ARCTIC FISHERIES WORKING GROUP (AFWG)

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Contents

i Executive summary

Since 30 March 2022, all Russian Federation participation in ICES has been suspended[1]. 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 of 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, capelin, beaked redfish (*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. Assessment and advice for these stocks are being conducted outside ICES through the bilateral Russian-Norwegian group, the Joint Russian-Norwegian Arctic Fisheries Working Group (JRN-AFWG). The most recent assessment reports are available via the Institute of Marine Research (IMR) website:

- The report of the JRN-AFWG 2022 is available here: https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2022-6
- Report of the Joint Russian-Norwegian Working Group on Arctic Fisheries (JRN-AFWG) 2023 (https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-7)
- Barents Sea Capelin–Report of the Joint Russian-Norwegian Working Group on Arctic Fisheries (JRN-AFWG) (https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-9)

The assessments in 2022 and 2023 occurred outside ICES but were based on the stock annexes previously agreed within ICES, used the same data and models as previously, and were conducted by the same Russian and Norwegian scientists that were involved in the previous ICES assessments. The managing body in the Barents Sea (the Joint Norwegian Russian Fisheries Commission; JNRFC) has endorsed this approach and has used the advice from the JRN-AFWG as the basis of management following the same procedures previously used for ICES advice. There is therefore currently no possibility to produce, and no current management need for, ICES assessments for these stocks.

This year AFWG is providing ICES advice for saithe, coastal cod north and coastal cod south, with golden redfish (*S. norvegicus)* advice next due in 2024. In addition, an assessment has been run for anglerfish, although there is no formal request for advice for this stock. Assessments for Greenland halibut, NEA cod, NEA haddock, beaked redfish (*S. mentella*), and capelin were run at the JRN-AFWG in 2022 and 2023, and there are links to the resulting advice below.

Stock-by-stock summaries (ICES)

The stock trends for the assessed stocks are as follows:

Cod (Gadus morhua) in subareas 1 and 2 north of 67°N (Norwegian Sea and Barents Sea), northern Norwegian coastal cod; cod.27.1-2.coastN

The coastal cod north assessment gives an SSB estimate of 71 599 tonnes for 2022 (down from 72 888 tonnes in 2021), and the catch advice is 26 612 tonnes (slightly up from 29 347 t last year). The stock has had a declining trend since 2016, partly due to the weak 2018-year class that is now part of the fishable biomass. There is no B_{lim} for this stock and the status relative to this reference point can therefore not be determined, but SSB is above the biomass limit for which the HCR is valid ($SSB_{lowerbound}$). The fishing mortality is 0.31, well above target F in the management plan

[1] https://www.ices.dk/news-and-events/news-archive/news/Pages/TemporarySuspension.aspx

(0.176). However, because of better recruitment in 2020–2021, a small increase in the stock is expected in 2023–2025 even under status quo fishing. 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 Sea), southern Norwegian coastal cod; cod.27.2.coastS

The new ICES advice guidelines for data-poor stocks indicate that advice should be given on a two-year basis. Accordingly, the advice given in 2022 for 2023 is extended to 2023 and 2024, and no new advice is given.

Saithe in subareas 1 and 2 (Northeast Arctic)

The NEA saithe stock is currently in good status, with the SSB well above B_{pa} at 727 666 tonnes, very slightly up from 715 674 t in last year's assessment. Following the HCR the catch advice is 223 123 tonnes (almost unchanged from 226 794 t last year). This stock, together with the associated North Sea saithe stock, is aiming for a benchmark, likely 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.

Stock-by-stock summaries (non-ICES)

Information for the stocks not currently assessed by AFWG (latest 2023 Greenland halibut, NEA cod, and NEA haddock; latest 2022 beaked redfish and capelin) via the IMR website:

Barents Sea capelin

- The JRN-AFWG advice from 2023 is available here: https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-8

NEA cod

- The JRN-AFWG advice from 2023 is available here: https://www.hi.no/hi/nettrapporter/imr-pinro-en-2023-5

NEA haddock

- The JRN-AFWG advice from 2023 is available here: https://www.hi.no/hi/nettrapporter/imr-pinro-en-2023-4

Greenland halibut

- The JRN-AFWG advice from 2023 is available here: https://www.hi.no/hi/nettrapporter/imr-pinro-en-2023-6

Beaked redfish (Sebastes mentella)

- The JRN-AFWG advice from 2022 is available here: https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2022-5

ii Expert group information

Expert group name	Arctic Fisheries Working Group (AFWG)
Expert group cycle	Annual
Year cycle started	2022
Reporting year in cycle	1/1
Chair	Daniel Howell, Norway
Meeting venue and dates	17–21 April 2023, Copenhagen, Denmark (20 participants)

1 Introduction

Arctic Fisheries Working Group 2023 report

1.1 Terms of reference

2022/2/FRSG02

The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell, Norway, will meet at ICES Headquarters in Copenhagen, Denmark, 17–21 April 2023 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 any time-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 2023 ICES data call.

AFWG will report by 8 May 2023 and October 2023[1] 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.

Generic ToRs for Regional and Species Working Groups

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS. Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries Overviews with a focus on:
   1. identifying and correcting mistakes and errors (both in the text, tables, and figures);
   2. proposing concrete evidence-based input that is considered essential to the advice but is currently underdeveloped or missing (with references and Data Profiling Tool entries, as appropriate).

The input will feed into the annual updates of the overviews. Delivery of contributions other than those outlined above is also welcomed but will be utilized during the revision process (around every 5 years).

b) Conduct an assessment on the stock(s) to be addressed in 2023 using the method (assessment, forecast or trends indicators) as described in the stock annex; complete and document an audit of the calculations and results; and produce a brief report of the work carried out regarding the stock, providing summaries of the following where relevant:
   1. Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with missing

[1] Dates subject to final confirmation.

data and the linked template that formulates how deviations from the stock annex are to be reported;

2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
3. For relevant stocks (i.e. all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2022;
4. For category 3 and 4 stocks requiring new advice in 2023, implement the methods recommended by WKLIFE X (e.g. SPiCT, rfb, chr, rb rules) to replace the former 2 over 3 advice rule (2 over 5 for elasmobranchs). MSY reference points or proxies for the category 3 and 4 stocks (ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3);
5. Evaluate spawning-stock biomass, total-stock biomass, fishing mortality, and catches (projected landings and discards) using the method described in the stock annex:
   1) For category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.
   2) If the assessment is deemed no longer suitable as basis for advice, provide advice using an appropriate Category 2–5 approach as described in ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3 or ICES.
   3) If the assessment has been moved to a Category 2–5 approach in the past year consider what is necessary to move back to a Category 1 and develop proposal for the appropriate benchmark process.
6. Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;
7. Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time-series of recruitment, spawning-stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR vii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

c) Produce a first draft of the advice on the stocks under consideration according to ACOM guidelines.

d) Review progress on benchmark issues and processes of relevance to the Expert Group:
1. update the benchmark issues lists for the individual stocks in SID;
2. review progress on benchmark issues and identify potential benchmarks to be initiated in 2024 for conclusion in 2025;
3. determine the prioritization score for benchmarks proposed for 2024–2025;
4. as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG).

e) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops.

f) Identify research needs of relevance to the work of the Expert Group.

g) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

h) If not completed previously, complete the audit spreadsheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate change, could be considered in the advice.

i) Deliver conservation status advice in accordance with the Technical guidelines on conservation status advice. The advice is only to be given when conservation aspects were identified and where clear, demonstrable management action can be recommended for any non-catch anthropogenic pressure. It can also be used to highlight clear demonstrable sensitivity to climate change. The qualification required to show clear, demonstratable management action is high. Avoid generic statements that are of no specific application to management.

j) Update SAG and SID with final assessment input and output.

Information on the stocks to be considered by each Expert Group is available here.

1.2 Additional requests

There were no additional requests.

1.3 Responses to terms of reference

The report of the JRN-AFWG 2022 is available here: https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2022-6

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. Note that due to Russia being suspended from ICES, it is not currently possible to provide "best available science" advice through ICES for NEA cod, NEA haddock, Greenland halibut, beaked redfish (*Sebastes mentella*), or capelin. Assessments for these stocks are being run outside ICES, and the reports and advice sheets can be found at the web links listed below (note that no Greenland halibut advice was released in 2022). Work on generic ToRs a and b will be conducted intersessionally as it becomes appropriate.

ToR b is normally handled in detail by the capelin subgroup of AFWG, held in autumn after the capelin survey, although this work is temporarily conducted outside ICES until the lifting of the Russian suspension.

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

1.4 Benchmarks

Benchmarks were held for capelin (WKCAPELIN 2022) and Greenland halibut (WKNORTH 2023). It should be noted that these stocks are not currently being assessed within ICES, and it is unclear to what extent the revised methodology will be used in the bilateral Russian-Norwegian assessments.

The next planned benchmark is that for saithe, which will be benchmarked jointly with the North Sea stock. The saithe stock is formally managed only by Norway, and this benchmark therefore forms part of the regular ICES advice update cycle.

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.

For further information on under- and misreporting, we refer to the 2016 and 2022 AFWG reports.

Discards estimates (1994–2022) 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 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.

1.5.1 Sampling effort–commercial fishery and recreational 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 2008–2022. 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 2022 data.

1.5.1.1 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.

1.5.1.2 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.

1.5.1.3 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.

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.

Kjell – recreational catch

1.5.2 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 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.

Russian 2022 catches are anticipated to be available via NEAFC for ICES 2024 AFWG and table will be updated then

	ICES 1.a^	ICES 2.a.1^	ICES 2.b.1^	Total	%NEAFC
2022					
NEA cod	1585.2	1.3	0.0	*	**
Coastal cod (south+north)	0.0	0.0	0.0	51016	0.0
NEA haddock	3.1	0.1	0.0	*	**
NEA saithe	0.0	0.0	0.0	206018	<0.01
Sebastes mentella	0.0	2657.5	0.0	*	**
Sebastes norvegicus	0.0	0.0	0.0	*	0.0
Greenland halibut	464.4	0.0	0.0	*	**
Capelin	0.0	0.0	0.0	65243	0.0
^Catches in ICES 1.a, 2.a.1. and 2.b.1 in 2022 does not include Russian catches					
* Total catch in 2022 not available due to lack of reporting from Russia					
** Can not be calculated without total catch					
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					
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%

	ICES 1.a^	ICES 2.a.1^	ICES 2.b.1^	Total	%NEAFC
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%
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%

	ICES 1.a^	ICES 2.a.1^	ICES 2.b.1^	Total	%NEAFC
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%
Anglerfish	0	0	0	1043	0.0%
2014					
NEA cod	534	0	0	986449	0.1%
Coastal cod	0	0	0	33660	0.0%

	ICES 1.a^	ICES 2.a.1^	ICES 2.b.1^	Total	%NEAFC
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

Owing to the Russian suspension from ICES, full survey data is not available for any of the shared stocks. This chapter therefore only discusses the Norwegian coastal survey. For details of uncertainty investigation in other surveys, please refer to AFWG 2022.

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.

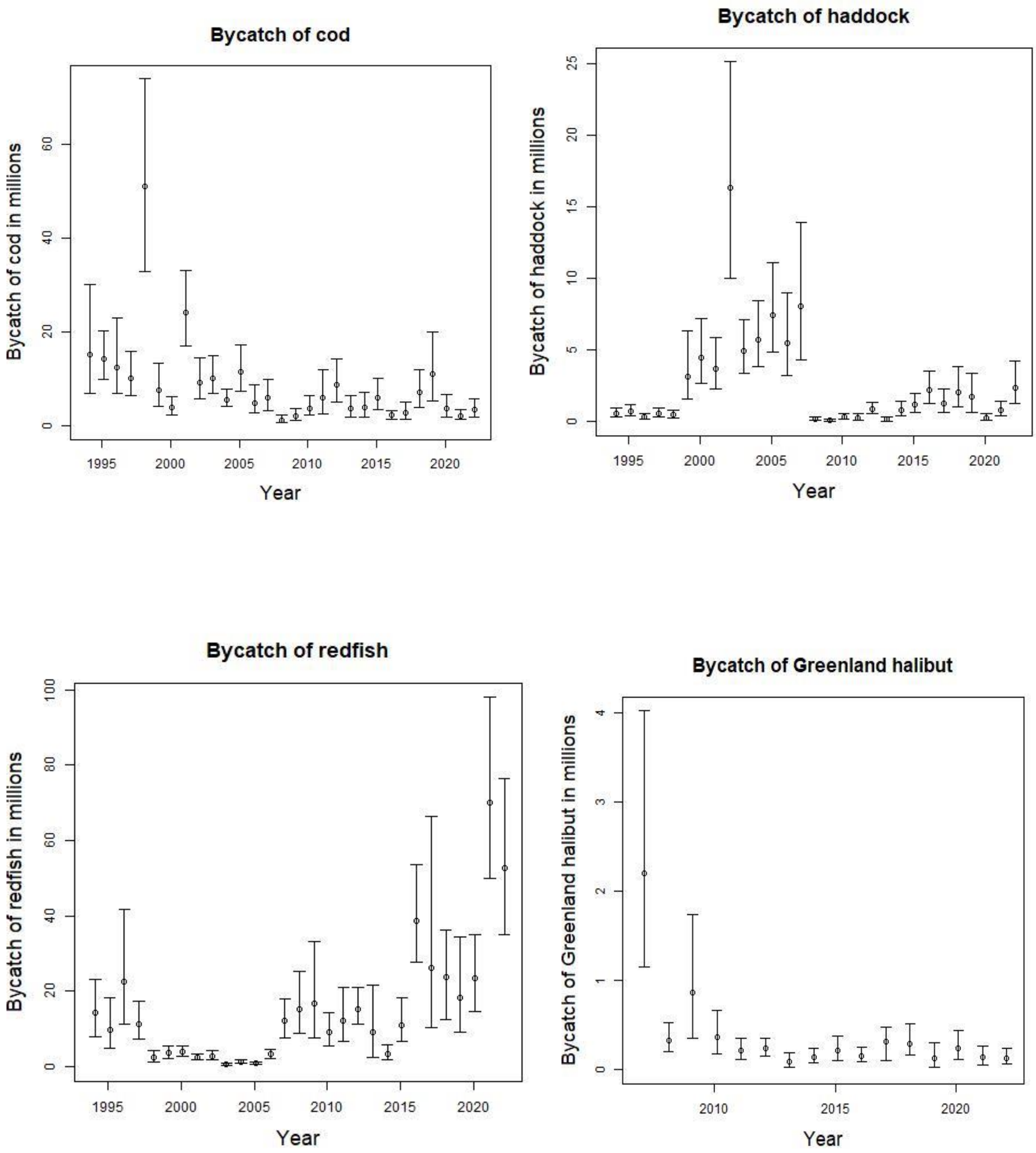


Figure 0.1. Estimated bycatch of cod, haddock, redfish and Greenland halibut in the Barents Sea shrimp fishery. Intervals are 90% confidence intervals.

1.7 Age reading

Refer to 2022 report for details, updates are not available owing to the Russian suspension.

1.8 Assessment method issues

For coastal cod, the 2021 benchmark resulted in a split into two stocks (ICES 2021a). For the northern (north of 67 degrees) stock there is now a SAM assessment model. There is also an adopted HCR to provide target fishing mortality, however there was not sufficient information to provide a reliable Blim (ICES, 2022). 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) stock advice follows the "rfb" rule for category 3 stocks (ICES, 2020c, 2022c), which is primarily driven by the trend in the coastal reference fleet gillnet CPUE index. However, this index has very high uncertainty and is not consistent (negatively correlated) with available indices from fishery-independent surveys. We therefore plan to propose using an alternative index within the 'rfb' rule for the 2024 assessment. We will also continue modelling efforts to better make use of existing survey and catch data, working towards a future benchmark.

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. Daniel to update

1.9 Proposals for status of assessments in 2023–2024

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 and capelin have been benchmarked in 2022, although following the Russian suspension there will be no ICES advice for either stock. AFWG is providing advice for *Sebastes norvegicus*, with the next advice here will be in 2024, it is to be hoped following a benchmark.

Therefore we anticipate providing ICES assessments in 2024 for northern and southern coastal cod, saithe, golden redfish (*Sebastes norvegicus*) 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. For southern coastal cod we plan to propose using an alternative index within the 'rfb' rule for the 2024 assessment (see sections 1.8 and 2.3.7-2.3.12).

Table 0.1. Age and length sampling by Norway of commercial catches in 2008–2022. 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											
Golden 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	28	698	8954	13	105	1403	3836	182.0	27.4	365.8	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
2014	42	432	5525	18	85	1264	3440	125.6	24.7	367.5	125
2015	41	514	5405	21	105	1400	2733	188.1	38.4	512.3	125
2016	42	600	7686	12	107	1360	4131	145.2	25.9	329.2	125
2017	43	678	6857	20	175	1754	3567	190.1	49.1	491.7	125
2018	44	797	8613	16	302	1819	4961	160.6	60.9	366.7	125
2019	44	810	9818	17	218	1791	5951	136.1	36.6	301.0	125
2020	48	765	9676	20	184	1450	6503	117.6	28.3	223.0	125
2021	36	894	10697	-	-	-	7703	116.1	-	-	125
2022	47	767	10387	-	-	-	7553	101.5	-	-	125
Beaked 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

	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
	2015	22	295	8324	5	19	174	19433	15.2	1.0	9.0	125
	2016	23	285	5470	9	23	169	18191	15.7	1.3	9.3	125
	2017	22	234	3507	7	29	177	17077	13.7	1.7	10.4	125
	2018	26	407	7295	8	41	374	18594	21.9	2.2	20.1	125
	2019	21	345	5884	6	38	329	23844	14.5	1.6	13.8	125
	2020	29	475	10796	9	75	686	32950	14.4	2.3	20.8	125
	2021	27	623	17001	6	53	970	43794	14.2	1.2	22.1	125
	2022	27	488	10658	7	71	1238	40716	12.0	1.7	30.4	125
Greenland halibut												
	2008	56	622	20307				7394	84.1			125
	2009	35	753	17233				8446	89.2			125
	2010	44	541	9222				7685	70.4			125
	2011	52	504	9239				8273	60.9			125
	2012	51	637	9765				10074	63.2			125
	2013	53	523	10554	1	2		12613	41.5	0.16	0.0	125
	2014	52	391	5140				10876	36.0			125
	2015	92	440	11200	21	22	944	10704	41.1	2.1	88.9	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	120	415	8040	22	29	1128	12573	33.0	2.3	89.7	125
2017	107	486	10385	24	28	1128	13194	36.8	2.1	85.5	125
2018	98	505	9083	5	27	629	14876	33.9	1.8	42.3	125
2019	93	455	9286	47	86	697	14813	30.7	5.8	47.0	125
2020	89	509	9110	52	80		14532	35.0	5.5	0.0	125
2021	73	590	10804	40	66	979	14008	42.1	4.7	69.9	125
2022	64	502	8164	40	59		13138	38.2	4.5	0.0	125
Anglerfish*****											
2013	5	41	1305	0	0	0	2988	14	0	0	125
2014	3	24	546	0	0	0	1655	15	0	0	125
2015	7	40	1063	0	0	0	933	43	0	0	125
2016	5	12	654	0	0	0	1355	9	0	0	125
2017	6	41	1593	0	0	0	1473	28	0	0	125
2018	6	27	1451	0	0	0	1884	14	0	0	125
2019	6	39	1486	0	0	0	2750	14	0	0	125
2020	8	99	2149	0	0	0	2258	44	0	0	125
2021	6	86	1649	0	0	0	2584	33	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
	2022	6	67	1250	0	0	0	2288	29	0	0	125
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
	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	0				125
	2017	21	43	2294	14	25	305	0				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				125
	2021							0				125
	2022	23	2256			673		42597				125

****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

	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
	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										
	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										

	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	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
	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

	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	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
	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

	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	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
	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

	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	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
	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

	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			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[2] of commercial catches and length sampling of surveys in 2008–2022. 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

[2] 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
	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
	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
	2022	2	22791	345		345	12214	1866	28	28	125
NEA-haddock*											
	2009	1	2561				240				
	2010	1	3243				379				
	2011	1	1796				408				
	2012	2	3198				647				

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
	2013	1	660				413				
	2014	1	2460				370				
	2015	1	702				418				
	2016	2	701				357				
	2017	1	710				156				
	2018	1	154				169				
	2019						280				
	2020						45				
	2021						131				
	2022						187				
NEA-saithe											
	2009	1	123				2				
	2013	1					5				
	2014	1					13				
	2015	1					33				
	2016						25				

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
	2017						85				
	2018						60				
	2019						199				
	2020						0				
	2021						3				
	2022						25				
S. mentella											
	2008**	1	2275	28			987	2304	28	0	125
	2011*	1	86				1237				
	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			

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
	2020**						737				
	2021**	1	2074	157			280	7396			
	2022						277				
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			
	2015	1	17552				111	158126			
	2016	1	15031				218	68837			
	2017										
	2018										
	2019	1					49				
	2020						96				

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
	2021						125				
	2022						164				

***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 2008–2022. 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
	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

	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
	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
	2022	2	1	14795	986	7171	2063	137	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
	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

	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
	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
	2022	2	1	3270	399	271	12066	1472	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
	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

	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	2	1	11900	745	1573	7565	474	125
	2021	2	1	3707	784	597	6209	1313	125
	2022	2	1	7333	1116	462	15872	2416	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
	2020	3	1	4248	0	1998	2126	0	125
	2021	2	1	2261	0	743	3043	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
	2022	2	1	8525	0	896	9515	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
	2022	2	1	672	0	95	7074	0	125

1.10 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. However due to the Russian suspension from ICES, little information is available within ICES. In addition to environmental variation, the overall 0-group abundance in the Barents Sea has large year to year variability, and this has important consequences for food supply as well as for recruitment. Such information is not currently available to ICES (although the joint Russian-Norwegian survey activity continues outside ICES). For both overall ecosystem information and stock specific factors, consult the WGIBAR and JRN-AFWG reports for more details.

1.10.1 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 incom-plete area coverage in the Barents Sea, but attempts have been made to correct for this (Pro-zorkevitch and Van der Meeren, 2021).

1.10.2 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 recruit-ment 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 Ponoma-renko (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-Norwe-gian 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).

1.10.3 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.

1.10.4 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).

1.10.5 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~ 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)~ Temp(-3) + log(Age0)(-3) +$BM_{cod3\text{-}6}$ /$ABM_{capelin}$(-2,-1)

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

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

H4: log(R3)~ 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.

1.10.6 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.

2 Norwegian coastal cod

cod.27.1-2.coastN – *Gadus morhua* in subareas 1 and 2, north of 67°N (Norwegian Sea and Barents Sea); northern Norwegian coastal cod

cod.27.2.coastS – *Gadus morhua* in Subarea 2 between 62°N and 67°N (Norwegian Sea); southern Norwegian coastal cod

A benchmark assessment (WKBARFAR) was conducted in February 2021 to address the failure of the previous 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 at 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).

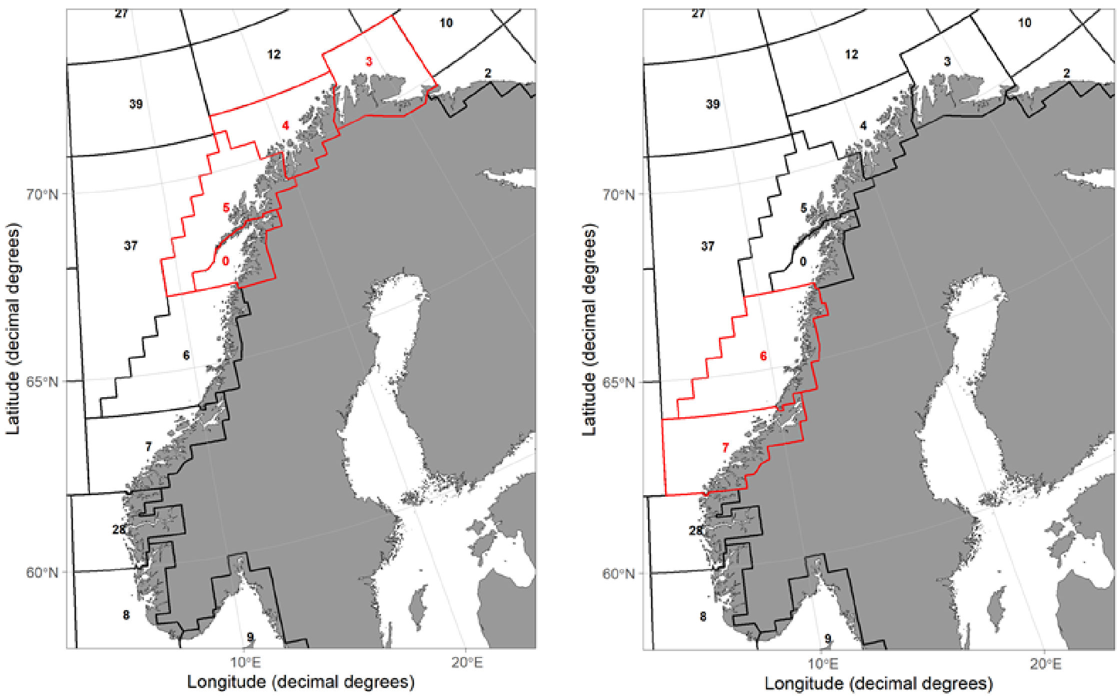


Figure 2.0.1 Norwegian catch reporting areas used to define stock distribution areas for northern Norwegian coastal cod (left; areas 3, 4, 5, and 0; north of 67°N) and southern Norwegian coastal cod (right, areas 6 and 7; 62–67°N).

The majority (approximately 85%) of NCC catches are taken north of 67°N (Table 2.1.1), and this is also where the coastal acoustic-trawl survey (A6335, NOcoast-Aco/BTr-Q4) has the best coverage. Population genetics studies have revealed a gradient, or isolation-by-distance pattern, in cod genetic differentiation along the Norwegian coast without areas of distinct breaks (Dahle *et al.*, 2018; Johansen *et al.*, 2020; Jorde *et al.*, 2021; Breistein *et al.*, 2022). This gradient is due to NCC in northern Norway having more genetic material in common with the Northeast Arctic cod (NEAC; cod.27.1-2) compared to NCC further south, as well as more influence of North Sea cod genes further south.

Updates of the catch series, 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 NCC were considered of high enough quality to support an age-based analytical assessment. Southern NCC (62–67°N) represents the remaining commercial catches of NCC north of 62°N (7% in 2022; Table 2.1.1) and is not as consistently covered by the coastal acoustic-trawl survey. In addition, a much higher, but uncertain, proportion of the catch is taken by recreational anglers in the south (60% in 2022; Table 2.1.1). These data challenges precluded a full analytical assessment at the benchmark meeting. Instead, a data-limited approach was developed to support management of this stock.

2.1 Fisheries (both stocks)

Coastal cod is fished throughout the year and within all of the coastal Norwegian statistical areas north of 62°N (Figure 2.0.1).

2.1.1 Commercial catch data

Most of the commercial NCC catches are taken as a bycatch in fisheries aimed at NEAC 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 the Varangerfjord to Lofoten (areas 03, 04, 05, 00). A mix of gillnet, Danish seine, bottom trawl, and longline/jig gears are used to target cod (Tables 2.2.2 and 2.3.4).

The basis for estimating commercial NCC catches is the total landings of cod within the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (Figure 2.0.1), which is then separated into types of cod (NEAC vs. NCC) by the structure of the otoliths in commercial catch samples. Figure 2.1.1 illustrates the main difference between the two types.

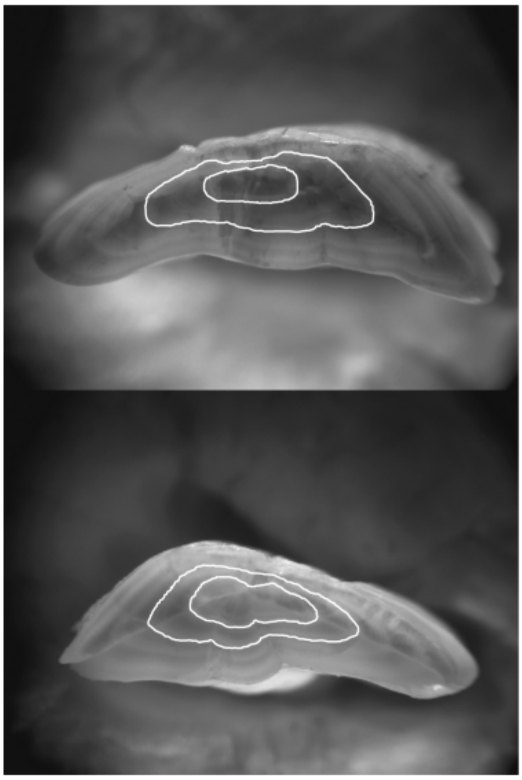


Figure 2.1.1. Image of a Norwegian coastal cod, NCC, otolith (top) and a Northeast Arctic cod, NEAC, otolith (bottom). The two first translucent zones are highlighted. From Berg *et al*. (2005).

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.

Since the catches are separated by otolith type, 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 2022, a total of 9657 fish were aged, whereof 37% were classified as Norwegian coastal cod (Table 2.1.2). This is approximately 1000 fish less than in 2021, but within normal variation and above the 2020 number. A contributing factor to fewer samples in 2022 is that three vessels in the Coastal reference fleet failed to deliver the expected number of otoliths due to changes in operation. These vessels were replaced ahead of the 2023 fishing season.

Since the 2021 benchmark (WKBARFAR; ICES, 2021a), catch numbers-at-age are estimated for both stocks by the ECA (Estimate Catch-at-Age) model (Hirst *et al*., 2004; Hirst *et al*. 2012; Rognebakke *et al*., 2016). ECA is a hierarchical Bayesian model that can account for uncertainty in stock identification (NCC vs. NEAC), correlation within sampling units, and age reading error. Commercial and recreational total catches in biomass have now been calculated back to 1977 for both stocks (Table 2.1.1, WD 03 in ICES, 2023). Catch-at-age in the years 1977–1993 have also been estimated for the northern stock, although these estimates are not included in the assessment model (WD 03 in ICES, 2023).

The benchmark also revised the total catch 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, year-round. From 2000 onwards, this factor was also agreed upon by the Joint Norwegian-Russian Fisheries Commission (JNRFC). However, there is a larger difference between "headed-and-gutted" weight and round weight in the winter season when the 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 stated 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 were therefore converted using

1.311 and 1.671 for the products "gutted with head" and "gutted without head", respectively, for each year since 1994.

Norwegian residents are allowed to sell some recreational catch. All sold recreational catches are assumed to be coastal cod since they generally come from small vessels close to shore. These sales must be reported to the Fisheries Directorate and are included in the commercial catch total (Table 2.1.1).

2.1.2 Recreational catch data

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 (60% vs. 15% in 2022; Table 2.1.1). However, there are only sporadic estimates of recreational catch, and several strong assumptions are required to construct a time-series of recreational catches.

WD 17 in ICES (2010) produced yearly recreational catch estimates for 1994–2009, primarily based on Hallenstvedt and Wulff (2000, 2004), but they are quite uncertain. No additional information was produced during 2010–2019, so the annual recreational catch during this period has been assumed equal to the one estimated for 2009 (12 700 t total for both NCC stocks). At the 2021 benchmark meeting (ICES, 2021a), the dataseries on recreational and tourist fisheries for Norwegian Coastal Cod were updated with new information up to and including 2019 (WD13, ICES, 2021a). The main new information compared to AFWG 2010 was due to Vølstad *et al*. (2011) estimating what had been fished by tourists associated with registered tourist businesses in 2009, and a new project conducted in 2017–2020 to develop cost-effective methods to map catches and socio-economic dimensions of Norwegian recreational fisheries. Results from this project have since been published in Ferter *et al*. (2023). The 2021 benchmark also produced separate time-series of recreational and tourist NCC catch north and south of 67˚N for the first time, according to the new stock split. Advice related to the recreational catches has since been given for these stocks by ICES.

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), except for catch from tourist businesses which was scaled up according to available biological sampling from this sector. For further details on the estimation of recreational catch, see WD04 and the Stock Annexes.

Improving the estimates of recreational catch is a priority in both stock areas, and especially in the south where they comprise the majority of the total catch. Specific needs include:

1. The status of tourist businesses in the national registry should be checked and updated once per year.
2. Data should be collected from both the tourist and resident recreational sectors to estimate (by stock area and in the priority listed below):
    a) Total catch,
    b) Catch numbers- and weight- at age (i.e. at least representative length distributions, ideally proportions-at-age), and
    c) Otoliths or genetic samples to separate NCC from NEAC.
3. The Norwegian resident recreational fishery, responsible for most of the total recreational catches, should be regularly monitored by roving creel surveys including both hook and line and fixed/passive gears. It is suggested to do this county by county following Ferter *et al*. (2023), i.e. one new county each year until all counties have been covered, and then repeat. Biological sampling should be part of the roving creel surveys.

2.1.3 Regulations

The Norwegian cod TAC is a combined TAC for the NEAC and both NCC stocks. Landings of NCC are counted against the overall cod TAC for Norway, where the expected total catch of NCC is on 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 coastal cod quotas given to different groups within the fleet. Catches of coastal cod are thereby not effectively restricted by quotas.

Since coastal cod is fished under a combined NCC/NEAC 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 regulatory measures for NEAC also apply 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. Several regulations confer some protection for 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 directed cod fishing with vessels larger than 15 metres. For more details about the technical regulations, see ICES (2020b).

The minimum size for all cod north of 62˚N is 44 cm, although 10% may be landed below this value. An increase in the minimum size to 55 cm is currently under consideration within 4 nm of the baseline, targeting coastal cod. This is based on the length at 50% maturity, L_{50}, which was estimated as 55.8 cm for the southern stock (all data between 62–67˚N) and 60.5 cm for the northern stock (coastal survey data north of 67˚N). Most commercial catch in both areas is taken with gillnets, which catch very few immature coastal cod (Figures 2.1.2 and 2.1.3). There is more potential to reduce catches of immature coastal cod by Danish seine (Tables 2.2.2 and 2.3.4; Figures 2.1.2 and 2.1.3).

