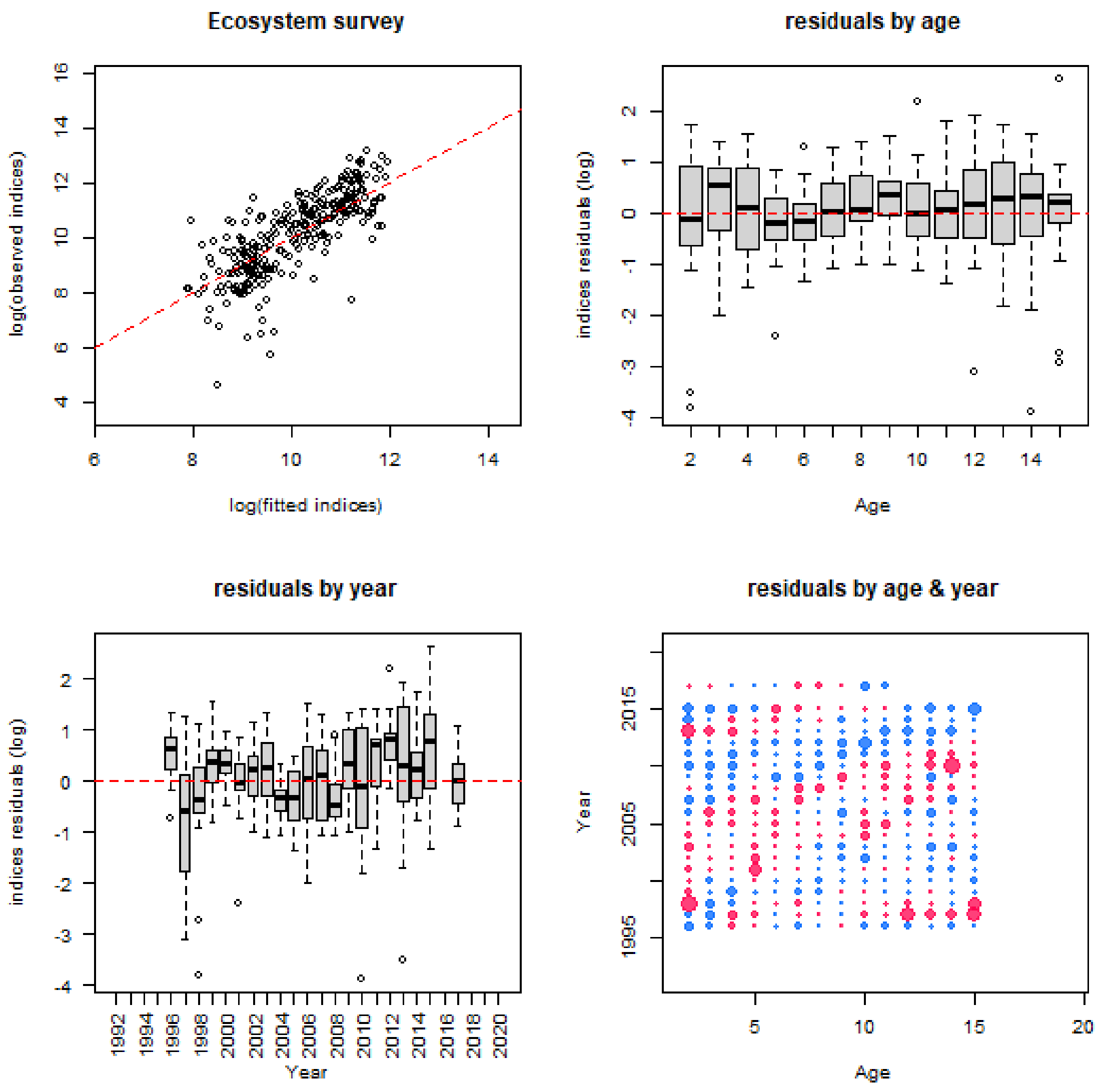


Figure 6.23d. Diagnostic plots for Ecosystem survey data. See legend from Figure 6.23a.

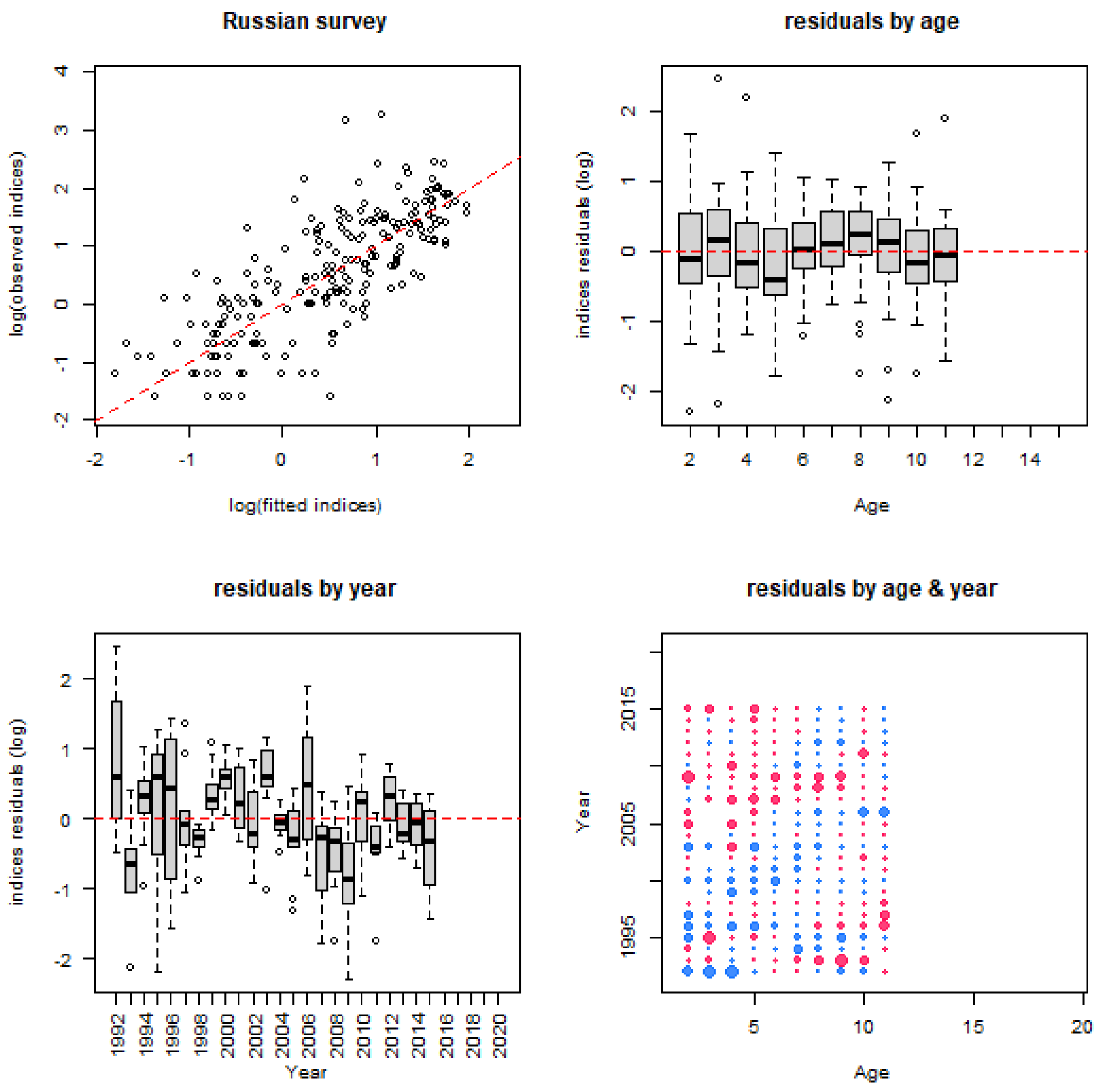


Figure 6.23e. Diagnostic plots for the Russian groundfish survey data. See legend from Figure 6.23a.

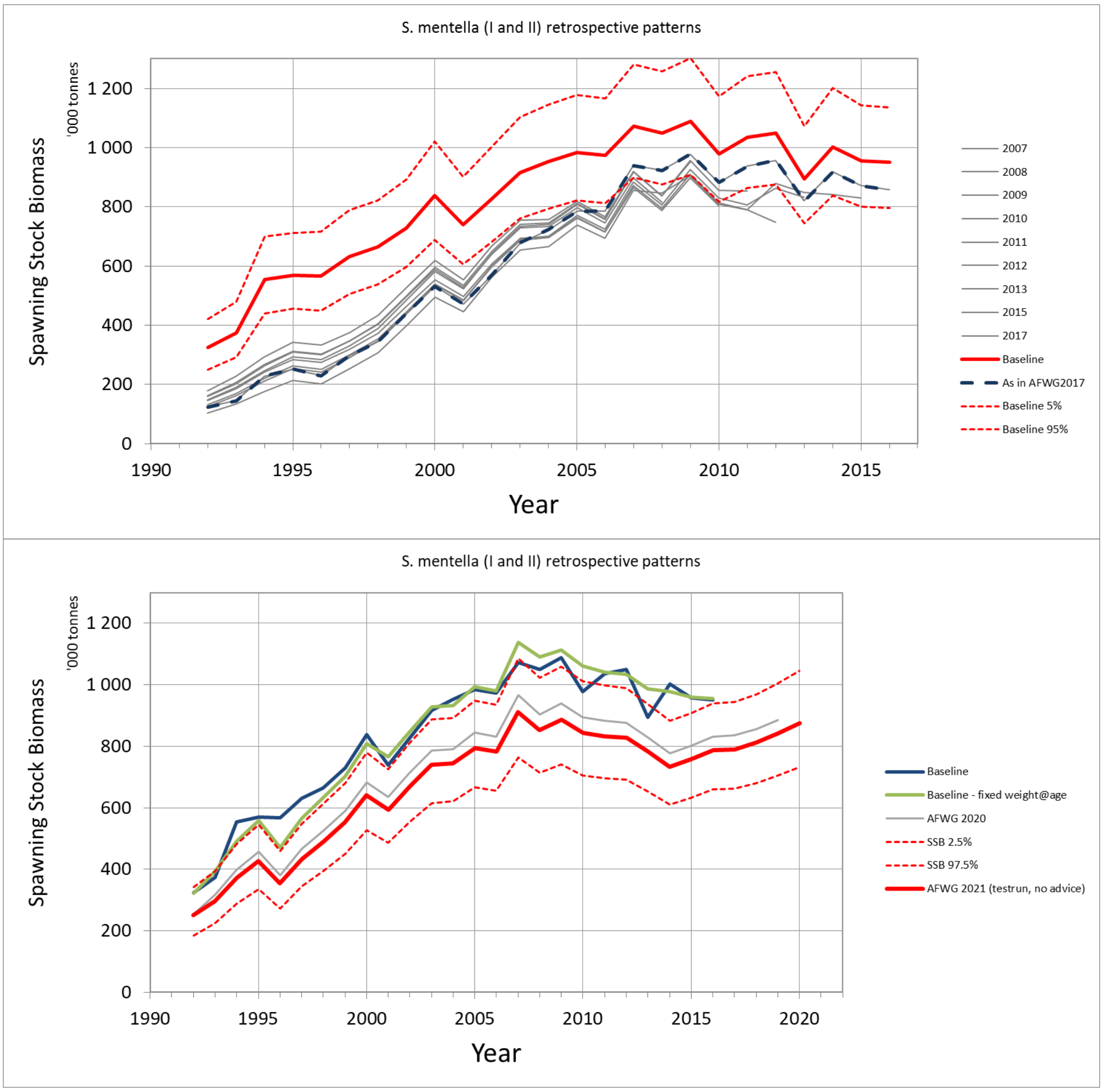


Figure 6.24. The upper panel shows the retrospective patterns of the spawning-stock biomass of *S. mentella* estimated by the SCAA model for runs up to years 2007–2017 and the baseline model of the 2018 benchmark. The lower panel presents the baseline model with fixed weights-at-age and the assessment models for 2020 and 2021. Confidence Intervals are shown for the latest assessment.

7 Northeast Arctic golden redfish[1]

The advice cycle for golden redfish in subareas 1 and 2 is biennial, following the recommendation of the benchmark assessment for redfish stocks in January 2018 (WKREDFISH, ICES 2018a). Advice was last given in 2020. The age-based GADGET model was then run for the period 1990-2019, in the configuration approved during the benchmark. The present report therefore updates the assessment and provides advice for the next two years.

7.1 Status of the fisheries

7.1.1 Recent regulations of the fishery

A description of the historical development of the fishery and regulations is found in the Stock Annex for this stock. The Stock Annex was last updated in February 2018.

Prior to 1 January 2003 there were no regulations particularly for the *S. norvegicus* fishery, and the regulations aimed at *S. mentella* had only marginal effects on the *S. norvegicus* stock. After this date, all directed trawl fishery for redfish (both *S. norvegicus* and *S. mentella*) outside the permanently closed areas were forbidden in the Norwegian Economic Zone north of 62°N and in the Svalbard area. When fishing for other species it was legal to have up to 15% redfish (both species together) in round weight as bycatch per haul and onboard at any time. Until 14 April 2004, there were no regulations of the other gears/fleets fishing for *S. norvegicus*. After this date, a minimum legal catch size of 32 cm has been set for all fisheries, with the allowance to have up to 10% undersized (i.e. less than 32 cm) specimens of *S. norvegicus* (s) per haul. In addition, a time-limited moratorium (up to 8 months) was enforced in the conventional fisheries (gillnet, longline, handline, Danish seine) except for handline vessels less than 11 metres. From 2016, when trawling outside 12 nm, vessels can have up to 20% by weight of redfish in each catch and upon landing. When trawling inside 12 nm, it is permitted to have up to 10% bycatch. Since 2015 it has been prohibited to fish for redfish with conventional gears north of 62°N. The ban does not, however, apply to vessels less than 15 metres fishing with handline from 1 June to 31 August. When fishing with conventional gears for other species, it is permitted to have up to 10% by weight of redfish. Vessels less than 21 metres can still have up to 30% by weight of redfish in the period 1 August to 31 December. Bycatch of redfish is calculated in live weight per week.

7.1.2 Landings prior to 2022 (Tables 7.1–7.4 and Figures 7.1–7.3)

Nominal catches of *S. norvegicus* for the years 1998–2021 by country for subareas 1 and 2 combined, and for each subarea and division are presented in Tables 7.1–7.4. The total landings for both *S. norvegicus* and *S. mentella* are presented in section 6 (Tables 6.6 and 6.7). The sources of information used are catches reported to ICES, NEAFC, Norwegian and Russian authorities (foreign vessels fishing in these countries' economic zone) or direct reporting to the AFWG. Where catches are reported as *Sebastes sp*., they are split into *S. norvegicus* and *S. mentella* by AFWG experts based on available correlation between official catches of these two species in the considered areas. Landings of *S. norvegicus* showed a decrease from a level of 23 000–30 000 t in 1984–1990 to a stable level of about 16 000–19 000 t in the years 1991–1999. Then the landings decreased further, and the total landings figures for *S. norvegicus* in 2003–2013 were low but remarkably

[1] Golden redfish (*Sebastes norvegicus*) in subareas 1 and 2 (Northeast Arctic); reg.27.1-2.

stable, between 5500–8000 t. In 2014 the landings decreased to 4825 t, followed by a further decrease in 2015 with landings of 3873 t, mainly due to stronger regulations. This has since reversed with 8559 tonnes in 2019, 9644 tonnes in 2020 and 10 193 tonnes in 2021 (provisional). This increase is likely due to the increased quota for beaked redfish and thereby increased bycatch of golden redfish. The time-series of *S. norvegicus* landings is given in Figure 7.1. A map of *S. norvegicus* catches from Norwegian vessels' logbooks in 2020 is shown in Figure 7.2. Note that species identification from landings and logbooks is not always trusted when the Norwegian final landings data are prepared (see Stock Annex).

The Norwegian landings are presented by gear and month/year in figures 7.3a,b. Reported landings were at the lowest level since World War II in 2015. Since 2015 only bycatches of *S. norvegicus* are allowed except for a limited amount caught by vessels less than 15 metres fishing with handline from 1 June to 31 August. The increase in landings since 2015 is due to increased bycatch in trawl.

The reported Russian catches of *S. norvegicus* have been around 600–900 t since 2001, but from 2017 onwards the catches increased steadily to a maximum of 2615 tonnes in 2020 and then decreasing again to 1737 tonnes in 2021 Twelve other countries together usually report catches in the 300–500 t range or less (Table 7.1).

The bycatch of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during the period 1983–2017 were dominated by *S. mentella*, and hence influenced the *S. norvegicus* to a much lesser extent. However, these bycatches probably inflicted extra mortality on *S. norvegicus* in the coastal areas before the sorting grid was enforced in 1990. From 1 January 2006, the maximum legal bycatch of redfish juveniles in the international shrimp fisheries in the northeast Arctic has been reduced from ten to three redfish per 10 kg shrimp.

Information describing the splitting of the redfish landings by species and area is given in the Stock Annex.

7.1.3 Expected landings in 2022

New regulations were designed and implemented in the Norwegian coastal fisheries with conventional gears in 2016. No directed fishery is allowed, but the bycatch–regulations are currently rather liberal with vessels less than 21 metres being allowed to have up to 30% by weight of redfish in the period 1 August–31 December. The bycatch is calculated in live weight per week.

As expected, total landings in 2021 increased due to the raised quota for *S. mentella*, and thus an increase in bycatch of *S. norvegicus*. The quota for *S. mentella* in 2021 was not fully exhausted but catches increased by about 10 000 t compared to the previous year. With an even higher *S. mentella* quota for 2022, the increase in bycatch of *S. norvegicus* is expected to continue in 2022.

7.2 Data used in the assessment (Table 0.1 and Figure E1)

An example of the sampling levels (by season, area and gear) of the data used in the assessment is presented in Figure E1 for 2013. Although Table 0.1 (see Section 0) shows a reasonably good total sampling level for this stock, the number of different boats sampled, and the gear and area coverage should be improved.

7.2.1 Catch–at–length and age (Table 7.5 and Figure 7.4)

The method previously used for calculating catch–at–length and age of Norwegian catches can no longer be used and the procedure was intended to use the new StoX-Reca software. However, this ran into problems with the bimodal growth pattern exhibited by golden redfish and the large number of length-samples compared with age-samples. Therefore, it was decided to fall back onto the workaround used in the 2020 assessment for catch-at-length and to use the age data from StoX-Reca for 2018 onwards with ages 30+, at which most of the differences occurred, set to missing. Work on the StoX-Reca method will continue towards the benchmark in 2024.

Age composition data were only provided by Norway in the latest years. Other countries were assumed to have the same relative age distribution and mean weight as Norway. The catch numbers-at-age matrix is shown in Table 7.5. Catch at length data were also only available from Norway (Figure 7.4).

7.2.2 Catch weight–at–age (Table 7.6)

Weight–at–age data for ages 7–24+ from Norwegian catches were estimated using StoX-Reca starting with the 2018-catches (Table 7.6). For 2021 weight-at-age-data was not available during the working group, due to a lack of age data from that year. Variations in the weight–at–age of young individuals (< 10 years) must be considered with caution as these numbers are derived from only a small number of aged individuals.

7.2.3 Maturity–at–age (Table E1, Figure 7.5a–b)

A maturity ogive has previously not been available for *S. norvegicus*, and knife-edge maturity–at–age 15 (age 15 as 100% mature) had hence been assumed. Maturity–at–age and length is available from Norwegian surveys and landings up to 2019, as reported in Table E1 and presented in Figure 7.5a. Only the data up to 2018 was considered in the model, due to insufficient age readings in the later years. The maturity ogive modelled by Gadget is presented (Figure 7.5b). This analysis shows that 50% of the fish at age 12 are mature.

7.2.4 Survey results (Tables E2a,b–E3a,b–E4, Figures 7.6a,b–7.8)

Results from the following research vessel survey series are available for *S. norvegicus*:

Joint Norwegian–Russian Barents Sea winter bottom–trawl survey (A6996 BS–NoRu–Q1 BTr) from 1986 to 2022 in fishing depths of 100–500 m. Length compositions for the years 1986–2022 are shown in Table E2a and Figure 7.6a. Age compositions for the years 1992–2016, 2018 and 2019 are shown in Table E2b and Figure 7.6b. This survey covers important nursery areas for the stock. As described in the stock annex, this survey is used in model tuning.

Norwegian Svalbard (Division 2.b) bottom–trawl survey (August–September) from 1985 to 2020 in fishing depths of 100–500 m (depths down to 800 m incl. in the swept–area). Since 2005 this is part of the Joint Norwegian–Russian Barents Sea Ecosystem survey (A6996 Eco–NoRu–Q3 BTr). Length compositions for the years 1985–2021 and age compositions for the years 1992–2008, 2012, 2013, 2016 and 2018 are shown in Table E3a and E3b, respectively. This survey covers the northernmost part of the species' distribution. Missing age compositions are due to insufficient number of age readings or too few age samples. This survey is not currently included in the model tuning.

Data on length and age from winter and ecosystem surveys have been combined and are shown in Figures 7.7a–b.

Norwegian Coastal and Fjord survey in 1998–2020 from Finnmark to Møre (NOcoast–Aco–Q4). Length composition from catch rates (numbers/nm^2 averaged for all stations within subareas and finally averaged, weighted by subarea, for the total surveyed area) are shown in Figure 7.8 and

Table E4. The survey is an acoustic survey designed to obtain indices of abundance and estimates of length and weight–at–age of saithe and coastal cod north of 62°N. The index for golden redfish was previously used in the assessment, but was considered unreliable and stopped in 2010. A new index series was recalculated for the benchmark in 2018 (WKREDFISH 2018a). The aggregated survey index varied too much year–to–year to be driven by the population dynamics, but the length distribution was included in the assessment.

SToX versions of winter and ecosystem surveys are used since AFWG 2020. The group recommended that work continues to investigate redfish–specific strata systems for the winter survey and continued monitoring whether the distribution of redfish shifts outside the strata system used for the ecosystem survey. The coastal survey for *S. norvegicus* is in the process of conversion to StoX and adoption of a species-specific strata system, aiming to establish a coherent index of abundance and/or biomass can be obtained for this survey (which is currently only used for annual length distributions).

The bottom–trawl surveys covering the Barents Sea and the Svalbard areas show that the abundance indices over the commercial size range (> 25 cm) were relatively stable up to 1998 but declined to lower levels afterwards. Abundance of pre–recruits (< 25 cm) has steadily decreased since 1991 and has dropped to very low levels after 2000 (Figure 7.6a). An increase in the number of pre–recruits is visible from 2008 onwards. Although this could partly result from taxonomic misidentification, the confirmation of increased numbers for individuals of size 15 cm and greater gives some confidence that at least some of the increasing numbers are *S. norvegicus*.

7.3 Assessment with the Gadget model

7.3.1 Description of the model

Since AFWG2005, the GADGET model has been used for this stock, first with experimental runs, and then as analytical assessments following its adoption by WKRED (2012) benchmark (ICES CM 2012/ACOM:48). The model was then approved again at WKREDFISH (2018a), where it was also recommended to switch to a two–year advice cycle. A number of changes have been made to the model at the benchmark WKREDFISH (2018a); the model is moved to a one–year time–step; the fleet structure has been revised to better reflect recent fishing patterns; age–length data are used for tuning in 5 cm (rather than the previous 1 cm) bins to reduce the extensive noise in this series; proportions (but not absolute abundance) by length in the coastal survey is used for tuning; the model weights have been recalculated; a number of minor errors in the model and data were fixed. Full details are in the WKREDFISH benchmark report (ICES 2018a).

The GADGET model used for the assessment of *S. norvegicus* in subareas 1 and 2 is closely related to the GADGET model that currently is used by the ICES Northwestern WG on *S. norvegicus* (Björnsson and Sigurdsson, 2003). The functioning of a Gadget model, including parameter estimation and data used for tuning, is described in Bogstad *et al.* (2004) and in the stock annex for *S. norvegicus*. In brief, the model is a single species forward simulation age–length structured model, split into mature and immature components. There are three commercial fleets (a gillnet, a trawl and a combined longline and handline fleet). Prior to 2009 the trawl and longline fleets are combined into one, due to difficulties in obtaining data on a finer resolution. The gillfleet has different selectivity from 2009 compared to 2008 and earlier. There are two surveys used in the model, winter survey and coastal survey. Winter survey tunes to total survey index, the coastal survey to length distributions only. Growth and fishing selectivity within each fleet and survey are assumed constant over time (except for the gilfleet), and recruitment is estimated on annual basis (no SSB–recruit relationship).

The weighting scheme for combining the different datasets into a single likelihood score is a method where weights are selected so that the catch and survey data have approximately equal contribution to the overall likelihood score in the optimized model, and that each dataset within each group gives approximately equal contributions to each other. This ensures that both noise and bias (actually divergence from the consensus) are taken into account in the weighting of datasets. The parameters in the model are estimated using a combination of Simulated Annealing (wide-area search) and Hooke and Jeeves (local search) repeated in sequence until a converged solution is found.

7.3.2 Data used for tuning

- Annual catch in tonnes from the commercial fishing fleets, i.e. Norwegian gillnet, and trawl fleet, longline since 2009 and "combined trawl and longline" prior to 2009.
- Annual length distribution of total international commercial landings from the commercial fishing fleets to 2021. Due to late data submissions, there is one–year time–lag in the inclusion of length distributions from other countries than Norway.
- Annual age–length data (1 year by 5 cm resolution) from the same fishing fleets, up to 2020. In the last three years (2018-2020) ages above 29 were excluded due to changes in age reading which particularly affected the proportion of fish aged 30+.
- Length disaggregated frequencies from the Barents Sea (Division 2.a) bottom–trawl survey (February) from 1990–2022 (Table E1a).
- Age–length data and aggregated survey indices from the same survey up to 2019, excluding 2017 (Table E1b).
- Length disaggregated frequencies from the Barents Sea (Division 2.a) coastal survey (February) from 1998–2021 (Table E3, Figure 7.8).

7.3.3 Assessment results using the Gadget model (Figures 7.9–7.13)

The general patterns in the stock dynamics of *S. norvegicus* are similar to those modelled for the past several years, but the recruitment event in 2003 is now beginning to have a noticeable positive effect on the overall stock. The overall stock numbers and biomass have shown a decline over a number of years, but the recent recruitment means that immature and total numbers as well as immature biomass are improving. By now some of the 2003 year class are mature, and the mature stock numbers are therefore stabilizing. The mature biomass is not responding yet, since the maturing fish are still relatively small.

As in previous years, we note that there has been a tendency for some recruitment signal to be reduced in subsequent years, possibly due to misidentification of small *S. mentella* (which is a larger stock and has had good recent recruitment) as *S. norvegicus*, and the model has repeatedly revised down the estimates of this recruitment, although not to zero. The largest fish from the 2003 year class are now entering the mature stock and the fishery, and this is providing multiple sources of information that this was a genuinely good recruitment. The WG stresses that the subsequent recruitment signals (for example the high estimated 2009 year class) should still be treated with extreme caution until they enter the fishery (c. 12–15 years after recruiting).

The most important conclusions to be drawn from the current assessment using the Gadget model are:

- The recruitment to the stock has been very poor for a long period, and especially prior to 2005 (Figure 7.10).
- There has been somewhat better-estimated recruitment in recent years, with a reasonably good recruitment in 2003 (Figure 7.13). Indications of a second pulse of good recruitment

in 2009 have strengthened in the current assessment, but are still highly uncertain, and will need to be tracked for some years to come, to reduce this uncertainty.

- The estimated fishing mortality (F_{15+}) declined between 1990 and 2005 but remained relatively stable until around 2015, (Figure 7.11, Table 7.7). The current mortality is estimated to F = 0.41 (Figure 7.11), well above a sustainable level for a redfish species, and above the F_{MSY} = 0.05 estimated at WKREDFISH (ICES 2018a). Note that the F estimate is based on the 2003 year class being a good one, and the estimate would be higher if this is not the case.

According to the model the total–stock biomass (3+) of *S. norvegicus* has decreased from about 119 000 tonnes in the early 1990s to just under 50 000 tonnes in 2021 (Figure 7.12, Table 7.8). Due to the improved recruitment from the 2003 year class, the total biomass is beginning to stabilize, although the SSB is continuing to decline. This reduction is primarily the result of prolonged low recruitment, combined with excessively high fishing pressure.

The average assessment bias (Mohn's Rho) over the last 5 assessments was 1% for recruitment, 56% for F(15+) and –29% for SSB. The retrospective plots (Figure 7.13) exhibit a sharp rise in the estimate of mature biomass compared to earlier assessments and a corresponding decline in F(15+). This can partially be explained by a change in the method of splitting the catch between beaked and golden redfish. However, also in earlier years the retrospectives exhibited a rise in mature biomass for which the reason is unclear and will have to be monitored.

7.3.4 State of the stock

Survey observations and the Gadget assessment update confirm previous diagnostics that this stock is currently in a very poor situation. This is confirmed by the production model run as a check at WKRED (ICES 2012) and for the 2020 red list evaluation, which produced similar trends. Indications are that the SSB is continuing to fall. This has led to an upwards trend in F to a level that may place an increasing burden on an already poorly performing stock. Furthermore, in the absence of a substantial population of fish in the 10 to 18 age range, the fishery has become increasingly concentrated on the oldest (18 years and older) individuals, reducing the reproductive capacity of the stock.

There are indications that new recruits from the 2003 year class may have entered the population in recent years as noted in previous AFWG reports. The estimated immature biomass is now beginning to increase, but SSB still declines. However, the total level of this recruitment is still uncertain, and although the 2003 year class is estimated to have been the best since the late 1990s, it is not the largest year class seen in the time–series. Consequently, any rebuilding from this year class is likely to be slow. Rebuilding of this stock is therefore dependent on protecting both the existing SSB and any fish recruiting to it. Note that there are significant uncertainties from misidentification between the redfish species in the Barents Sea, and thus the exact values of both stock and F are uncertain, although the trends are clearly defined.

S. norvegicus is currently on the Norwegian Redlist as a threatened (EN) species according to the criteria given by the International Union for Conservation of Nature (IUCN).

Red–listing is understood to mean that a species (or stock) is at risk of extinction. ICES convened two workshops in 2009. The first Workshop WKPOOR1 (ICES CM 2009/ACOM:29) addressed methods for evaluating extinction risk and outlined approaches that could support advice on how to avoid potential extinction. The second Workshop WKPOOR2 (ICES CM 2009/ACOM:49) applied the results of the first workshop to four stocks selected as being of interest to Norway and ICES.

There are three general methods for evaluating extinction risk: (1) screening methods, such as the IUCN redlisting criteria; (2) simple population viability analysis (PVA) based on time–trends; and (3) age-structured population viability analysis. None of the methods are considered reliable for accurately estimating the absolute probability of extinction, but they may be useful to evaluate the relative probability of extinction between species or between management options.

The fishery is largely concentrated on mature individuals. With a currently estimated SSB of below 30 000 tonnes and a F_{MSY} of 0.05, one would expect a sustainable catch to be in the order of 1000 to 1500 tonnes. The current catches are about ten times as much.

7.3.5 Biological reference points

Reference point calculations were conducted at WKREDFISH benchmark (2018a), based on a B_{LOSS} with reasonable recruitment, and a forecast with constant recruitment to produce an F_{MSY} candidate. Note that the benchmark used preliminary data and that the results presented here are slightly changed from those at WKREDFISH (2018). We, therefore, follow the methodology presented at WKREDFISH (2018a) but adjust the B_{lim} based on the revised SSB estimate for 2002. This has the effect of raising the proposed B_{lim} from 44 000 tonnes to 49 000 tonnes. The F_{MSY} calculations are unaffected, as these are based on steady-state forecasts.

No stock–recruitment relationship is presented for this stock. Within the model, recruitment is modelled as an annual recruitment value with no relationship with the SSB.

- B_{lim}: B_{lim} is based on the Lowest Observed Stock Size at which reasonable recruitment was observed. This is assumed to be the 2003 year class, at which time the SSB is estimated to be 49 000 tonnes (or 44 000 tonnes using the benchmark values)
- B_{pa}: Using the ICES default multiplier of 1.4 for B_{pa} gives a B_{pa} value of 68 600 tonnes (61 000 tonnes using the benchmark values)

The stock is currently well below the biomass limit reference point, and thus F_{MSY} is not recommended as the current fishing level. However, it was considered useful to try to estimate a candidate F_{MSY} reference point, which can be used to compare against management performance. Using yield–per–recruit analysis WKREDFISH (2018a) proposes $F_{0.1}$(15+), estimated to be 0.0525, as a candidate F_{MSY} (Figure E2).

Given the poor state of this stock, management should be based on the need to protect and recover the stock, not on F_{MSY}.

7.3.6 Management advice

AFWG considers that the stock is severely depleted. There are signs that recruitment in 2003 is now beginning to stabilize the population and, for the immature fish, improve the stock status. However, the stock remains in a poor state, and as of now, there are only weak indications that the mature stock is improving. AFWG, therefore, recommends that current area closures and low bycatch limits should be maintained. No directed fishery should be conducted on this stock at the moment, and the percent legal bycatch should be set as low as possible for other fisheries to continue. There will be no directed fishery for *S. norvegicus* in 2022. It is critical that the bycatch regulations do not allow the catch to increase, as this would impair prospects for recovery.

7.3.7 Implementing the ICES F_{MSY} framework

As a long-lived species, *S. norvegicus* has many year classes contributing to the population, and consequently a relatively stable stock level from year–to year. This makes it relatively simple to manage to some proxy of MSY (e.g. F0.1) once the biomass has reached close to B_{MSY}, provided adequate measures can be implemented to reduce fishing pressure to an appropriate level. It should be noted that the current fishery is well above the preliminary F_{MSY} for the stock. The main focus should therefore be on reducing total F. The current priority is to stabilize the stock and prevent further decline and allow the recruiting 2003 year class to grow and reproduce. Only then could a recovery strategy and eventually an MSY fishery be implemented. The recent upturn in immature biomass gives some hope that such recovery may be possible, given low fishing pressure.

7.4 Tables and figures

Table 7.1. *S. norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1 and divisions 2.a and 2.b combined.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	–	78	494	131	33	–	19	–	–	16540	–	6	1632	51	171	19155
1999	–	35	35	228	47	14	7	–	–	16750	–	3	1691	7	169	18986
2000	–	17	13	160	22	16	–	–	–	13032	–	16	1112	–	73	14461
2001	–	37	30	238	17	–	1	–	–	9134	–	7	963	1	119	10547
2002	–	60	31	42	31	3	–	–	–	8561	–	34	832	3	46	9643
2003	–	109	8	122	36	4	–	–	89	6853	–	6	479	–	134	7840
2004	–	19	4	68	20	30	–	–	33	6233	–	5	722	3	69	7206
2005	–	47	10	72	36	8	–	–	48	6085	–	56	614	8	52	7036
2006	–	111	8	35	44	31	3	–	21	6305	–	69	713	9	39	7388
2007	–	146	15	67	84	68	13	–	20	5784	–	225	890	5	55	7372
2008	–	274	63	30	71	27	6	–	2	5216	–	72	749	4	85	6599
2009	–	70	1	58	81	66	–	–	1	5451	–	30	698	–	31	6487
2010	–	171	51	31	72	22	–	–	–	5994	1	28	565	3	44	6981
2011	–	24	53	9	51	22	–	–	1	4681	48	25	919	6	13	5852

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
2012	–	87	182	71	58	23	12	–	5	4247	34	17	681	–	100	5517
2013	1	83	353	1	45	8	1	–	–	3836	19	36	797	–	493	5673
2014	–	67	219	6	20	29	–	–	1	3440	21	5	806	–	211	4825
2015	1	76	53	24	211	35	–	–	–	2733	17	–	664	2	57	3873
2016	7	183	30	4	87	55	–	–	–	4131	26	–	864	–	76	5463
2017	–	123	17	19	61	65	–	–	2	3567	27	90	1297	44	160	5472
2018	1	146	37	66	77	67	–	–	–	4961	36	67	1834	12	37	7341
2019	–	236	25	93	56	83	–	3	–	5951	20	73	1929	65	25	8559
2020[1]	–	166	1	88	99	52	–	–	–	6503	9	86	2615	6	19	9644
2021[1]	2	323	6	76	92	72	–	–	–	7701	20	60	1737	8	96	10193

1 – Provisional figures.

Table 7.2. *S. norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	78	–	5	–	–	–	–	2109	–	–	308	–	30	**2530**
1999	35	–	18	9	14	–	–	2114	–	–	360	–	11	**2561**
2000	–	–	1	–	16	–	–	1983	–	–	146	–	12	**2158**
2001	4	–	11	–	–	–	–	1053	–	–	128	–	16	**1212**
2002	15	1	5	–	–	–	–	693	–	–	220	–	9	**943**
2003	15	–	–	1	–	–	–	815	–	–	140	–	4	**975**
2004	7	–	–	–	–	–	–	1237	–	–	213	–	12	**1469**
2005	10	1	–	–	–	–	–	1002	–	–	61	–	4	**1078**
2006	46	–	–	–	–	–	–	690	–	–	136	–	–	**872**
2007	15	–	12	15	–	–	–	1034	–	–	49	2	20	**1147**
2008	45	7	2	–		–	–	634	–	3	49	–	15	**755**
2009	–	–	3	2	6	–	–	701	–	30	19	–	24	**768**
2010	58	–	–	–	–	–	–	497	–	–	21	1	6	**583**
2011	24	–	–	2	1	–	–	674	–	–	7	–	–	**708**
2012	17	–	3	1	9	2	–	546	–	–	27	–	18	**623**

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2013	28	2	1	–	+	–	–	563	–	–	41	–	4	**639**
2014	59	10	6	17	4	–	–	573	2	–	26	–	17	**714**
2015	57	4	9	211	13	–	–	624	2	–	51	2	10	**983**
2016	161	7	4	74	51	–	–	1152	4	–	136	–	60	**1649**
2017	81	5	–	8	4	–	–	970	2	2	211	2	23	**1308**
2018	146	28	35	29	–	–	–	1151	5	3	302	5	25	**1729**
2019	220	10	32	22	30	–	2	1104	4	1	422	3	10	**1860**
2020	143	–	14	18	33	–	–	1284	2	8	708	6	1	**2217**
2021[1]	296	–	–	54	15	–	–	1445	–	12	305	–	–	**2127**

1 – Provisional figures.

+ denotes less than 0.5 tonnes.

Table 7.3 *S. norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.a.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherland	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	–	494	116	33		19	–	14326	–	6	1078	51	137	16260
1999	–	35	210	38		7	–	14598	–	3	976	7	156	16030
2000	17	13	159	22		–	–	11038	–	16	658	–	61	11984
2001	33	30	227	17		1	–	8002	–	6	612	1	103	9032
2002	45	30	37	31	3	–	–	7761	–	18	192	2	32	8151
2003	94	9	122	35	4	–	89	5970	–	6	264		130	6723
2004	12	4	68	20	30	–	33	4872	–	5	396	3	58	5501
2005	37	9	60	36	8	–	48	4855	–	56	265	8	48	5430
2006	60	8	35	44	31	3	21	4404	–	59	293	9	39	5006
2007	119	15	55	69	68	13	20	4101	–	70	599	3	35	5167
2008	229	56	28	71	27	6	2	4456	–	68	450	4	70	5467
2009	70	1	55	79	60	–	1	4543	–	17	500	–	7	5333
2010	113	51	31	72	22	–	–	5414	1	26	287	2	38	6057
2011	–	51	9	49	20	–	1	3942	–	–	695	2	13	4782
2012	49	182	33	57	13	2	2	3599	–	1	427	–	33	4398

Year	**Faroe Islands**	**France**	**Germany**	**Greenland**	**Iceland**	**Ireland**	**Netherland**	**Norway**	**Poland**	**Portugal**	**Russia**	**Spain**	**UK**		**Total**
2013	55	343	–	45	8	–	–	3170	–	9	475	–	466	**Denmark** – 1	4572
2014	8	209	–	3	25	–	1	2732	–	2	559	–	178		3717
2015	18	49	15	–	22	–	–	2081	12	–	439	–	47		2683
2016	22	23	–	13	4	–	–	2946	8	–	545	–	15		3576
2017	41	12	19	36	61	–	2	2549	22	88	680	38	137		3685
2018	–	9	17	43	67	–	–	3746	12	64	489	7	12	**–**	4466
2019	16	14	61	34	53	–	–	4744	16	72	794	61	14	**Lithuania – 1**	5880
2020[1]	23	1	61	81	19	–	–	4838	–	78	946	–	16		6063
2021[1]	24	5	21	36	57	–	–	5680	–	48	1073	2	90		7036

1 – Provisional figures.

Table 7.4 *S. norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.b.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998	–	–	–	10	–				105	–	–	246	–	3	364
1999	–	–	–	–	–				38	–	–	355	–	2	395
2000	–	–	–	–	–				10	–	–	308	–	–	318
2001	–	–	–	–	–				79	–	1	223	–	–	303
2002	–	–	–	–	–				107	–	16	420	1	5	549
2003	–	–	–	–	–				68	–	–	75	–	–	143
2004	–	–	–	–	–				124	–	–	113	–	–	237
2005	–	–	–	13	–				228	–	–	288	–	–	529
2006	–	5	–	–	–				1211	–	10	284	–	–	1510
2007	–	12	–	–	–				649	–	155	242	–	–	1058
2008	–	–	–	–	–				126	–	1	250	–	–	377
2009	–	–	–	–	–				207	–	–	179	–	–	386
2010	–	–	–	–	–				83	–	2	257	–	–	342
2011	–	–	2	–	–	1	–	–	65	48	25	217	4	–	362
2012	–	21	–	35	–	1	8	3	102	34	16	227	–	49	496

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
2013	–	–	9	–	–	–	1	–	102	19	27	281	–	23	462
2014	–	–	–	–	–	–	–	–	135	19	3	221	–	16	394
2015	1	–	–	–	–	–	–	–	28	3	–	175	–	–	207
2016	7	–	–	–	–	–	–	–	34	14	–	183	–	–	238
2017	–	–	–	–	18	–	–	–	48	2	–	405	4	–	477
2018	1	–	–	14	6	–	–	–	64	19	–	1043	–	–	1147
2019	–	–	–	–	–	–	–	–	103	–	–	712	1	1	817
2020	–	–	–	13	–	–	–	–	381	7	–	961	–	3	1365
2021[1]	2	3	+	55	2	–	–	–	576	20	–	359	6	6	1030

1 – Provisional figures.

+ denotes less than 0.5 tonnes.

Table 7.5. *S. norvegicus* in subareas 1 and 2. Catch numbers-at-age (in thousands). Since 2018, numbers are from StoX-Reca.

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
1992	5	22	78	114	394	549	783	1718	3102	2495	2104	1837	998	858	688	547	268	3110	19670	16185
1993	0	24	193	359	406	1036	1022	1523	2353	1410	1655	1678	745	716	534	528	576	3482	18240	16651

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
1994	46	7	292	640	816	1930	2096	2030	1601	2725	2668	1409	617	733	514	256	177	1508	20065	18120
1995	60	85	230	672	908	1610	2038	2295	1783	1406	785	563	670	593	419	368	250	3232	17967	15616
1996	9	119	313	361	879	1234	1638	2134	1675	1614	1390	952	679	439	560	334	490	3135	17955	18043
1997	9	98	156	321	686	1065	1781	2276	2172	1848	1421	851	804	608	511	205	334	2131	17277	17511
1998	28	51	206	470	721	968	1512	1736	1582	1045	1277	970	1018	846	443	764	486	3389	17512	19155
1999	78	593	855	572	1006	1230	1618	1480	1612	1239	1407	1558	1019	394	197	459	174	2131	17622	18986
2000	4	13	70	245	902	958	1782	1409	2121	2203	1715	753	483	458	132	230	224	895	14597	14460
2001	23	23	44	199	347	482	1120	1342	1674	1653	1243	568	119	183	154	112	135	254	9675	10547
2002	14	36	71	143	414	686	1199	1943	1377	1274	1196	388	313	99	104	117	113	253	9740	9643
2003	22	25	30	44	204	359	705	1687	1338	1071	937	481	367	146	84	51	18	69	7637	7841
2004	19	47	46	65	198	277	504	590	677	963	1059	787	436	169	183	108	79	186	6390	7320
2005	40	55	94	80	165	173	393	779	741	916	926	743	376	210	189	129	111	220	6338	7037
2006	45	32	56	70	245	204	201	809	549	779	794	747	496	332	310	188	165	397	6419	7348
2007	15	21	31	68	138	306	448	495	523	637	892	616	510	396	225	322	170	630	6443	7306
2008	1	4	14	12	49	139	265	366	361	443	442	538	547	479	281	223	144	1032	5342	6557
2009	0	11	2	4	9	23	144	277	315	248	406	374	509	404	331	323	253	911	4544	6487
2010	1	0	10	7	4	20	75	261	291	529	359	311	531	502	385	295	247	776	4605	6982
2011	2	1	3	0	2	5	64	304	466	266	312	223	378	289	247	229	253	985	4028	5852

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
2012	15	10	5	12	0	2	228	226	322	295	191	169	184	283	266	268	262	1152	3891	5517
2013	31	88	138	57	10	44	58	202	241	437	321	205	213	270	258	196	322	1216	4309	5608
2014	5	4	8	8	8	15	26	49	67	204	197	148	167	184	165	156	213	1197	2821	4438
2015	15	16	14	17	26	43	29	96	113	128	170	147	159	115	99	96	220	1156	2661	3628
2016	53	59	60	88	88	147	293	217	266	81	178	176	110	162	110	182	191	1103	3563	4674
2017	106	82	132	69	132	165	311	455	225	132	105	83	85	102	88	138	182	1169	3760	5257
2018	129	65	230	443	246	496	158	170	236	171	145	183	194	232	233	229	249	2425	6235	7341
2019	36	98	169	130	318	635	356	282	96	123	71	99	67	57	145	129	93	2159	5064	5951
2020	26	14	108	439	472	580	651	324	190	153	55	62	126	49	112	98	90	1751	5302	6503

Table 7.6. *S. norvegicus* in subareas 1 and 2. Catch weights at age (kg). Since 2018, numbers are from StoX-Reca.

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
1992	0.18	0.29	0.48	0.42	0.50	0.59	0.58	0.65	0.65	0.71	0.82	0.84	0.94	1.02	1.03	1.15	1.27	1.27
1993	0.2	0.33	0.36	0.43	0.51	0.51	0.64	0.64	0.76	0.86	0.89	0.98	1	1.03	1.21	1.03	1.2	1.14
1994	0.25	0.37	0.38	0.49	0.51	0.64	0.74	0.76	0.86	0.95	1.03	1.07	1.11	1.16	1.15	1.13	1.02	1.36
1995	0.33	0.43	0.64	0.61	0.59	0.65	0.74	0.79	0.84	0.92	1.12	1.01	1.01	1.21	1.14	1.09	1.3	1.01
1996	0.22	0.49	0.56	0.65	0.71	0.81	0.84	0.88	0.96	1	1.02	1.01	1	1.03	1.04	1.14	1.09	1.16
1997	0.23	0.51	0.53	0.74	0.72	0.78	0.8	0.86	0.91	0.99	1.16	1.18	1.21	1.34	1.28	1.54	1.19	1.29
1998	0.37	0.21	0.47	0.62	0.67	0.77	0.77	0.85	1.05	0.96	1.25	1.28	1.3	1.23	1.87	1.46	1.73	1.29

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
1999	0.14	0.26	0.44	0.57	0.69	0.78	0.86	1.04	1.07	1.12	1.18	1.71	1.09	1.18	1.04	1.34	1.18	1.34
2000	0.19	0.24	0.32	0.44	0.53	0.64	0.73	0.84	0.96	1.11	1.25	1.32	1.53	1.06	1.29	1.32	1.12	1.2
2001	0.15	0.26	0.45	0.55	0.58	0.67	0.8	0.89	1.01	1.14	1.33	1.43	1.62	1.6	1.47	2	2.7	2.31
2002	0.17	0.25	0.33	0.42	0.54	0.67	0.72	0.84	0.98	1.09	1.2	1.3	1.44	1.78	1.68	1.88	2.12	1.84
2003	0.19	0.22	0.31	0.39	0.49	0.58	0.69	0.84	0.96	1.05	1.29	1.36	1.65	1.74	2.09	1.85	2.3	2.38
2004	0.21	0.26	0.36	0.45	0.51	0.59	0.68	0.8	0.96	1.07	1.22	1.34	1.57	1.67	1.75	2.09	1.9	2.04
2005	0.16	0.21	0.36	0.45	0.52	0.58	0.68	0.82	0.94	1.03	1.16	1.36	1.46	1.51	1.67	1.91	2.23	2.27
2006	0.13	0.15	0.28	0.41	0.51	0.58	0.66	0.74	0.83	1	1.14	1.27	1.39	1.46	1.37	1.47	1.64	2.03
2007	0.15	0.21	0.33	0.39	0.5	0.59	0.65	0.77	0.9	1	1.09	1.27	1.42	1.32	1.53	1.47	1.69	1.81
2008	0.41	0.55	0.55	0.57	0.52	0.58	0.65	0.81	0.9	1.07	1.14	1.36	1.51	1.81	1.99	2.01	2.26	1.93
2009	0.00	1.01	0.34	0.59	0.61	0.66	0.82	0.92	0.94	1.09	1.22	1.35	1.40	1.57	1.68	1.74	1.73	2.25
2010	0.15	0.00	0.10	0.32	0.52	0.73	0.77	0.89	0.98	1.09	1.25	1.40	1.48	1.64	1.77	1.99	1.82	1.86
2011	0.16	0.20	0.21	0.00	0.54	0.52	0.72	0.91	1.08	1.14	1.20	1.45	1.40	1.43	1.54	1.60	1.74	1.93
2012	0.19	0.25	0.33	0.72	0.61	0.88	0.70	0.86	0.95	1.02	1.13	1.18	1.33	1.48	1.31	1.55	1.50	2.59
2013	0.20	0.27	0.32	0.44	0.47	0.55	0.63	0.88	0.96	1.08	1.08	1.19	1.21	1.39	1.38	1.62	1.41	1.81
2014	0.20	0.26	0.39	0.41	0.56	0.61	0.71	0.87	0.95	1.07	1.14	1.28	1.46	1.35	1.51	1.62	1.69	1.84
2015	0.16	0.22	0.30	0.50	0.51	0.60	0.66	0.88	0.93	1.04	1.15	1.18	1.23	1.34	1.51	1.50	1.48	1.62
2016	0.17	0.21	0.34	0.62	0.53	0.66	0.68	0.86	0.94	1.03	1.11	1.32	1.43	1.29	1.42	1.43	1.48	2.67

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
2017	0.18	0.23	0.29	0.38	0.55	0.59	0.70	0.80	0.92	1.06	1.15	1.35	1.40	1.56	1.37	1.74	1.83	2.92
2018	0.75	0.76	0.80	0.86	0.92	1.00	1.04	1.06	1.15	1.23	1.24	1.27	1.35	1.40	1.43	1.50	1.48	2.34
2019	0.93	0.98	1.07	1.12	1.20	1.26	1.28	1.34	1.38	1.33	1.36	1.43	1.44	1.45	1.43	1.50	1.48	1.95
2020[1]	1.71	1.13	1.28	1.14	1.31	1.28	1.39	1.49	1.56	1.59	1.52	1.59	1.64	1.68	1.67	1.69	1.64	2.09

1 – Provisional figures.

Table 7.7. *S. norvegicus* in subareas 1 and 2. Fishing mortalities as estimated by Gadget.

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
9	0.07	0.05	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
10	0.10	0.08	0.07	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.02
11	0.13	0.11	0.10	0.09	0.07	0.05	0.06	0.06	0.06	0.06	0.05	0.04	0.04	0.03	0.03
12	0.17	0.13	0.12	0.12	0.12	0.08	0.09	0.08	0.09	0.09	0.07	0.06	0.05	0.04	0.04
13	0.22	0.17	0.14	0.14	0.15	0.12	0.11	0.11	0.12	0.12	0.10	0.08	0.07	0.06	0.06
14	0.28	0.20	0.17	0.16	0.17	0.14	0.16	0.13	0.15	0.16	0.13	0.10	0.09	0.07	0.07

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
15	0.34	0.24	0.19	0.18	0.19	0.16	0.18	0.17	0.18	0.19	0.15	0.11	0.10	0.09	0.08
16	0.41	0.29	0.22	0.21	0.21	0.17	0.20	0.19	0.22	0.21	0.17	0.13	0.12	0.10	0.09
17	0.48	0.33	0.25	0.23	0.24	0.19	0.21	0.21	0.24	0.25	0.19	0.15	0.13	0.11	0.10
18	0.52	0.38	0.29	0.26	0.26	0.21	0.23	0.22	0.25	0.27	0.22	0.16	0.14	0.12	0.11
19	0.55	0.40	0.31	0.28	0.28	0.22	0.25	0.24	0.27	0.28	0.23	0.17	0.15	0.13	0.12
20	0.58	0.42	0.32	0.30	0.30	0.24	0.26	0.25	0.28	0.29	0.24	0.17	0.16	0.13	0.12
21	0.61	0.43	0.33	0.31	0.31	0.25	0.27	0.26	0.29	0.30	0.24	0.18	0.16	0.13	0.12
22	0.62	0.44	0.33	0.31	0.31	0.25	0.27	0.26	0.29	0.31	0.25	0.18	0.16	0.13	0.12
23	0.62	0.43	0.33	0.30	0.30	0.24	0.27	0.26	0.29	0.31	0.25	0.18	0.16	0.12	0.11
24	0.61	0.42	0.32	0.29	0.29	0.23	0.26	0.25	0.29	0.30	0.24	0.17	0.15	0.12	0.11
25	0.58	0.40	0.29	0.27	0.27	0.22	0.25	0.24	0.27	0.29	0.23	0.17	0.15	0.12	0.11
26	0.55	0.36	0.26	0.24	0.24	0.20	0.22	0.22	0.25	0.26	0.21	0.16	0.14	0.11	0.10
27	0.50	0.33	0.23	0.21	0.22	0.17	0.20	0.20	0.22	0.23	0.18	0.14	0.13	0.10	0.09
28	0.46	0.30	0.21	0.19	0.19	0.15	0.17	0.17	0.20	0.20	0.16	0.12	0.11	0.09	0.09
29	0.42	0.27	0.19	0.16	0.16	0.13	0.15	0.15	0.17	0.17	0.14	0.10	0.09	0.08	0.08
30	0.34	0.20	0.13	0.11	0.13	0.11	0.12	0.11	0.13	0.14	0.10	0.08	0.07	0.04	0.04
15+	0.513	0.351	0.264	0.241	0.243	0.196	0.219	0.212	0.239	0.251	0.199	0.147	0.132	0.107	0.099

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03
10	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.03	0.04	0.05	0.06
11	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.05	0.06	0.07	0.10
12	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.03	0.05	0.05	0.07	0.09	0.11	0.14
13	0.05	0.06	0.06	0.06	0.04	0.06	0.05	0.05	0.05	0.05	0.04	0.06	0.06	0.09	0.12	0.15	0.19
14	0.07	0.07	0.07	0.07	0.06	0.07	0.06	0.06	0.07	0.06	0.05	0.08	0.08	0.12	0.15	0.18	0.24
15	0.08	0.08	0.09	0.08	0.07	0.09	0.07	0.07	0.08	0.07	0.06	0.09	0.10	0.14	0.18	0.22	0.29
16	0.09	0.10	0.10	0.10	0.08	0.10	0.08	0.08	0.09	0.09	0.07	0.11	0.11	0.16	0.21	0.26	0.34
17	0.10	0.11	0.11	0.11	0.09	0.11	0.09	0.09	0.10	0.09	0.08	0.12	0.12	0.18	0.23	0.29	0.38
18	0.11	0.11	0.12	0.11	0.10	0.12	0.10	0.10	0.11	0.10	0.08	0.13	0.13	0.19	0.25	0.32	0.43
19	0.11	0.12	0.12	0.12	0.10	0.13	0.11	0.11	0.12	0.11	0.09	0.13	0.14	0.21	0.27	0.34	0.46
20	0.11	0.12	0.12	0.12	0.11	0.14	0.11	0.11	0.12	0.11	0.09	0.14	0.14	0.21	0.28	0.36	0.48
21	0.11	0.12	0.12	0.12	0.11	0.14	0.11	0.11	0.13	0.11	0.09	0.14	0.15	0.22	0.28	0.36	0.50

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
22	0.11	0.12	0.12	0.12	0.11	0.14	0.11	0.12	0.13	0.11	0.09	0.14	0.15	0.21	0.28	0.36	0.50
23	0.11	0.12	0.12	0.11	0.11	0.14	0.11	0.11	0.12	0.11	0.09	0.14	0.15	0.21	0.28	0.36	0.49
24	0.10	0.11	0.12	0.11	0.11	0.14	0.11	0.11	0.12	0.11	0.09	0.13	0.14	0.21	0.27	0.35	0.47
25	0.10	0.10	0.11	0.10	0.11	0.13	0.11	0.11	0.12	0.11	0.09	0.13	0.14	0.20	0.26	0.33	0.45
26	0.09	0.10	0.10	0.09	0.10	0.13	0.11	0.11	0.12	0.10	0.09	0.13	0.13	0.19	0.25	0.32	0.43
27	0.09	0.09	0.10	0.08	0.10	0.13	0.10	0.10	0.11	0.10	0.08	0.12	0.13	0.18	0.23	0.30	0.40
28	0.08	0.09	0.09	0.08	0.09	0.12	0.10	0.10	0.11	0.10	0.08	0.12	0.12	0.17	0.22	0.28	0.37
29	0.08	0.08	0.08	0.07	0.09	0.11	0.09	0.10	0.10	0.09	0.08	0.11	0.12	0.16	0.21	0.26	0.35
30	0.04	0.04	0.04	0.04	0.07	0.09	0.08	0.08	0.09	0.08	0.06	0.09	0.09	0.13	0.16	0.19	0.25
15+	0.095	0.101	0.104	0.098	0.096	0.123	0.101	0.102	0.111	0.101	0.083	0.122	0.129	0.186	0.240	0.307	0.411

Table 7.8. *S. norvegicus* in subareas 1 and 2. Stock numbers, biomass, mean weight and maturity ogives as estimated by GADGET.

	total stock			mature			immature				recruit
year	Number (millions)	mean wt (kg)	biomass (1000t)	number (millions)	mean wt (kg)	biomass	number (millions)	mean wt (kg)	biomass (1000t)	F(15+)	age 3 (millions)
1986	375	0.35	132.28	103	0.67	69.06	271	0.23	63.22		4.25
1987	370	0.35	129.94	101	0.65	65.92	268	0.24	64.01		3.54
1988	348	0.36	125.06	98	0.61	60.02	250	0.26	65.04		1.98
1989	328	0.37	122.35	96	0.58	56.21	231	0.29	66.14		1.84

year	Number (millions)	total stock mean wt (kg)	biomass (1000t)	number (millions)	mature mean wt (kg)	biomass	number (millions)	immature mean wt (kg)	biomass (1000t)	F(15+)	recruit age 3 (millions)
1990	305	0.37	113.79	92	0.54	49.82	213	0.30	63.97	0.51	1.98
1991	289	0.39	113.64	94	0.55	51.17	195	0.32	62.47	0.35	1.83
1992	275	0.42	115.73	96	0.57	55.39	178	0.34	60.34	0.26	1.65
1993	260	0.45	116.56	98	0.61	59.71	162	0.35	56.85	0.24	1.56
1994	248	0.46	115.09	97	0.64	62.75	151	0.35	52.33	0.24	1.91
1995	233	0.49	115.17	97	0.69	66.78	136	0.36	48.38	0.20	1.24
1996	213	0.52	111.60	94	0.72	68.08	119	0.37	43.52	0.22	0.85
1997	195	0.55	107.39	90	0.76	68.37	105	0.37	39.02	0.21	0.85
1998	173	0.58	100.10	84	0.79	65.81	89	0.39	34.29	0.24	0.42
1999	151	0.60	91.59	76	0.81	61.68	75	0.40	29.91	0.25	0.42
2000	135	0.64	86.51	71	0.85	59.87	64	0.41	26.64	0.20	0.35
2001	124	0.68	84.51	67	0.90	60.37	56	0.43	24.14	0.15	0.44
2002	113	0.73	82.75	64	0.95	61.03	49	0.44	21.72	0.13	0.35
2003	104	0.79	81.95	61	1.02	62.45	43	0.46	19.51	0.11	0.32
2004	98	0.83	81.10	59	1.09	63.66	40	0.44	17.44	0.10	0.52
2005	92	0.87	79.89	56	1.15	64.41	36	0.43	15.48	0.09	0.38

		total stock			mature			immature			recruit
year	Number	mean wt	biomass	number	mean wt	biomass	number	mean wt	biomass	F(15+)	age 3
	(millions)	(kg)	(1000t)	(millions)	(kg)		(millions)	(kg)	(1000t)		(millions)
2006	92	0.84	78.05	52	1.22	64.13	40	0.35	13.91	0.10	1.08
2007	86	0.88	75.63	49	1.28	63.13	37	0.34	12.50	0.10	0.33
2008	82	0.90	73.58	46	1.34	62.08	35	0.33	11.50	0.10	0.49
2009	77	0.93	71.48	44	1.39	60.63	33	0.32	10.85	0.10	0.36
2010	74	0.92	67.86	41	1.42	57.50	33	0.31	10.36	0.12	0.51
2011	80	0.82	66.07	38	1.45	55.56	42	0.25	10.51	0.10	1.36
2012	93	0.70	64.94	37	1.46	53.64	56	0.20	11.29	0.10	2.03
2013	89	0.71	63.43	36	1.43	51.47	53	0.22	11.96	0.11	0.39
2014	82	0.76	62.65	36	1.41	50.07	47	0.27	12.57	0.10	0.03
2015	76	0.82	62.73	36	1.39	49.63	41	0.32	13.10	0.08	0.04
2016	95	0.65	62.00	35	1.37	47.86	60	0.23	14.14	0.12	2.58
2017	117	0.53	61.98	35	1.32	46.26	82	0.19	15.72	0.13	2.95
2018	114	0.53	60.04	35	1.24	43.26	79	0.21	16.78	0.19	0.77
2019	130	0.44	57.79	35	1.14	39.45	96	0.19	18.35	0.24	2.70
2020	118	0.46	54.15	34	1.02	35.03	83	0.23	19.12	0.31	0.03
2021	104	0.47	49.18	33	0.90	29.89	71	0.27	19.29	0.41	0.03

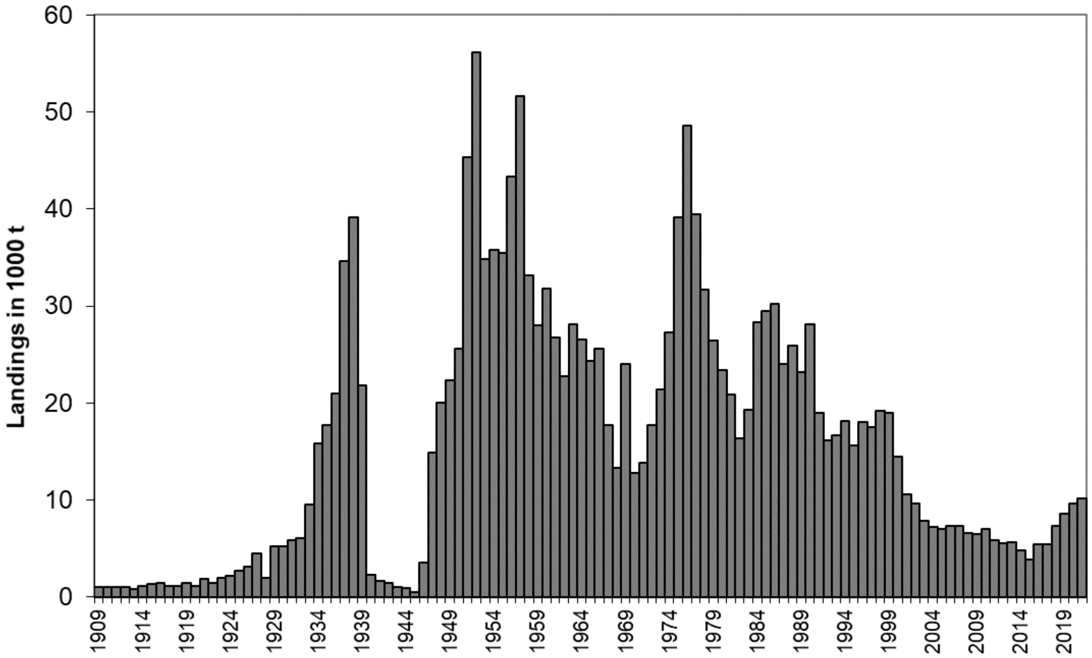


Figure 7.1. ***S. norvegicus*** **in subareas 1 and 2. Total international landings 1908–2021 (in thousand tonnes).**

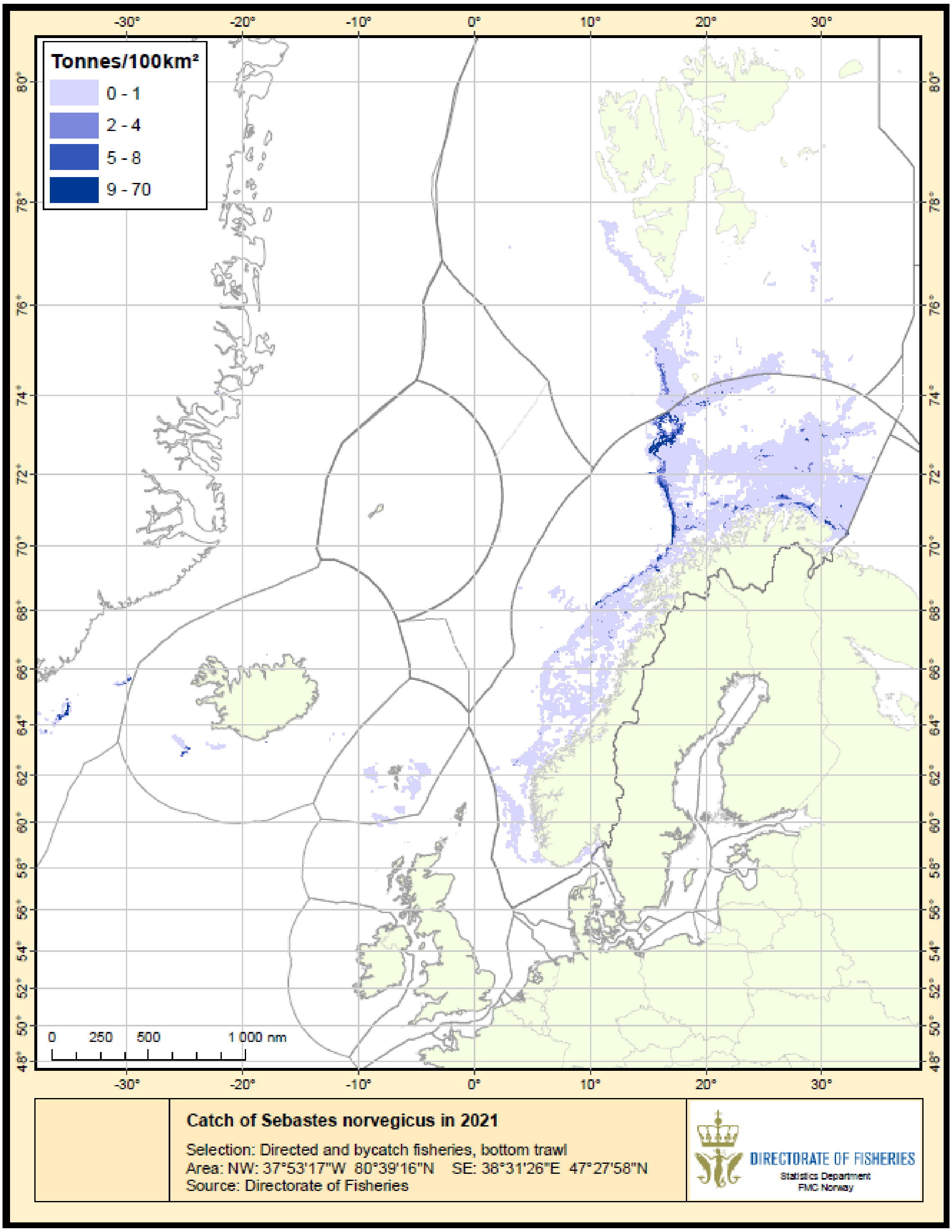


Figure 7.2. S. norvegicus in subareas 1 and 2. Catches (including bycatch) of *S. norvegiucs* in 2021 from Norwegian log-books. Due to reporting on the genus level these catches may contain a considerable amount of *S. mentella.*

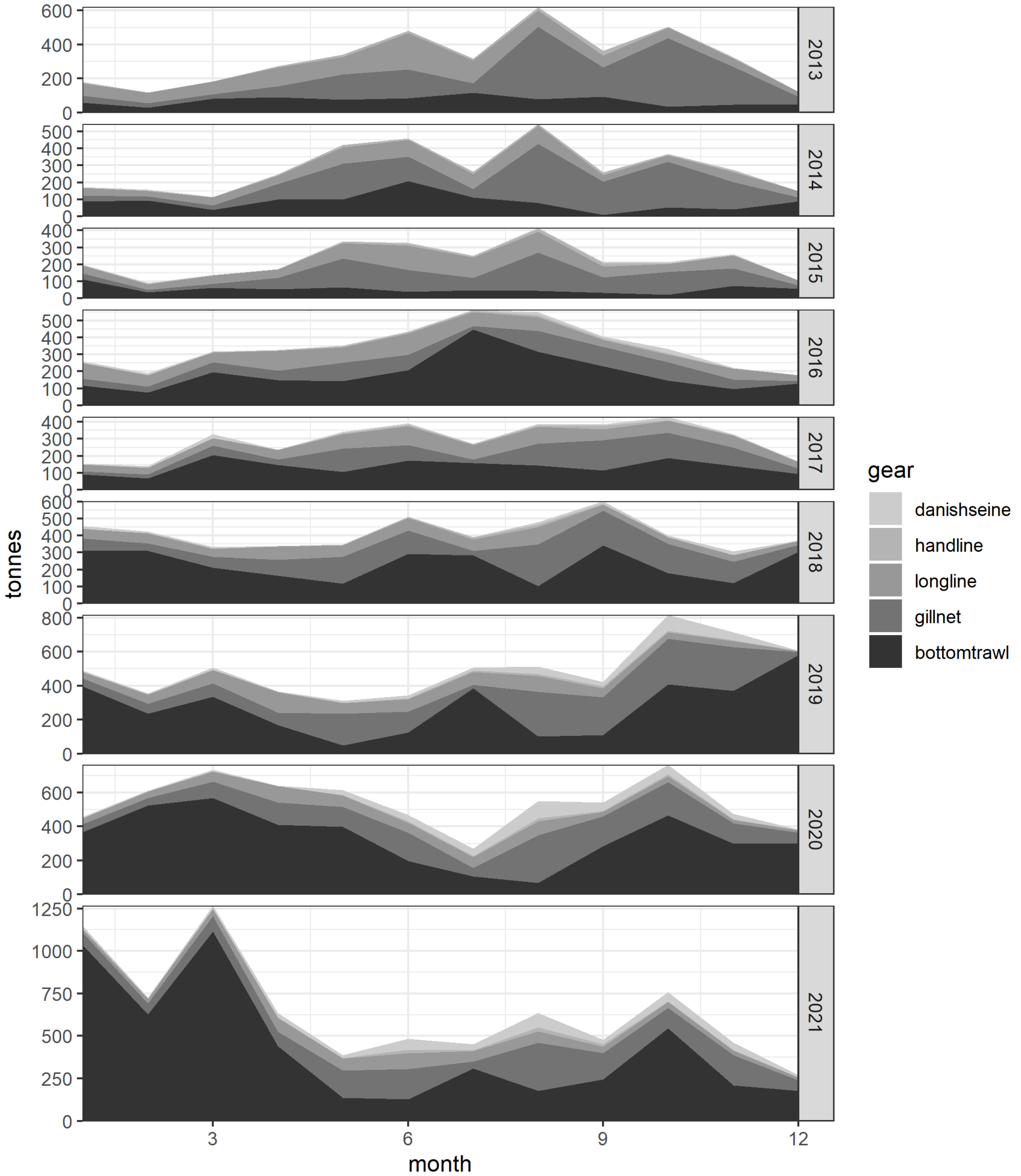


Figure 7.3a. Illustration of the seasonality in the different Norwegian *S. norvegicus* fisheries in 2013-2021, also illustrating how the current regulations are working.

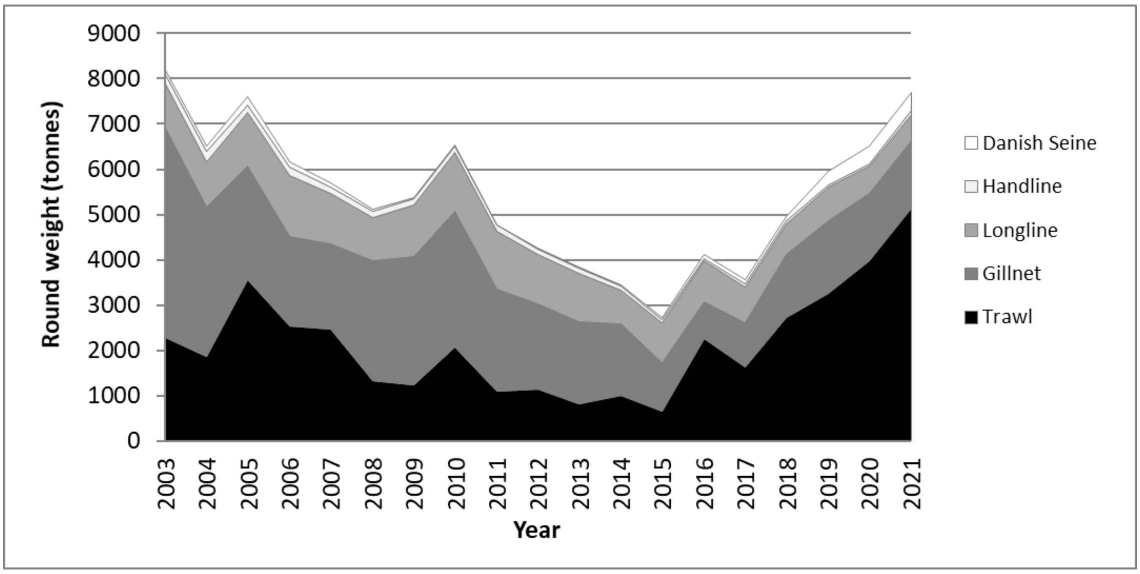


Figure 7.3b. Interannual changes in the Norwegian catches by fleet of *S. norvegicus* fisheries (2003–2021).

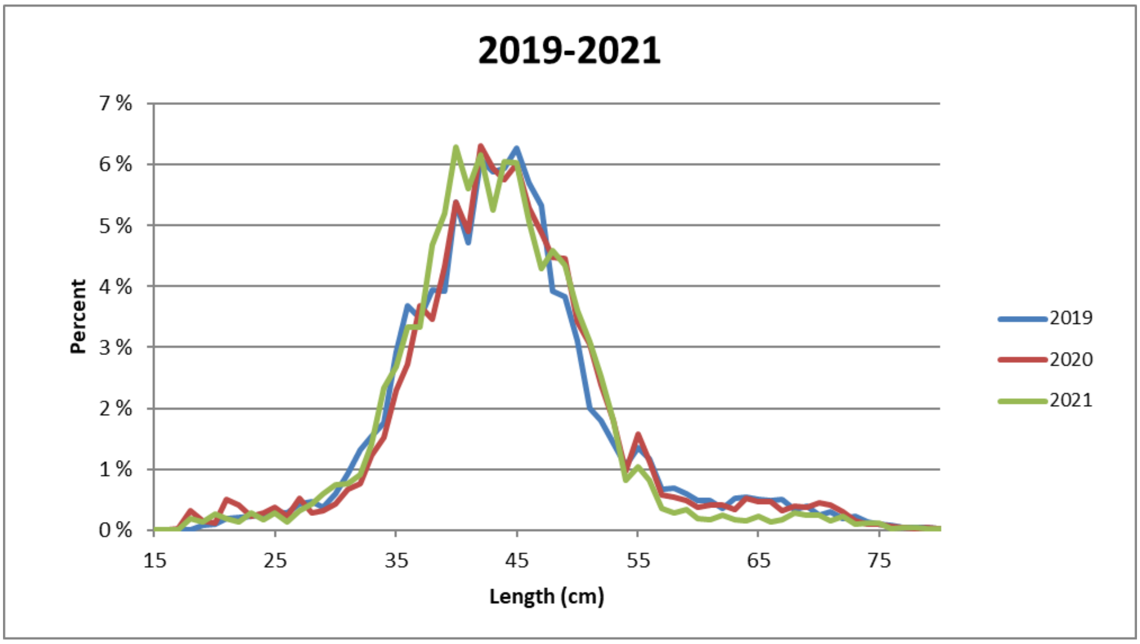


Figure 7.4. *S. norvegicus*. Length frequency of *S. norvegicus* reported from Norwegian catches in 2019-2021, all gears combined.

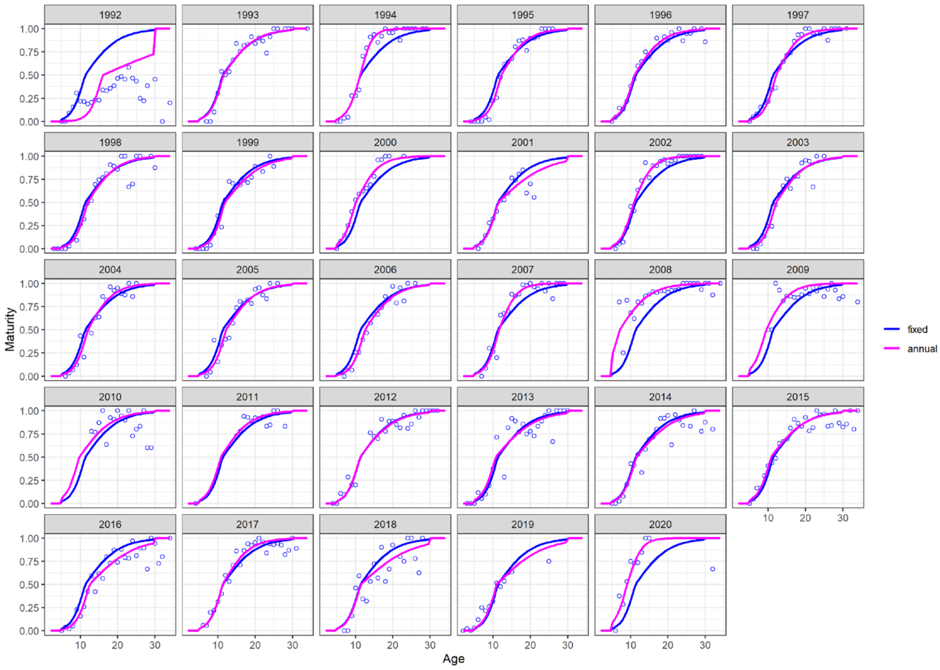
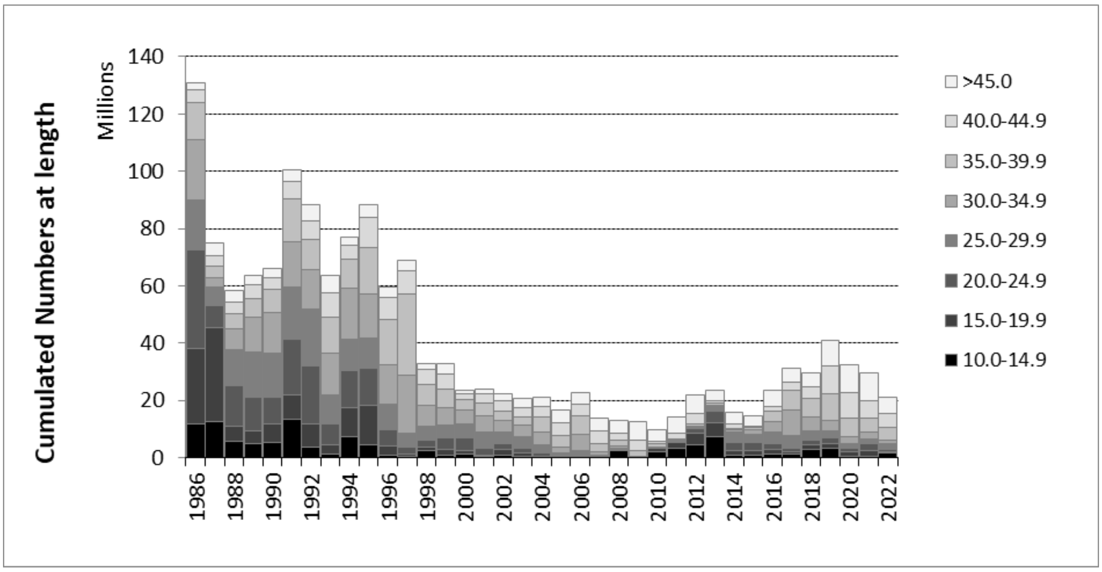


Figure 7.5a. Proportion maturity–at–age of *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table E4). The proportions were derived from samples with at least five individuals. Updated for the 2022 assessment, but due to a lack of data in later years only the data up to 2018 was used in the model.

Figure 7.5b. *S. norvegicus* in subareas 1 and 2. Estimates of maturity–at–age by Gadget. Input data have been proportions of *S. norvegicus* mature both at age and length as collected and classified from Norwegian commercial landings and surveys.



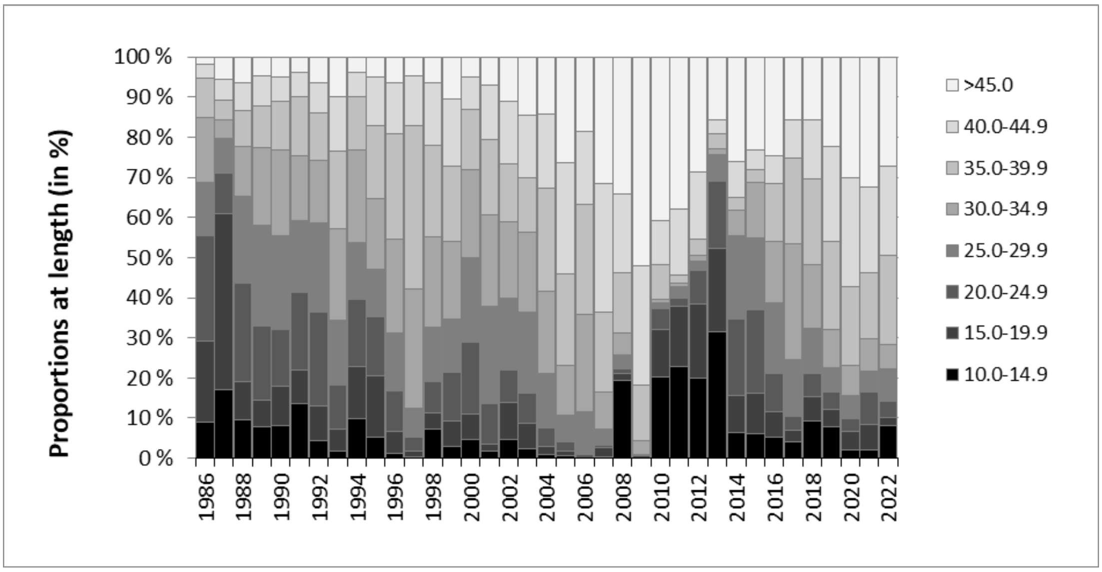
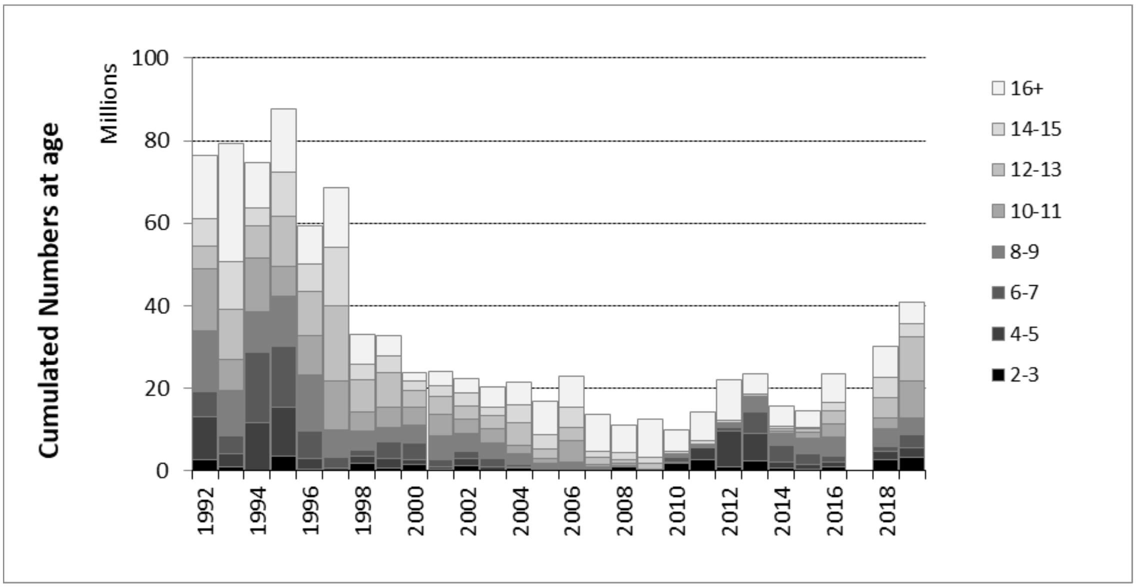


Figure 7.6a. *S. norvegicus*. Abundance indices disaggregated by length for the winter Norwegian Barents Sea (Division 2.a) bottom trawl survey (BS–NoRu–Q1 (BTr); joint with Russia some of the years since 2000), for 1986–2022 (ref. Table

E2a). Numbers for 2022 are preliminary as Russian data were not available during AFWG 2022. Top: absolute index values, bottom: relative frequencies.



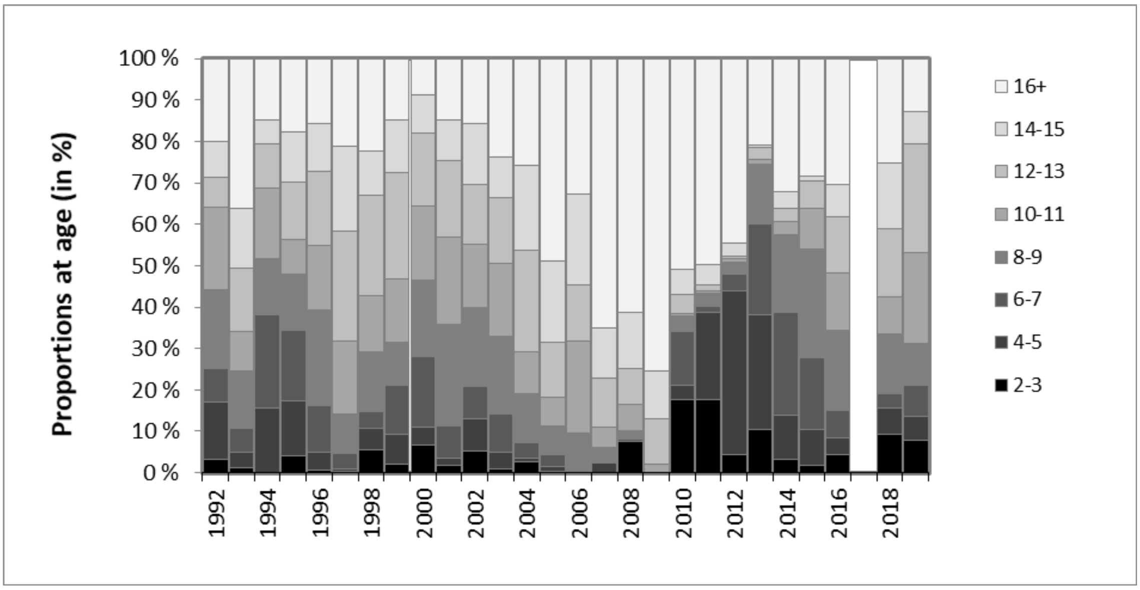
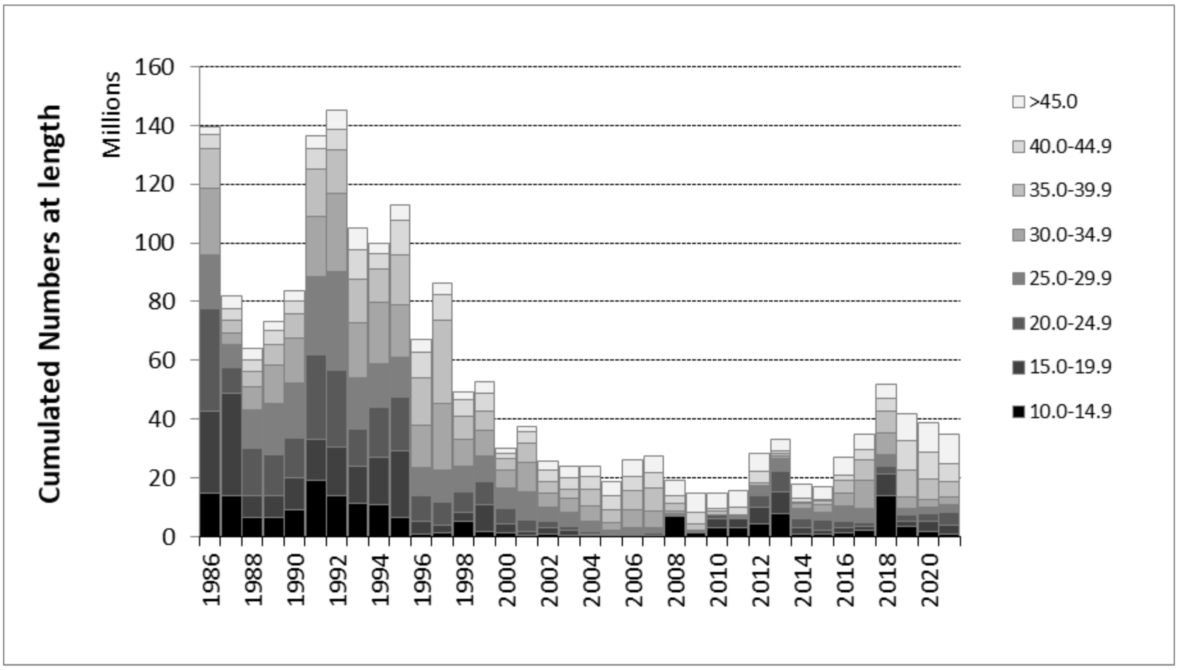


Figure 7.6b. ***S. norvegicus.*** **Abundance indices by age from the winter Norwegian Barents Sea (Division 2.a) bottom–trawl survey (BS–NoRu–Q1 (BTr); joint with Russia some of the years since 2000), for 1992–2019 (ref. Table E2b). Age readings for 2017 and 2020-2022 not available during AFWG 2021. Top: absolute index, bottom: relative frequencies.**



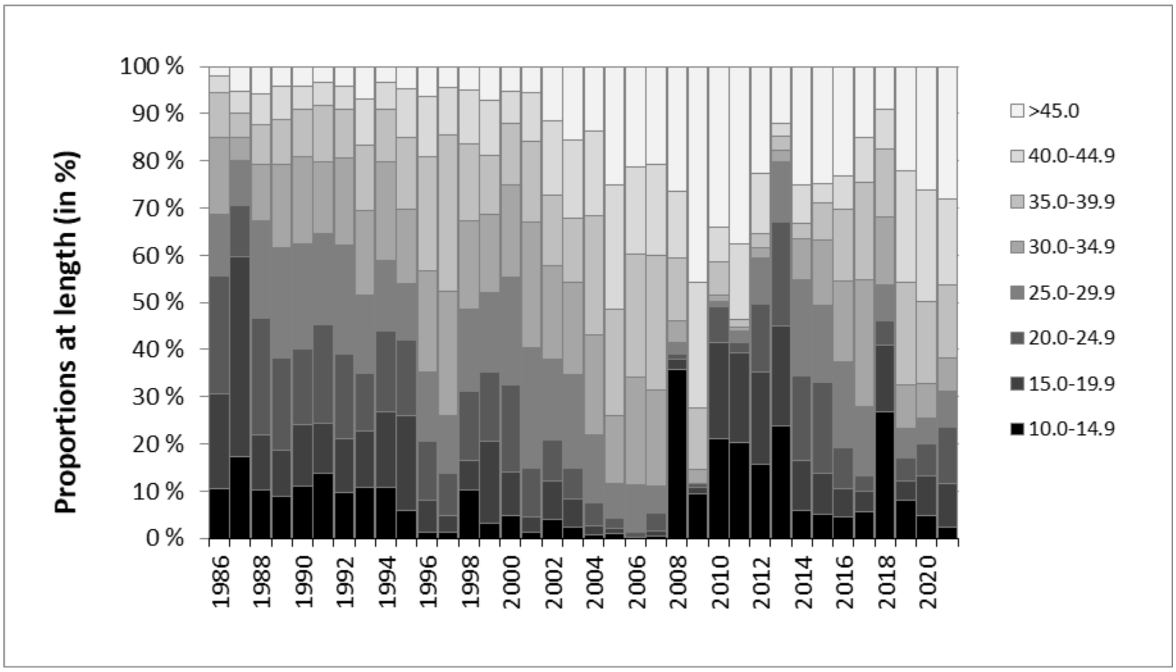


Figure 7.7a. ***S. norvegicus.*** **Abundance indices disaggregated by length when combining the Norwegian bottom–trawl surveys 1986–2021 in the Barents Sea (winter) and at Svalbard (summer/autumn). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**

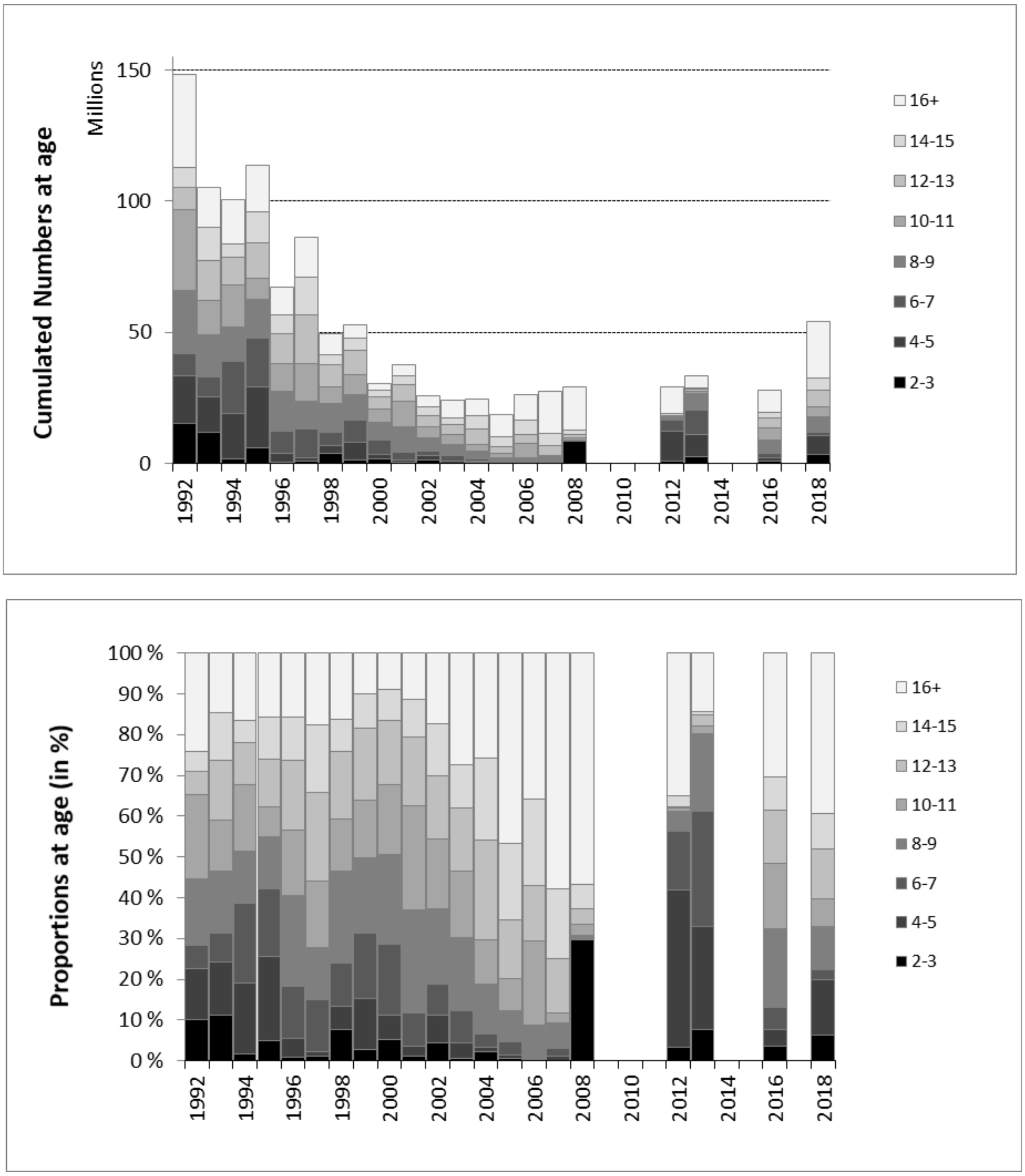


Figure 7.7b. *S. norvegicus*. Abundance indices disaggregated by age. Combined Norwegian bottom–trawl surveys 1992–2018 in the Barents Sea (winter) and Svalbard survey (summer/autumn). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population. In 2009–2011, 2014–2015, 2017, 2019-2021 there was insufficient number of age readings to derive numbers-at-age.

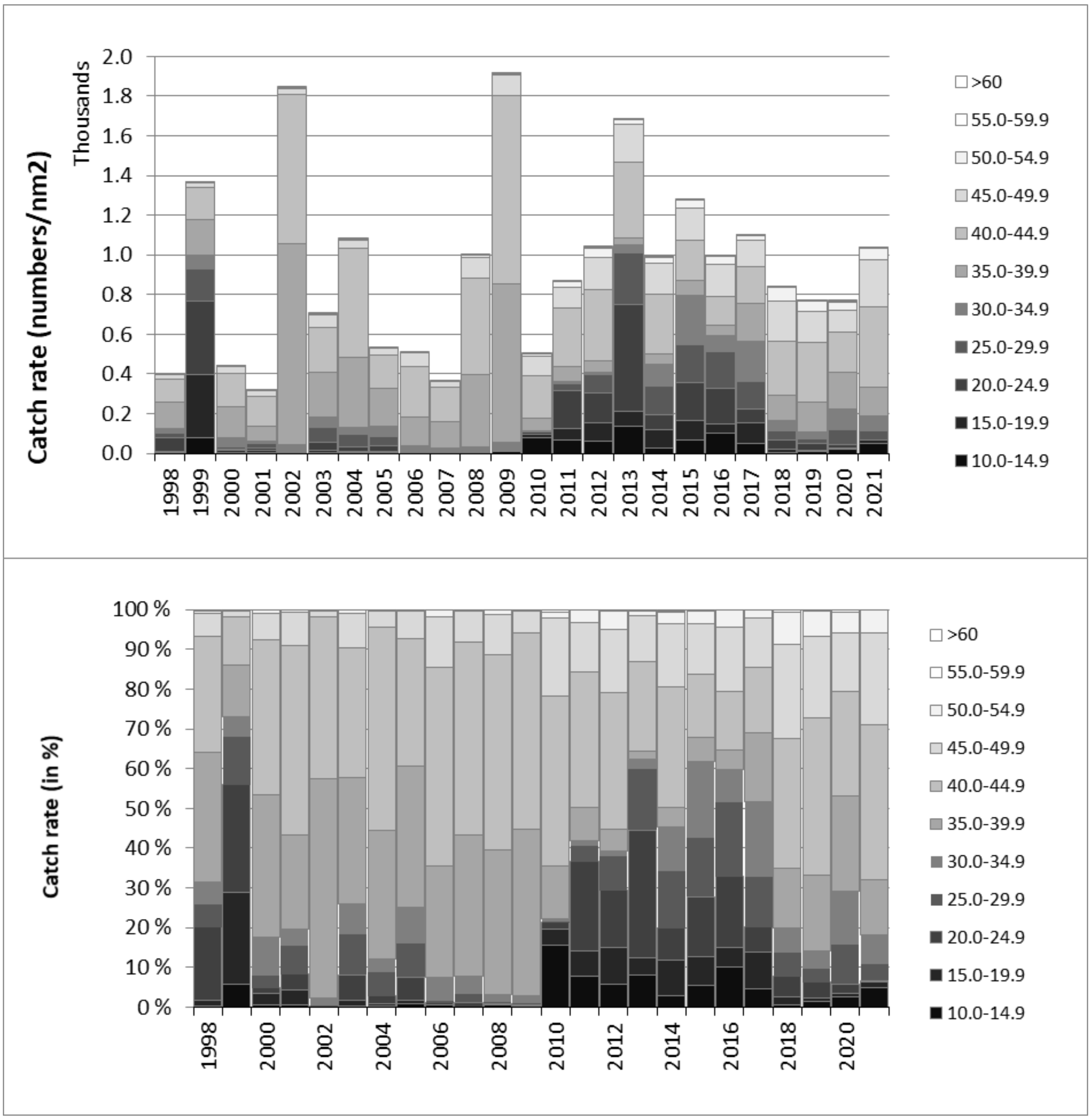


Figure 7.8. *S. norvegicus.* Catch rates (numbers/nm) disaggregated by length for the Barents Sea coastal survey 1998–2021. Top: absolute catch rates. Bottom: relative values.

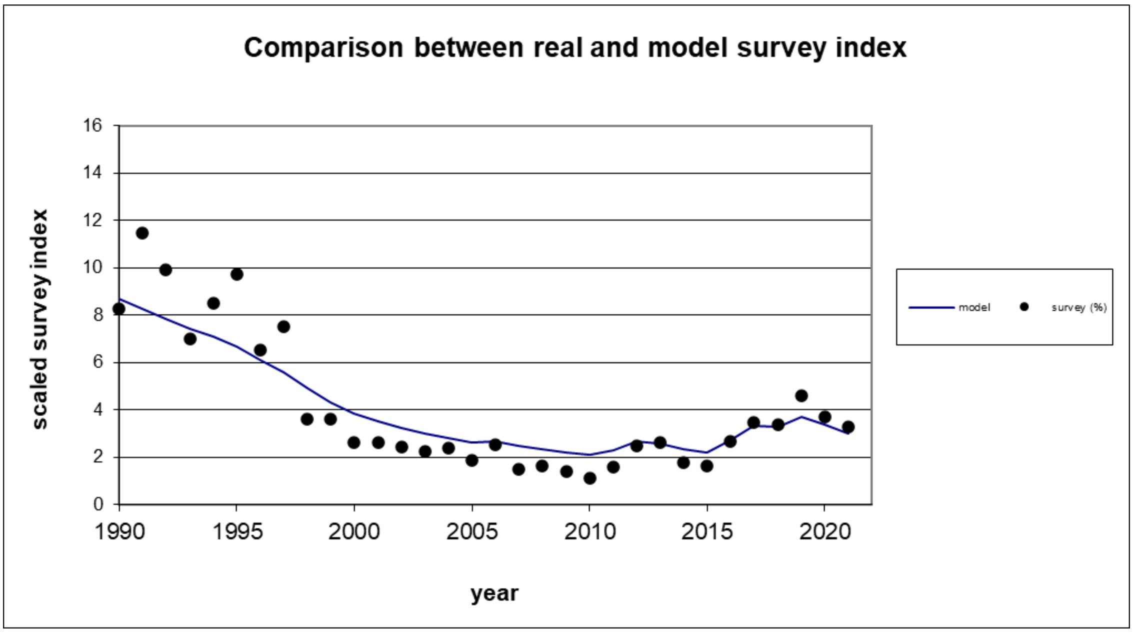


Figure 7.9. ***S. norvegicus*** **in subareas 1 and 2. Comparison of observed and modelled survey indices (total number scaled to sum=100 during the period) for the Barents Sea winter survey in February. Dots: survey indices. Plain lines: survey indices estimated by the model.**

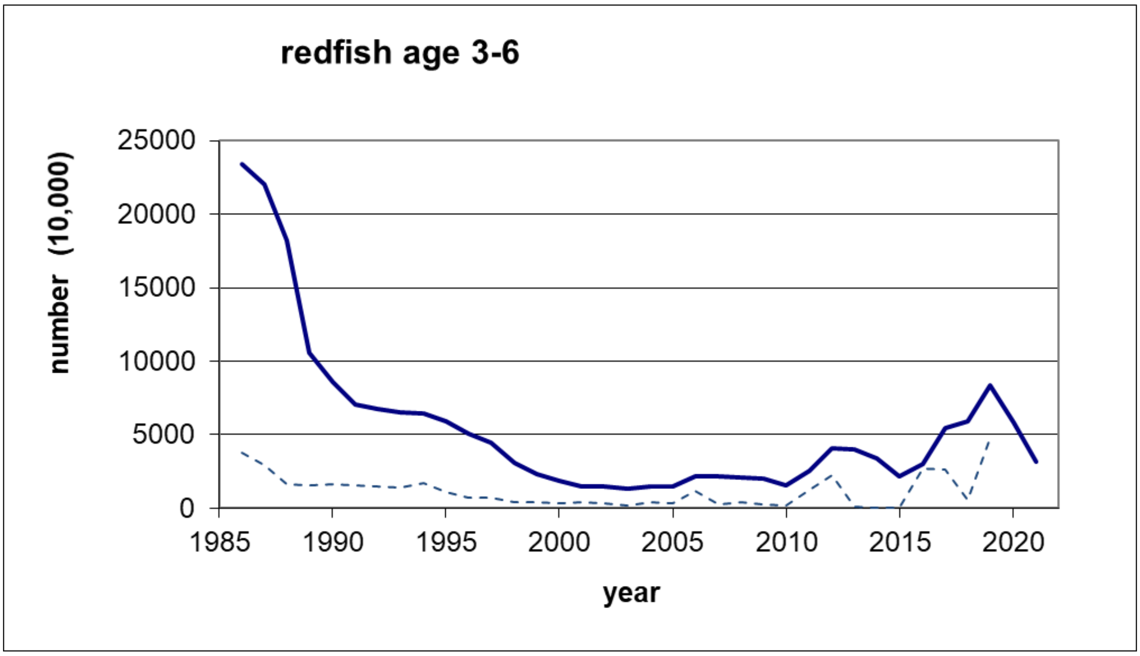


Figure 7.10. ***S. norvegicus*** **in subareas 1 and 2. Estimates of abundance–at–age 3–6 by Gadget for this year's assessment (solid line) and the last assessment (broken line), with data up to 2019 and 2021, respectively. Note that recent year (since 2015) have very little tuning data behind them.**

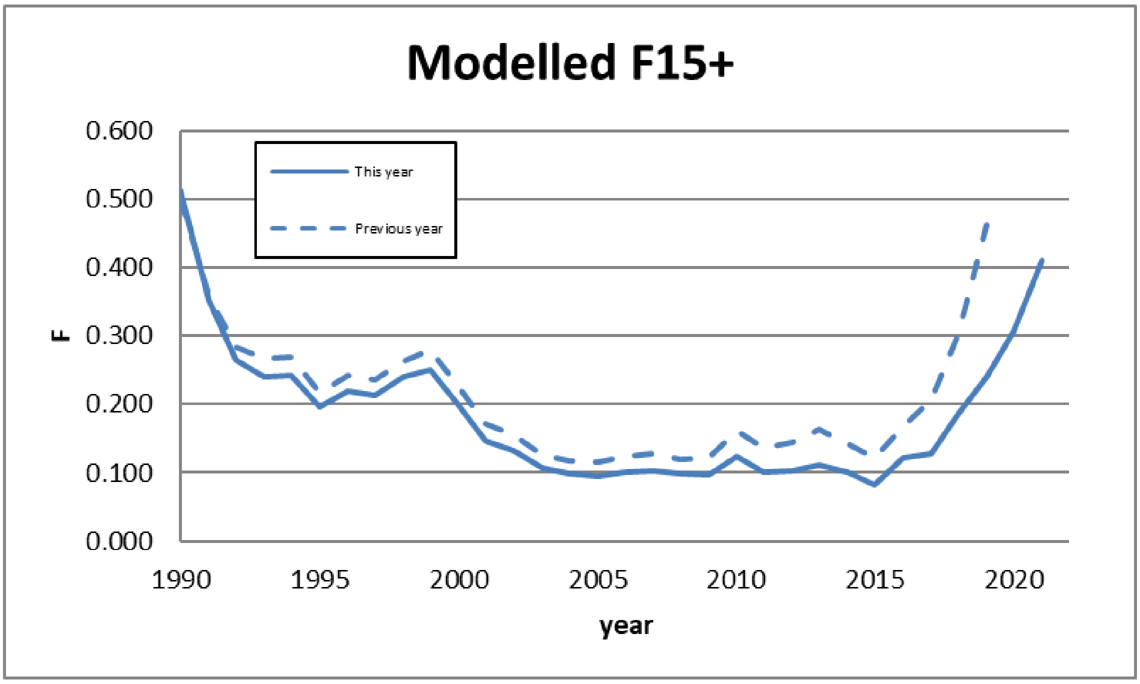


Figure 7.11. *S. norvegicus* in subareas 1 and 2. Unweighted average fishing mortality of ages 15+. Solid line shows this year's assessment (data up to 2021) and the dashed line shows last assessment (data up to 2019).

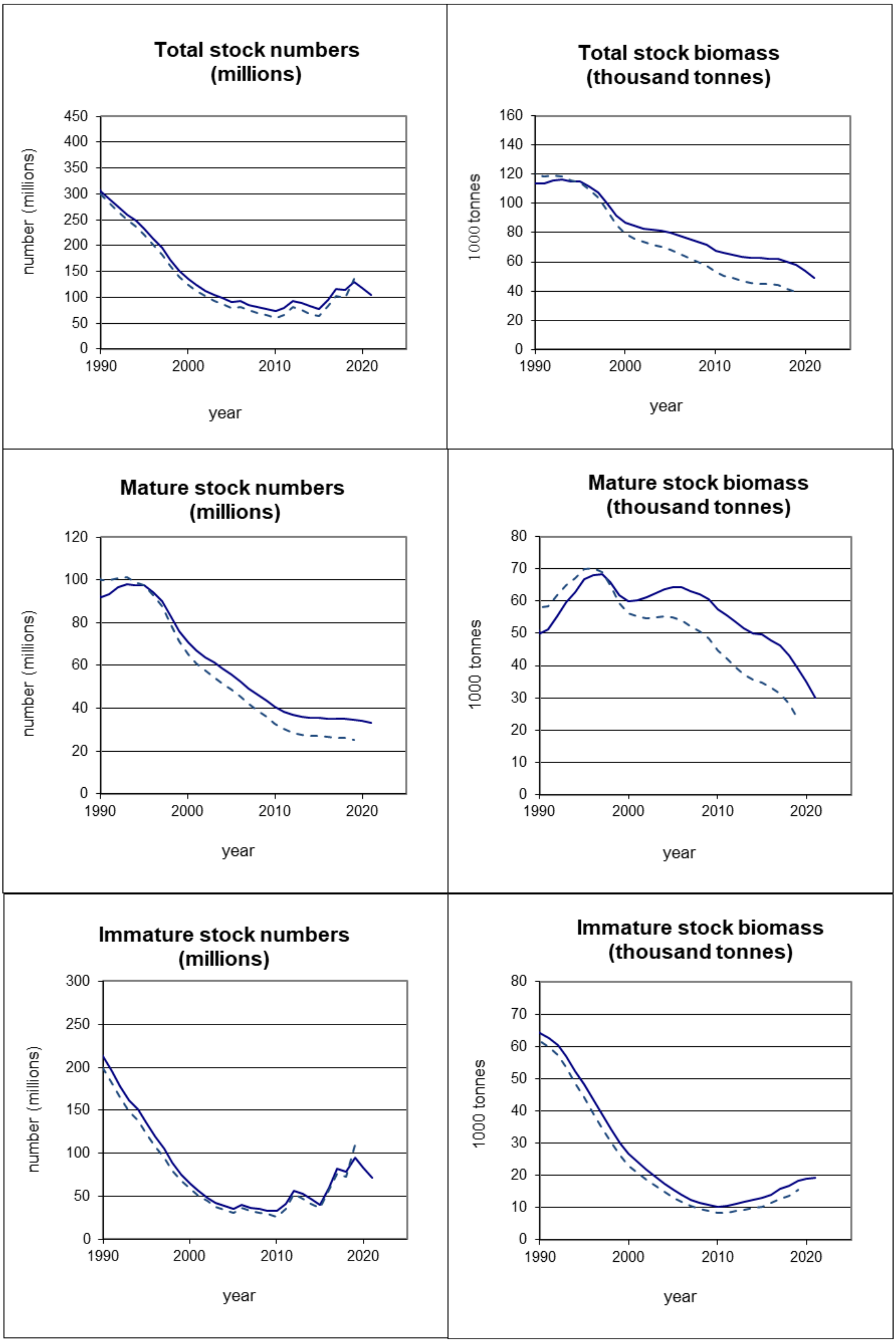


Figure 7.12. *S. norvegicus* in subareas 1 and 2. Stock numbers (in millions) and biomass (in 1000 tonnes) for the total stock (3+; upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Solid line shows this year's assessment (data up to 2021), and the dashed line shows last assessment (data up to 2019).

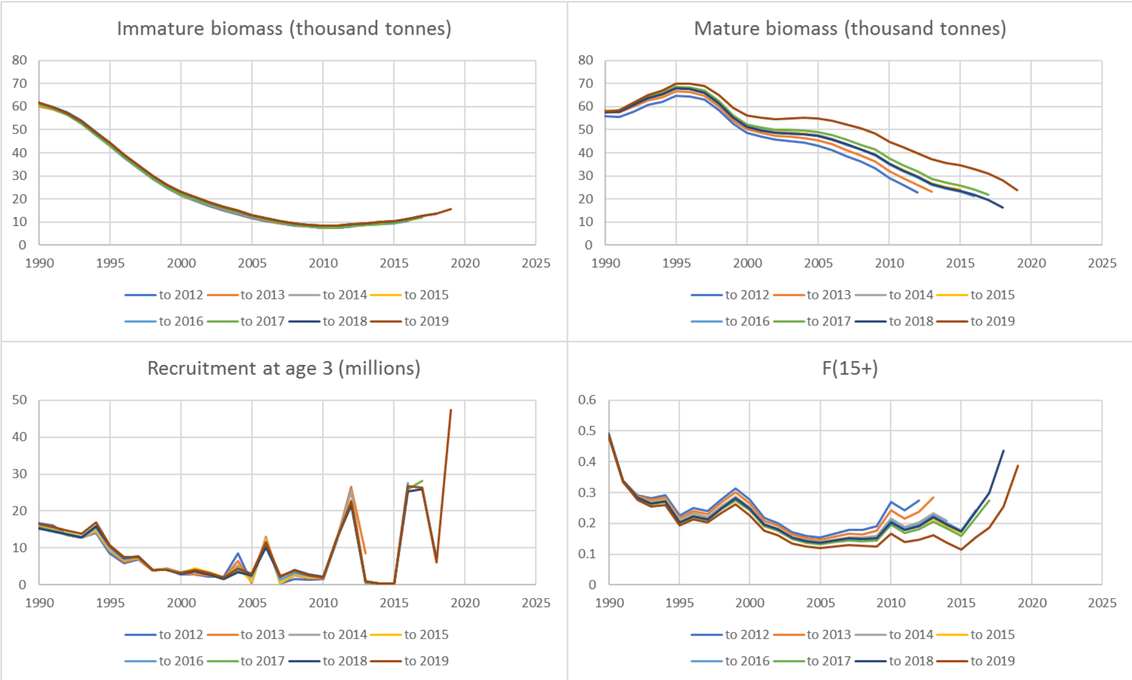


Figure 7.13. Gadget retrospective trends 2012 to 2019, immature biomass, mature biomass, recruitment–at–age 3, and F(15+).