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 NCC. 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			

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
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			
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

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
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	1206	340	1546
2019	35861	2965	1677	7900	4800	12700	1603	339	1943
2020	43133	3481	987	6233	3806	10039	1785	347	2132
2021	38347	3696	578	6623	4039	10661	565	321	885
2022	37482	2827	188	6459	4248	10707	524	244	768

*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

Year	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Total		
	NCC	NEAC	NCC	NEAC	NCC	NEAC	NCC	NEAC	NCC	NEAC	%NCC
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
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
2022	1504	3836	1036	1887	393	224	736	341	3369	6288	37
µ85–22	**1136**	**4017**	**637**	**2085**	**522**	**461**	**792**	**825**	**3087**	**7388**	**29**

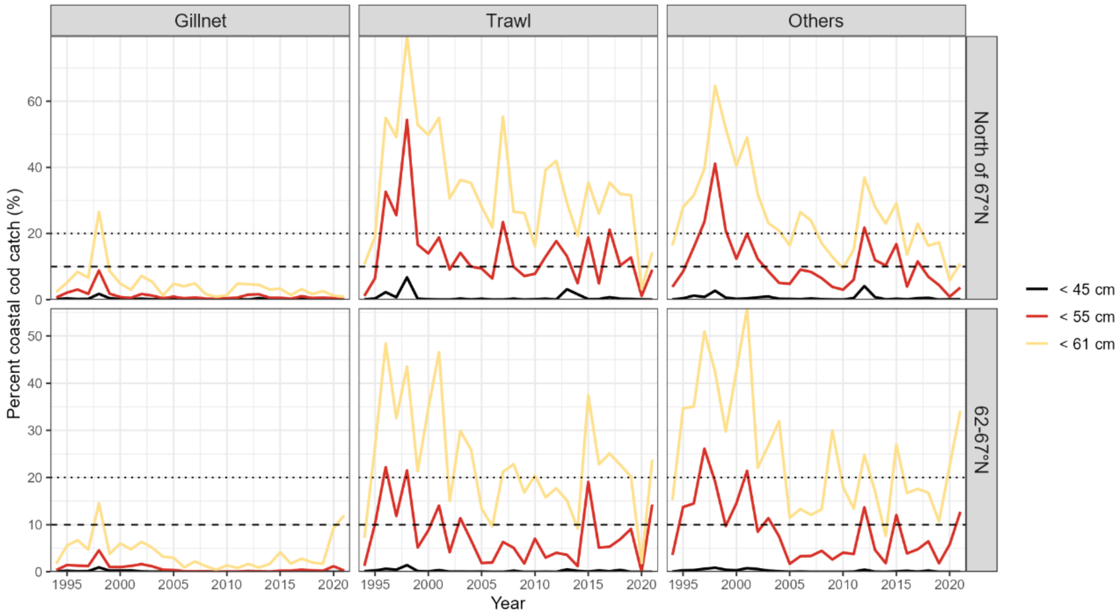


Figure 2.1.2. Percent of coastal cod commercial catch below 45, 55, and 61 cm, by gear and stock area. The current minimum size is 44 cm and 10% (dashed line) may be landed below this value. Increasing the minimum size to 55 cm is currently under consideration. Red indicates catch of coastal cod under 55 cm (length at 50% maturity is estimated as 55.8 cm between 62–67˚N and 60.5 cm north of 67˚N).

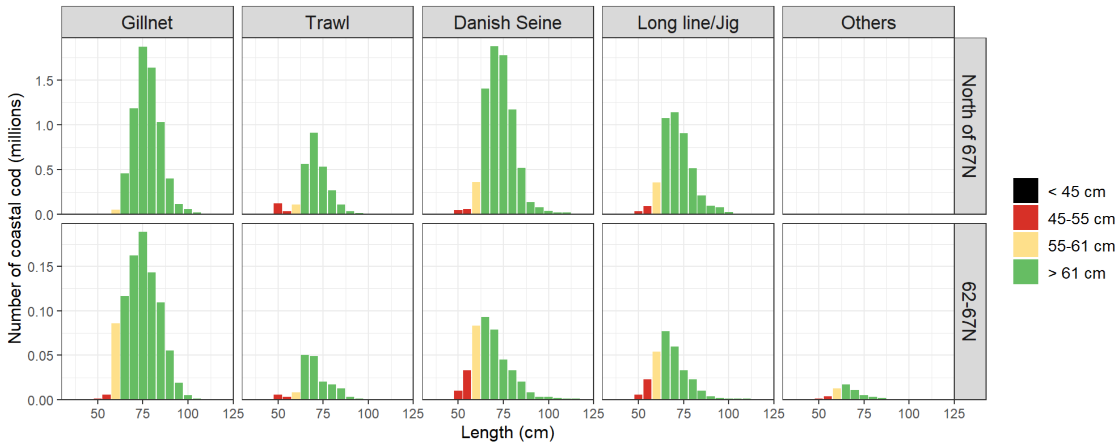


Figure 2.1.3. Length distributions of coastal cod commercial catch by gear and stock area, combined for the years 2020–2021. The current minimum size is 44 cm and 10% may be landed below this value. Increasing the minimum size to 55 cm is currently under consideration. Red indicates catch of coastal cod under 55 cm (length at 50% maturity is estimated as 55.8 cm between 62–67˚N and 60.5 cm north of 67˚N).

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, 2022a). 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 2023 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 fluctuated around a similar level until 2010, after which it increased to approximately 25 000 t lower than the peak 1994 level. After 2016, the stock has declined back towards the level estimated in 2003–2010 and the declining trend continues in 2022. Fishing mortality mainly follows the trend in SSB, with highest F in the period with lowest estimated SSB, and vice versa. However, F increased from 2019 to 2020 despite increasing SSB, and decreased from 2020 to 2022 despite a small decrease in SSB. This is mainly driven by changes in F on ages 7+. 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 estimates of this cohort in 2021 and 2022 are also the lowest of their respective age in the time-series. While SSB declined with 1300 t from 2021 to 2022, TSB increased by about 17 000 t compared to 2021 when it was at its lowest since 2006–2007 due to the low age 3 numbers that year. The increase in 2022 is mainly driven by increases in ages 2–3, while the abundance of ages 10+ has seen a steady decline since 2015 and is now comparable to the lowest values observed in the time-series (in 2003 and 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). This advice was based on the old HCR (ICESAR) and more conservative than the advice given for 2023 (29 347 t). Nevertheless, total landings in 2022 were 43 941 t, far 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 2022 were 37 482 t, down c. 1000 t from 2021. Of the total landings, 29% were taken in ICES Division 1.b and the rest in Division 2.a, up from 22% in 2021 but comparable to 2020 (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 2021, catch proportions were lower in area 05 and higher in areas 03 and 04. In total, 41% of the landings were taken in gillnet fisheries and 36% in Danish seine, while longline/jig made up 18% of the landings and trawl 5% (down from 12% in 2021).

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. The estimate for 2022 was refined based on improved records from the same reporting system, leading to a recreational catch estimate similar to the pandemic years, despite increasing fishing tourism (WD 04).

Catch-at-age (commercial + recreational) of ages 4, 5 and 10+ were lower compared to 2021, as expected from catch numbers of the same cohorts the year before, while catches of ages 3 and 6–9 increased. The total catch in tonnes decreased by 1000 t compared to 2021 and was very close to the status quo prediction from the 2022 assessment (forecasted in 2022: 43 688 t, estimated in 2023: 43 941 t).

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. For further details on the estimation of recreational catch, see WD 04 and the Stock Annex. Inclusion of discard estimates in the commercial landings based on recent methodological improvements for discard estimation in Norwegian fisheries should be explored in future (Berg *et al.*, 2022).

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 a fixed trawl station grid 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 was done, resulting in a decision to change the acoustic index from an index by age to an aggregated biomass index (ICES, 2022a). This was due to the disaggregated index 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 2022 survey north of 67°N are presented in Tables 2.2.5–2.2.11.

2.2.3.1 Indices of abundance and survey mortality (Tables 2.2.5–2.2.7, Figures 2.2.2–2.2.5)

As has been the case since 2017, the acoustic index in 2022 was considerably higher than the swept-area index, both about total abundance and biomass (Tables 2.2.5 and 2.2.7, Figures 2.2.2–2.2.4). Earlier in the time-series, the swept-area index has been higher than the acoustic index. The reasons behind these patterns are not fully understood (but see general challenges of surveying the coastal habitat in section 2.2.3 above).

The 2022 age 1 swept-area abundance index was much higher than age 1 in 2020 and 2021 and just above the time-series average. Note, however, that some 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. Fluctuations in abundance of age 1 are therefore not necessarily reflective of true fluctuations in recruitment. In 2021, age 2 indices were higher than expected from the low 2020 estimate of the same year class, and the 2022 estimate of age 3 are consistent with the higher 2021 estimate (Table 2.2.6 and Figure 2.2.4b). Estimates of ages 4, 6 and 7 in 2022 were lower than expected based on estimates of the same cohort the previous year. Indices for the oldest fish (ages 10+) declined in 2022 and are much lower than those seen in 2009–2019 (Table 2.2.6). The coefficients of variation (CVs) in the swept-area index are higher for ages 8 and above where there is less data (Table 2.2.7).

Survey mortalities generally increased in 2021–2022 compared to 2020–2021 as a result of lower than expected indices for several ages (Figure 2.2.5). Survey mortalities for the acoustic index by age is also shown in Figure 2.2.5 for comparison, though this index is only included as an aggregated biomass index in the assessment. 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 2.2.8)

About 2600 cod otoliths were sampled north of 67°N during the 2022 survey, which is up from 2400 in 2021 and above the long-term average (Table 2.2.8). The proportions of NCC at age followed the trend in previous years of being higher than the long-term average, but within ranges previously observed.

2.2.3.3 Length and weights-at-age (Tables 2.2.9–2.2.10, 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 2022 were similar to previous years and generally a bit higher than the time-series average. One exception is the 2018-cohort, which at age 3 (in 2021) and age 4 (in 2022) was both lighter and approximately 1.5 cm smaller than the time-series average (Tables 2.2.9–2.2.10). Mean weights at age decreased compared to 2021 for ages 1, 4, 6, and 8, while it increased slightly for the other ages (Table 2.2.10). 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 2.2.11, Figure 2.2.7)

The fraction of mature fish in the autumn survey (Table 2.2.12, Figure 2.2.7) show rather large variation between years. While some of the variation is likely related to variation in growth, it may also be influenced by the difficulty of distinguishing mature and immature cod in autumn. Coastal cod spawn in February–June and most mature individuals are in a resting state at the time of the survey in October–November. The maturity ogive therefore 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 maturity data were collected in the 2022 survey due to an error in the sampling protocol.

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 1994–2022, 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 2.2.12)

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 2.2.13)

The weight-at-age for ages 2–7 in the stock (Table 2.2.13) is obtained from the Norwegian coastal survey (Table 2.2.10), 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 2.2.11, Figure 2.2.7)

Annual maturity-at-age observed in the survey is used in the assessment (Table 2.2.11). Maturity of the plus group is an average for the ages included in the plus group, weighted by abundance-at-age. Since no maturity data were collected in 2022, averages of the last three years (2019–2021) were used in the assessment.

2.2.4.6 Natural mortality (Table 2.2.14, 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 2.2.14).

2.2.5 Final assessment run

The 2023 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, 2022a). 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 together with the same estimates from last year's assessment. There were no problems with model convergence.

Model	Log(L)	#par	AIC
2022 assessment	−185.44	19	408.88
2023 assessment	−194.08	19	426.16

The estimated survey catchabilities at age are presented in Table 2.2.16.

2.2.5.1 Model diagnostics (Figures 2.2.9–2.2.11)

A 5-year retrospective peel indicated that the model tends to systematically overestimate SSB and consequently underestimate Fbar, though in most cases the peels do not fall far outside the confidence interval of the 2023 run. The model has low precision in the recruitment (age 2) estimate, particularly in the 2013–2017 period (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 shows a different trend than the acoustic index. Mohn's rho (average 5-year retrospective bias) was 0.2 for SSB, −0.17 for Fbar, and 0.3 for recruitment. Thus, the model would have overestimated SSB and recruitment and underestimated Fbar, particularly from 2013 and onwards, had it been run in these 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 (Tables 2.2.17–2.2.19, Figure 2.2.1)

SSB decreased with 1000 t from 2021 to 2022, but Fbar (ages 4–8) also decreased slightly reflecting the decreased catches of older ages (Table 2.2.3c, 2.2.17, and 2.2.18). Fishing mortality for ages 1–5 in 2022 were slightly higher than in 2020 and 2021, while Fs for ages 6 and above were lower (Table 2.2.18). The weak 2018-cohort is reflected in the stock number estimate for age 4 in 2022, which is the lowest in the time-series (Table 2.2.19). Stock numbers for ages 7–9 were rather low and similar to the two preceding years, while the estimate of age 10+ fell further in 2022 (Table 2.2.19). Stock numbers of ages 2 and 5 increased compared to 2021.

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 current advice (ICES, 2022a). 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 WKNC-CHCR (ICES, 2022a). 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 2.2.20a–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 2.2.20a). Process noise is included in the prediction (i.e. processNoiseF=FALSE). Averages from the last 5 years of the assessment are used for stock weights, catch weights, maturity, and natural mortality-at-age (Table 2.2.20b). Recruitment-at-age 2 in 2023 and 2024 is the median resampled from the years 2013–2022 (Table 2.2.20a).

2.2.7.2 Catch scenarios (Table 2.2.21, 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 26 612 tonnes in 2024 (commercial and recreational catches combined). This catch level is expected to lead to an 14% increase in SSB relative to SSB predicted for 2023, while the same level of fishing in 2024 as in 2022 is expected to give a 2.5% increase in SSB. Zero catch in 2024 is expected to give a 32% increase in SSB (Table 2.2.21, Figure 2.2.12).

2.2.7.3 Comparison of the present and last year's assessments

Compared to last year's assessment, SSB has been revised downwards (with a corresponding upwards revision of F) going approximately five years back in time. SSB in 2021 was estimated to be 7500 t less in the 2023 assessment compared to the 2022 assessment, which is similar to the revision from 2021 to 2022 (ICES, 2023). The main reason for the downwards revision is that the swept-area survey index in 2022 came in lower than expected for several ages, possibly indicating an increase in mortality that is not reflected in the catches.

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 (see Stock Annex for a more comprehensive list):

- Examining whether survey index uncertainty can be improved, e.g. by adjusting the survey design or the post-stratification applied to calculate indices.
- Extending the swept-area index back to 1995.
- Re-examining the coupling of ages applied in the swept-area index observation correlation in SAM.
- Investigating inclusion of external variance estimates for survey indices in SAM.
- Considering the option of modelling natural mortality, stock weights, proportion mature and catch weights as processes with error (as opposed to fixed values) in SAM
- Developing and applying methodology for estimation of catch in recreational and tourist fishing.

2.2.9 Tables and figures

Table 2.2.1. Northern Norwegian coastal cod. Total commercial catch (t) by fishing areas in the last three years. The numbers differ slightly from table 2.2.3 due to different spatial units used in the estimation.

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
2022	10738	8606	13601	4511	10738	26718	37456

Table 2.2.2. Commercial catch of northern Norwegian coastal cod (t) in 2022 by gear and Norwegian statistical fishing area. The numbers differ slightly from table 2.2.3 due to different spatial units used in the estimation.

Year	2022					
Area	03	04	05	00	Total north of 67°N	% by gear
Gillnet	1213	3762	6794	3426	15195	41
L.line/Jig	4484	825	1104	495	6908	18
Danish seine	4455	3366	4968	578	13367	36
Trawl	575	645	735	7	1962	5
Others*	11	8	0	5	24	0.1
Total	10738	8606	13601	4511	37456	

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
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

	Age								Tonnes
Year	2	3	4	5	6	7	8	9	10+	Landed
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
2022	145	958	1252	2140	2622	1389	749	232	147	37482

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
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

	Age									Tonnes
Year	2	3	4	5	6	7	8	9	10+	landed
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
2022	31	215	233	376	472	237	130	40	31	6459

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

	Age									Tonnes
Year	2	3	4	5	6	7	8	9	10+	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
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

Year	Age 2	3	4	5	6	7	8	9	10+	Tonnes landed
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
2022	176	1173	1485	2516	3093	1626	879	272	178	43941

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

Year	Age 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
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

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
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
2022	1.102	1.659	2.407	3.291	4.174	5.173	6.325	6.978	8.276

Table 2.2.5. Northern Norwegian coastal cod. Acoustic total abundance and biomass indices (t) for ages 2+ from the Coastal survey (A6335). Data from 2021 are highlighted in cursive due to high uncertainty leading to the decision to remove this data point from the assessment (see ICES, 2023).

Year	Abundance age 2+ (millions)	5% quantile abundance	95% quantile abundance	Biomass age 2+ (tonnes)	5% quantile biomass	95% quantile biomass
1995	33.395	28.062	38.729	53586	43397	64603
1996	31.513	26.741	36.286	38553	31598	48020
1997	47.938	36.740	59.136	45079	39186	51910
1998	29.757	24.069	35.446	39064	33020	46647
1999	13.154	10.789	15.519	16012	13438	18968
2000	24.871	20.649	29.092	35243	31182	40197
2001	17.500	12.168	22.832	27051	21134	33620
2002	11.695	8.802	14.587	21098	17500	25428
2003	13.128	10.076	16.179	23749	20263	28331
2004	11.593	9.613	13.572	17968	15832	20236
2005	8.253	6.720	9.785	14601	12719	16731
2006	10.989	8.299	13.679	21748	18146	25659
2007	15.494	12.653	18.335	33075	28672	38131
2008	7.476	5.937	9.016	15266	12998	17454
2009	9.128	7.363	10.894	18428	15714	21151
2010	11.022	9.203	12.840	21637	18777	24624
2011	10.425	8.591	12.259	22991	19439	26565
2012	10.581	8.703	12.458	20654	18418	22856
2013	10.131	8.146	12.117	20705	17766	23934
2014	16.259	13.220	19.299	36710	30858	44568
2015	10.942	9.227	12.657	22892	20541	25319
2016	14.157	12.567	15.747	30551	27801	32919
2017	12.782	10.546	15.018	25918	22094	30227
2018	10.298	8.268	12.327	22347	19450	24616
2019	13.753	11.212	16.295	29829	25725	34023
2020	12.701	10.251	15.151	26833	23162	30655

Year	Abundance age 2+ (millions)	5% quantile abundance	95% quantile abundance	Biomass age 2+ (tonnes)	5% quantile biomass	95% quantile biomass
2021	21.727	18.325	25.128	43571	38323	49365
2022	15.241	12.301	18.180	24858	21148	29051

Table 2.2.6. Northern Norwegian coastal cod. Swept-area abundance indices by age (in thousands), and abundance (thousands) and biomass (t) for ages 1+ and 2+ from the Coastal survey (A6335). The split between coastal cod and Northeast Arctic cod is uncertain for age 1. Ages 2–10+ are included in the assessment model.

	Age													
Year	1	2	3	4	5	6	7	8	9	10+	Abundance age 1+	Biomass age 1+	Abundance age 2+	Biomass age 2+
2003	5254	3268	3763	4521	2700	2319	863	489	220	69	23467	33861	18212	33421
2004	2837	2201	2396	2602	1463	722	359	181	46	63	12868	15980	10033	15693
2005	665	1042	1988	1478	1268	746	157	107	68	54	7574	11379	6908	11311
2006	1802	2156	2623	2946	1554	1026	941	171	107	23	13349	22526	11547	22344
2007	446	911	853	1071	789	465	394	114	75	29	5146	11943	4701	11901
2008	2463	1822	2795	1883	1419	1145	580	348	161	94	12710	23090	10247	22846
2009	6642	2251	3570	3716	1584	868	712	466	204	160	20172	24986	13531	24504
2010	7412	2353	3268	3385	2397	784	383	733	317	328	21360	29875	13948	29451
2011	2322	3471	2498	2866	2095	1445	292	315	213	310	15827	27845	13505	27712
2012	4299	3218	4485	2784	1537	1042	930	411	200	346	19251	28587	14953	28278
2013	6382	4101	1706	2666	1887	1575	890	578	297	419	20502	32875	14119	32340
2014	5696	5448	4026	3034	3521	2016	1388	465	364	337	26296	43823	20599	43394
2015	4298	4733	4154	3727	2068	1818	902	506	397	222	22827	40385	18527	40049
2016	3944	4433	4522	2610	1995	746	735	413	203	210	19810	31320	15867	31057
2017	768	2891	2407	1563	1151	715	308	200	147	157	10308	18682	9539	18615
2018	4070	3197	1916	1879	1049	748	323	183	128	168	13661	18815	9591	18573
2019	2234	2114	2470	1508	1460	839	490	148	129	211	11601	19974	9369	19831
2020	560	1670	2599	2416	1188	611	291	177	49	72	9632	16780	9073	16736
2021	1412	2531	1367	1589	1367	732	289	239	82	81	9690	14699	8277	14584
2022	3627	2516	1709	727	1000	614	238	108	117	56	10712	11923	7085	11696

Table 2.2.7. 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
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	21	14	16	13	13	16	15	19	31	41
2021	28	19	21	16	21	18	13	16	25	35
2022	18	14	15	12	13	15	15	25	25	37

Table 2.2.8. 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

Year	Age 1	2	3	4	5	6	7	8	9	10	**Total number aged**
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
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
2022	0.97	0.98	0.96	0.79	0.83	0.76	0.78	0.77	0.86	1.00	2670
Average 95–22	**0.92**	**0.92**	**0.88**	**0.80**	**0.74**	**0.67**	**0.64**	**0.61**	**0.63**	**0.66**	**2196**

Table 2.2.9. 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.

	Age								
Year	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
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

	Age								
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2022	20.1	36.0	46.8	54.7	65.3	71.2	76.6	79.2	80.9	91.4

Table 2.2.10. 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.

	Age									
Year	**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
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

	Age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
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
2022	65	450	1003	1572	2658	3561	4559	4826	5471	8172

Table 2.2.11. 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. No maturity data were collected in 2022, and the value presented and used in the assessment is the average of 2019–2021.

	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
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

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
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
2022	0.00	0.01	0.06	0.28	0.56	0.83	0.92	0.98	0.99	1.00

Table 2.2.12. Northern Norwegian coastal cod. Tuning data used in the final SAM run.

Norw-Coast-Ac-Q4-1995 (Aco)

1995	2002		
1	1	0.8	0.8
-1	-1		
1	53586		
1	38553		
1	45079		
1	39064		
1	16012		
1	35255		
1	27051		
1	21098		

Norw-Coast-Ac-Q4-2003 (Aco)

2003	2022		
1	1	0.8	0.8
-1	-1		
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
1	NA
1	24858

Norw-Coast-Ac-Q4 (BTr)

2003	2022								
1	1	0.8	0.8						
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
1	2.516	1.709	0.727	1	0.614	0.238	0.108	0.117	0.056

Table 2.2.13. Northern Norwegian coastal cod. Stock mean weight-at-age (kg) as 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
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

	Age								
Year	2	3	4	5	6	7	8	9	10+
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
2022	0.450	1.003	1.572	2.658	3.561	4.559	6.325	6.978	8.276

Table 2.2.14. Northern Norwegian coastal cod. Natural mortality-at-age as 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
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

Year	Age 2	3	4	5	6	7	8	9	10+
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
2022	0.573	0.448	0.391	0.333	0.305	0.283	0.256	0.248	0.236