7.5 Additional tables and figures

Table E1. Observed proportion of maturity–at–age 5 through 30 in *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data. The proportions were derived from samples with at least five individuals. Data for years after 2018 was considered insufficient until further age reading and is not presented.

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1992	0.00	0.00	0.09	0.15	0.31	0.22	0.21	0.20	0.22	0.26	0.30	0.44	0.45	0.47	0.45	0.62	0.51	0.63	0.76	0.60	0.57	0.60	0.68	0.74	0.82	0.80
1993	-	-	0.00	0.00	0.10	0.29	0.54	0.47	0.53	0.67	0.80	0.75	0.78	0.82	0.91	0.85	0.82	0.87	0.75	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.00	0.03	0.05	0.28	0.28	0.32	0.70	0.79	0.91	0.94	0.85	0.92	1.00	0.96	0.96	1.00	0.88	1.00	1.00	1.00	1.00	-	1.00	1.00	-
1995	0.00	0.00	0.00	0.05	0.02	0.22	0.25	0.48	0.61	0.64	0.68	0.80	0.87	0.88	0.76	0.89	0.90	0.91	1.00	1.00	1.00	1.00	-	-	-	-
1996	0.00	0.05	0.14	0.13	0.22	0.38	0.43	0.60	0.64	0.75	0.69	0.77	0.90	0.85	0.91	0.88	0.96	0.93	1.00	0.87	0.95	0.95	1.00	-	1.00	0.86
1997	0.00	0.05	0.08	0.15	0.17	0.21	0.34	0.35	0.57	0.64	0.72	0.73	0.85	0.93	0.94	1.00	1.00	0.95	0.89	0.94	0.93	0.89	1.00	1.00	1.00	-
1998	0.00	0.00	0.03	0.11	0.09	0.26	0.32	0.49	0.52	0.69	0.74	0.77	0.81	0.91	0.89	0.86	1.00	1.00	0.67	0.70	1.00	1.00	-	-	1.00	0.88
1999	0.00	0.00	0.00	0.04	0.17	0.35	0.22	0.53	0.73	0.71	0.67	0.69	0.74	0.71	0.77	0.89	-	0.83	-	1.00	0.89	-	-	-	-	-
2000	0.00	0.08	0.14	0.25	0.40	0.51	0.59	0.62	0.65	0.69	0.78	0.96	0.96	1.00	1.00	-	-	-	1.00	-	-	-	-	-	-	-
2001	-	0.00	0.06	0.14	0.28	0.32	0.40	0.52	0.53	0.60	0.76	0.74	0.81	0.85	0.60	0.70	0.56	-	-	-	-	-	-	-	-	-
2002	-	0.00	0.05	0.07	0.23	0.44	0.41	0.63	0.74	0.93	0.77	0.89	0.90	0.94	0.96	0.92	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
2003	-	-	-	0.05	0.13	0.24	0.24	0.47	0.58	0.68	0.75	0.65	0.77	0.78	0.93	0.96	0.94	0.67	1.00	-	1.00	-	-	-	-	-
2004	-	-	0.03	0.07	0.13	0.43	0.21	0.51	0.46	0.63	0.64	0.86	0.82	0.96	0.92	0.95	0.89	0.88	1.00	0.86	1.00	-	-	-	-	-
2005	-	-	-	0.04	0.39	0.16	0.33	0.40	0.41	0.57	0.74	0.81	0.78	0.82	0.78	0.94	0.95	0.88	0.83	1.00	-	1.00	-	-	-	-
2006	-	-	-	0.10	0.07	0.26	0.26	0.39	0.47	0.57	0.67	0.67	0.74	0.86	0.83	0.97	0.79	0.95	0.81	1.00	-	1.00	-	-	-	-

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2007	-	-	-	0.08	0.30	0.26	0.20	0.66	0.68	0.70	0.88	0.86	0.89	0.99	0.98	1.00	0.96	0.94	1.00	0.92	1.00	0.83	1.00	1.00	1.00	-
2008	-	-	0.80	0.25	0.82	0.68	0.62	0.80	0.79	0.86	0.88	0.91	0.90	0.92	0.92	0.90	0.93	0.93	0.94	1.00	1.00	1.00	1.00	1.00	0.93	1.00
2009	-	-	-	-	-	0.50	0.50	1.00	0.93	0.81	0.86	0.86	0.85	0.85	0.88	0.95	0.89	0.95	0.92	0.95	0.86	0.94	1.00	0.93	0.83	0.86
2010	-	-	-	-	-	-	-	-	0.78	0.77	0.87	1.00	0.64	0.93	0.91	1.00	0.95	0.90	1.00	0.73	0.80	0.83	1.00	0.60	0.60	-
2011	-	-	-	-	-	-	-	-	-	-	0.73	0.78	0.94	0.93	0.89	0.92	0.92	0.93	0.83	0.85	1.00	1.00	-	0.83	-	-
2012	-	0.11	0.10	0.29	0.20	0.20	-	-	-	0.76	0.72	0.70	0.91	0.78	0.88	0.89	0.85	0.81	0.95	0.81	0.86	1.00	0.93	1.00	1.00	1.00
2013	-	0.12	0.05	0.10	0.19	0.38	0.71	-	0.29	0.82	0.92	0.89	0.77	0.86	0.75	0.78	0.73	0.83	0.89	0.95	1.00	0.67	1.00	1.00	1.00	1.00
2014	-	-	0.02	0.08	0.21	0.43	0.41	0.53	0.33	0.58	0.69	0.71	0.80	0.92	0.92	0.95	0.63	0.96	0.90	0.84	0.95	0.83	1.00	-	0.78	0.88
2015	-	0.05	0.17	0.17	0.30	0.41	0.44	0.49	0.65	0.67	0.69	0.81	0.91	0.86	0.83	0.93	0.78	0.82	1.00	0.95	0.96	0.83	0.84	1.00	0.87	0.82
2016	-	0.04	0.02	0.05	0.23	0.16	0.26	0.43	0.59	0.42	0.62	0.57	0.80	0.73	0.87	0.74	0.88	0.79	0.78	0.97	0.81	0.89	0.89	0.67	1.00	0.94
2017	-	0.06	0.06	0.20	0.22	0.31	0.40	0.60	0.53	0.71	0.86	0.71	0.86	0.94	0.92	0.95	1.00	0.96	0.84	0.94	0.93	0.94	0.92	0.82	0.87	1.00
2018	-	-	-	-	0.16	0.46	0.59	0.34	0.32	0.53	0.72	0.57	0.90	0.53	0.67	0.92	-	0.80	0.75	1.00	1.00	0.78	0.63	1.00	-	-

Table E2a. *S. norvegicus* in subareas 1 and 2. Abundance indices (numbers in millions) – on length – from the winter Norwegian Barents Sea (Division 2.a) bottom–trawl survey (BS–NoRu–Q1 (BTr)) from 1986 to 2022. The area coverage was extended from 1993. Indices recalculated from 1994 onwards.

Length group (cm)										
Year	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
1986	3.0	11.7	26.4	34.3	17.7	21.0	12.8	4.4	2.6	133.9
1987	7.7	12.7	32.8	7.7	6.4	3.4	3.8	3.8	4.2	82.5
1988	1.0	5.6	5.5	14.2	12.6	7.3	5.2	4.1	3.7	59.2

Length group (cm)										
Year	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
1989	48.7	4.9	4.3	11.8	15.9	12.2	6.6	4.8	3.0	112.2
1990	9.2	5.3	6.5	9.4	15.5	14.0	8.0	4.0	3.4	75.3
1991	4.2	13.6	8.4	19.4	18.0	16.1	14.8	6.0	4.0	104.5
1992	1.8	3.9	7.7	20.6	19.7	13.7	10.5	6.6	5.8	90.3
1993	0.1	1.2	3.5	6.9	10.3	14.5	12.5	8.6	6.3	63.9
1994	0.7	7.5	10.1	12.8	10.9	17.8	10.1	4.8	2.9	77.6
1995	0.4	4.7	13.5	13.1	10.4	15.4	16.2	10.6	4.6	88.9
1996	0.0	0.7	3.3	5.9	8.7	14.0	15.7	7.5	3.9	59.7
1997	0.0	0.3	1.0	2.2	5.1	20.3	28.0	8.5	3.3	68.8
1998	0.1	2.4	1.3	2.6	4.5	7.4	7.5	5.1	2.2	33.0
1999	0.2	0.9	2.1	4.0	4.4	6.3	6.1	5.5	3.5	32.4
2000	0.5	1.1	1.5	4.2	4.9	5.1	3.6	1.9	1.2	23.9
2001	0.1	0.4	0.4	2.5	5.8	5.4	4.5	3.2	1.7	24.1
2002	0.1	1.0	2.0	1.8	3.9	4.2	3.2	3.5	2.4	22.3
2003	0.0	0.5	1.3	1.5	4.2	4.1	2.8	3.2	3.0	20.5
2004	0.7	0.2	0.4	1.0	2.8	4.4	5.4	3.9	3.0	21.8
2005	0.0	0.1	0.2	0.4	1.1	2.1	3.8	4.7	4.4	16.8

Length group (cm)									
Year	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
2006	0.0	0.0	0.0	0.2	2.5	5.5	6.3	4.2	4.3	22.9
2007	0.0	0.1	0.3	0.1	0.5	1.3	2.7	4.4	4.3	13.7
2008	1.7	2.5	0.2	0.2	0.4	0.7	2.0	2.5	4.5	14.7
2009	0.0	0.0	0.1	0.0	0.0	0.4	1.7	3.8	6.6	12.7
2010	0.4	2.0	1.1	0.5	0.1	0.1	0.9	1.1	4.0	10.2
2011	0.3	3.2	2.1	0.3	0.4	0.1	0.3	2.3	5.3	14.4
2012	0.8	4.4	4.0	1.8	0.5	0.3	0.9	3.6	6.3	22.7
2013	0.1	7.4	4.9	4.0	1.6	0.4	0.9	0.8	3.7	23.7
2014	0.1	1.0	1.5	3.0	3.3	1.0	0.5	1.4	4.1	16.0
2015	0.1	0.9	1.5	3.0	2.6	2.0	0.5	0.7	3.4	14.7
2016	0.7	1.3	1.5	2.3	4.2	3.6	3.4	1.7	5.8	24.3
2017	0.3	1.3	0.9	1.1	4.5	9.1	6.7	3.0	5.0	31.7
2018	1.1	2.7	1.8	1.7	3.3	4.7	6.3	4.3	4.7	30.6
2019	0.7	3.2	1.7	1.8	2.5	3.9	9.0	9.7	9.1	41.7
2020	1.0	0.6	1.5	1.0	1.9	2.4	6.5	8.8	9.9	33.6
2021	0.1	0.6	1.9	2.3	1.5	2.4	4.9	6.3	9.6	29.8
2022[1]	1.7	1.7	0.4	0.8	1.7	1.3	4.7	4.7	5.8	23.0

1 – Provisional figures. Russian data not provided in time for AFWG 2022.

Table E2b. *S. norvegicus* in subareas 1 and 2. Norwegian bottom-trawl indices (numbers in thousands) – on age – from the annual Winter Norwegian Barents Sea (Division 2.a) bottom trawl survey (BS–NoRu–Q1 (BTr)) from 1986 to 2019. Age readings not available for 2017 and 2020–2022 at the time of AFWG 2022. The area coverage was extended from 1993 onwards. Indices recalculated from 1994 and onwards.

Year/age	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1992	2509	4070	6395	2375	3757	10392	4299	3567	11526	2276	3239	3070	3666	15183	76324
1993	996	1308	1661	3005	1559	7689	3346	4801	2712	5480	6568	2735	8801	28737	79398
1994	0	9249	2475	5998	10871	6530	3523	8189	4566	1639	6285	1486	2964	11035	74809
1995	3544	4554	7203	9362	5598	8583	3308	2305	5004	7512	4602	4848	5948	15455	87826
1996	365	800	1825	2917	3715	8299	5343	3038	6373	4653	5945	3113	3720	9357	59462
1997	154	37	489	1012	1588	2717	3764	2925	9098	6036	12131	11643	2430	14607	68629
1998	1604	1118	607	550	858	2233	2470	2310	2157	3345	4618	827	2785	7320	32803
1999	489	1079	1289	2708	1220	1315	2060	3177	1766	3129	5342	2053	2085	4828	32537
2000	437	427	588	1774	2274	2559	1814	2378	1850	1817	2396	1838	336	2089	22577
2001	322	105	280	583	1346	2759	3072	2603	2488	2511	1886	1377	1016	3552	23903
2002	973	919	796	1126	640	1511	2744	1694	1754	2144	1090	1102	2172	3492	22157
2003	165	88	773	1329	523	1154	2638	1391	2140	1330	1890	801	1165	4809	20197
2004	0	163	68	250	544	978	1513	1069	1110	2135	3150	1559	2832	5541	20911
2005	57	85	86	114	393	532	627	460	689	1095	1178	1713	1545	8244	16818
2006	0	0	0	0	26	1025	1157	2641	2424	1244	1888	3242	1795	7480	22922
2007	19	39	256	39	0	320	173	369	293	868	751	809	847	8941	13724
2008	826	0	0	0	76	97	116	224	477	320	623	885	621	6744	11010

Year/age	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
2009	0	0	0	0	0	0	12	80	176	220	1168	417	1018	9507	12598
2010	0	0	328	1012	250	0	364	62	0	96	343	264	345	4955	8018
2011	2001	1750	1283	135	64	0	440	0	103	0	214	119	560	7110	13776
2012	938	3955	4777	547	342	267	391	112	102	86	0	247	506	9811	22083
2013	1594	1773	4772	2651	2504	2050	1386	275	0	483	143	166	0	4925	22721
2014	485	985	724	1030	2856	1906	1048	532	0	262	228	113	513	5056	15737
2015	223	438	814	1034	1481	1909	1947	483	943	484	471	104	53	4130	14514
2016	338	557	408	390	1163	2022	2567	2214	1027	805	2392	1324	555	7162	22925
2017		Age data not available during AFWG 2022													
2018	1597	1016	892	354	696	1784	2627	1082	1596	2558	2358	3461	1307	7626	28953
2019	899	1684	780	2120	900	1240	2821	3276	5770	7289	3393	2170	983	5251	38577

16+ group is considered in the calculation since 2005. Values prior to this date were derived by subtracting the sum of abundance in groups 1–15 to the total abundance, available in Table E1a.

Table E3a. *S. norvegicus* in subareas 1 and 2. Abundance indices (numbers in thousands) – on length – from the Norwegian Svalbard (Division 2.b) bottom–trawl survey (August–September) from 1985 to 2021. Since 2005 this is part of the Ecosystem survey (Eco–NoRu–Q3 (BTr)).

	Length group (cm)									
Year	5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
1985[1]	–	1307	795	1728	2273	1417	311	142	194	8167
1986[1]	200	2961	1768	547	643	1520	639	467	196	8941

	Length group (cm)								
Year	**5.0–9.9**	**10.0–14.9**	**15.0–19.9**	**20.0–24.9**	**25.0–29.9**	**30.0–34.9**	**35.0–39.9**	**40.0–44.9**	**> 45.0**	**Total**
1987[1]	100	1343	1964	1185	1367	652	352	29	44	7036
1988[1]	500	1001	1953	1609	684	358	158	68	95	6426
1989	200	1629	2963	2374	1320	846	337	323	104	10096
1990	1700	3886	4478	4047	2972	1509	365	140	122	19219
1991	100	5371	5821	9171	8523	4499	1531	982	395	36393
1992	1700	10228	8858	5330	13960	12720	4547	494	346	58183
1993	200	10160	9078	5855	7071	4327	2088	1552	948	41279
1994	100	3340	5883	4185	3922	3315	1021	845	423	23034
1995	470	2000	9100	5070	3060	2400	1040	920	780	24840
1996	80	130	1260	2480	1030	480	550	990	400	7400
1997	0	810	1980	5470	5560	2340	590	190	450	17390
1998	180	2698	1741	4620	4053	1761	535	545	241	16374
1999	0	794	7057	3698	4563	2449	467	619	369	20016
2000	40	360	1240	1390	2010	760	400	160	390	6750
2001	10	110	790	1470	3710	4600	1880	680	370	13620
2002	0	0	65	415	459	880	621	565	521	3526
2003	87	87	104	84	534	635	459	759	738	3487

	Length group (cm)									
Year	**5.0–9.9**	**10.0–14.9**	**15.0–19.9**	**20.0–24.9**	**25.0–29.9**	**30.0–34.9**	**35.0–39.9**	**40.0–44.9**	**> 45.0**	**Total**
2004	0	8	9	192	581	667	607	395	213	2672
2005	0	52	0	84	267	608	411	274	283	1979
2006	0	0	75	74	138	437	470	668	1264	3126
2007	0	29	52	938	1069	4268	5154	892	1390	13792
2008	8603	4255	211	25	50	169	525	180	536	14554
2009	216	1403	108	108	0	0	197	214	220	2466
2010	868	1117	1845	607	0	123	189	0	996	5745
2011	0	0	850	50	0	0	0	159	578	1637
2012	0	111	1565	2242	2217	285	0	0	146	6566
2013	56	489	2155	3307	2738	433	136	34	349	9697
2014	64	0	425	167	296	531	74	0	312	1869
2015	0	0	0	216	198	303	877	18	810	2422
2016	0	0	121	119	813	1007	754	300	498	3612
2017	838	675	577	93	585	291	476	288	262	4085
2018	826	11129	5619	1000	677	2741	1134	127	110	23363
2019	78	90	104	219	68	0	115	131	182	987
2020	527	1193	1728	1591	290	368	318	365	264	6644

Year	Length group (cm) 5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0–34.9	35.0–39.9	40.0–44.9	> 45.0	Total
2021	0	184	1277	1849	1074	95	407	20	69	4975

1 – Old trawl equipment (bobbins gear and 80 m sweep length).

Table E3b. *S. norvegicus* in subareas 1 and 2. Norwegian bottom trawl survey indices—on age—from the Norwegian Svalbard (Division 2.b) bottom trawl survey (August–September) from 1985 to 2019. Since 2005 this is part of the Ecosystem survey (Eco–NoRu–Q3 (BTr)). In 2009–2011, 2014–2015 and 2019-2021, there was insufficient number of age readings to derive numbers-at-age, or age readings were not available at the time of the AFWG 2022.

Year	Age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	284	12378	5576	2279	371	2064	3687	5704	9215	6413	1454	1387	696	22	51530
1993	32	10704	5710	5142	1855	1052	1314	3520	2847	2757	2074	1245	844	119	39215
1994	429	1150	3418	2393	1723	1106	1714	1256	1938	1596	2039	484	550	319	20115
1995	600	1600	6400	5100	1800	2200	1800	700	700	400	700	500	400	500	23400
1996	40	110	–	560	1050	940	930	400	1050	280	320	590	160	70	6500
1997	320	490	–	480	1500	6950	2720	1680	800	1310	550	30	–	120	16950
1998	210	1817	881	202	1555	2187	4551	1913	1010	797	49	264	73	187	15696
1999	0	760	2893	1339	3534	1037	3905	2603	762	1663	481	361	258	152	19748
2000	40	20	400	350	840	480	730	1670	620	340	510	100	80	70	6250
2001	0	40	50	450	330	790	1760	1970	3300	1200	1810	150	660	430	12940
2002	0	0	–	–	65	160	204	326	364	614	442	328	15	0	2518
2003	0	0	0	0	95	0	283	227	93	296	285	189	228	341	2035

	Age													
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
2004	0	0	0	0	0	0	359	144	362	152	343	315	316	220	2209
2005	0	50	0	0	0	73	25	286	106	191	271	167	125	152	1447
2006	0	0	0	0	0	71	0	0	233	106	174	194	305	179	1261
2007	0	0	0	0	0	513	776	399	0	0	292	1752	1759	1349	6841
2008	7844	0	0	0	0	0	0	37	98	16	18	148	86	164	8412
2009	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2010	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2011	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2012	0	40	123	2445	2105	1205	642	92	35	0	0	0	0	0	6687
2013	0	56	383	1532	3963	377	1910	1029	214	121	250	0	0	166	10000
2014	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2015	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2016	0	0	124	0	0	0	0	813	455	739	0	483	136	263	3015
2017	356	187	322	97	145	130	193	205	79	292	205	176	278	0	2667
2018	543	0	1363	4066	0	367	885	422	0	970	1625	0	0	0	10239

Table E4. *S. norvegicus* in Sub-area 1 and 2. Mean catch rates (numbers/nm) of *S. norvegicus* from the Norwegian Coastal Surveys (NOcoast-Aco-Q4; Division 2.a) in 1998-2021.

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>60	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1998	0	0	692	6632	73075	22255	22430	130161	116216	23519	2547	880	0	89	139	778	NA	43574
1999	0	7587	77067	317802	369258	165769	67222	178802	163919	20445	3642	1520	0	103	138	2144	NA	43574
2000	0	0	1856	13048	6459	13065	42990	156418	171407	29117	3036	331	191	99	144	756	503	43574
2001	0	295	2031	11787	12305	22408	14127	74790	150763	26573	1787	345	191	81	113	460	325	43574
2002	0	0	0	0	2321	7588	34283	1011 273	754947	26769	3195	513	0	109	172	3289	332	43574
2003	0	0	2579	10118	44506	72473	52479	224734	228374	62121	5536	481	0	123	160	1367	1053	43574
2004	0	937	3139	5591	21042	66182	34613	351154	552183	41851	2666	1345	0	104	130	1290	950	43574
2005	0	554	5209	4627	30272	46072	48379	189993	170639	37468	1450	0	0	99	132	833	780	43574
2006	0	0	2884	496	1738	3065	29933	144743	256394	65959	9272	0	0	112	112	771	680	43574
2007	0	0	0	0	4335	7308	17338	129412	177332	29042	1182	0	0	131	140	637	637	43574
2008	0	3644	4555	955	3957	4679	17440	362633	490611	99469	11772	1630	0	110	139	1156	850	43574
2009	0	0	6976	2285	2984	4530	39275	800208	945004	106479	6244	663	1122	114	136	2947	598	43574
2010	0	39758	77542	20364	8814	1378	2582	66948	214182	99061	7417	2454	0	117	136	833	690	43574
2011	0	3654	67407	55725	193640	35323	10043	72244	296697	107318	27832	286	0	113	104	998	571	43574
2012	0	39530	59337	95227	150260	89534	12686	58890	356556	163645	46792	4640	263	98	96	1191	778	43574
2013	0	5176	137751	72253	540679	260689	38079	34628	384207	190595	21534	3528	2091	93	95	2231	1105	43574

Length range (cm)	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	>60	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
2014	0	524	28653	89876	78267	144543	109523	47736	302185	157358	30251	2343	3361	107	108	1717	777	43574
2015	0	5081	69615	93690	193721	189891	246181	77869	202765	163442	41838	3335	0	97	103	1886	984	43574
2016	0	0	100206	49233	177926	186202	81997	49197	145043	163426	41278	869	567	99	101	1648	1153	43574
2017	0	1789	51611	101305	67426	140564	205389	191361	182391	134508	21507	1130	515	110	147	2996	1866	43574
2018	0	509	5230	16112	43173	50831	52728	124778	273489	200310	67433	4181	988	154	220	2182	1837	43574
2019	0	646	10371	6780	31170	26133	34875	145733	303319	158832	48546	1234	635	159	182	1856	1363	43574
2020	0	8763	19753	7782	16762	75324	104097	184328	200398	113592	40320	4186	475	136	201	3338	1703	43574
2021	2786	28669	51554	12878	4767	41451	78399	142549	404448	238166	60729	530	470	127	160	2482	1484	43574

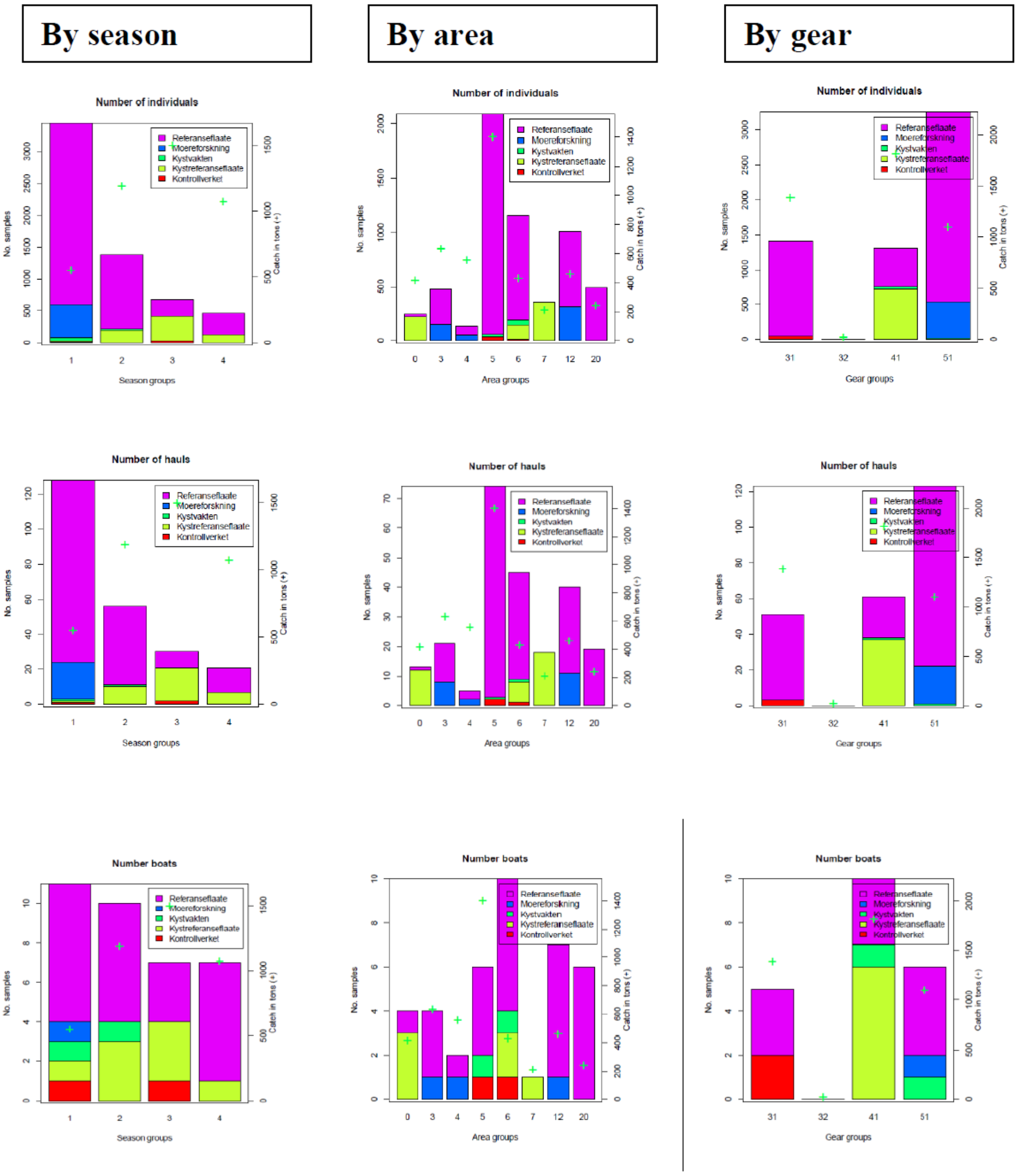


Figure E1. Overview of the Norwegian biological age samples (number individuals, number hauls/sets, number of boats) from the commercial fisheries for *S. norvegicus* in 2013 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which sampling platform has been used: High Seas Reference fleet, port sampling, Coast guard, Coastal Reference Fleet, or inspectors/observers at sea. The green crosses show the catch in tonnes for the different seasons, areas and gears.

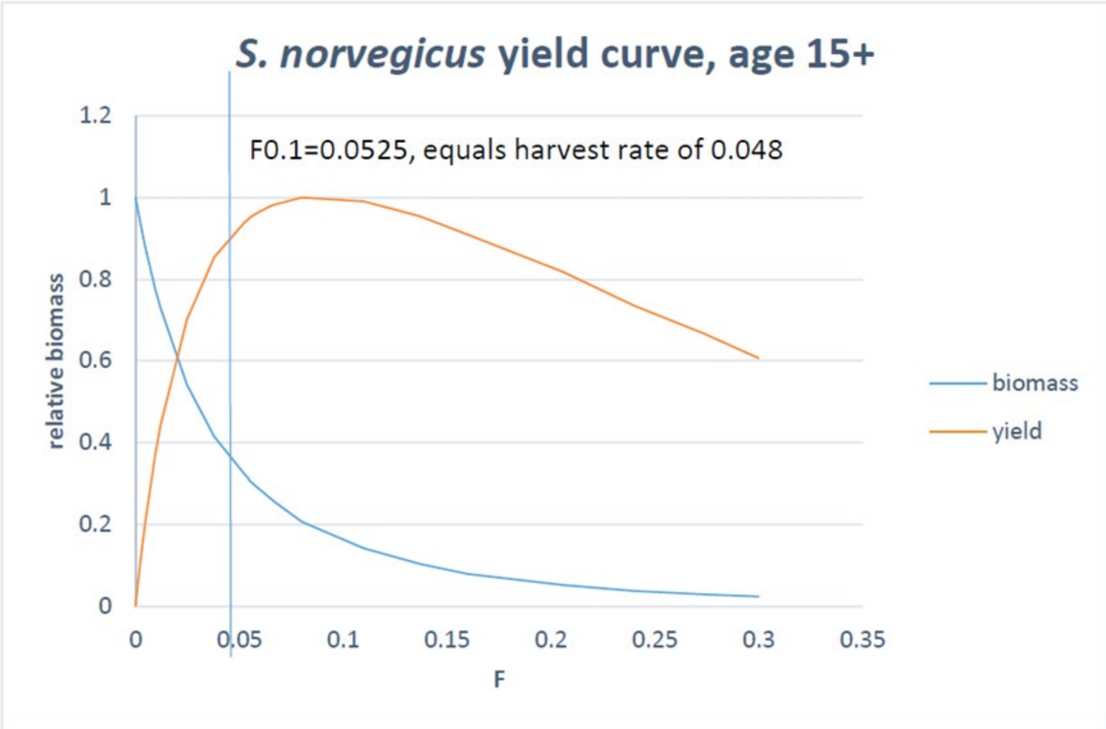


Figure E2. *S. norvegicus* in subareas 1 and 2. Yield-per-recruit for *S. norvegicus*, computed from the GADGET assessment model presented at the benchmark assessment in January 2018 (WKREDFISH, ICES 2018a).

8 Northeast Arctic Greenland halibut[1]

8.1 Status of the fisheries

8.1.1 Landings prior to 2022 (Tables 8.1–8.8, Figures 8.1–8.3)

Nominal landings by country for subareas 1 and 2 combined are presented in Table 8.1. Tables 8.2 to 8.4 give the landings for Subarea 1 and divisions 2.a and 2.b separately, and landings separated by gear type are presented in Table 8.5. For most countries, the landings listed in the tables are similar to those officially reported to ICES. Some of the values in the tables vary slightly from the official statistics and represent those presented to the Working Group by the members. Catch per unit effort is presented in Table 8.6 and total catch from 1935 to now in Table 8.7 and Figure 8.1.

The preliminary estimate of the total landings for 2021 is 28 431 t. This is 282 t less than the landings in 2020 and about 5431 t more than the ICES advised maximum catch for 2021 (23 000 t). The catches from most countries remained stable, compared to 2020. Combined landings exceeded the quotas set by the Joint Russian-Norwegian Fisheries Commission for 2021 by 1431 t (total TAC 27 000 t). One explanation is the difficulties in bycatch regulation. Also, catches in the report include all landings in ICES 1 and 2, and thus include catches in EU waters in the southern part of ICES 2.

Some fishing for Greenland halibut has taken place in the northern part of Division 4.a during the past 20–30 years, varying between a few tonnes and up to 1670 t in 1995 and 2577 in 1999. From 2005 to 2011 this catch was mostly below 200 t, taken mostly by Norway, France, and the UK. Preliminary numbers show 144 t in 2021, a reduction from 719 t the year before mainly due to that the Norwegian trawl fleets did not have access to British waters in 2021 (Table 8.8, Figures 8.2 and 8.3). Although there is a continuous distribution of this species from the southern part of Division 2a along the continental slope towards the Shetland area, the stock structure is unclear in this area and these landings have therefore not been added to the total from subareas 1 and 2. Recent mark-recapture and genetic investigations indicate that the stock might have a more south and westward distribution than the current ICES definition of the stock boundaries (Albert and Vollen, 2015; Westgaard *et al.*, 2016).

8.1.2 ICES advice applicable to 2021–2023

The roll over advice from ICES for 2021 was as follows:

ICES advises that when the precautionary approach is applied, catches in 2020 should be no more than 23 000 tonnes. This corresponds to a harvest rate of ≈0.036. All catches are assumed to be landed.

Last advice:

ICES advises that when the precautionary approach is applied, catches in the year 2022 should be no more than 19 094 tonnes and catches in the year 2023 should be no more than 18 494 tonnes.

---

[1] Greenland halibut (*Reinhardtius hippoglossoides*) in subareas 1 and 2 (Northeast Arctic); ghl.27.1-2.

8.1.2.1 Additional considerations

A benchmark and data workshop process led to an agreed analytic assessment in 2015.

A benchmark meeting (WKBUT; ICES 2013/ACOM:44) was held for the Northeast Arctic (NEA) Greenland halibut in 2013, but the benchmark process was prolonged due to problems with data. A data workshop was conducted in November 2014 (DCWKNGHD ICES CM 2014/ACOM:65), followed by a benchmark by correspondence that ended in 2015. The assessment is reported in the benchmark by correspondence (IBPHALI; ICES CM 2015/ACOM:54) and in the stock annex.

A new benchmark is planned in early 2023.

8.1.3 Management

The 38th JRNFC's session in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established the TAC at 15 000 t for the next three years (2010–2012). The 40th JRNFC Session in 2011 decided to increase the TAC for 2012 up to 18 000 t, and at the 42nd JRNFC Session in 2012, the TAC for 2013 was increased to 19 000 t. The 43rd and 44th sessions kept the same TAC for 2014 and 2015. For 2016 and 2017 TAC was set to 22 and 24 thousand tonnes, respectively. The TAC for 2018 was 27 thousand tonnes and the same for 2019, 2020 and 2021.

The TAC for Greenland halibut set by JNRFC applies to catches in ICES areas 1, 2a and 2b, except the Jan Mayen EEZ and the part of the EU EEZ which is north of 62°N.

In 2021 catches of 32 tonnes were taken in the Jan Mayen area (within ICES Subarea 2), where Greenland halibut fisheries are not regulated by TAC.

Norway previously had a quota for Greenland halibut in the EU EEZ which could be fished in ICES areas 2a and 6. Thus this TAC was given partly within and partly outside the stock boundary. This area is now in UK EEZ and there was no agreement for quota to Norway in this area for 2021. Norway and UK now have agreement on 600 t quota to Norway in area 2a, 4, 5b, 6 in 2022, with only longline fisheries allowed in area 6. There is no ICES separate advice for the fishery in this area.

The TAC sat by EU for 2020 applied to "Union waters of 2a and 4; Union and international waters of 5b and 6" were allocated to Norway with the footnote "To be taken in Union waters of 2a and 6. In 6, this quantity may only be fished with longlines (GHL/*2A6-C)." Additionally EU had sat another TAC in "International waters of 1 and 2(GHL/1/2INT)" and a minor quota in "Norwegian waters of 1 and 2 (GHL/1N2AB.)", both with the footnote "Exclusively for bycatches[2].

EU has sat a TAC of 629 t for 2021 to be taken in Union waters of 2a and 6. In 6, this quantity may only be fished with longlines. EU has sat 1800 t TAC in international waters of ICES 1 and 2, exclusively for bycatches. No directed fisheries are permitted under this[3].

EU has sat a TAC of 2571 t for 2022 in area6; United Kingdom and Union waters of 4; United Kingdom waters of 2a and United Kingdom and international waters of 5b (GHL/2A-C46)[3].

Further information on regulations is found in the Stock Annex.

---

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0123&from=EN

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32021R0092&from=EN

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32022R0515&qid=1650982320384&from=en

8.1.4 Expected landings in 2022

Catches in 2021 were 28 431 t, and exceeded the TAC sat by JRNFC. The total Greenland halibut landings in the Barents Sea and adjacent waters (ICES Subarea 1 and divisions 2a and 2b) in 2022 may thus be higher than the JRNFC TAC of 25 000 t. Discards at present are not regarded as a problem.

8.2 Status of research

8.2.1 Survey results (Tables 8.9–8.13, Figures 8.4–8.14)

Survey indices from the Russian autumn survey (Figures 8.4–8.6), the Norwegian slope survey (Figures 8.4–8.5 and 8.7–8.8), the Joint Norwegian-Russian Ecosystem survey (A5216), Eco-juv and Eco-south indices; Figures 8.9–8.10) and the Joint Norwegian-Russian Winter Survey (Figure 8.11) are given. Length distributions from these surveys are presented in Tables 8.9–8.12 and Figure 8.12. Results from Spanish surveys are presented in Table 8.13 and Figure 8.13. Results from a Polish spring survey is presented in Figure 8.14.

The Russian bottom-trawl surveys in October-December (ICES acronym: *RU-BTr-Q4*) are important since they usually cover large parts of the total known distribution area of the Greenland halibut within 100–900 m depth. However, it has been considered imprudent to use 2002, 2003 and 2013 data from this survey series. During the 2002 survey, no observations were available from the Exclusive Economic Zone of Norway (NEEZ). In 2003, observations on the main spawning grounds were conducted three weeks later than usual because access to NEEZ was obtained too late. The number of trawl stations was also insufficient due to the same reason. Due to technical problems indices in 2013 were not obtained. Technical and practical changes were made in 2003. In 2017 and 2019 the coverage was insufficient. The 2020 estimate was not considered appropriate to use due to gear-related problems during the survey. A working document with a revision of the Russian index was provided to the 2021 meeting (Russkikh WD12). Revised and recalculated length distributions were not implemented in the 2021 assessment but will be subject to the upcoming benchmark. Length distributions by year for this survey are given in Table 8.9. The biomass indices for this survey increased steeply from 2005 to 2011, but have mainly showed a downward trend since then (Figures 8.4 and 8.5).

Total biomass indices from the Norwegian autumn slope survey (*NO-GH-Btr-Q3*) showed an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 until it increased again in 2009 but levelled out again in 2011, 2013, and 2015 (Figures 8.4–8.5, and 8.7–8.8). Since then, there has been a downward trend until 2020 when the index was at its lowest since the start of the survey. In 2021 there was an increase in the index but it is still among the lowest estimates in the time series. The length distributions from this survey (Figure 8.12, Tables 8.10 and 8.11) show modes that can be followed through the years and indicate new recruitment to the adult stock in 2007. Since then, no such large recruit events are apparent in the length distributions, and since 2009 abundance of fish in adult lengths has been declining s as well. This survey was conducted every year during 1994–2009 but is now run biennially.

The Joint Ecosystem Survey in autumn (A5216; *Eco-NoRu-Q3 (Btr)*) covers a large part of the Barents Sea down to 500 m and concerning Greenland halibut it can be regarded to be in the areas where mainly juveniles and immature fish are found. Two indices for Greenland halibut are based on the Joint Ecosystem Survey in the Barents Sea and previous juvenile survey, one for juvenile areas (Figure 8.9) denoted Eco-juv index in the northernmost survey area, and another denoted Eco-south index defined by the survey area south from 76.5°N and west of Spitsbergen (Figure 8.10). The juvenile index, covering the juvenile area (see section 8.3), indicates a highly variable recruitment success with years between good year classes. The trend has mainly been downward since around 2007 and the 2015 estimates are the lowest registered so far, followed by a minor peak in 2017. The juvenile index has increased the last two years and is now around average for the time series. The Eco-south index for both females and males showed an increasing trend until 2012, followed by a decrease since then. The 2018 estimate in the Eco-south index was excluded from the 2021-assessment. The abundance estimate in 2018 peaked to extend that can be considered unrealistic for a slow-growing species. Additionally, there are concerns about the quality of the estimate due to the lack of survey coverage in 2018, especially in the area south of 76.5°N as defined for the Eco-south index. The male index shows a similar trend except the increase started a year later, in 2016 - 2018, but is also down in 2019. The general downward trend continues in 2021. Length distributions by year for this survey are given in Table 8.11.

The joint winter survey in the Barents Sea (*Eco-NoRu-Q3 (Btr)*) has been run from 1986 to the present (jointly with Russia since 2000, except 2006 and 2007). The survey mainly covers depths of 100–500 m and does not cover the deeper slope areas. Spatially, the survey focuses on the central Barents Sea, and west of Svalbard for some years. The northward coverage is limited by sea ice in some years. It is conducted in February and can thus give information on the stock at a different time of the year, as the other surveys are run in autumn. The biomass index has shown an increasing trend since 2004 with large variations in recent years. This survey is not currently used in the assessment.

The Spanish bottom-trawl survey, (Table 8.13, Figure 8.13) was carried out on a new hired commercial vessel and some changes have been done in the initial standard protocol. The indices for Greenland halibut from earlier Spanish surveys (1997–2005) cannot be standardized with more recent ones (2008 to present, Basterretxea *et al.*, WD13 2013). This means that biomass estimates from the survey are only available for years 2008 and onwards. The Spanish survey has since 2015 only been run in autumn. This survey is not conducted every year. The biomass index from the Spanish survey shows a downward trend since around 2012. This survey is not currently used in the assessment.

Polish bottom-trawl surveys on Greenland halibut were carried out in the Svalbard-Bear Island area (ICES 2b) in October 2006, April 2007, April 2008, June 2009, and March 2011. The main objectives of the survey were to determine the biological structure, distribution, density and standing biomass of Greenland halibut in the survey area (Trella and Janusz, WD6 ICES AFWG 2012). The survey has not been conducted since then. Polish survey index is shown in Figure 8.14, no new data were presented to the meeting. This survey is not currently used in the assessment.

8.2.2 Commercial catch-per-unit-effort (Table 8.6, Figure 8.15)

The CPUE series for the stock was subject to the last benchmark and following data workshops (see reports from WKBUT 2013, DCWKNGHD 2014 and IBPHALI 2015, and working documents by Bakanev (WD14 WKBUT 2013) and Nedreaas (WD 2 DCWKNGHD 2014); Figure 8.15). An alternative CPUE series for the Russian fisheries for the years 2004–2015 was presented at the 2016 meeting (Mikhaylov, WD14 ICES AFWG 2016). It shows some discrepancies compared to the previous CPUE series used for the Russian fisheries for the same years. See the Stock Annex for further comments. The CPUE series are not currently used in the assessment.

8.2.3 Age readings

Based on the scientific understanding that the species is slower growing and more vulnerable than the previous age readings suggest, the Norwegian age reading methods were changed in

2006. The new Norwegian age readings are not comparable with older data or the Russian age readings.

The report from Workshop on Age Reading of Greenland Halibut (WKARGH) 14–17 February 2011 (ICES CM 2011/ACOM:41) described and evaluated several age reading methods for Greenland halibut.

The different methods can be classified into two groups: A) Those that produce age–length relationships that broadly compare with the traditional methods described by the joint NAFO-ICES workshop in 1996 (ICES CM 1997/G:1); and B) Several recently developed techniques that show much higher longevity and approximately half the growth rate from 40–50 cm onwards compared to the traditional method.

A second workshop on age reading of Greenland halibut (WKARGH 2) was conducted in August 2016 and worked on further validation on new age reading methods. The workshop recommended that two of the new methods can be used to provide age estimations for stock assessments. Further, recognizing some bias and low precision in methods, the WKARGH2 suggested that an aging error matrix or growth curve with error be provided for use in future stock assessments (WKARGH2 report 2016, ICES CM 2016/SSGIEOM:16).

WKARGH2 recommends regular inter-lab calibration exercises to improve precision (i.e. exchange of digital images between readers for each method and between methods).

AFWG suggests that Russian and Norwegian scientists and age readers meet to work out issues of disagreements on Greenland halibut aging.

8.3 Data used in the assessment

In the assessment, the catch data are split into four aggregated fleets by gear and countries. Longline/gillnet fleets include landings from gillnet, longline, and handline. Trawl fleets include landings from bottom trawl, purse-seine (very minor catches, can be bycatch or misreporting) and Danish seine. Catch in tonnes and length distributions per quarter per fleet per sex from 1992–2020 are used in the assessment. Fleets are split between Norwegian (including 3rd countries) and Russian catches, and selectivities are allowed to vary by sex (logistic for gill fleets, asymmetric dome-shaped for trawl fleets), to account for sexual dimorphism influencing vulnerability to fishing. For each fleet listed below, length distributions and reported catch in tonnes are split by quarter and sex (although length distributions are not available for all quarters for some fleets).

- Russian, trawl and minor gears (split by sex)
- Russian, gillnet and longline (split by sex)
- Norwegian and 3rd countries, trawl and minor gears (split by sex)
- Norwegian and 3rd countries, gillnet and longline (split by sex)

In addition, the model has four surveys, all modelled with asymmetric dome-shaped selectivities (note that in a model context "selectivity" encompasses all aspects of vulnerability to the fishery, including gear effects, vessel effects, area effects etc.). In each case, data are used as length distribution and biomass index. The biomass index was not available to split by sex for all years, so a combined sex index is used. The four survey indices that go into the current assessment are:

- Norway slope (*NO-GH-Btr-Q3*)– based on the Norwegian Greenland halibut slope survey (yearly 1996–2009, biennially since then). Split by sex.
- EcoJuv - a juvenile index based on data from the northern/northeastern areas of the Joint Ecosystem survey (A5216; *Eco-NoRu-Q3 (Btr)*; 2003–present) and the precursory Norwegian juvenile Greenland halibut survey north and east of Svalbard (1996–2002; Hallfredsson and Vollen, WD 1 ICES IBPhali 2015). Split by sex.

- EcoSouth - an index for the Barents Sea south of 76.5°N, based on data from the Joint Ecosystem survey (A5216; *Eco-NoRu-Q3 (Btr)*; 2003–present; Hallfredsson and Vollen, ICES AFWG, WD 20, April 2015). Split by sex.
- Russian - Russian bottom-trawl survey in the Barents Sea (1992–2015 and 2017; *RU-BTr-Q4*). Sex aggregated (can be split by sex in future work).

No age data or CPUE indices are used in the tuning.

8.4 Methods used in the assessment

A new assessment method with a length-based GADGET model was benchmarked in 2015 (IPHALI 2015) and accepted by ACOM the same year. The model is further described in the IPHALI report and the Stock Annex. Advice for the stock is given biennially and last advice applies for 2022 and 2023. Next advice year is 2023 for the years 2024 and 2025. Thus, no analytical assessment was run this year. For description of last assessment see ICES AFWG 2021 report.

8.4.1 Model settings

For last assessment see ICES AFWG 2021 report.

8.4.1.1 Estimated parameters:

For last assessment see ICES AFWG 2021 report.

8.5 Results of the assessment

For last assessment see ICES AFWG 2021 report.

8.5.1 Biological reference points

For last assessment see ICES AFWG 2021 report

8.6 Comments to the assessment

For last assessment see ICES AFWG 2021 report.

8.6.1 Future work

Further development of the assessment is needed, in consistency with conclusions of the IBPHALI benchmark and report of the external benchmark reviewer.

A new benchmark on the stock is planned for early 2023. Towards the benchmark work is ongoing on revision of all indices that go into the assessment, update of the Gadget model in new version of the program package, amongst other improvements

8.7 Tables and figures

Table 8.1. Greenland halibut in subareas 1 and 2. Nominal Catch (t) by countries (Subarea 1, divisions 2a, and 2b combined) as officially reported to ICES.

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	138	2165	0	0	0	0	0	4376	0	0	15181	0	0	23	0	21883
1985	0	0	0	239	4000	0	0	0	0	0	5464	0	0	10237	0	0	5	0	19945
1986	0	0	42	13	2718	0	0	0	0	0	7890	0	0	12200	0	0	10	2	22875
1987	0	0	0	13	2024	0	0	0	0	0	7261	0	0	9733	0	0	61	20	19112
1988	0	0	186	67	744	0	0	0	0	0	9076	0	0	9430	0	0	82	2	19587
1989	0	0	67	31	600	0	0	0	0	0	10622	0	0	8812	0	0	6	0	20138
1990	0	0	163	49	954	0	0	0	0	0	17243	0	0	4764	0	0	10	0	23183
1991	11	2564	314	119	101	0	0	0	0	0	27587	0	0	2490	132	0	0	2	33320
1992	0	0	16	111	13	13	0	0	0	0	7667	0	31	718	23	0	10	0	8602
1993	2	0	61	80	22	8	56	0	0	30	10380	0	43	1235	0	0	16	0	11933
1994	4	0	18	55	296	3	15	5	0	4	8428	0	36	283	1	0	76	2	9226
1995	0	0	12	174	35	12	25	2	0	0	9368	0	84	794	1106	0	115	7	11734
1996	0	0	2	219	81	123	70	0	0	0	11623	0	79	1576	200	0	317	57	14347

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1997	0	0	27	253	56	0	62	2	0	0	7661	12	50	1038	157	0	67	25	9410
1998	0	0	57	67	34	0	23	2	0	0	8435	31	99	2659	259	0	182	45	11893
1999	0	0	94	0	34	38	7	2	0	0	15004	8	49	3823	319	0	94	45	19517
2000	0	0	0	45	15	0	16	1	0	0	9083	3	37	4568	375	0	111	43	14297
2001	0	0	0	122	58	0	9	1	0	0	10896	2	35	4694	418	0	100	30	16365
2002	0	219	0	7	42	22	4	6	0	0	7143	5	14	5584	178	0	41	28	13293
2003	0	0	459	2	18	14	0	1	0	0	8216	5	19	4384	230	0	41	58	13447
2004	0	0	0	0	9	0	9	0	0	0	13939	1	50	4662	186	0	43	0	18899
2005	0	170	0	32	8	0	0	0	0	0	13011	0	23	4883	660	0	29	18	18834
2006	0	0	204	46	8	0	8	0	0	196	11119	201	26	6055	29	0	10	2	17904
2007	0	0	203	41	8	198	15	0	0	0	8230	200	47	6484	8	0	11	8	15453
2008	0	0	663	42	5	0	28	0	0	0	7393	201	46	5294	94	0	16	10	13792
2009	0	0	422	16	19	16	15	2	0	0	8446	204	237	3335	210	0	9	60	12990
2010	0	0	272	102	14	15	16	0	0	0	7700	3	11	6888	182	0	4	22	15229
2011	0	0	538	46	80	4	7	0	0	234	8270	169	21	7053	144	0	36	4	16606
2012	0	0	564	40	40	12	13	0	0	0	9331	22	1	10041	190	0	21	14	20288

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
2013	0	0	783	168	49	22	106	1	0	0	10403	30	7	10310	196	0	17	75	22167
2014	0	0	887	269	33	20	86	0	0	0	11232	19	0	10061	206	0	28	184	23025
2015	0	0	312	227	33	14	53	0	0	5	10874	13	1	12953	159	0	25	79	24748
2016	0	359	483	229	9	17	79	0	0	0	12932	8	19	10576	198	0	20	19	24948
2017	0	523	917	177	21	26	10	0	1	72	13741	27	13	10714	56	0	83	0	26380
2018	2	574	401	150	50	20	24	0	0	206	14712	27	6	12072	60	134	0	0	28438
2019	0	587	350	103	44	21	8	0	32	377	14845	122	7	12198	87	74	0	0	28824
2020	1	578	514	49	72	41	19	0	149	226	14532	97	28	12266	96	45	0	0	28713
2021*	1	382	754	137	86	14	40	0	96	159	14008	14	46	12394	124	176	0	0	28431

*** Provisional figures.**

Table 8.2. Greenland halibut in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1 as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
1984	0	0	0	0	0	0	0	0	0	593	0	0	81	0	0	17	0	691
1985	0	0	0	0	0	0	0	0	0	602	0	0	122	0	0	1	0	725
1986	0	0	1	0	0	0	0	0	0	557	0	0	615	0	0	5	1	1179
1987	0	0	2	0	0	0	0	0	0	984	0	0	259	0	0	10	0	1255
1988	0	9	4	0	0	0	0	0	0	978	0	0	420	0	0	7	0	1418
1989	0	0	0	0	0	0	0	0	0	2039	0	0	482	0	0	0	0	2521
1990	0	7	0	0	0	0	0	0	0	1304	0	0	321	0	0	0	0	1632
1991	164	0	0	0	0	0	0	0	0	2029	0	0	522	0	0	0	0	2715
1992	0	0	0	0	0	0	0	0	0	2349	0	0	467	0	0	0	0	2816
1993	0	32	0	0	0	56	0	0	0	1754	0	0	867	0	0	0	0	2709
1994	0	17	217	0	0	15	0	0	0	1165	0	0	175	0	0	0	0	1589
1995	0	12	0	0	0	25	0	0	0	1352	0	0	270	84	0	0	0	1743
1996	0	2	0	0	0	70	0	0	0	911	0	0	198	0	0	0	0	1181
1997	0	15	0	0	0	62	0	0	0	610	0	0	170	0	0	0	0	857
1998	0	47	0	0	0	23	0	0	0	859	0	0	491	0	0	2	0	1422

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
1999	0	91	0	0	13	7	0	0	0	1101	0	0	1203	0	0	0	0	2415
2000	0	0	0	0	0	16	0	0	0	1021	0	0	1169	0	0	0	0	2206
2001	0	0	0	0	0	9	0	0	0	925	0	0	951	0	0	2	0	1887
2002	0	0	3	0	0	0	0	0	0	834	0	0	1167	0	0	0	0	2004
2003	0	48	0	0	2	0	1	0	0	962	1	0	735	0	0	0.3	0	1749
2004	0	0	0	0	0	0.3	0	0	0	866	0	0	633	0	0	3	0	1503
2005	0	0	0	1	0	0	0	0	0	572	0	0	595	0	0	3	0	1171
2006	0	17	1	0	0	1	0	0	0	575	0	0	626	2	0	2	0	1224
2007	0	18	0	1	198	3	0	0	0	514	0	3	438	0	0	4	0	1179
2008	0	13	0	1	0	5	0	0	0	599	0	0	390	0	0	0	0	1008
2009	0	33	0	0	16	5	0	0	0	734	0	0	483	0	0	1	0	1272
2010	0	15	0	0	0	16	0	0	0	659	0	0	708	2	0	0	0	1399
2011	0	63	0	0	0	6	0	0	0	867	0	0	782	0	0	0	0	1718
2012	0	8	5	0	0	7	0	0	0	921	0	0	1368	1	0	7	0	2318
2013	0	39	1	8	0	100	0	0	0	1055	4	0	1442	4	0	8	0	2661
2014	0	143	8	11	19	38	0	0	0	1271	7	0	1261	10	0	14	0	2782

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
2015	0	96	14	3	12	47	0	0	5	1424	5	0	1681	8	0	4	0	3299
2016	353	84	2	3	3	38	0	0	0	1265	7	0	1172	7	0	20	0	2954
2017	519	125	4	4	2	8	0	1	72	1389	9	1	1124	13	0	21	0	3293
2018	574	104	9	16	2	20	0	0	199	1008	4	1	894	2	97	0	0	2930
2019	587	116	27	9	5	5	0	32	347	939	119	0	932	15	49	0	0	3182
2020	578	123	37	7	11	18	0	142	223	1388	96	17	787	36	1	0	0	3464
2021*	382	207	17	1	10	35	0	96	159	1617	9	14	713	14	11	0	0	3285

*** Provisional figures.**

Table 8.3. Greenland halibut in subareas 1 and 2. Nominal catch (t) by countries in Division 2a as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Greenland	Ireland	Iceland	Lithuania	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
1984	0	0	265	138	0	0	0	0	3703	0	0	5459	0	0	1	0	9566
1985	0	0	254	239	0	0	0	0	4791	0	0	6894	0	0	2	0	12180
1986	0	6	97	13	0	0	0	0	6389	0	0	5553	0	0	5	1	12064
1987	0	0	75	13	0	0	0	0	5705	0	0	4739	0	0	44	10	10586

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Greenland	Ireland	Iceland	Lithuania	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
1988	0	177	150	67	0	0	0	0	7859	0	0	4002	0	0	56	2	12313
1989	0	67	104	31	0	0	0	0	8050	0	0	4964	0	0	6	0	13222
1990	0	133	12	49	0	0	0	0	8233	0	0	1246	0	0	1	0	9674
1991	1400	314	21	119	0	0	0	0	11189	0	0	305	0	0	0	1	13349
1992	0	16	1	108	13	0	0	0	3586	0	15	58	0	0	1	0	3798
1993	0	29	14	78	8	0	0	0	7977	0	17	210	0	0	2	0	8335
1994	0	0	33	47	3	4	0	0	6382	0	26	67	0	0	14	0	6576
1995	0	0	30	174	12	2	0	0	6354	0	60	227	0	0	83	2	6944
1996	0	0	34	219	123	0	0	0	9508	0	55	466	4	0	278	57	10744
1997	0	0	23	253	0	0	0	0	5702	0	41	334	1	0	21	25	6400
1998	0	0	16	67	0	1	0	0	6661	0	80	530	5	0	74	41	7475
1999	0	0	20	0	25	2	0	0	13064	0	33	734	1	0	63	45	13987
2000	0	0	10	43	0	0	0	0	7536	0	18	690	1	0	65	43	8406
2001	0	0	49	122	0	1	9	0	8740	0	13	726	5	0	56	30	9751
2002	0	0	9	7	22	0	4	0	5877	0	3	849	0	0	12	28	6811
2003	0	390	5	2	12	0	0	0	6713	0	10	1762	14	0	5	58	8971
2004	0	0	4	0	0	0	9	0	11704	0	24	810	4	0	1	0	12556

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Greenland	Ireland	Iceland	Lithuania	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
2005	0	0	3	31	0	0	0	0	11216	0	11	1406	0	0	5	18	12690
2006	0	175	0	38	0	0	7	0	8897	0	6	950	0	0	6	2	10081
2007	0	162	2	37	0	0	12	0	6761	0	2	489	1	0	2	8	7475
2008	0	646	4	38	0	0	23	0	5566	1	1	1170	0	0	6	10	7465
2009	0	379	0	13	0	0	10	0	6456	0	9	1531	0	0	0	60	8459
2010	0	255	0	102	15	0	0	0	6426	0	0	4757	0	0	0	22	11577
2011	0	467	0	45	4	0	1	0	6637	0	0	3643	2	0	0	4	10803
2012	0	553	0	37	12	0	6	0	7934	0	0	3878	0	0	0	14	12434
2013	0	739	0	150	22	0	6	0	8215	0	2	4143	0	0	0	75	13352
2014	0	741	0	255	1	0	48	0	8640	0	0	4800	0	0	0	184	14669
2015	0	215	2	221	2	0	6	0	8166	0	1	3691	0	0	0	79	12383
2016	6	380	6	216	14	0	41	0	10073	0	6	1797	7	0	0	19	12566
2017	0	773	0	161	20	0	2	0	10122	0	7	1852	1	0	16	0	12955
2018	0	297	1	104	9	0	4	1	11226	2	5	695	0	6	0	0	12350
2019	0	232	15	94	16	0	3	0	12122	3	7	2754	3	11	0	0	15260
2020	0	385	21	34	28	0	1	0	11437	0	8	2691	0	3	0	0	14608
2021*	0	529	19	123	4	0	5	0	9647	0	5	842	5	108	0	0	11287

* Provisional figures.

Table 8.4. Greenland halibut in subareas 1 and 2. Nominal catch (t) by countries in Division 2b as officially reported to ICES.

Year	Denmark	Estonia	Faroe Islands	Fed. rep. Germ.	France	Greenland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[4]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	1900	0	0	0	0	0	80	0	0	9641	0	0	5	0	11626
1985	0	0	0	3746	0	0	0	0	0	71	0	0	3221	0	0	2	0	7040
1986	0	0	36	2620	0	0	0	0	0	944	0	0	6032	0	0	0	0	9632
1987	0	0	0	1947	0	0	0	0	0	572	0	0	4735	0	0	7	10	7271
1988	0	0	0	590	0	0	0	0	0	239	0	0	5008	0	0	19	0	5856
1989	0	0	0	496	0	0	0	0	0	533	0	0	3366	0	0	0	0	4395
1990	0	0	23	942	0	0	0	0	0	7706	0	0	3197	0	0	9	0	11877
1991	11	1000	0	80	0	0	0	0	0	14369	0	0	1663	132	0	0	1	17256
1992	0	0	0	12	3	0	0	0	0	1732	0	16	193	23	0	9	0	1988
1993	2	0	0	8	2	0	0	0	30	649	0	26	158	0	0	14	0	889
1994	4	0	1	46	8	0	1	0	4	881	0	10	41	1	0	62	2	1061
1995	0	0	0	5	0	0	0	0	0	1662	0	24	297	1022	0	32	5	3047
1996	0	0	0	47	0	0	0	0	0	1204	0	24	912	196	0	39	0	2422
1997	0	0	12	33	0	0	2	0	0	1349	12	9	534	156	0	46	0	2153
1998	0	0	10	18	0	0	1	0	0	915	31	19	1638	254	0	106	4	2996

Year	Denmark	Estonia	Faroe Islands	Fed. rep. Germ.	France	Greenland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[4]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1999	0	0	3	14	0	0	0	0	0	839	8	16	1886	318	0	31	0	3115
2000	0	0	0	5	2	0	1	0	0	526	3	19	2709	374	0	46	0	3685
2001	0	0	0	9	0	0	0	0	0	1231	2	22	3017	413	0	42	0	4736
2002	0	219	0	30	0	0	6	0	0	432	5	11	3568	178	0	29	0	4478
2003	0	0	21	13	0	0	0	0	0	541	4	9	1887	216	0	35	0	2726
2004	0	0	0	5	0	0	0	0	0	1369	1	26	3219	182	0	39	0	4840
2005	0	170	0	5	0	0	0	0	0	1223	0	12	2882	660	0	21	0	4973
2006	0	0	12	7	8	0	0	0	196	1647	201	20	4479	27	0	2	0	6600
2007	0	0	23	6	3	0	0	0	0	955	200	45	5557	7	0	5	0	6801
2008	0	0	4	1	3	0	0	0	0	1228	200	45	3734	94	0	10	0	5319
2009	0	0	10	19	3	0	2	0	0	1256	204	228	1321	210	0	8	0	3260
2010	0	0	2	14	0	0	0	0	0	615	3	11	1423	180	0	4	0	2252
2011	0	0	8	80	1	0	0	0	234	766	169	21	2628	142	0	36	0	4085
2012	0	0	2	35	3	0	0	0	0	476	22	1	4795	189	0	14	0	5537
2013	0	0	5	48	10	0	1	0	0	1133	26	5	4725	192	0	9	0	6154
2014	0	0	3	25	3	0	0	0	0	1321	12	0	4000	196	0	14	0	5574
2015	0	0	1	17	3	0	0	0	0	1284	8	0	7581	151	0	21	0	9066

Year	Denmark	Estonia	Faroe Islands	Fed. rep. Germ.	France	Greenland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[4]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
2016	2	0	19	1	10	0	0	0	0	1594	1	13	7608	183	0	0	0	9431
2017	0	4	19	17	12	3	0	0	0	2230	17	5	7737	42	0	46	0	10132
2018	2	0	1	40	30	9	0	6	0	2477	21	0	10483	58	31	0	0	13159
2019	0	0	2	2	0	01	0	0	0	1784	0	1	8512	68	14	0	0	10353
2020	1	0	6	15	8	2	0	6	3	1708	1	3	8788	60	40	0	0	10641
2021*	1	0	18	50	13	0	0	0	0	2744	5	27	10839	105	57	0	0	13859

*** Provisional figures.**

Table 8.5. Greenland halibut in subareas 1 and 2. Landings by gear (tonnes). Approximate figures, the total may differ slightly from Table 8.1.

Year	Gillnet	Longline	Trawl	Danish seine	Other
1980	1189	336	11759	-	-
1981	730	459	13829	-	-
1982	748	679	15362	-	-
1983	1648	1388	19111	-	-
1984	1200	1453	19230	-	-
1985	1668	750	17527	-	-
1986	1677	497	20701	-	-
1987	2239	588	16285	-	-

Year	Gillnet	Longline	Trawl	Danish seine	Other
1988	2815	838	15934	-	-
1989	1342	197	18599	-	-
1990	1372	1491	20325	-	-
1991	1904	4552	26864	-	-
1992	1679	1787	5787	-	-
1993	1497	2493	7889	-	-
1994	1403	2392	5353	-	-
1995	1500	4034	5494	-	-
1996	1480	4616	7977	-	-
1997	998	3378	5198	-	-
1998	1327	7395	6664	-	-
1999	2565	6804	10177	-	-
2000	1707	5029	7700	-	-
2001	2041	6303	7968	-	-
2002	1737	5309	6115	-	-
2003	2046	5483	6049	-	-
2004	2290	7135	8778	599	-
2005	1842	7539	9420	447	-

Year	Gillnet	Longline	Trawl	Danish seine	Other
2006	1503	6146	10042	205	-
2007	997	4503	9618	119	-
2008	901	3575	9285	9	8
2009	1409	4952	6583	34	18
2010	1449	5427	8165	170	10
2011	1583	5039	9351	239	15
2012	1929	5602	12130	413	5
2013	2398	5805	13791	176	0
2014	2647	6166	13673	183	0
2015	2508	6287	15445	489	18
2016	2646	7290	14333	650	304
2017	2677	7221	15774	679	29
2018	3021	6542	17367	842	20
2019	3323	7028	17046	1119	0
2020	2976	6989	17675	1044	28
2021*	2930	7385	17203	866	50

*** Provisional figures.**

Table 8.6. Greenland halibut in subareas 1 and 2. Catch per unit effort and total effort.

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-
1977	0.27	0.41	0.33	-	0.30	0.37	96	0.26	-
1978	0.21	0.32	0.21	-	0.21	0.27	123	0.17	-
1979	0.23	0.35	0.28	-	0.26	0.32	67	0.19	-
1980	0.24	0.33	0.32	-	0.28	0.33	47	0.25	-

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1981	0.30	0.36	0.36	-	0.33	0.36	42	0.28	-
1982	0.26	0.45	0.41	-	0.34	0.43	39	0.37	-
1983	0.26	0.40	0.35	-	0.31	0.38	58	0.32	-
1984	0.27	0.41	0.32	-	0.30	0.37	59	0.30	-
1985	0.28	0.52	0.37	-	0.33	0.45	44	0.37	-
1986	0.23	0.42	0.37	-	0.30	0.40	57	0.32	-
1987	0.25	0.50	0.35	-	0.30	0.43	44	0.35	-
1988	0.20	0.30	0.31	-	0.26	0.31	63	0.26	4.26
1989	0.20	0.30	0.26	-	0.23	0.28	73	0.19	2.95
1990	-	0.20	0.27	-	-	0.24	95	0.16	1.66
1991	-	-	0.24	-	-	-	134	0.18	-
1992	-	-	0.46	0.72	-	-	20	0.29	-
1993	-	-	0.79	1.22	-	-	15	0.65	-
1994	-	-	0.77	1.27	-	-	11	0.70	-
1995	-	-	1.03	1.48	-	-	-	-	-
1996	-	-	1.45	1.82	-	-	-	-	-
1997	0.71	-	1.23	1.60	-	-	-	-	-

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1998	0.71	-	0.98	1.35	-	-	-	-	-
1999	0.84	-	0.82	1.77	-	-	-	-	-
2000	0.94	-	1.38	1.92	-	-	-	-	-
2001	0.82 [11]	-	1.18	1.57	-	-	-	-	-
2002	0.85	-	1.07	1.82	-	-	-	-	-
2003	0.97 [12]	-	0.86	2.45	-	-	-	-	-
2004	0.63 [13]	-	1.16	1.79	-	-	-	-	-
2005	0.61 [12]	-	1.30	2.29	-	-	-	-	-
2006	0.57 [12]	-	0.96	2.09	-	-	-	-	-
2007	0.64 [12]	-	-	-	-	-	-	-	-
2008	0.48 [12]	-	-	-	-	-	-	-	-
2009	0.77 [13]	-	-	-	-	-	-	-	-
2010		1.57 [12]	-	-	-	-	-	-	-
2011		2.32 [12]							
2012		2.06 [12]							
2013		2.25 [12]							
2014		2.52 [12]							

[1] Side trawlers, 800–1000 hp. From 1983 onwards, stern trawlers (SRTM), 1000 hp. From 1997 based on research fishing.

[2] Stern trawlers, up to 2000 HP.

[3] Arithmetic average of CPUE from USSR RT (or SRTM trawlers) and Norwegian trawlers.

[4] Arithmetic average of CPUE from USSR PST and Norwegian trawlers.

[5] For the years 1981–1990, based on average CPUE type B. For 1991–1993, based on the Norwegian CPUE, type A.

[6] Total catch (t) of seven years and older fish divided by total effort.

[7] For the years 1988–1989, frost-trawlers 995 BRT (FAO Code 095). For 1990, factory trawlers S IV, 1943 BRT (FAO Code 090).

[8] Norwegian trawlers, ISSC-code 07, 250–499.9 GRT.

[9] Norwegian factory trawlers, ISSCFV-code 09, 1000-1999.9 GRT

[10] From 1992 based on research fishing. 1992–1993: two weeks in May/June and October; 1994–1995: 10 days in May/June

[11] Based on fishery from April-October only, a period with relatively low CPUE. In previous years fishery was carried out throughout the whole year.

[12] Based on fishery from October-December only, a period with relatively high CPUE.

[13] Based on fishery from October-November only.

Table 8.7. Greenland halibut in subareas 1 and 2. Catch history back to 1935.

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1935	1534	n/a	-	1534	1979	2843	10311	4088	17312
1936	830	n/a	-	830	1980	3157	7670	2457	13284
1937	616	n/a	-	616	1981	4201	9276	1541	15018
1938	329	n/a	-	329	1982	3206	12394	1189	16789
1939	459	n/a	-	459	1983	4883	15152	2112	22147
1940	846	n/a	-	846	1984	4376	15181	2326	21883
1941	1663	n/a	-	1663	1985	5464	10237	4244	19945

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1942	955	n/a	-	955	1986	7890	12200	2785	22875
1943	824	n/a	-	824	1987	7261	9733	2118	19112
1944	678	n/a	-	678	1988	9076	9430	1081	19587
1945	1148	n/a	-	1148	1989	10622	8812	704	20138
1946	1337	25	-	1362	1990	17243	4764	1176	23183
1947	1409	28	-	1437	1991	27587	2490	3243	33320
1948	1877	110	-	1987	1992	7667	718	217	8602
1949	198	177	-	375	1993	10380	1235	318	11933
1950	1853	221	-	2074	1994	8428	283	515	9226
1951	2438	423	-	2861	1995	9368	794	1572	11734
1952	2576	377	-	2953	1996	11623	1576	1148	14347
1953	2208	393	-	2601	1997	7661	1038	711	9410
1954	3674	416	-	4090	1998	8435	2659	799	11893
1955	3010	290	-	3300	1999	15004	3823	690	19517
1956	3493	446	-	3939	2000	9083	4568	646	14297
1957	4130	505	-	4635	2001	10896	4694	775	16365
1958	2931	1261	-	4192	2002	7143	5584	566	13293
1959	4307	3632	-	7939	2003	8216	4384	847	13447

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1960	6662	4299	-	10961	2004	13939	4662	298	18899
1961	7977	3836	-	11813	2005	13011	4883	940	18834
1962	11600	1760	-	13360	2006	11119	6055	730	17904
1963	11300	3240	-	14540	2007	8230	6484	739	15453
1964	14200	26191	-	40391	2008	7393	5294	1105	13792
1965	18000	16682	-	34751	2009	8446	3335	1210	12990
1966	16434	9768	119	26321	2010	7700	6888	641	15229
1967	17528	5737	1002	24267	2011	8270	7053	1283	16606
1968	22514	3397	257	26168	2012	9331	10041	916	20288
1969	14856	19760	9173	43789	2013	10403	10310	1454	22167
1970	15871	35578	38035	89484	2014	11232	10061	1732	23025
1971	9466	54339	15229	79034	2015	10874	12953	921	24748
1972	15983	16193	10872	43055	2016	12932	10576	1440	24948
1973	13989	8561	7349	29938	2017	13741	10714	1925	26380
1974	8791	16958	11972	37763	2018	14874	12072	1598	28544
1975	4858	20372	12914	38172	2019	14813	12198	1471	28482
1976	6005	16580	13469	36074	2020	14532	12266	1915	28713
1977	4217	15045	9613	28827	2021*	14008	12394	2029	28431

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1978	4082	14651	5884	24617					

* Provisional figures.

Table 8.8. Greenland halibut in ICES Division 4.a (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Netherlands	Total
1973	0	0	0	4	0	0	9	8	0	28	0	0	49
1974	0	0	0	2	0	0	2	0	0	30	0	0	34
1975	0	0	0	1	0	0	4	0	0	12	0	0	17
1976	0	0	0	1	0	0	2	0	0	18	0	0	21
1977	0	0	0	2	0	0	2	0	0	8	0	0	12
1978	0	0	2	30	0	0	0	0	0	1	0	0	33
1979	0	0	2	16	0	0	2	0	0	1	0	0	21
1980	0	177	0	34	0	0	5	0	0	0	0	0	216
1981	0	0	0	0	0	0	7	0	0	0	0	0	7
1982	0	0	2	26	0	0	17	0	0	0	0	0	45
1983	0	0	1	64	0	0	89	0	0	0	0	0	154
1984	0	0	3	50	0	0	32	0	0	0	0	0	85
1985	0	1	2	49	0	0	12	0	0	0	0	0	64

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Netherlands	Total
1986	0	0	30	2	0	0	34	0	0	0	0	0	66
1987	0	28	16	1	0	0	35	0	0	0	0	0	80
1988	0	71	62	3	0	0	19	0	0	1	0	0	156
1989	0	21	14	1	0	0	197	0	0	5	0	0	238
1990	0	10	30	3	0	0	29	0	0	4	0	0	76
1991	0	48	291	1	0	0	216	0	0	2	0	0	558
1992	1	15	416	3	0	0	626	0	0	+	1	0	1062
1993	1	0	78	1	0	0	858	0	0	10	+	0	948
1994	+	103	84	4	0	0	724	0	0	6	0	0	921
1995	+	706	165	2	0	0	460	0	0	52	283	0	1668
1996	+	0	249	1	0	0	1496	0	0	105	159	0	514
1997	+	0	316	3	0	0	873	0	0	1	162	0	1355
1998	+	0	71	10	0	10	804	0	0	35	435	0	1365
1999	+	0		1	0	18	2157	0	0	43	358	0	2577
2000	+		41	10	0	19	498	0	0	67	192	0	827
2001	+		43	0	0	10	470	0	0	122	202	0	847
2002	+		8	+	0	2	200	0	0	10	246	0	466

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Netherlands	Total
2003	0	0	1	+	+	+	453	0	0	+	122	0	576
2004	0	0	0	0	0	0	413	0	0	90	0	0	503
2005	0	0	2	0	0	0	58	0	0	4	0	0	64
2006	0	0	3	0	0	0	90	0	0	0	7	0	100
2007	0	1	0	0	0	0	133	0	0	1	6	0	141
2008	0	0	0	0	0	0	14	0	0	0	22	0	36
2009	0	9	22	0	0	0	5	0	0	0	129	0	165
2010	+	1	38	0	0	0	10	0	0	0	49	0	98
2011	0	1	39	0	0	0	94	0	0	0	44	0	178
2012	0	0	14	0	0	0	788	0	0	0	43	0	845
2013	0	0	25	0	0	0	122	0	0	0	174	0	321
2014	0	2	27	0	0	0	723	0	0		104	0	856
2015	0	0	34	1	0	0	1151	0	0	0	127	0	1313
2016	0	0	31	0	0	0	983	0	0	0	120	0	1134
2017	0	0	20	0	0	0	753	0	0	0	73	0	846
2018	0	0	15	0	0	0	472	0	42	0	0	0	532
2019	0	0	21	0	0	0	241	0	14	0	0	1	277

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Netherlands	Total
2020	0	0	10	0	0	0	663	0	45	0	0	1	719
2021*	0	4	19	0	0	0	0	0	121	0	0	0	144

* **Provisional figures.**

Table 8.9. Abundance indices of different length groups in Russian autumn survey.

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
1984	4837	5078	11690	21171	15167	10886	7370	6549	3751	1786	1128	483	89896
1985	4003	6748	16858	24897	23244	15702	8376	5704	3776	2054	1028	698	113088
1986	3482	6062	13765	18945	15997	10369	4839	3022	2534	1325	440	205	80985
1987	2010	4828	7228	10490	8831	5513	2123	1784	1437	645	481	421	45791
1988	3374	5111	9022	10147	10128	5828	2265	1862	1218	511	361	341	50168
1989	2030	7055	13962	17252	16790	10028	3789	1916	1279	415	200	388	75104
1990	2762	6056	12802	13061	9527	9829	4967	2094	589	312	115	119	62233
1991	1036	5012	16237	20998	17418	11728	8012	4562	814	181	122	174	86294
1992	184	2153	17185	32399	22481	12977	6229	3473	1869	502	182	106	99740
1993	-	290	3593	14782	21080	16013	6743	3341	2031	859	269	164	69165
1994	49	17	1651	12582	16203	12566	5391	3320	2019	819	188	106	54911
1995	-	38	1245	13193	20571	12445	5432	2717	1587	579	187	82	58076

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
1996*	-	11	786	13012	30573	18294	5730	1795	773	534	169	12	71689
1997	140	152	1318	7744	18504	17221	6932	3079	1952	465	195	142	57844
1998	2449	2238	2949	10847	24266	19640	11112	5946	2158	440	172	90	82307
1999	1070	2815	4632	7886	17734	18489	10158	4827	2043	529	196	74	70453
2000	1274	1698	5184	14996	24170	20721	12805	5675	3100	1228	240	143	91234
2001	1399	2887	7496	18136	34752	29886	13463	6759	3772	1511	593	369	121024
2002**	662	2033	6395	13329	19810	13135	7180	3406	1311	381	129	58	67828
2003***	955	2396	7420	13006	17160	11630	7978	5332	3541	985	485	238	71126
2004	1431	2705	11945	16937	20155	18274	12594	6948	4783	2087	813	536	99209
2005	830	3970	10726	17850	17547	15164	9726	5859	3343	1150	453	545	87163
2006****	293	1981	18471	35224	36563	26335	14138	7248	4943	1669	668	488	148021
2007	376	1431	6937	24330	26780	26086	22157	15586	7480	3786	932	628	136510
2008	463	4626	19991	28799	30062	32159	23175	11326	8368	4198	1872	1089	166129
2009	152	4919	29389	48321	45833	33915	24484	10227	6568	3032	881	616	208338
2010	146	5097	37901	66086	57863	46321	25428	10058	8612	3983	1587	1610	264692
2011	456	1285	22470	61115	78247	64186	49620	19412	11607	7226	3529	874	320025
2012	213	798	12051	49062	56704	52393	36362	13622	7533	4213	1944	1611	236506
2013*****													

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
2014	17	1697	10296	34074	45287	35861	22621	8613	5505	2227	929	427	167553
2015	318	2099	13542	35864	43551	36082	21114	10924	4472	1342	850	339	170497
2016*****													
2017	158	2198	10687	32464	61577	71590	40700	16830	7449	3483	1206	1245	249585
2018*****													
2019	144	2186	13500	27129	28572	22536	13943	5825	3080	1654	707	406	119742
2020*****													
2021*****													

*** Only half of the standard area was investigated**

**** No observations in NEEZ**

***** Observations in the NEEZ on the main spawning grounds were conducted considerably later than usual**

****** Survey was conducted by one vessel with a reduced number of trawls at depths less than 500 m**

*******No indices for 2013, 2016, 2018,2020 and 2021**

Table 8.10. Abundance indices of different length groups in Norwegian autumn slope survey (in thousands).

Year	<30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1994	0	0	0	0	1	15	23	80	197	335	645	1225	1611	2432	3431	3511	3830	3519	3940	3724	2896	3020
1995	0	0	1	3	6	15	29	86	141	242	472	931	1210	2294	3092	3840	4475	4540	4633	4321	3836	3856
1996	0	2	1	6	6	2	18	49	54	166	321	772	957	1787	2912	3769	4728	5199	5944	5644	5224	5132
1997	7	5	11	4	33	27	49	186	250	297	443	862	1009	1814	2888	3578	5451	5402	6132	5206	4125	5455

Year	<30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1998	7	2	6	15	17	22	51	103	174	219	372	504	727	1061	1491	2103	2941	3092	3609	3735	3851	4850
1999	10	4	18	15	20	40	61	75	110	174	202	377	476	862	1175	1655	2397	2543	3485	4214	3694	5274
2000	2	7	11	30	34	46	128	122	163	264	383	677	739	932	1183	1439	2038	2030	2268	2644	2846	3888
2001	21	20	35	37	77	147	274	270	440	462	724	986	1176	1373	1630	1720	2724	2655	3349	3128	3973	3999
2002	97	75	107	122	180	267	399	404	723	669	869	1026	1097	1360	1883	1870	2560	2185	3322	3450	3597	4032
2003	38	27	65	97	172	270	383	692	783	894	1214	1100	1481	1561	2082	1792	2468	2104	3193	3360	3506	3117
2004	27	15	47	125	191	402	636	639	951	1042	1092	1206	1337	1319	1398	1546	2013	1967	2638	2646	3337	3373
2005	66	104	285	317	517	765	861	1220	1492	1540	2053	2295	2293	2588	2262	2677	3041	2446	2854	2095	3056	2336
2006	12	50	80	158	258	456	849	1022	1429	1579	1603	1900	1823	1824	2015	1974	2529	2359	2350	2137	2338	2175
2007	157	96	161	359	766	1423	2508	3142	4411	5679	5346	5639	5502	5038	4600	3632	3667	3628	3278	2571	2882	2597
2008	378	384	723	1323	1763	1793	2441	2911	3249	3685	4229	4300	4257	3568	3911	3534	3020	3066	2769	2582	2639	2284
2009	31	36	93	349	505	934	1663	2660	3050	3680	4138	4885	5567	4148	5327	4639	3688	3752	3682	3410	3553	3215
2011	0	0	20	36	57	124	288	563	646	1414	1454	2228	2680	3174	3649	3750	3532	3031	3299	3991	3251	2454
2013	17	5	3	1	13	64	103	122	324	582	1022	1266	2138	2207	3553	3748	3476	4124	3717	3045	3718	3052
2015	3	24	24	36	131	318	439	721	757	1043	1253	1473	2602	2444	3776	4459	4602	4598	4371	3962	4156	3694
2017	6	20	45	54	63	144	184	328	593	365	928	955	1267	1457	1764	1983	2367	2465	2651	2569	2816	3011
2019	0	0	28	43	128	362	372	569	874	1322	1290	1424	1667	2285	2210	2168	2208	2229	2434	2119	2305	2405
2021	80	67	177	211	375	813	662	1010	1103	1156	1332	1680	1826	2338	2439	3818	3133	3597	2874	3601	3688	2875

Year	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
1994	2545	2729	2398	2092	1975	1547	1488	1103	920	788	565	702	576	523	577	370	367	386
1995	3165	3152	2963	2647	2272	1756	1586	1153	970	880	764	690	680	592	525	461	387	334
1996	4106	3638	3571	2752	2177	1568	1443	1017	867	782	512	449	538	404	391	356	281	248
1997	3644	3427	3018	2302	2111	1502	1131	1042	617	849	585	576	537	403	446	481	294	230
1998	4211	3824	3166	2988	2857	1974	1714	1515	981	1172	783	613	598	668	641	569	479	364
1999	4092	5196	4136	3909	4122	2631	2299	1787	1374	1388	895	1037	865	886	923	791	807	594
2000	3692	3681	3512	3016	3197	2388	2007	1545	1227	1327	915	1028	734	630	732	517	509	505
2001	3649	4512	4106	3005	3358	2552	2589	2147	1293	1350	1099	939	1187	684	787	612	751	603
2002	4241	3516	3966	3602	3855	2837	2511	2248	1672	1787	1239	1237	1139	808	882	604	679	474
2003	4400	3465	3808	3512	3907	3368	3035	2319	1896	1705	1612	1384	1542	1130	1350	972	994	675
2004	3535	4405	3614	3801	3249	2751	2252	1911	1493	1455	1372	1360	1284	1162	962	763	891	590
2005	2400	2734	2413	2084	2295	1882	1681	1492	1458	1168	1241	1057	1065	984	903	782	865	479
2006	2493	2125	2290	2025	2189	1790	1668	1542	1337	1159	1188	1009	925	1036	807	798	647	678
2007	2109	2249	2123	2142	1758	1609	1581	1070	1008	1044	625	938	672	558	537	526	394	469
2008	2288	2248	2229	1815	1751	1514	1150	1019	861	668	652	657	508	582	629	523	484	361
2009	2668	2944	2850	2441	2372	2233	1837	1698	1503	1135	845	962	647	858	715	607	653	609
2011	2905	2746	2602	2713	2387	1709	1704	1529	978	1179	577	649	554	440	466	315	440	550
2013	2498	2035	1905	1631	1710	1573	1424	1009	790	671	503	506	400	456	234	266	227	176

Year	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
2015	3469	2384	2546	2084	2142	1734	1336	1108	1020	899	713	621	605	495	274	289	341	291
2017	2890	2547	2501	2091	1792	1786	1532	1274	1269	1029	765	579	481	446	294	299	247	245
2019	1653	1799	1617	1490	1057	1185	846	840	670	568	461	313	304	312	231	242	179	130
2021	2949	2978	2916	2231	1852	1665	1400	1372	1159	942	934	882	622	713	613	408	387	393

Year	69	70	71	72	73	74	75	76	77	78	79	>80	SUM
1994	256	253	151	136	122	74	113	47	39	40	30	97	57444
1995	339	244	181	179	97	100	137	56	53	53	34	101	64574
1996	232	168	118	123	93	97	61	28	40	39	21	74	68887
1997	171	207	216	119	109	111	104	61	32	35	40	185	67819
1998	308	320	235	222	229	144	102	64	65	61	43	192	59786
1999	478	406	385	319	182	205	223	125	109	145	51	328	67569
2000	341	376	232	210	168	153	141	77	96	77	47	233	55187
2001	490	375	279	170	207	178	157	85	133	69	49	306	66941
2002	469	383	297	251	183	163	134	104	130	48	65	251	70069
2003	563	632	464	249	244	170	242	201	128	125	114	356	74961
2004	654	420	373	325	521	248	181	135	121	100	109	431	68415
2005	523	508	400	262	196	159	156	162	109	82	61	426	67190
2006	474	508	397	285	185	276	185	140	136	81	96	497	59886

Year	69	70	71	72	73	74	75	76	77	78	79	>80	SUM
2007	289	254	261	101	140	130	75	52	80	59	47	278	90260
2008	313	258	226	201	138	107	59	62	89	66	76	508	80851
2009	574	541	271	386	219	171	191	112	121	89	100	407	93764
2011	415	409	200	285	235	193	225	204	175	51	87	503	67066
2013	162	173	124	114	109	112	66	72	79	34	43	260	55662
2015	252	265	176	195	186	205	89	78	73	141	53	286	69236
2017	178	185	88	98	77	51	61	50	35	40	46	184	49195
2019	144	117	71	81	50	44	32	31	9	13	12	113	43056
2021	226	188	130	103	154	113	77	58	76	70	27	175	64668

***Biennial surveys since 2009.**

Table 8.11. Abundance indices of females of different length groups in Norwegian autumn slope survey (in thousands).

Year	<30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1994	0	0	0	0	1	15	23	80	196	335	643	1223	1611	2429	3426	3503	3824	3510	3934	3716	2886	3018
1995	0	0	1	3	6	15	29	86	141	242	472	930	1210	2291	3088	3837	4470	4537	4629	4317	3835	3855
1996	0	0	0	4	0	1	10	26	28	64	123	228	233	424	415	773	937	1020	1185	1151	1037	1374
1997	6	5	7	4	17	14	36	134	139	146	187	337	331	419	569	685	899	852	1169	1058	828	1226
1998	5	0	0	11	4	7	26	41	78	77	156	170	190	274	290	364	413	526	605	665	743	970
1999	2	0	1	0	7	14	19	12	41	68	93	137	117	227	285	300	336	313	496	574	533	1049
2000	1	5	6	14	16	16	44	44	65	121	155	201	229	245	268	278	374	311	303	411	410	517

Year	<30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
2001	13	6	14	15	38	61	118	123	177	167	293	411	462	355	425	376	544	477	493	379	558	673
2002	51	48	58	60	77	109	178	182	290	275	326	319	306	407	500	378	515	331	483	461	501	575
2003	25	25	27	43	100	124	182	276	413	429	532	504	512	545	610	450	552	394	539	487	523	406
2004	15	3	13	61	83	160	305	278	436	358	434	404	440	384	381	454	413	362	382	309	427	472
2005	30	24	110	99	182	258	322	464	565	537	723	758	619	630	452	633	723	467	593	293	500	329
2006	4	19	48	81	148	187	327	442	595	674	713	686	648	568	649	482	619	501	503	512	468	452
2007	85	67	104	178	371	731	1321	1539	2259	2654	2515	2403	2454	2145	1580	1242	1132	988	851	727	640	554
2008	216	210	432	698	829	958	1190	1372	1529	1597	1720	1516	1625	1069	1180	9 28	889	948	834	677	773	615
2009	13	19	33	146	210	343	662	1001	1263	1470	1491	1814	1979	1441	1752	1533	1044	1195	1037	988	922	878
2011	0	0	8	22	24	31	103	175	195	469	311	538	642	722	623	645	686	664	528	665	751	298
2013	0	0	0	0	3	11	49	30	50	186	261	246	521	286	650	509	621	693	626	664	745	576
2015	0	7	7	19	67	149	183	304	380	358	391	377	491	387	549	490	682	904	632	689	761	766
2017	4	17	16	43	44	79	83	120	267	117	395	312	365	373	288	411	524	444	6277	453	439	579
2019	0	0	16	25	92	119	183	300	360	500	527	498	604	609	512	517	426	558	489	503	541	479
2021	41	15	96	105	239	423	355	536	475	484	450	595	551	475	592	450	522	539	450	733	744	591

***Biennial surveys since 2009.**

Year	51	52	53	54	55	56	57	58	69	60	61	62	63	64	65	66	67	68	69	70	71	72	73
1994	2535	2719	2384	2088	1969	1545	1482	1098	917	785	560	700	571	522	573	368	364	385	254	253	151	136	122
1995	3162	3145	2958	2646	2271	1752	1586	1152	968	875	761	689	680	592	525	461	387	333	339	244	181	179	97

Year	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**69**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**
1996	1044	886	895	771	527	547	639	548	508	602	410	401	481	383	387	344	281	230	232	167	118	123	93
1997	911	985	824	650	669	590	523	562	346	633	484	501	506	364	433	437	289	225	171	207	216	119	109
1998	995	1043	999	1056	903	758	754	831	667	907	615	543	569	639	638	567	453	362	308	307	235	222	225
1999	830	1105	928	1042	1287	1019	1002	955	845	1106	754	927	816	814	890	780	798	582	478	403	384	317	182
2000	590	591	593	663	756	816	704	649	670	839	699	829	620	588	665	487	491	495	328	376	230	210	167
2001	479	632	761	643	680	698	962	877	743	936	928	714	1062	594	772	577	746	598	488	370	279	170	207
2002	610	438	638	694	823	672	824	779	780	989	780	1024	813	705	827	598	656	443	458	383	295	251	183
2003	604	582	662	611	968	854	1111	964	1057	1126	1260	1165	1314	1085	1278	938	962	670	555	625	462	249	242
2004	461	638	570	693	760	937	876	839	966	998	1202	1186	1227	1116	932	749	885	585	639	420	373	325	461
2005	378	411	427	451	597	638	775	718	800	871	935	938	965	904	860	740	860	449	523	465	390	262	192
2006	490	458	461	392	537	523	545	678	805	796	893	865	820	927	775	768	637	633	468	499	376	285	178
2007	476	499	471	491	469	533	607	549	566	776	494	790	587	534	517	515	394	469	278	254	261	101	133
2008	509	481	515	495	443	547	441	543	466	490	530	572	482	539	610	514	483	361	309	252	226	201	138
2009	640	665	738	639	733	724	698	783	814	605	653	765	534	776	701	525	616	587	561	526	263	378	219
2011	557	468	480	472	466	369	329	469	324	378	341	523	477	348	450	300	415	550	393	409	192	285	235
2013	518	381	477	308	375	529	526	304	296	334	324	377	329	390	218	260	227	174	159	173	120	114	109
2015	826	770	744	579	811	649	471	494	553	537	470	462	420	450	270	283	339	283	251	265	176	195	186
2017	530	438	516	448	392	555	578	498	563	530	473	330	378	371	271	286	243	245	178	185	88	98	77

Year	51	52	53	54	55	56	57	58	69	60	61	62	63	64	65	66	67	68	69	70	71	72	73
2019	401	481	431	494	351	391	324	458	402	367	277	254	260	257	210	218	174	123	143	114	71	81	50
2021	623	672	574	541	506	440	555	692	687	603	721	741	557	676	585	382	387	379	226	188	130	103	154

***Biennial surveys since 2009**

Year	74	75	76	77	78	79	>80	SUM
1994	74	113	47	39	40	30	95	51911
1995	100	137	56	53	53	34	99	58202
1996	92	61	28	40	39	21	74	18961
1997	111	104	61	29	35	40	185	20387
1998	144	102	64	65	61	43	192	19839
1999	205	223	125	109	140	47	328	22940
2000	153	141	77	96	77	47	233	17914
2001	178	157	85	131	69	49	306	22069
2002	163	131	104	130	48	65	251	21985
2003	170	242	201	128	125	114	356	28378
2004	241	181	135	119	100	109	431	25728
2005	149	156	152	109	82	61	426	24995
2006	259	185	138	136	81	96	491	24521
2007	124	75	52	80	59	47	275	38016
2008	107	59	62	89	66	76	506	32917

Year	74	75	76	77	78	79	>80	SUM
2009	171	191	104	121	80	100	385	36529
2011	193	225	204	175	51	87	503	18768
2013	112	66	72	79	34	43	260	14415
2015	205	89	78	73	141	53	286	20002
2017	51	61	50	35	40	46	184	20388
2019	44	32	31	9	13	12	113	14444
2021	113	77	58	76	70	27	175	21179

***Biennial surveys since 2009.**

Table 8.12. Abundance indices (numbers in thousands) from bottom-trawl surveys in the Barents Sea standard area winter (Mehl *et al.*, WD4 AFWG 2019).

	Length group (cm)															Biomass
Year	≤14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	≥80	Total	(tonnes)
1994	0	0	21	76	148	1117	3139	4740	3615	1941	889	541	21	0	0	16248	19228
1995	298	0	0	0	90	129	2877	7182	5739	2027	1622	839	489	86	0	21378	27459
1996	4121	0	0	0	62	124	1214	4086	4634	1871	1112	638	337	74	12	18285	20256
1997[1]	0	68	0	0	55	163	949	4313	5629	2912	1609	643	300	65	21	16728	24214
1998[1]	68	220	945	578	481	487	1088	4016	6591	3076	1798	707	326	93	44	20518	27248
1999	43	84	241	436	566	269	784	1701	3097	1669	1094	491	89	75	0	10640	14681
2000	140	184	344	836	1722	3857	2253	1560	2144	1714	1191	615	249	76	0	16883	17246
2001	68	49	147	179	737	1525	3716	3271	2302	2010	1088	529	160	50	39	15871	18224

Year	Length group (cm) ≤14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	≥80	Total	Biomass (tonnes)
2002	271	0	70	34	382	1015	1916	3803	3250	2279	1138	976	242	159	114	15648	21198
2003	51	0	74	19	304	715	1842	3008	4765	2235	714	561	245	146	0	14678	19635
2004	106	104	15	0	319	1253	1229	1717	2277	1227	798	298	148	94	26	9615	11872
2005	263	70	159	1139	2235	2621	4206	3782	3847	2037	917	585	336	118	0	22314	22293
2006[2]	0	72	94	414	1968	5149	4613	5743	4283	2132	891	449	258	34	18	26118	25579
2007[1]	0	18	146	1869	1418	3114	5710	5947	4287	2205	963	658	391	80	89	26896	28006
2008	0	0	0	243	1708	5974	4654	6136	5198	3403	827	638	174	82	50	29088	30153
2009	55	0	0	26	1044	4327	8133	4551	4084	2266	996	627	442	253	154	26960	28919
2010	0	0	0	99	678	3648	5729	6560	4897	2467	1064	552	229	128	41	26092	25979
2011	51	0	0	0	216	4396	5864	5498	5237	3698	699	936	327	252	97	27271	31552
2012[3]	77	0	0	0	51	1145	4524	5366	4517	2774	1147	195	73	0	48	19917	22656
2013	0	0	0	0	0	511	5368	4868	5374	3687	1944	939	348	131	154	23504	31748
2014	0	0	46	92	156	368	2271	5587	5903	3555	2251	1369	154	260	79	22090	31112
2015	367	0	61	0	284	1612	3187	6452	7249	6752	3350	1936	587	334	0	32172	46828
2016	205	0	124	511	950	1953	3486	4539	5479	5613	1999	1973	646	98	80	27657	35831
2017[4]	52	0	0	78	592	1328	1885	3850	4852	4550	1721	1455	317	190	23	20827	29756
2018	0	0	62	0	383	1333	2049	3445	4258	3573	1904	1366	736	196	20	19325	28688

	Length group (cm)															Biomass
Year	**≤14**	**15–19**	**20–24**	**25–29**	**30–34**	**35–39**	**40–44**	**45–49**	**50–54**	**55–59**	**60–64**	**65–69**	**70–74**	**75–79**	**≥80**	**Total**	**(tonnes)**
2019	0	0	0	375	272	1671	3285	4034	5177	4265	3570	2526	1328	535	137	27176	45912
2020[3]	80	91	2464	442	790	2272	4391	5136	4929	4613	3278	1803	894	384	250	29599	43631
2021[3]	0	154	927	927	2370	2976	3869	4265	3516	2991	2378	1649	670	682	238	27613	37090

[1] **Indices raised to also represent the Russian EEZ**

[2] **Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005**

[3] **Indices not raised to also represent uncovered parts of the Russian EEZ.**

[4] **Indices raised to also represent uncovered parts of the Russian EEZ**

Table 8.13. Greenland halibut catch in weight, numbers, and biomass (in tonnes) and abundance (in thousands) estimated from Spanish autumn and spring surveys. NB. Absolute biomass and abundance values must not be compared between spring and autumn surveys due to different gears. The trawl used during spring surveys is considered less efficient on benthic species as Greenland halibut and skates, and better to catch species less associated with bottom.

Autumn survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance ('000)
1997	195056	211533	344014	379444
1998	180974	187259	351466	373149
1999	198781	172687	436956	377792
2000	169389	140355	340619	291265
2001	152681	129289	283511	249219
2002	144335	115213	256460	207466
2003	151952	132117	283644	256327
2004	153859	135631	320485	283965
2005	144573	134566	317320	313459
2008	91573	101578	129221*	144561*
2010	167862	182464	191510*	216731*
2012	178607	174670	336543*	339697*
2013	172762	168619	264101*	267548*
2014	175553	160557	321485*	307679*
2016	176015	142413	247644*	214778*
2019	50880	45631	209439*	187830*

No survey in 2006, 2007, 2009, 2011, 2015, 2017, 2018, 2020 and 2021.

***New swept-area estimation method**

Spring survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance ('000)
2008	96797	109515	38406	38951
2009	200299	222018	58273	65464
2011	136610	160566	98142	117666
2015**	111425	105385	150385	155333

No survey in 2010, 2012, 2013 and 2014.

****Different from the one used during the 2014 Spanish "autumn" survey.**

Table 8.14. Greenland halibut in subareas 1 and 2. The catch scenarios. Weights in tonnes. Assessment 2021 as basis for advice for 2022 and 2023. NB. according to working group forecast, this may diverge slightly from final advice by ACOMTAC for 2021 from EU/UK was not sat at the time of the working group and TAC change is thus relative only to the TAC sat by JRNFC.

Table a Greenland halibut in subareas 1 and 2. Annual catch scenarios for 2022. All weights are in tonnes.

Basis	Total catch (2022)	HR_{total} (2022)	Biomass 45 cm+ (2023)	% Biomass 45 cm+ change *	% TAC change **	% Advice change ***
ICES advice basis						
HR = 0.035	19094	0.035	535	−5%	−29%	−17%
Other scenarios						
HR = 0	0	0	554	−1%	−100%	−100%
HR = 0.025	13873	0.025	540	−4%	−49%	−40%
Catch_SQ (HR=0.052/0.055)	28713	0.052/0.055	526	−6%	6%	25%

* Biomass 45 cm+ 2023 relative to 2022 (561 tonnes).

** Advice in 2022 relative to TAC in 2021. Only TAC sat by JRNFC in 2021 (27 000 tonnes) was available.

*** Advice value for 2022 relative to the advice value for 2021.

Table b Greenland halibut in subareas 1 and 2. Annual catch scenarios for 2023. All weights are in tonnes.

Basis	Total catch (2023)	HR_{total} (2023)	Biomass 45 cm+ (2024)	% Biomass 45 cm+ change *	% Advice change **
ICES advice basis					
HR = 0.035	18494	0.035	523	−2%	−3%
Other scenarios					
HR = 0	0	0	558	1%	0%
HR = 0.025	13590	0.025	533	−1%	−2%
Catch_SQ (HR=0.052/0.055)	28713	0.052/0.055	505	−4%	0%

* Biomass 45cm+ 2024 relative to 2023 (biomass 2023 depends on scenario).

** Advice value for 2023 relative to the advice value for same scenario in 2022.

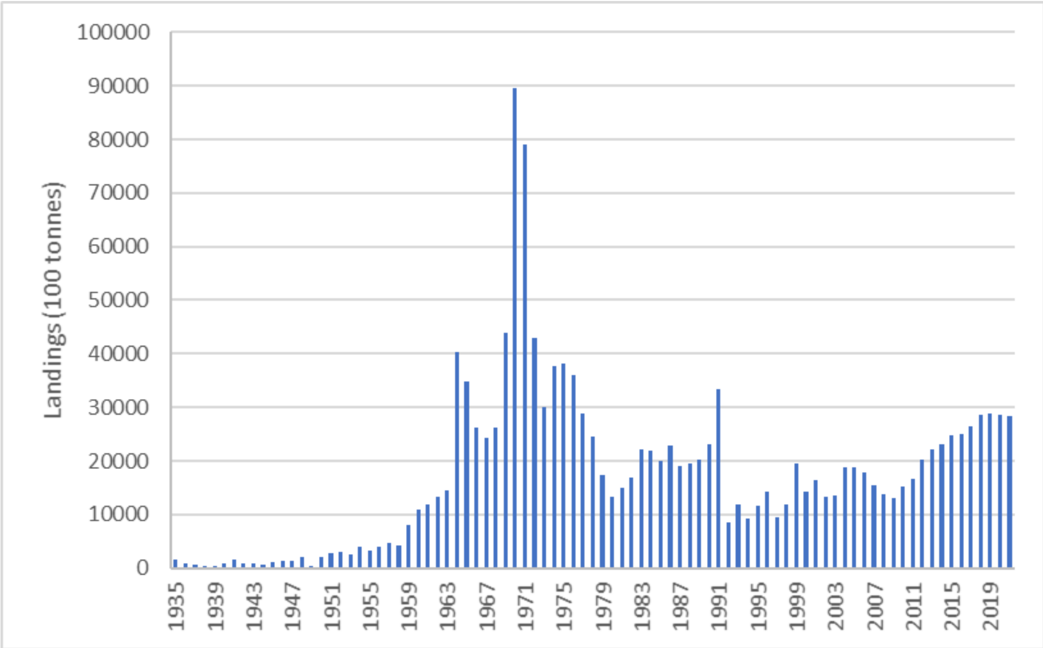


Figure 8.1. NEA Greenland halibut landings. Historical landings (Nedreaas and Smirnov 2003 and AFWG).

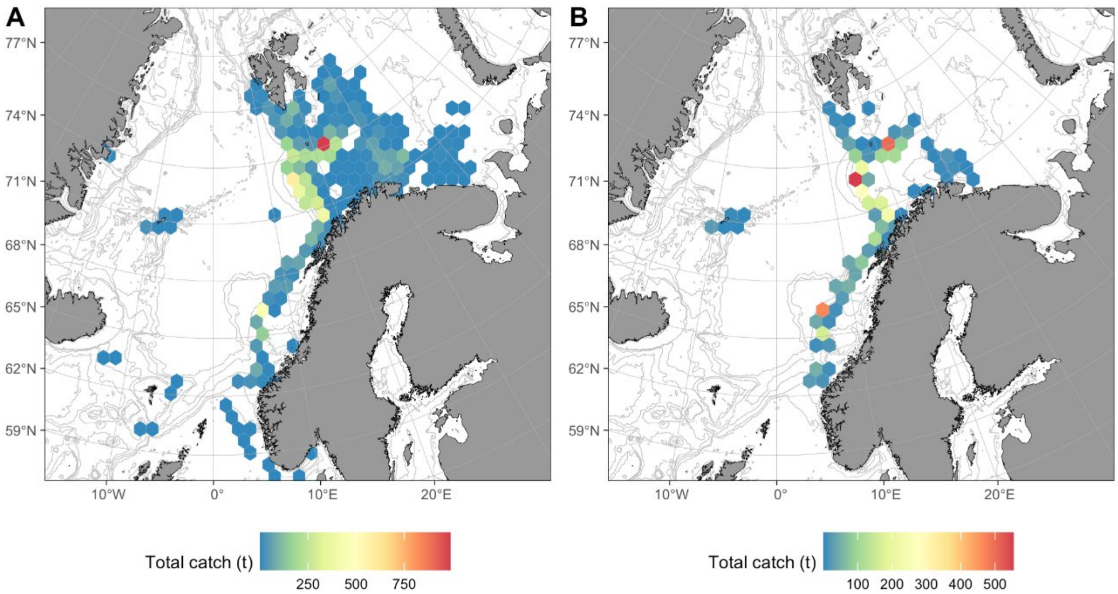


Figure 8.2. Spatial distribution of Greenland halibut catches in 2021 according to Norwegian electronic logbooks, in all registered fisheries including bycatch (A), and catches where G. halibut make more than 50% of the total catches (B).

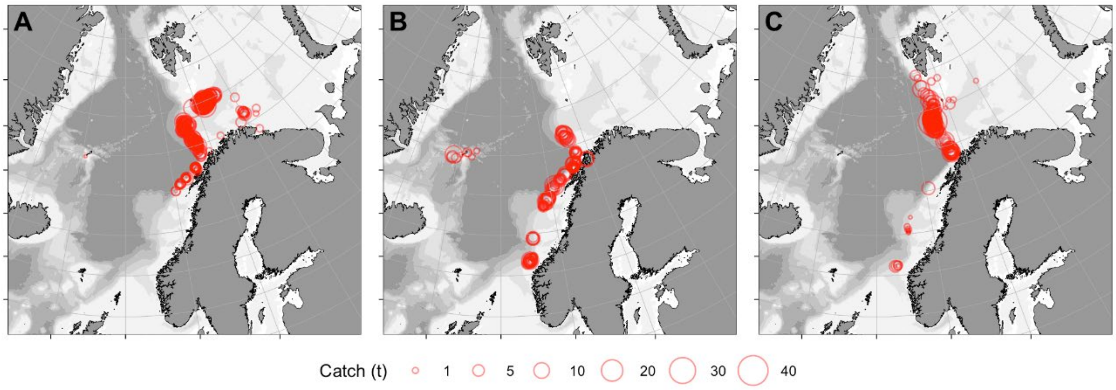


Figure 8.3. Spatial distribution of catches where Greenland halibut make more than 50% of the total catches, according to Norwegian electronic logbooks from 2021. Bubble area is proportional to the size of single catches expressed in metric tonnes. The panels show longline (A), gillnet (B) and trawl (C) catches.

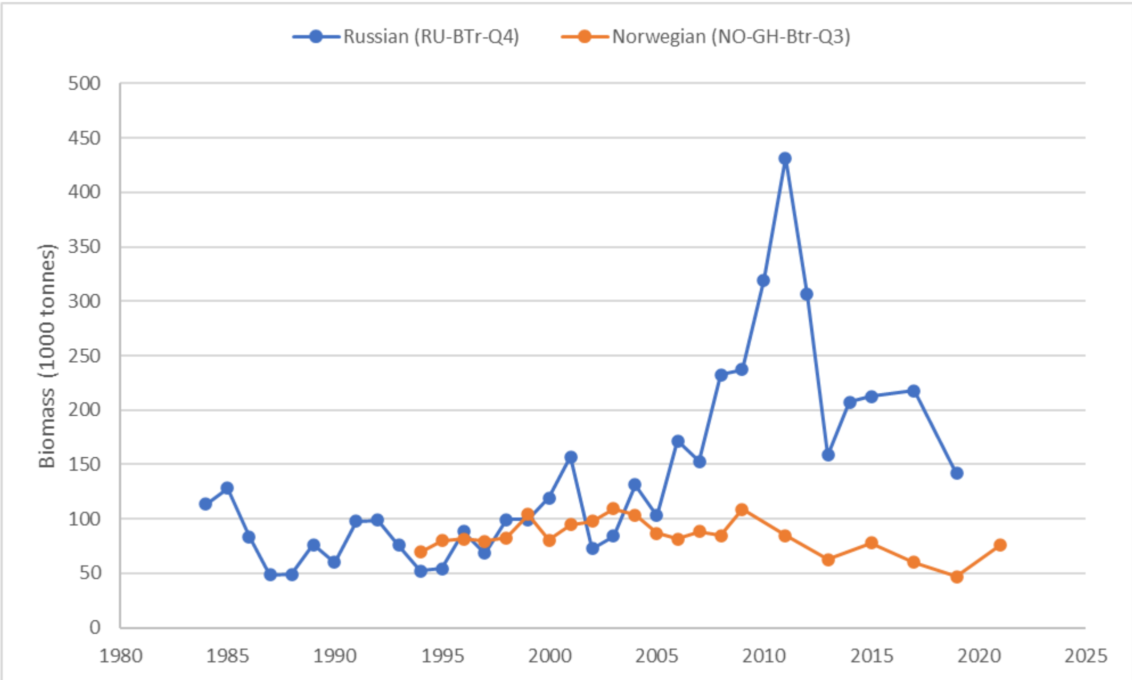


Figure 8.4. NEA Greenland halibut. Total biomass estimates from Russian autumn survey and the Norwegian slope survey. Note that the Norwegian survey is run every other year since 2009. Uncertain estimate for 2013 from the Russian survey. Russian data from 1992 and onwards are revised in 2021 (Russkikh WD12). No Russian data for 2016, 2018 and 2020.

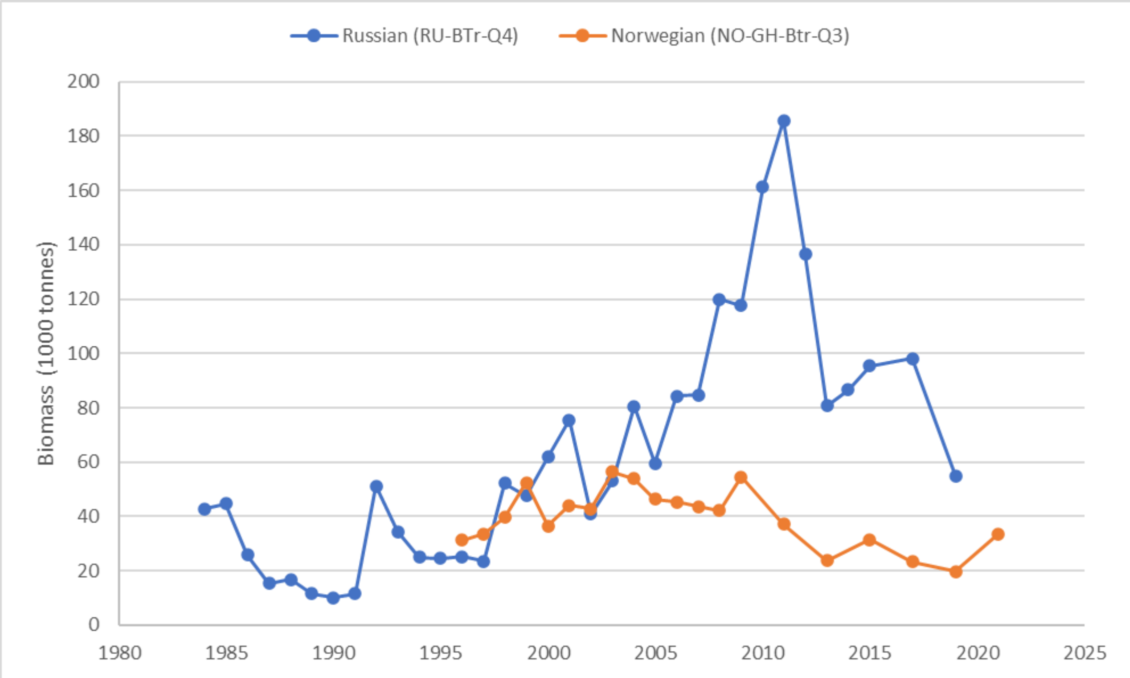


Figure 8.5. NEA Greenland halibut. Swept–area estimate of the female biomass based on the data from the Norwegian slope survey in August (every other year since 2009) and the Russian trawl survey in October–December (compared to previous reports, . Russian data from 1992 and onwards are revised in 2021 (Russkikh WD12)). Uncertain estimate for 2013 from the Russian survey.

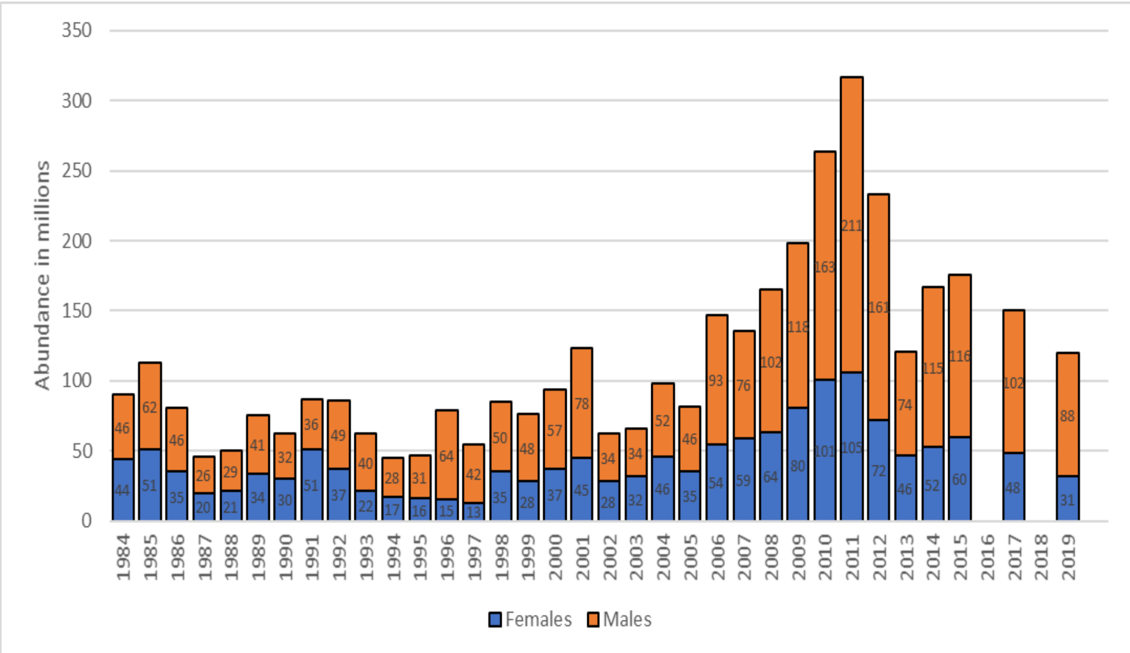


Figure 8.6. Russian autumn survey; Greenland halibut abundance by sex (Russkikh and Smirnov, WD16 AFWG 2016). Russian data from 1992 and onwards are revised in 2021 (Russkikh WD12). In this figure the 1992, 1996, 2002, 2017 and 2019 indices were not raised to also represent uncovered parts of the standard survey area.