Table 2.2.15. 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_AFWG2023

```
# 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 2.2.16. 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	-	-	-	-	-	-	-	-	-	0.085
Swept-area index	0.000060	0.000099	0.000139	0.000156	0.000156	0.000156	0.000156	0.000156	0.000191	-

Table 2.2.17. 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	34736	27309	44181	131682	97542	177770	0.277	0.222	0.346	320128	274839	372881
1995	40641	32895	50211	111730	83789	148988	0.363	0.297	0.444	304622	265606	349370
1996	51097	42281	61751	89198	71111	111886	0.363	0.297	0.443	251105	224031	281451
1997	63009	52108	76191	68899	55713	85207	0.454	0.373	0.554	226735	204148	251821
1998	53062	44557	63191	58127	46308	72962	0.468	0.389	0.564	241433	217963	267430
1999	55499	46372	66422	47072	38965	56866	0.431	0.349	0.532	219976	199755	242244
2000	53687	45005	64043	51688	44240	60391	0.331	0.267	0.412	230754	209560	254093
2001	45501	38228	54157	67442	59799	76062	0.274	0.224	0.335	234949	213487	258568
2002	46214	38623	55297	81263	72109	91580	0.306	0.253	0.369	252248	229009	277845
2003	47706	40051	56823	67539	59553	76595	0.298	0.247	0.359	235186	213204	259435
2004	42639	36400	49947	76736	67442	87311	0.324	0.267	0.394	237475	214313	263141
2005	44249	37789	51813	68962	60110	79119	0.288	0.237	0.352	229899	206991	255342
2006	35171	30042	41175	87510	75521	101402	0.334	0.271	0.412	238930	214663	265941
2007	32754	27913	38434	94203	80486	110256	0.234	0.188	0.292	247918	221505	277481
2008	42766	36371	50286	94224	79855	111178	0.221	0.179	0.274	265280	236627	297402
2009	40809	34978	47612	73138	60777	88014	0.184	0.148	0.228	258614	230243	290480
2010	37390	32103	43547	84755	71095	101040	0.226	0.183	0.279	270351	242157	301827

Year/Age	R (age 3)	Low	High	SSB	Low	High	Fbar (4–8)	Low	High	TSB	Low	High
2011	35951	30595	42244	95598	80667	113292	0.206	0.166	0.256	291300	261070	325030
2012	44979	38669	52319	100408	84414	119432	0.166	0.135	0.205	285082	255684	317861
2013	33938	29032	39674	101368	85584	120064	0.143	0.116	0.176	273881	246002	304920
2014	39951	34386	46417	105914	90480	123981	0.14	0.115	0.171	293369	264914	324879
2015	39798	34190	46326	97475	83444	113865	0.2	0.166	0.242	312083	282815	344379
2016	41741	35423	49187	101657	87895	117573	0.287	0.24	0.345	303298	274021	335702
2017	41481	34827	49406	84407	72527	98234	0.377	0.316	0.448	292696	261695	327370
2018	40241	32970	49116	79120	67583	92626	0.33	0.274	0.398	289181	253233	330233
2019	51246	40497	64849	67666	56375	81218	0.365	0.299	0.446	274685	234492	321767
2020	41708	31527	55178	77487	61430	97740	0.399	0.312	0.511	259402	213701	314877
2021	28673	20514	40078	72888	53826	98702	0.318	0.231	0.438	233023	182745	297135
2022	45595	30874	67336	71599	48215	106324	0.308	0.204	0.464	249818	184321	338590

Table 2.2.18. 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	0.005	0.038	0.16	0.325	0.431	0.431	0.431	0.324
1995	0	0.009	0.055	0.182	0.388	0.596	0.596	0.596	0.416
1996	0.001	0.018	0.091	0.228	0.399	0.548	0.548	0.548	0.415
1997	0.001	0.025	0.12	0.277	0.532	0.672	0.672	0.672	0.539
1998	0.003	0.053	0.244	0.469	0.624	0.502	0.502	0.502	0.413
1999	0.001	0.027	0.169	0.385	0.539	0.53	0.53	0.53	0.448
2000	0.001	0.016	0.126	0.32	0.406	0.402	0.402	0.402	0.402
2001	0	0.01	0.084	0.221	0.342	0.361	0.361	0.361	0.617
2002	0.001	0.012	0.082	0.212	0.377	0.429	0.429	0.429	0.807
2003	0.001	0.013	0.067	0.179	0.331	0.456	0.456	0.456	0.817
2004	0.001	0.008	0.05	0.145	0.324	0.551	0.551	0.551	0.965
2005	0	0.008	0.054	0.151	0.279	0.479	0.479	0.479	1.063
2006	0.001	0.011	0.068	0.19	0.329	0.542	0.542	0.542	1.475
2007	0.001	0.016	0.076	0.182	0.25	0.332	0.332	0.332	0.89
2008	0.001	0.018	0.073	0.203	0.259	0.285	0.285	0.285	0.604
2009	0.001	0.015	0.046	0.152	0.237	0.241	0.241	0.241	0.394
2010	0.001	0.018	0.055	0.184	0.298	0.297	0.297	0.297	0.542
2011	0.002	0.022	0.064	0.142	0.221	0.301	0.301	0.301	0.511
2012	0.005	0.039	0.08	0.132	0.185	0.218	0.218	0.218	0.418
2013	0.003	0.026	0.062	0.107	0.15	0.198	0.198	0.198	0.342
2014	0.003	0.023	0.061	0.103	0.143	0.196	0.196	0.196	0.358
2015	0.005	0.04	0.096	0.145	0.209	0.276	0.276	0.276	0.542
2016	0.003	0.03	0.098	0.159	0.286	0.447	0.447	0.447	0.749
2017	0.009	0.058	0.15	0.224	0.362	0.573	0.573	0.573	0.809
2018	0.003	0.026	0.089	0.166	0.285	0.556	0.556	0.556	0.66
2019	0.002	0.021	0.084	0.169	0.306	0.633	0.633	0.633	0.717
2020	0.001	0.019	0.092	0.199	0.389	0.658	0.658	0.658	0.657
2021	0.002	0.025	0.106	0.203	0.321	0.48	0.48	0.48	0.547

Year/Age	2	3	4	5	6	7	8	9	10+
2022	0.003	0.03	0.117	0.198	0.331	0.446	0.446	0.446	0.437

Table 2.2.19. 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	81825	34736	38991	36079	17743	10182	4876	1126	3132
1995	99166	40641	21040	25034	21230	9228	4919	2440	2433
1996	124960	51097	24258	13365	14671	10315	3833	2056	2324
1997	106521	63009	29788	14529	7388	7153	4444	1682	2151
1998	111966	53062	37841	17406	7615	3137	2664	1689	1642
1999	103725	55499	31311	20177	7600	2959	1429	1225	1640
2000	86352	53687	32807	17790	9689	3178	1306	632	1395
2001	82968	45501	33181	19214	9072	4727	1578	656	1082
2002	87736	46214	28074	20911	10741	4645	2447	835	821
2003	81403	47706	29556	17248	12098	5347	2268	1214	696
2004	80479	42639	30118	18647	10230	6243	2512	1083	847
2005	61881	44249	25901	19679	11621	5405	2664	1090	737
2006	60073	35171	27691	16641	12032	6319	2525	1263	712
2007	72978	32754	22554	17438	9714	6524	2708	1140	690
2008	72655	42766	20644	14147	10471	5533	3594	1499	865
2009	67613	40809	27980	13310	8347	5943	3138	2130	1254
2010	62728	37390	25554	18863	8255	4861	3530	1890	2016
2011	79092	35951	23989	16524	11299	4554	2734	2022	2047
2012	66095	44979	23368	15683	10446	6667	2603	1528	2140
2013	74048	33938	28641	15222	10144	6441	4032	1625	2054
2014	74296	39951	20697	18809	10099	6411	3957	2557	2188
2015	77087	39798	25266	13384	12343	6553	3943	2520	2822
2016	75527	41741	24537	16084	8390	7459	3824	2292	2771
2017	74094	41481	24970	15528	9881	4761	3598	1888	2165
2018	87754	40241	25491	14719	9063	5046	2063	1562	1587
2019	74797	51246	24794	16288	9202	5019	2199	917	1350

Year/Age	2	3	4	5	6	7	8	9	10+
2020	54408	41708	32311	15968	9789	5093	2022	890	892
2021	84070	28673	26462	20285	9579	4837	2045	786	721
2022	90998	45595	16912	16620	11809	5137	2247	989	699

Table 2.2.20a. Northern Norwegian coastal cod. Assumptions for the interim year and in the forecast: Fbar, recruitment, SSB and catch.

Variable	Value	Notes
$F_{ages\ 4–8}$ (2023)	0.31	F_{sq} = median fishing mortality in 2022.
SSB (2023)	74 654	Short-term forecast fishing at *status quo* (F_{sq}); Tonnes.
$R_{age\ 2}$ (2023 and 2024)	75 527	Median resampled recruitment (2013–2022). The youngest age in the model is age 2. Other reported re-cruitments are at age 3 when the fish enter the fishery; thousands.
Total catch (2023)	43 978	Short-term forecast fishing at F_{sq}; Tonnes.

Table 2.2.20b. 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	1.270	0.414	0.007	0.590
3	1.851	1.022	0.063	0.447
4	2.533	1.857	0.275	0.372
5	3.302	2.870	0.569	0.326
6	4.155	3.727	0.823	0.301
7	5.037	4.884	0.923	0.277
8	5.966	5.966	0.982	0.260
9	6.759	6.759	0.992	0.250
10+	8.838	8.838	1.000	0.230

Table 2.2.21. Northern Norwegian coastal cod. Catch scenarios.

Basis	Total catch (2024)	F_{total} (2024)	SSB (2024)*	% SSB change**	% advice change***	% probability of SSB falling below $SSB_{lower\ bound}$ in 2024
ICES advice basis						
Management plan^	26 612	0.176	85 209	14	−9.3	18

Basis	Total catch (2024)	F_{total} (2024)	SSB (2024)*	% SSB change**	% advice change***	% probability of SSB falling below $SSB_{lower\ bound}$ in 2024
Other scenarios						
F = 0	0	0	98 633	32	−100	5.2
$F = F_{2022}$	44 395	0.31	76 490	2.5	51	32

*** 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 2024 relative to SSB in October 2023 (74 654 tonnes).**

***** Advice for 2024 relative to advice for 2023 (29 347 tonnes).**

^According to the harvest control rule (HCR) in the MP (ICES, 2022a).

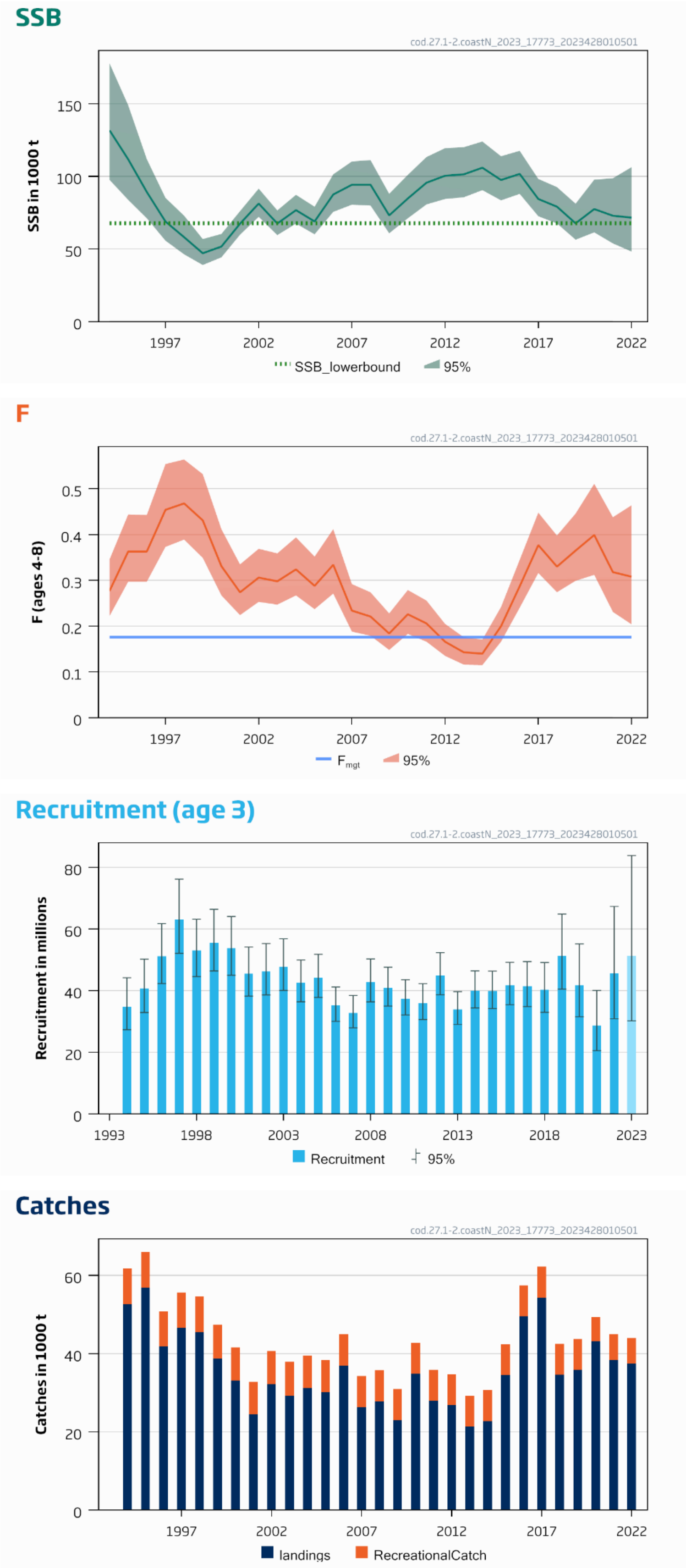


Figure 2.2.1. Northern Norwegian coastal cod. Standard figures. SAM estimates of a) SSB, b) Fbar(4–8), c) recruitment (age 3), and d) catch input data.

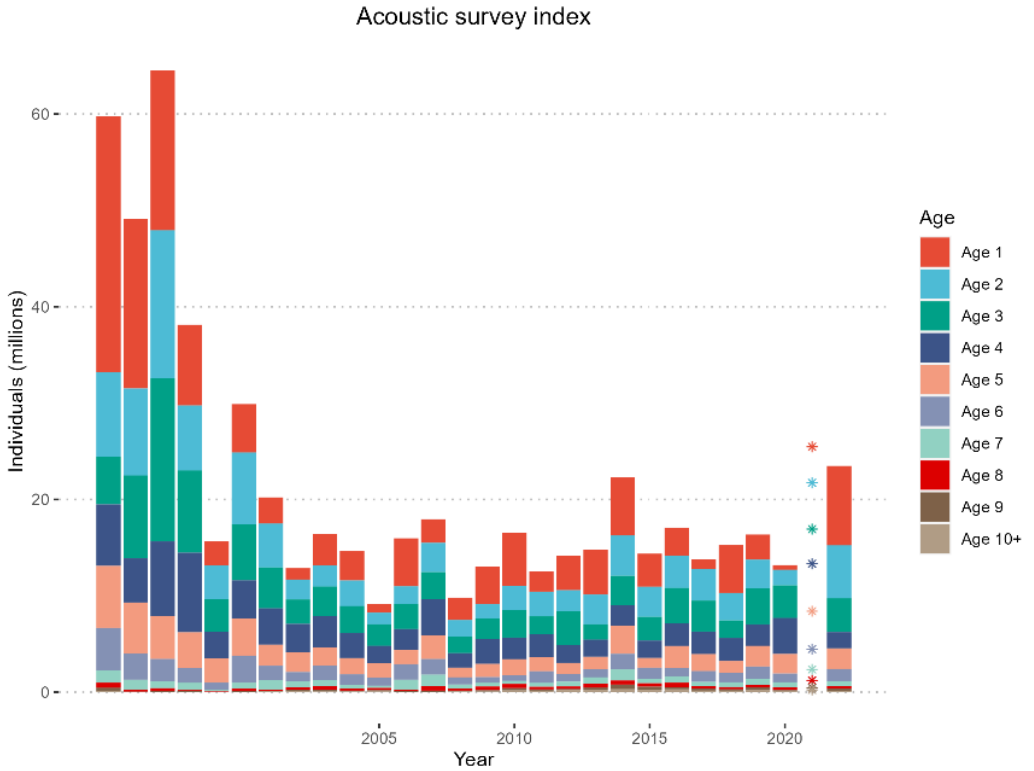


Figure 2.2.2. Northern Norwegian coastal cod. Acoustic abundance index by age (colours) from the Coastal survey in October–November (survey code A6335). 2021 estimates are indicated by stars because of the decision to exclude that year's index from the assessment (see ICES, 2023). Note that starting in 2022, the acoustic index is included in the assessment model as a total biomass index rather than numbers-at-age.

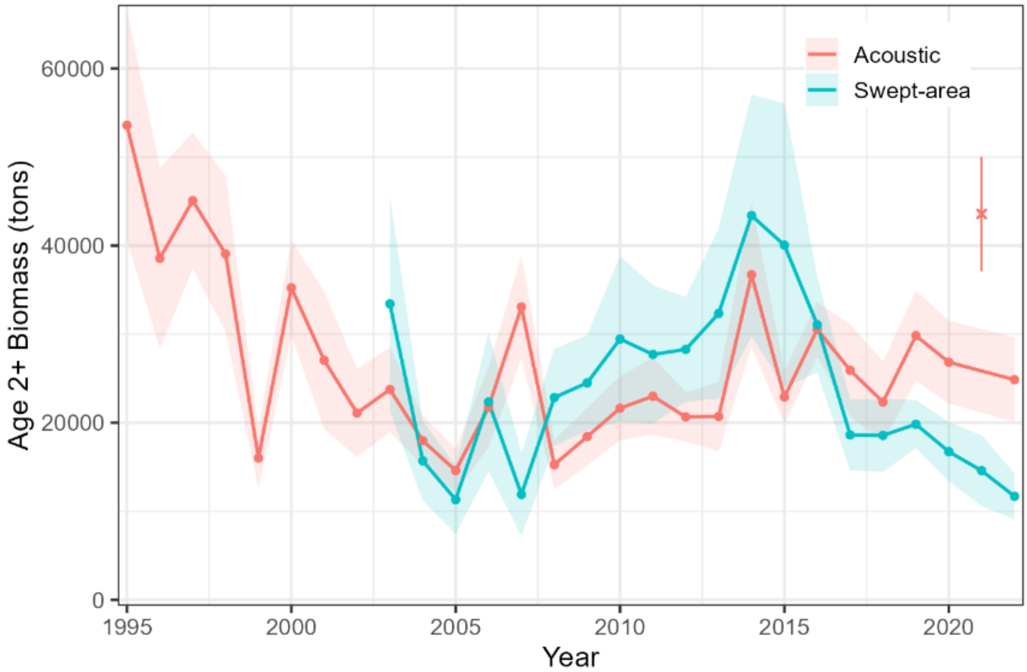


Figure 2.2.3. Northern Norwegian coastal cod. Acoustic and swept-area biomass indices (ages 2+) from the Coastal survey in October-November. Biomass for ages 1+ are reported in Table 2.2.5. The acoustic biomass index for ages 2+ is included as a tuning series in the assessment model, while the swept-area index is included by age (see Figure 2.2.4). Note that the 2021 data point was excluded from the assessment (see ICES, 2023).

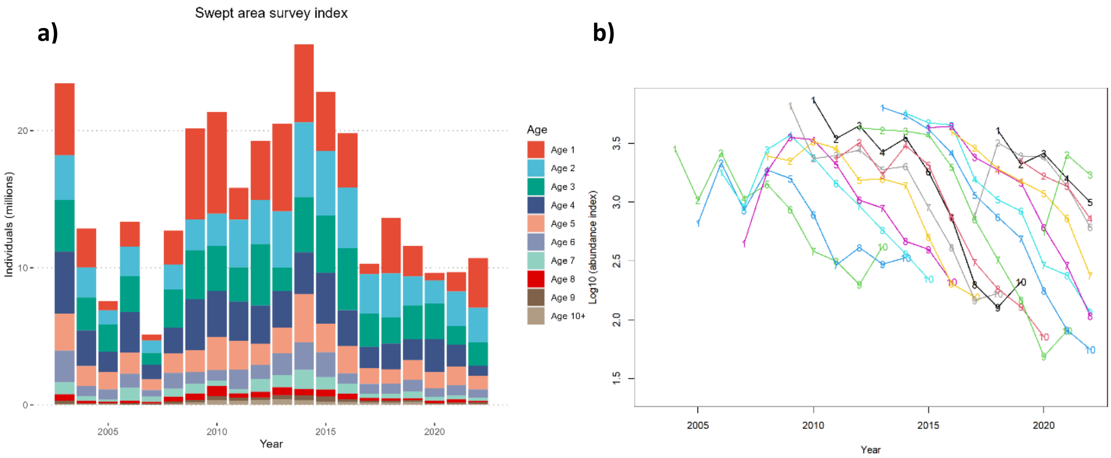


Figure 2.2.4. Northern Norwegian coastal cod. a) Swept-area abundance index by age (colours) from the Coastal survey in October–November (survey code A6335), and b) cohort-tracking of log-abundance swept-area indices. Colours represent cohorts and numbers indicate ages.

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*. 2020–2021 and 2021–2022 estimates from the acoustic index are indicated by stars because of the decision to exclude the 2021 index from the assessment (see ICES, 2023).

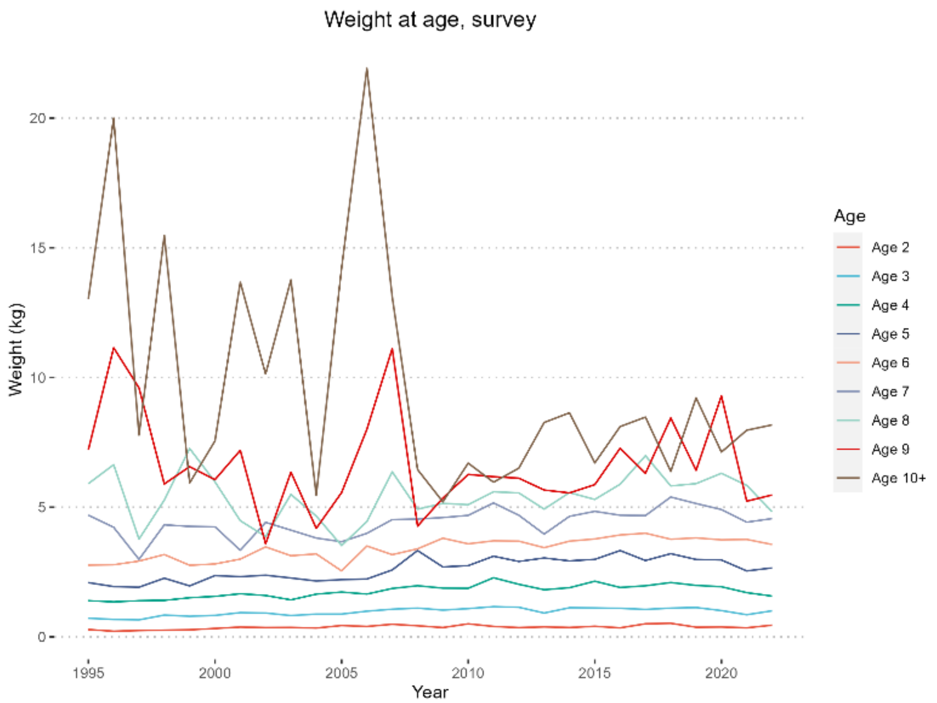


Figure 2.2.6. Northern Norwegian coastal cod. Mean weight-at-age in the coastal survey. Few individuals of ages 10+ were sampled at the beginning of the time-series, leading to extremely large variation in mean weights. In the stock assessment model, stock weights for ages 8–10+ are set equal to mean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

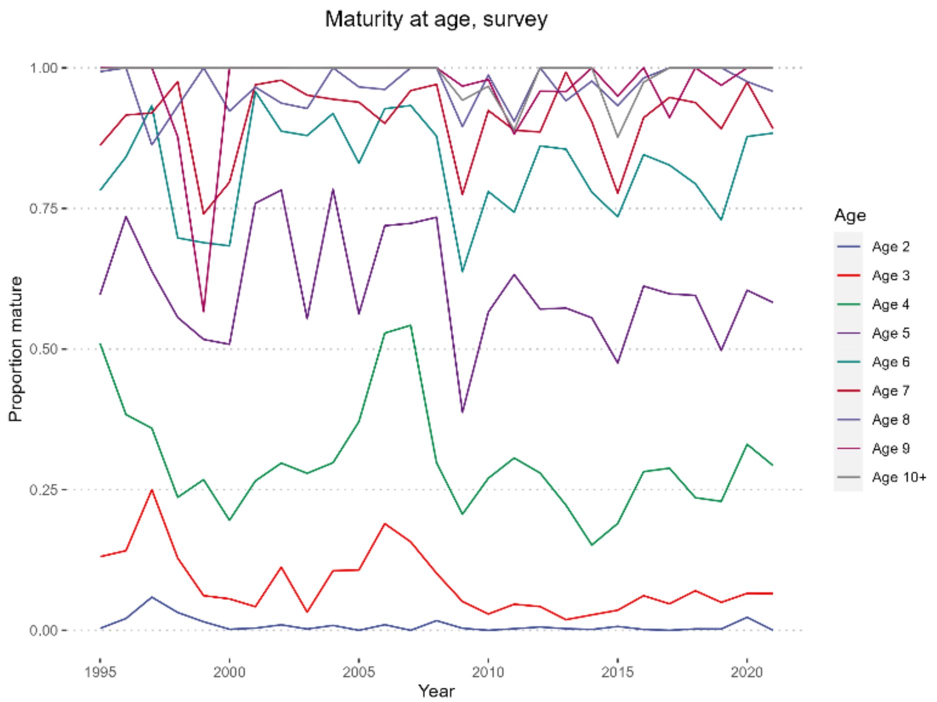


Figure 2.2.7. Northern Norwegian coastal cod. Proportions mature-at-age as observed in the Coastal survey. Since the survey takes place in October-November and the main spawning season is in March-April, spent/resting individuals are included as mature when calculating these proportions. No maturity data were collected in 2022, and averages of the last 3-years were therefore used in the assessment (Table 2.2.11) .

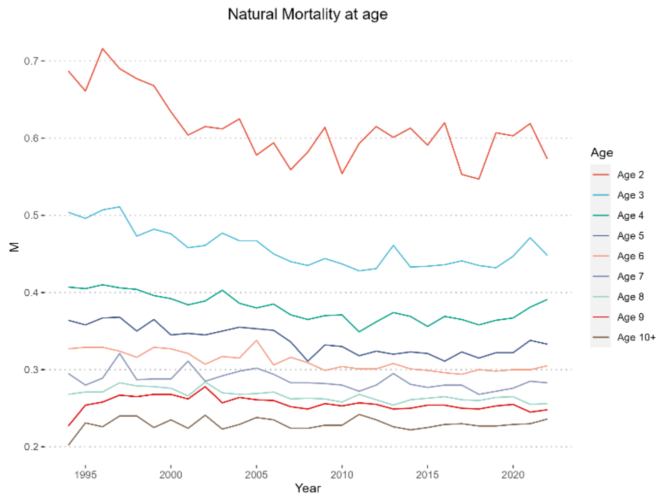


Figure 2.2.8. Northern Norwegian coastal cod. Natural mortality-at-age estimated from stock weights-at-age by the Lorenzen (1996) method.

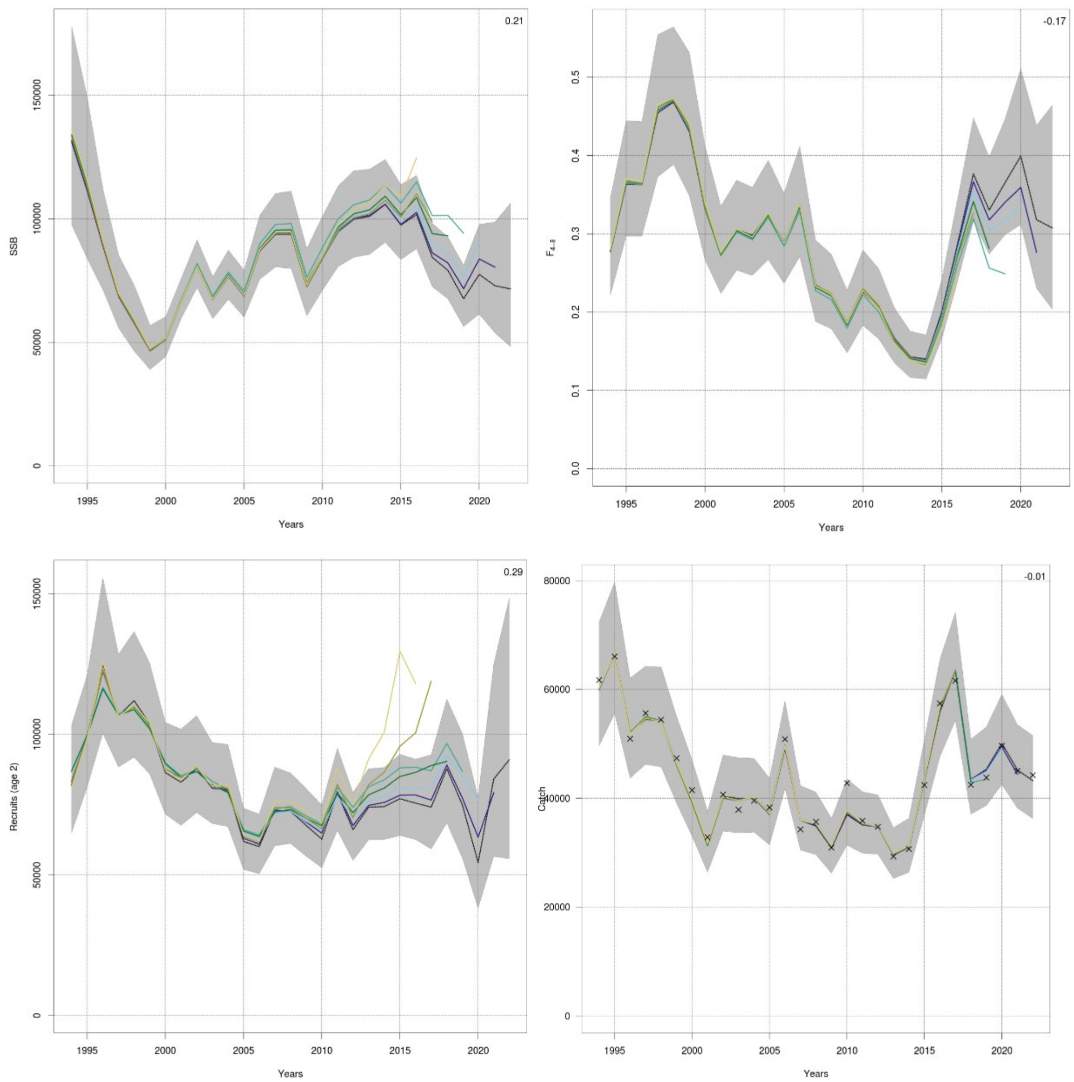


Figure 2.2.9. Northern Norwegian coastal cod. Northern Norwegian coastal cod. 5-year retrospective peel: a) SSB, b) Fbar, c) recruitment, and d) catch. The Mohn's rho value (5-year average retrospective bias) is indicated in the upper right corner of each panel.

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

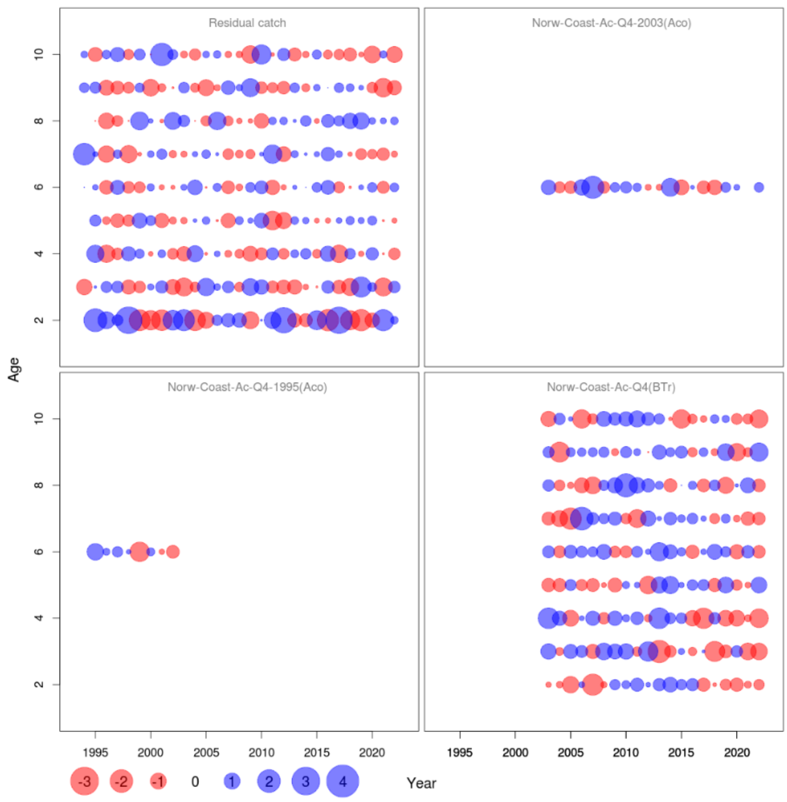


Figure 2.2.11. Northern Norwegian coastal cod. One-step-ahead residuals by fleet from the final SAM run. Blue circles indicate positive residuals and red circles indicate negative residuals. Top left: catch, top right: acoustic index pt. 2, bottom left: acoustic index pt. 1, bottom right: swept-area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

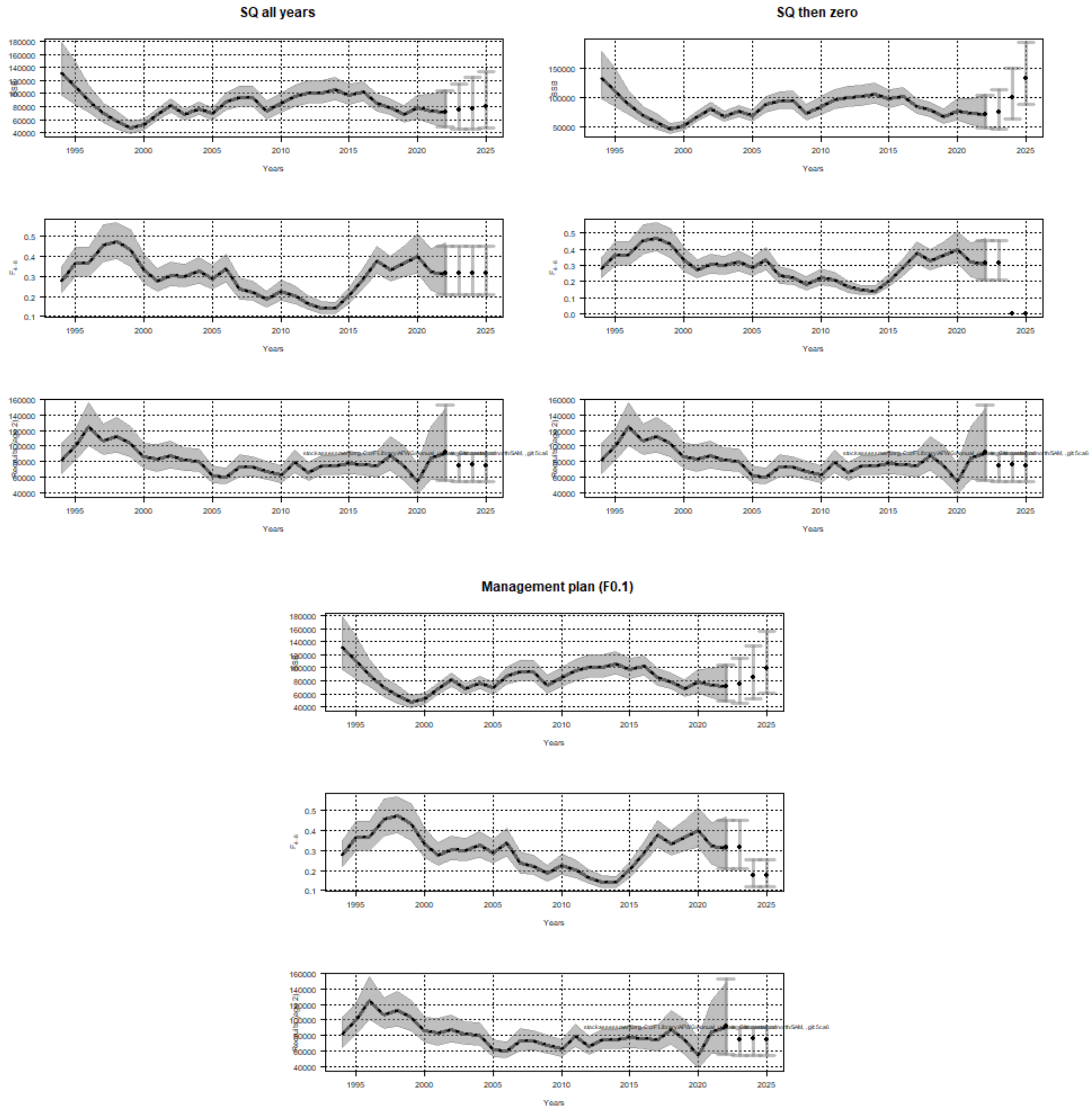


Figure 2.2.12. Northern Norwegian coastal cod. Short-term prediction. Predicted SSB (top panels), Fbar (middle panels) and recruitment (bottom panels) at status quo fishing (top left), status quo then zero fishing (top right), and fishing according to the management plan (F0.1 = 0.176). In the forecast, recruitment is the same for all scenarios (resampled from the last 10 years).

2.3 Southern Norwegian coastal cod

2.3.1 Stock status summary

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

Commercial catches have decreased since 2008 (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 2.3.9 and 2.3.10). Estimates of recreational catch are very uncertain but assumed to be on a similar scale as the commercial fishery and an increasing proportion of the overall total (Figure 2.3.1 and Table 2.3.3). A priority 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, 2020c, 2022c). 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 changes to the CPUE index reflecting changes in population abundance (Fischer *et al*., 2020). Catch advice under the "rfb" rule is given every other year because "'setting the advice more frequently does not necessarily lead to better management performance and can increase the risks of the stock falling below B_{lim}"(ICES, 2022c). Therefore, the catch advice given in 2022 for 2023 also applies for 2024 and has not been updated (Table 2.3.7).

A stochastic length-based spawning potential ratio (LBSPR) model and survey-based indices are presented as additional information. The LBSPR was previously 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, 2021a).

The LBSPR model estimates that stock size is below, and fishing pressure is above, possible MSY reference points (Figures 2.3.11 and 2.3.12). From 2010–2022, 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 20–40% with an overall downward trend. SPR in 2022 was estimated as 0.25 (95% CI: 0.19–0.29). One change to the benchmark SPR estimation method this year is that length at 50% maturity, L_{50}, was estimated using only data from the southern stock area, i.e. 62–67°N. Coastal cod grow faster and mature earlier further south, so this resulted in a decrease in L_{50} used in the SPR estimation from 62.8 cm to 57.6 cm and a perceived improvement in status, an increase in SPR of about 0.04 in all years. Still, SPR = 0.25 in 2022 means the stock is below generally accepted target values (SPR = 0.30–0.40). Thus, the SPR analysis of length data depicts a somewhat depleted and worsening stock status.

One positive sign is that the proportion of immature fish in the commercial catch has declined over the last two decades (Figure 2.1.2). In addition, managers have proposed increasing the minimum size to further reduce catch of immature coastal cod.

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, 2) combining the multiple available indices, and 3) attempting to fit SPiCT or SAM.

The catch advice for 2022 was 7613 tonnes. The advice for 2023 and 2024 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 2022 this share was 53% gillnet, 17% longline/handline, 25% Danish seine, and 2% 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. In 2022, 60% of total NCC catch between 62–67°N were estimated to come from the recreational fishery (Table 2.3.3). However, several strong assumptions are required to construct a time-series of recreational catches. For further details on the estimation of recreational catch, see WD 04 and the Stock Annex.

Discarding is known to take place. Two studies have tried 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 (Tables 2.3.2–2.3.4, Figures 2.3.1–2.3.3)

The assessment area for southern Norwegian coastal cod covers the Norwegian catch reporting areas 6 and 7 (Figure 2.0.1). Estimated commercial and recreational catches of NCC and Northeast Arctic cod (NEAC) in the stock area are shown in Table 2.1.1 and Figures 2.3.1–2.3.3.

The estimated commercial catch-at-age (2–10+) is given in Table 2.3.2 and Figure 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 catches by gear and Norwegian statistical area are 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. See WD 04 for a description of how tourist and resident recreational catch weights-at-age are estimated.

2.3.2.3 Recreational catches in 2023–2024

To split the 2023–2024 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 reports catch-per-gillnet soaking time (CPUE) from their daily catch operations (WD 07 in ICES, 2021a).

These fleets catch both NCC and NEAC, and cod type is determined based on 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.

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

To derive an index of NCC abundance in the stock area, 62–67°N, we follow these steps:

1. Estimate the proportion NCC vs. NEAC by year, quarter, and area.
2. Estimate total cod CPUE by year, quarter, and area.
3. Multiply the output from the previous two steps.

In this update assessment, we only use the models selected in the benchmark (ICES, 2021a), after confirming that model diagnostics were satisfactory (Figures 2.3.4 and 2.3.6). To calculate the CPUE index between 62–67°N we only use quarters 3–4 because at that time of year there are few NEAC caught in the area (Figure 2.3.5).

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

To determine the proportion of NCC, we use all reference fleet gillnet data 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. 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. Covariate combinations (i.e. gear x quarter x area x year) with less than three observations were removed 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:

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

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

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 2.3.4). We then predict the proportion of NCC expected in areas 6 and 7, during quarters 3 and 4, between 2007–2022 (Figure 2.3.5).

Step 2: Total cod CPUE standardization

The final lognormal GLMM selected in the benchmark was fitted to total cod CPUE data (no distinction between coastal and NEA cod) in areas 6–7 and quarters 3–4 between 2007–2022 (ICES, 2021a). As in the benchmark, data were filtered to remove gears with less than 3 observations or only used in one year. Three zero catch observations were removed. We fit the model:

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

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

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

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 2.3.6).

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

We combined 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 from the two models above to estimate the standardized coastal cod CPUE index, $I_{y,q,a}$:

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

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

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

The resulting standardized coastal cod CPUE indices for areas 6 and 7 are shown in Figure 2.3.7, 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 coastal cod CPUE index for the entire southern stock area is shown in Figure 2.3.8 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, 2021a), 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.

We re-estimated each of the life-history parameter models selected in the benchmark with data updated through 2022 (Table 2.3.1). All parameter estimates and residual diagnostics were very similar to those from the benchmark, except for maturity (Section 2.3.5.3).

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. Since coastal cod grow faster and mature earlier further south, we estimated LM_{50} and LM_{95} using only data from the southern stock area, i.e. 62–67°N instead of all data north of 62°N as in the benchmark. This resulted in a decrease in L_{50} used in the SPR estimation from 62.8 cm to 57.6 cm and a perceived improvement in status, an increase in SPR of about 0.04 in all years. 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 2022, 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 (0.004)	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	0.903 (0.007)	M/k at L_{inf}, derived from the above estimates
L_{inf}	94.1 (0.446)*	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}	57.6 (3.296)†	Length (cm) at 50% maturity. Estimated from resampled coastal survey data (1995–2022, only data in 62–67°N stock area) using a binomial glm.
LM_{95}	72.6 (6.395)†	Length (cm) at 95% maturity. Estimated from resampled coastal survey data (1995–2022, only data in 62–67°N stock area) using a binomial glm.

***randomly generated preserving the correlation structure between k and L_{inf} using a multinormal distribution.**
†pairs ($LM50$, $LM95$) estimated from the same bootstrapped dataset, 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 2.3.7). 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 2.3.8). 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 the previous assessment. CPUE in 2020–2022 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 2.3.9 and 2.3.10 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 2.3.10).

2.3.6.3 Stochastic LBSPR outputs and interpretation

SPR has fluctuated between 20 and 40% with an overall downward trend (Figure 2.3.11). 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 2022 was estimated as 0.25 (95% CI: 0.19–0.29). In all years 2010–2022, 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 2.3.12). F/M in 2022 was estimated as 2.14 (95% CI: 1.73–2.60). 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 2010–2022 (Figure 2.3.13). 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 $F_{SPR40\%}/M = 1.04$ (95% CI: 0.87–1.17), 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.

2.3.7 Additional information

2.3.7.1 Total mortality (*Z*) from catch curves

Since catch numbers-at-age data are available for this stock for a longer period (1994–2022; 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. 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 2.3.14 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.

2.3.7.2 Additional indices: coastal acoustic-trawl survey

The last benchmark considered and rejected indices calculated from the main survey covering coastal cod, the autumn coastal acoustic-trawl survey (A6335, NOcoast-Aco/BTr-Q4), due to concerns about poor and inconsistent coverage south of 67°N (WD33 in ICES, 2021a). The reference fleet CPUE index was used instead (Section 2.3.4), although the reviewers commented that it was "not entirely clear that this was justified" (ICES, 2021a). Here, we update and present two indices of aggregate (across ages 2+) biomass from the coastal survey: acoustic and trawl swept-area. Methods for estimating these indices are described for northern coastal cod in Section 2.2.3. We note that it is possible that the coastal survey data may not provide reliable abundance-at-age indices, yet still produce useable aggregate (across ages) biomass indices. This was the conclusion of Aglen *et al*. (2021), who wrote, "for subareas B and C [62–67°N], acoustic and trawl indices of biomass of age 2+ may be used in biomass models or to assess changes in stock abundance from year to year, using methods for data-poor stocks.”

The coastal survey acoustic and trawl indices are shown in Figure 2.3.15, together with the reference fleet CPUE index. There are notable differences from the reference fleet CPUE index:

1. The survey indices extend further back in time (acoustic index begins in 1995, trawl index begins in 2003, reference fleet CPUE index starts in 2007).
2. The 95% CIs are much smaller for the survey indices. The acoustic index CIs are unrealistically small.
3. The trends differ. The acoustic index starts high in the mid-1990s and declines until the 2000s, then is noisy without clear trend. The trawl index has no clear trend from 2003 to about 2015, then declines in the last ten years to a very low level in 2021–2022. The reference fleet CPUE decreases from 2007–2013 and increases 2013–2022, with high uncertainty.

2.3.7.3 Additional indices: shallow net survey

IMR established a shallow net 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 in ICES, 2023). Here we update indices-at-ages 0–5 and an aggregate (ages 2–5) biomass index from the shallow net survey data.

The shallow net survey aggregate biomass index has declined from 2013 to 2022 (Figure 2.3.15), with CV between 0.2 and 0.3 (Figure 2.3.16). The survey is conducted in north (62–65°N) and south (65–68°N) subareas in alternate years and a spatio-temporal model is used to interpolate non-sampled area-year combinations and construct indices. Since the density of coastal cod is higher in the north, the index CVs are lower in years where the northern subarea is sampled (2013, 2016, 2018, 2020, 2022; Figures 2.3.16 and 2.3.18). The shallow net 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 2.3.18). 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, except for age-2 to age-3, which was about 0.15.

2.3.7.4 Comparison of all available indices

The CPUE index has high uncertainty, with 95% CIs extending to 0 in all years (Figures 2.3.7 and 2.3.8) and CV between 0.7–0.85 (Figure 2.3.16). The trawl and shallow net index CVs are 0.2–0.4 and the CV for SPR is 0.1 (Figure 2.3.16). The correlations of the CPUE index with all other indices are small or negative, whereas the trawl index, shallow net index, and SPR are positively correlated (0.55 and 0.42; Figure 2.3.17). In contrast to the age-aggregated trawl index, the trawl index-at-age probably is too uncertain to be useful (CVs > 0.3–0.4 for most ages and years; Figure 2.3.18).

The coastal trawl and shallow net survey indices have both declined for all ages 0–5 over the period 2013–2022, with the coastal survey estimating steeper declines for all ages (Figure 2.3.19). The coastal trawl survey indices-at-age were stable or increasing for all ages in the decade before the shallow water survey was initiated, 2003–2012 (Figure 2.3.19).

Further exploration of how to produce or combine indices from the available survey data is warranted, as well as which indices are most likely to reflect changes in coastal cod abundance. The coastal 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 trawl index, shallow net index, and SPR, and the lower CV of the survey indices, indicates that they may be more appropriate than the reference fleet CPUE for assessing southern coastal cod.

2.3.8 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 trawl index, and shallow net 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.

2.3.9 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.

2.3.10 Catch scenarios for 2023 and 2024

The ICES Guidance for completing single-stock advice for category 3 stocks was applied (ICES, 2020c, 2022c). Catch advice under the "rfb" rule is given every other year, so the catch advice given in 2022 for 2023 also applies for 2024 and has not been updated. The catch advice for 2023 and 2024 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.

2.3.11 Management considerations

Applying the official ICES Guidance for catch advice resulted in an increase of 20% for 2023 and 2024 relative to 2022. 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 2.3.8). 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 2.3.7).
- The LBSPR results indicate fairly poor status: SPR = 0.25 (95% CI: 0.19–0.29) and F/M = 2.14 (95% CI: 1.73–2.60; Figures 2.3.11 and 2.3.12).
- Length-based indicators in the reference fleet data have declined over the past decade (Figure 2.3.13). Mean length decreased from ca. 70 to 60 cm from 2010 to 2020 but has increased back to 70 cm in 2022. $L_{max5\%}$ (mean length of the largest 5% of individuals) has slightly declined.

- The minimum legal size (44 cm) is well below the length at 50% maturity (55.8 cm using all data, 57.6 cm using only coastal survey data). Although most of the catch is taken by gillnet and is above the length at 50% maturity, there is opportunity to reduce catch of immature coastal cod by Danish seine and longline gear (Figures 2.1.1 and 2.1.2).
- Commercial catches have decreased over the last 15 years while effort has probably remained stable or increased since 2013 (Figures 2.3.1, 2.3.9, and 2.3.10).
- SPR and abundance indices from the coastal trawl survey and shallow net survey have all decreased from 2013–2022, in contrast to the CPUE index (Figure 2.3.15).

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. In addition to total recreational catch, ICES needs estimates of recreational catch numbers- and weight- at age (i.e. at least representative length distributions, and ideally, proportions-at-age) to develop an age-based assessment. Otoliths and/or genetic samples are needed to separate NCC from NEAC catches.

2.3.12 Management plan

Following the splitting of NCC into two stocks at 67°N (ICES, 2021a), a new management plan for northern NCC (cod.27.1-2coastN) was recently evaluated as precautionary by ICES and adopted for management (ICES, 2022). However, there is still no management plan for southern NCC. Since NCC cannot be visually distinguished from NEAC, a direct TAC cannot be established and both coastal cod stocks are managed by technical regulatory measures, i.e. restrictions on gear, area, season, and minimum size. These actions have not led to significantly reduced fishing mortality.

For southern NCC, stock status remains unknown, although SPR is estimated below common targets (Figure 2.3.11). Efforts to improve data collection (especially of the recreational fishery), reassess how to model existing survey and reference fleet data, and develop an age-based or production stock assessment model are needed to determine reference points and stock status. In the meantime, managers should continue to develop measures to reduce fishing pressure on coastal cod. Given the difficulties of estimating catch and controlling fishing pressure with a TAC, two measures are particularly worth considering: (1) protecting known spawning grounds, (2) increasing the minimum size limit above the size of maturity. In addition, there is a complex structure of substocks within this stock unit (ICES, 2022a) and management measures are needed to avoid local depletion and maintain diversity, e.g. of potential local substocks in inner fjord areas.

2.3.13 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 2012–2021 the advice was to follow the rebuilding plan.

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

2.3.14 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
2022	0	92	234	179	137	52	23	18	9	2827

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

	Age									Tonnes	Hereof
	2	3	4	5	6	7	8	9	10+	landed	rec. (t)
2016	2	151	448	566	371	360	218	120	150	10762	4800
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
2022	9	272	565	447	376	140	67	45	29	7075	4248

Table 2.3.4. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Commercial catch in 2022 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	752	757	1509	53.4
Longline/Handline	243	229	472	16.7
Danish seine	0	698	698	24.7
Trawl	12	37	49	1.7
Others	0	99	99	3.5
Total	1007	1820	2827	

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 commercial 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

CWT	2	3	4	5	6	7	8	9	10+
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
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
2022	1.086	1.94	2.811	3.717	4.677	5.723	6.962	7.945	9.237

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 (quarters 3–4, gillnet only). 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	0.39	0.38	0	1.13
2008	0.40	0.29	0	0.96
2009	0.28	0.19	0	0.65
2010	0.18	0.12	0	0.42
2011	0.28	0.21	0	0.69
2012	0.34	0.34	0	1.02
2013	0.07	0.05	0	0.16

Year	CPUE index	SE	CI low (2.5%)	CI high (97.5%)
2014	0.15	0.10	0	0.35
2015	0.34	0.25	0	0.83
2016	0.40	0.29	0	0.96
2017	0.52	0.50	0	1.49
2018	0.21	0.17	0	0.55
2019	0.24	0.20	0	0.63
2020	0.41	0.33	0	1.06
2021	0.32	0.27	0	0.84
2022	0.47	0.40	0	1.26

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}×1.4)	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

Quantity	Value
Catch advice for 2023 and 2024	**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 and 2024 relative to the advice value for 2022.

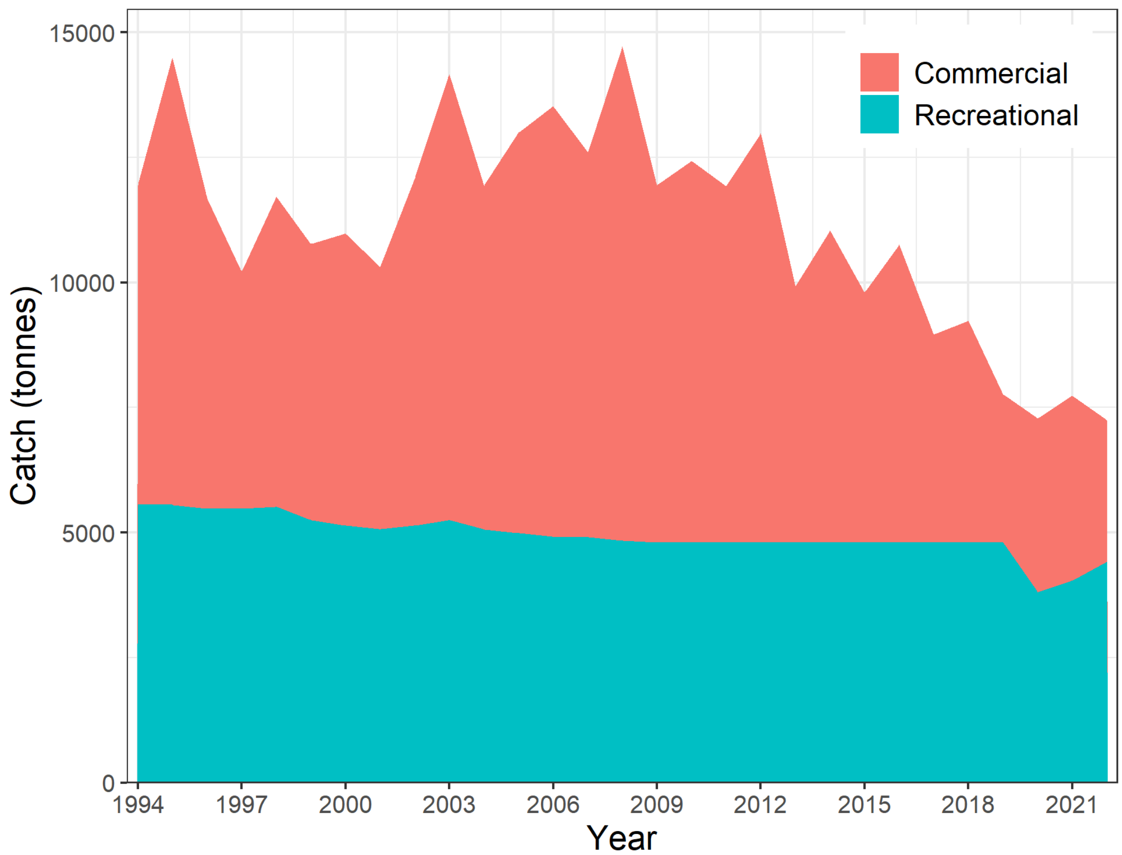


Figure 2.3.1. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Commercial landings and recreational catches. Recreational catches are fixed from 2009–2019 at 4800 tonnes and then reduced from 2020–2021 due to COVID-19 impacts on tourist fishing.

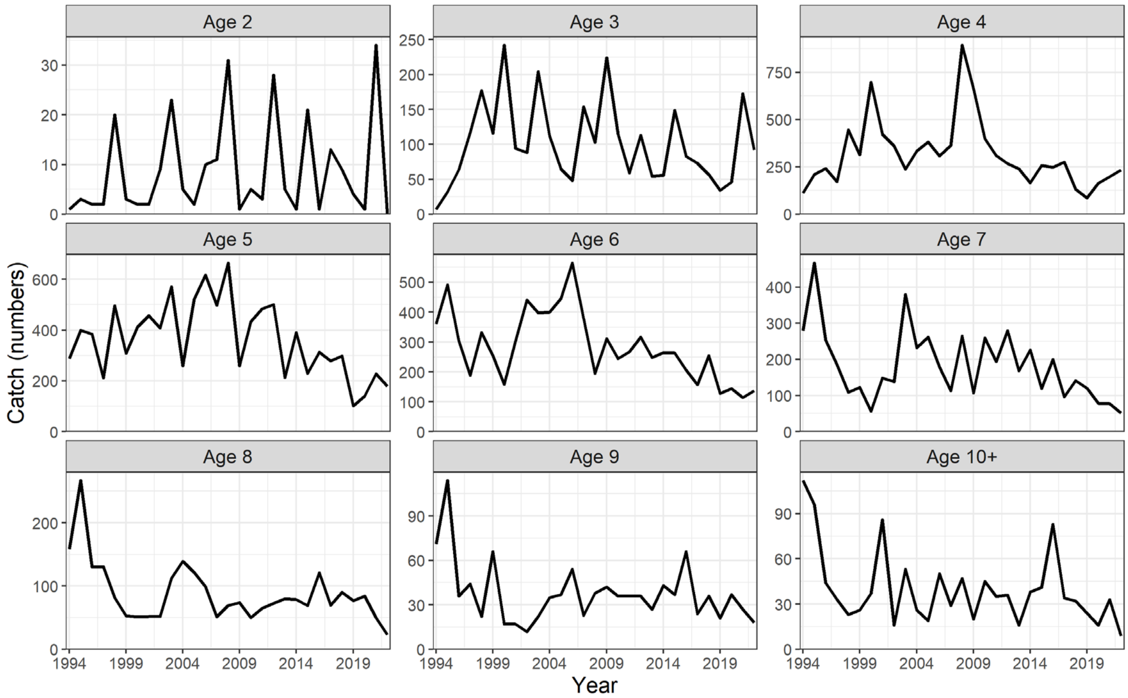


Figure 2.3.2. Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N, Southern Norwegian coastal cod. Commercial landings in numbers-at-age.

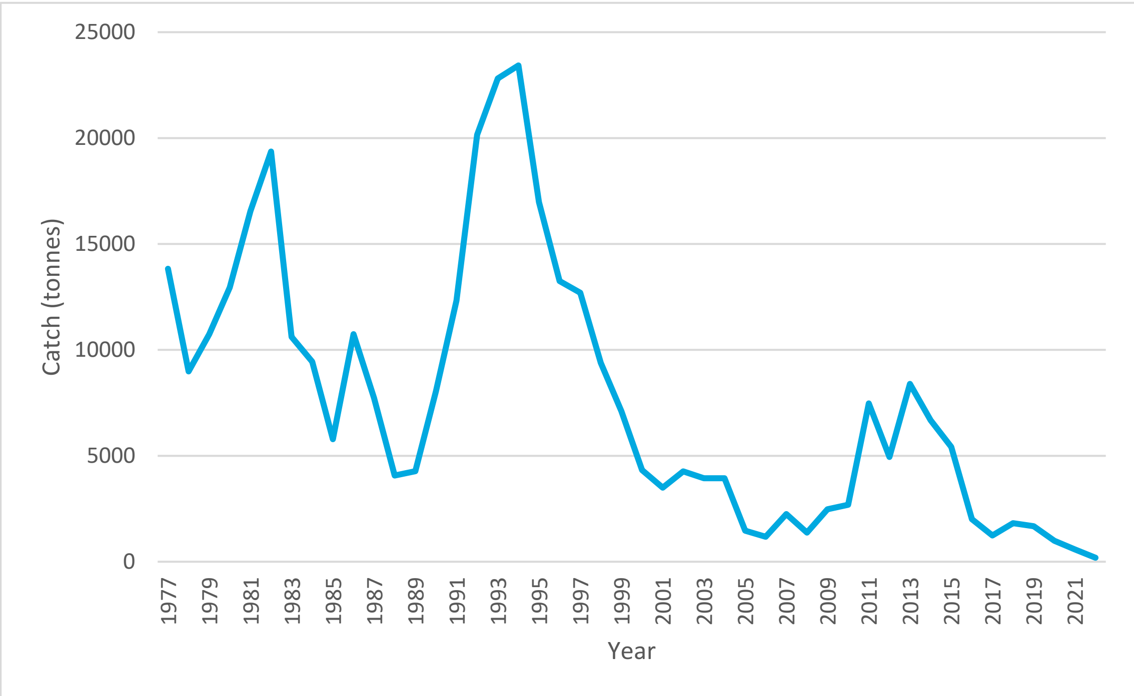


Figure 2.3.3. Estimated commercial landings of Northeast Arctic cod (NEAC, *Gadus morhua*) in Subarea 2 between 62°N and 67°N. NEAC catch in 2022 was the lowest observed, 188 t.

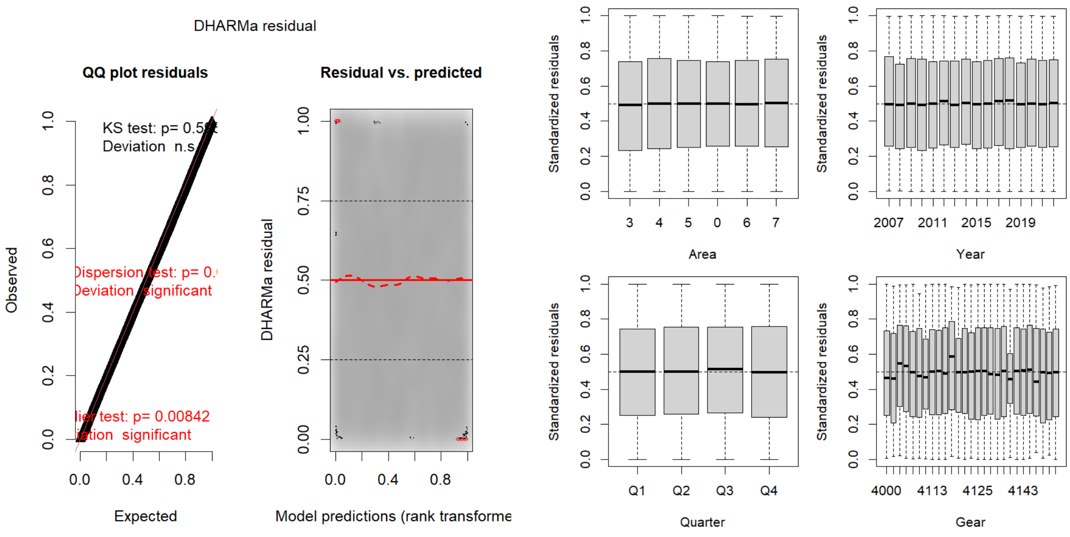


Figure 2.3.4. Residual diagnostic plots for the final binomial model to differentiate coastal cod vs. NEAC. The panel on the left is a standard output from the residual diagnostics using the R package DHARMa. The panel on the right plots the model standardized residuals against available covariates. Both panels indicate no significant issues with the final model.

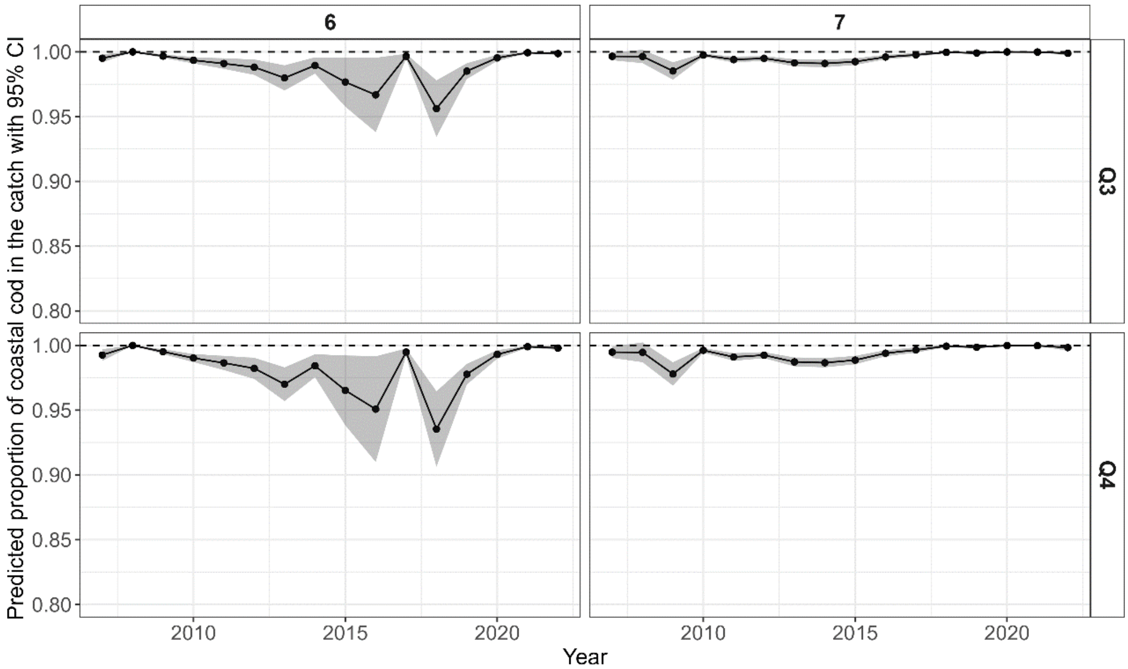


Figure 2.3.5. Predicted probability of cod being classified as coastal instead of Northeast Arctic, based on the quarter (vertical panels), area (horizontal panels), and year (x-axis within each panel). The grey shaded polygon represents the 95% confidence interval.

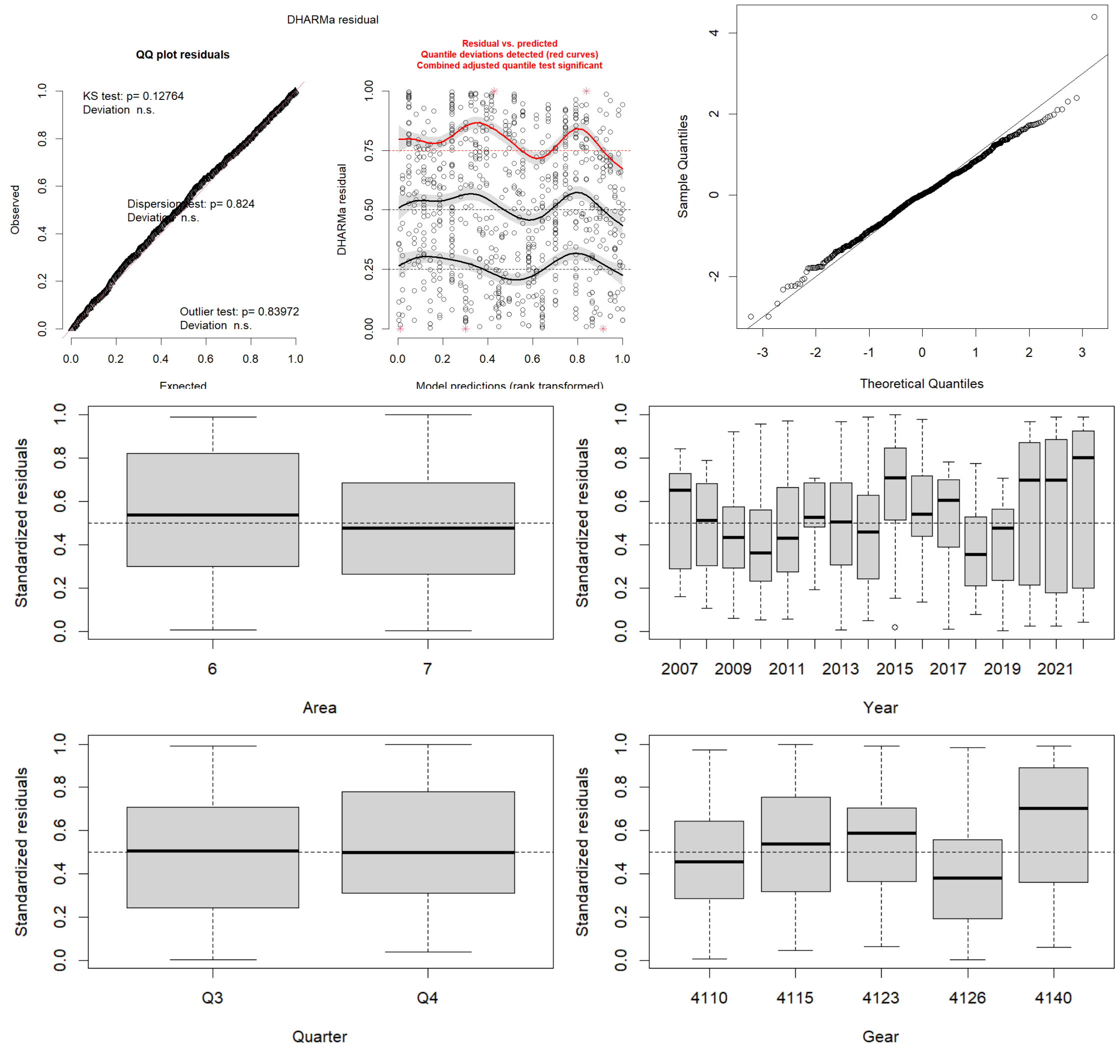


Figure 2.3.6. Residual diagnostic plots for the final CPUE model fitted to cod data in area 6 and 7, and quarters 3 and 4. Top panel left: standard output from the residual diagnostics using the R package DHARMa. Top panel right: normal QQ-plot. Bottom panel: model standardized residuals vs. available covariates. All panels indicate no significant (though some) issues with the final model.

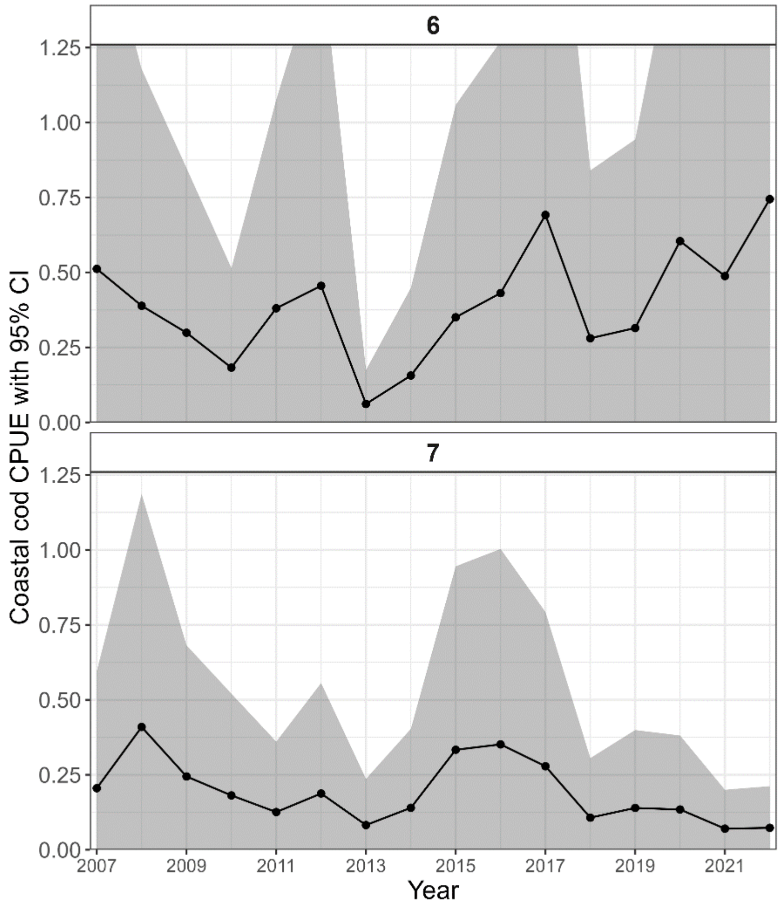


Figure 2.3.7. Standardized reference fleet CPUE (kg per gillnet per day) index for coastal cod in areas 6 and 7 during quarters 3 and 4. The grey shaded polygon represents the 95% confidence interval (calculated using the approximation: mean +/- 1.96 SE).

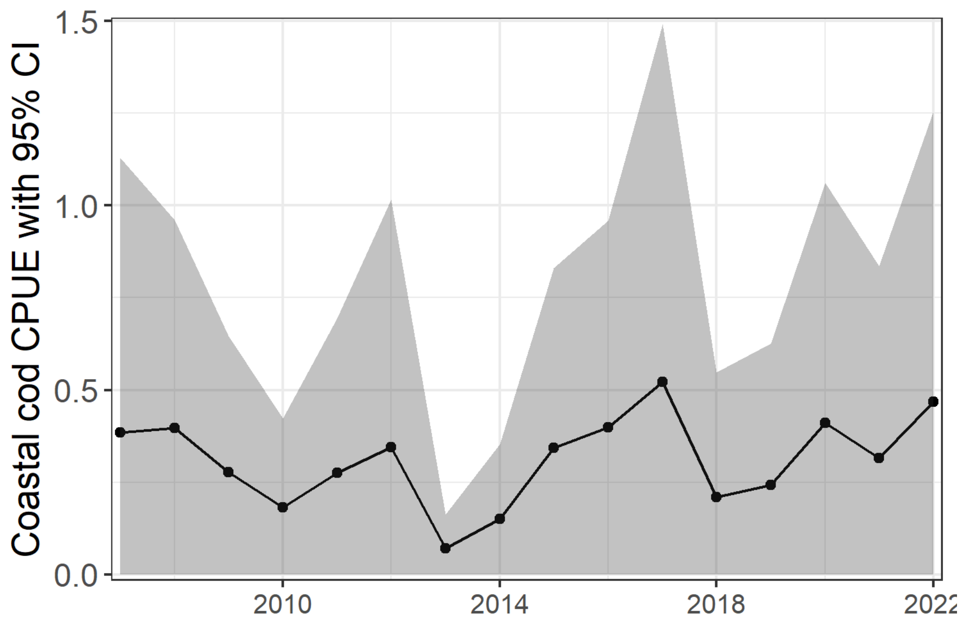


Figure 2.3.8. Composite reference fleet CPUE (kg cod per gillnet per day) index for southern Norwegian coastal cod, areas 6 and 7 combined. 95% confidence intervals are calculated using the approximation: mean +/- 1.96 SE.

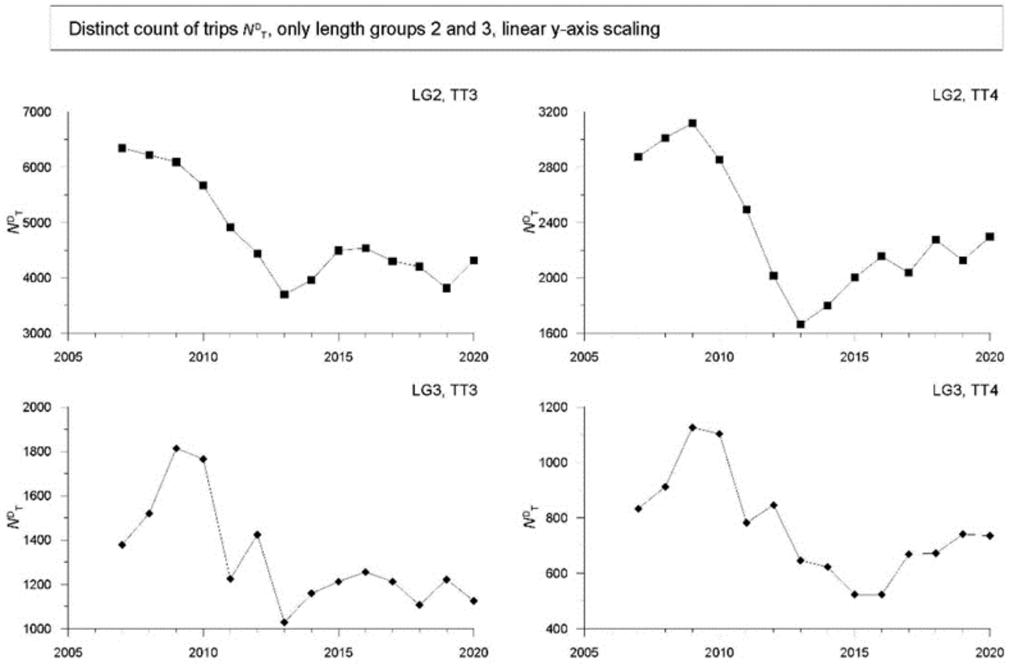


Figure 2.3.9. Full commercial fleet fishing effort presented as the number of sales note trips for two boat sizes, LG2 = <11 m and LG3 = 11–14.99 m, for areas 62–67°°N in the second half of the year. Left panel: all gears; right panel: gillnet only. Note different y-axes.

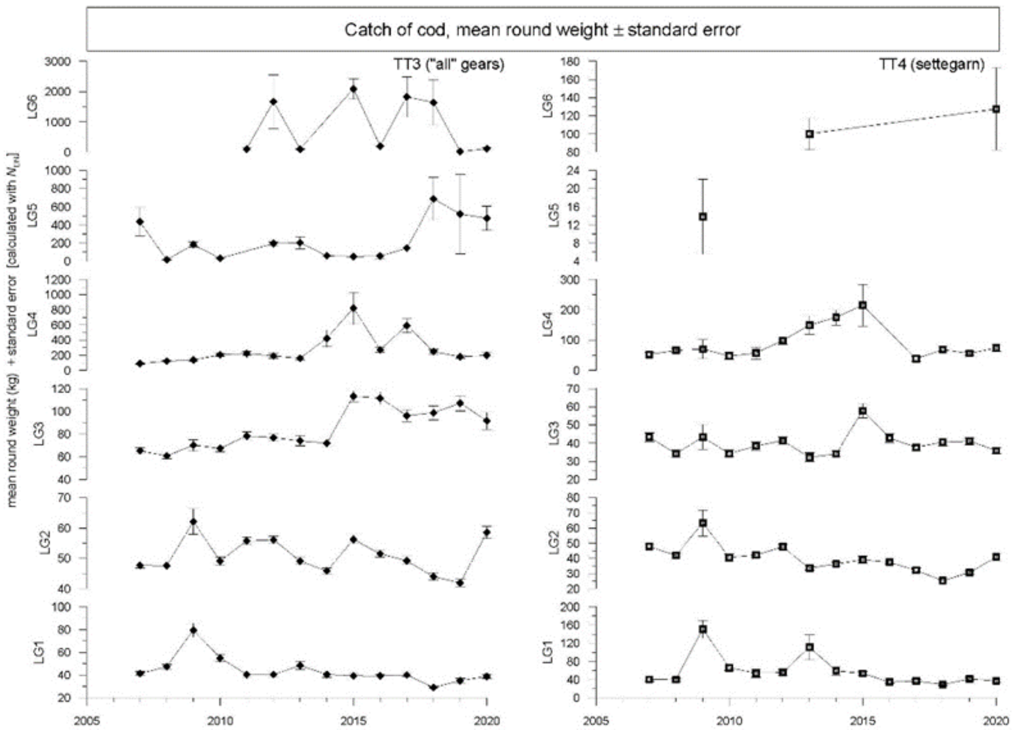


Figure 2.3.10. Full commercial fleet CPUE (kg cod per sales note trip) per boat size (LG1-LG6) for area 62–67°N in the second half of the year. Left panel: all gears; right panel: gillnet only.

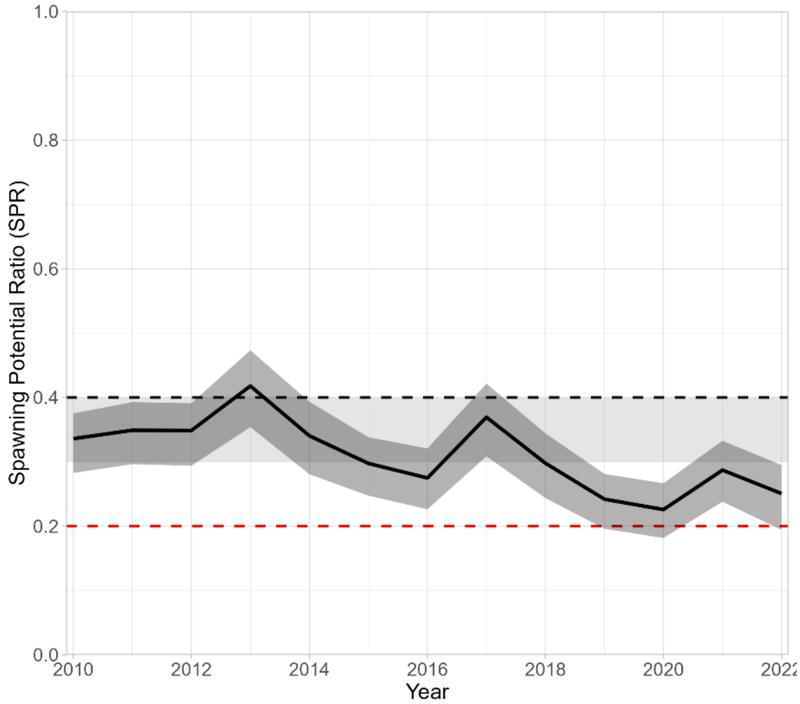


Figure 2.3.11. Spawning potential ratio (SPR) per year estimated by the length based spawning potential ratio (LBSPR) model. Mean (black line) and confidence intervals (dark shaded area, 95% interquartile range [IQR]), based on the stochastic LBSPR. The light shaded area delimits the $SPR_{30\%-40\%}$ zone (common targets) and the red dashed horizontal line the $SPR_{20\%}$ limit reference point.

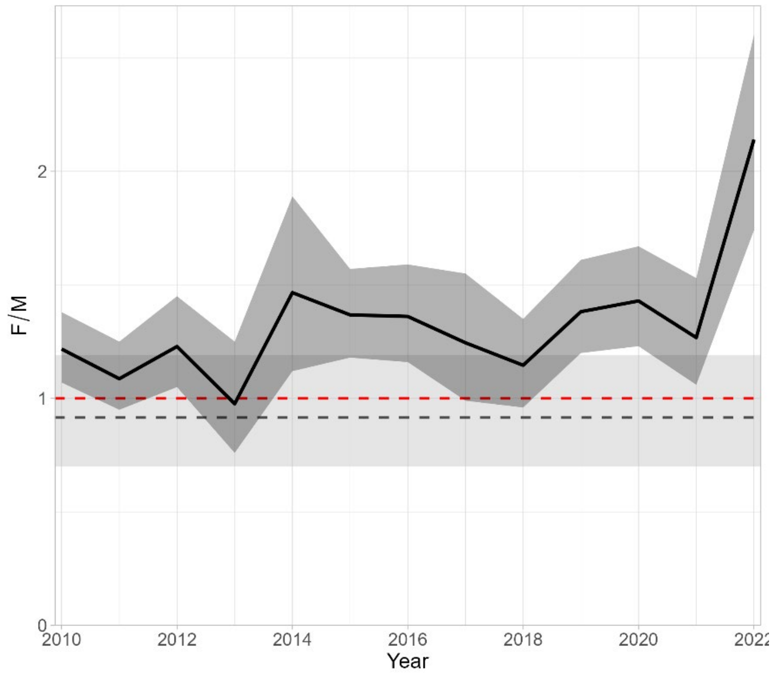


Figure 2.3.12. Estimated fishing mortality relative to natural mortality (F/M) per year estimated by the length based spawning potential ratio (LBSPR) model. Mean (black line) and confidence intervals (dark shaded area, 95% IQR), based on the stochastic LBSPR. Red dashed line indicates F/M = 1, and grey dashed line indicates $F_{40\%SPR}/M$ (with 95% IQR, light shaded area), common target reference points.

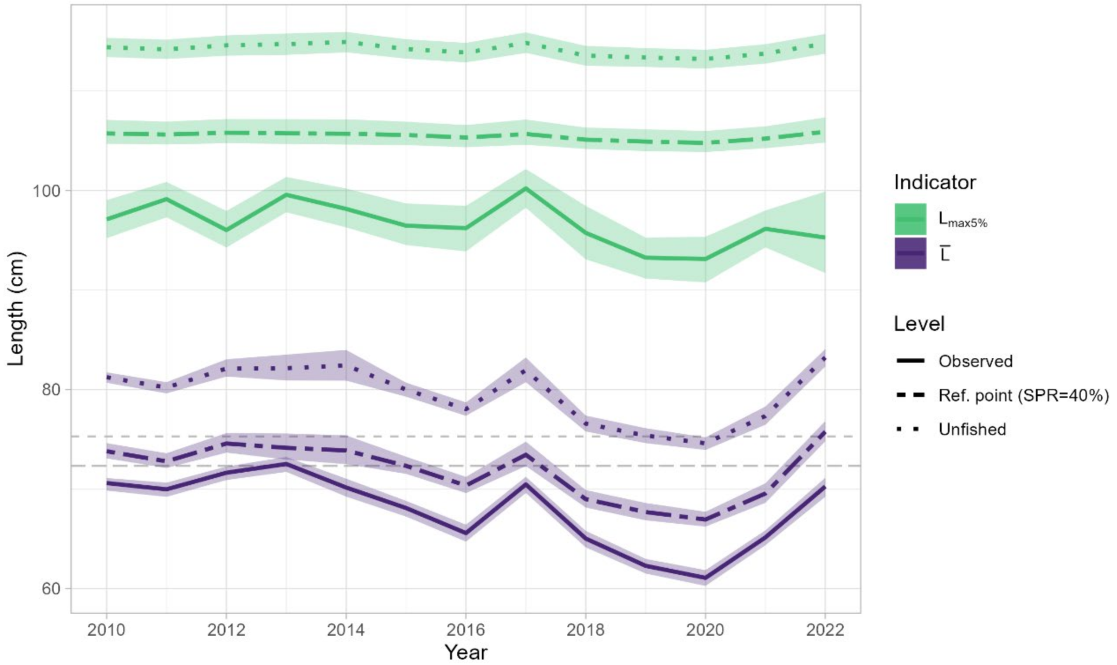


Figure 2.3.13. Length-based indicators $L_{max5\%}$ and mean catch length ($\bar{L}$) in relation to their reference points (mean and 95%CI). The reference points were estimated using the LBSPR simulation model together with the stochastic parameters detailed in Table 2.3.1 (mortality scenario following Lorenzen, 1996) and SPRs of 40% and 100% (unfished).

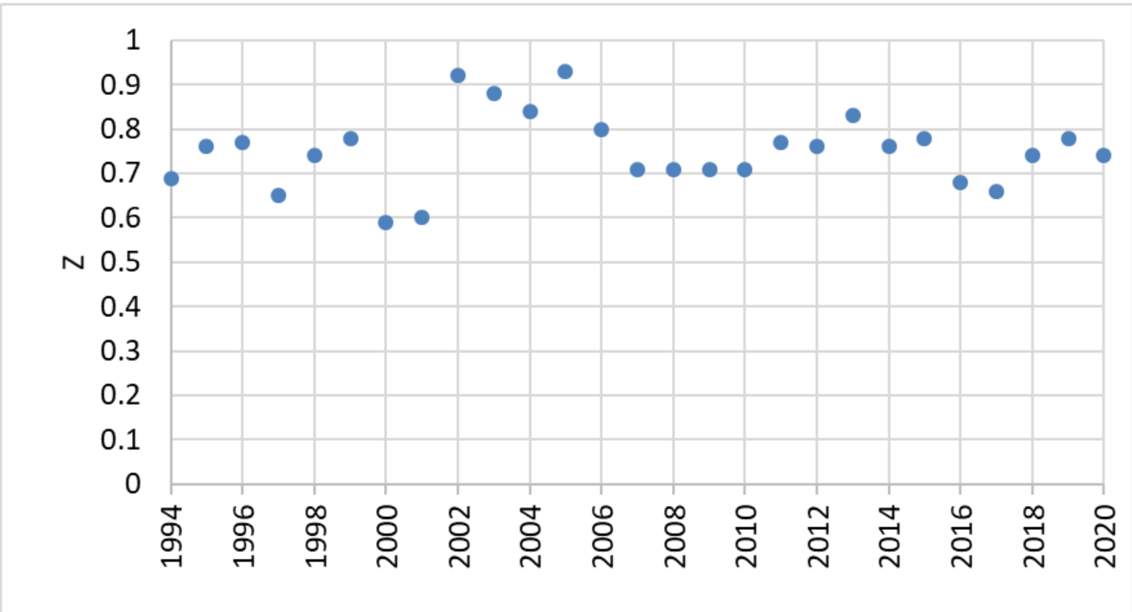


Figure 2.3.14. Total mortality (Z) estimated from catch curves (average over ages 5–14 in commercial and recreational catches) 1994–2020.

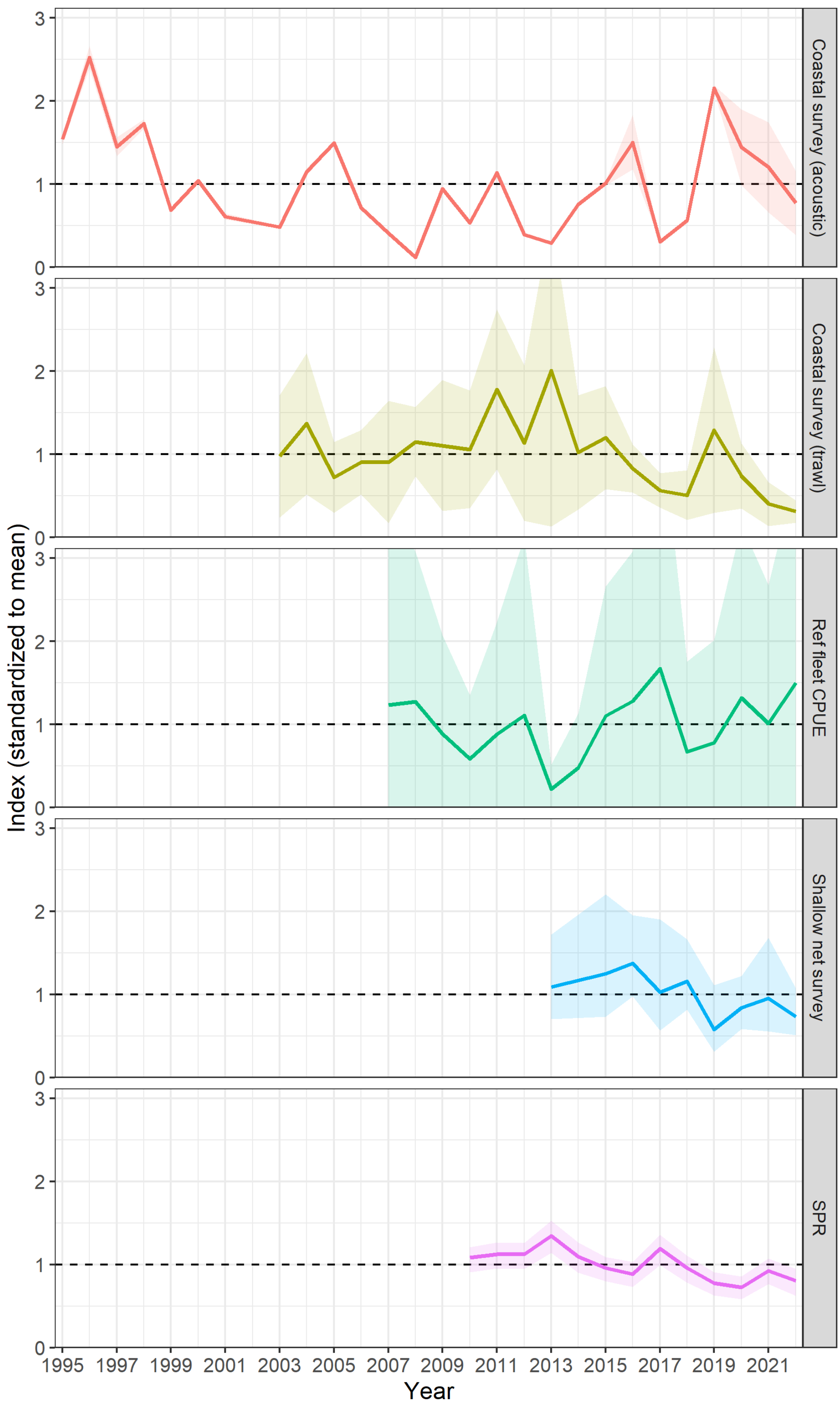


Figure 2.3.15. Reference fleet CPUE index (panel 3, green) in relation to other available indices: coastal survey acoustic biomass (panel 1, red), coastal survey trawl swept-area (panel 2, olive), shallow net survey biomass (panel 4, blue) and spawning potential ratio (SPR, panel 5, pink). All indices are mean-standardized. Shading depicts 95% confidence intervals.

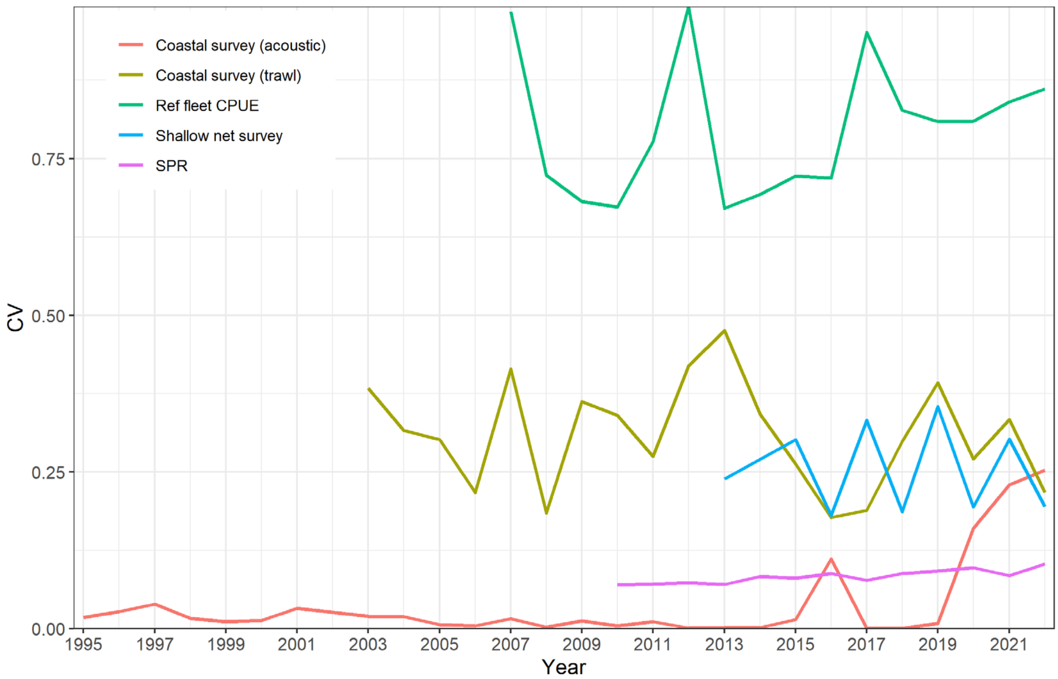


Figure 2.3.16. Coefficient of variation (CV) of the reference fleet CPUE index compared to other available indices.

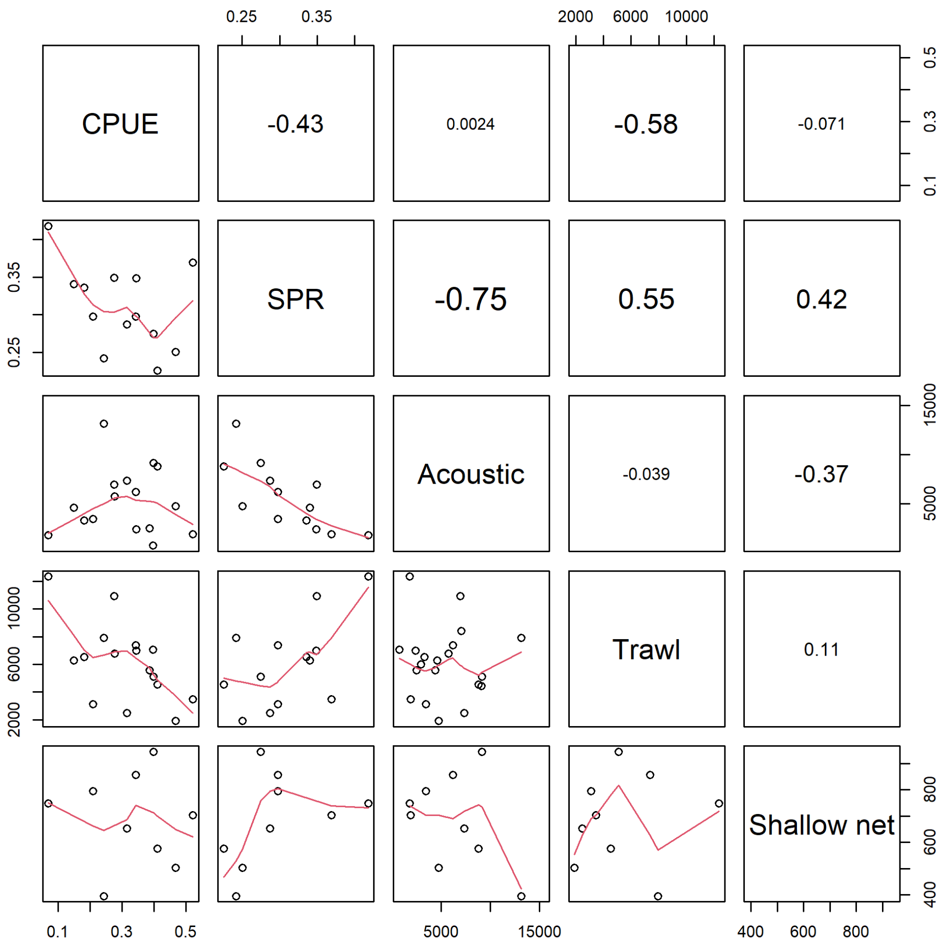


Figure 2.3.17. Correlation between the reference fleet CPUE and other available indices. SPR = spawning potential ratio, Acoustic = coastal survey acoustic biomass age 2+, Trawl = coastal survey trawl swept-area biomass age 2+, Shallow net = shallow net survey biomass ages 2–5.

Figure 2.3.18. Coefficient of variation (CV) for additional survey indices-at-age, by year. Green: coastal survey swept-area (trawl). Orange: shallow net (garn ruse) survey, split into north (dotted lines) and south (dashed lines) subareas. Black dashed horizontal line indicates CV = 0.3, a commonly used upper threshold for considering indices to be informative on stock trends.

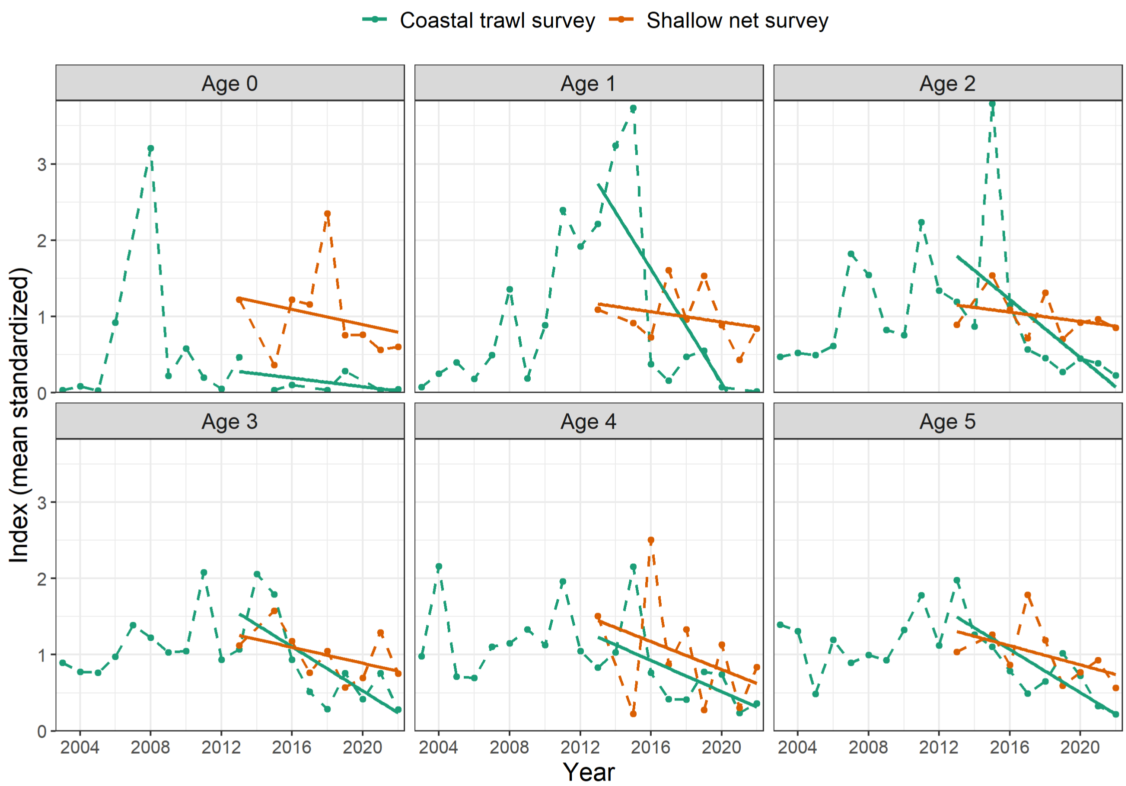


Figure 2.3.19. Southern Norwegian coastal cod indices-at-age from two available surveys, standardized to their means. Green: coastal survey swept-area (trawl). Orange: shallow net (garn ruse) survey. Lines are linear model fits from 2013–2022.

3 Northeast Arctic cod

cod.27.1-2 – *Gadus morhua* in subareas 1 and 2

On 30 March 2022, all Russian participation in ICES was suspended. Owing to this temporary suspension, it is not currently possible to run an ICES assessment for NEA cod. It is however critical for good ecosystem and fisheries management that such assessments be run and be used as the basis of management. An assessment for this stock has therefore been conducted in 2022 outside ICES by a bilateral Russian-Norwegian group, the "Joint Russian-Norwegian Arctic Fisheries Working Group" (JRN-AFWG). The assessments occur outside ICES but follow the stock annexes previously agreed within ICES, use the same data and models as previously, and are conducted by the same Russian and Norwegian scientists that were involved in the previous ICES assessments. The managing body in the Barents Sea (the Joint Norwegian Russian Fisheries Commission; JNRFC) has used the advice as the basis of management, following the same procedures previously used for ICES advice. JNRFC also endorsed this approach to be continued for the 2023 advice (52nd session[1], Appendix 10).

The report of the JRN-AFWG assessment and the associated advice sheets also follow closely the previous ICES reporting format and are published online by the Norwegian Institute of Marine Research. For NEA cod the relevant information for 2023 can be found at:

2023 report:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-7

Advice on fishing opportunities in 2024:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-5

[1] https://www.jointfish.com/OM-FISKERIKOMMISJONEN/PROTOKOLLER.html

4 Northeast Arctic haddock

had.27.1-2 –*Melanogrammus aeglefinus* in subareas 1 and 2

On 30 March 2022, all Russian participation in ICES was suspended. Owing to this temporary suspension, it is not currently possible to run an ICES assessment for NEA cod. It is however critical for good ecosystem and fisheries management that such assessments be run and be used as the basis of management. An assessment for this stock has therefore been conducted in 2022 outside ICES by a bilateral Russian-Norwegian group, the "Joint Russian-Norwegian Arctic Fisheries Working Group" (JRN-AFWG). The assessments occur outside ICES but follow the stock annexes previously agreed within ICES, use the same data and models as previously, and are conducted by the same Russian and Norwegian scientists that were involved in the previous ICES assessments. The managing body in the Barents Sea (the Joint Norwegian Russian Fisheries Commission; JNRFC) has used the advice as the basis of management, following the same procedures previously used for ICES advice. JNRFC also endorsed this approach to be continued for the 2023 advice (52nd session[1], Appendix 10).

The report of the JRN-AFWG assessment and the associated advice sheets also follow closely the previous ICES reporting format and are published online by the Norwegian Institute of Marine Research. For NEA haddock the relevant information for 2023 can be found at:

2023 report:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-7

Advice on fishing opportunities in 2024:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-4

[1] https://www.jointfish.com/OM-FISKERIKOMMISJONEN/PROTOKOLLER.html

5 Northeast Arctic saithe

pok.27.1-2 – *Pollachius virens* in subareas 1 and 2

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 2021 landings were 188 176 t and assumed to be 205 672 t in 2022. Official Russian landings were not available at the time of the working group meeting, and the landing figure of 11 506 t for 2022, available from Norwegian parliamentary announcement 11 (Mel. St. 11) was used in the assessment. Russian landings of 70 t in the Svalbard Fisheries Protection Zone were not included.

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 2022 and 2023

- The advice from ICES for 2022 was as follows: ICES advised that catches in 2022 should be no more than 197 212 t.
- The advice from ICES for 2023 was as follows: ICES advised that catches in 2023 should be no more than 226 794 t.

5.1.2 Management applicable in 2022 and 2023

Management of saithe in subareas 1 and 2 is by TAC and technical measures. For 2022, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 197 212 t.

For 2023, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 226 794 t.

5.1.3 The fishery in 2022 and expected landings in 2023

Provisional figures show that the landings in 2022 were assumed to be 205 672 t, which is 8460 t higher than the TAC of 197 212 t.

Since the WG does not have any prognosis of total landings in 2023 available, the TAC of 226 794 t is used in the projections.

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 2022 (Staby *et al.*, in press) decreased by 18% compared to 2021 and was similar to the average for 2003–2021. The abundance estimated with StoX de-creased with 8% compared to 2021, which is the result of a decrease in estimates of 3 and 5-year-old saithe (respectively 29% and 53% lower than in 2021). Estimates 4-, 6- and 10+year old saithe were higher than the 2021 estimates. The proportion of saithe in the south-ern part of the survey area (south of the Lofoten islands between 620—67°N) increased from about 20% in 1997 to above 60% in 2008, decreased in later years and to approximately 20% until 2021, but increased sharply to above 40% in 2022 due to high abundances of 3 and 4 year old saithe in the most southern survey strata.

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 2022 were updated based on the official total catch (preliminary) reported to ICES or to Norwegian authorities.

Age composition data for 2022 were available for Norwegian and German landings. Despite lacking coverage of catches by the purse-seine fishery in some areas, the biological sampling of all remaining gear groups, areas, and quarters was sufficient to produce a reliable catch-at-age matrix for 2022. Unlike in previous years age data from the Danish seine was not combined with biological samples from the bottom-trawl fishery data.

Catch-at-age estimates (numbers and mean weight and length-at-age) for the Norwegian catches were produced with StoX- Reca (version 3.7.0–9001) for the 2022 assessment[1]. Comparative runs with the older ECA program for the 2021 data produced near identical catch-at-age numbers. 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. Total catch-at-age and average weight-at-age was calculated separately in excel, using catch-at-age proportions from the Norwegian bottom-trawl fishery to split Russian and non-Norwegian catches by age.

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 2021, estimated weight-at-age for age groups 3–12+ differed only slightly in 2022, with a slight increase in weights for 3-year-old saithe.

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.

[1] https://github.com/StoXProject/RstoxFDA/

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 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 2002–2022, 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 2023 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 2021 was 0.186 (AFWG 2022), which is lower than 0.193 from this year's assessment and below the F_{pa} of 0.35. The fishing mortality (F_{4-7}) in 2022 was estimated at 0.2. 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 5.6. Based on the 2022 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 2022 was estimated at > 1 163 597 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)

The estimated numbers of age group 3 have varied considerably during the period 2004–2022 (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 161 475 thousand was used in 2023 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 2020–2022 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 (2020–2022) 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 2023 (short-term predictions; Tables 5.13–14)

The management option table (Table 5.13) shows that the expected landings of 226 794 t in 2023 will result in a fishing an adjusted mortality F_{bar} of 0.242, which is higher compared to 2022 of 0.207, but well below the F_{pa} of 0.35. A catch in 2024 corresponding to the $F_{status\ quo}$ level of 0.242 will be 203 835 t, while a catch in 2024 corresponding to the evaluated and implemented HCR of 223 123 t will result in F of 0.269 (Table 5.14).

For a catch in 2023 corresponding to the TAC of 226 794 t, the SSB is expected to decrease from about 727 666 t at the beginning of 2023 to 686 937 t at the beginning of 2024. At $F_{status\ quo}$ in 2023 SSB is estimated to decrease to 55 327 t at the beginning of 2025 and for a catch corresponding to the HCR it will decrease to about 557 261 t in 2025.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2023 to be 5% higher and the SSB 1% lower compared to the previous assessment. The F in 2021 from the current assessment is higher than the F from the previous assessment, and the realized F in 2022 is lower compared to the predicted one in 2022 based on the TAC.

	Total stock (3+) by 1 January 2022 (tonnes)	SSB by 1 January 2022 (tonnes)	F4–7 in 2022	F4–7 in 2021
WG 2022	1103920	748913	0.207	0.186
WG 2023	1163597	741480	0.2	0.193

5.8 Comments to the assessment and the forecast (Fig. 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 2022 biological sampling from the saithe purse-seine fishery catches in Norwegian waters was adequate, but lacked sampling in some areas in quarter 2

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
1975	28	3156	28517	41260		122598	3860	6430	13389	11397	2763	55	233453

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
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
1993	31	566	78	3687	3	140604		1	9509	4[2]	415	5	154903

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
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
2011	306	504.2	445	1371	66	143314	0	45.34	10007	2	972	15.14	157048

Year	Faroe Islands	France	Germany (Dem Rep)	Germany (Fed Rep)	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others[5]	Total: all countries
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
2022	570	764	425	485	318	191 305		104	11 506	25	32	138	205673

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

Year	Purse-seine	Trawl	Gillnet	Others	Total
2005	42.1	91.8	25.6	19.1	178.6
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
2022	41.8	88.5	31.5	43.9	205.7

[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

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1965	42578	5737	30171	11635	3282	2421	3135	802	1136	2986
1966	25127	61199	14727	14475	5220	1542	1047	1083	530	2724
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

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1993	22812	61931	31102	3747	1759	1378	1027	797	76	71
1994	7063	32671	49410	19058	2058	724	421	278	528	129
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

Year	Age groups 3	4	5	6	7	8	9	10	11	12+
2021	5732	7938	26311	12418	11357	12295	3544	1580	954	1939
2022	10717	14040	13340	32216	12655	6452	5394	1289	506	1859

Table 5.4 Catch weight-at-age (kg) northeast Arctic saithe.

Year	Age groups 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

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
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
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

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
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
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
2022	0.92	1.30	1.70	2.05	2.51	3.03	3.42	3.96	4.32	6.00

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

Year	3	4	5	6	7	8	9	10	11	12+
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
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
2022	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)
1994 2001
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)
2002 2022
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
1            46.35        48.26        25.73        22.21        7.06
```