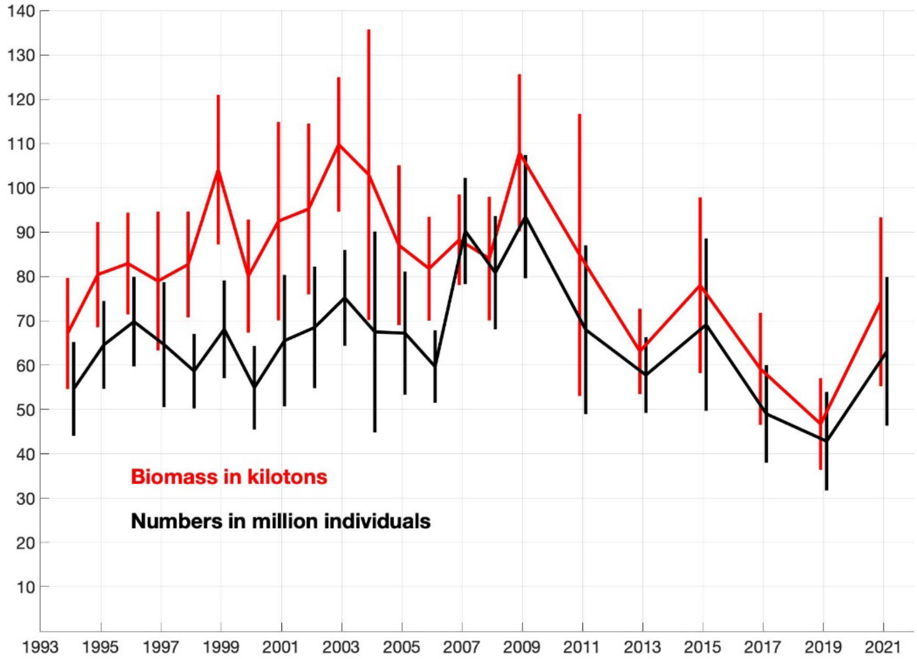


Figure 8.7. Estimated Greenland halibut total abundance in biomass and by number of individuals from the Norwegian slope surveys. The vertical bars show 95% confidence intervals.

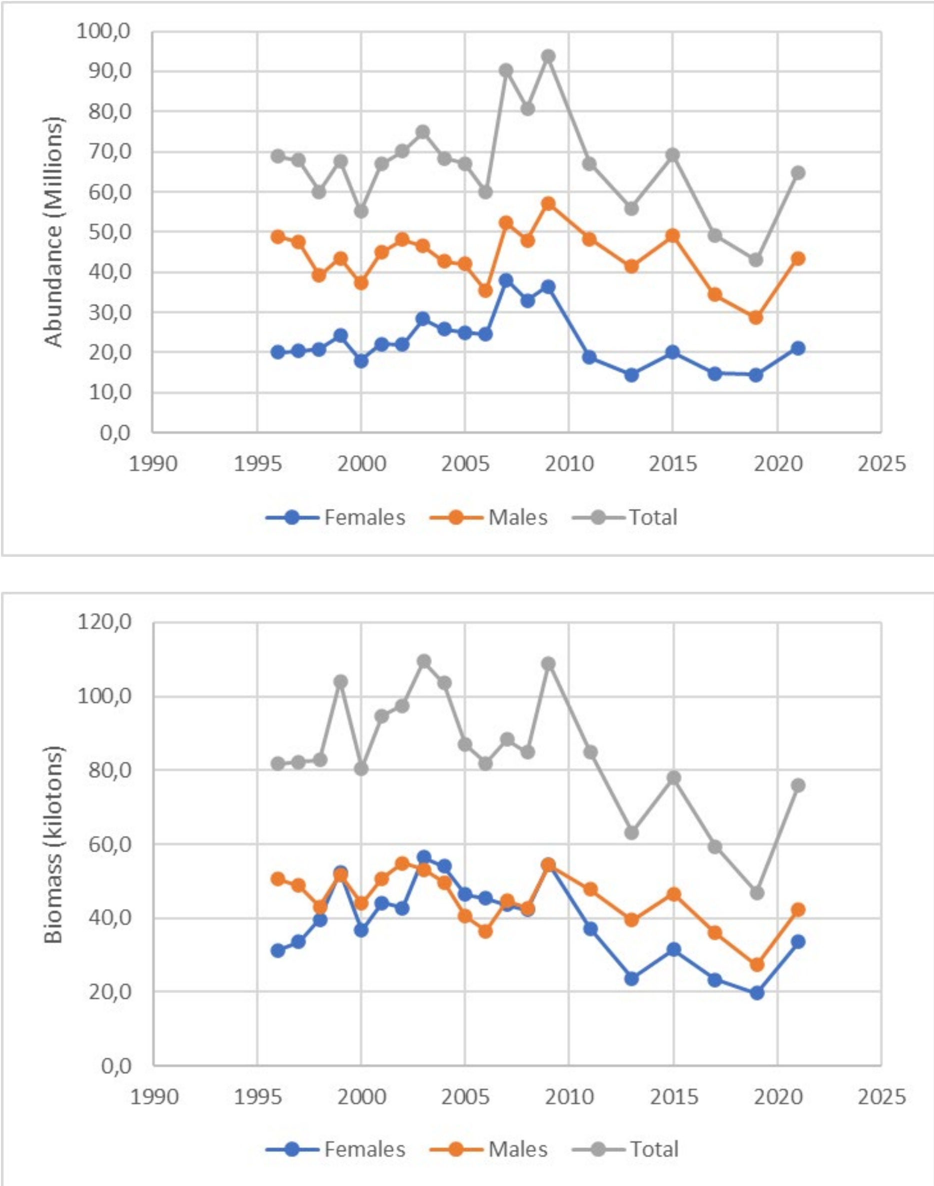


Figure 8.8. Estimated Greenland halibut abundance (upper panel) and biomass (lower panel), by sex, from the Norwegian autumn slope survey.

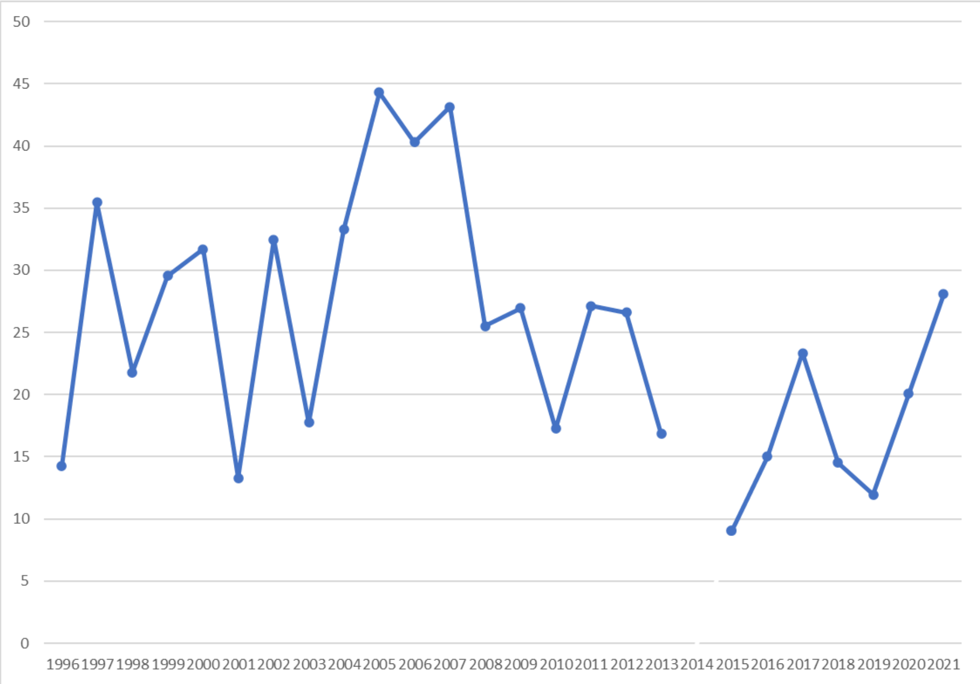


Figure 8.9. Total juvenile biomass index (EcoJuv) (sex distribution is assumed 50/50 in the juvenile area so in the figure female biomass = male biomass) for Greenland halibut based on the Barents Sea Ecosystem Survey (A5216) (2014 not included due to poor survey coverage in the juvenile area) and the juvenile survey 1996–2002 (for area see Hallfredsson and Vollen, WD20 AFWG 2015).

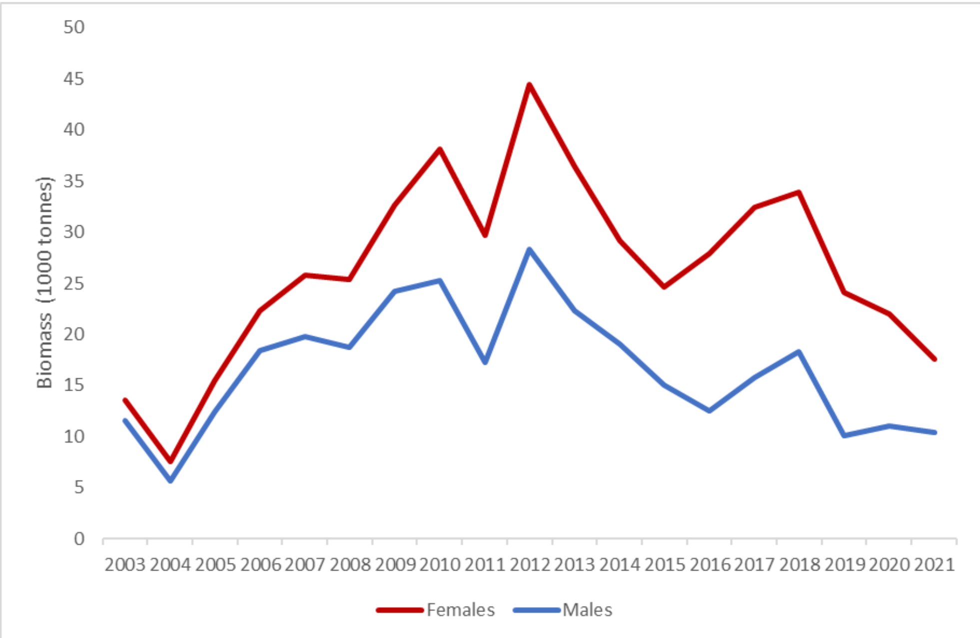


Figure 8.10. Eco–south biomass index by sex for Greenland halibut in the Barents Sea Ecosystem Survey (A5216) , outside the juvenile area (for area see Hallfredsson and Vollen, WD20 AFWG 2015). The 2018 estimate is not considered reliable mainly due to lack in survey coverage, and was excluded from the 2021 assessment.

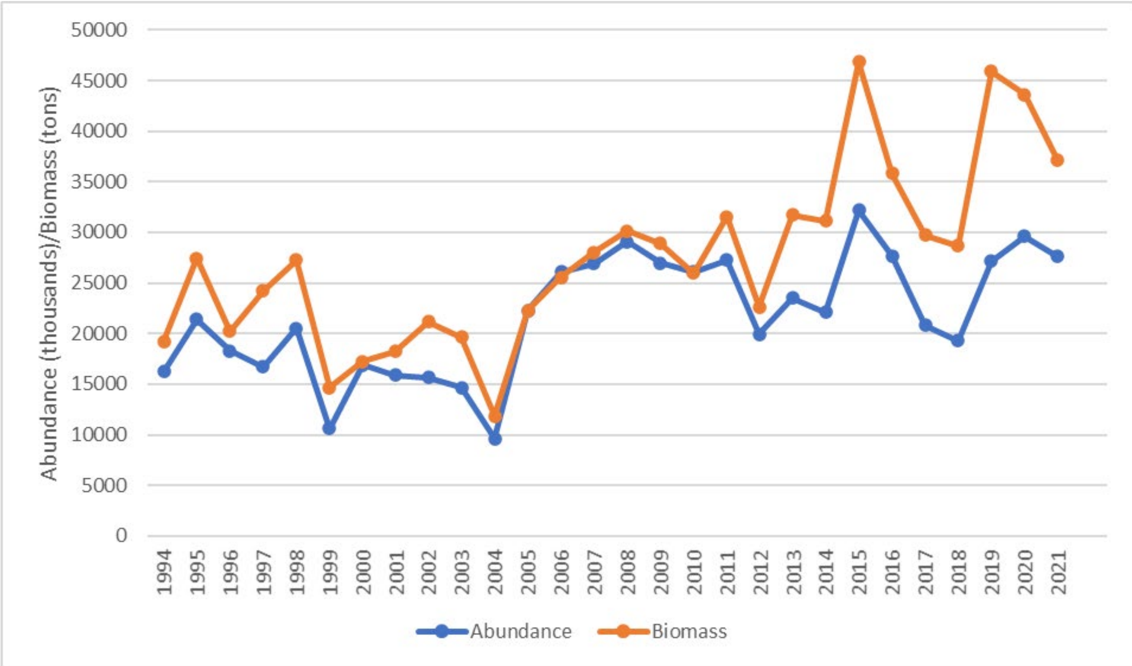


Figure 8.11. Joint Norwegian−Russian winter survey in the Barents Sea ; Greenland halibut abundance and biomass estimates.

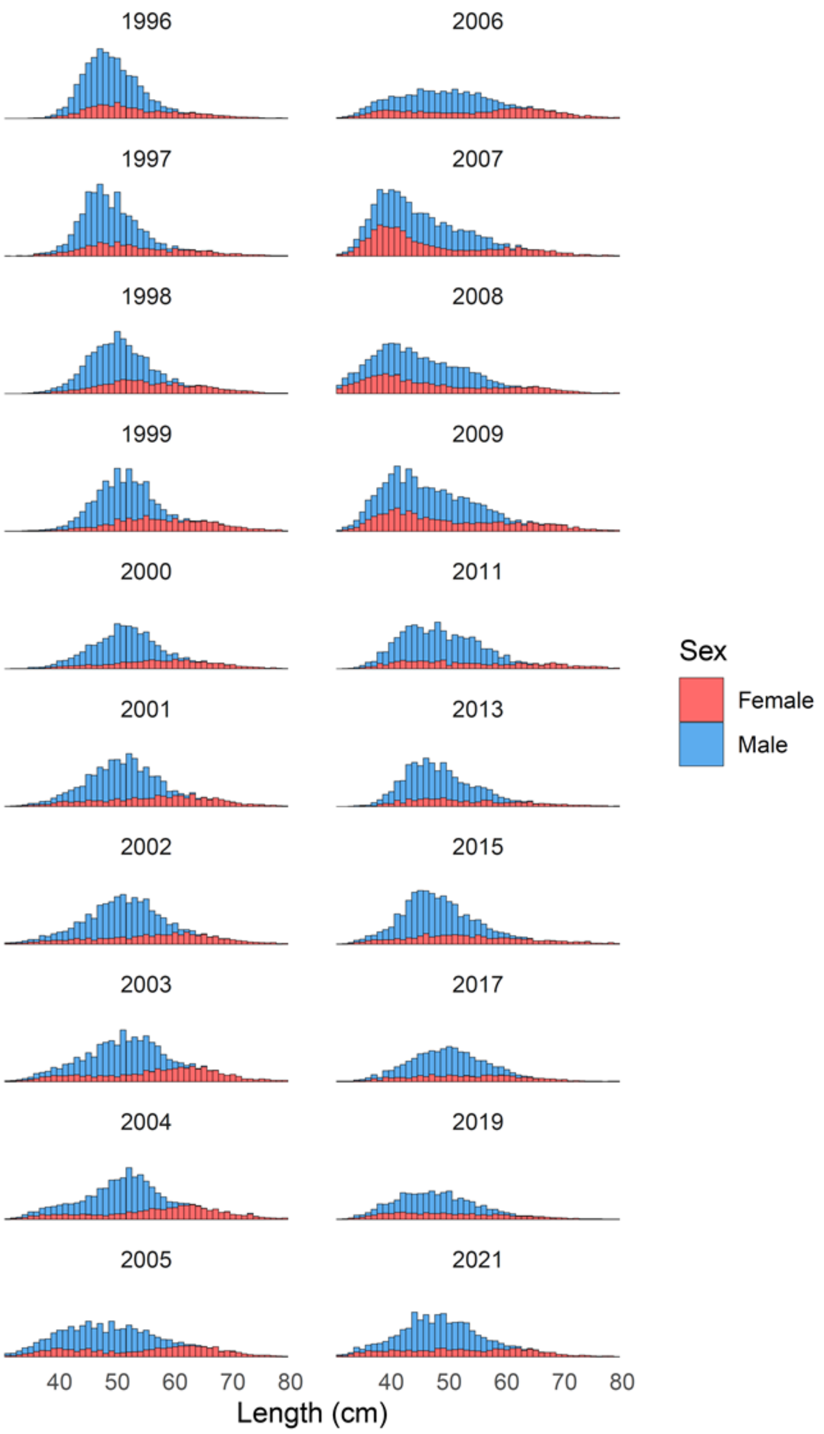


Figure 8.12. Length frequency distribution estimates for the entire area covered by the Norwegian Slope survey during autumn. Note biennial surveys after 2009.

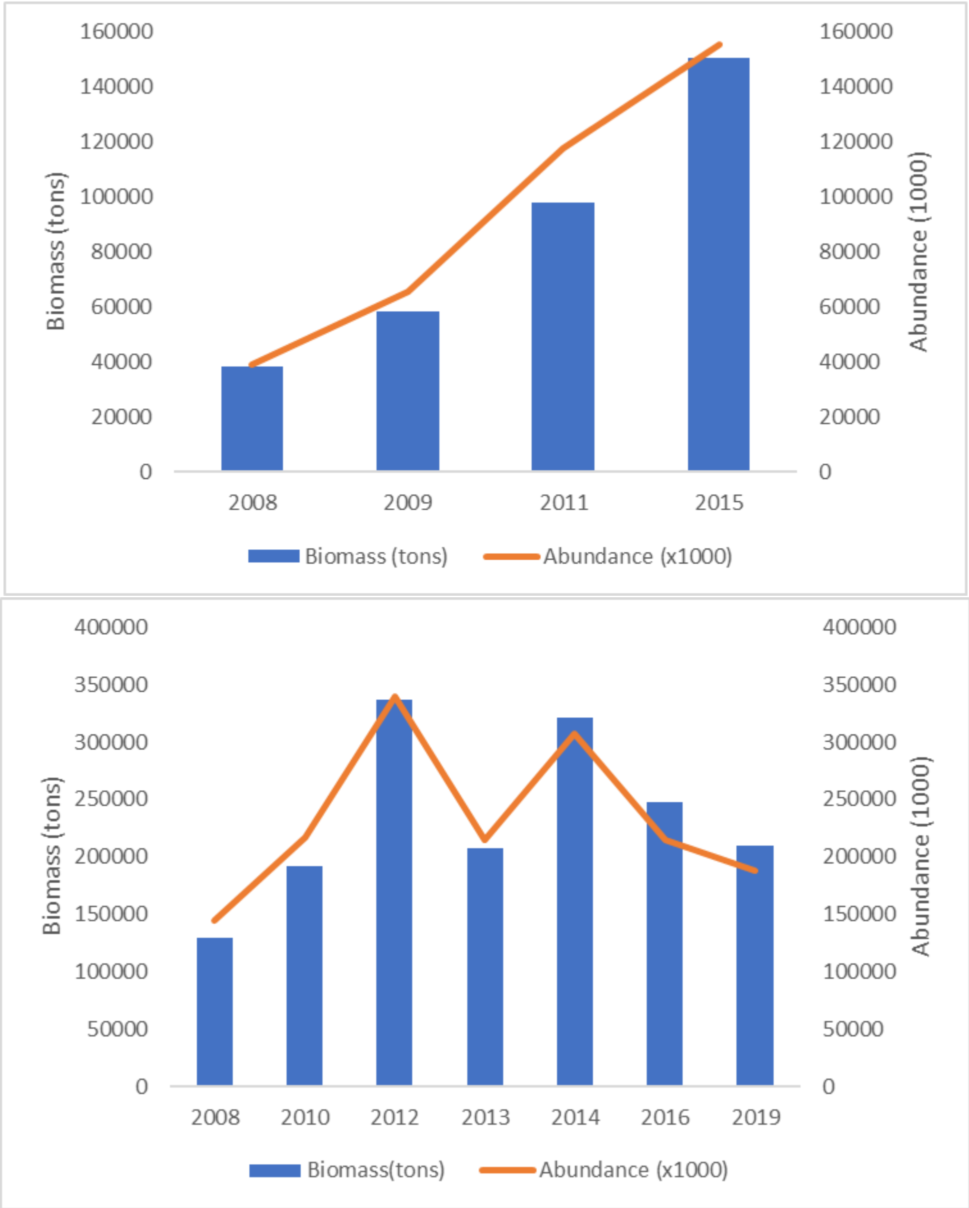


Figure 8.13. Abundance and biomass estimates from Spanish autumn surveys (lower panel) (Muñoz *et al.*, WD7 AFWG 2017), and abundance and biomass estimates from Spanish spring surveys (upper panel) (Muñoz *et al.*, WD10 AFWG 2016). Note that X–axis is not continuous.

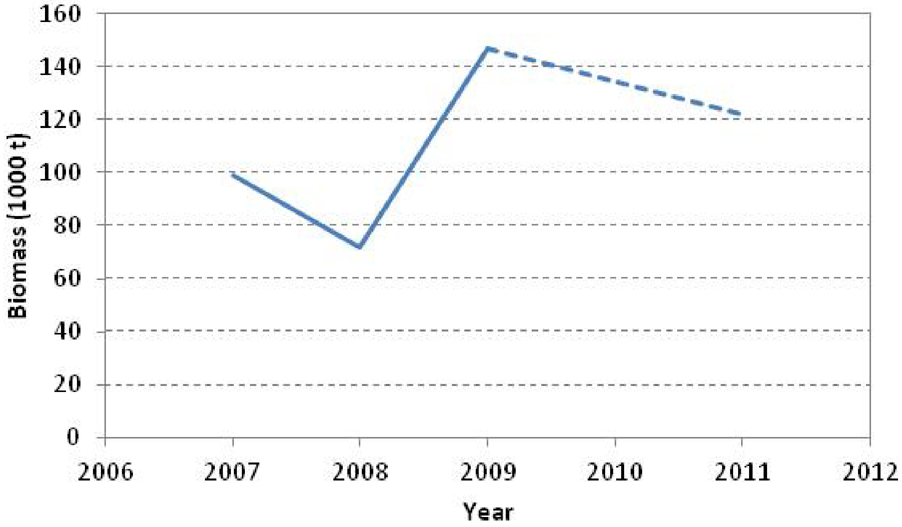


Figure 8.14. Biomass estimates from Polish spring survey (based on: Janusz *et al.*, WD8 AFWG 2008; Janusz and Trella, WD10 AFWG 2009; Trella and Janusz, WD6 AFWG 2012). No update presented to the 2020 AFWG.

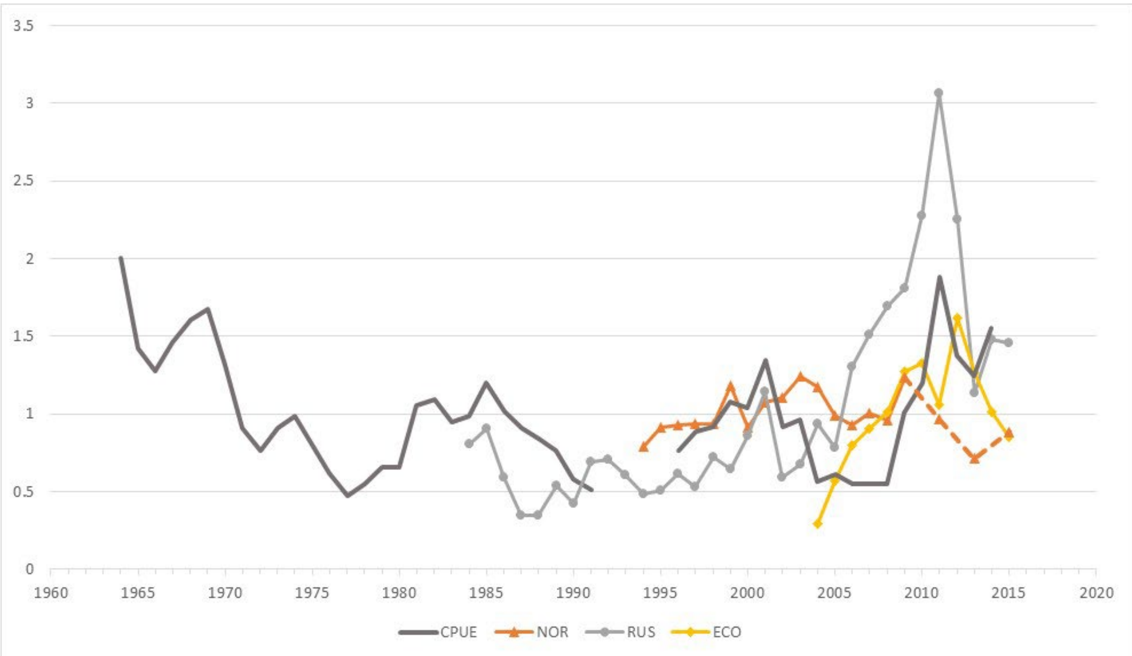


Figure 8.15. Dynamics of indices of the Barents Sea Greenland halibut stock in 1964–2015. Indices are divided by corresponding mean to put them in comparable scale. CPUE series divided in two, 1964–1991 and after 1996. In addition to the standardized CPUE three survey indices are shown; the Russian autumn survey (RUS), the Norwegian autumn survey (NOR) and the EcoSouth index (ECO).

9 Northeast Arctic anglerfish[1]

9.1 General

Our present knowledge of anglerfish (*Lophius* spp.) in ICES subareas 1 and 2 is based on two masters' theses (Staalesen, 1995; Dyb, 2003), a report from a Nordic project (Thangstad *et al.*, 2006), working documents to the ICES ASC, WGNSDS, and WGCSE, and more recent catch data collected by the Norwegian Reference Fleet since 2006 (Anon., 2013; Clegg and Williams, 2021). In February 2018, anglerfish in ICES subareas 1 and 2 was subject to a benchmark assessment (WKANGLER 2018). After this benchmark assessment, it was determined that this stock (or rather a stock component and a management unit) is considered a category 3 stock, for which survey or other indices are available that provide reliable indications of trends in stock metrics, such as total mortality, recruitment, and biomass.

9.1.1 Species composition

Two European anglerfish species of the genus *Lophius* are distributed in the Northeast Atlantic: white (or white-bellied) anglerfish (*Lophius piscatorius*) and black (or black-bellied) anglerfish (*Lophius budegassa). L. budegassa* are rarely caught in Nordic waters. In Norwegian waters, 1 out of about 2600 anglerfish landed from the Møre coast north of 62°N (2.a) and 1 out of about 1000 from the North Sea were *L. budegassa* back in 2003 (Dyb, 2003; K. Nedreaas, pers. comm.). In the most recent period (2014–2021), the ratio of *L. budegassa* in Norwegian waters has been up to 1 out of 200 anglerfish for some years, but usually about 1 out of 1000.

9.1.2 Stock description and management units

The WGNSDS (Northern Shelf Demersal Stocks) considered the stock structure on a wider European scale in 2004, and found no conclusive evidence to indicate an extension of the stock area northwards to include Division 2.a. Anglerfish in 2.a have therefore been treated and described separately by the ICES Celtic Sea Ecoregion Working Group (WGCSE) who is now assessing the anglerfish in the neighbouring areas. Currently, anglerfish on the Northern Shelf are split into Subarea 6 (including 5.b (EC), 12 and 14) and the North Sea (and 2.a (EC)) for management purposes. However, genetic studies have found no evidence of separate stocks over these two regions (including Rockall) and particle-tracking studies have indicated interchange of larvae between the two areas and further towards ICES divisions 2.a, 5.a and 5.b (Hislop *et al.*, 2001). So, previous working groups assessments have been made for the whole Northern Shelf area combined, but exclusive ICES divisions 2.a, 5.a and 5.b. In fact, both microsatellite DNA analysis (O'Sullivan *et al.*, 2006) and particle tracking studies carried out as part of EC 98/096 also suggested that anglerfish from further south (Subarea 7) could also be part of the same stock. Hislop *et al.* (2001) simulated the dispersal of *Lophius* eggs and larvae using a particle tracking model. Their results also show the likelihood of *Lophius* around Iceland (Solmundsson *et al.,* 2007), Faroe Islands (Ofstad, 2013) and Norwegian waters north of 62°N (i.e. subareas 1 and 2) are recruited from the area west of Scotland including Rockall. This is also supported by research survey data as a migration east-/north-eastwards with size is seen in the International Bottom Trawl Survey (IBTS) and other survey data (e.g. Dyb, 2003).

---

[1] Anglerfish (*Lophius budegassa, Lophius piscatorius*) in subareas 1 and 2 (Northeast Arctic); anf.27.1-2.

Results from the use of otolith shape analysis in stock identification of anglerfish (*L. piscatorius*) in the Northeast Atlantic (Cañás *et al.*, 2012) and previous references on *L. piscatorius* stock identification find no biological evidence to support the current separation of *Lophius* stocks in the Northeast Atlantic, but find substructures within the area.

Anglerfish were tagged during two IBTS surveys in the North Sea and five one-day trips using a small (15 m) Danish seiner off the Norwegian coast at around 62°40'N (Møre; Thangstad *et al.*, 2006; Otte Bjelland, IMR-Norway, pers. comm.). A total of 872 individuals were tagged with conventional Floy dart type tags, 123 in the North Sea (25–78 cm) and 749 at Møre (30–102 cm). Some of this is further described in Thangstad *et al*. (2006). The 2019 AFWG report shows the tagging locations and the hitherto recaptures. There are migrations in all directions, i.e. recaptures from the southern North Sea, at the Shetland/Faroes and northwards to Lofoten. Most of the recaptures were done at Møre where most of the fish were tagged.

In 2000–2001 a total of 1768 trawl caught *L. piscatorius* was tagged using conventional dart tags and released on inshore fishing grounds at Shetland (Laurenson *et al*., 2005). Anglerfish between 25 and 83 cm total length were tagged. The overall recapture rate was 4.5% and times at liberty ranged from 5 to 1078 days. After Laurenson et al. (2005), Dr Laurenson reported to www.fishupdate.com a 104 cm anglerfish caught off the Norwegian coast near Ålesund in 2006. The fish had been tagged and released in the Scalloway Deeps on 13 September 2000 when it was 45 cm long and had hence been at liberty for five years and nine months. This is of particular importance as it may indicate a wider mixing of stocks and validate the growth rate of anglerfish.

WKANGLER (2018) considered that most recruitment in subareas 1 and 2 is from the more southerly stock unit, and this would require further R&D work in collaboration with ICES 3.a, 4, and 6 looking at egg and larval dispersion and transportation as well as tagging and genetic studies. To address stock structure, mixing rates, and growth estimates, WKANGLER (2018) recommended a tagging program coordinated between all countries harvesting *Lophius* and to align tagging methods, measurement protocols and outreach to industry. The WK further recommended a shared site for *Lophius* tagging data and other applicable research projects concerning *Lophius*. Until the true biological stock structure is better understood, WKANGLER (2018) recommends keeping the anglerfish in subareas 1 and 2 as a separate management unit for the time being.

9.1.3 Biology

Sex ratios in Subarea 2 show that females outnumber males (> 50%) above approximately 75 cm, and above 100 cm all fish were females (Thangstad *et al.*, 2006). This is very similar to the sex ratios reported from distant Portuguese and Spanish waters (Duarte *et al.*, 1997) and hence supports a sex growth difference independent of latitude.

Spawning has been documented to occur in ICES Division 2.a in spring, but the present abundance of anglerfish in subareas 1 and 2 seems to be dependent on the influx or migration of juveniles from ICES subareas 4 and 6. Estimates of GSI (gonad-somatic index) for females in Division 2.a indicate that ovaries develop from January to June. The highest values of GSI were found in June when some of the ovaries were 20–30% of the round weight. Only females bigger than 90 cm had elevated GSI values indicating developing or developed ovaries. Dyb (2003) found that the length at which 50% of the females were mature (L50) was between 60–65 cm and that all females above 80 cm were mature.

Some age readings exist for anglerfish in Division 2.a, and comparative analyses of different structures, preparations and methods used for age readings were done by Staalesen (1995) and Dyb (2003). The Norwegian Institute of Marine Research adopted the ICES age reading criteria using the first dorsal fin ray (*illicium*) as its routine method, but few fish have been aged since the above-mentioned projects. The material collected and read was, however, considered sufficient for preliminary yield-per-recruit estimations (ICES, 2019). As a very simplified 'rule of thumb' one may divide the fish length by 10 get an approximate age, i.e. a fish of 100 cm is approximately 10 years old and 13 kg while a fish of 70 cm is about 7 years old and 7 kg.

Exploitation using gillnets with 300 mm mesh size will select for males and females in a more equal ratio than 360 mm gillnets (Dyb, 2003). However, a change to lower mesh size will, without additional regulations, not decrease the effort, but rather increase it, at least towards younger fish. A mesh size of 300 mm will catch more anglerfish down to 50 cm, i.e. more immature fish. Preliminary analyses have also shown that the maximum yield-per-recruit will be 22% less using 300 mm instead of 360 mm gillnets (Staalesen, 1995). A possible sudden increase in catch rates when going from 360 mm to 300 mm would therefore be of short duration. A mesh size of 360 mm is also more in line with the minimum legal catch size of 60 cm, the length at first maturity of females and the utilization of the species' (especially the females') growth potential.

Some basic biological input parameters for the current assessment approaches are shown in Table 9.3. Some of these are further described in WKANGLER (2018).

9.1.4 Fishery

In autumn 1992 a direct gillnet fishery for anglerfish (*L. piscatorius*) started on the continental shelf in ICES Division 2.a off the northwest coast of Norway (Norwegian statistical area 07; Figure 9.1). The anglerfish had previously only been taken as bycatch in trawls and gillnets. Until 2010–2011 there was a geographical expansion of the fishery which was largely due to a northward expansion of the Norwegian gillnet fishery (Figure 9.2). It is not known to what extent this northwards expansion of the fishing area is caused by an expansion of favourable environmental conditions for the anglerfish or the fishers discovering new anglerfish grounds.

Near Iceland, Solmundsson *et al.* (2007) concluded that changes in the distribution of anglerfish and increased stock size have co-occurred with rising water temperatures that have expanded suitable grounds for the species. Another observed feature of the fisheries is that regional peaks in the landings of anglerfish representing northward migration become visible after multiple years of data collection (Figure 9.2). The recent increase in landings first happened along the coast of western Norway but did the last year expand to all subareas north of 62°N as well.

Norway is by far the largest exploiter of the anglerfish in subareas 1 and 2 accounting for 96–99% of the official landings (Table 9.1). The coastal gillnetting accounts for more than 90% of the landings (Table 9.2). The landings of anglerfish in subareas 1 and 2 have been about 1/4–1/3 of the total landings from the other Northern Shelf areas (3.a, 4, and 6), but was in 2017 only 7% of the total landings in these areas.

No TAC is given for subareas 1 and 2 of Norwegian waters. Catches of anglerfish in Division 2.a of the former European Union (EC) waters, now UK waters, are taken as a part of the combined EC/UK anglerfish quota for ICES areas 3, 4, and 6, or as part of the Norwegian 'others' quota in EC/UK waters. The Norwegian fishery is regulated through:

- A discard ban on anglerfish regardless of size.
- A prohibition against targeting anglerfish with other fishing gear than 360 mm (stretched mesh) gillnets.
- A minimum catch size of 60 cm in all gillnet fisheries, and maximum permission of 5% anglerfish (in numbers) below 60 cm when fishing with gillnets.
- 72 hours maximum soak time in the gillnet fishery.
- A maximum of 500 gillnets (each net being maximum 27.5 m long) per vessel.

- Closure of the gillnet fishery from 1 March to 20 May. This closure period was expanded to 20 December–20 May in the areas north of 65°N in 2008 and further expanded southwards to 64°N since 2009.
- A maximum of 15% bycatch (in weight) of anglerfish in the trawl- and Danish seine fisheries, and maximum 10% bycatch (in weight) of anglerfish in the shrimp trawl fishery. When fishing for argentines and Norway pout/sandeel a maximum of 0.5% bycatch is allowed within a maximum limit of 500 kg anglerfish per trip.
- A maximum of 5% bycatch (in weight) of anglerfish is allowed to be caught in gillnets targeting other species.

9.1.5 Scientific surveys

Anglerfish appear in demersal trawl surveys along the Norwegian shelf, but in very small numbers. The survey design has changed from single species to multispecies during recent years. The procedures for data collection on anglerfish have varied and, at present, no time-series from surveys in Division 2.a yields reliable information on the abundance of anglerfish. On the other hand, surveys in the North Sea and especially the SIAMISS (Scottish Irish Anglerfish Megrim Industry Science Survey; Figure 9.3), seem to be predictive for the recruitment of anglerfish to the ICES subareas 1 and 2 (Northeast Arctic). This is seen with the likely development of the large 2012 year class in the SIAMISS survey (Figure 9.4), which is corroborated with a subsequent decrease in mean catch length in Division 2a in 2017 and an increase in fishing effort at the same time.

The SIAMISS is a dedicated anglerfish survey (see ICES 2021). It covers much of the known distribution of the northern shelf anglerfish (ICES divisions 4a, 6a and 6b), with the exception of the central and southern parts of Subarea 4 and the Skagerrak and Kattegat (Division 3a). The survey began in 2005 and has been more or less carried out on an annual basis (usually in spring, but sometimes in November). The total biomass estimate for the Northern Shelf in 2021, the most recent survey year, was 48 355 t. This is a decrease of 19% compared to 2019 (there is no 2020 estimate due to incomplete survey coverage) and the lowest value since 2013. A large proportion of total population numbers consisted of individuals <30 cm in 2021, suggesting strong incoming recruitment (ICES 2021).

In Subarea 4, the International Bottom Trawl Surveys in the North Sea (indices NS-IBTS-Q1 and Q3) show declining mean weights per hour for the recent five years across all length groupings (ICES 2021). The IBTS surveys are currently not used in the assessment of anglerfish in ICES subareas 4 and 6, and in Division 3.a.

9.2 Data

9.2.1 Landings data

The official landings as reported to ICES for subareas 1 and 2 for each country are shown in Table 9.1. Landings decreased rapidly from 2010 to 2015, to the lowest since 1997, but has since shown an increase until last year. It is worth noting that the recent increase in landings first happened along the coast of western Norway, and then in the following years also subsequently further north in ICES Subarea 2. And likewise, the decrease seen in 2021 happened first in the south, i.e. both along the coast of western Norway and in the southern part of ICES Subarea 2 while the northern areas still showed an increase. Norway has by far the largest reported catches of the anglerfish in subareas 1 and 2, accounting for 96–99% of the official international landings. The coastal gillnetting accounts for more than 90% of the landings, of which about 90% are caught by the special designed large-meshed gillnets (360 mm stretched meshes; Table 9.2).

The Norwegian coastal reference fleet (see Appendix figure H1) provides us with length measurements and catch per gillnet days from ICES subareas through 4, from 2007–present and these have been presented for the AFWG in recent years. The catch rates vary spatially and temporally, and the WKANGLER (2018) therefore recommended to model and standardize the catch rates to better represent the general abundance trend of anglerfish in the entire ICES Subarea 2. The available material is shown in Tables 9.4 and 9.5 for the Norwegian statistical coastal areas (Figure 9.1) and total for ICES subareas 1 and 2.

9.2.2 Discards

The absence of a TAC in Norwegian waters probably reduces the incentive to underreport landings. Anecdotal evidence from the industry, observer trips and data from the self-sampling fleet (the Norwegian reference fleet; Anon. 2013; Clegg and Williams 2021) suggest that up to 8–9% of the catch (not marketable) is discarded. This happens when the soaking time is too long, mostly due to bad weather. The average percentage of discarded anglerfish was higher south of 62°N (ICES 3 and 4) than north of 62°N (ICES 2.a). Average length of discarded anglerfish was on average only 6–7 cm smaller than the landed anglerfish. This is also confirmed by Berg and Nedreaas (2021) who estimated the annual discards of anglerfish by the Coastal reference fleet in subareas 1 and 2 to vary between 11 and 32 tonnes during 2014–2018 (i.e. 1.5–2.5% of total gillnet catch) but went up to 178 tonnes (7.2%) in 2012.

9.2.3 Length composition data

Length distributions are available from the directed gillnet fishery during the period 1992–2021, but data are lacking for 1997–2001 (Table 9.3). The length data indicates a drop in mean length of 15–20 cm occurring during the period without length samples (Figure 9.5). Since then, the mean length increased steadily during the last decade to about 95 cm (about 10 years old and 12 kg) in 2014–2016, i.e. the same size level as seen during the 1990s. One-third of the anglerfish measured during the 1990s were above 100 cm, this proportion was between 1–6% for the early 2000s, 12–17% in 2006–2013 and 15% in 2021. This indicates strong recruitment into Subarea 2 during 1997–2001, which has not been observed again until 2017–2019 when a new drop in mean length is seen, again indicating some recruitment of smaller sized anglerfish to the area (ref. Figure 9.4).

Length distributions of retained anglerfish (*L. piscatorius*) caught by the reference fleet as target species during 2007–2021 by the specially designed-large-meshed gillnets, and as bycatch in other gillnets or other gears are shown in Appendix figures H2-H4. All subsequent analyses (in the methods and results section) have only used the length distributions from the target fishery since 2007 using the large-meshed gillnets which represent more than 80% of the international landings in subareas 1 and 2.

9.2.4 Catch per unit effort (CPUE) data

The Norwegian coastal reference fleet (see Appendix figure H1) has reported catch per gillnet soaking time (CPUE) from their daily catch operations. For the current modelling and hence standardization of the annual CPUE from subareas 1 and 2, we have used the following data:

- Only catch rates of retained anglerfish from the fishery using special large-meshed anglerfish gillnets (stretched meshes = 360 mm).
- Years 2007–2021.
- Discards excluded.
- Adding zero catches where gillnets are used, but anglerfish not present.

- All coastal areas (i.e. ICES 3.a, 4.a, 2.a, and 1) included in the model since it is documented (e.g. WKANGLER 2018) that anglerfish are migrating across the ICES area borders.
- The area (km^2) of each subarea inside 12 nautical miles (covering most of the anglerfish distribution) is calculated and used as weighing factor when annual CPUEs are estimated for each subarea (Figure 9.6).

9.3 Methods and results

9.3.1 The length-based-spawning-potential-ratio (LBSPR) approach

The LBSPR method has been developed for data-limited fisheries, where only a few data are available: some representative sample of the size structure of the vulnerable portion of the population (i.e. the catch) and an understanding of the life history of the species (Hordyk *et al*., 2016). The LBSPR method does not require knowledge of the natural mortality rate (M) but instead uses the ratio of natural mortality and the von Bertalanffy growth coefficient (K; M/K), which is believed to vary less across stocks and species than M (Prince *et al*., 2015) although individual estimates of M and K can be used if available. Like any assessment method, the LBSPR model relies on a number of simplifying assumptions. In particular, the model is equilibrium-based, assumes that the length composition data are representative of the exploited population at steady state, and logistic selectivity (see the results section below for more discussion).

The LBSPR model originally developed by Hordyk *et al*. (2015a; 2015b) used a conventional age-structured equilibrium population model and a size-based selectivity. As a consequence, this approach could not account for "Lee's phenomenon"—the fact that larger specimens-at-age experience greater mortality than its cohort of smaller size because of the size-based selectivity. This is because the age-structured model has a 'regeneration assumption' i.e. it redistributes at each time-step the length-at-age using the same distribution. Hordyk *et al*. (2016) since developed a length-structured version of the LBSPR model that used growth-type-groups (GTG) to account for the above phenomenon and showed that the new approach reduced bias related to the "Lee's phenomenon"[2]. GTG LBSPR is therefore used for all subsequent analyses.

Some of the life-history parameters for the analysis were originally taken from WKANGLER (2018) but kept the same as in AFWG 2021. Hordyk *et al*. (2015a; 2015b) showed that the LBSPR approach was sensitive to the input parameters. We, therefore, drew 1000 random samples for each input parameter (i.e. from a bivariate normal distribution for L_{inf} and K, a univariate normal distribution for M, L50, L95 (see Table 9.3)) and rerun the model in order to account for the effect of uncertainty around the input parameters on the results. We will refer to it as the "stochastic LBSPR approach" hereon.

Once the stochastic LBSPR runs were finished, we conducted some simulations through the LBSPR package to calculate some target SPR value. To do this, we used the mean input values from the stochastic LBSPR, the average estimated parameters values (from the stochastic LBSPR approach) and set the "steepness" to a value between 0.7 and 0.9 to perform a YPR analysis and determine the target reference points (which gives the maximum yield). Steepness values between 0.7 and 0.9 were chosen based on a literature search (values close to 1 are also found in the literature but were not included in the test as it seemed unrealistic for the species). The analysis gave target reference points of SPR = 0.4 (with F/M~1) and SPR = 0.25 (with F/M~2) for steepness values of 0.7 and 0.9, respectively. What we obtained from the stochastic LBSPR runs instead are relatively stable annual estimates of SPR (between 0.15 and 0.5 (the IQR range)) and F/M

[2] https://github.com/AdrianHordyk/LBSPR

(between 1.5 and 2.5; Figure 9.7). This suggests that—while there is a lot of uncertainty—fishing effort is probably slightly above but close to the effort that would lead to maximum yield.

The relationship between the biomass of reproductively mature individuals (spawning stock) and the resulting offspring added to the population (recruitment), the stock–recruitment relationship, is a fundamental and challenging problem in all population biology. The steepness of this relationship is the fraction of unfished recruitment obtained when the spawning-stock biomass is 20% of its unfished level. Steepness has become widely used in fishery management, where it is usually treated as a statistical quantity. If one has sufficient life-history information to construct a density-independent population model then one can derive an associated estimate of steepness (Mace and Doonan, 1988; Mangel *et al.*, 2010; 2013).

As mentioned in the introduction, the LBSPR approach is an equilibrium-based method (i.e. assumes that the fishery experiences constant recruitment and F over time) and violation of this assumption can lead to biased SPR estimates. However, some management strategy evaluations conducted by Hordyk *et al*. (2015) on harvest control rules based on SPR-based size targets showed that while annual assessments of SPR may be imprecise due to the transitory dynamics of a population's size structure, smoothed trends estimated over several years may provide a robust metric for harvest control rules. SPR estimates in our study were relatively stable, thus large recruitment fluctuations may not be an issue.

9.3.2 CPUE standardization

Raw CPUE data are seldom proportional to population abundance as many factors (e.g. changes in fish distribution, catch efficiency, effort, etc) potentially affect its value. Therefore, CPUE standardization is an important step that attempts to derive an index that tracks relative population dynamics.

In the data preparation step, we quickly noticed that there was not enough data from ICES Subarea 1 to perform model inference. Therefore, we decided to omit data from this Subarea from the analyses. ICES Subarea 1 is the northern margin of *L. piscatorius* distribution, and only 3 tonnes were caught in this area in 2019, mostly as bycatch in other fisheries.

Below, we defined some important terms we used for the CPUE standardization:

Standardized effort (gillnet day) = gear count x soaking time (hours)/24 hours

CPUE (per gillnet day) = catch weight/standardized effort

CPUE standardization was performed using the glmmTMB package (Brooks *et al.*, 2017) and the best model was chosen based on AICc and residuals checks using the DHARMa package (Hartig 2021) i.e. the most parsimonious model had the lowest AICc while showing no problematic residuals pattern (i.e. overdispersion, underdispersion, etc). If problematic residual patterns were found, we tried to address the issue by either reconsidering the input data, changing model parameterization, or changing the model distribution assumption.

Using the model investigation/selection steps as in the last assessment (AFWG 2021), the final model was based on the Tweedie distribution. The Tweedie distribution belongs to the exponential family and its variance term is modelled as a power function of the mean (μ) i.e. φμ p. This distribution is commonly used for generalized linear models (e.g. Jørgensen 1997) – with the following parameterization (for fixed and random effects):

CPUE = year + subarea + month + (1∣vessel) + (1∣subarea_year) + (1∣month_year) + (1∣month_subarea)

The expression (1∣vessel) indicates that the vessel effect is considered a random effect and acts on the intercept. The expression (1∣month_year) indicates that the month and year variable was concatenated into a single variable and considered as a random effect. In essence, this treatment models the interaction effect between year and month, but the approach only considers existing interaction (as opposed to all possible combinations of year and month which would be un-estimable)—which is an advantage in a data-limited situation such as ours.

Additionally, like the last two assessments (AFWG 2020, 2021), data were filtered to keep only vessels that had more than 10 observations (as these rare vessel observations were causing deviations in the residual patters). Using the 10-minimum-observations criteria improved the residual pattern of the model but was not able to eliminate the residuals pattern (Figure 9.8). Such residual pattern started to appear in the last assessment (AWFG 2021) – though much less pronounced, thus not investigated – but was absent from the 2020 assessment (AFWG 2020). Therefore, another type of modelling approach, namely a delta model (or hurdle model), was briefly examined in this study to possibly correct for the observed residual pattern.

A delta model consists of a pair of models: one that models the species occurrence (presence/absence) and another that models the positive values.

Presence = (1|year) + subarea + month + (1|vessel) + (1|subarea_year) + (1|month_year) + (1|month_subarea)

CPUE_pos = year + subarea + month + (1|vessel) + (1|subarea_year) + (1|month_year) + (1|month_subarea)

Anglerfish occurrence was modelled using a binomial model with logit transform and positive CPUE was modelled using a Gamma distribution with log link. All variables were kept the same as in the original Tweedie model except for the year effect in the occurrence model that was converted to a random effect due to some estimability issue. The delta model specification helped improve the residual behaviour but did not completely eliminate the pattern (Figure 9.8).

For all subsequent analysis, we therefore examined the sensitivity of the model results to using the delta model as CPUE standardization approach.

As in the AFWG 2021, the standardized annual CPUE index was created by summing up all predictions based on all possible combination of year (2007–2021), subarea (in ICES Area 2.a), and month (1–12) after weighting the prediction for each subarea by its surface (in km^2 within the 12 nautical miles as shown in Figure 9.6) relative to the total surface (sum of all subarea surfaces in the ICES area 2a). In this process, we removed the vessel random effect (assuming it equals 0, the mean value) as it only affects catch efficiency and does not represent the underlying fish abundance. We note that glmmTMB can handle any missing new levels for random effect variables when making prediction (it assumes it is equal to zero and inflates the prediction error by its associated random effect variance). The standard deviation of the summed prediction (for the original Tweedie model) was directly calculated in glmmTMB by modifying the source code ('glmmTMB.cpp' file).

A similar approach was taken for the delta model to derive an abundance index except that model predictions were manually calculated while accounting for the covariance in fixed effect estimates. More precisely, fixed effect parameters were resampled 100,000 times based on their estimated mean and covariance for both components of the delta model (while random effect were kept at their MLE). These values were then used to predict the probability of occurrence and CPUE value for all combination of year, subarea, and month (as above) that were then multiplied together to calculate the expected CPUE. The final index was then calculated in a similar approach as in the original Tweedie model by weighted average of the predictions by area.

Figure 9.9 shows that anglerfish population in ICES Subarea 2a might have declined over the last decade (as well as the raw effort) but could be increasing again in more recent years. Nonetheless, there is a lot of year-to-year variability and uncertainty around the point estimates.

9.3.3 JABBA

JABBA stands for 'Just Another Bayesian Biomass Assessment' and is open-source modelling software that can be used for biomass dynamic stock assessment applications. It has emerged from the development of a Bayesian State-Space Surplus Production Model framework applied in stock assessments of sharks, tuna, and billfish around the world (Winker *et al*., 2018). JABBA requires a minimum of two input comma-separated value files (.csv) in the form of catch and abundance indices (and SE; see Appendix table H1). The Catch input file contains the time-series of year and catch by weight, aggregated across fleets for the entire fishery. Missing catch years or catch values are not allowed. JABBA is formulated to accommodate abundance indices from multiple sources (i.e. fleets) in a single CPUE file, which contains all considered abundance indices. The first column of the CPUE input is year, which must match the range of years provided in the Catch file. In contrast to the Catch input, missing abundance index (and SE) values are allowed.

The catch data comes from the different fishing countries' official reporting of annual landings to ICES (see Table 9.1) and the CPUE data (along with its standard deviation) comes from the CPUE standardization process described above with values in 1992–1994 imputed based on expert knowledge. We assumed that the CPUE index from ICES Subarea 2.a calculated using data from the anglerfish targeted fishery is representative of the stock status in ICES areas 1 and together.

In addition to these .csv files, JABBA also requires users to define the prior distribution for the model parameters which will be subsequently updated with data to form the posterior distributions (Figure 9.10). In addition to the base case, 10 additional scenarios were run to examine the sensitivity of the model results to the choice of priors (Table 9.6).

Figure 9.11 shows the trajectory of the population estimates from 1990–2021 based on the tested scenarios (Table 9.7). In general, population abundance has never fallen below B_{MSY} (at least the mean trajectory) but fishing mortality fluctuated above and below the F_{MSY} (Figure 9.12). Figure 9.13 is the Kobe plot from the base model run showing the estimated trajectories of B/B_{MSY} and F/F_{MSY} along with the credibility intervals of the 2021 estimates of biomass and fishing mortality. The percentage numbers at the top right indicate how much of the 2021 population estimates that fall within the green (not overfished, no overfishing), yellow (overfished, but no overfishing), orange (overfishing, but not overfished), and red (overfished and overfishing) zones, after accounting for all the parameter uncertainty (basically, the area under the oval-shaped density plot that falls into each coloured quadrant). The model estimates that there is roughly a 15% (23%) probability that the 2021 population estimate falls within the red zone, 30% (22%) in the orange, 0.5% (2%) in the yellow, and 54.5% (53%) in the green zone (in parentheses corresponding percentages from last year's assessment). Finally, retrospective analysis on the base model run was slightly worse than the previous assessment cycle (AFWG 2021) overall (especially for F/F_{MSY}; Figure 9.13, Table 9.7). In general, the error in parameter estimates was consistent (same sign) across peel 2–5 but changed sign in peel 1 (Table 9.7).

The sensitivity analysis says that MSY could be around or slightly above 2000 tonnes, with a B_{MSY} ~ 30 000 tonnes (Figure 9.14). Though the MSY value is quite sensitive to the choice of prior on r = population growth rate, which makes sense if population grows slowly, one cannot fish too hard, i.e. lower MSY.

However, the retrospective analysis (Figure 9.15) also shows that the estimate of MSY could be influenced by the addition of 1 year of data, i.e. the scaling of F/F_{MSY} is not very steady across time, and the figure suggests that it could be a bit lower, maybe between 1500–2000 t. Though the B_{MSY} still stays around ~30 000 tonnes. So an initial guestimate of MSY would be somewhere between 1500–2000 t. MSY of 1500 t was also the MSY estimate based on the low r scenario.

9.4 Management considerations and future investigations

The present abundance of anglerfish in subareas 1 and 2 seems to depend on the influx or migration of juveniles from ICES subareas 4 and 6. It is therefore expected that an effective discard ban on anglerfish in subareas 4 and 6 will have a positive effect on the abundance north of 62°N. Reduced mean size of the landed anglerfish in recent years (fishing with the same large-meshed gillnets) indicates a new influx of recruitment to the ICES subareas 1 and 2. Monitoring of the fishery will be important in the near future to protect the young specimens from recruitment- and growth- overfishing.

AFWG has previously recommended that the anglerfish stock component in subareas 1 and 2 is annually monitored and a 20% reduction in fishing effort per year (also as an uncertainty cap) should be imposed until the decrease in CPUE is stopped. Despite that the decrease in CPUE has stopped for time being, the current exploratory assessment shows that there is nothing to gain in increasing effort. The "2-over-3" rule used on the CPUE time-series, including both an uncertainty cap and a precautionary buffer, suggest a 10% reduction in effort or catch advice for 2023.

The standardized CPUE analysis shows that anglerfish population in ICES Subarea 2.a has declined over the last decade (as well as the raw effort) with an increase in the most recent year.

The spawning potential ratio, as calculated by the LBSPR method using input biological parameters and the estimated exploitation parameters suggests that—while there is a lot of uncertainty—fishing effort is probably slightly above but close to the effort that would lead to maximum yield.

The relative population stock status is around B_{MSY}, though fishing intensity could be close or slightly higher than F_{MSY}. Therefore, effort should not be increased at the risk of the population falling below the biomass and SPR targets. New promising recruitment seen from scientific survey in the northern North Sea is expected to contribute to the fishery north of 62˚N after 3–4 years if it continues to develop as the observed recruits seen in the 2013–2014 surveys did. The quality of the current assessment was this year further evaluated by analysing another type of CPUE modelling approach (the Delta model), to possibly correct for an observed residual pattern. The AFWG considers the current assessment of sufficient quality to base catch advice on for subareas 1 and 2.