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) "NEAsaithe_2023_v3".
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	0.872	0.593	1.281
2	2	4	1.174	0.8	1.721
3	2	5	0.608	0.414	0.892
4	2	6	0.375	0.279	0.505
5	2	7	0.375	0.279	0.505
6	3	3	0.566	0.467	0.687
7	3	4	0.483	0.398	0.585
8	3	5	0.289	0.238	0.351
9	3	6	0.188	0.158	0.223
10	3	7	0.188	0.158	0.223

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	0.279	0.222	0.163	0.163	0.163	0.163	0.163
1961	0.222	0.260	0.273	0.227	0.174	0.126	0.126	0.126	0.126	0.126
1962	0.222	0.261	0.267	0.226	0.177	0.132	0.132	0.132	0.132	0.132
1963	0.224	0.273	0.281	0.238	0.194	0.153	0.153	0.153	0.153	0.153
1964	0.237	0.297	0.318	0.277	0.240	0.207	0.207	0.207	0.207	0.207
1965	0.233	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	0.260	0.310	0.319	0.264	0.224	0.217	0.217	0.217	0.217	0.217
1968	0.222	0.241	0.230	0.185	0.152	0.147	0.147	0.147	0.147	0.147
1969	0.232	0.242	0.222	0.175	0.143	0.131	0.131	0.131	0.131	0.131
1970	0.329	0.362	0.341	0.284	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	0.383	0.391	0.351	0.283	0.259	0.244	0.244	0.244	0.244	0.244
1973	0.422	0.428	0.386	0.317	0.299	0.284	0.284	0.284	0.284	0.284
1974	0.544	0.560	0.513	0.429	0.417	0.395	0.395	0.395	0.395	0.395
1975	0.598	0.619	0.566	0.477	0.489	0.479	0.479	0.479	0.479	0.479
1976	0.653	0.682	0.611	0.498	0.496	0.471	0.471	0.471	0.471	0.471
1977	0.580	0.615	0.541	0.430	0.417	0.378	0.378	0.378	0.378	0.378
1978	0.575	0.651	0.596	0.487	0.476	0.432	0.432	0.432	0.432	0.432
1979	0.555	0.676	0.639	0.528	0.509	0.454	0.454	0.454	0.454	0.454
1980	0.494	0.637	0.620	0.519	0.481	0.422	0.422	0.422	0.422	0.422
1981	0.457	0.629	0.623	0.522	0.460	0.392	0.392	0.392	0.392	0.392
1982	0.422	0.621	0.625	0.527	0.448	0.374	0.374	0.374	0.374	0.374
1983	0.402	0.630	0.656	0.595	0.531	0.453	0.453	0.453	0.453	0.453
1984	0.444	0.715	0.732	0.722	0.681	0.593	0.593	0.593	0.593	0.593
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	0.495	0.571	0.649	0.595	0.595	0.595	0.595	0.595
1987	0.223	0.453	0.528	0.663	0.809	0.756	0.756	0.756	0.756	0.756
1988	0.213	0.455	0.536	0.660	0.772	0.662	0.662	0.662	0.662	0.662
1989	0.201	0.424	0.472	0.526	0.535	0.401	0.401	0.401	0.401	0.401
1990	0.223	0.478	0.523	0.593	0.602	0.452	0.452	0.452	0.452	0.452
1991	0.192	0.427	0.478	0.552	0.568	0.429	0.429	0.429	0.429	0.429
1992	0.172	0.429	0.540	0.689	0.754	0.604	0.604	0.604	0.604	0.604
1993	0.130	0.354	0.475	0.620	0.680	0.541	0.541	0.541	0.541	0.541
1994	0.100	0.297	0.420	0.569	0.630	0.505	0.505	0.505	0.505	0.505
1995	0.081	0.250	0.340	0.439	0.472	0.372	0.372	0.372	0.372	0.372
1996	0.072	0.227	0.315	0.422	0.488	0.417	0.417	0.417	0.417	0.417
1997	0.053	0.164	0.227	0.298	0.339	0.291	0.291	0.291	0.291	0.291
1998	0.046	0.154	0.221	0.298	0.347	0.322	0.322	0.322	0.322	0.322
1999	0.045	0.157	0.230	0.299	0.339	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	0.140	0.206	0.268	0.296	0.290	0.290	0.290	0.290	0.290
2001	0.029	0.115	0.179	0.239	0.266	0.272	0.272	0.272	0.272	0.272
2002	0.026	0.108	0.169	0.231	0.262	0.289	0.289	0.289	0.289	0.289
2003	0.024	0.103	0.159	0.218	0.263	0.324	0.324	0.324	0.324	0.324
2004	0.022	0.095	0.149	0.208	0.263	0.350	0.350	0.350	0.350	0.350
2005	0.031	0.126	0.182	0.243	0.292	0.379	0.379	0.379	0.379	0.379
2006	0.038	0.154	0.216	0.287	0.347	0.456	0.456	0.456	0.456	0.456
2007	0.045	0.171	0.231	0.302	0.358	0.464	0.464	0.464	0.464	0.464
2008	0.070	0.248	0.302	0.368	0.423	0.531	0.531	0.531	0.531	0.531
2009	0.079	0.275	0.325	0.376	0.421	0.521	0.521	0.521	0.521	0.521
2010	0.097	0.328	0.377	0.409	0.434	0.505	0.505	0.505	0.505	0.505
2011	0.096	0.312	0.372	0.413	0.442	0.490	0.490	0.490	0.490	0.490
2012	0.101	0.302	0.356	0.388	0.412	0.437	0.437	0.437	0.437	0.437
2013	0.085	0.248	0.296	0.321	0.342	0.351	0.351	0.351	0.351	0.351
2014	0.074	0.218	0.267	0.292	0.318	0.325	0.325	0.325	0.325	0.325
2015	0.068	0.204	0.254	0.278	0.303	0.305	0.305	0.305	0.305	0.305
2016	0.059	0.183	0.241	0.279	0.318	0.332	0.332	0.332	0.332	0.332
2017	0.051	0.157	0.211	0.256	0.303	0.320	0.320	0.320	0.320	0.320
2018	0.052	0.152	0.207	0.259	0.316	0.336	0.336	0.336	0.336	0.336
2019	0.049	0.135	0.181	0.231	0.285	0.295	0.295	0.295	0.295	0.295
2020	0.047	0.125	0.164	0.213	0.269	0.279	0.279	0.279	0.279	0.279
2021	0.048	0.122	0.161	0.212	0.276	0.293	0.293	0.293	0.293	0.293
2022	0.054	0.134	0.172	0.220	0.275	0.278	0.278	0.278	0.278	0.278

Table 5.10 Estimated stock numbers.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	84079	103226	53980	28173	26059	14372	10479	7303	3630	12079
1961	116214	56698	68778	30139	17271	15941	8962	7002	5132	11302
1962	206621	67991	36514	44527	18665	12602	11347	6196	5191	12547
1963	273528	132908	38603	25443	28630	11904	9852	8217	4494	13418

Year Age	3	4	5	6	7	8	9	10	11	12
1964	81169	192620	77480	22472	17643	18909	8042	7491	6151	13828
1965	254961	50031	112526	45156	14487	11618	12321	5019	5203	13937
1966	134476	182203	34550	63062	26328	9318	7532	7288	3181	12706
1967	174381	83363	111102	20172	36558	16003	6318	5244	4556	10145
1968	143868	116792	47240	64260	12981	23801	10027	4115	3364	8275
1969	266743	88148	80530	31741	42485	10738	17820	6984	2676	6827
1970	220529	168816	58099	54845	22491	29909	9248	14113	5138	7173
1971	229792	143804	87176	35366	32827	14322	17676	6580	9307	7923
1972	154318	138647	86061	46363	22951	19551	9605	10386	4323	10125
1973	201313	80104	79486	52469	27756	15440	12677	6824	6374	8952
1974	101040	110832	41722	46290	32918	16780	10298	8261	4293	9027
1975	168387	44127	52926	19840	23853	17925	9299	6053	4792	7159
1976	220290	75077	19336	25755	10499	11396	8682	4695	3077	5759
1977	202595	90031	30957	8406	13339	5459	5694	4261	2303	4200
1978	136803	89530	38536	15025	4596	7305	3204	3089	2395	3965
1979	195887	60073	38714	17165	7706	2361	4024	1757	1537	3421
1980	119022	94840	23541	16835	8556	3656	1125	2061	963	2671
1981	231779	57069	43571	9995	8255	4419	1832	687	1063	1822
1982	128129	125161	24415	19534	4696	4370	2240	1033	398	1631
1983	101092	68261	54157	9872	9339	2589	2501	1242	605	1293
1984	94913	58277	30644	20676	4286	4555	1300	1334	711	1061
1985	104326	42188	23148	12852	7066	1921	2089	554	609	830
1986	178816	49304	17688	11018	5986	2437	946	955	268	630
1987	144333	132638	22561	8348	5504	2778	853	480	424	466
1988	80758	101721	76586	11143	3461	2046	1326	229	201	292
1989	78116	55056	56087	39228	4882	1189	817	615	51	289
1990	87239	47799	29605	26555	18855	2442	594	459	369	216
1991	226128	48323	22077	15107	11246	8486	1239	297	264	325
1992	281572	142477	22451	10926	7826	5046	4680	647	168	376

Year Age	3	4	5	6	7	8	9	10	11	12
1993	211195	213251	76279	10125	4267	3120	1967	2310	280	239
1994	150391	162523	132423	37401	4346	1719	1485	757	1244	269
1995	273698	132560	112143	75455	15566	1847	795	778	301	828
1996	158175	243535	88164	68459	40373	7958	1036	484	448	706
1997	164454	119907	178058	57926	40086	21558	4150	503	259	630
1998	104242	135278	83593	127604	32828	24078	12874	2553	332	631
1999	240168	78876	95525	53406	73772	18342	15008	7664	1477	581
2000	158541	192183	51062	55699	31145	40581	11311	9610	4371	1130
2001	211794	106083	139384	35301	33070	18947	24102	7238	6071	3183
2002	359919	177595	77616	93122	23797	20523	12597	14969	4485	5906
2003	152144	316927	122993	51134	56259	17106	12703	8613	9123	6489
2004	155024	121582	208700	85354	35212	36152	10916	7418	5492	9120
2005	438601	119479	78729	124586	56076	23640	22144	6872	3799	7567
2006	74583	345403	79622	48195	73346	34565	14779	12527	3908	6072
2007	114083	54185	215236	52212	29553	39664	19717	8275	6249	4387
2008	201813	76384	37703	114141	29929	16411	19872	10760	4183	5079
2009	147080	154557	45931	24844	62134	15615	7847	9254	5299	4242
2010	271353	99013	90765	28389	14069	32976	7745	3759	4143	4379
2011	114066	199649	50435	46592	15549	8081	15919	3921	1844	3946
2012	154814	92081	123283	30926	24536	8987	4378	7716	1912	2863
2013	210355	92310	63589	77194	18248	13153	4984	2438	3908	2503
2014	109238	170823	60152	42421	45620	10958	7618	3127	1443	3687
2015	165684	80773	120680	41590	28370	26826	6424	4420	1950	3237
2016	253893	119653	54304	73330	27280	17487	15589	3752	2870	3784
2017	179118	220097	81199	33948	41589	16230	10315	8635	2089	4703
2018	131707	150607	177339	58864	23883	23388	9741	6165	4976	4381
2019	263024	124821	110826	118264	34922	14225	12953	5597	3458	5532
2020	132807	242131	104484	80238	72090	21379	8699	7573	3316	5781
2021	151158	104116	203031	80100	54021	45591	12979	5337	4647	6217

Year Age	3	4	5	6	7	8	9	10	11	12
2022	150445	121225	85401	151384	54133	32665	27140	7468	3043	6948
pred		116703	86827	58878	99419	33671	20244	16820	4628	6192

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	84079	52714	134104	462719	339250	631125	0.276	0.198	0.386	686938	534636	882626
1961	116214	76781	175898	454759	336232	615070	0.233	0.171	0.319	661651	517853	845379
1962	206621	137234	311091	460750	343996	617130	0.233	0.172	0.315	725691	577504	911903
1963	273528	181849	411426	458092	345758	606923	0.247	0.184	0.330	837367	676279	1036824
1964	81169	53533	123072	483310	370432	630585	0.283	0.213	0.376	818411	659651	1015379
1965	254961	169667	383135	523287	405529	675238	0.289	0.218	0.384	858523	696756	1057848
1966	134476	89721	201557	482287	371181	626650	0.299	0.226	0.397	827034	671120	1019170
1967	174381	116106	261906	493982	383301	636624	0.279	0.210	0.372	800254	650786	984052
1968	143868	95911	215804	469867	363567	607248	0.202	0.151	0.270	758286	617277	931506
1969	266743	177311	401282	509886	402962	645182	0.195	0.147	0.260	868987	718470	1051038
1970	220529	147366	330016	567910	458192	703901	0.309	0.238	0.402	973203	818089	1157727
1971	229792	154257	342316	554559	452428	679746	0.327	0.253	0.422	954117	807044	1127993
1972	154318	103734	229568	535897	440865	651413	0.321	0.250	0.412	878601	746245	1034433
1973	201313	135387	299340	537164	447236	645175	0.358	0.281	0.456	846518	723803	990037
1974	101040	67696	150807	493549	413138	589611	0.480	0.380	0.605	735942	632574	856202
1975	168387	113226	250419	398906	335045	474941	0.538	0.428	0.675	614215	527937	714592
1976	220290	147745	328454	281395	234816	337213	0.572	0.457	0.716	544151	461858	641108
1977	202595	136229	301293	209075	173859	251424	0.500	0.398	0.629	478340	402945	567843
1978	136803	91902	203642	189121	158387	225820	0.552	0.442	0.691	418444	354877	493397
1979	195887	131773	291195	170457	142714	203592	0.588	0.471	0.734	410434	343926	489803
1980	119022	80040	176988	150230	125646	179625	0.564	0.452	0.705	392006	328520	467761
1981	231779	155146	346263	154477	128513	185688	0.558	0.447	0.698	447649	369101	542913
1982	128129	85966	190973	135722	112992	163025	0.556	0.443	0.696	403308	334037	486944
1983	101092	67592	151196	163889	135419	198344	0.603	0.484	0.752	410137	343053	490341

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
1984	94913	63214	142506	146768	121662	177054	0.713	0.575	0.884	323412	272554	383761
1985	104326	69384	156864	110731	92138	133076	0.632	0.507	0.787	270857	226456	323963
1986	178816	118990	268721	83529	69419	100506	0.541	0.432	0.677	266745	217693	326850
1987	144333	96672	215492	72095	60041	86569	0.613	0.495	0.759	284738	232707	348403
1988	80758	53541	121809	88401	73051	106975	0.606	0.488	0.752	303296	249740	368338
1989	78116	51664	118110	104198	80787	134393	0.489	0.389	0.616	286636	236935	346763
1990	87239	57301	132820	120215	96015	150513	0.549	0.437	0.689	273090	228831	325909
1991	226128	149736	341494	114715	94100	139845	0.506	0.403	0.636	355308	288684	437308
1992	281572	186896	424206	95221	80140	113140	0.603	0.483	0.752	464067	373206	577048
1993	211195	141557	315090	97284	81037	116787	0.532	0.426	0.666	533253	431809	658530
1994	150391	102652	220333	148368	120558	182591	0.479	0.380	0.603	485777	402461	586341
1995	273698	185243	404391	197382	158422	245924	0.375	0.295	0.477	587883	488841	706993
1996	158175	107657	232399	246300	200738	302205	0.363	0.284	0.463	681142	569585	814547
1997	164454	112130	241194	245799	200884	300756	0.257	0.199	0.332	724261	603961	868525
1998	104242	71349	152299	294132	240682	359453	0.255	0.197	0.330	801821	669047	960945
1999	240168	164321	351025	309293	249982	382677	0.256	0.197	0.333	804184	677002	955260
2000	158541	108495	231674	368293	297991	455181	0.228	0.175	0.296	823627	696901	973397
2001	211794	146289	306633	373894	306856	455576	0.200	0.154	0.259	880459	749503	1034297
2002	359919	253865	510277	448064	373993	536805	0.193	0.149	0.248	1024865	879264	1194578
2003	152144	107102	216129	434942	366522	516136	0.185	0.144	0.239	999662	856951	1166140
2004	155024	108055	222411	515190	438685	605036	0.179	0.138	0.232	1012293	868588	1179775
2005	438601	308156	624263	598107	507119	705420	0.211	0.164	0.272	1094304	940312	1273514
2006	74583	52768	105415	531879	453991	623130	0.251	0.196	0.322	938859	807812	1091165
2007	114083	80979	160720	542373	464693	633039	0.266	0.208	0.340	877537	753171	1022437
2008	201813	143821	283187	465652	392823	551983	0.335	0.263	0.426	728565	628921	843996
2009	147080	104996	206031	359677	303496	426259	0.349	0.277	0.441	676066	585281	780934
2010	271353	194251	379057	326093	276090	385153	0.387	0.307	0.489	698092	600492	811556
2011	114066	81072	160488	290881	245996	343956	0.385	0.304	0.488	584113	501946	679730
2012	154814	110305	217283	299618	254058	353348	0.364	0.288	0.461	594030	510699	690958

Year	R (age 3)	Low	High	SSB	Low	High	Fbar (4–7)	Low	High	TSB	Low	High
2013	210355	150281	294443	321355	269250	383544	0.302	0.237	0.385	607239	520669	708202
2014	109238	77882	153219	346463	290173	413673	0.274	0.214	0.349	640254	548989	746691
2015	165684	118228	232189	355503	297714	424510	0.260	0.203	0.333	624140	533862	729685
2016	253893	179872	358376	388877	322707	468614	0.255	0.198	0.329	791132	671289	932370
2017	179118	127046	252532	398106	329512	480980	0.232	0.179	0.300	887013	750160	1048832
2018	131707	91953	188647	458189	376478	557634	0.234	0.180	0.304	931515	783488	1107511
2019	263024	184594	374777	547833	440741	680946	0.208	0.158	0.274	1047133	874815	1253395
2020	132807	93258	189130	598474	473223	756875	0.193	0.144	0.257	1065723	880945	1289259
2021	151158	103550	220655	701042	545746	900529	0.193	0.142	0.262	1154001	935950	1422853
2022	150445	93996	240795	741480	556921	987201	0.200	0.141	0.284	1163597	920295	1471222

Table 5.12 Northeast Arctic saithe. Prediction input data

rMFDP version
Run: r
F_{bar} age range: 4–7

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161475	0.2	0	0	0	0.81	0.05	0.81
4	116703	0.2	0.05	0	0	1.172	0.127	1.172
5	86827	0.2	0.42	0	0	1.626	0.166	1.626
6	58878	0.2	0.87	0	0	2.085	0.215	2.085
7	99419	0.2	0.97	0	0	2.615	0.273	2.615
8	33671	0.2	0.98	0	0	3.141	0.283	3.141
9	20244	0.2	0.98	0	0	3.618	0.283	3.618
10	16820	0.2	0.97	0	0	4.103	0.283	4.103
11	4628	0.2	0.97	0	0	4.648	0.283	4.648
12	6192	0.2	0.994	0	0	6.388	0.283	6.388

2024

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161475	0.2	0	0	0	0.81	0.05	0.81

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
4	.	0.2	0.05	0	0	1.172	0.127	1.172
5	.	0.2	0.42	0	0	1.626	0.166	1.626
6	.	0.2	0.87	0	0	2.085	0.215	2.085
7	.	0.2	0.97	0	0	2.615	0.273	2.615
8	.	0.2	0.98	0	0	3.141	0.283	3.141
9	.	0.2	0.98	0	0	3.618	0.283	3.618
10	.	0.2	0.97	0	0	4.103	0.283	4.103
11	.	0.2	0.97	0	0	4.648	0.283	4.648
12	.	0.2	0.994	0	0	6.388	0.283	6.388

2025

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	161475	0.2	0	0	0	0.81	0.05	0.81
4	.	0.2	0.05	0	0	1.172	0.127	1.172
5	.	0.2	0.42	0	0	1.626	0.166	1.626
6	.	0.2	0.87	0	0	2.085	0.215	2.085
7	.	0.2	0.97	0	0	2.615	0.273	2.615
8	.	0.2	0.98	0	0	3.141	0.283	3.141
9	.	0.2	0.98	0	0	3.618	0.283	3.618
10	.	0.2	0.97	0	0	4.103	0.283	4.103
11	.	0.2	0.97	0	0	4.648	0.283	4.648
12	.	0.2	0.994	0	0	6.388	0.283	6.388

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

2023

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1100574	727666	1.240	0.242	226794

2024–2025

2024					2025	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
1011526	638756	0	0	0	1174065	769181
	638756	0.1	0.0195	18669	1153541	751232
	638756	0.2	0.039	36911	1133494	733727
	638756	0.3	0.0586	54736	1113912	716655
	638756	0.4	0.0781	72156	1094783	700005
	638756	0.5	0.0976	89180	1076096	683766
	638756	0.6	0.1172	105818	1057840	667927
	638756	0.7	0.1367	122080	1040005	652479
	638756	0.8	0.1562	137975	1022579	637410
	638756	0.9	0.1757	153511	1005552	622712
	638756	1	0.1952	168698	988915	608375
	638756	1.1	0.2148	183545	972658	594390
	638756	1.2	0.2343	198059	956771	580748
	638756	1.3	0.2538	212250	941246	567439
	638756	1.4	0.2734	226124	926073	554456
	638756	1.5	0.2929	239690	911243	541790
	638756	1.6	0.3124	252955	896749	529433
	638756	1.7	0.3319	265927	882582	517377
	638756	1.8	0.3515	278612	868733	505615
	638756	1.9	0.371	291018	855195	494139
	638756	2	0.3905	303152	841961	482942

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

2023

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1100574	727666	1.240	0.2071	226794

2024

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
1050549	686937	1.378	0.269	223124

2025

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
929354	557261	1.6389	0.32	230315

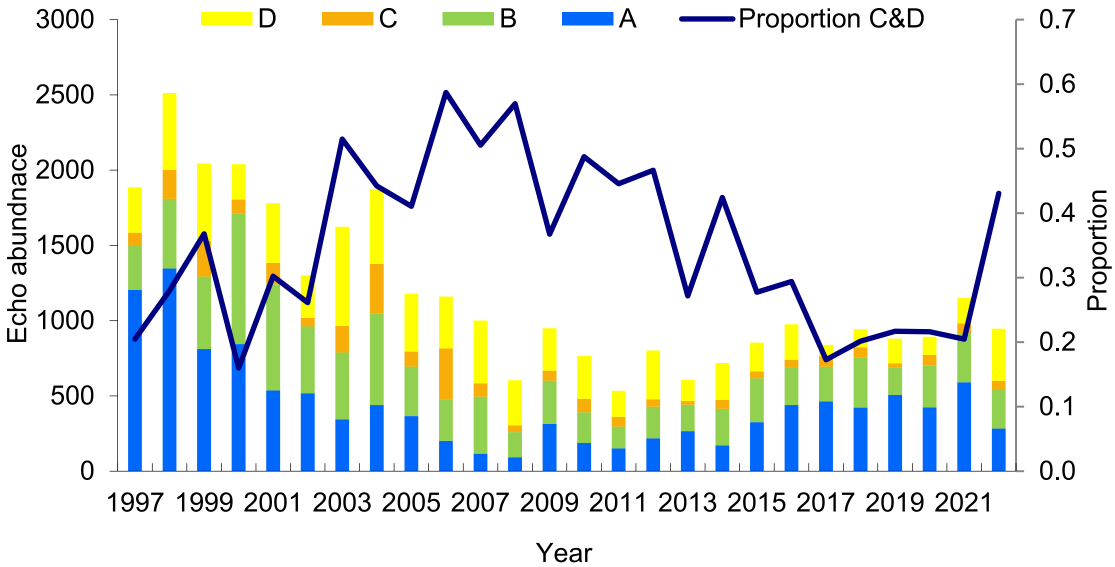


Figure 5.1. Northeast Arctic saithe. Echo abundance and proportion of saithe in the southern half of the survey area (subarea C+D).

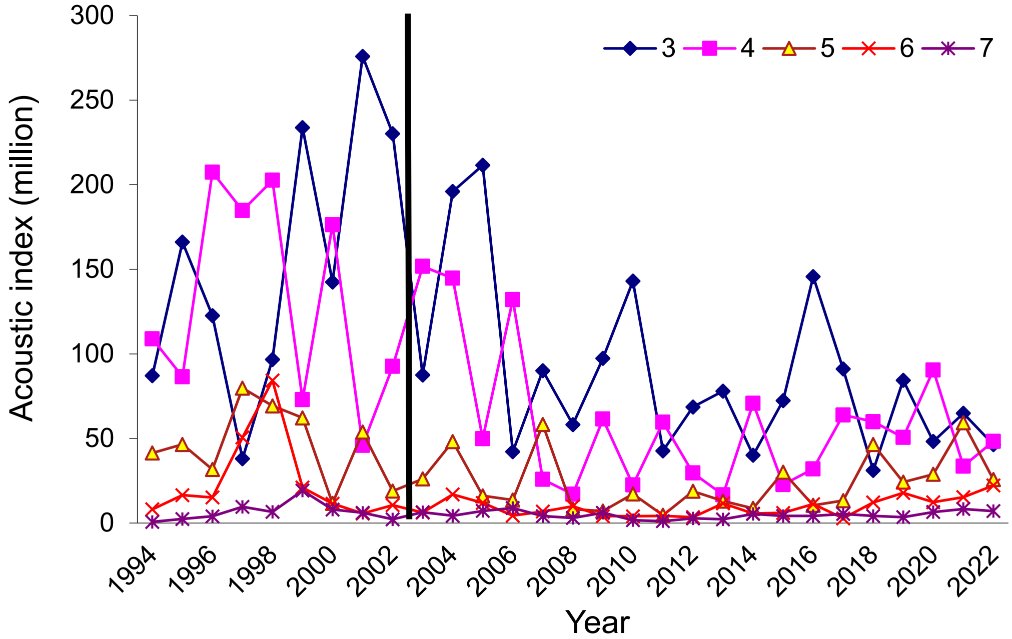


Figure 5.2. Northeast Arctic saithe. acoustic survey tuning indices by age class (3–7). break in 2002 black line.

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.

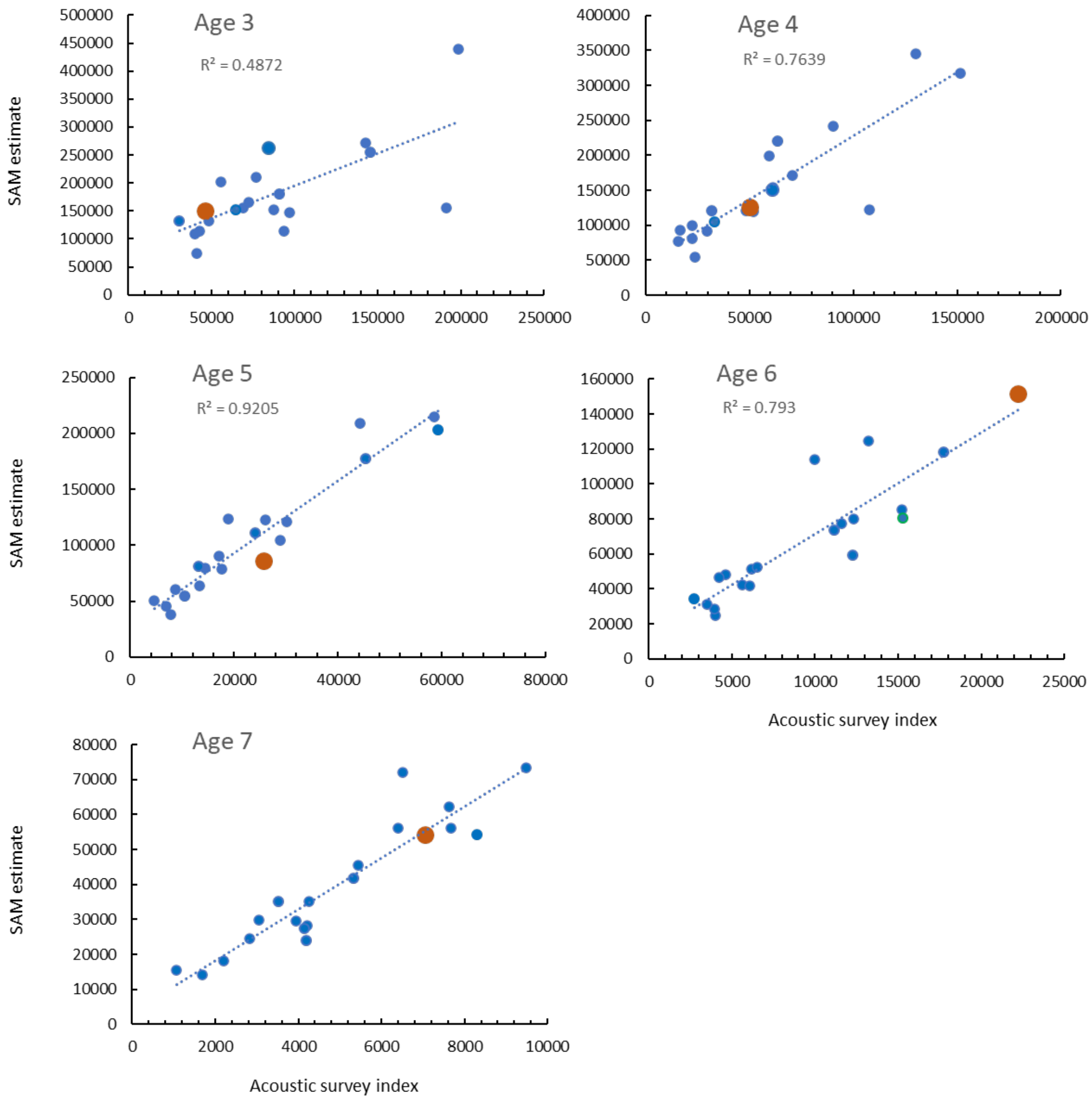


Figure 5.4. NEA saithe - Acoustic survey vs. SAM. Red point 2022 data.

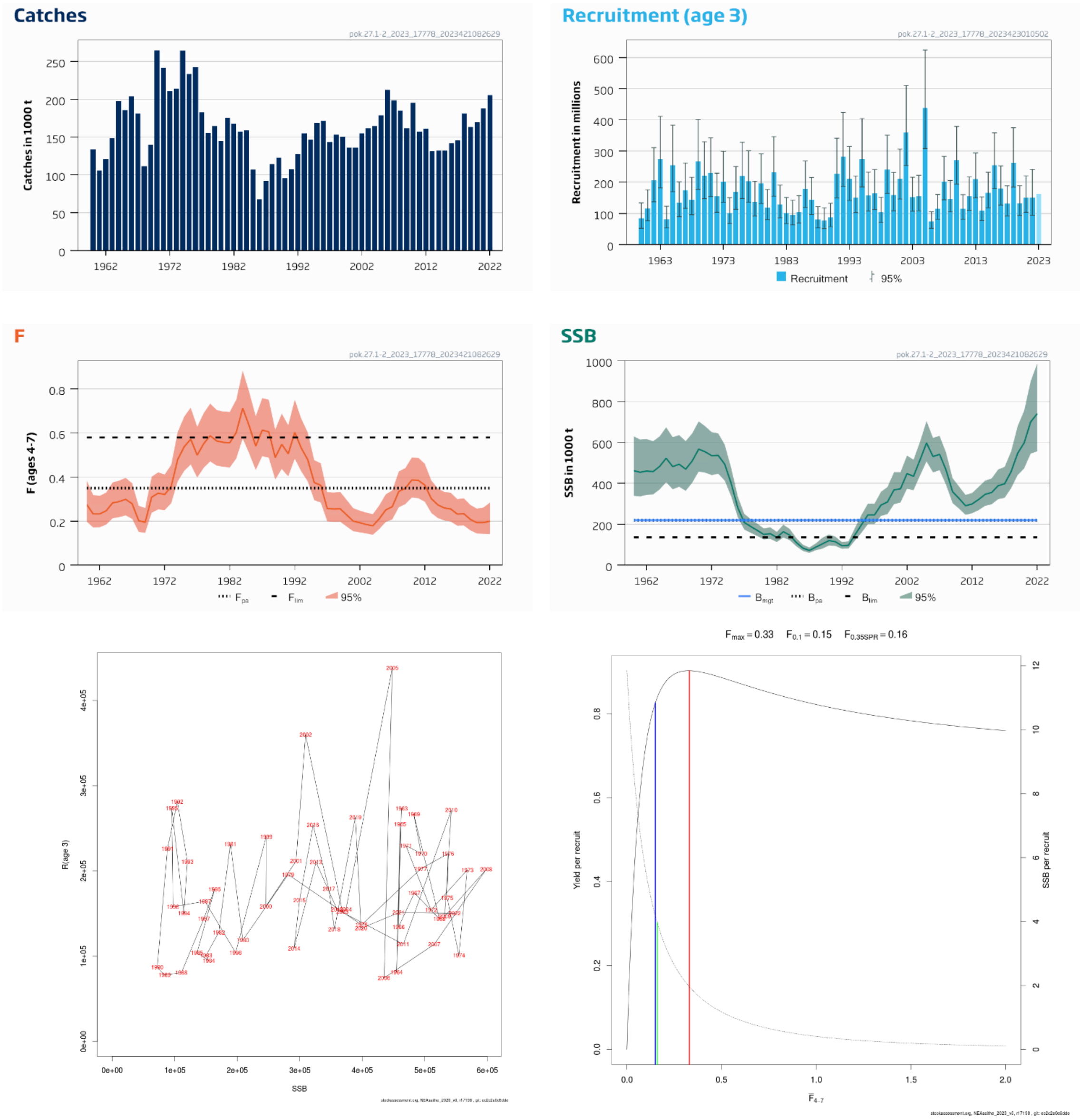


Figure 5.5. Northeast Arctic saithe (subareas 1 and 2).

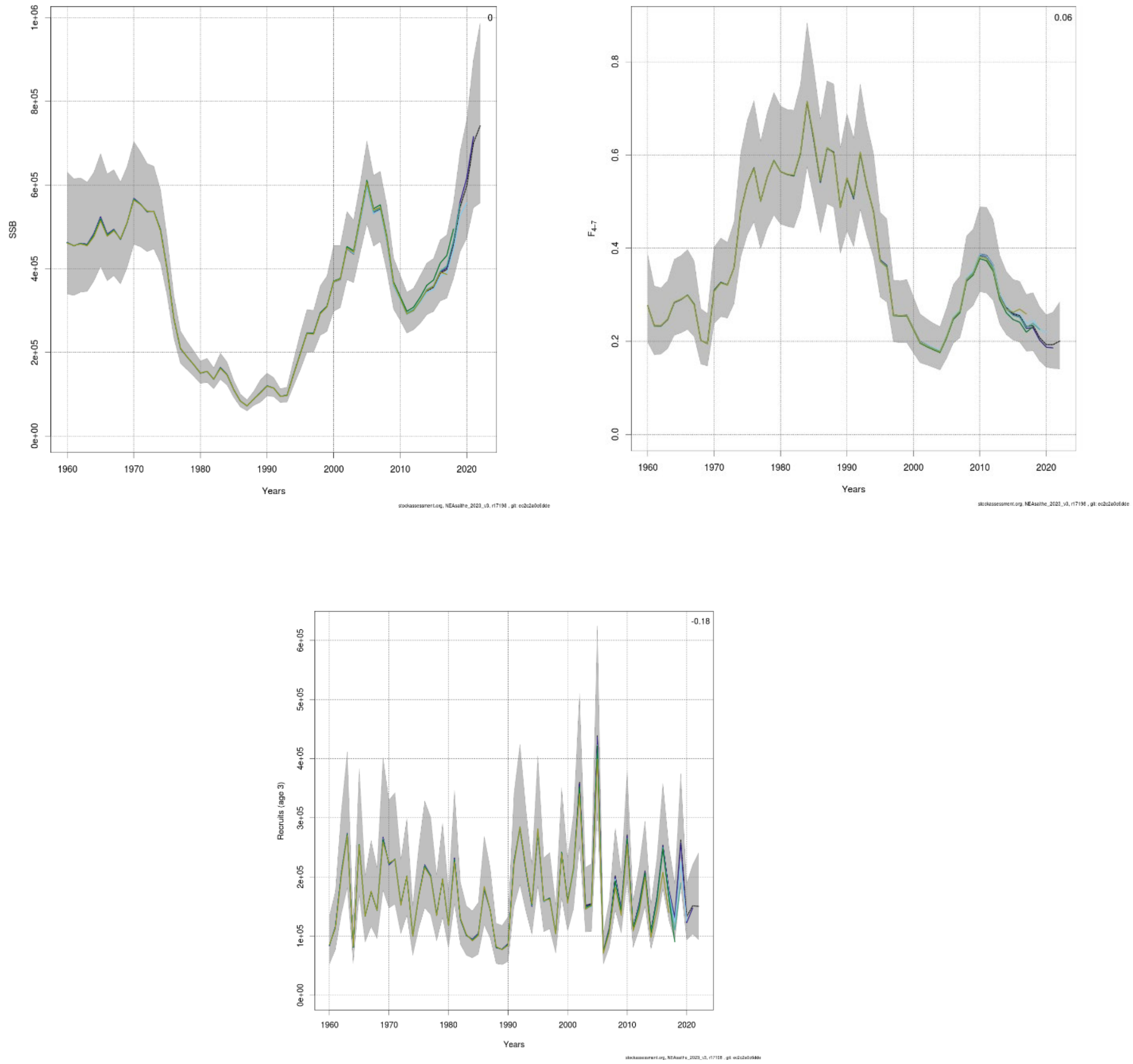


Figure 5.6. Saithe in subareas 1 and 2 (Northeast Arctic) RETROSPECTIVE SAM SSB. F4–7. and recruits.

6 Northeast Arctic beaked redfish

reb.27.1-2 – *Sebastes mentella* in subareas 1 and 2

On 30 March 2022, all Russian participation in ICES was suspended. Owing to this temporary suspension, it is not currently possible to run an ICES assessment for NEA cod. It is however critical for good ecosystem and fisheries management that such assessments be run and be used as the basis of management. An assessment for this stock has therefore been conducted in 2022 outside ICES by a bilateral Russian-Norwegian group, the "Joint Russian-Norwegian Arctic Fisheries Working Group" (JRN-AFWG). The assessments occur outside ICES but follow the stock annexes previously agreed within ICES, use the same data and models as previously, and are conducted by the same Russian and Norwegian scientists that were involved in the previous ICES assessments. The managing body in the Barents Sea (the Joint Norwegian Russian Fisheries Commission; JNRFC) has used the advice as the basis of management, following the same procedures previously used for ICES advice. JNRFC also endorsed this approach to be continued for the 2023 advice (52nd session[1], Appendix 10).

The report of the JRN-AFWG assessment and the associated advice sheets also follow closely the previous ICES reporting format and are published online by the Norwegian Institute of Marine Research. For NEA beaked redfish the relevant information for 2023 can be found at:

2023 report:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-7

Advice on fishing opportunities in 2024:

TBD

[1] https://www.jointfish.com/OM-FISKERIKOMMISJONEN/PROTOKOLLER.html

7 Northeast Arctic golden redfish

reg.27.1-2 – *Sebastes norvegicus* in subareas 1 and 2

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 2022. The age-based GADGET model was then run for the period 1990–2021, in the configuration approved during the benchmark. The present report updates the tables and figures, but the group did not re-run the assessment model and does not give advice.

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 some permanently closed areas were forbidden in the Norwegian Exclusive 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 15% (in numbers) undersized (i.e. less than 32 cm) specimens of *S. norvegicus* 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 meters. From 2016, when trawling outside 12 nm, vessels can only 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. However, vessels less than 21 metres can 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 1998–2022 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 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 9639 tonnes in 2020, 10 195 tonnes in 2021 and 8407 tonnes in 2022 (provisional). Landings in 2022 do not include Russian landings. 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 2022 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. No data on Russian catches is available for 2022. 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 1994–2022 was dominated by *S. mentella*, and hence influenced the *S. norvegicus* to a much lesser extent (Figure 0.1). 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 2023

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 meters 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*. Although total landings cannot be compared in 2022, it is notable that Norwegian landings decreased by 150 tonnes. The Norwegian quota for *S. mentella* in 2022 was not fully exhausted and catches decreased by about 3000 t compared to the previous year. With a slight reduction in the total quota for *S. mentella* in 2023, bycatch of *S. norvegicus* is expected to stagnate on that high level.

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 2025.

Except for 2021 and 2022, 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 and 2022 weight-at-age-data were not available during the working group, due to a lack of age data from those 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 2020, 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 2023 in fishing depths of 100–500 m. Length compositions for the years 1986–2023 are shown in Table E2a and Figure 7.6a. Age compositions for the years 1992–2019 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 2022 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 1985–2022 and age compositions for the years 1992–2008, 2012, 2013, 2016, 2017 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 1998–2022 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 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 the 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 is currently 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 an 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 15% for recruitment, 121% for F(15+) and –43% 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 years before this change in method 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 2021 red list evaluation, which produced similar trends (Hesthagen et al. 2021). 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 an endangered (EN) species (Hesthagen et al. 2021), 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 2023. 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 up-turn 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	–	166	1	88	99	53	–	–	–	6503	9	80	2615	6	19	9639
2021[1]	2	323	6	76	92	72	–	–	–	7703	20	60	1737	8	96	10195
2022[1]	–	311	12	60	161	220	–	–	–	7553	0	75	N. a.	4	11	8407[2]

1 – Provisional figures.

2 – Excluding Russian data

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	34	–	–	1284	2	0	708	6	1	**2210**
2021[1]	296	–	–	54	15	–	–	1445	–	12	305	–	–	**2127**
2022[1]	288	6	5	48	–	–	–	1632	–	2	N. a.	–	–	**1981[2]**

1 – Provisional figures.

2 – Excluding Russian data

+ 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	23	1	61	81	20	–	–	4838	–	80	946	–	16		6066
2021[1]	24	5	21	36	57	–	–	5682	–	48	1073	2	90		7038
2022[1]	22	5	53	112	220	-	-	5490	-	72	N. a.	1	7		5982[2]

1 – Provisional figures.

2 – Excluding Russian data

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	1029
2022[1]	–	1	1	2	1	–	–	–	431	–	1	N. a.	4	4	445[2]

1 – Provisional figures.

2- Excluding Russian data

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

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
1993	0	24	193	359	406	1036	1022	1523	2353	1410	1655	1678	745	716	534	528	576	3482	18240	16651
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

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
2011	2	1	3	0	2	5	64	304	466	266	312	223	378	289	247	229	253	985	4028	5852
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	52	141	243	187	458	913	513	405	138	177	101	143	97	83	209	185	133	3105	7283	8559
2020[1]	39	20	161	652	700	861	965	481	282	227	82	92	187	73	166	145	133	2596	7862	9644

1 – Provisional figures.