When it comes to reference points, it should be further discussed if and which defined values of F/M, F/F_{MSY}, SPR and B/B_{MSY} may be used.

Any potential harvest control should take account of both recruitment- and growth- overfishing. LBSPR provides measures for both, F/M and SPR, with the SPR values being the transient SPR and thus an estimate of current stock status. While maximum sustainable catch is often a key management objective, it may not be the only one. In that case, it may be worth modifying a reference point to reflect other management objectives.

The AFWG supports that ICES subareas 1, 2, 3, 4, and 6 should be investigated together to get a more complete understanding of migrations and distributions.

9.5 Tables and figures

Table 9.1. Nominal catch (t) of anglerfish in ICES subareas 1 and 2, 2001–2021, as officially reported to ICES.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021*
DK	2	+	-	1	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Faroes	1	1	2	5	11	4	7	4	2	1	+	+	1	+	+	1	1	+	+	1	-
France	-	-	-	-	-	1	-	-	-	-	1	3	2	-	4	2	4	3	8	5	4
Germany	65	59	55	70	55	+	+	0	+	82	70	0	-	+	+	+	1	1	50	-	-
Iceland	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-
Norway	3554	2000	2405	2907	2650	4257	4470	4007	4298	5391	5031	3758	2988	1655	933	1355	1473	1884	2750	2258	2584
Portugal	-	-	-	-	-	-	-	2	6	1	+	-	-	-	-	-	-	-	-	-	-
UK	2	11	15	18	19	86	114	138	152	40	3	3	111	2	105	76	5	15	+	16	13
Others												1	1	-	-	+	-	+	-	-	-
Total	3624	2071	2477	3001	2735	4348	4591	4151	4458	5515	5112	3765	3103	1657	1043	1435	1484	1903	2809	2280	2601

*Preliminary.

Table 9.2. Anglerfish in ICES subareas 1 and 2. Norwegian landings (tonnes) by fishery in 2008–2021. The coastal area is here defined as the area inside 12 nautical miles from the baseline.

Fleet NORWAY	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021*
Coastal gillnet	3574	3934	4806	4557	3521	2758	1506	829	1231	1320	1727	2502	1939	2233
Offshore gillnet	240	171	391	319	115	158	95	52	62	87	68	153	168	229

Danish seine	75	68	40	26	16	19	11	12	17	23	28	26	35	78
Demersal trawl	34	36	48	19	11	8	7	3	5	6	10	5	3	2
Other gears	84	89	106	83	96	45	36	37	40	31	51	64	113	42
Total	4007	4298	5391	5031	3759	2988	1655	934	1355	1468	1884	2750	2258	2584

***Preliminary per 5 April 2022.**

Table 9.3. Basic input parameters and parameters for resampling as used for the LBSPR analysis.

Basic input parameters	**Value**
von Bertalanffy K parameter (mean)	0.12
von Bertalanffy Linf parameter (mean)	146
von Bertalanffy t0 parameter	−0.34
Length-weight parameter a	0.149
Length-weight parameter b	2.964
Steepness	0.8
Maximum age	25
Length at 50% maturity (L50; mean)	82
Length at 95% maturity (L95; mean)	100
ΔMat = L95 - L50 (mean)	18
Length at first capture	40
Length at full selection	60
M (mean)	0.2

Basic input parameters	**Value**
M/k (mean)	1.67
Parameters for resampling	**Value**
N_{samp}	1000
CV(M)	0.15
Cor (L_{inf}_K)	0.9
CV(K)	0.3
CV(L_{inf})	0.15
CV(L50)	0.05
CV(ΔMat)	0.05

Table 9.4. Number of coastal reference fleet fishing days with anglerfish, per national stat. subareas (0–7) and total for ICES subareas 1 and 2. Only large-meshed gillnets included.

Year/ area	0	5	6	7	ICES 1 and 2
2007	106	26		280	412
2008	62	37	6	171	276
2009	86	35	36	176	333
2010	14	41	37	143	235
2011	64	19	51	116	250
2012	49	12	24	21	106
2013	64	20	18	81	183
2014	5		19	107	131
2015	109		5	116	230
2016	92		22	35	149
2017	88			109	197
2018	108			89	197
2019	86	34		63	183
2020	74	28	52	104	258
2021	66		72	78	216

Table 9.5. Number of fishing days with length measured anglerfish (left) and number of length measured fish (right). Only large-meshed gillnets included.

Year	ICES 1 and 2
2007	78
2008	43
2009	47
2010	67
2011	78
2012	39
2013	52
2014	29
2015	31
2016	45
2017	74
2018	64
2019	50
2020	83
2021	75

Year	ICES 1 and 2
2007	2265
2008	1407
2009	2325
2010	2171
2011	2423
2012	995
2013	1305
2014	546
2015	1063
2016	654
2017	1593
2018	1451
2019	1486
2020	2149
2021	1608

Table 9.6. Eleven scenarios were run to examine the sensitivity of the model results to the choice of priors.

Scenario name	K	r	σ_P	Initial depletion	B_{MSY}/K value
Base	LN(1e6,1)	LN(0.1,1)	IG(4,0.01)	LN(0.8,0.5)	0.35
Low_K	LN(5e5,1)	LN(0.1,1)	IG(4,0.01)	LN(0.8,0.5)	0.35

High_K	LN(1.5e6,1)	LN(0.1,1)	IG(4,0.01)	LN(0.8,0.5)	0.35
Low_r	LN(1e6,1)	LN(0.05,1)	IG(4,0.01)	LN(0.8,0.5)	0.35
High_r	LN(1e6,1)	LN(0.2,1)	IG(4,0.01)	LN(0.8,0.5)	0.35
Low_sigmaP	LN(1e6,1)	LN(0.1,1)	IG(4,0.005)	LN(0.8,0.5)	0.35
High_sigmaP	LN(1e6,1)	LN(0.1,1)	IG(4,0.02)	LN(0.8,0.5)	0.35
Low_initdep	LN(1e6,1)	LN(0.1,1)	IG(4,0.01)	LN(0.7,0.5)	0.35
High_initdep	LN(1e6,1)	LN(0.1,1)	IG(4,0.01)	LN(0.9,0.5)	0.35
Low_BmsyK	LN(1e6,1)	LN(0.1,1)	IG(4,0.01)	LN(0.8,0.5)	0.30
High_BmsyK	LN(1e6,1)	LN(0.1,1)	IG(4,0.01)	LN(0.8,0.5)	0.40

***LN stands for lognormal and IG stands for inverse gamma distribution. B_{MSY}/K value controls for the position of the inflection point of the surplus production curve with respect to K (a value from o 1).**

Table 9.7. Relative error (RE) in parameter estimates between the base run with full dataset (Table 9.6) and the retrospective peels (1 to 5 years) and the associated Mohn's rho statistics (i.e. average RE from the 5 peels). Relative error is calculated as: RE = (peel-ref)/ref.

	B	F	B/B_{MSY}	F/F_{MSY}	B/B0	MSY
RE_peel1	-0.031	0.032	0.063	-0.025	0.063	-0.046
RE_peel2	-0.142	0.166	-0.211	0.779	-0.211	-0.324
RE_peel3	-0.112	0.127	-0.288	0.855	-0.288	-0.277
RE_peel4	-0.122	0.139	-0.084	0.295	-0.084	-0.173
RE_peel5	-0.092	0.102	-0.117	0.186	-0.117	-0.074
Mohn's rho	-0.100	0.113	-0.127	0.418	-0.127	-0.179

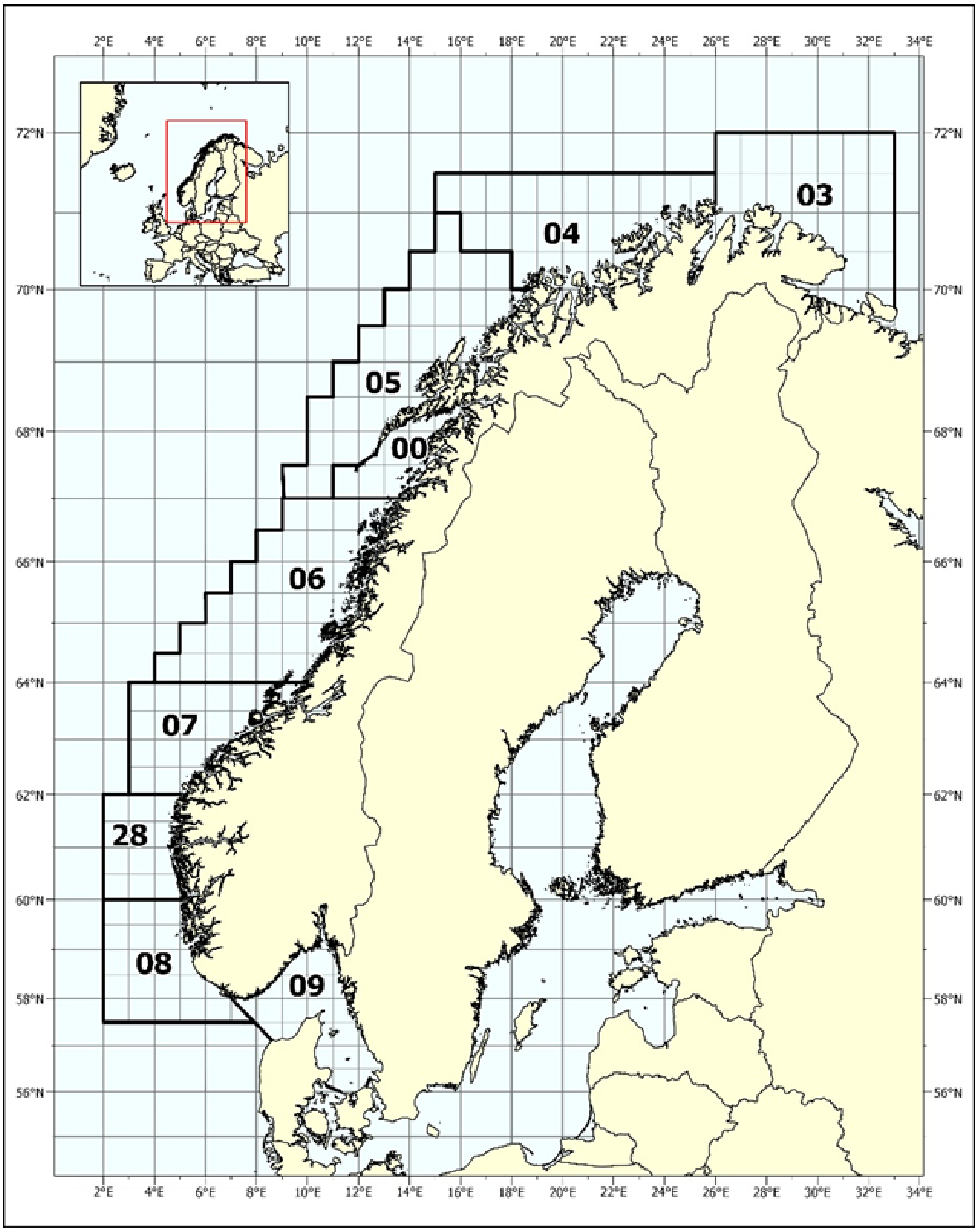


Figure 9.1. Map showing the Norwegian statistical coastal areas. Area 03 is part of ICES Subarea 1; areas 04, 05, 00, 06, and 07 are part of ICES Subarea 2; Areas 28 and 08 are part of ICES Subarea 4, and Area 09 corresponds roughly with ICES Subarea 3.

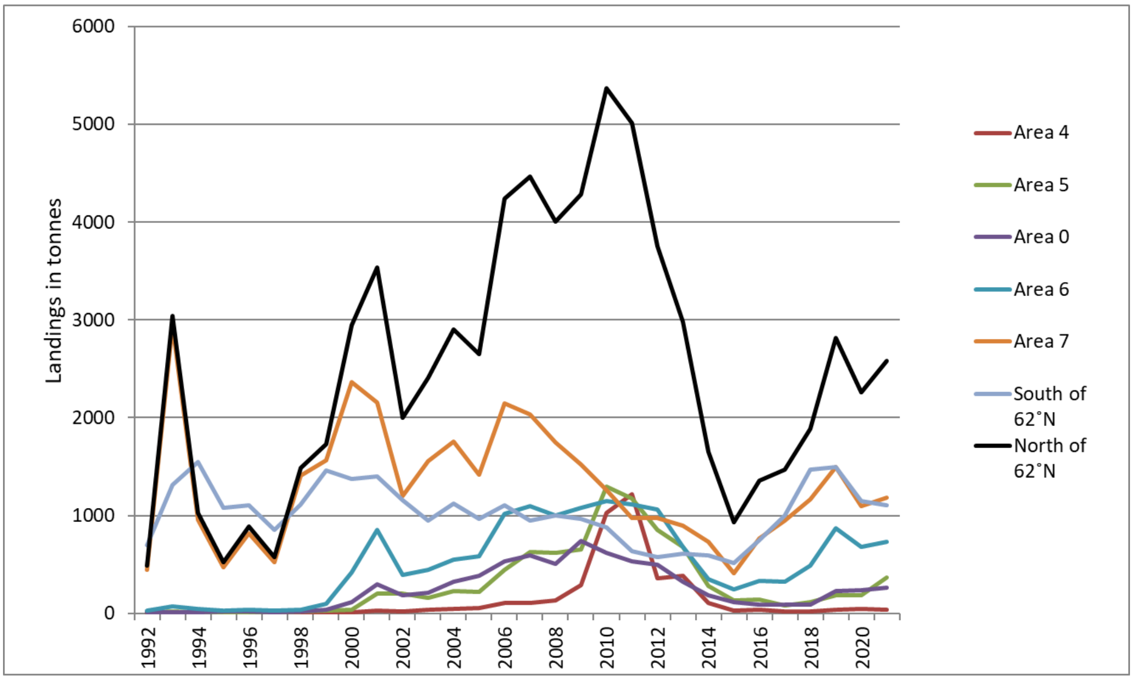


Figure 9.2. Norwegian official landings (in tonnes) of anglerfish (*Lophius piscatorius*) per statistical area (see Figure 9.1) within ICES areas 1 and 2 during 1992–2021. Norwegian landings from the area south of 62°N (ICES 4 and 3) are shown for comparison.

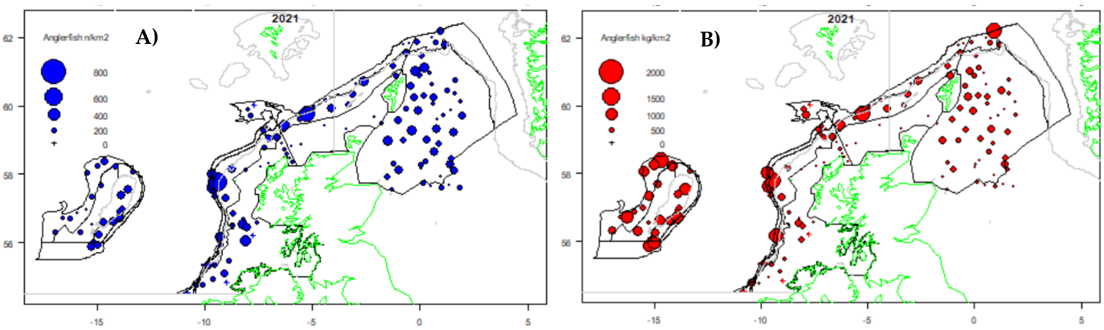


Figure 9.3. Excerpt from WGCSE 2021: A) WGCSE 2021 figure 4.16 - Numbers of anglerfish per km2 observed by SIAMISS surveys 2021. B) WGCSE 2021 figure 4.17 - Weight of anglerfish (kg) per km2 observed by SIAMISS surveys 2021.

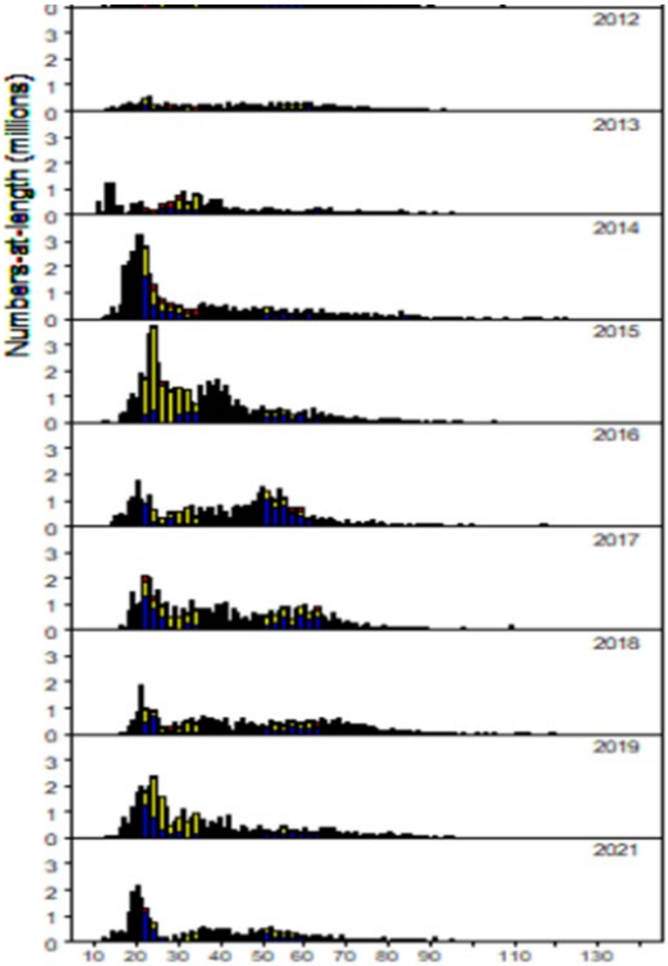


Figure 9.4. Excerpt from WGCSE 2021: Figure 4.8. SIAMISS-Q2 estimates of total numbers (millions) at-length (cm) for subareas 4.a (blue)–c and 6.a (yellow)–b (red) combined, 2012–2021.

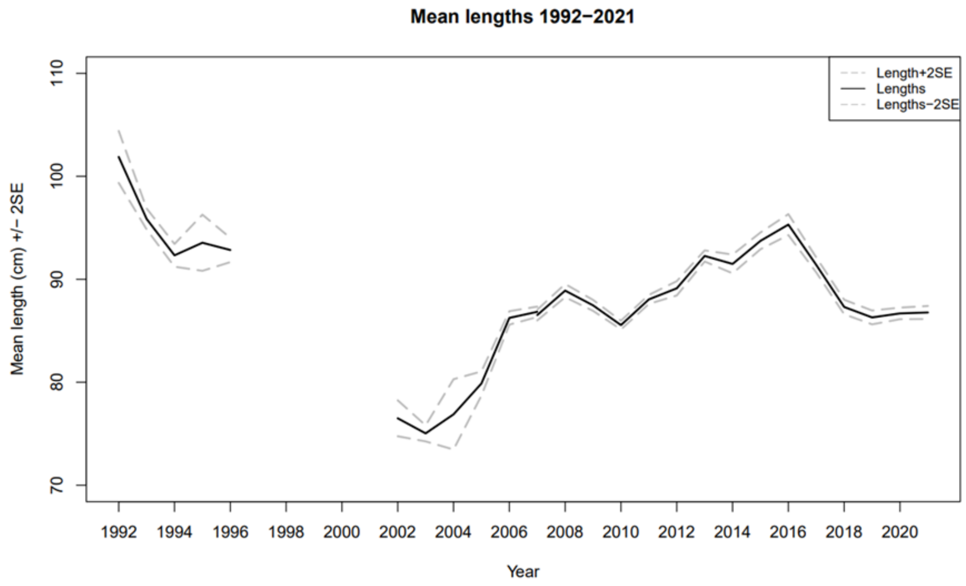


Figure 9.5. Anglerfish (*Lophius piscatorius*) in ICES Subareas 1 and 2. Mean lengths for anglerfish caught in the directed coastal gillnetting in Division 2.a during 1992–2021, dotted lines represent ±2SE of the mean. Note that data are lacking for 1997–2001. This illustrates pulses of new recruitment entering Division 2.a from ICES subareas 4 and 6; last time during 2002–2003, and to a lesser extent in 2017–2019.

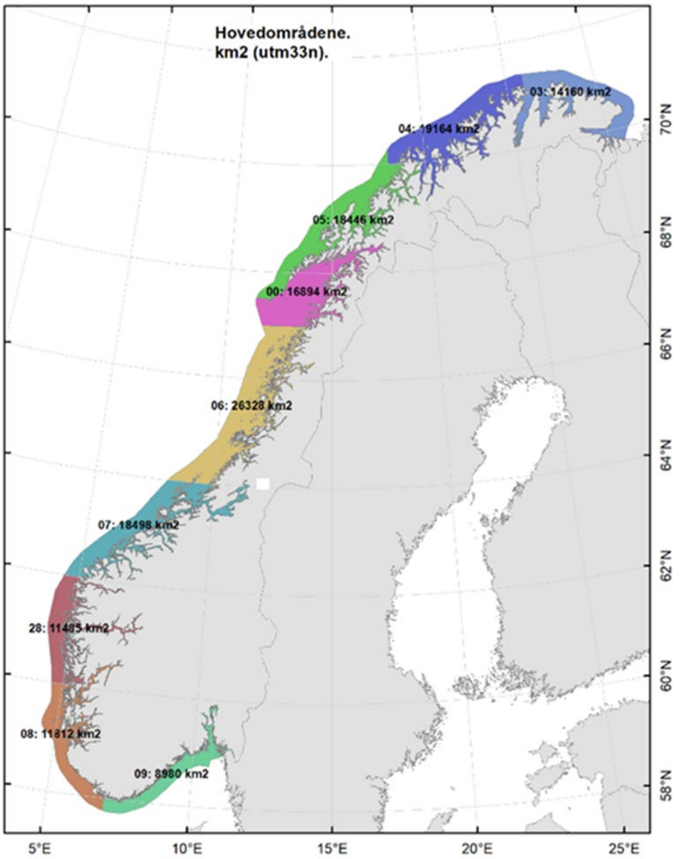


Figure 9.6. Map showing the area (km2) of each Norwegian statistical subarea inside 12 nautical miles. The subareas 4, 5, 0, 6, and 7 belong to the ICES Division 2.a.

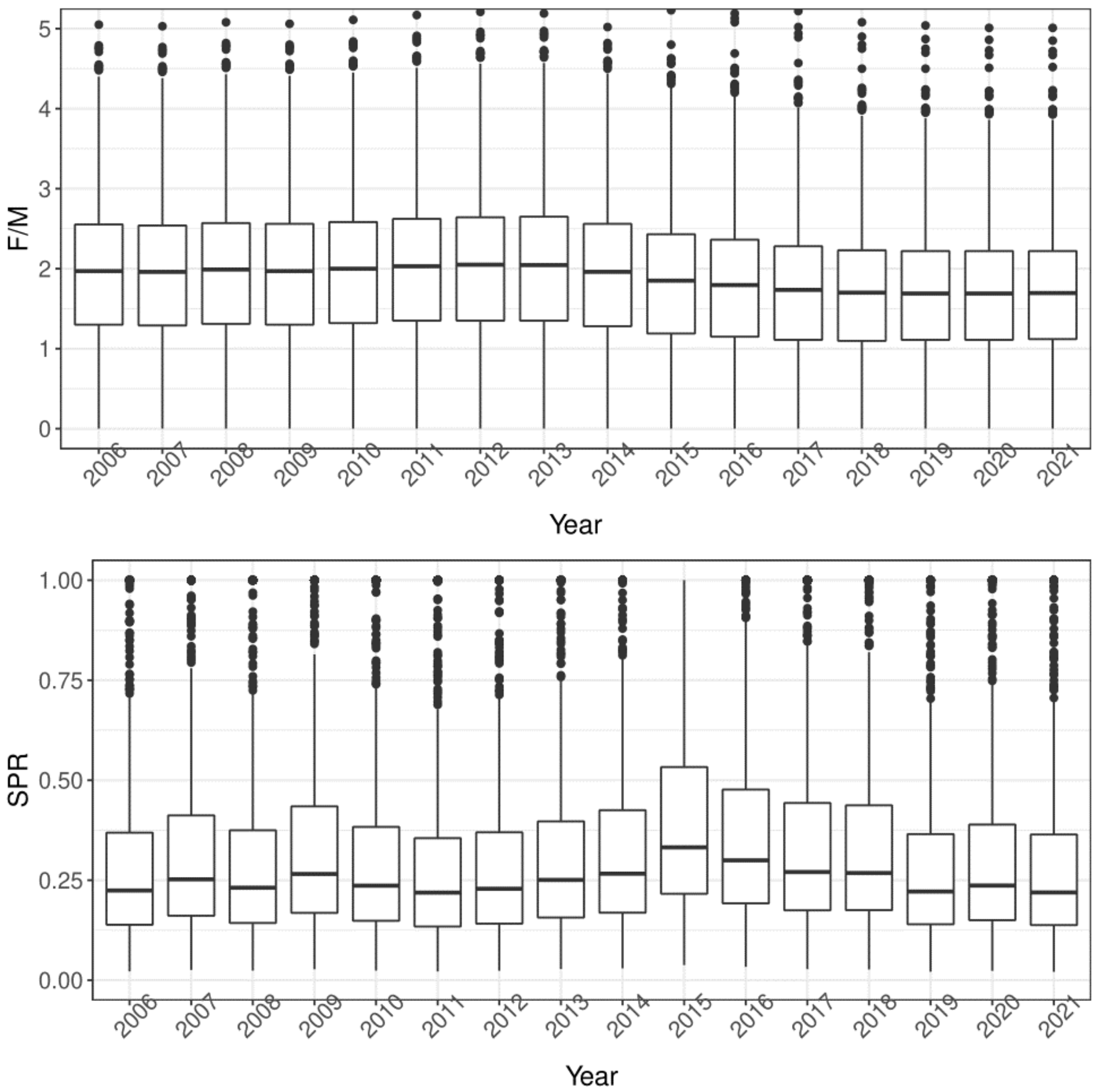


Figure 9.7. Annual estimates of F/M (above) and SPR (below) from the stochastic LBSPR approach using the length composition data from 2006- 2021.

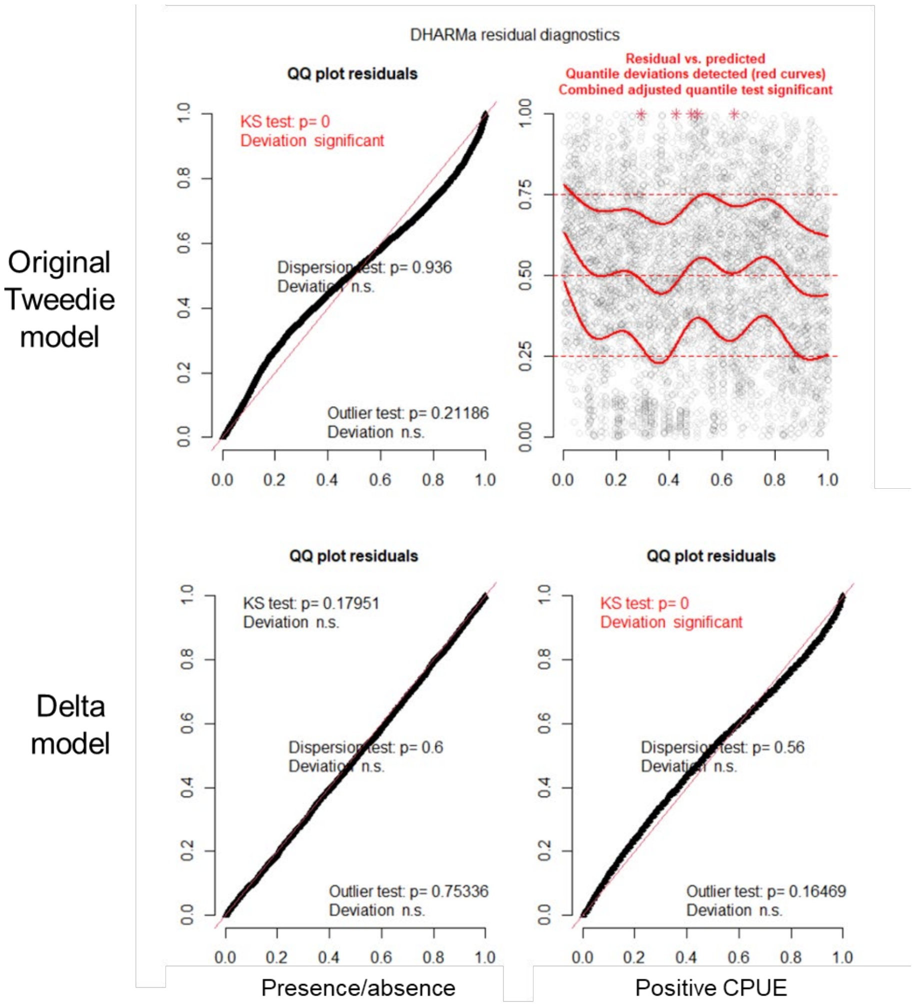


Figure 9.8. CPUE model residual diagnostics. Top panel shows the residual pattern in the original Tweedie model using the latest data. Bottom panel shows the results from the new delta model.

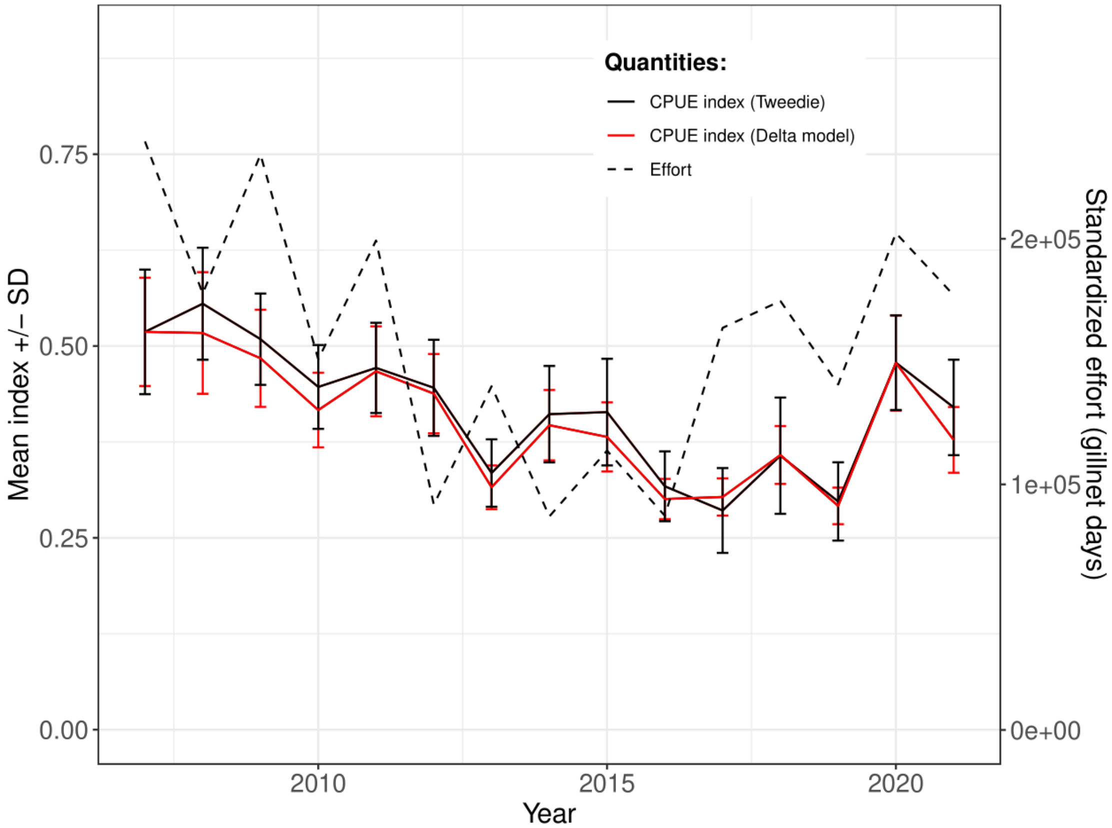


Figure 9.9. Standardized CPUE (kg per gillnet day) +/- SD (solid black line with error bars for the original Tweedie model, and solid red line with error bars for the new delta model) and the corresponding standardized effort (dash line) for anglerfish based on the data from the Norwegian coastal reference fleet in ICES Subarea 2a, from vessels targeting anglerfish with large meshed gillnets.

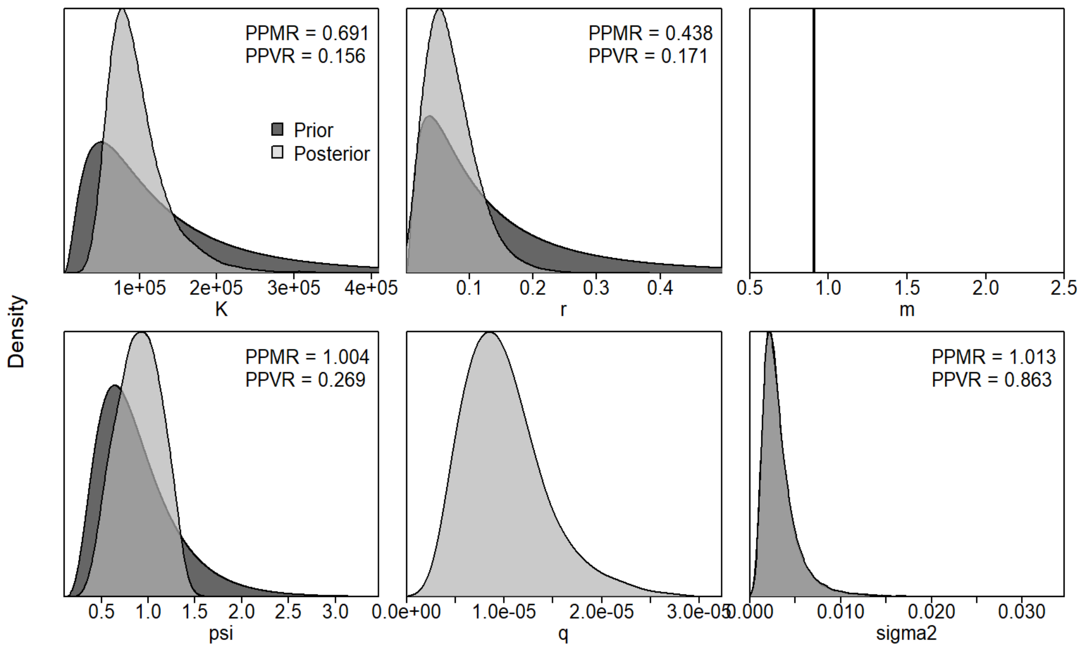


Figure 9.10. Prior and posterior distributions of the JABBA model parameters for the anglerfish assessment.

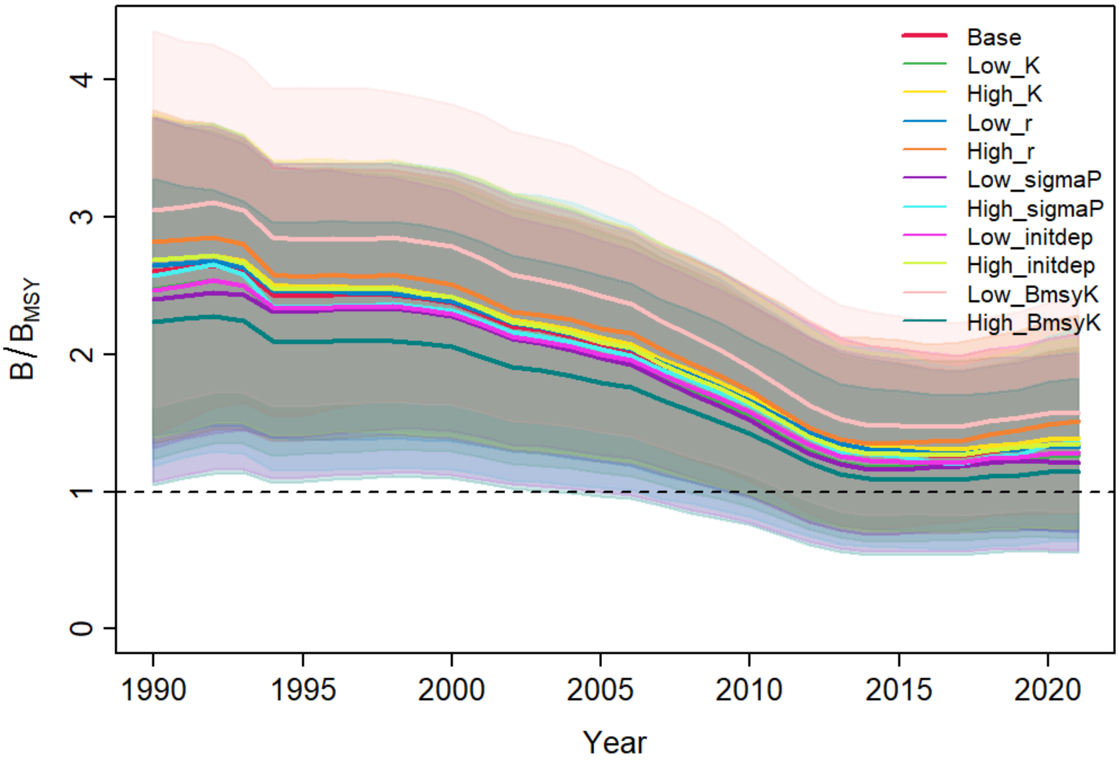


Figure 9.11. Estimated trajectories for B/B$_{MSY}$ for the ICES subareas 1 and 2 anglerfish based on 11 JABBA scenarios (the name of scenario and the associated colour is indicated in the figure). The lines show the mean trajectory and the shaded areas denote 95% credibility intervals.

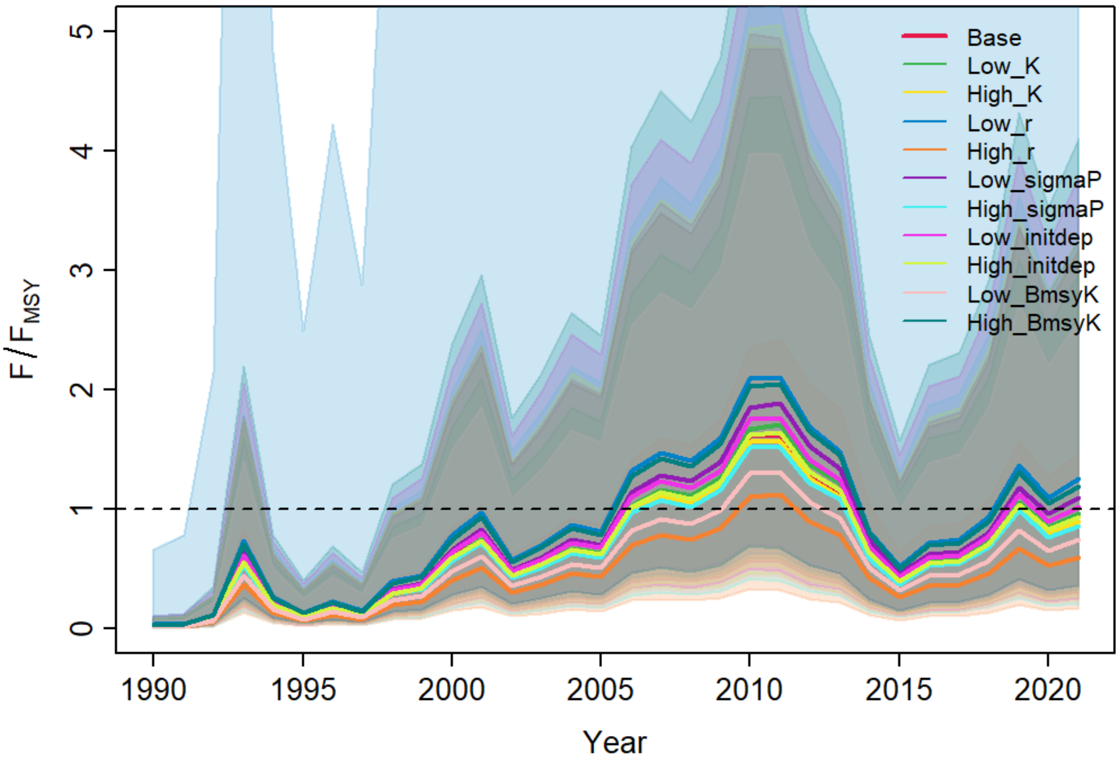
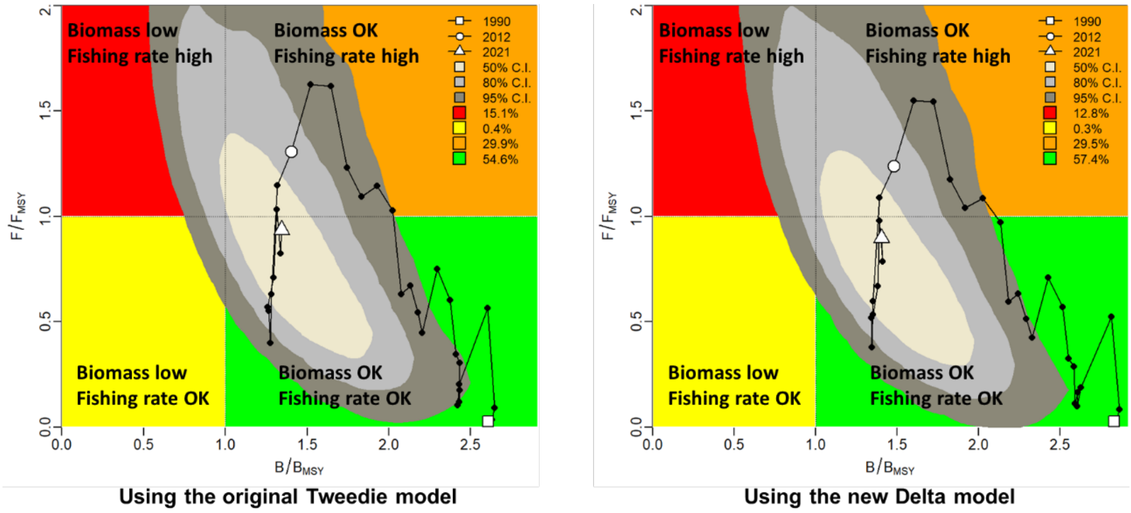


Figure 9.12. Estimated trajectories for F/F$_{MSY}$ for the ICES subareas 1 and 2 anglerfish based on 11 JABBA scenarios (the name of scenario and the associated colour is indicated in the figure). The lines show the mean trajectory and the shaded-areas denote 95% credibility intervals.



9.13. Kobe plot for the JABBA base case scenario showing the estimated joint trajectories (1990–2021) of B/B_{MSY} and F/F_{MSY}. Different grey shaded areas denote the 50%, 80%, and 95% credibility interval for the terminal assessment year. The probability of terminal year points falling within each quadrant is indicated in the figure legend. The figure on the left shows the results using the original Tweedie model when calculating the abundance index while the figure on the right uses the index derived from the delta model.

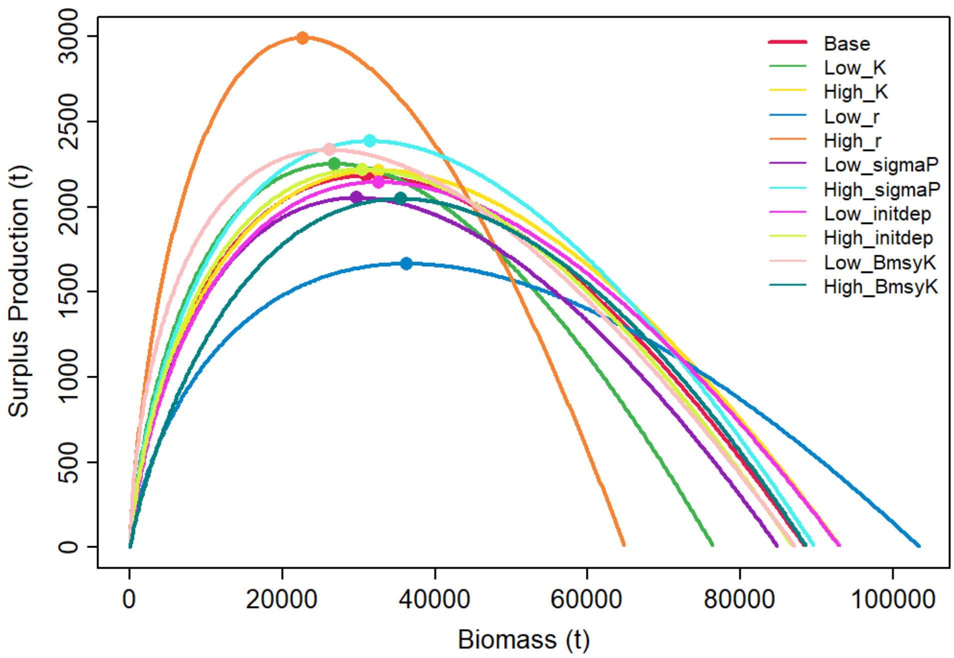


Figure 9.14. Sensitivity analysis for the ICES subareas 1 and 2 anglerfish based on 11 JABBA scenarios (the name of scenario and the associated colour is indicated in the figure). The analysis says that MSY could be around 2000 tonnes, with B_{MSY} ~30000 tonnes. Note that the MSY value is quite sensitive to the choice of prior on r = population growth rate.

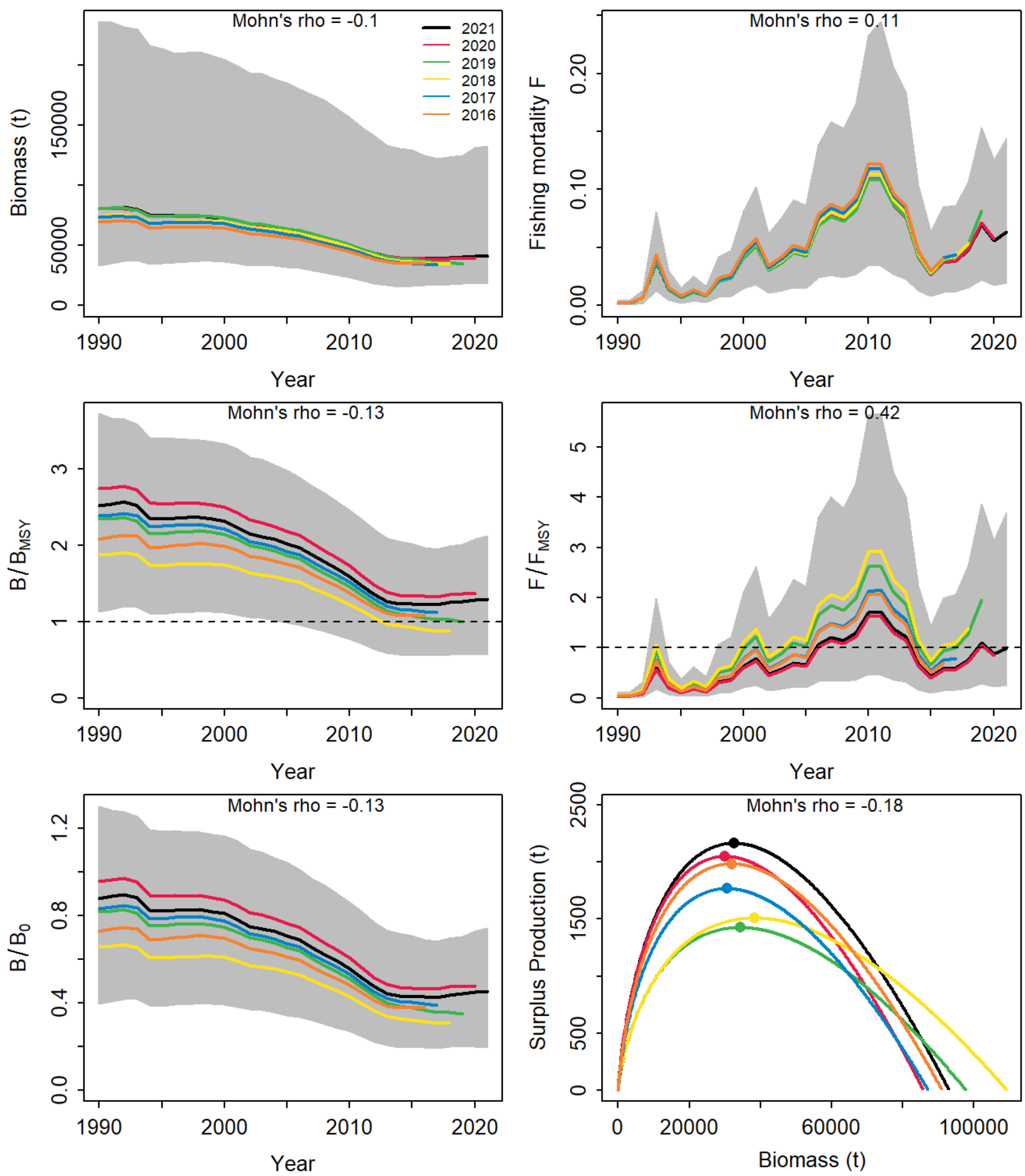


Figure 9.15. Retrospective analysis from the JABBA base case scenario. Different colours illustrate the results from different peels.

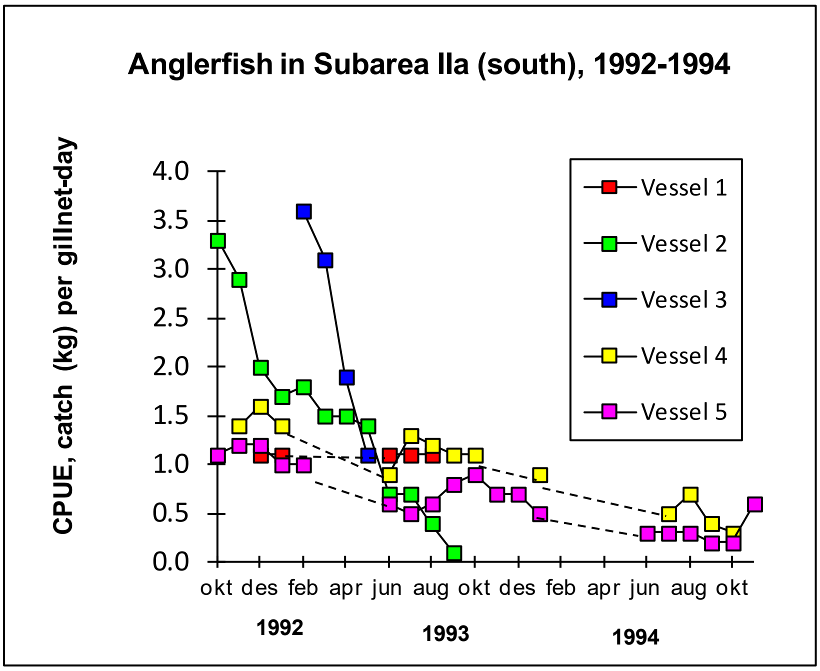
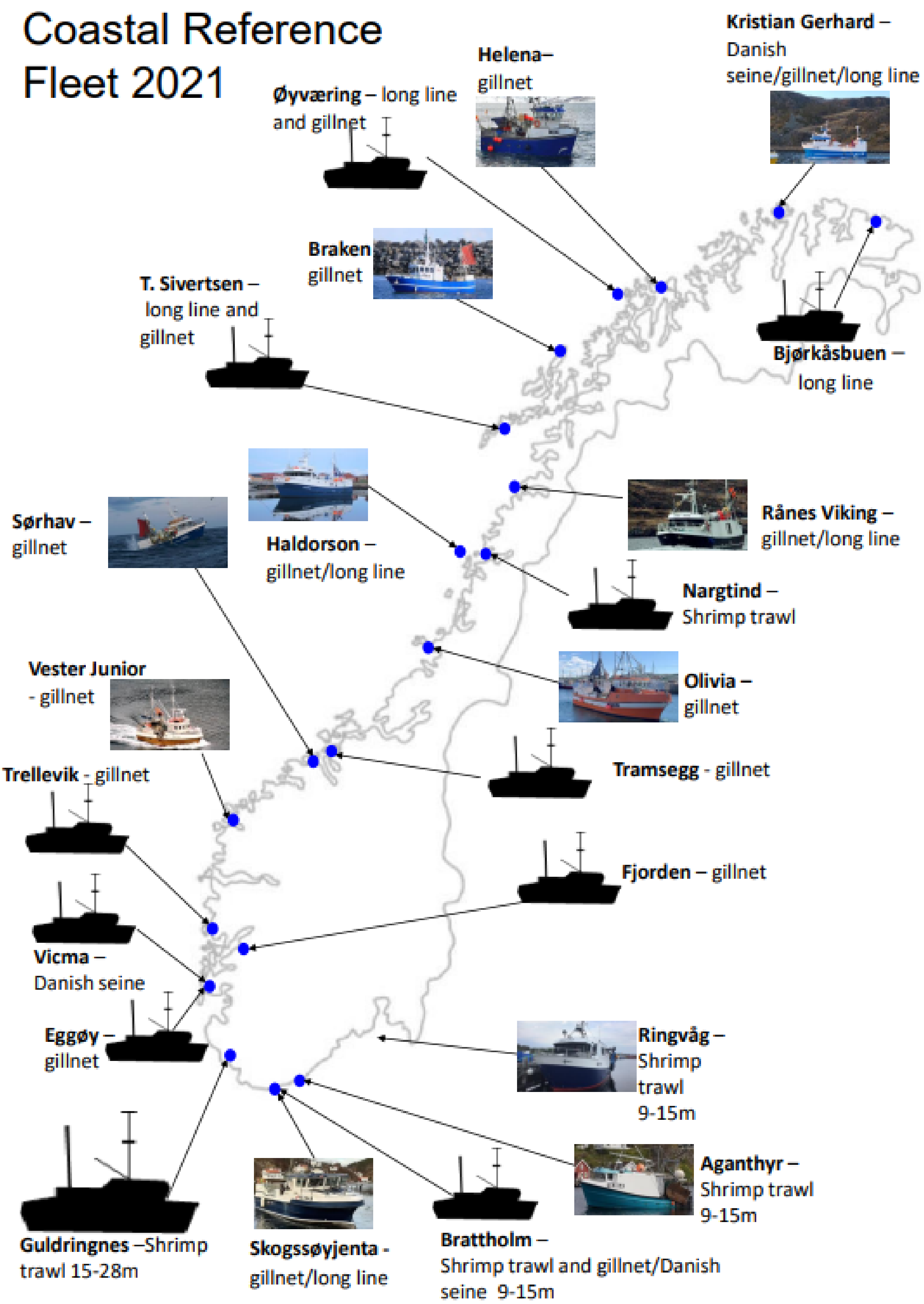


Figure 9.16. Catch per unit effort for five boats in the gillnet fishery for anglerfish in Møre and Romsdal (the same area as vessel A in figure 8 is fishing in) in the period October 1992 to October 1994. Boat 1 > 25m; Boat 2 ca. 20 m; Boat 3 ca. 10 m; Boat 4 and 5 ca. 16 m. Boats 1–4 were fishing with gillnet 360 mm nesh size, boat 5 with 300 mm mesh size.

Appendix figure H1.

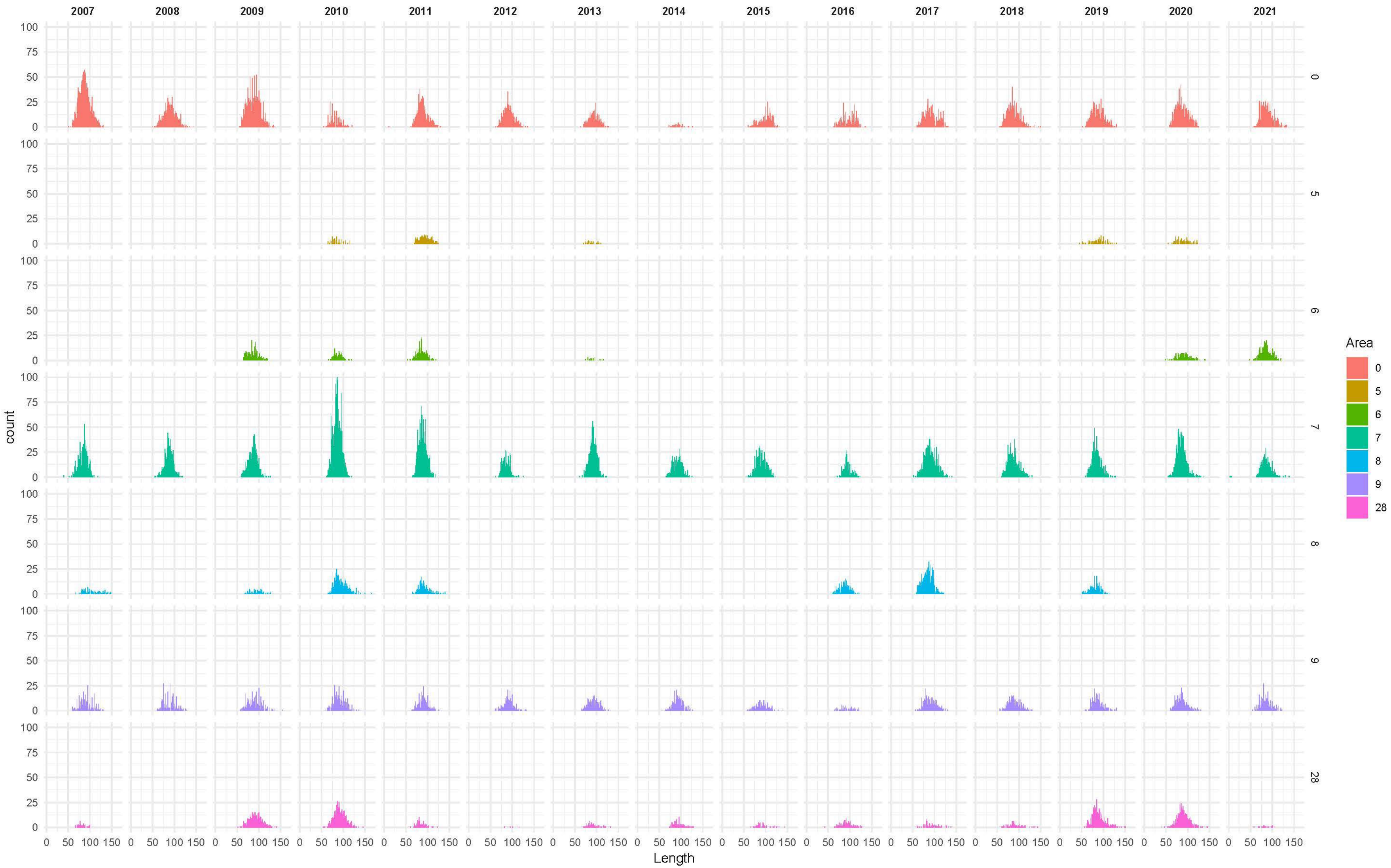


Appendix table H1. Input data to the JABBA assessment in the form of catch and abundance indices of anglerfish (*L. piscatorius*) in ICES subareas 1 and 2.

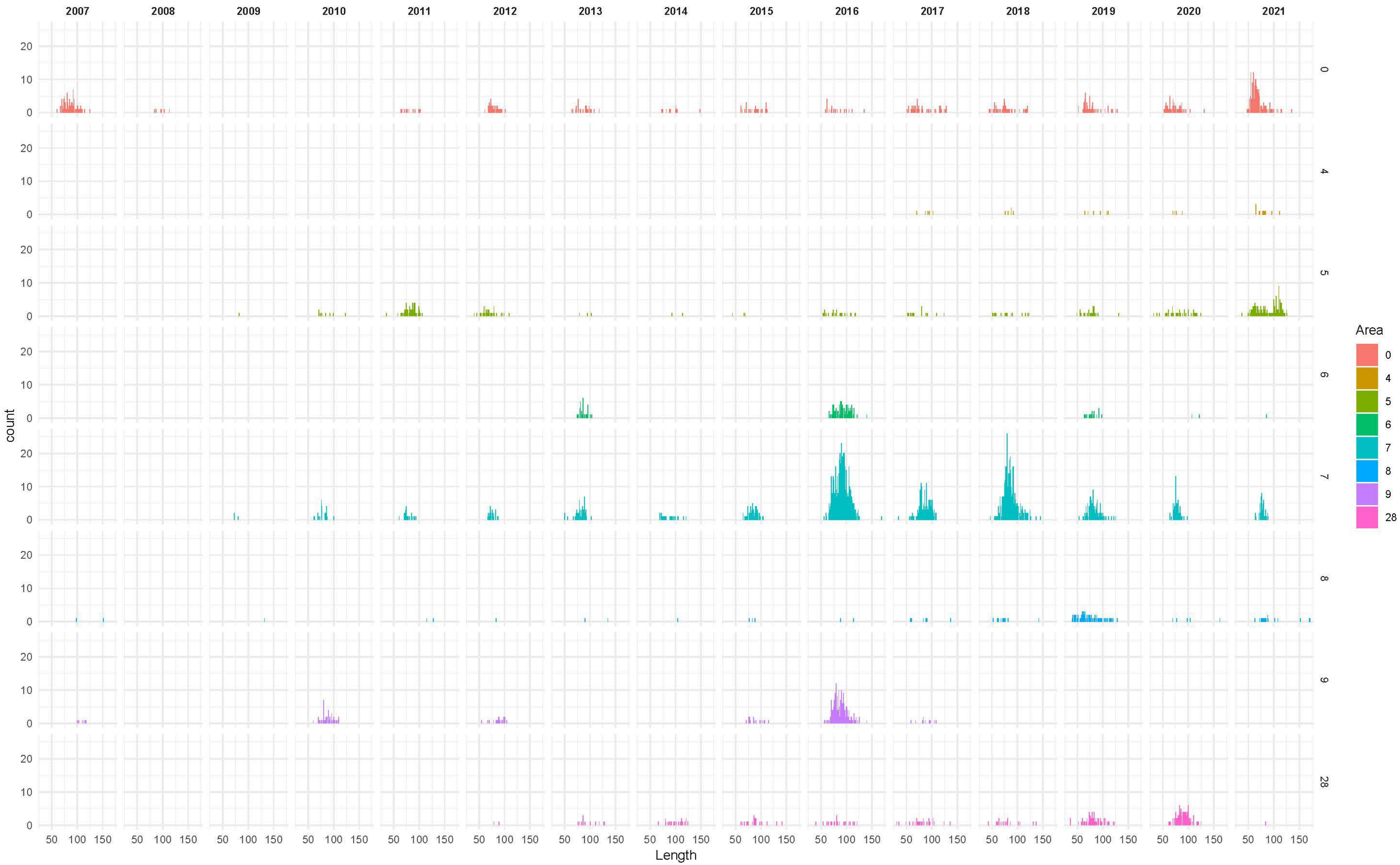
Year	Catch	CPUE (mean)	CPUE (SE)
1990	151		
1991	180		
1992	488	1.5	0.3
1993	3042	1	0.2
1994	1024	0.5	0.1
1995	526		
1996	887		
1997	601		
1998	1549		
1999	1743		
2000	2999		
2001	3624		
2002	2071		
2003	2477		
2004	3001		
2005	2735		
2006	4348		
2007	4591	0.52	0.08
2008	4151	0.56	0.07
2009	4458	0.51	0.06
2010	5515	0.45	0.05
2011	5112	0.47	0.06
2012	3765	0.45	0.06
2013	3103	0.33	0.04
2014	1657	0.41	0.06
2015	1043	0.41	0.07
2016	1435	0.32	0.05
2017	1484	0.29	0.06

Year	Catch	CPUE (mean)	CPUE (SE)
2018	1903	0.36	0.08
2019	2809	0.30	0.05
2020	2280	0.48	0.06
2021	2601	0.42	0.06

Appendix figure H2. Length distributions of anglerfish (*L. piscatorius*) caught and retained in large-meshed gillnets per year and Norwegian statistical areas. Areas 0, 5, 6 and 7 represent ICES Subarea 2. Note the different scale of the y-axis in App. figs H2-H4.



Appendix figure H3. Length distributions of anglerfish (*L. piscatorius*) caught as bycatch and retained in other gillnets per year and Norwegian statistical areas. Note the different scale of the y-axis in App. figs H2-H4.



Appendix figure H4. Length distributions of anglerfish (*L. piscatorius*) caught as bycatch and retained in other gears per year and Norwegian statistical areas. Note the different scale of the y-axis in App. figs H2-H4.

10 Barents Sea capelin[1]

10.1 Regulation of the Barents Sea capelin fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for winter fishery and for autumn fishery. From 1999, no autumn fishery has taken place, except for a small Russian experimental fishery in some years. A minimum landing size of 11 cm has been in force since 1979. AFWG strongly recommends capelin fishery only on mature fish during the period from January to April.

10.2 TAC and catch statistics (Table 10.1)

The Joint Russian-Norwegian Fishery Commission set a zero TAC for 2021 and a TAC of 70 000 tonnes for 2022. For both years, the quotas were in accordance with the ICES advice. The international historical catch by country and season in the years 1965–2022 is given in Table 10.1. The Norwegian catch in 2022 was 42 346 tonnes which was 396 tonnes above the national TAC. Russian catches were 22 646 tonnes which was 5404 tonnes below the national TAC.

The age–length distribution of Russian catches in 2022 is summarized in the text table below (age distribution (%) for each length group and catch at length in numbers).

Norwegian age–length composition of 2022 catches were not ready at the time of AFWG.

The capelin sampling from the Barents Sea in 2021–2022 is summarized below:

Investigation	No. of trawl hauls	Length measurements	Aged individuals
Winter capelin survey 2022 (Norway)	25	2383	978
Joint Winter survey 2022 (Norway)	292	10859	1059
Joint Winter survey 2022 (Russia)	97	5759	200
IESNS 2021 (Russia)	12	362	156
BESS 2021 (Norway)	339	22261	6221
BESS 2021 (Russia)	195	15255	1103

[1] Capelin (*Mallotus villosus*) in subareas 1 and 2 (Northeast Arctic), excluding Division 2.a west of 5°W (Barents Sea capelin); cap.27.1-2.

10.3 Stock assessment

10.3.1 Acoustic stock size estimates in 2021 (Table 10.2, Figure 10.1, 10.2 and 10.3)

The geographical survey coverage of the Barents Sea capelin stock during the BESS in 2021 was almost complete (Figure 10.1). However, as last year, an area in the central part of the Barents Sea ("Loophole") was not covered.

The geographical distribution of capelin in 2021 is shown in Figure 10.1, and the position and weighting of the trawl stations is shown in Figure 10.2.

The stock estimate from the area covered by the 2021 survey was 3.998 million tonnes (Table 10.2). About 36% (1.438 million tonnes) of the estimated stock biomass consisted of maturing fish (>14.0 cm). The mean weight at age in the 2021 survey was the lowest since 2014 for age 2 (Figure 10.3).

As decided during the 2016 assessment meeting, the capelin abundance was estimated using the software StoX (Johnsen *et al*. 2019), applying agreed settings.

A fixed sampling variance expressed as Coefficient of Variance (CV) of 0.2 per age group has been applied as input for CapTool in the capelin assessment and was also used this year (Tjelmeland 2002; Gjøsæter *et al.* 2002). The survey design and estimation software now allow for estimation of a direct CV by age group, and for the 2021 survey this was estimated:

- for age group 1: 0.17;
- for age group 2: 0.10;
- and for age group 3: 0.29.

These values are lower than previous years for age group 1 and 2 and similar for age group 3. Relative sampling error based only on acoustic recordings (Nautical Area Scattering Coefficient (NASC; m^2nmi^{-2})) was estimated to 9.27% which is much lower than in the two previous years. Detailed information about previous CV estimates can be found in AFWG WD5, 2018. Future implementation of direct survey CV in the assessment is discussed under future work (10.4.6).

10.3.2 Stock assessment in 2021 (Table 10.3–10.5, Figure 10.4)

Probabilistic projections of the maturing stock to the time of spawning on 1 April 2022 were made using the spreadsheet model CapTool (implemented in the @RISK add-on for EXCEL, 50 000 simulations were used). The settings were the same as last year. The projection was based on a maturation and predation model with parameters estimated by the model Bifrost and data on cod abundance and size at age in 2022 from the 2021 Arctic Fisheries Working Group (ICES Scientific Reports. 2.52). The revised cod assessment made in September 2021 was used.

The methodology is described in the 2009 WKSHORT report (ICES C.M. 2009/ACOM:34) and the WKARCT 2015 report (ICES C.M. 2015/ACOM:31). The natural mortality M for the months October to December is drawn among a set of M-values estimated for different years based on historical data. The same set of M-values was used in 2021 as in 2020 (ICES 2011/ACOM:05, Annex 12).

The CapTool forecast methodology has been implemented in the R package Bifrost and was run alongside the standard procedure. The results were similar, and it produced the same advice.

With no catch, the estimated median spawning stock size on 1 April 2022 is 479 000 tonnes (90% confidence interval: 259 000–916 000 tonnes), and the probability for the spawning stock to be above B_{lim} (200 000 t) is 99 %.

With a catch of 70 000 tonnes, the probability for the spawning stock in 2022 to be below 200 000 t, the B_{lim} value used by ACFM in recent years, is 5 % (Figure 10.4). The median spawning stock size in 2022 will then be 420 000 tonnes (90% confidence interval: 200 000–833 000 tonnes), and the corresponding median modelled consumption by immature cod in the period January–March 2022 will then be 570 000 tonnes. Figure 10.4 shows the probabilistic forecast from 1 October 2021 to 1 April 2022 conditional on a quota of 70 000 tonnes, while Figure 10.5 shows the probability of SSB < B_{lim} as a function of the catch.

As in previous years, the catch corresponding to 95% probability of being above B_{lim} was calculated to the nearest 5000 tonnes.

Estimates of stock in number by age group and total biomass for the historical period are shown in Table 10.4. Other data which describe the stock development are shown in Table 10.5. Information about spawning surveys going back to the 1980s are given in Gjøsæter and Prozorkevitch (WD05, 2020). Summary plots are given in Figure 10.6.

10.3.3 Recruitment

The coverage of the 0-group survey in 2018 and 2020 was incomplete, and an estimate of the 0-group numbers was made for only half of the survey area. In 2021, the coverage was complete. The 0-group series was recalculated by WGIBAR in 2022. Table 10.3 shows the number of fish in the various year classes from surveys at age 0–2, and their "survey mortality" from age one to age two is also shown in Figure 10.7.

The 1-group abundance in 2021 was 220.8 billion which is higher than the long-term average (Figure 10.6). The most recent evaluation of the spawning stock and recruitment time-series was made by Gjøsæter *et al.* (2016).

Future recruitment conditions: High abundance of young herring (mainly age groups 1 and 2) has been suggested to be a necessary but not a single factor causing recruitment failure in the capelin stock (Hjermann *et al.*, 2010; Gjøsæter *et al.* 2016). In 2021, very little herring at age 1–4 were recorded in the Barents Sea during the ecosystem survey.

10.3.4 Comments to the assessment

10.3.4.1 Ecological considerations

The number of young herring in the Barents Sea can be an important factor that affects the capelin recruitment. It is not currently taken into account in the assessment model. The benchmark for capelin stocks in the Barents Sea (WKARCT, ICES C.M. 2015/ACOM:31) noted the need for further study of this effect as well as better monitoring of the young herring abundance.

The amount of other food than capelin for cod and other predators may also have changed in recent years. This may also indirectly have affected the predation pressure on capelin. A more detailed discussion of interactions between capelin and other species is given in the 2016–2022 ICES WGIBAR reports.

The abundance of 2-year-olds observed is the highest in 30 years and the high abundance is corresponded by low length-at-age. This is likely a result of high internal competition for food and reduced growth. This tendency is likely enhanced by a strong 2020-yearclass at least partly competing for the same food. The implication is that the majority of this year class had not reached a length of 14 cm and is not expected to migrate to the coast and spawn before winter of 2023.

10.3.5 Further work on survey and assessment methodology

10.3.5.1 Survey

On 27 February–13 March 2022, IMR carried out a trawl-acoustic monitoring and stock estimation of spawning capelin (Skaret *et al*. 2022). The survey is the fourth in a series to evaluate whether such a monitoring can be used in the assessment to improve the advice. The initiative and funding come from the Norwegian industry, and the idea in the long term is that monitoring closer to when fishery and spawning happens, can reduce uncertainty in stock advice. Monitoring during spawning has been attempted before, last time in 2007–2009, and has proven to be methodologically challenging due to unpredictable timing and location of the spawning migration.

The survey was carried out using two fishing vessels 'Vendla' and 'Eros'. A stratified design using zig-zag transects with randomized starting points was used and the effort was allocated based on historical and recent information about capelin distribution. The fishery sonar was used actively during the whole survey to estimate size distribution of capelin schools, migration speed and direction. In addition, target-strength measurements were carried out using submersible TS-probes on both vessels. The coverage of the capelin spawning migration was successful and the estimate of ca. 427 000 tonnes with a CV of 0.42 was within the expected range from the predictions made in autumn 2021.

Despite the methodological challenges due to timing and distribution of capelin as well as acoustic target strength, the survey results from all four test years have fallen within the uncertainty range of the autumn prediction. This consistency is promising for the use of the survey in an advisory process. An evaluation of the four-year series will be carried out as part of the benchmark for this stock which is planned to be held in 2022.

10.3.5.2 Assessment model

In the present capelin assessment model, the only species interaction in the Barents Sea taken explicitly into account is predation by cod on mature capelin. The model does not take into account possible changes in capelin stock dynamics (e.g. maturation), the current state of the environment and stock status of other fish species and mammals in the Barents Sea. The ICES Working Group of Integrated Assessment of the Barents Sea (WGIBAR) has addressed some of these issues.

Consumption of prespawning capelin by mature cod in winter-spring season and autumn season is still not included in the assessment model. It may have a significant impact on capelin SSB calculations.

Gjøsæter *et al*. (2015) calculated what the quota advice and spawning stock would have been in the period 1991–2013, given the present assessment model and knowledge of the cod stock. By exchanging that cod forecast with the actual amount of cod from the cod assessment model run later in time and rerunning the model, they showed that considerably smaller annual quotas would have been advised if the amount of cod had been known and the present assessment model had been used when the capelin quota was set. Following this work, a retrospective analysis of the capelin assessment as well as of the assessment performance should be included annually. This is a feature which so far has been missing from the capelin assessment.

There is ongoing work to address specific points related to modelling for the benchmark meeting in 2022. These include implementation of survey CV in the capelin assessment model, incorporating the assessment model in Template Model Builder (R-package), validating both the cod consumption part of the model, and the capelin maturation part and updating consumption parameters to reflect recent state in the Barents Sea. As mentioned above, the CapTool methodology for half-year predictions has already been implemented in R. Historic CVs of SSB estimates will be calculated back to 2004.

10.3.6 Reference points

A B_{lim} (SSB_{lim}) management approach has been suggested for this stock (Gjøsæter *et al.*, 2002). In 2002, the JRNFC agreed to adopt a management strategy based on the rule that, with 95% probability, at least 200 000 tonnes of capelin should be allowed to spawn. Consequently, 200 000 tonnes was used as a B_{lim}. Alternative harvest control rules of 80, 85 and 90% probability of SSB > B_{lim} were suggested by JNRFC and evaluated by ICES (WKNEAMP-2, ICES C. M. 2016/ACOM:47). ICES considers these rules not to be precautionary. At its 2016 meeting, JNRFC decided not to change the adopted management strategy.

Table 10.1 Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	224	0	0	0	224
1966	380	9	0	389	0	0	0	389
1967	403	6	0	409	0	0	0	409
1968	460	15	0	475	62	0	62	537
1969	436	1	0	437	243	0	243	680
1970	955	8	0	963	346	5	351	1314
1971	1300	14	0	1314	71	7	78	1392
1972	1208	24	0	1232	347	13	360	1591
1973	1078	34	0	1112	213	12	225	1337
1974	749	63	0	812	237	99	336	1148
1975	559	301	43	903	407	131	538	1441
1976	1252	228	0	1480	739	368	1107	2587
1977	1441	317	2	1760	722	504	1226	2986
1978	784	429	25	1238	360	318	678	1916
1979	539	342	5	886	570	326	896	1782
1980	539	253	9	801	459	388	847	1648
1981	784	429	28	1241	454	292	746	1986
1982	568	260	5	833	591	336	927	1760
1983	751	373	36	1160	758	439	1197	2357
1984	330	257	42	629	481	368	849	1477

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1985	340	234	17	591	113	164	277	868
1986	72	51	0	123	0	0	0	123
1987–1990	0	0	0	0	0	0	0	0
1991	528	159	20	707	31	195	226	933
1992	620	247	24	891	73	159	232	1123
1993	402	170	14	586	0	0	0	586
1994–1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	1	1	1
1998	0	2	0	2	0	1	1	3
1999	50	33	0	83	0	22	22	105
2000	279	94	8	381	0	29	29	410
2001	376	180	8	564	0	14	14	578
2002	398	228	17	643	0	16	16	659
2003	180	93	9	282	0	0	0	282
2004	0	0	0	0	0	0	0	0
2005	1	0	0	1	0	0	0	1
2006	0	0	0	0	0	0	0	0
2007	2	2	0	4	0	0	0	4
2008	5	5	0	10	0	2	0	12
2009	233	73	0	306	0	1	1	307
2010	246	77	0	323	0	0	0	323
2011	273	87	0	360	0	0	0	360
2012	228	68	0	296	0	0	0	296
2013	116	60	0	177	0	0	0	177
2014	40	26	0	66	0	0	0	66
2015	71	44	0	115	0	0	0	115
2016–2017	0	0	0	0	0	0	0	0
2018	129	66	0	195	0	0	0	195

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
2019–2021	0	0	0	0	0	0	0	0
2022	42	23	0	65				

Table 10.2. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size (10^9) by age and length, and biomass (1000 tonnes) from the acoustic survey in August–October 2021. TSN: Total stock number. TSB: Total-stock biomass. MSN: Maturing stock number. MSB: Maturing stock biomass.

Length (cm)	Age/year class					Sum	Biomass (10^3 t)	Mean weight (g)
	1	2	3	4	5	10^9		
	2020	2019	2018	2017	2016			
7.0–7.5	1.92					1.92	2.53	1.32
7.5–8.0	4.82					4.82	9.07	1.88
8.0–8.5	15.46					15.46	34.93	2.26
8.5–9.0	26.72	1.07				27.79	73.09	2.63
9.0–9.5	53.27	2.98				56.25	170.44	3.03
9.5–10.0	60.28	6.18				66.46	227.95	3.43
10.0–10.5	32.24	14.56				46.8	187.67	4.01
10.5–11.0	15.64	44.08				59.72	284.86	4.77
11.0–11.5	4.68	39.57				44.25	241.61	5.46
11.5–12.0	2.93	40.58	0.02			43.53	278.59	6.4
12.0–12.5	1.41	34.22				35.63	265.09	7.44
12.5–13.0	0.93	31.6	0.17			32.7	285.18	8.72
13.0–13.5	0.35	26.38	0.24			26.97	273.76	10.15
13.5–14.0	0.13	18.48	0.44			19.04	224.8	11.81
14.0–14.5	0.07	15.84	0.34			16.25	215.82	13.28
14.5–15.0		13.36	0.53			13.89	215.3	15.5
15.0–15.5		14.24	0.23			14.47	251.54	17.38
15.5–16.0		9.74	1.51			11.25	223.36	19.85
16.0–16.5		6.27	0.68			6.95	154.24	22.18
16.5–17.0		6.74	0.32			7.06	177.3	25.1
17.0–17.5		2.774	1.03	0.01		3.814	105.26	27.6

Length (cm)	Age/year class					Sum	Biomass (10^3 t)	Mean weight (g)
	1	2	3	4	5	10^9		
	2020	2019	2018	2017	2016			
17.5–18.0		1.043	0.454			1.497	48.24	32.23
18.0–18.5		0.164	0.924			1.089	36.55	33.58
18.5–19.0		0.115				0.115	4.3	37.39
19.0–19.5		0.0344	0.1013	0.0006		0.1362	5.38	39.46
19.5–20.0				0.0208		0.0208	0.91	43.87
20.5–21.0				0.0002		0.0002	0.01	47.88
TSN (10^9)	220.85	330.0204	6.996	0.0316		557.89		
TSB (10^9)	757.71	3081.46	157.23	1.22			3997.62	
Mean length (cm)	9.58	12.57	16.11	18.95		11.43		
Mean weight (g)	3.43	9.34	22.47	38.66				7.17
SSN (10^9)	0.07	70.3204	6.12	0.0316		76.54		
SSB (10^9)	0.93	1287.85	147.96	1.22			1437.96	

Table 10.3 Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic estimate in August–September, total mortality from age 1+ to age 2+.

Year class	Larval abundance (10^{12})	0-group swept-area numbers (10^9 ind.)	Acoustic estimate (10^9ind.)		Mortality survey(1—2)
	0 (Y)	0+(Y)	1(Y+1)	2(Y+2)	%
1980	-	740	402.6	147.6	63
1981	9.7	477	528.3	200.2	62
1982	9.9	600	514.9	186.5	64
1983	9.9	340	154.8	48.3	69
1984	8.2	275	38.7	4.7	88
1985	8.6	64	6.0	1.7	72
1986	0.0	42	37.6	28.7	24
1987	0.3	4	21.0	17.7	16
1988	0.3	65	189.2	177.6	6
1989	7.3	862	700.4	580.2	17

Year class	Larval abundance (10^{12})	0-group swept-area numbers (10^9 ind.)	Acoustic estimate (10^9ind.)	Mortality survey(1—2)	
1990	13.0	116	402.1	196.3	51
1991	3.0	169	351.3	53.4	85
1992	7.3	2	2.2	3.4	--
1993	3.3	1	19.8	8.1	59
1994	0.1	14	7.1	11.5	--
1995	0.0	3	81.9	39.1	52
1996	2.4	137	98.9	72.6	27
1997	6.9	189	179.0	101.5	43
1998	14.1	113	156.0	110.6	29
1999	36.5	288	449.2	218.7	51
2000	19.1	141	113.6	90.8	20
2001	10.7	90	59.7	9.6	84
2002	22.4	67	82.4	24.8	70
2003	11.9	341	51.2	13.0	75
2004	2.5	54	26.9	21.7	19
2005	8.8	148	60.1	54.7	9
2006	17.1	516	221.7	231.4	--
2007	-	480	313.0	166.4	46
2008	-	995	124.0	127.6	--
2009	-	673	248.2	181.1	27
2010	-	319	209.6	156.4	25
2011	-	594	145.9	216.2	-
2012	-	989	324.5	106.6	67
2013	-	316	105.1	40.5	62
2014	-	164	39.5	8.1	79
2015	-	457	31.6	123.7	-
2016	-	779	86.4	59.6	31
2017	-	214	58.6	7.0	88

Year class	Larval abundance (10^{12})	0-group swept-area numbers (10^9 ind.)	Acoustic estimate (10^9ind.)	Mortality survey(1—2)	
2018	-	680	17.5	31.1	-
2019	-	1465	366.4	330.0	10
2020	-	1077	220.9		
2021	-	325			
Average	9.0	372	176.8	105.2	

***In the brackets – the correction numbers, taking into account not surveyed area.**

Table 10.4 Barents Sea CAPELIN. Stock size in numbers by age, total-stock biomass, biomass of the maturing component (MSB) at 1. October.

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051
2011	209	181	55	8	0	454	3707	2115
2012	146	156	88	2	0	392	3586	1997
2013	324	216	59	7	0	610	3956	1471
2014	105	107	39	2	0	253	1949	873
2015	40	40	13	1	0	94	842	375
2016	32	8	3	0	0	43	328	181
2017	86	124	17	0	0	227	2506	1723
2018	59	60	21	0	0	140	1597	1056
2019	17	9	7	1	0	35	411	302

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
2020	366	31	4	1	0	403	1884	533
2021	221	330	7	0	0	558	3998	1438

Table 10.5 Barents Sea CAPELIN. Summary stock and data for prognoses table. Recruitment and total biomass (TSB) are survey estimates back-calculated to 1 August (before autumn fishing season) for 1985 and earlier; for 1986 and later it is the survey estimate. Maturing biomass (MSB) is the survey estimate of fish above length of maturity (14.0 cm). SSB is the median value of the modelled stochastic spawning-stock biomass (after winter/spring fishery). * - indicates a very small spawning stock. "SSB by winter" is acoustic assessment in the winter-spring survey in next year. For most of the years, the survey area was covered partly. Estimates from spawning surveys going back to the 1980s are given in Gjøsæter and Prozorkevitch (WD05, AFWG 2021) and not included here.

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		SSB, assessment model, April 1 year+1 (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^3 tons) source: WGIBAR 2022	Herring 0-group swept-area index (10^9 ind.p) source: WGIBAR 2022	Capelin landing (10^3 t)
	TSB	MSB					
1972	6600	2727		152	2		1591
1973	5144	1350	33	529	2		1337
1974	5733	907	*	305	48		1148
1975	7806	2916	*	190	74		1441
1976	6417	3200	253	211	39		2587
1977	4796	2676	22	360	46		2986
1978	4247	1402	*	84	52		1916
1979	4162	1227	*	12	39		1782
1980	6715	3913	*	270	66	0	1648
1981	3895	1551	316	403	47	0	1986
1982	3779	1591	106	528	9	3	1760
1983	4230	1329	100	515	12	195	2357
1984	2964	1208	109	155	1467	27	1477
1985	860	285	*	39	2638	20	868
1986	120	65	*	6	191	0	123
1987	101	17	34	38	288	0	0
1988	428	200	*	21	77	61	0

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October	SSB, assessment model, April 1 year+1 (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^3 tons) source: WGIBAR 2022	Herring 0-group swept-area index (10^9 ind.p) source: WGIBAR 2022	Capelin landing (10^3 t)
1989	864	175	84	189	277	18	0
1990	5831	2617	92	700	434	15	0
1991	7287	2248	643	402	929	268	933
1992	5150	2228	302	351	1329	84	1123
1993	796	330	293	2	2432	291	586
1994	200	94	139	20	1887	104	0
1995	193	118	60	7	647	11	0
1996	503	248	60	82	238	550	0
1997	909	312	85	99	537	463	1
1998	2056	932	94	179	560	476	3
1999	2775	1718	382	156	1616	36	105
2000	4273	2098	599	449	2109	470	410
2001	3630	2019	626	114	1233	10	578
2002	2210	1291	496	60	428	152	659
2003	533	280	427	82	1794	178	282
2004	628	294	94	51	3790	774	0
2005	324	174	122	27	2191	126	1
2006	787	437	72	60	2115	295	0
2007	2119	844	189	222	876	144	4
2008	4428	2468	330	313	958	201	12
2009	3765	2323	517	124	440	104	307
2010	3500	2051	504	248	605	117	323
2011	3707	2115	487	209	816	83	360
2012	3586	1997	504	146	445	177	296
2013	3956	1471	479	324	492	289	177
2014	1949	873	504	105	673	136	66

Year	**Estimated stock by autumn acoustic survey (10^3 t) 1 October**	**SSB, assessment model, April 1 year+1 (10^3 t)**	**Recruitment Age 1, survey assessment 1 October 10^9 sp.**	**Young herring biomass age 1+2 (10^3 tons) source: WGIBAR 2022**	**Herring 0-group swept-area index (10^9 ind.p) source: WGIBAR 2022**	**Capelin landing (10^3 t)**	
2015	842	375	82	40	963	83	115
2016	328	181	37	32	498	79	0
2017	2506	1723	462	124	1106	154	0
2018	1597	1056	317	59	2034	55	195
2019	411	302	85	17	389	50	0
2020	1884	533	154	366	359	12	0
2021	3998	1438	420	221	152	209	0
2022						65	

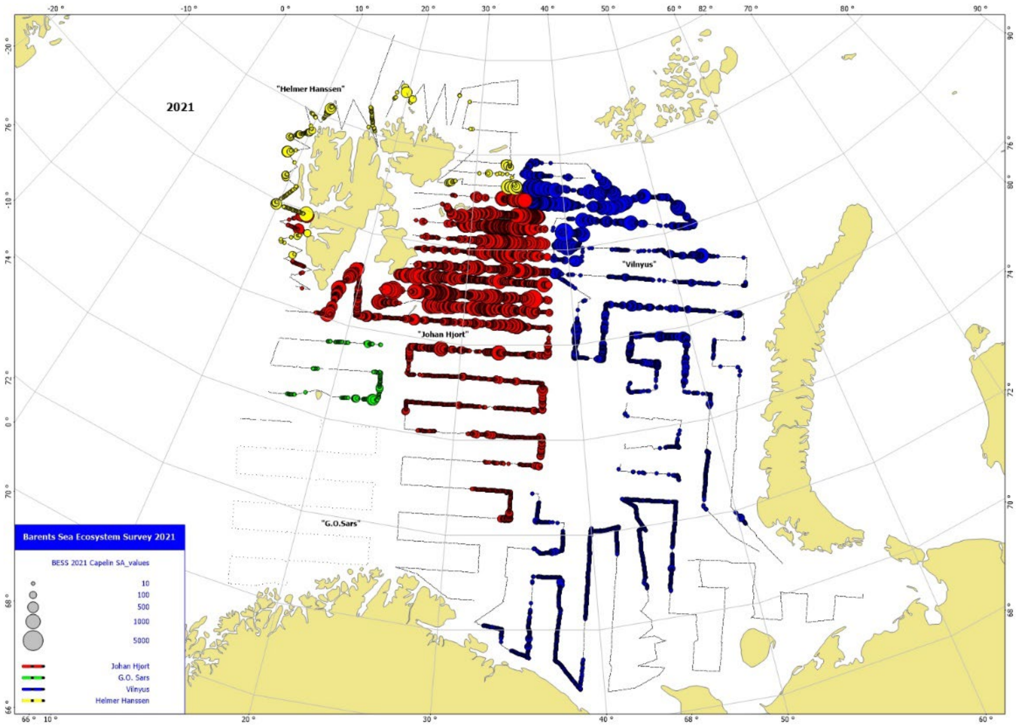


Figure 10.1. Geographical distribution of capelin in August-September 2021.

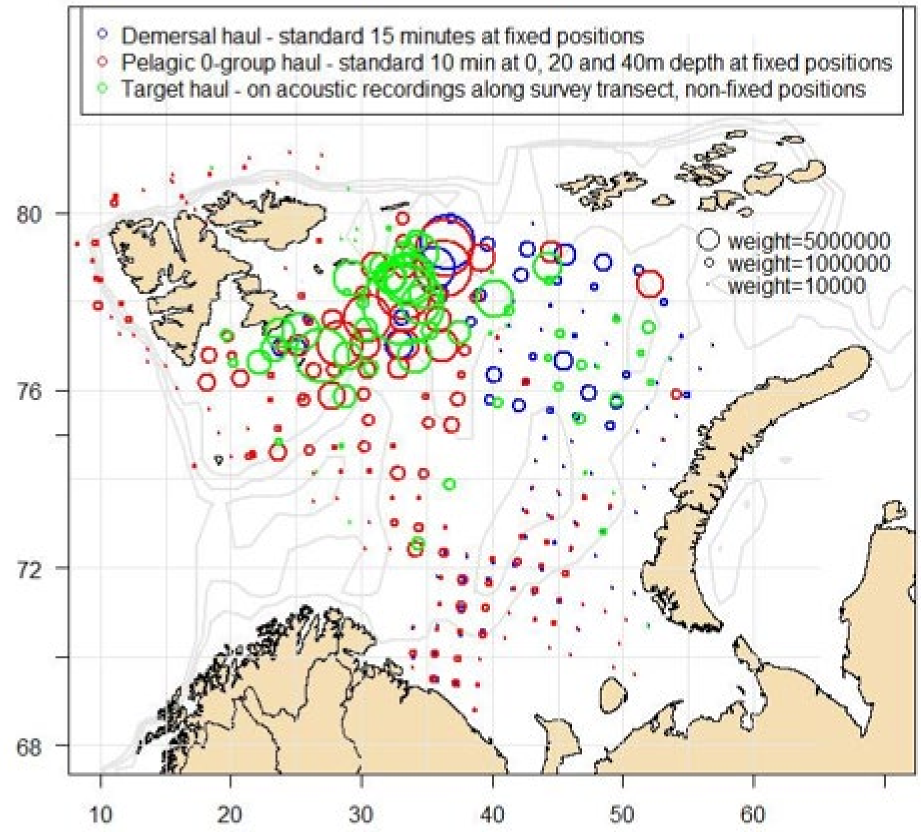


Figure 10.2. Position of trawl hauls and weighting of the corresponding capelin length distributions applied in the acoustic estimate in 2021. The weighting is proportional to NASC within a 10 nm radius.

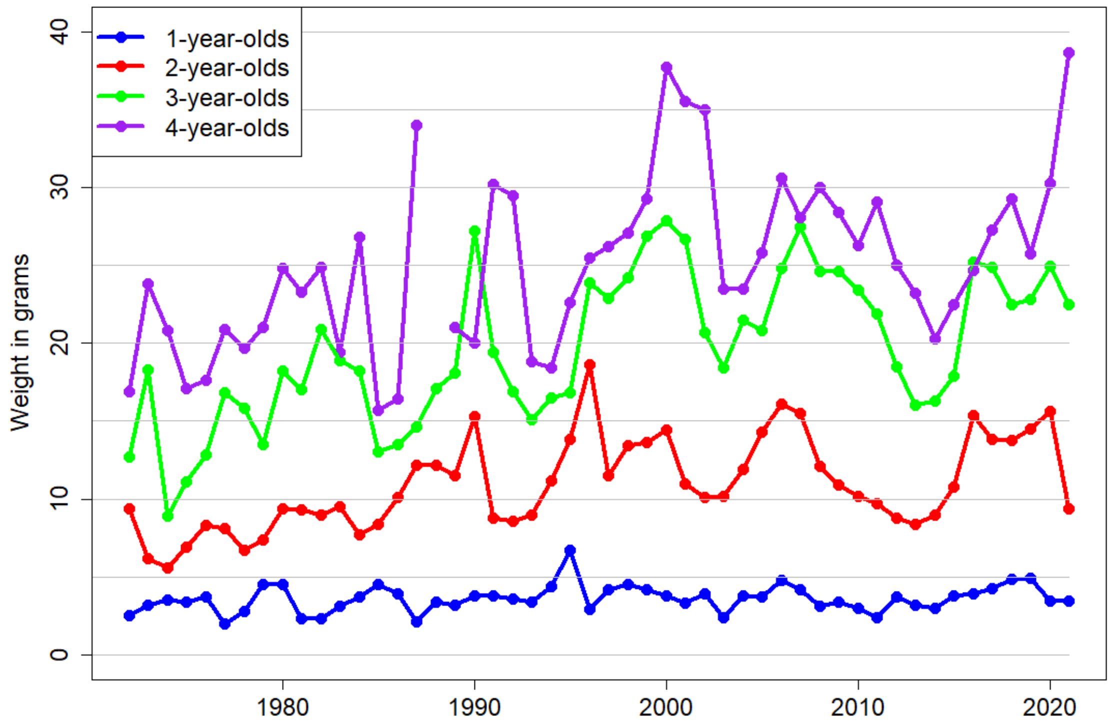


Figure 10.3 Weight-at-age (grammes) for capelin from the autumn survey.

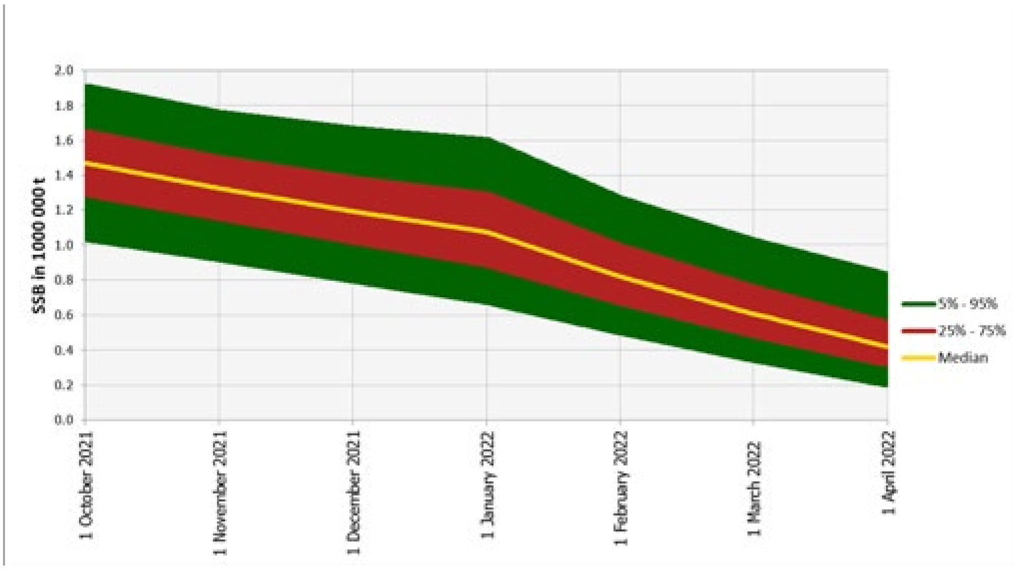


Figure 10.4. Probabilistic prognosis 1 October 2021—1 April 2022 for Barents Sea capelin maturing stock, with a catch of 70 000 tonnes (model CapTool, 50 000 simulations).

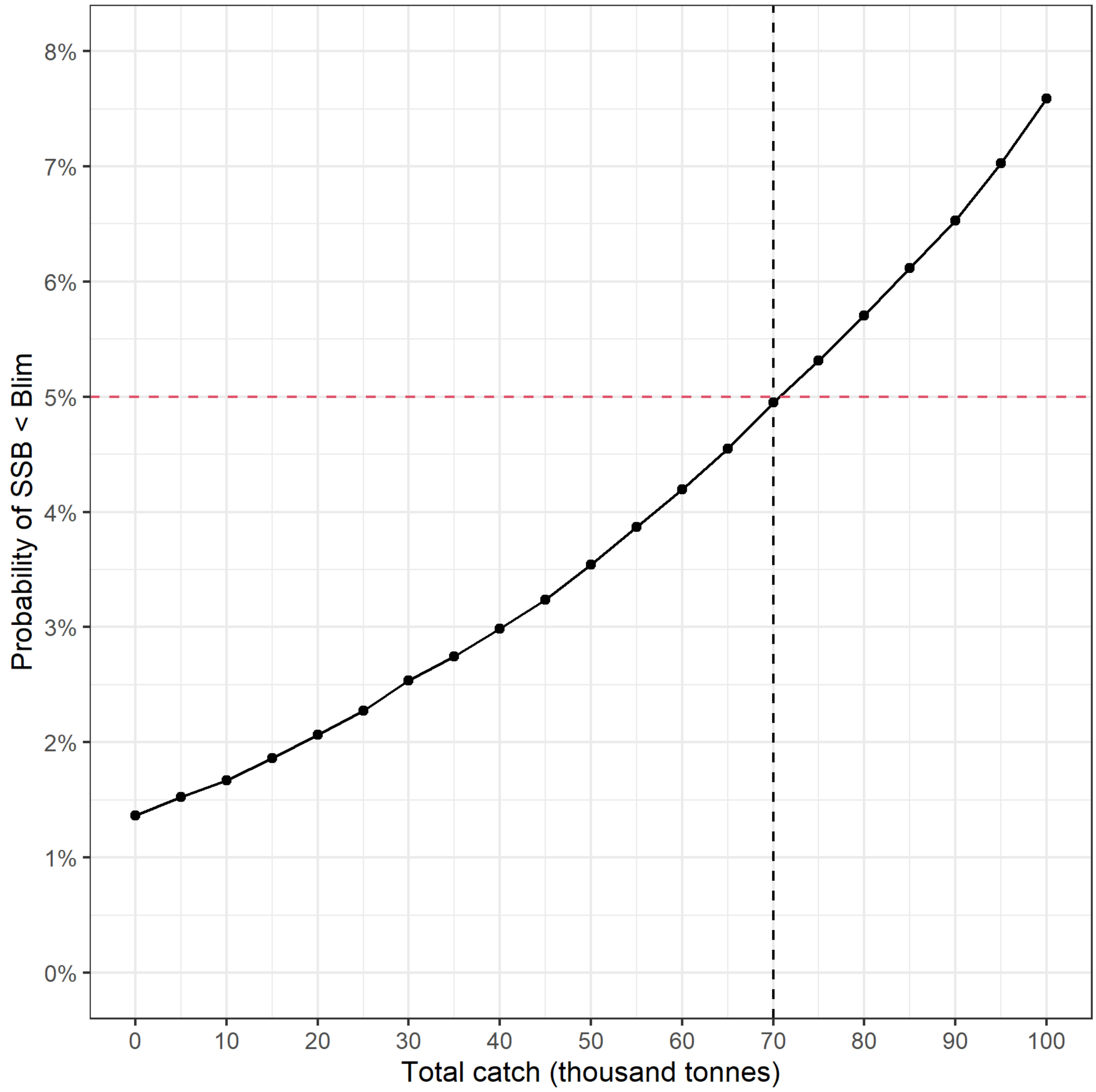
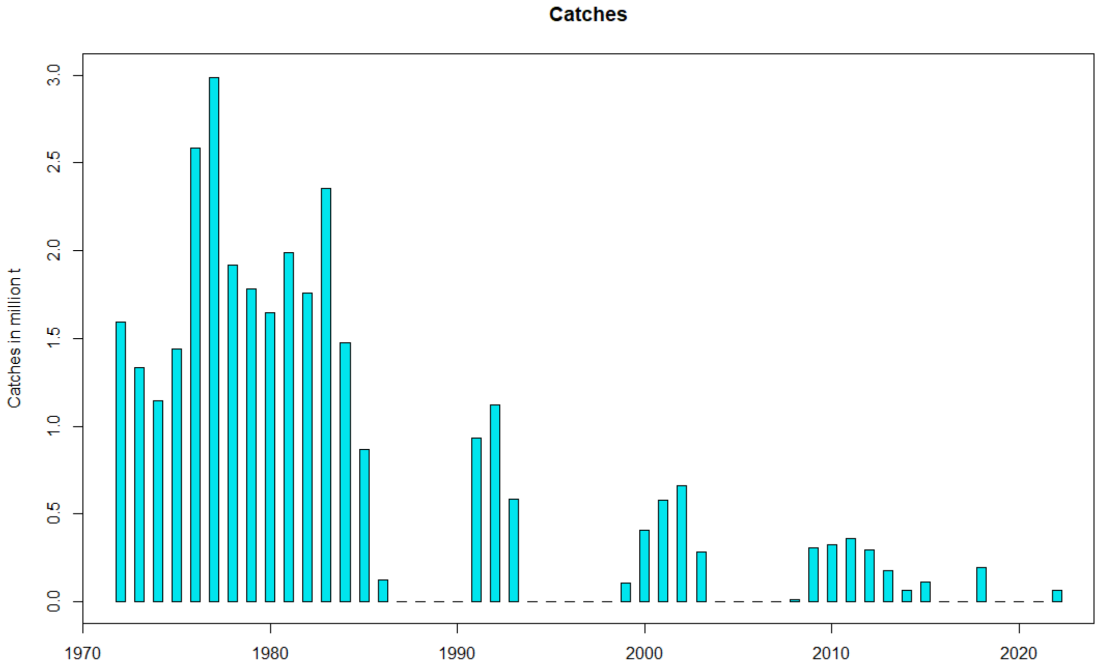
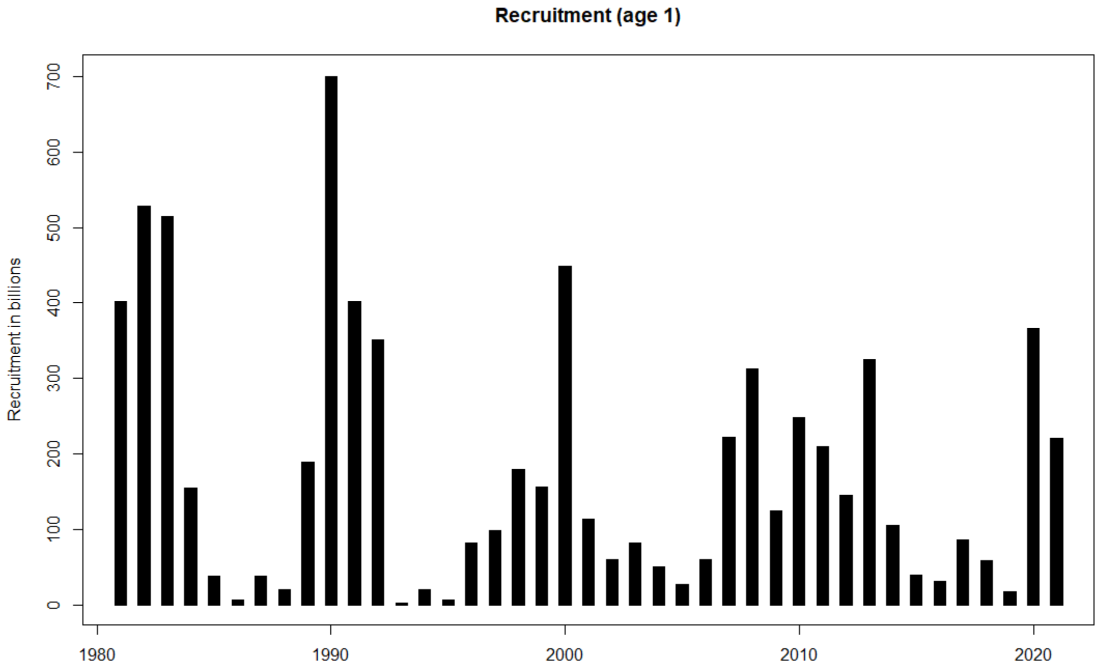


Figure 10.5. Probability of SSB 2022 < B_{lim} as a function of the catch


Catches
Catches in million t
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1970
1980
1990
2000
2010
2020


Recruitment (age 1)
Recruitment in billions
0
100
200
300
400
500
600
700
1980
1990
2000
2010
2020

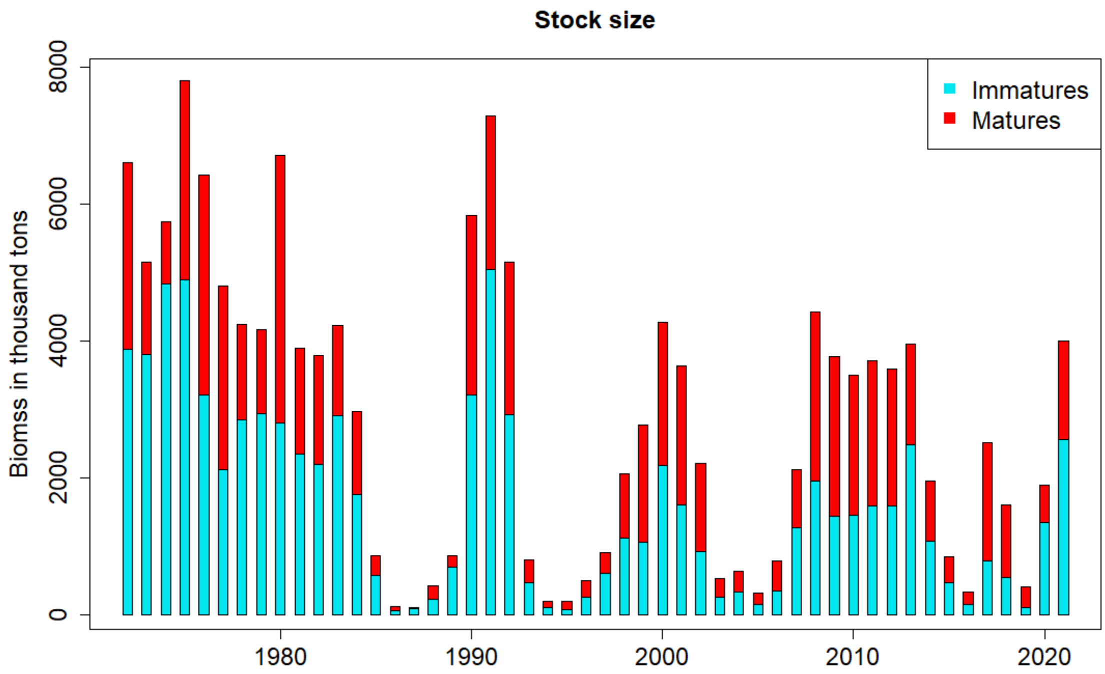


Figure 10.6. Capelin in subareas 1 and 2, excluding Division 2a west of 5°W (Barents Sea capelin). Landings, recruitment, and summary of stock assessment (mature and immature stock biomass in tonnes.

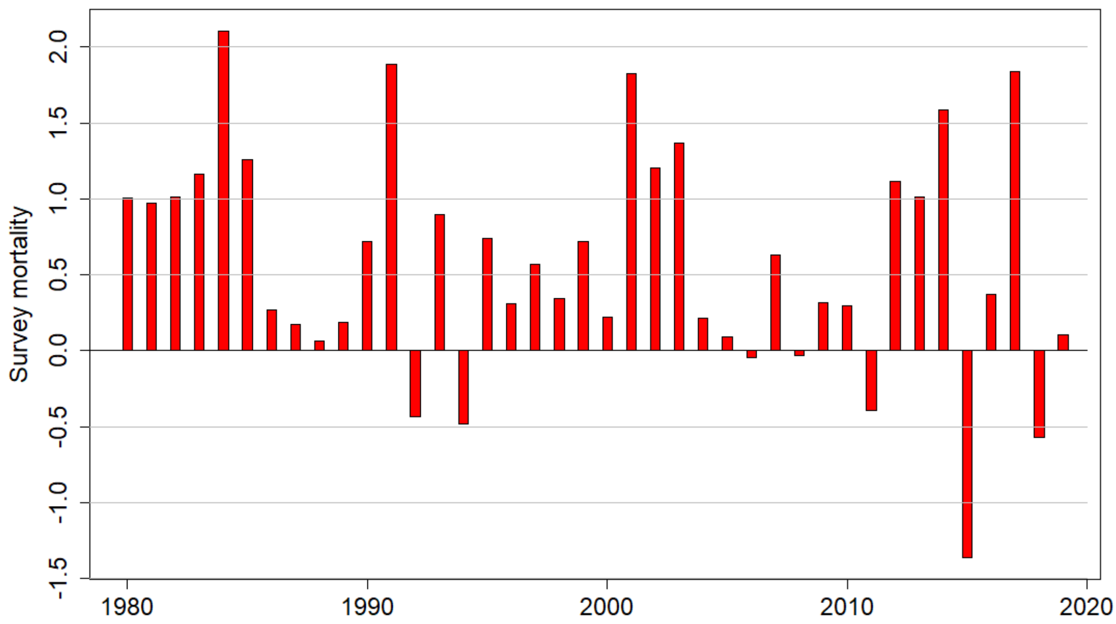


Figure 10.7. Capelin survey mortality per year class from age 1–2 (survey data).

11 References

Aanes, S. 2002. Precision in age determination of Northeast Arctic cod. Working document in: Report of the Arctic Fisheries Working Group. ICES Headquarters 16–25 April 2002. ICES CM 2002/ACFM:18. 451 pp.

Aanes, S. and Pennington, M. 2003. On estimating the Age composition of the Commercial Catch of Northeast Arctic cod from a Sample of Clusters. ICES Journal of Marine Science, 60: 297–303.

Aanes, S. 2016. Stock Annex: Herring (Clupea harengus) in subareas 1, 2, and 5, and in division 4.a and 14.1 (Norwegian Spring Spawning). WKPELA2016

Aas, C. A.2007. Predation by saithe on juvenile fish (cod and others). Master's thesis, University of Tromsø, 2007 (In Norwegian).

Ajiad, A. M., Aglen, A., Nedreaas, K., and Kvamme, C. 2008. Estimating bycatch at age of Northeast arctic cod from the Norwegian shrimp fishery in the Barents Sea 1984–2006. WD2, AFWG 2008.

Albert, O.T. and Vollen, T., 2015. A major nursery area around the Svalbard archipelago provides recruits for the stocks in both Greenland halibut management areas in the Northeast Atlantic. ICES Journal of Marine Science: Journal du Conseil, 72(3): 872–879.

Anon. 2013. The Norwegian Reference Fleet – a trustful cooperation between fishermen and scientists. Focus on Marine Research 3/2013, Institute of Marine Research, Norway. 12 pp.

Anfinsen, L. 2002. Ressursøkologisk betydning av nise (Phocaena phocaena) i norske farvann. Dr. scient thesis. Institute of fisheries and marine biology, University of Bergen, Autumn 2002. 51pp. (In Norwegian).

Bakanev, S 2013. Assessment of the Barents Sea Greenland halibut stock using the stochastic version of the production model. Working document no 14. in: Report of the Benchmark Workshop on Greenland Halibut Stocks (WKBUT), 26–29 November 2013, Copenhagen, Denmark. ICES CM 2013/ ACOM:44. 367 pp.

Barrett, R.T., T. Anker-Nilssen, G.W. Gabrielsen and G. Chapdelaine. 2002. Food consumption by seabirds in Norwegian waters. ICES Journal of Marine Science 59(1): 43–57.

Basterretxea, M., J. Ruiz, A. Iriondo and E. Mugerza 2013. Spanish Greenland halibut survey 2012. Working document in: Report of the Arctic Fisheries Working Group. ICES Headquarters, Copenhagen, 18–24 April 2013. ICES CM 2013/ACOM:05. 726 pp.

Berg, E., and Albert, O. T. 2003. Cod in fjords and coastal waters of North Norway: distribution and variation in length and maturity at age. ICES Journal of Marine Science, 60: 787–797.

Berg, E., Sarvas, T. H., Harbitz, A., Fevolden, S.E. and Salberg, A.B. 2005. Accuracy and precision in stock separation of north-east Arctic and Norwegian coastal cod by otoliths - comparing readings, image analyses and a genetic method. Marine and Freshwater Research, No. 56 10 pp.

Berg, H-S. and Nedreaas, K. 2021. Estimering av utkast i norsk kystfiske med garn ved bruk av Kystreferanseflåten. Estimation of discards in the Norwegian coastal gillnet fisheries based on catch reportings from the Coastal reference fleet. Institute of Marine Research report series: 2021-1, 95 pp. (In Norwegian)

Björnsson, H., and Sigurdsson, T. 2003. Assessment of golden redfish (*Sebastes marinus* L.) in Icelandic waters. Scienta Marina 67 (Suppl. 1):301-314. Scientia Marina, 67: 301–314.

Blom, G. 2015. Omregningsfaktorer for produkter av torsk (Gadus morhua) nord for 62° nord i vintersesongen 2015/Conversion factors for products of cod (Gadus morhua) north of 62°north in the winter season 2015. Directorate of Fisheries, Norway, Report no. 14/17412. 65 pp.

Bogstad B., and Gjøsæter H., 1994. A method for calculating the consumption of capelin by cod. ICES J. mar. Sci. 51:273–280.

Bogstad, B., Howell, D., Åsnes, M. N. (2004). A closed life-cycle model for Northeast Arctic cod. ICES C.M.2004/K:26, 12 pp.

Bogstad, B., Haug, T. and Mehl, S. 2000. Who eats whom in the Barents Sea? NAMMCO Sci. Publ. 2: 98–119.

Bogstad, B. and Mehl, S. 1997. Interactions Between Cod (*Gadus morhua*) and Its Prey Species in the Barents Sea. *Forage Fishes in Marine Ecosystems*. Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 97-01: 591–615. University of Alaska Fairbanks.

Brander, K. 2002. Predicting weight at age. Internal ICES note to assessment working groups. 2003. Software implementation of process models. Working Document No. 2 to the Arctic Fisheries Working Group, San Sebastian, Spain, 23 April- 2 May 2003.