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

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
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
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

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
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
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

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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
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

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
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
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	mean wt	biomass	number	mean wt	biomass	number	mean wt	biomass	F(15+)	age 3
	(millions)	(kg)	(1000t)	(millions)	(kg)		(millions)	(kg)	(1000t)		(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

		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)
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
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

		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)**
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
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

	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)
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

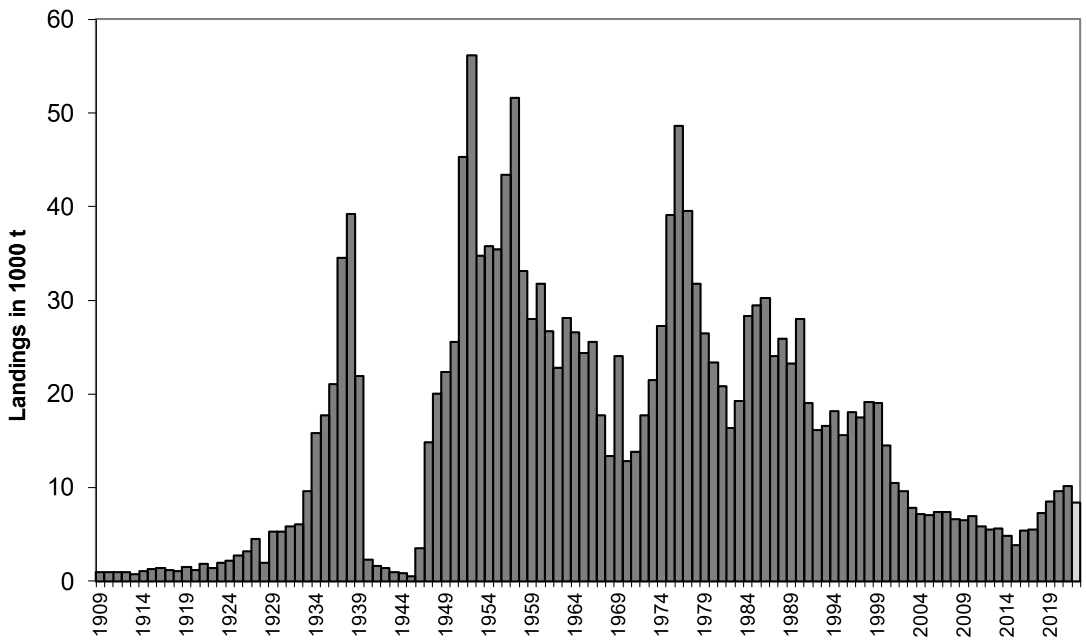


Figure 7.1. *S. norvegicus* in subareas 1 and 2. Total international landings 1908–2022 (in thousand tonnes), excluding Russian landings in 2022.

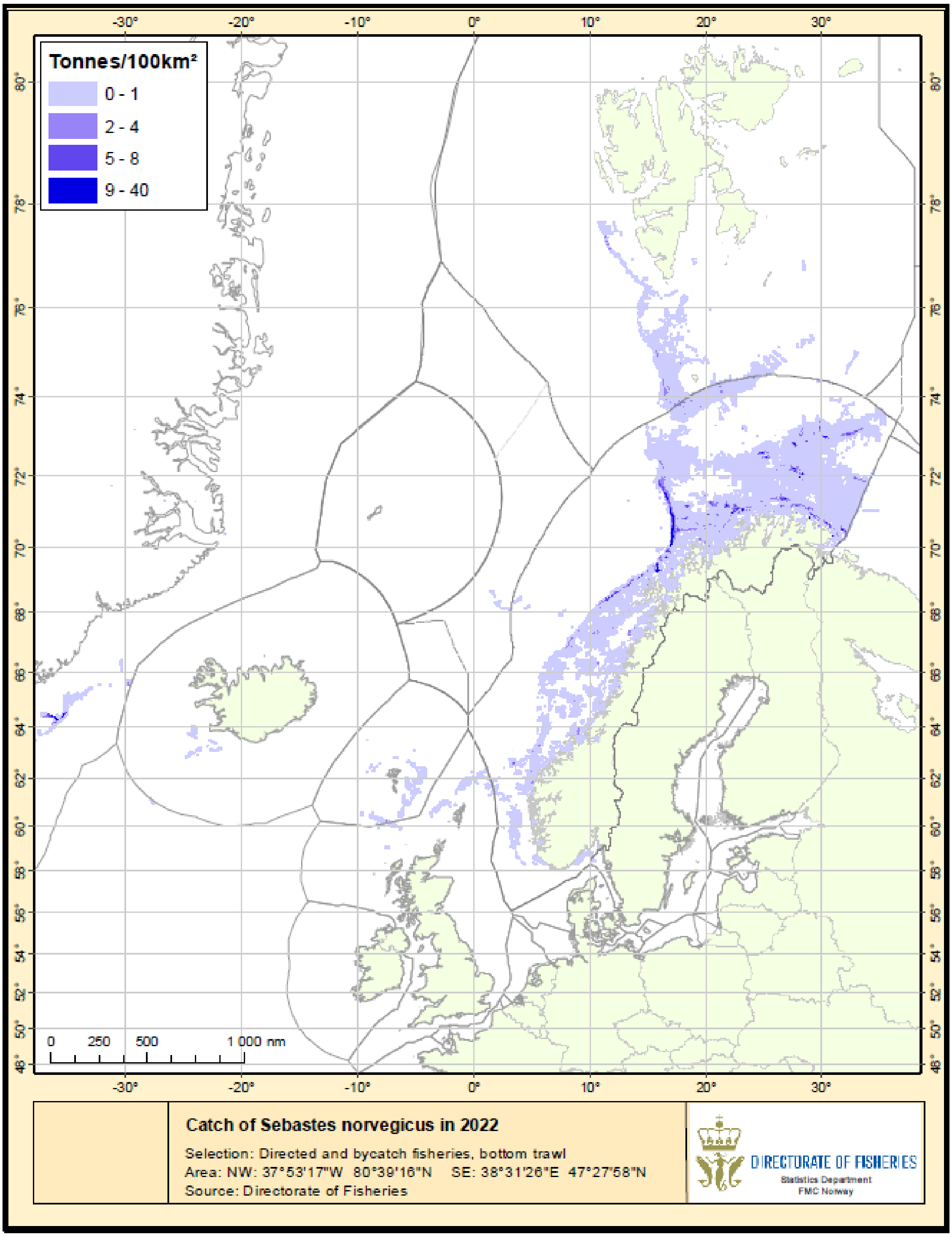


Figure 7.2. S. norvegicus in subareas 1 and 2. Catches (including bycatch) of *S. norvegiucs* in 2022 from Norwegian log-books. Due to some reporting on the genus level some catches may contain *S. mentella.*

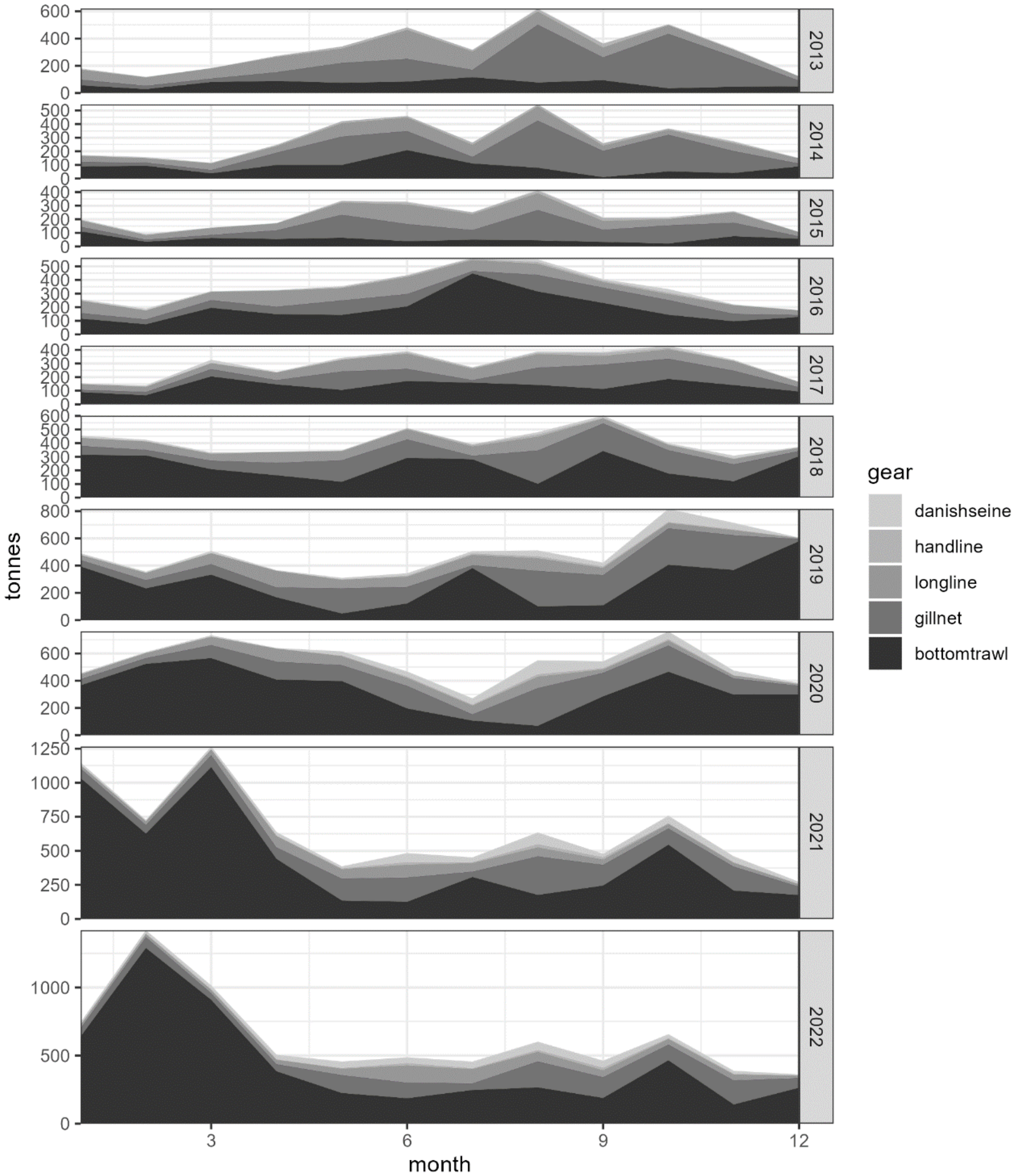


Figure 7.3a. Illustration of the seasonality in the different Norwegian *S. norvegicus* fisheries in 2013–2022, also illustrating how the current regulations are working.

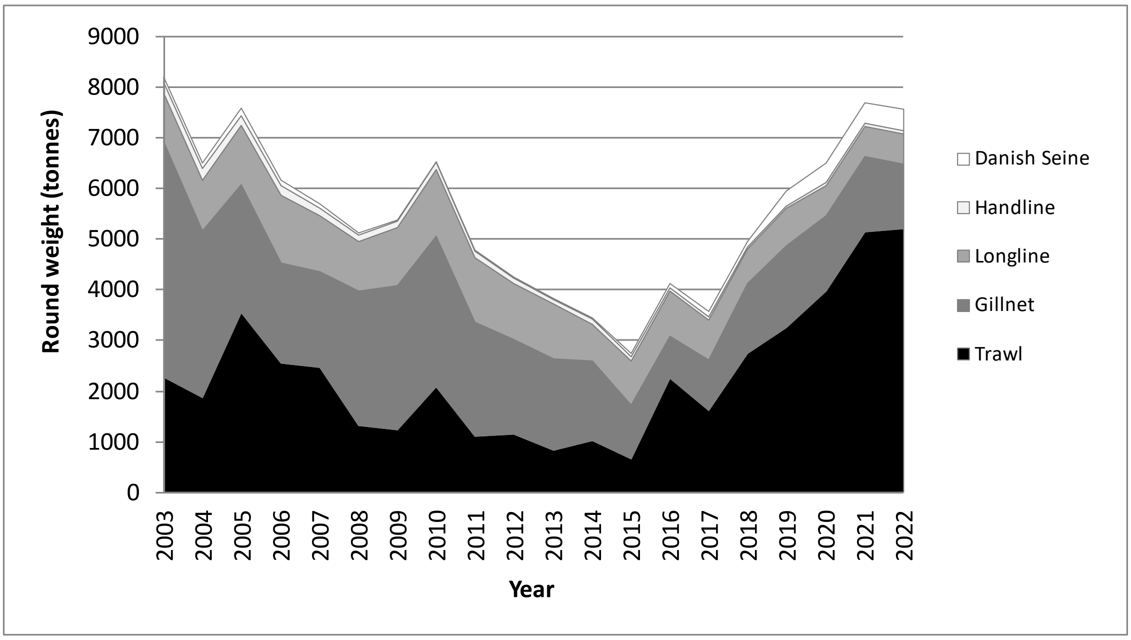


Figure 7.3b. Interannual changes in the Norwegian catches by fleet of *S. norvegicus* fisheries (2003–2022).

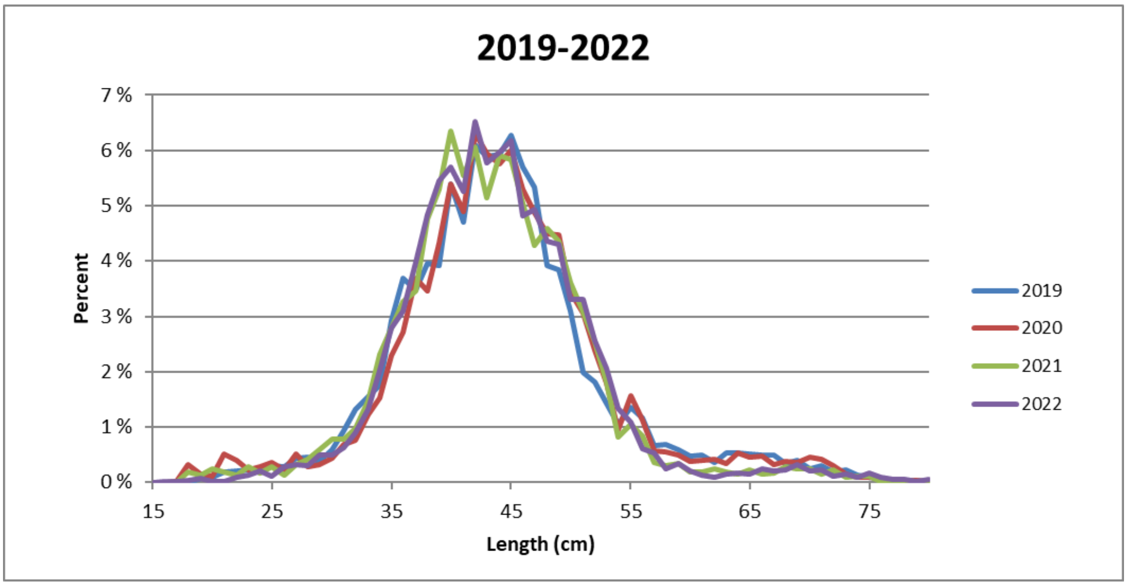


Figure 7.4. *S. norvegicus*. Length frequency of *S. norvegicus* reported from Norwegian catches in 2019–2022, all gears combined.

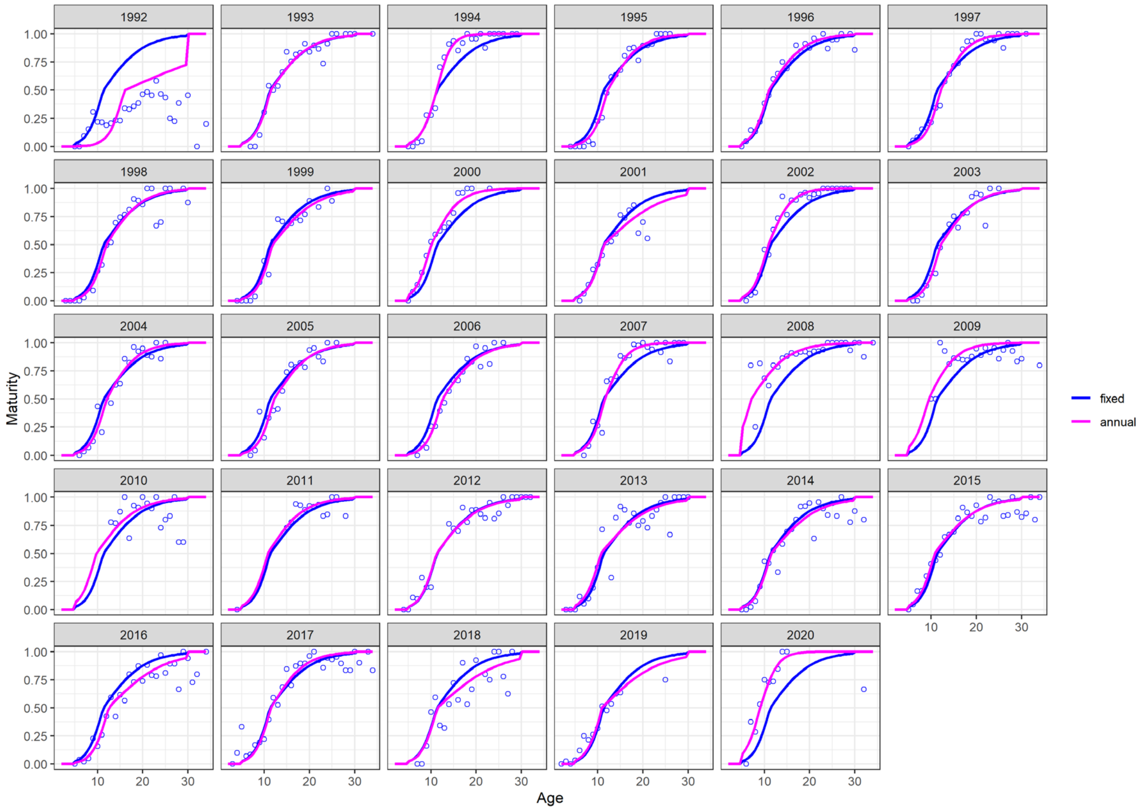


Figure 7.5a. Proportion maturity–at–age of *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table E4). The proportions were derived from samples with at least five individuals. Updated for the 2023 report. Due to a lack of data in later years only the data up to 2018 was used in the 2022 assessment model. The blue line depicts the fixed-effects model across all years and pink line depicts the annual models, including random-effects.

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.

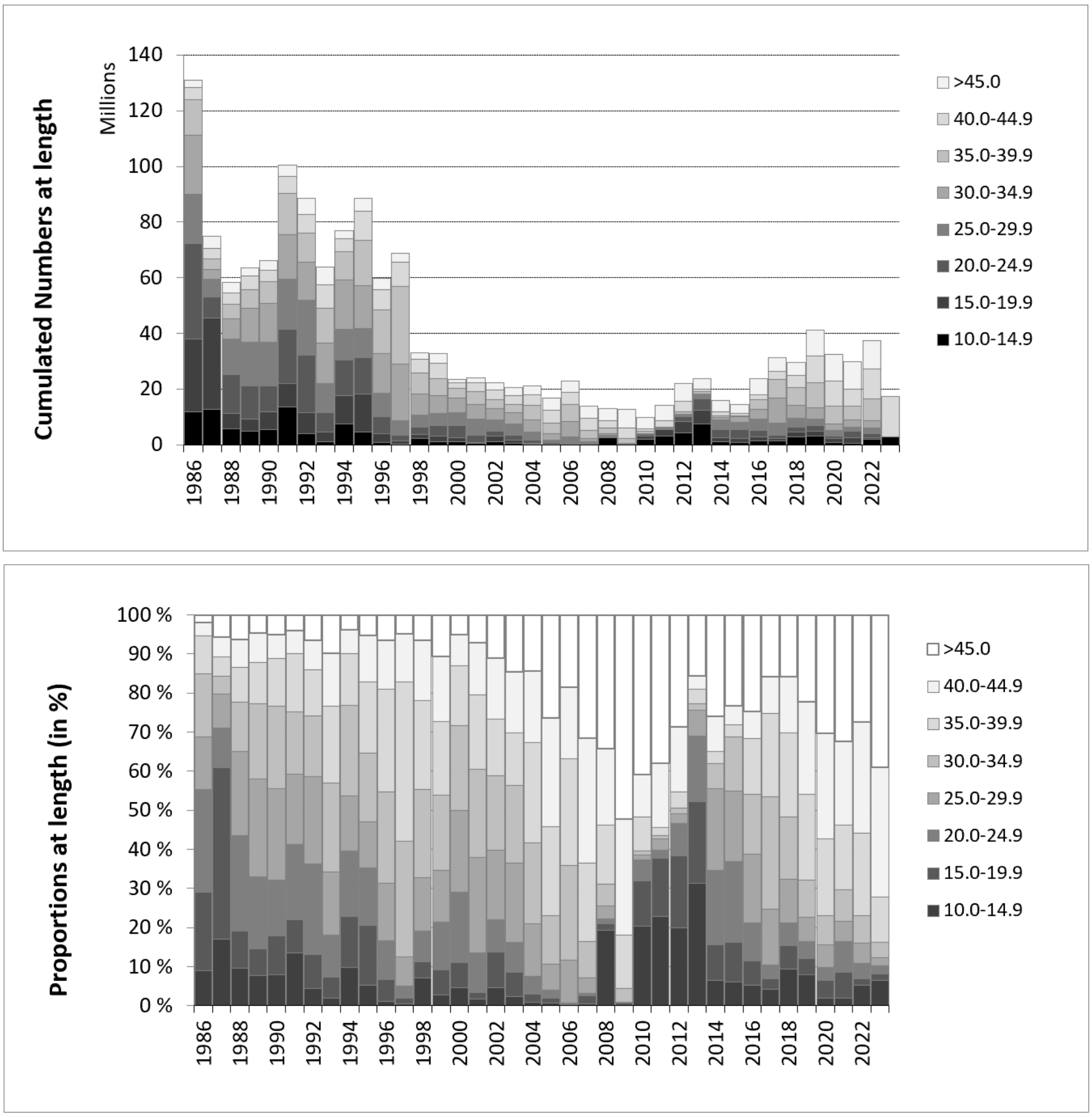


Figure 7.6a. ***S. norvegicus*. Abundance indices disaggregated by length for the winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS–NoRu–Q1 (BTr); joint with Russia some of the years since 2000), for 1986–2023 (ref. Table E2a). Numbers for 2023 are preliminary as Russian data were not available during AFWG 2023. Top: absolute index values, bottom: relative frequencies.**

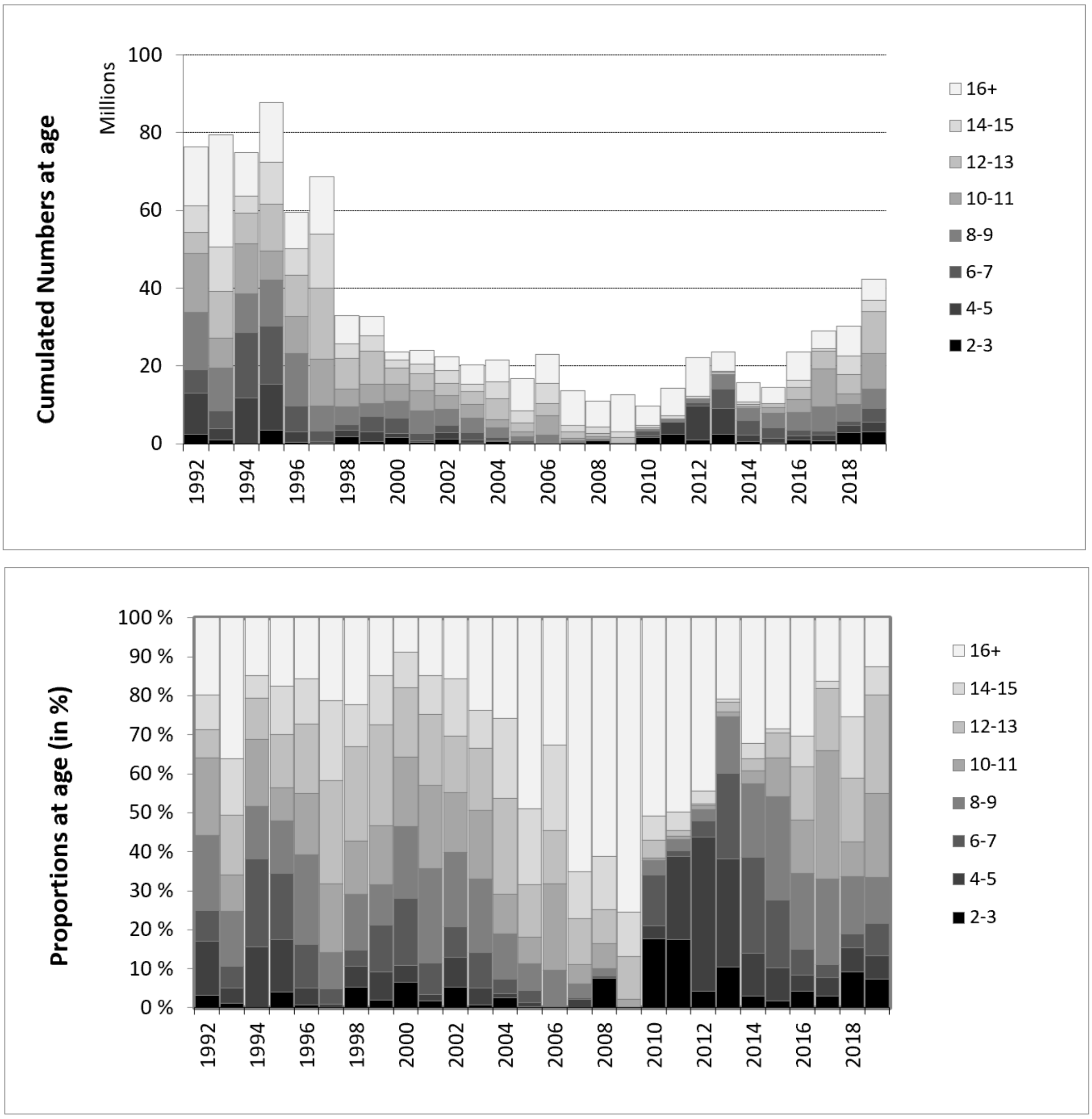


Figure 7.6b. *S. norvegicus.* Abundance indices by age from the winter Norwegian Barents Sea (Division 2.a) bottom–trawl survey (BS–NoRu–Q1 (BTr); joint with Russia some of the years since 2000), for 1992–2019 (ref. Table E2b). Age readings for 2020–2022 not available during AFWG 2023. Top: absolute index, bottom: relative frequencies.

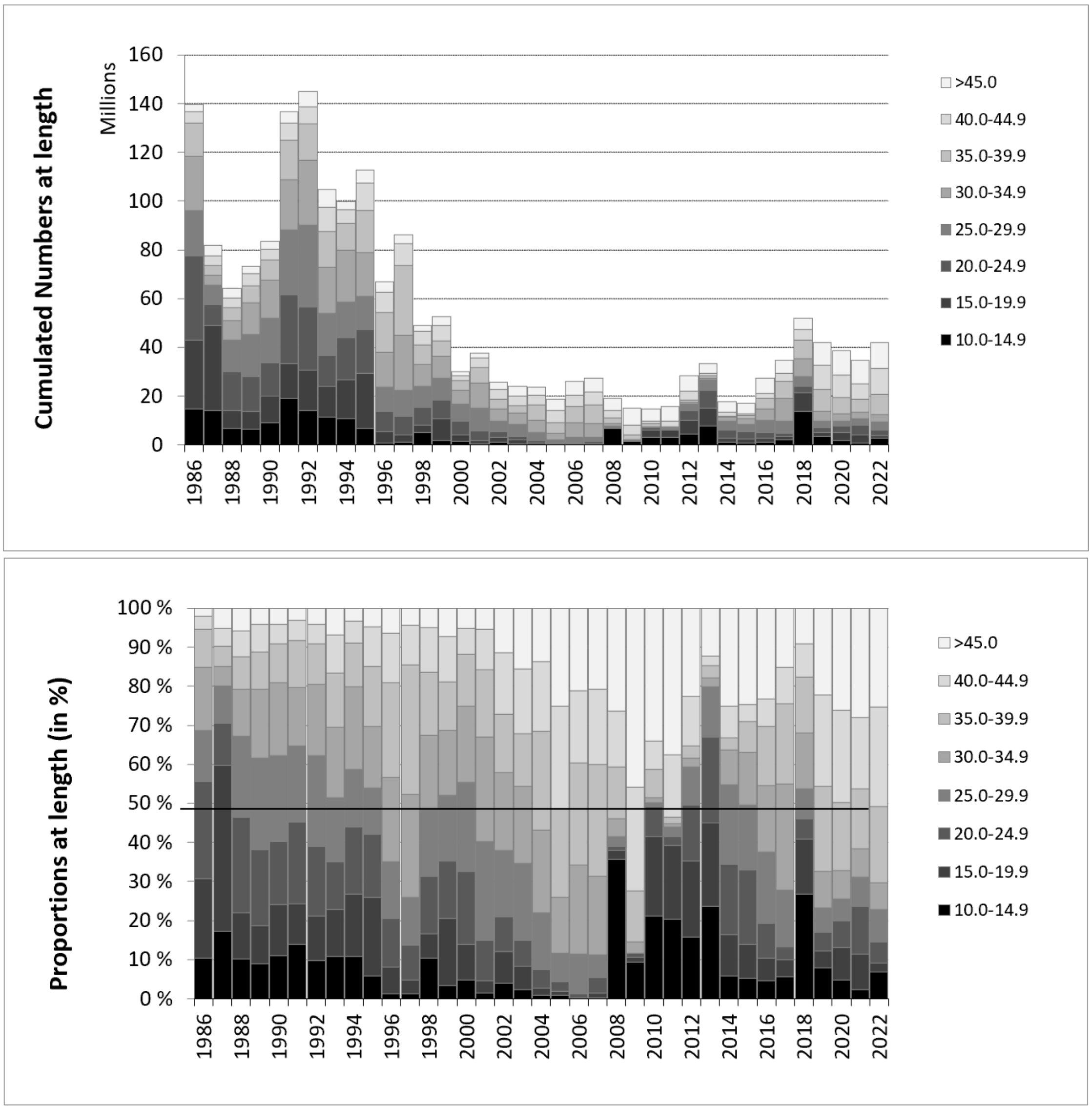
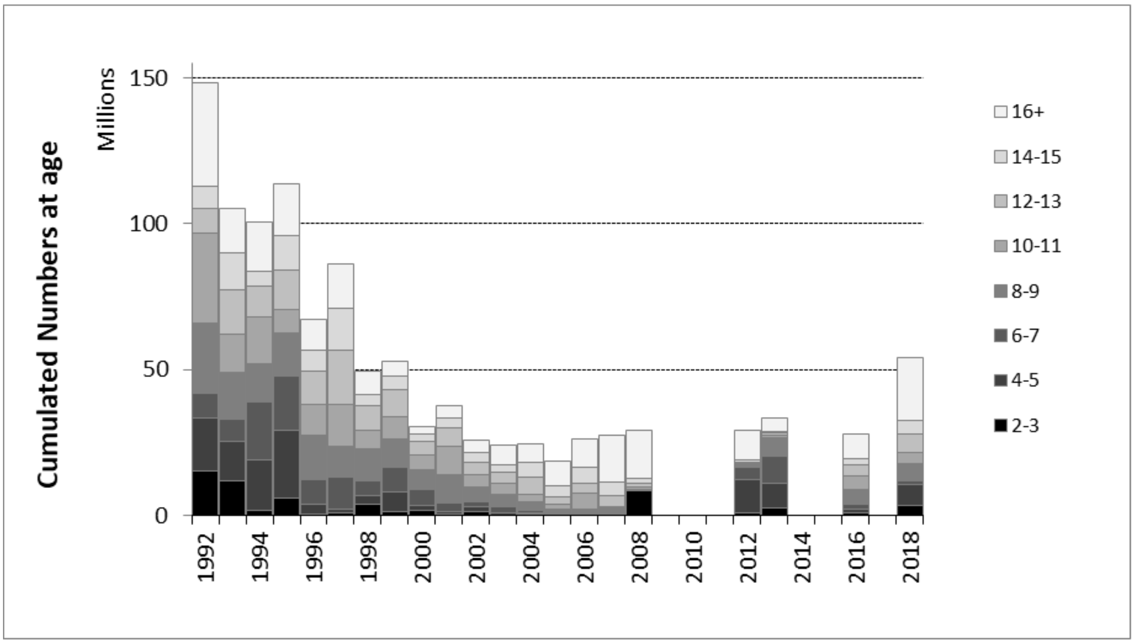


Figure 7.7a. ***S. norvegicus.*** **Abundance indices disaggregated by length when combining the Norwegian bottom–trawl surveys 1986–2022 in the Barents Sea (winter) and at Svalbard (summer/autumn). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**



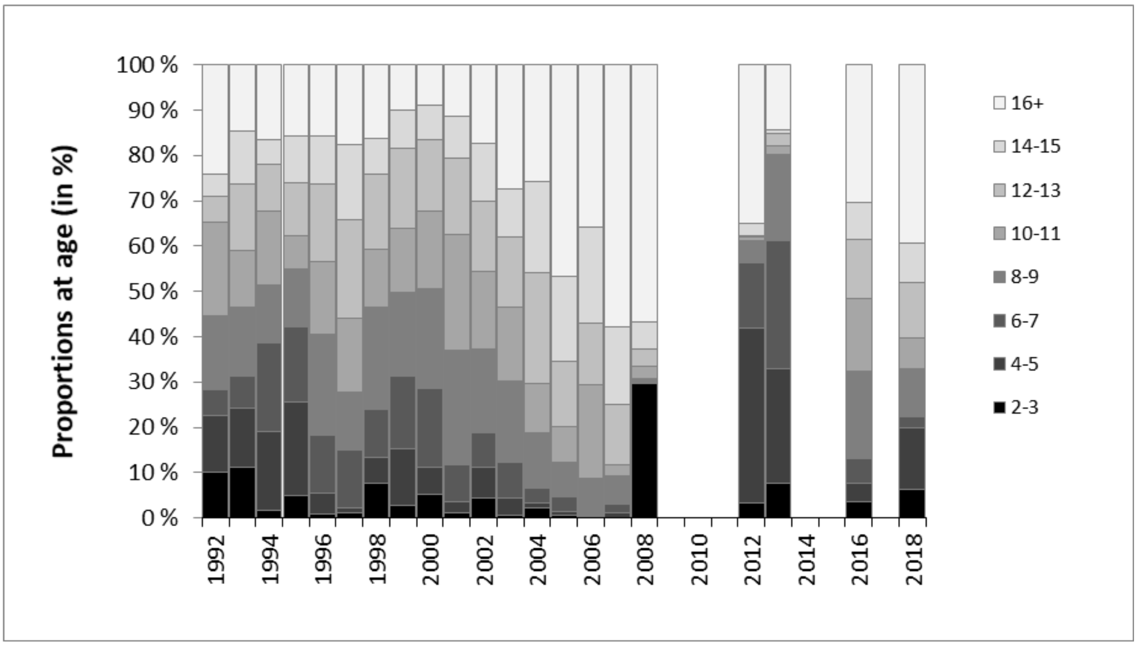


Figure 7.7b. *S. norvegicus*. Abundance indices disaggregated by age. Combined Norwegian bottom–trawl surveys 1992–2018 in the Barents Sea (winter) and Svalbard survey (summer/autumn). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population. In 2009–2011, 2014–2015, 2017, 2019–2022 there was insufficient number of age readings to derive numbers-at-age.