Breivik, O. N., Storvik, G. O., Nedreaas, K. H. 2017. Latent Gaussian models to predict historical bycatch in commercial fishery. Fisheries Research 185: 62–72. doi: 10.1016/j.fishres.2016.09.033

Brooks, M.E, Kristensen, K., van Benthem, K.J., Magnusson, A., Berg, C.W., Nielsen, A., Skaug, H.J., Maechlerm M., and Bolker, B.M. 2017. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. The R Journal, 9(2), 378–400.

Bulgakova, T., 2005. 'To recruitment prognosis of NEA cod'. Working document #20 in: Report of the Arctic Fisheries Working Group', Murmansk, Russia, April 19–28, 2005. ICES C.M. 2005/ACFM:20, 564 pp.

Cañás, L., Stransky, C., Schlickeisen, J., Sampedro, M. P., and Fariña, A. C. 2012. Use of the otolith shape analysis in stock identification of anglerfish (*Lophius piscatorius*) in the Northeast Atlantic. – ICES Journal of Marine Science, 69: 1–7.

Capizzano, C. W., Mandelman, J. W., Hoffman, W. S., Dean, M. J., Zemeckis, D. R., Benoıˆt, H. P., Kneebone, J., Jones, E., Stettner, M. J., Buchan, N. J., Langan, J. A., and Sulikowski, J. A. 2016. Estimating and mitigating the discard mortality of Atlantic cod (Gadus morhua) in the Gulf of Maine recreational rod-and-reel fishery. – ICES Journal of Marine Science, 73: 2342–2355.

Charnov, E.L., Gislason, H., and Pope, J.G. 2013. Evolutionary assembly rules for fish life histories. Fish Fish. 14(2): 213–224.

Clark, W. G. 2002. F 35% Revisited Ten Years Later. North American Journal of Fisheries Management, 22: 251–257. http://www.tandfonline.com/doi/abs/10.1577/1548-8675%282002%29022%3C0251%3AFRTYL%3E2.0.CO%3B2 (Accessed 4 January 2018).

Clegg, T. and Williams, T. 2020. Monitoring bycatches in Norwegian fisheries - Species registered by the Norwegian Reference Fleet 2015-2018. Rapport fra Havforskningen 2020-8. ISSN:1893-4536. https://www.hi.no/hi/nettrapporter/rapport-fra-havforskningen-en-2020-8

Dahle, G., Johansen, T., Westgaard, J-I., Aglen, A., Glover, K. 2018. Genetic management of mixed-stock fisheries "real-time": The case of the largest remaining cod fishery operating in the Atlantic in 2007–2017. Fisheries Research 205 (2018) pp 77–85.

Dahle, G., et al. 2018. Analysis of coastal cod (Gadus morhua L.) sampled on spawning sites reveals a genetic gradient throughout Norway's coastline. - BMC Genetics 19: 42.

Dingsør, G. E. 2001. Estimation of discards in the commercial trawl fishery for Northeast Arctic cod (*Gadus morhua* L.) and some effects on assessment. Cand. Scient thesis, University of Bergen, 2001.

Dingsør, G.E. 2005. Estimating abundance indices from the international 0-group fish survey in the Barents Sea. Fisheries Research 72(2-3): 205–218.

Dingsør G.E., Bogstad B., Stiansen J.E., and Subbey S. 2010. How can we assess recruitment models for (age-3) NEA cod? / WD 19, AFWG 2010.

Dolgov, A.V., Yaragina, N.A., Orlova, E.L., Bogstad, B., Johannesen, E., Mehl, S. 2007. 20th anniversary of the PINRO-IMR cooperation in the investigations of fish feeding in the Barents Sea – results and perspectives. In : Haug,. T., Misund, O.A., Gjøsæter, H., and Røttingen, I. (eds.). Long-term bilateral Russian-Norwegian scientific cooperation as a basis for sustainable management of living marine resources in the Barents Sea. Proceeding of the 12th Norwegian-Russian Symposium. Tromsø, 21–22 August 2007. P.44–78.

Duarte R, Azevedo M, and Pereda P 1997. Study of the growth of southern black and white monkfish stocks. *ICES Journal of Marine Science* 54(5): 866–874.

Dyb J.E., 2003. Bestandsstudie av breiflabb (*Lophius piscatorius* L.*)* langs kysten av Møre og i Nordsjøen. *Cand.scient* thesis, University of Bergen. 105 pp. (In Norwegian)

Eikeset A.M., Richtera A., Dunlop E.S., Dieckmann U., and Stenseth N. C. 2013. Economic repercussions of fisheries-induced evolution. PNAS vol. 110, no. 30: 12259–12264.

Eriksen, E., Prozorkevich, D. V. and Dingsør, G. E. 2009. An evaluation of 0-group abundance indices of Barents Sea Fish Stocks. The Open fish Science Journal, 2: 6–14.

Fall J., 2020. NEA cod and haddock indices from the Barents Sea winter survey 2020. Working document no 10 in: Report of the Arctic Fisheries Working Group (AFWG), 15–22 April 2020. ICES CM 2015/ACOM:05. 639 pp.

Fotland, Å., Nedreaas, K. 2020. Adjusted conversion factors for products of cod (Gadus morhua) and consequences for Norwegian catch data from ICES Subareas 1 and 2 during 1992–2018. WD no. 9 to ICES AFWG 2020 (ICES 2020).

Gislason, H., Daan, N., Rice, J. C., and Pope, J. G. 2010. Size, growth, temperature and the natural mortality of marine fish. Fish and Fisheries, 11: 149–158. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-2979.2009.00350.x (Accessed 3 January 2020).

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

Gjøsæter, H., Bogstad, B., Tjelmeland, S., and Subbey, S. 2015. Retrospective evaluation of the Barents Sea capelin management advice Marine Biology Research 11(2):135–143.

Gjøsæter, H., Hallfredsson, E. H., Mikkelsen, N., Bogstad, B., and Pedersen, T. 2016. Predation on early life stages is decisive for year class strength in the Barents Sea capelin (*Mallotus villosus*) stock. ICES Journal of Marine Science 73(2):182–195.

Golovanov S.E., Sokolov A.M., and Yaragina, N.A. 2007. Revised indices of the Northeast Arctic cod abundance according to the 1982–2006 data from Russian trawl-acoustic survey (TAS). Working Document #3 for AFWG 2007.

Gulland, J. 1964. The abundance of fish stocks in the Barents Sea. Rapp. P.-v. Réun. Cons. Int. Explor. Mer, 155: 126–137.

Håkon Otterå and Kjell Nedreaas, 2020. Effort and catch-per-unit-effort (CPUE) for Norwegian trawlers fishing cod north of 67°N in 2011–2019. Working document no 2 in: Report of the Arctic Fisheries Working Group (AFWG), 15–22 April 2020. ICES CM 2015/ACOM:05. 639 pp.

Hallfredsson, E. and Vollen, T. 2015. Juvenile index for Barents Sea Greenland halibut. Working document no. 1 in Report of the Inter Benchmark Process on Greenland Halibut in ICES areas I and II (IBPHALI). ICES CM 2015\ACOM:54. 37 pp.

Hallfredsson, E. and Vollen, T. 2015. Two abundance indices for Greenland halibut based on the Joint Ecosystem Survey in the Barents Sea and previous surveys in the nursery area. Working document no 20. in: Report of the Arctic Fisheries Working Group (AFWG), 23–29 April 2015, Hamburg, Germany. ICES CM 2015/ACOM:05. 639 pp.

Hamel, O.S. 2014. A method for calculating a meta-analytical prior for the natural mortality rate using multiple life history correlates. ICES J. Mar. Sci. 72(1): 62–69.

Hartig, F. 2020. DHARMa: residual diagnostics for hierarchical (multi-level/mixed) regression models. R package version 0.2.7. https://CRAN.R-project.org/package=DHARMa

Heino M, Dieckmann U, Godø OR 2002. Reaction norm analysis of fisheries-induced adaptive change and the case of the Northeast Arctic cod. ICES CM 2002/Y: 14.

Hirst, D., Aanes, S., Storvik, G. and Tvete, I.F. 2004. Estimating catch at age from market sampling data using a Bayesian hierarchical model. Journal of the Royal statistical society. Series C, applied statistics, 53: 1–14.

Hirst, D., Storvik, G., Aldrin, M., Aanes, S. and Huseby, R.B. 2005. Estimating catch-at-age by combining data from different sources. Canadian Journal of Fisheries and Aquatic Sciences 62:1377–1385.

Hirst, D., Storvik, G., Rognebakke, H., Aldrin, M., Aanes, S., and Vølstad, J. H. 2012. A Bayesian modelling framework for the estimation of catch-at-age of commercially harvested fish species. Can. J. Fish. Aquat. Sci. 69: 2064–2076.

Hislop, J. R. G., Gallego, A., Heath, M. R., Kennedy, F. M., Reeves, S. A., and Wright, P. J. 2001. A synthesis of the early life history of the anglerfish, *Lophius piscatorius* (Linnaeus, 1758) in northern British waters. ICES Journal of Marine Science 58:70–86.

Hjermann, D. Ø., Bogstad, B., Eikeset, A. M., Ottersen, G., Gjøsæter, H., and Stenseth, N. C. 2007. Food web dynamics affect Northeast Arctic cod recruitment. Proceedings of the Royal Society, Series B 274:661–669.

Hjermann, D. Ø., Bogstad, B., Dingsør, G. E., Gjøsæter, H., Ottersen, G., Eikeset, A. M., and Stenseth, N. C. 2010. Trophic interactions affecting a key ecosystem component: a multi-stage analysis of the recruitment of the Barents Sea capelin. Canadian Journal of Fisheries and Aquatic Science 67:1363–1375.

Höffle H. and Planque B. (in revision). Natural mortality estimations for beaked redfish (*Sebastes mentella*) - a long-lived ovoviviparous species of the Northeast Arctic. Fisheries Research11 pp.

Höffle H. and Tranang C. A. 2020. Use of RstoX for recalculating numbers at age of *Sebastes mentella* from the joint NOR-RUS Barents Sea Ecosystem Survey in summer and autumn. WD18 - ICES AFWG2020. xx pp.

Hoenig, J. M. 1983. Empirical use of longevity data to estimate mortality rates. Fisheries Bulletin U.S. 81:898–903.

Holt, R.E., Bogstad, B., Durant, J. M., Dolgov, A. V., and Ottersen, G. 2019. Barents Sea cod (*Gadus morhua*) diet composition: long-term interannual, seasonal, and ontogenetic patterns. ICES Journal of Marine Science 76(6): 1641–1652, doi:10.1093/icesjms/fsz082

Hordyk, A.R., Ono, K., Sainsbury, K.J., Loneragan, N., and Prince, J.D. 2015a. Some explorations of the life history ratios to describe length composition, spawning-per-recruit, and the spawning potential ratio. ICES J. Mar. Sci. 72: 204 - 216.

Hordyk, A.R., Ono, K., Valencia, S.R., Loneragan, N.R., and Prince, J.D. 2015b. A novel length-based empirical estimation method of spawning potential ratio (SPR), and tests of its performance, for small-scale, data-poor fisheries. ICES J. Mar. Sci. 72: 217–231.

Hordyk, A., Ono, K., Prince, J.D., and Walters, C.J. 2016. A simple length-structured model based on life history ratios and incorporating size-dependent selectivity: application to spawning potential ratios for data-poor stocks. Can. J. Fish. Aquat. Sci. 13: 1– 13. doi: 13.1139/cjfas-2015-0422.

Howell, D. 2020. Greenland halibut HR_{pa} proposal. Working document no 15. in: Report of the Arctic Fisheries Working Group (AFWG), 16-22 April 2020, Copenhagen, Denmark.

Høie, H., Bernreuther, M., Ågotnes, P., Beußel, F., Koloskova, V., Mjanger, H., Schröder, D., Senneset, H. and Zuykova, N. 2009. Report of Northeast Arctic cod otolith exchange between Russia, Norway and Germany 2008. WD # 6 ICES Arctic Fisheries Working Group 2009, San Sebastian 21–27th April 2009.

ICES 1997. Report of the ICES/NAFO workshop on Greenland halibut age determination. 26–29 November 1996, Reykjavik, Iceland. ICES CM1997/G:1. 16 pp.

ICES 2001. Report of the Arctic Fisheries Working Group. Bergen, Norway, 24 April – 3 May 2001. ICES CM 2001/ACFM:19. 380 pp.

ICES 2003. Study Group on Biological Reference Points for Northeast Arctic Cod. Svanhovd, Norway 13–17 January 2003. ICES CM 2003/ACFM:11.

ICES 2006a. ICES Workshop on Biological Reference Points for North East Arctic Haddock (WKHAD). Svanhovd, Norway, 6–10 March 2006. ICES C.M. 2006/ACFM:19, 102 pp.

ICES 2006b. Report of the Arctic Fisheries Working Group, Copenhagen 19–28 April 2006. ICES C.M. 2006/ACFM:25, 594 pp.

ICES 2007b. Report of the Arctic Fisheries Working Group, Vigo, Spain 18–27 April 2007. ICES C.M. 2007/ACFM:16, 651 pp.

ICES 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT). ICES C.M. 2009/ACOM: 34: 1–166.

ICES. 2009. Report of the Workshop on analytical methods for evaluation of extinction risk of stocks in poor condition (WKPOOR1), 18–20 May 2009, Copenhagen, Denmark. ICES CM 2009\ACOM:29. 21 pp.

ICES 2009. Report of the workshop for the exploration of the dynamics of fish stocks in poor conditions (WKPOOR2). ICES CM, 2009/ACOM:49: 30pp.

ICES 2010. Report of the Arctic Fisheries Working Group, Lisbon/Bergen, 22–28 April 2010. ICES C.M. 2010/ACOM:05, 664 pp.

ICES 2010. Report of the Benchmark Workshop on Roundfish (WKROUND), 9–16 February 2010, Copenhagen, Denmark. ICES CM 2010/ACOM: 36. 183 pp.

ICES 2011. Report of the Arctic Fisheries Working Group, Hamburg, Germany 28 April – 4 May 2011. ICES C.M. 2011/ACOM:05, 659 pp.

ICES 2011. Report of the Workshop of Implementing the ICES Fmsy framework (WKFRAME2), 10–14 February 2011, ICES, Denmark. ICES C. M. 2011/ACOM:33, 110 pp.

ICES 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks, Lisbon 24–31 January 2011. ICES C.M. 2011/ACOM:38, 418 pp.

ICES. 2011. Report of the Planning Group on Commercial Catches, Discards and Biological Sampling (PGCCDBS), 7–11 February 2011, Vienna, Austria. ICES CM 2011/ACOM:40. 174 pp.

ICES. 2011. Report of the Workshop on Age Reading of Greenland Halibut (WKARGH), 14–17 February 2011, Vigo, Spain. ICES CM 2011/ACOM:41. 39 pp.

ICES. 2012. Report of the Study Group on Recruitment Forecasting (SGRF),15–19 October 2012, Barcelona, Spain. ICES CM 2012/ACOM:24. 36 pp.

ICES. 2012b. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp. https://doi.org/10.17895/ices.pub.5322

ICES 2012. Report of the benchmark workshop on redfish (WKRED). ICES CM, 2012/ACOM: 48: 289 pp.

ICES 2013. Report of the Arctic Fisheries Working Group, Copenhagen, 18–24 April 2013. ICES C.M. 2013/ACOM:05, 726 pp.

ICES. 2013. Report of the Study Group on Recruitment Forecasting (SGRF), 18–22 November 2013,Lisbon. ICES CM 2013/ACOM:24. 29 pp.

ICES 2013. Report of the Benchmark Workshop on Greenland Halibut Stocks (WKBUT), 26–29 November 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:44

ICES 2014. Report of the Data Compilation Workshop on Northeast Arctic Greenland Halibut and Assessment Methods (DCWKNGHD), 10–12 November 2014, Murmansk, Russia. ICES CM 2014/ACOM:65. 58pp.

ICES 2014. Report of the Working Group on Harp and Hooded Seals Quebec City 17–21 November 2014. ICES C. M. 2014/ACOM:20, 62 pp.

ICES. 2015. Report of the Benchmark Workshop on Arctic Stocks (WKARCT), 26–30 January 2015, ICES Headquarters, Denmark. ICES CM 2015\ACOM:31. 126 pp.

ICES 2015. Report of the Arctic Fisheries Working Group, Hamburg, Germany, 23–29 April 2015. ICES C.M. 2015/ACOM:05, 590 pp.

ICES 2015. Report of the Inter Benchmark Process on Greenland Halibut in ICES areas I and II (IBPHALI). By Correspondence, August 2015. ICES CM 2015/ACOM:54, 41 pp.

ICES 2015. Report of the first Workshop on Management Plan Evaluation on Northeast Arctic cod and haddock and Barents Sea capelin (WKNEAMP-1), 5, Series title. ICES CM 2015/ACOM:60, 27 pp.

ICES 2016. Report of the second Workshop on Management Plan Evaluation on Northeast Arctic cod and haddock and Barents Sea capelin (WKNEAMP-2), 25–28 January 2016, Kirkenes, Norway. ICES CM 2016/ACOM:47, 76 pp.

ICES 2016. The Third Report of the Working Group on Integrated Assessments of the Barents Sea (WGIBAR). Murmansk, Russia, 22–25 February 2016. ICES CM 2016/SSGIEA:04, 126 pp.

ICES 2016. Report of the Arctic Fisheries Working Group, ICES HQ, Copenhagen, Denmark. 19–25 April 2016. ICES CM 2016/ACOM:06. 621 pp.

ICES 2016. Final Report of the Working Group on International Deep Pelagic Ecosystem Surveys (WGIDEEPS). ICES CM, ICES CM 2016/SSGIEOM:02: 21pp.

ICES 2016. Report of the Workshop on age reading of Greenland halibut 2 (WKARGH2), 22–26 August, Reykjavik, Iceland. ICES CM 2016/SSGIEOM:16. 36 pp.

ICES 2017. Report of Inter-benchmark protocol on Northeast Arctic cod (IBP ARCTIC COD 2017), Copenhagen, 3–6 April 2017. ICES CM 2017/ACOM:29.

ICES 2017, ICES fisheries management reference points for category 1 and 2 stocks. http://ices.dk/sites/pub/Publication%20Reports/Guidelines%20and%20Policies/12.04.03.01_Reference_points_for_category_1_and_2.pdf

ICES. 2018a. Report of the Benchmark Workshop on Redfish Stocks (WKREDFISH), 29 January-2 February 2018, Copenhagen, Denmark. ICES CM 2018/ACOM:34. 174 pp.

ICES. 2018b. Report of the Workshop on the evaluation of harvest control rules for *Sebastes mentella* in ICES areas 1 and 2 (WKREBMSE), June–August 2018, by correspondence. ICES CM 2018/ACOM:52. 32 pp.

ICES 2018. NAFO/ICES Pandalus Assessment Group Meeting, 17 to 22 October 2018 NAFO Secretariat, Dartmouth, Canada. ICES CM 2018/ACOM:08

ICES 2018. Report of the Arctic Fisheries Working Group, Ispra, Italy, 18–24 April 2018. ICES C.M. 2018/ACOM:06, 865 pp.

ICES. 2018. Technical Guidelines - ICES reference points for stocks in categories 3 and 4. http://www.ices.dk/sites/pub/Publication Reports/Forms/DispForm.aspx?ID=34082 (Accessed 25 February 2021).

ICES. 2019. Interbenchmark Protocol on assessment model changes for Cod (*Gadus morhua*) in subareas 1 and 2 (Northeast Arctic) (IBPNEACod2019). ICES Scientific Reports. 1:26. 26 pp. http://doi.org/10.17895/ices.pub.5278

ICES. 2019. Report of the Arctic Fisheries Working Group (AFWG). ICES Scientific Reports. 1:30. 934 pp. http://doi.org/10.17895/ices.pub.5292

ICES. 2020. Benchmark Workshop for Demersal Species (WKDEM). ICES Scientific Reports. 2:31. 136 pp. http://doi.org/10.17895/ices.pub.5548

ICES. 2020. Report of the Arctic Fisheries Working Group (AFWG). ICES Scientific Reports. 2:52. 577 pp. http://doi.org/10.17895/ices.pub.6050

ICES. 2020c. Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE X). ICES Scientific Reports. 2:98. 72 pp. http://doi.org/10.17895/ices.pub.5985

ICES. 2021a. Benchmark Workshop for Barents Sea and Faroese Stocks (WKBARFAR 2021). ICES Scientific Reports. 3:21. 205 pp. https://doi.org/10.17895/ices.pub.7920

ICES. 2021b. Working Group on the Integrated Assessments of the Barents Sea (WGIBAR). ICES Scientific Reports. 3:xx. (in press).

ICES 2021c. ICES Guidance for completing single-stock advice 2021. ICES Advice guide 2021. Last update 22 April 2021.

ICES 2021d. Arctic Fisheries Working Group (AFWG). ICES Scientific Reports. 3:58. 817pp. https://doi.org/10.17895/ices.pub.8196

ICES 2022. Workshop on the evaluation of northern Norwegian coastal cod harvest control rules (WKNCCHCR). ICES Scientific Reports. 4:49. 115 pp. https://doi.org/10.17895/ices.pub.20012459

IUCN. 2001. IUCN red list categories and criteria. Version 3.1. IUCN (World Conservation Union, Gland, Switzerland, and Cambridge UK). (Also available in full text format at: www.iucnredlist.org/static/categories_criteria)

IUCN. 2003. Guidelines for application of IUCN red list criteria at regional levels. IUCN (World Conservation Union, Gland, Switzerland, and Cambridge UK). (Also available in full text format at: www.iucnredlist.org/static/categories_criteria)

Jakobsen, T., Korsbrekke, K., Mehl, S., and Nakken, O. 1997. Norwegian combined acoustic and bottom trawl surveys for demersal fish in the Barents Sea during winter. ICES CM 1997/Y:17.

Janusz, J., Trella, K. and Nermer, T. 2008. Report on Polish fishing activity and survey on redfish(Sebastes mentella) in the NEAFC Regulatory Area (ICES IIa) in 2007. Working document no 8. in: Report of the Arctic Fisheries Working Group (AFWG), 21-29 April 2008, ICES Headquarters, Copenhagen. ICES CM 2008\ACOM:01. 531 pp

Janusz, J. and Trella, K. 2009. Results of the Polish fishing survey of Greenland halibut in the Svalbard Protection Zone (ICES IIb) in April 2008. Working document no 10. in: Report of the Arctic Fisheries Working Group (AFWG), 21 -27 April 2009, San-Sebastian, Spain. Diane Lindemann. 579 pp.

Johannesen, E., Johansen, G. O., and Korsbrekke, K. 2016. Seasonal variation in cod feeding and growth in a changing sea. Canadian Journal of Fisheries and Aquatic Sciences 73(2): 235–245.

Johnsen, E., A. Totland, Å. Skålevik, A. J. Holmin, G. E. Dingsør, E. Fuglebakk, and N. O. Handegard. 2019. StoX: An open source software for marine survey analyses. 10:1523–1528.

Johansen, T., Westgaard,J.-I., Seliussen, B.B., Nedreaas, K., Dahle, G., Glover, G.A., Kvalsund, R., and Aglen, A. 2017. "Real-time" genetic monitoring of a commercial fishery on the doorstep of an MPA reveals unique insights into the interaction between coastal and migratory forms of the Atlantic cod. ICES Journal of Marine Science (2017), doi:10.1093/icesjms/fsx22

Jørgensen, B 1997. The theory of dispersion models. Chapman & Hall. ISBN 978-0412997112.

Jørgensen C., Enberg K., Dunlop E.S,. Arlinghaus R., Boukal D.S., Brander K., Ernande B., Gårdmark A., Johnston F., Matsumura S., Pardoe H., Raab K., Silva A., Vainikka A., Dieckmann U., Heino M., Rijnsdorp A.D. 2008. The role of fisheries-induced evolution – response. Science. 320: 48–50.

Kenchington, T.J. Natural mortality estimators for information-limited fisheries. Fish and Fisheries, 2014, 15.4: 533–562.

Kennedy, J., Gundersen, A.C. and Boje, J.2009. When to count your eggs: Is fecundity in Greenland halibut (*Reinhardtius hippoglossoides* W.) down-regulated? Fisheries Research, 100(3): 260–265.

Kennedy, J., Gundersen, A.C., Høines, Å.S. and Kjesbu, O.S., 2011. Greenland halibut (*Reinhardtius hippoglossoides*) spawn annually but successive cohorts of oocytes develop over 2 years, complicating correct assessment of maturity. Canadian Journal of Fisheries and Aquatic Sciences, 68(2): 201–209.

Kennedy, J., Hedeholm, R.B., Gundersen, A.C. and Boje, J., 2014. Estimates of reproductive potential of Greenland halibut (*Reinhardtius hippoglossoides*) in East Greenland based on an update of maturity status. Fisheries Research, 154: 73–81.

Korsbrekke, K. 1997. Norwegian acoustic survey of Northeast Arctic cod on the spawning grounds off Lofoten. ICES C.M 1997/Y:18.

Kovalev, Yu.A., and Yaragina N.A. 2009. The effects of population density on the rate of growth, maturation, and productivity of the stock of the Northeast Arctic cod. Journal of Ichthyology 49, № 1: 56–65.

Kovalev, Y., Prozorkevich, D., and Chetyrkin, A. 2017. Estimation of Ecosystem survey 2016 index in situation of not full area coverage. Working Document No. 12 to the Arctic Fisheries Working Group, Copenhagen, 18–25 April 2017.

Kovalev, Y., and Chetyrkin, A. 2019. What does NEA cod want for prediction - Fsq or TAC constrain? Working Document No. 11 to the Arctic Fisheries Working Group. ICES. 2019. Arctic Fisheries Working Group (AFWG). ICES Scientific Reports. 1:30. 934 pp.

Kuparinen A., Stenseth N. C., Hutchings J. A. 2014. Fundamental population-productivity relationships can be modified through density-dependent feedbacks of life-history evolution. Evol Appl 7(10):1218-25.

Laurenson CH, Johnson A, Priede IG. 2005. Movements and growth of monkfish *Lophius piscatorius* tagged at the Shetland Islands, Northeastern Atlantic. Fisheries Research. 2005 Febru-ary 28; 71(2):185–95.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. - Journal of fish biology 49: 627–642.

Mace, P. M. and Doonan, I. J. 1988. A generalised bioeco-nomic simulation model for Àsh population dynamics. New Zealand Fishery Assessment Research Document 88/4. Fisheries Research Centre, MAFFish, POB 297: Wellington, NZ.

Mace, P.M. and M.P. Sissenwine. 1993. How much spawning per recruit is enough? In S.J. Smith, J.J. Hunt and D. Rivard [eds.] Risk evaluation and biological reference points for fisheries management. Canadian Special Publications in Fisheries and Aquatic Sciences 120:101–118.

Mangel, M., Brodziak, J., and DiNardo, G. 2010. Reproductive ecology and scientific inference of steepness: a fundamental metric of population dynamics and strategic fisheries management. Fish Fish. 11: 89–104. doi:13.1111/j.1467-2979.2009.00345.x

Mangel, M., MacCall, A.D., J. Brodziak, E.J. Dick, R. E. Forrest, R. Pourzand, and S. Ralston 2013. A perspective on steepness, reference points, and stock assessment. Can. J. Fish. Aquat. Sci. 70: 930–940 (2013) dx.doi.org/13.1139/cjfas-2012-0372

Mehl, S., Aglen, A., Alexandrov, D.I., Bogstad, B., Dingsør, G.E., Gjøsæter, H., Johannesen, E., Korsbrekke, K., Murashko, P.A., Prozorkevich, D.V., Smirnov, O., Staby, A., and Wenneck, T. de Lange, 2013. Fish investigations in the Barents Sea winter 2007–2012. IMR-Pinro Joint Report Series 1-2013, 97 pp.

Mehl, S., Aglen, A., Bogstad, B., Dingsør, G.E., Gjøsæter, H., Godiksen, J., Johannesen, E., Korsbrekke, K., Staby, A., Wenneck, T. de Lange, Wienerroither, R., Murashko, P. A., and Russkikh, A. 2014. Fish investigations in the Barents Sea winter 2013–2014. IMR-PINRO Joint Report Series 2-2014, 73 pp.

Mehl, S. Aglen, A., Amelkin, A., Dingsør, G.E., Gjøsæter, H., Godiksen, Staby, A., Wenneck, T. de Lange, and Wienerroither, R. 2015. Fish investigations in the Barents Sea, winter 2015. IMR-PINRO report series 2-2015. 61 pp.

Mehl, S., Aglen, A., Bogstad, B., Dingsør, G.E., Korsbrekke, K., Olsen, E., Staby, A., Wenneck, T. de Lange, Wienerroither, R., Amelkin, A. V., and Russkikh, A. A. 2016. Fish investigations in the Barents Sea winter 2016. IMR-PINRO Joint Report Series 4-2016, 78 pp.

Mehl, S., Aglen, A., Berg, E., Dingsør, G. and Korsbrekke, K. 2014. Akustisk mengdemåling av sei, kysttorsk og hyse, Finnmark – Møre, hausten 2014. [Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2014]. *In Norwegian, legends in English***.** Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 1 – 2014 (38pp).

Mehl, S, Aglen, A., Berg, E. Dingsør, G. and Korsbrekke, K. 2015. Akustisk mengdemåling av sei, kyst-torsk og hyse Finnmark – Møre hausten 2015. Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2015. *In Norwegian, legends in English***.** Toktrapport/Havforskningsinstituttet/ISSN 1503-6294, Nr. 4 – 2015. 38pp.

Mehl, S, Aglen, A., Berg, E. Dingsør, G. and Korsbrekke, K. 2016. Akustisk mengdemåling av sei, kyst-torsk og hyse Finnmark – Møre hausten 2016. Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2016. *In Norwegian, legends in English***.** Toktrapport/Havforskningsinstituttet/ISSN 1503-6294, Nr. 15 – 2016. 38pp.

Mehl, S., Aglen, A., Bogstad, B., Staby, A., de Lange Wenneck, T. Wienerroither, R., and Russkikh, A.A. 2017a. Fish investigations in the Barents Sea winter 2017. Working Document No. 3 to the Arctic Fisheries Working Group, Copenhagen, 18–25 April 2017.

Mehl, S., Aglen, A. and Johnsen, E. 2017b. Re-estimation of swept area indices with CVs for main demersal fish species in the Barents Sea winter survey 1994 – 2016 applying the Sea2Data StoX software2017. Fisken og Havet No. 10, 2016. Institute of Marine Research, Bergen, Norway. 43 pp.

Mehl S., Aglen A., Johnsen E. and Å. Skålevik. 2018a. Estimation of acoustic indices with CVs for cod and haddock in the Barents Sea winter survey 1994 – 2017 applying the Sea2Data StoX software. Fisken og Havet, №5, 29 p.

Mehl, S. Berg, E., Korsbrekke, K., Olsen, E., and Staby, A. 2018b. Acoustic abundance of saithe, coastal cod and haddock Finnmark – Møre Autumn 2017. Toktrapport/ Havforskningsinstituttet/ISSN 15036294/Nr. 2–2018.

Mehl, S., de Lange Wenneck, T., Aglen, A., Fuglebakk, E., Gjøsæter, H., Godiksen, J. A., Seim, S. E., and Staby, A. 2019. Fish investigations in the Barents Sea winter 2019. IMR-PINRO Joint Report Series 4-2019, 77 pp.

Mehl, S., and Yaragina, N. A. 1992. Methods and results in the joint PINRO-IMR stomach sampling program. In: Bogstad, B. and Tjelmeland, S. (eds.), *Interrelations between fish populations in the Barents Sea*. Proceedings of the fifth PINRO-IMR Symposium. Murmansk, 12–16 August 1991. Institute of Marine Research, Bergen, Norway, 5–15.

Mikhaylov, A. 2016. Long-term HCR-parameters estimation for Greenland halibut based on production model. Working paper no 14. in: Report of the Arctic Fisheries Working Group (AFWG), Dates 19–25 April 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:06. 621 pp.

Mikhaylov, A. 2019. Update reference point estimation for Greenland halibut based on production model. Working document no. 21 in report of the Arctic Fisheries Working Group, ICES CM 2018/ACOM:06.

Mjanger H. and J.A. Godiksen. 2018. Report of the workshop on age reading of cod (Gadus morhua L.) and haddock (Melanogrammus aeglefinus) between IMR and PINRO May 30 – June 1 2017. Working Document no. 10. ICES Arctic Fisheries Working Group, ICES CM 2018/ACOM:XX.

Mortensen, E. 2007. Er det variasjon i diett og lengde ved alder hos torsk (Gadus morhua L.) nord for 64°N? [in Norwegian]. Master Thesis, University of Tromsø, June 2007.

Muñoz, P. D., Martinez-Escauriaza, R., González, C., and Ramilo, L. 2016. Spanish bottom trawl spring survey "Fletán Ártico 2015" in the Slope of Svalbard (ICES Division IIb2). Working document no 10. in: Report of the Arctic Fisheries Working Group (AFWG), Dates 19–25 April 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:06. 621 pp.

Muñoz, P. D., Bagués, A. S., González, C., González-Troncoso, D., Nogueira, A., and Ramilo, L. 2017. Spanish bottom trawl autumn survey "Fletán Ártico 2016" in the Slope of Svalbard (ICES Division IIb2). Working document no 7. in: Report of the Arctic Fisheries Working Group (AFWG), 19–25 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:06. 493 pp.

Nedreaas, K. 2014. Review of historic commercial catch-per-unit-of-effort (CPUE) series previously used in stock evaluation of Greenland halibut (*Reinhardtius hippoglossoides*) in ICES Subareas I and II. Are such CPUE series appropriate to use in future Greenland halibut stock assessments? Working document no 2. in: Report of the Data Compilation Workshop on Northeast Arctic Greenland Halibut and Assessment Methods (DCWKNGHD), 10–12 November 2014, Murmansk, Russia. ICES CM 2014/ACOM:65. 56 pp.

Nedreaas K. and Smirnov O, 2003. Stock characteristics, fisheries and management of Greenland halibut (*Reinhardtius hippoglossoides* Walbaum) in the northeast Arctic. Proceedings of the 10th Norwegian-Russian Symposium Bergen, Norway 27–29 August 2003.

Nedreaas, K. 2017. Conversion factors for products of cod (Gadus morhua) north of 62°N in the winter season 2015 – inaccurate current practice. WD no. 15 to ICES AFWG 2017.

Nielsen, A., Berg, C.W., 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fish. Res. 158:96–101.

Núñez, L.A., Hallfredsson, E.H. and Falk-Petersen, I.-B., 2015. Different maturity scales affect estimations of fecundity, TEP and spawning stock size of Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum, 1792). Marine Biology Research: 1–10.

Ofstad, L. H. 2013. Anglerfish *Lophius piscatorius* L. in Faroese waters. Life history, ecological importance and stock status. Dr. scient thesis, University of Tromsø. February 2013. 81 pp.

O'Sullivan M., Wright P. J., Verspoor E., Knox D., Piertney S. 2006. Absence of spatial and temporal genetic differentiation at microsatellite loci in north east Atlantic anglerfish (*Lophius piscatorius*). Journal of Fish Biology 2006; 69:261.

Pedersen, T., Nilsen, M., Berg, E., and Reigstad M. 2007. Trophic model of a lightly exploited cod-dominated ecosystem. In; Nilsen, M: "Trophic interactions and the importance of macrobenthic invertebrate production in two Arctic fjord systems". A dissertation for PhD, University of Tromsø, Autumn 2007

Pedersen, T. and Pope, J.G. 2003a. Sampling and a mortality model of a Norwegian cod (Gadus morhua L.) fjord population. Fish. Res. 63, 1–20.

Pedersen, T., and Pope, J. 2003b. How may feeding data be integrated into a model for a Norwegian fjord population of cod (Gadus morhua L.)? Scientia Marina, 67(Suppl. 1): 155–169.

Planque, B. 2015. *S. mentella* assessment - handling the +group.: WD03 - ICES AFWG2015. 8 pp.

Planque, B. 2016. Possible use of the Pelagic and slope surveys in the analytical assessment of *Sebastes mentella* in ICES areas 1 and 2.: WD05 - ICES AFWG2016. 6 pp.

Planque, B., Vollen, T., Höffle, H., Harbitz A., 2018. Use of StoX for estimating numbers@age of Sebastes mentella from the international deep pelagic ecosystem survey in the Norwegian Sea.: WD07 - ICES AFWG2018. 38 pp.

Ponomarenko 1973, 1984

Ponomarenko, I.Ya. and N.A.Yaragina. 1990. Long-term dynamics of the Barents Sea cod feeding on capelin, euphausiids, shrimp and the annual consumption of these objects. Feeding resources and interrelations of fishes in the North Atlantic: Selected papers of PINRO. Murmansk. 1990. p.109–130 (in Russian).

Prince, J.D., Hordyk, A.R., Valencia, S.R., Loneragan, N.R., and Sainsbury, K.J. 2015. Revisiting the concept of Beverton–Holt life-history invariants with the aim of informing data-poor fisheries assessment. ICES J. Mar. Sci. 72: 194 - 203.

Prince, J., Creech, S., Madduppa, H., and Hordyk, A. 2020. Length based assessment of spawning potential ratio in data-poor fisheries for blue swimming crab (Portunus spp.) in Sri Lanka and Indonesia: Implications for sustainable management. Regional Studies in Marine Science, 36: 101309.

Prozorkevich Dmitry, Johannesen Edda, and Johansen Geir Odd. 2020. Barents Sea ecosystem survey 2019: cod and haddock indices. Working document no 1 in: Report of the Arctic Fisheries Working Group (AFWG), 15–22 April 2020. ICES CM 2015/ACOM:05. 639 pp.

Prozorkevitch, D. and van der Meeren, G. (eds) 2021. Survey report from the joint Norwegian/ Russian ecosystem survey in the Barents Sea and adjacent waters August-October 2019. IMR/PINRO Joint Report Series, 1-2021, In press

Russkikh, A. A., amd Smirnov, O. V. 2016. Results of the Russian trawl survey of Greenland halibut in the Barents Sea and adjacent waters in 2015. Working document no 16. in: Report of the Arctic Fisheries Working Group (AFWG), Dates 19–25 April 2016, ICES HQ, Copenhagen, Denmark. ICES CM 2016/ACOM:06. 621 pp.

Skaret, G., D. Prozorkevich, H. Gjøsæter, and B. Bogstad. 2019. Evaluation of potential sources of error leading to an underestimation of the capelin stock in 2016. Pp. 166–175 in Proceedings of the 18th Russian-Norwegian symposium, Murmansk 5–7 June 2018. Edited by Evgeny Shamray, Geir Huse, Alexander Trofimov, Svein Sundby, Andrey Dolgov, Hein Rune Skjoldal, Konstantin Sokolov, Lis Lindal Jørgensen, Anatoly Filin, Tore Haug and Vladimir Zabavnikov. IMR/PINRO report Series 1-2019.

Skaret, G. et al. 2021. Testing of trawl-acoustic stock estimation of spawning capelin 2021. IMR Survey report (in prep.)

Skjæraasen, J. E., Kennedy, J., Thorsen, A., Fonn, M., Strand, B. N., Mayer, I., and Kjesbu, O. S. 2009. Mechanisms regulating oocyte recruitment and skipped spawning in Northeast Arctic cod (*Gadus morhua*). Canadian Journal of Fisheries and Aquatic Sciences, 66: 1582–1596.

Smirnov, O. 2011. Results of the Russian survey of Greenland halibut in the Barents Sea and adjacent waters 2009. Working document no 21. in: Report of the Arctic Fisheries Working Group (AFWG), 28 April - 4 May 2011, Hamburg, Germany. ICES CM 2011/ACOM:05. 659 pp.

Sokolov A., Russkikh A., Kharlin S., Kovalev Yu. A., and Yaragina N.A. 2018. Results of the Russian trawl-acoustic survey on cod and haddock in the Barents Sea and adjacent waters in October-December 2017. Working Document no. 11. ICES Arctic Fisheries Working Group, ICES CM 2018/ACOM:06.

Solmundsson, J, Jonsson, E and Björnsson, H. 2007. Recent changes in the distribution and abundance of monkfish (*Lophius piscatorius*) in Icelandic waters. ICES CM 2007/K:02. 16pp.

Staalesen, B.I. 1995. Breiflabb (*Lophius piscatorius* L.) langs norskekysten. *Cand.scient* thesis, University of Bergen. 88 pp. (In Norwegian, summary in English)

Staby, A., E. Aglen, A., Gjøsæter, H. and J. Fall. 2021. Akustisk mengdemåling av sei og kysttorsk Finnmark - Møre høsten 2020. (Acoustic Abundance of saithe and coastal cod Finnmark-Møre 20120). Institute of Marine Research, Norway. Cruise report 4-2021. 34 pp.

Stiansen *et al.*, 2005. IMR status report on the Barents Sea ecosystem, 2004–2005. WD1, AFWG 2005.

Subbey, S., JE. Stiansen, B. Bogstad, T. Bulgakova and O. Titov, 2008. Evaluating Recruitment Models for (Age 3) NEA Cod. Working document #27. Report of the Arctic Fisheries Working Group (AFWG). 21–29 April 2008, ICES Headquarters, Copenhagen. ICES CM 2008\ACOM:01.

Svendsen, E., Skogen, M., Budgell, P., Huse, G., Ådlandsvik, B., Vikebø, F., Stiansen, J.E., Asplin, L., and Sundby, S. 2007. An ecosystem modelling approach to predicting cod recruitment. Deep-Sea Research Part II, 54:2810-2821.

Thangstad, T., Bjelland, O., Nedreaas, KH, Jónsson, E., Laurenson, CH and Ofstad, LH 2006. Anglerfish (*Lophius* spp.) in Nordic waters. TemaNord 2006:570. © Nordic Council of Ministers, Copenhagen 2006. ISBN 92-893-1416-8. 162 pp.

Then, A. Y., Hoenig, J. M., Hall, N. G., and Hewitt, D. A. 2018. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science, 75: 1509–1509. https://doi.org/10.1093/icesjms/fsx199 (Accessed 18 January 2021).

Thygesen, U. H., Albertsen, C. M., Berg, C. W., Kristensen, K., and Nielsen, A. 2017. Validation of ecological state space models using the Laplace approximation Environmental and Ecological Statistics 24 (2): 317–339.

Titov, O., Pedchenko, A. and Karsakov, A., 2005. 'Assessment of Northeast Arctic cod and capelin recruitment from data on ecological situation in the Barents Sea in 2004–2005'. Working document #16 in: Report of the Arctic Fisheries Working Group', Murmansk, Russia, April 19–28, 2005. ICES C.M. 2005/ACFM:20, 564 pp.

Titov O.V. 2010. Assessment of population recruitment abundance of Northeast Arctic cod considering the environment data. WD 22, AFWG 2010.

Titov O. 2018. Assessment of population recruitment abundance of Northeast Arctic cod considering the environment data. Working document 17. ICES Arctic Fisheries Working Group (AFWG), ICES CM 2018\ACOM:XX.

Tjelmeland, S. 2002. A model for the uncertainty around the yearly trawl-acoustic estimate of biomass of Barents Sea capelin, *Mallotus villosus* (Müller). ICES Journal of Marine Science, 59: 1072–1080.

Tjelmeland, S. 2005. Evaluation of long-term optimal exploitation of cod and capelin in the Barents Sea using the Bifrost model. Pp. 112–129 in: Shibanov, V. (ed.). "Ecosystem Dynamics and Optimal Long-term Harvest in Barents Sea Fisheries". Proceedings of the 11th Russian-Norwegian Symposium, Murmansk, Russia, 15–17 August 2005. IMR/PINRO report series 2/2005, 331 pp.

Tjelmeland, S. and Lindstrøm, U. 2005. An ecosystem element added to the assessment of Norwegian spring spawning herring: implementing predation by minke whales. ICES Journal of Marine Science 62(2):285–294.

Totland, A., and Godø, O. R. 2001. BEAM–an interactive GIS application for acoustic abundance estimation. In Proceedings of the First Symposium on Geographic Information System (GIS) in Fisheries Science. Fishery GIS Research Group. Saitama, Japan (Vol. 52).

Tranang C. A., Vollen T. and Höffle H. 2020. Use of StoX for recalculating numbers at age and numbers at length of *Sebastes norvegicus* from the Barents Sea NOR-RUS demersal fish cruise in winter.: WD17 - ICES AFWG2020. 60 pp.

Trella, K. and J. Janusz 2012. Results of the Polish fishing survey of Greenland halibut (*Reinhardtius hippoglossoides*) in the Svalbard Protection Zone (ICES IIb) in March 2011. Working document no 6. in: Report of the Arctic Fisheries Working Group 2012 (AFWG), 20 - 26 April 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:05. 670pp.

Vasilyev D. 2005 Key aspects of robust fish stock assessment. M: VNIRO Publishing, 2005. 105 p.

Vasilyev D. 2006. Change in catchability caused by year class peculiarities: how stock assessment based on separable cohort models is able to take it into account? (Some illustrations for triple-separable case of the ISVPA model - TISVPA). ICES CM 2006/O:18. 35 pp

Vasilyev D. 2020. NEA cod stock assessment by means of TISVPA. Working document no 12 in: Report of the Arctic Fisheries Working Group (AFWG), 15–22 April 2020. ICES CM 2015/ACOM:05. 639 pp.

Vasilyev D. NEA cod stock assessment by means of TISVPA. Working document no 18 in: Report of the Arctic Fisheries Working Group (AFWG), 14–20 April 2021. ICES CM 2021/ACOM:05. 639 pp

Vølstad, J. H., Korsbrekke, K., Nedreaas, K. H., Nilsen, M., Nilsson, G. N., Pennington, M., Subbey, S., and Wienerroither, R. 2011. Probability-based surveying using self-sampling to estimate catch and effort in Norway's coastal tourist fishery. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsrXXX

Westgaard, J.-I., Saha, A., Kent, M.P., Hansen, H.H., Knutsen, H., Hauser, L., Cadrin, S.X., Albert, O.T. and Johansen, T., 2016. Genetic population structure in Greenland halibut (*Reinhardtius hippoglossoides*) and its relevance to fishery management. Canadian Journal of Fisheries and Aquatic Sciences.

Weltersbach, M. S., and Strehlow, H. V. 2013. Dead or alive—estimating post-release mortality of Atlantic cod in the recreational fishery. – ICES Journal of Marine Science, 70: 864–872. doi:10.1093/icesjms/fst038

Winker, H., Carvalho, F., Kapur, M. 2018. JABBA: Just Another Bayesian Biomass Assessment. Fisheries Research 204: 275–288.

WKANGLER 2018. Report of the Benchmark Workshop on Anglerfish Stocks in the ICES Area (WKANGLER), 12–16 February 2018, Copenhagen, Denmark. ICES CM 2018/ACOM:31. 177 pp.

Yaragina, N. A. 2010. Biological parameters of immature, ripening and non-reproductive mature Northeast Arctic cod in 1984–2006. ICES Journal of Marine Science, 67: 2033–2041.

Yaragina N.A. and B. Bogstad. 2017. Historic difference in stock weight and maturity at age in Northeast Arctic cod. Working document 10. In: Report of the Arctic Fisheries Working Group (AFWG), 19–25 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:06. 486 pp

Yaragina N.A. Nedreaas K.H., Koloskova V., Mjanger H., Senneset H., Zuykova N. and Ǻgotnes P. 2009. Fifteen years of annual Norwegian-Russian cod comparative age readings. Marine Biology Research 5(1): 54–65.

Yaragina N.A. and Bogstad B. 2017. Historic difference in stock weight and maturity at age in Northeast Arctic cod. Working Document No. 10 to the Arctic Fisheries Working Group, Copenhagen, 18–25 April 2017.

Yaragina N. A., Kovalev Yu. A., and Chetyrkin A. 2018. Extrapolating predation mortalities back in time: an example from North-east Arctic cod cannibalism, Marine Biology Research: https://doi.org/10.1080/17451000.2017.1396342

Zuykova N.V., Koloskova V.P., Mjanger H., Nedreaas K.H., Senneset H., Yaragina N.A., Ågotnes P. and Aanes S. 2009. Age determination of Northeast Arctic cod otoliths through 50 years of history. Marine Biology Research 5(1): 66–74.

Zuykova N.V., Mjanger H. at all. 2020. Report on the meeting between Norwegian and Russian age reading specialists at Polar Branch of FSBSI "VNIRO" Murmansk, 20–24 May 2019. Working document no 8 in: Report of the Arctic Fisheries Working Group (AFWG), 15–22 April 2020. ICES CM 2015/ACOM:05. 639 pp.

WD 15. 2019. Updated mean ratios between the combined and Norwegian data on weight at age and maturity at age in Northeast Arctic cod. Working document no 8 in: Report of the Arctic Fisheries Working Group (AFWG), 15–22 April 2020. ICES CM 2015/ACOM:05. 639 pp.

Annex 1: List of participants

Member	Institute	Country of institute	E-mail
Anders Nielsen	DTU Aqua	Denmark	an@aqua.dtu.dk
Arved Staby	IMR	Norway	arved.staby@hi.no
Bjarte Bogstad	IMR	Norway	bjarte.bogstad@hi.no
Brian Stock	IMR	Norway	brian.stock@hi.no
Caroline Aas Tranang	IMR	Norway	caroline.aas.tranang@hi.no
Daniel Howell	IMR	Norway	daniel.howell@hi.no
Edda Johannesen	IMR	Norway	edda.johannesen@hi.no
Elena Eriksen	IMR	Norway	elena.eriksen@hi.no
Elise Eidset	IMR	Norway	elise.eidset@hi.no
Elvar H. Hallfredsson	IMR (Tromsø)	Norway	elvar.hallfredsson@hi.no
Erik Berg	IMR (Tromsø)	Norway	erik.berg@hi.no
Georg Skaret	IMR	Norway	georg.skaret@hi.no
Hannes Höffle	IMR	Norway	hannes.hoffle@hi.no
Harald Gjøsæter	IMR	Norway	harald.gjoesaeter@hi.no
Jane Aanestad Godiksen	IMR	Norway	jane.godiksen@hi.no
Johanna Fall	IMR	Norway	johanna.fall@hi.no
John Tyler Trochta	IMR	Norway	john.tyler.trochta@hi.no
José Miguel Casas Sanchez	IEO	Spain	mikel.casas@ieo.csic.es
Kjell Nedreaas	IMR	Norway	kjell.nedreaas@hi.no
Kristin Windsland	IMR	Norway	kristin.windsland@hi.no
Laura Clain	University of La Rochelle	France	laura.clain@etudiant.univ-lr.fr
Maria Fossheim	IMR	Norway	maria.fossheim@hi.no
Matthias Bernreuther	Thünen-Institute of Sea Fisheries	Germany	matthias.bernreuther@thuenen.de
Olav Nikolai Breivik	Norwegian Computing Center	Norway	olavbr@nr.no
Ross Tallman	DFO	Canada	foss.tallman@dfo-mpo.gc.ca

Member	Institute	Country of institute	E-mail
Samuel Subbey	IMR	Norway	samuel.subbey@hi.no
Sofie Gundersen	IMR	Norway	sofie.gundersen@hi.no
Tone Vollen	IMR	Norway	tone.vollen@hi.no

Annex 2: Resolutions

2021/2/FRSG02

Approved November 2021

The Arctic Fisheries Working Group (AFWG), chaired by Daniel Howell, Norway, will meet online 21–27 April 2022 to:

d) Address generic ToRs for Regional and Species Working Groups, for all stocks except the Barents Sea capelin, which will be addressed at a meeting in autumn;

e) For Barents Sea capelin oversee the process of providing intersessional assessment;

f) Conduct reviews as required of time any series computed using the STOX and ECA open-source software for use in assessment in the Barents Sea.

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 to the meeting must be available to the group on the dates specified in the 2022 ICES data call.

AFWG will report by 6 May 2022 and October 2022 for Barents Sea capelin for the attention of the Advisory Committee.

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: Working documents

Working documents can be found in the SharePoint folder here.

WD_01_BESS_cod_index_2004-2021-updated-with-summaries.xls
WD_02_BESS_haddock_index_2004-2021-updated-with-summaries.xlsx
WD_03 Revision_of_Coastal_cod_catch_data_1977-1993.docx
WD_04 Cod effort and CPUE NOR TRAWL LOG BOOK - 2011-2021-per 4 mar 2022.docx
WD_05 Haddock effort and CPUE NOR TRAWL LOG BOOK - 2011-2021-per 4 March 2022.docx
WD_06 Anglerfish in ICES 1 and 2_per 260422.doc
WD_07_Spanish Cod fisheries 2021.docx
WD_08_Spanish Pelagic Redfish fishery 2021.docx
WD 09 NEA Haddock Cod Ecosystem survey indices StoX 3.3 2020-2021.docx
WD_10_EffectOfErrorIn2020SurveyIndexNCCN67.docx
WD_11 S. norvegicus landings data method revision.pdf
WD_12 - AFWG PRT Report 2021 Div 1, 2.pdf
WD_12 - AFWG PRT Report 2021 Div. 1, 2 (Tables).xlsx
WD_13_shallow_water_garn_ruse_survey_coastal_cod_south.docx

Annex 4: Audit reports

Audit of Golden redfish (AFWG 2022)

Date: 10 June 2022
Auditor: Arved Staby

General

The Northeast Arctic Haddock assessment and draft advice have been approved by the Working Group.

For single stock summary sheet advice:

- **Assessment type:** Length based model that uses a range of tuning series (commercial and survey)
- **Assessment**: analytical
- **Forecast**: presented
- **Assessment model**: Age-length based Gadget model
- **Data issues:** Numbers at age could not be estimated using StoXReca
- **Consistency**:
- **Stock status**: SSB still very low (under Blim and Bpa) though signs of improvement. Fishing mortality much too high, and no significant signs of recruitment the last couple of years
- **Management Plan**: no direct fishery, keep bycatch at a minimum

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret. All data sets described in the stock annex are available.

Technical comments

No technical comments.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice.

Audit of Anglerfish in subareas 1 and 2

Date: 04. May 2022
Auditor: John T. Trochta

General

The Northeast Arctic Anglerfish assessment update has been approved by the Working Group. This is the first audit conducted for Anglerfish.

For advice other than single-stock summary fisheries advice

Section: Report chapter (Chapter 9)

Short description of the assessment

1) **Assessment type:** Update
2) **Assessment:** Accepted
3) **Forecast:** Not presented
4) **Assessment model:** Combination of three assessment methods for Category 3 stocks: LBSPR, CPUE standardization, and JABBA.
5) **Consistency:** Last year's assessment accepted. Same methodology from 2021 assessment update used this year, but with 2021 data and additional sensitivity analyses.
6) **Stock status:** It is likely that $B \geq B_{MSY}$. Mean fishing intensity may be near or slightly above F_{MSY}, and posteriors suggest a slightly higher probability of $F<F_{MSY}$ (~60% probability). A shift in length distributions to smaller fish in surveys suggest abundant recruitment that may contribute to fishery in 3-4 years time.
7) **Management plan:** There is no management plan for Anglerfish. Catch advice comes in the form of the "2-over-3" rule on CPUE with an uncertainty cap and precautionary buffer, which justifies a 10% reduction in F for 2023. AFWG previously recommended 20% reduction in fishing effort per year until survey CPUE stopped declining, and CPUE increased in 2021 after a decade of decline.

General comments

This was a well documented, well ordered and considered section. Aside from minor issues related to clarity in several places, it was easy to follow and interpret. The additional sensitivity analyses for 2022 were well executed and thorough.

Technical comments

No technical issues were found.

Conclusions

The assessment has been performed correctly and consistently with the previous assessment (2021), while exploring and improving upon several issues (residual patterns in the CPUE).

Audit of Haddock in subareas 1 and 2 (AFWG 2022)

Date: 09. June 2022
Auditor: Hannes Höffle

General

The Northeast Arctic Haddock assessment was not updated for 2022, due to it being a shared stock with Russia. Assessment will be done on a bilateral basis later in the year. The audit addresses the updated data tables approved by the Working Group.

For single stock summary sheet advice:

1) **Assessment type:** Age-based analytical assessment that uses catches in the models.
2) **Assessment**: not assessed
3) **Forecast**: not presented

Assessment model, data issues, consistency, stock status and management plan are unchanged from AFWG 2021.

General comments

Most of this section was taken over from AFWG 2021. The section is well documented, ordered and considered, offering little to comment on.

Technical comments

No technical issues were found.

Conclusions

The section was updated to the extent that was possible for AFWG 2022. Assessment was not performed.

Audit of Northeast Arctic saithe (AFWG 2022)

Date: 18 May 2022
Auditors: Matthias Bernreuther & Brian Stock

General
The Northeast Arctic saithe assessment and draft advice have been approved by the Working Group.

For single stock summary sheet advice:

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: SAM – tuning by one acoustic survey (split in two time series)
5) **Data issues:** The biological sampling from the fishery has been criticized in the last years as being critically low after the termination of the original Norwegian port-sampling program in 2009. However, the biological sampling has improved since 2016 and in 2020-2021 the coverage of the commercial fisheries may be (under these circumstances) considered as adequate.
   The lack of reliable recruitment estimates is still a major problem for the short-term catch forecast.
6) **Consistency**: Last year´s assessment was accepted. The assessment, recruitment and forecast models have been applied as specified in the stock annex.
7) **Stock status**: The SSB has been above B_{pa} since 1996, declined considerably from 2007 to 2011, then increased again and is presently (2021/2022) estimated to be well above B_{pa}. The fishing mortality was below F_{pa} from 1997 to 2009, started to increase in 2005 and was above F_{pa} from 2010 to 2012, but is presently estimated to be most likely below F_{pa}. The recruitment has since 2005 been at about the long-term geometric mean level.
8) **Management Plan**: Agreed 2013 (first time in 2007): F_{MP}=0.32 and SSB above B_{pa}=220 000 t. The TAC is based on an average TAC for the coming three years based on F_{MP}. There is a 15% constraint on TAC change between years. The plan was evaluated by ICES and was found in agreement with the precautionary approach.

General comments
This was a well documented, well ordered and considered section. It was easy to follow and interpret. All data sets described in the stock annex are available.

Technical comments
No technical comments.

Conclusions
The assessment has been performed correctly and gives a valid basis for advice.