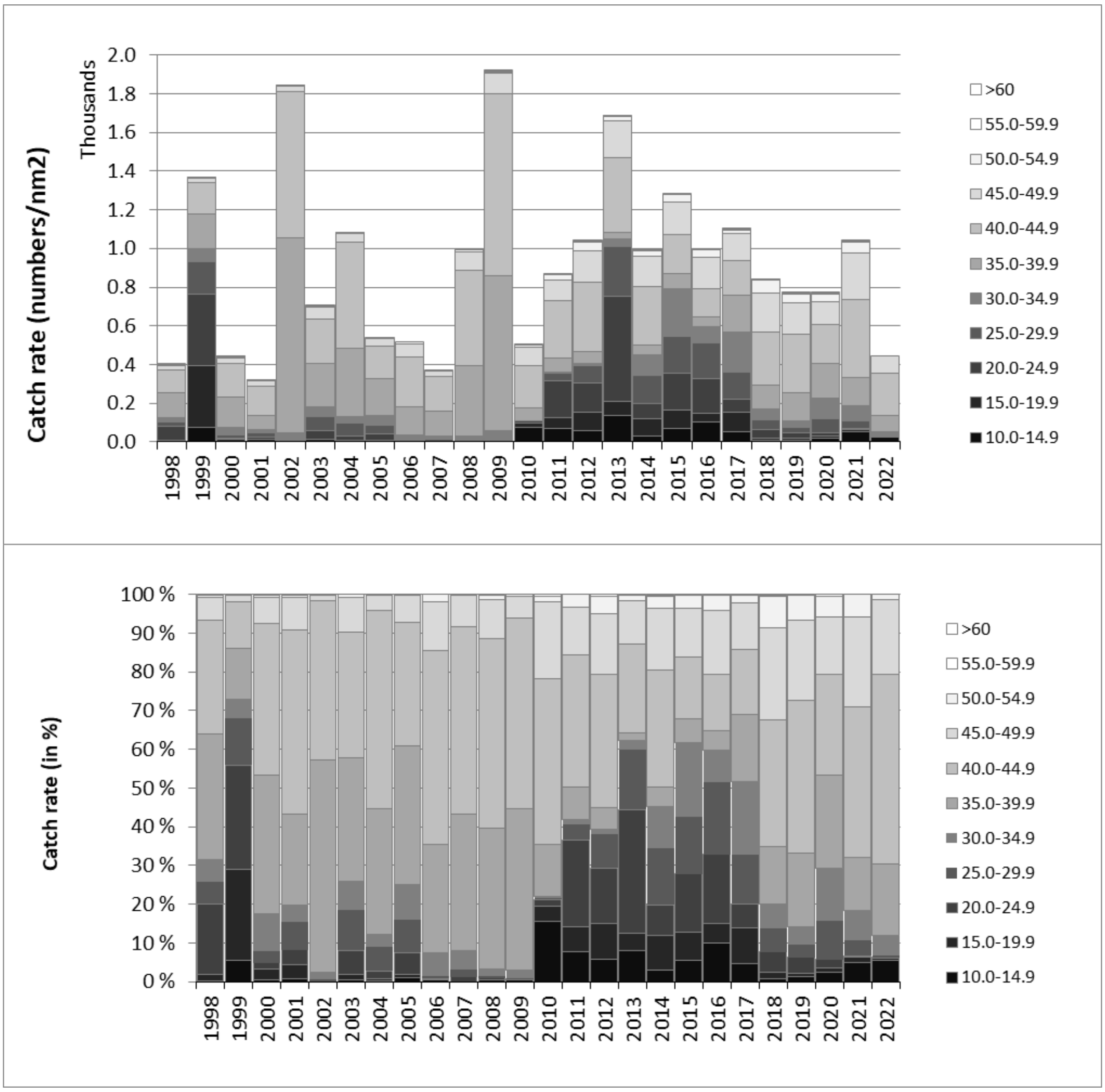


Figure 7.8. *S. norvegicus.* Catch rates (numbers/nm) disaggregated by length for the Norwegian coastal survey 1998–2022. Top: absolute catch rates. Bottom: relative values.

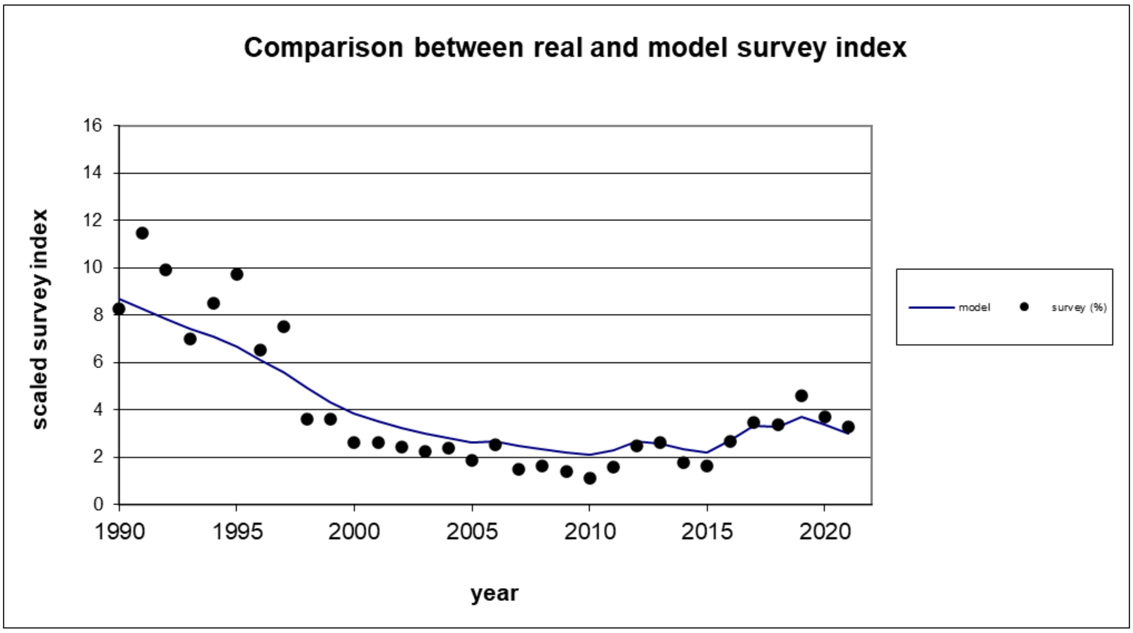


Figure 7.9. ***S. norvegicus*** **in subareas 1 and 2. Comparison of observed and modelled survey indices (total number scaled to sum=100 during the period) for the Barents Sea winter survey in February. Dots: survey indices. Plain lines: survey indices estimated by the model.**

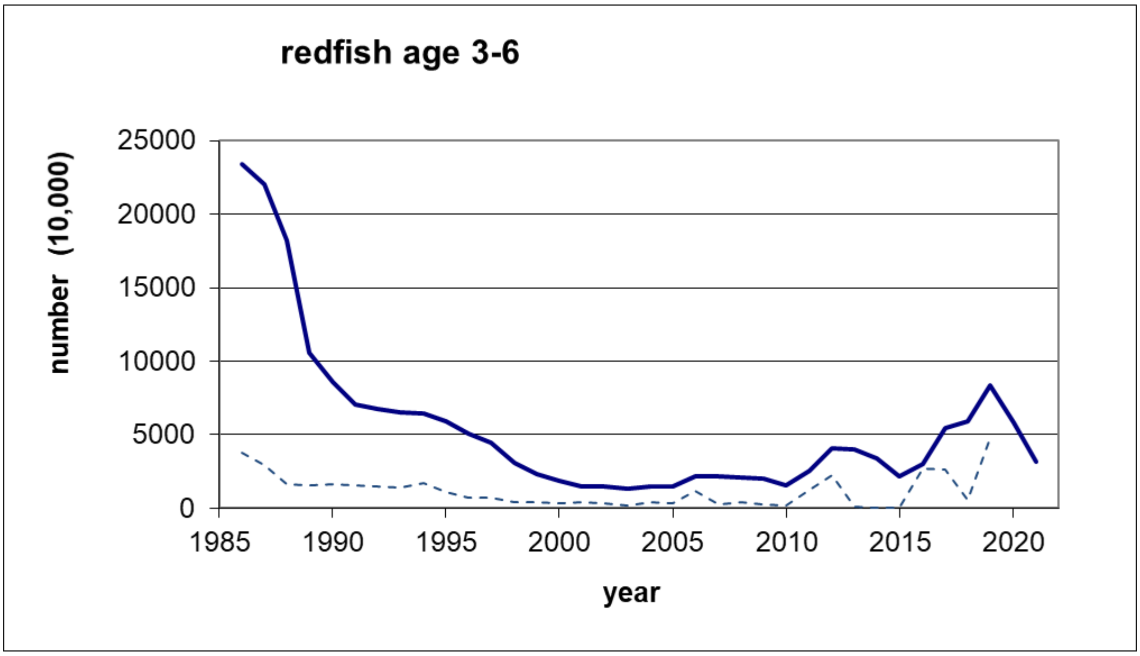


Figure 7.10. ***S. norvegicus*** **in subareas 1 and 2. Estimates of abundance–at–age 3–6 by Gadget for this year's assessment (solid line) and the last assessment (broken line), with data up to 2019 and 2021, respectively. Note that recent year (since 2015) have very little tuning data behind them.**

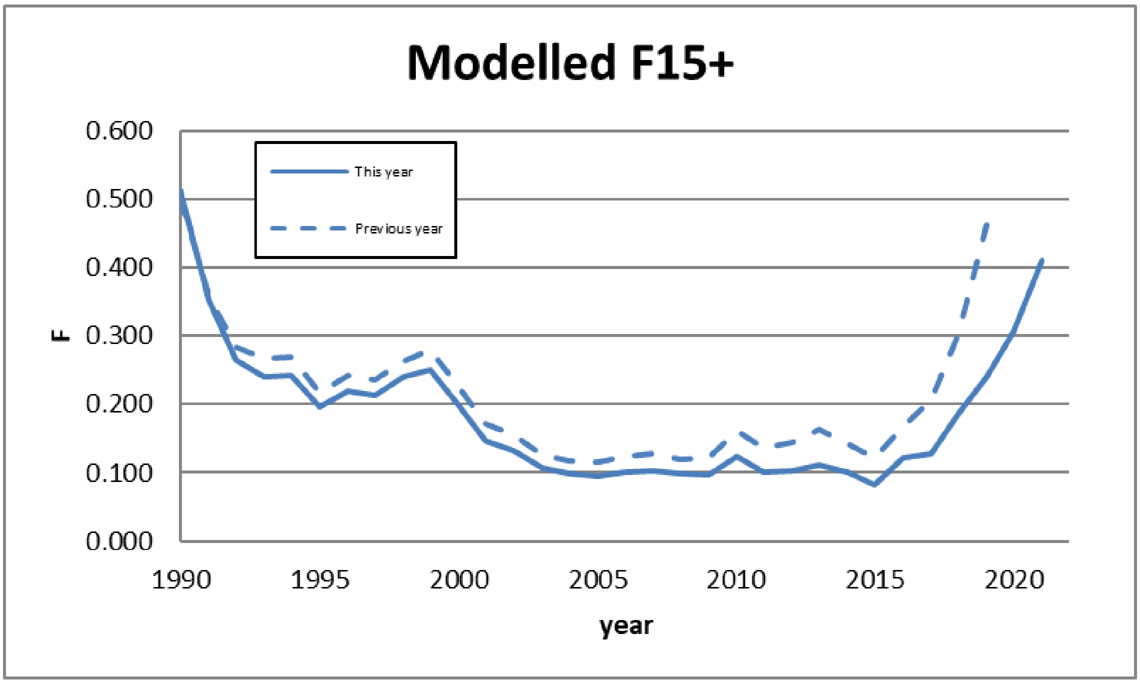


Figure 7.11. *S. norvegicus* in subareas 1 and 2. Unweighted average fishing mortality of ages 15+. Solid line shows this year's assessment (data up to 2021) and the dashed line shows last assessment (data up to 2019).

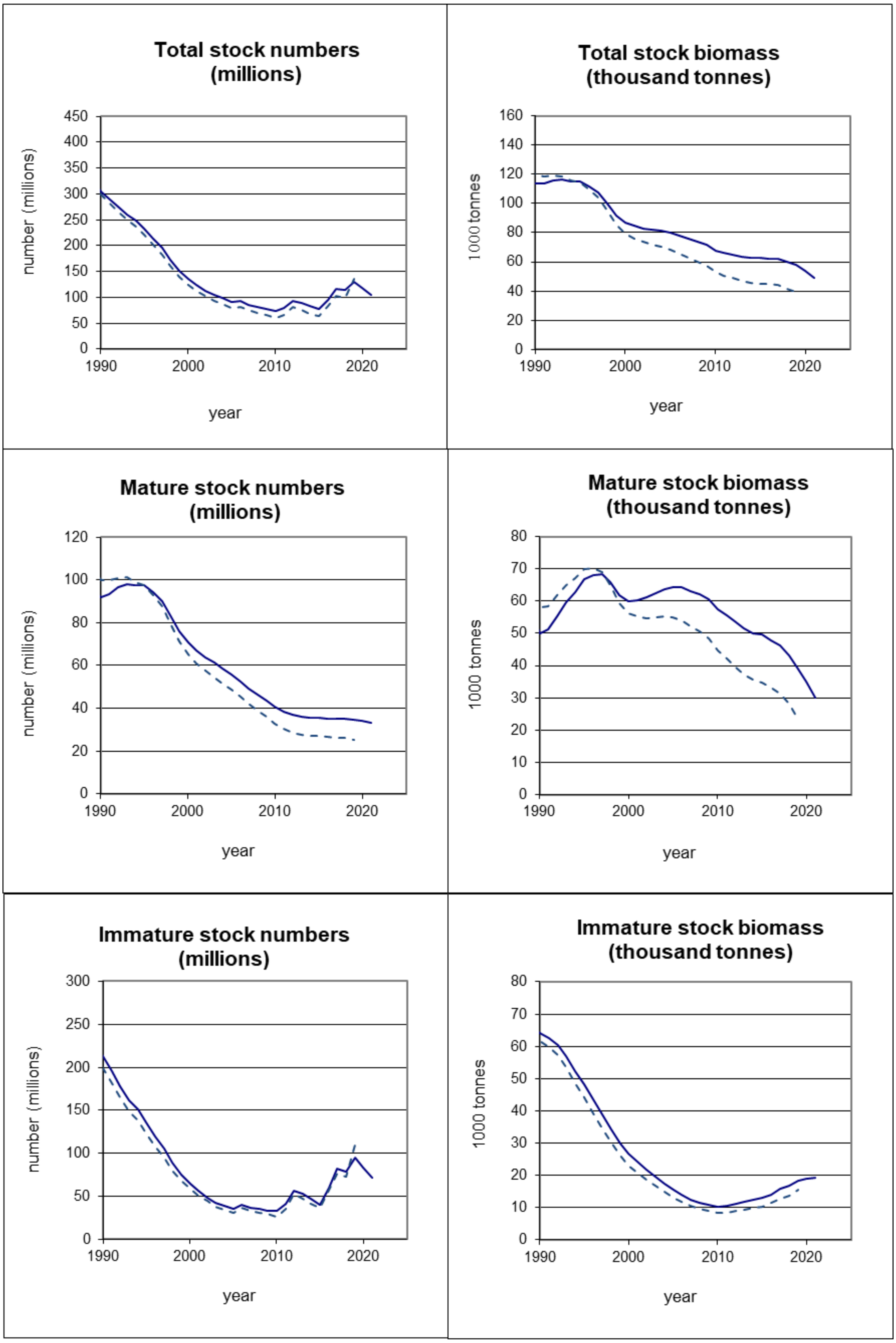


Figure 7.12. ***S. norvegicus*** **in subareas 1 and 2. Stock numbers (in millions) and biomass (in 1000 tonnes) for the total stock (3+; upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input. Solid line shows this year's assessment (data up to 2021), and the dashed line shows last assessment (data up to 2019).**

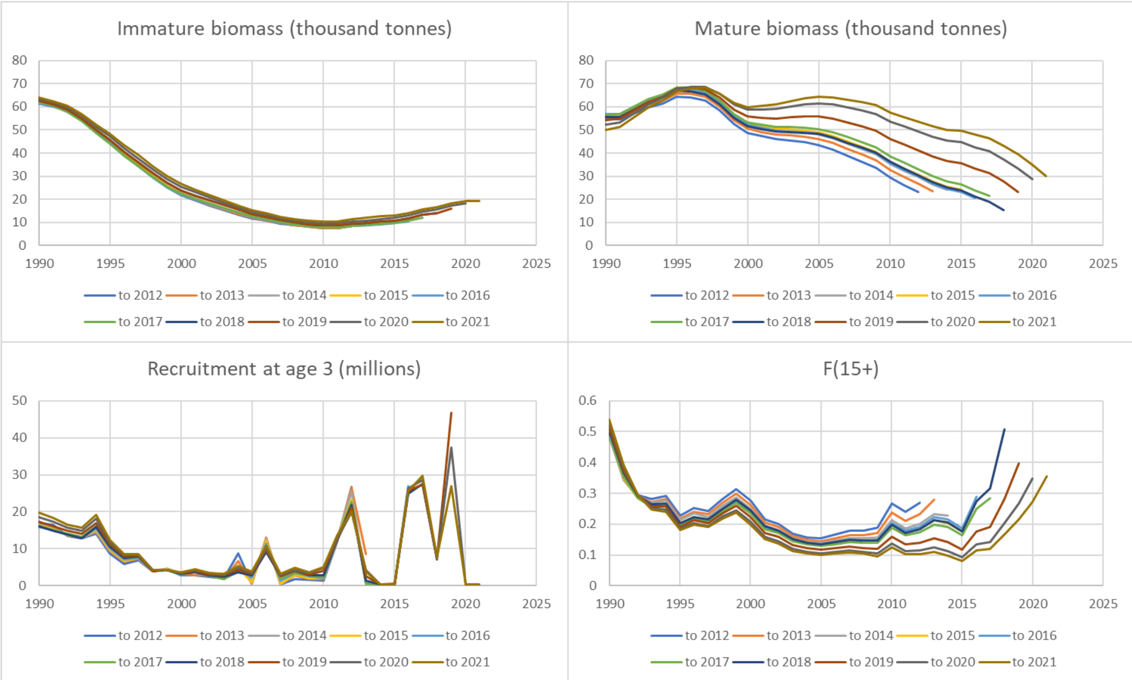


Figure 7.13. Gadget retrospective trends 2012 to 2021, immature biomass, mature biomass, recruitment–at–age 3, and F(15+).

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	0	0.09	0.15	0.31	0.22	0.21	0.19	0.21	0.23	0.23	0.34	0.33	0.36	0.38	0.46	0.48	0.45	0.58	0.47	0.43	0.25	0.22	0.38	-	0.45
1993	-	-	0	0	0.1	0.31	0.54	0.5	0.54	0.66	0.84	0.76	0.82	0.83	0.91	0.84	0.9	0.87	0.74	0.91	1	1	-	1	1	1
1994	0	0	0.03	0.05	0.28	0.28	0.34	0.7	0.79	0.91	0.94	0.85	0.92	1	0.96	0.96	1	0.88	1	1	1	1	-	1	1	-
1995	0	0	0	0.05	0.02	0.22	0.25	0.48	0.62	0.64	0.68	0.8	0.87	0.88	0.76	0.89	0.9	0.91	1	1	1	1	-	-	-	-
1996	0	0.05	0.14	0.13	0.22	0.38	0.45	0.6	0.65	0.75	0.69	0.77	0.9	0.85	0.91	0.88	0.96	0.93	1	0.87	0.95	0.95	1	-	1	0.86
1997	0	0.05	0.08	0.15	0.17	0.21	0.34	0.36	0.58	0.64	0.72	0.74	0.86	0.93	0.94	1	1	0.95	0.96	0.94	1	0.88	1	1	1	-
1998	0	0	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	1	0.67	0.7	1	1	-	-	1	0.88
1999	0	0	0	0.04	0.17	0.35	0.23	0.53	0.73	0.71	0.67	0.69	0.74	0.71	0.77	0.89	-	0.83	-	1	0.89	-	-	-	-	-
2000	0	0.08	0.14	0.25	0.4	0.53	0.59	0.62	0.65	0.69	0.78	0.96	0.96	1	1	-	-	-	1	-	-	-	-	-	-	-
2001	-	0	0.06	0.14	0.28	0.32	0.4	0.52	0.53	0.6	0.76	0.74	0.81	0.85	0.6	0.7	0.56	-	-	-	-	-	-	-	-	-
2002	-	0	0.05	0.07	0.23	0.46	0.41	0.63	0.74	0.93	0.77	0.89	0.9	0.94	0.96	0.92	0.95	0.95	1	1	1	1	1	1	1	-
2003	-	0	0	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	-	1	-	-	-	-	-
2004	-	0	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	0.86	1	-	-	-	-	-
2005	-	-	0	0.04	0.39	0.16	0.33	0.4	0.41	0.57	0.74	0.81	0.78	0.82	0.78	0.94	0.95	0.88	0.83	1	-	1	-	-	-	-
2006	-	-	0	0.1	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	-	1	-	-	-	-

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	0.08	0.3	0.26	0.2	0.66	0.68	0.7	0.88	0.86	0.89	0.99	0.98	1	0.96	0.94	1	0.92	1	0.83	1	1	1	-
2008	-	-	0.8	0.25	0.82	0.68	0.62	0.8	0.79	0.86	0.88	0.91	0.9	0.92	0.92	0.9	0.93	0.93	0.94	1	1	1	1	1	0.93	1
2009	-	-	-	-	-	0.5	0.5	1	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	0.93	0.83	0.86
2010	-	-	-	-	-	-	-	-	0.78	0.77	0.87	1	0.64	0.93	0.91	1	0.95	0.9	1	0.73	0.8	0.83	1	0.6	0.6	-
2011	-	-	-	-	-	-	-	-	-	-	0.73	0.78	0.94	0.93	0.89	0.92	0.92	0.93	0.83	0.85	1	1	-	0.83	-	-
2012	0	0.11	0.1	0.29	0.2	0.2	-	-	-	0.76	0.72	0.7	0.91	0.78	0.88	0.89	0.85	0.81	0.95	0.81	0.86	1	0.93	1	1	1
2013	0	0.12	0.05	0.1	0.19	0.38	0.71	-	0.29	0.82	0.92	0.89	0.77	0.86	0.75	0.79	0.73	0.83	0.89	0.95	1	0.67	1	1	1	1
2014	0	0	0.02	0.08	0.21	0.43	0.41	0.53	0.33	0.58	0.69	0.71	0.8	0.92	0.92	0.95	0.63	0.96	0.9	0.84	0.95	0.83	1	-	0.78	0.88
2015	0	0.05	0.17	0.17	0.3	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	0.95	0.96	0.83	0.84	1	0.87	0.82
2016	0	0.04	0.02	0.05	0.23	0.16	0.26	0.43	0.59	0.42	0.62	0.57	0.8	0.73	0.87	0.74	0.88	0.79	0.78	0.97	0.81	0.89	0.89	0.67	1	0.94
2017	0.33	0.07	0.09	0.17	0.19	0.22	0.4	0.59	0.53	0.68	0.85	0.7	0.87	0.89	0.9	0.96	1	0.92	0.86	0.94	0.93	0.95	0.9	0.83	0.83	1
2018	-	-	0	0	0.16	0.46	0.59	0.34	0.32	0.53	0.72	0.57	0.9	0.53	0.67	0.92	-	0.8	0.75	1	1	0.78	0.63	1	-	-
2019[1]	0.03	0.12	0.25	0.22	0.26	0.32	0.51	0.48	0.53	0.63	0.64	-	-	-	-	-	-	-	-	-	0.75	-	-	-	-	-
2020[1]	-	0	0.38	0.29	0.53	0.75	0.73	0.74	0.85	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1 – Provisional figures.

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 2023. 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
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

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**
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
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

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
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	1.8	1.9	0.6	1.5	2.0	2.6	8.0	10.6	39.4	68.4
2023[1]	1.7	2.8	0.7	0.9	0.9	1.7	5.1	14.4	16.9	45.1

1 – Provisional figures. Russian data not provided in time for AFWG 2023.

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 2020–2023 at the time of AFWG 2023. 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

Year/age	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
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
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	402	737	648	953	0	2522	3842	7964	1661	787	3806	352	204	4747	28625
2018	1597	1016	892	354	696	1784	2627	1086	1596	2558	2358	3478	1311	7647	28999

Year/age	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
2019	939	1725	780	2080	1464	2136	2821	3349	5696	7266	3475	2071	942	5334	40076

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 2022. 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
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

	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
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
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

	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
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
2021	0	184	1277	1849	1074	95	407	20	69	4975
2022	958	913	376	811	1449	342	189	104	422	5564

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 2018. Since 2005 this is part of the Ecosystem survey (Eco–NoRu–Q3 (BTr)). In 2009–2011, 2014–2015 and 2019–2022, there was insufficient number of age readings to derive numbers-at-age, or age readings were not available at the time of the AFWG 2023.

	Age													
Year	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

	Age														
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
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
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

	Age														
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
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/nm²) of *S. norvegicus* from the Norwegian Coastal Survey (NOcoast-Aco-Q4; Division 2.a) in 1998–2022.

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

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)
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
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
2022	0	12281	24472	2385	751	2481	23120	83750	219794	87298	5834	0	0	97	130	839	839	43574

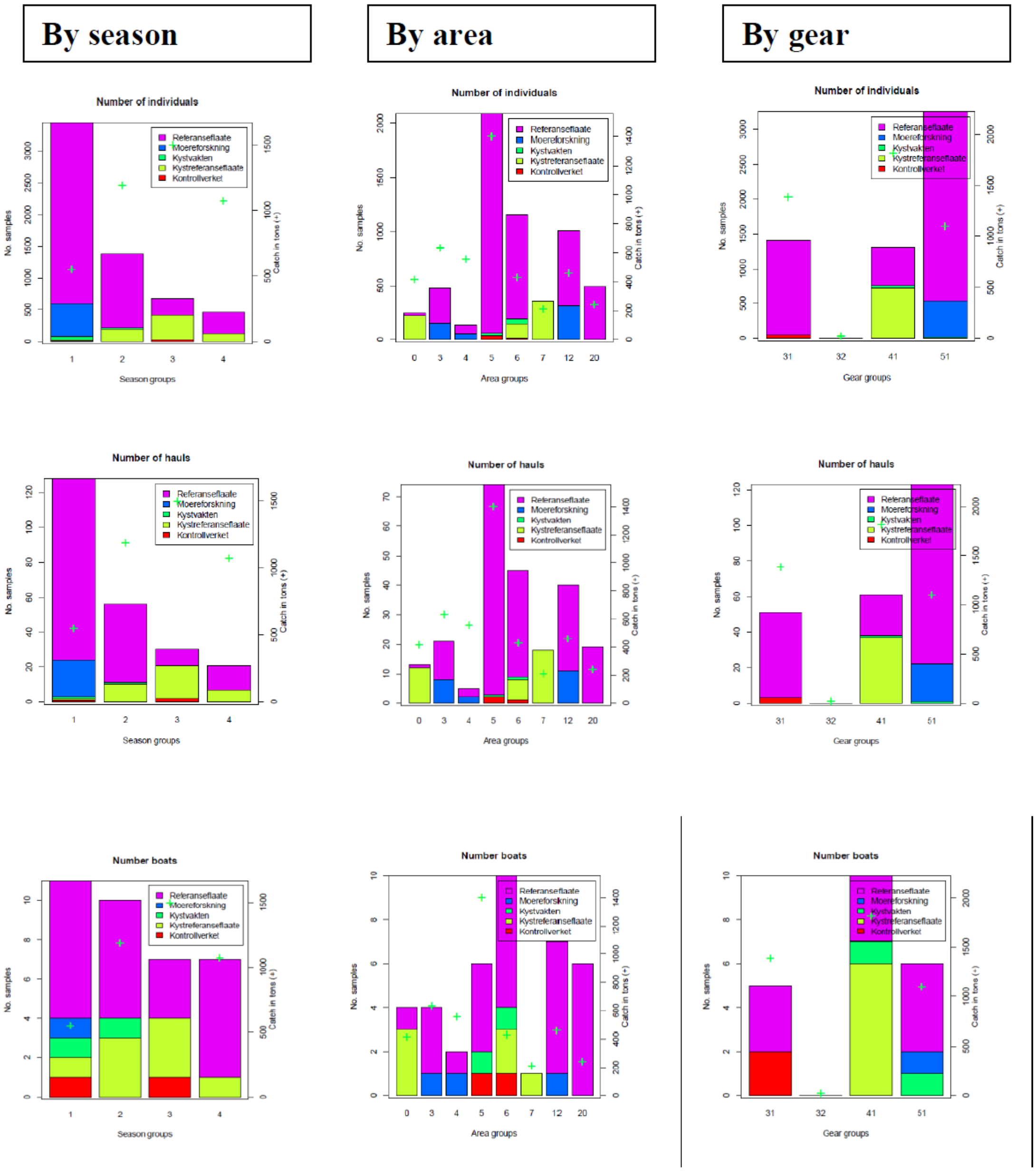


Figure E1. Overview of the Norwegian biological age samples (number individuals, number hauls/sets, number of boats) from the commercial fisheries for *S. norvegicus* in 2013 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which 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.

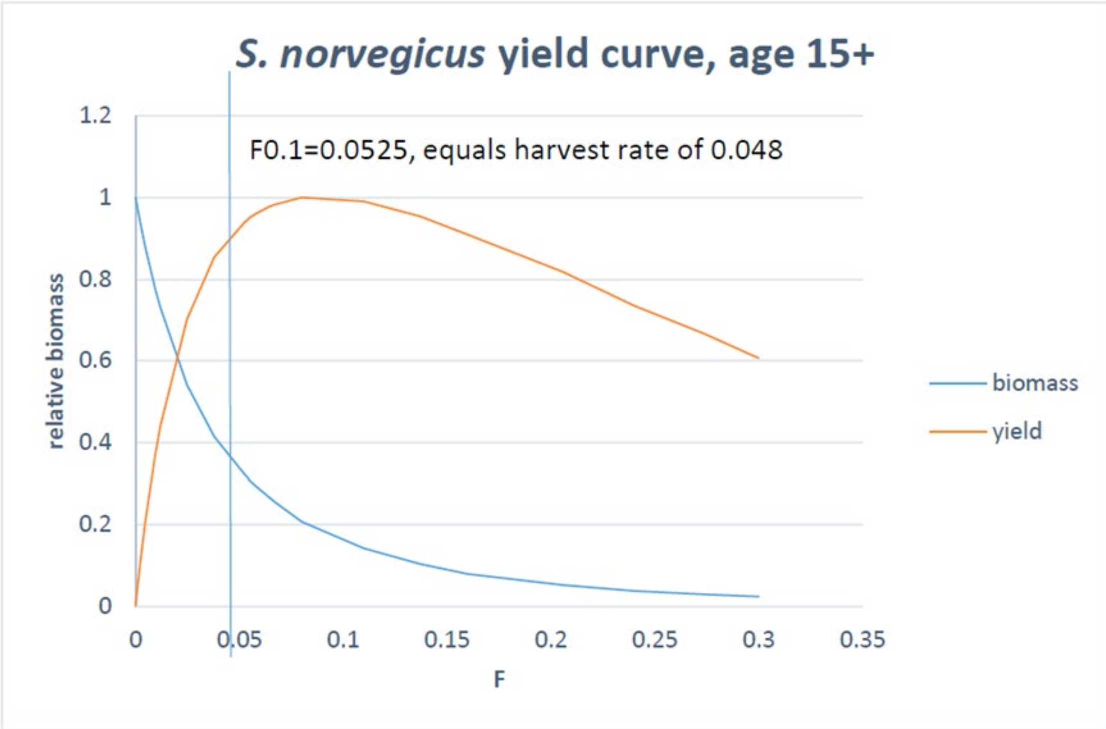


Figure E2. *S. norvegicus* in subareas 1 and 2. Yield-per-recruit for *S. norvegicus*, computed from the GADGET assessment model presented at the benchmark assessment in January 2018 (WKREDFISH, ICES 2018a).

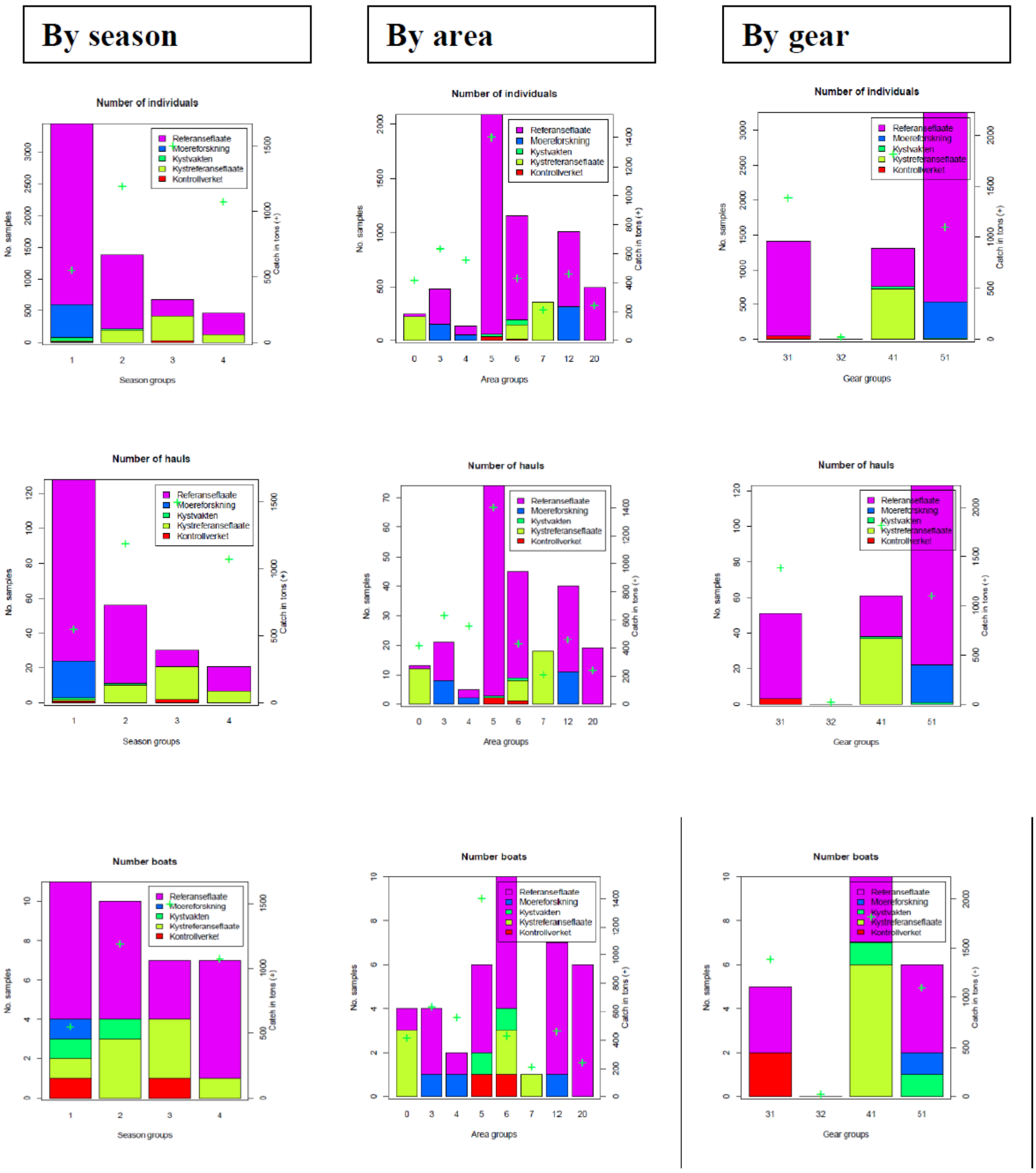


Figure E1. Overview of the Norwegian biological age samples (number individuals, number hauls/sets, number of boats) from the commercial fisheries for *S. norvegicus* in 2013 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which 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.

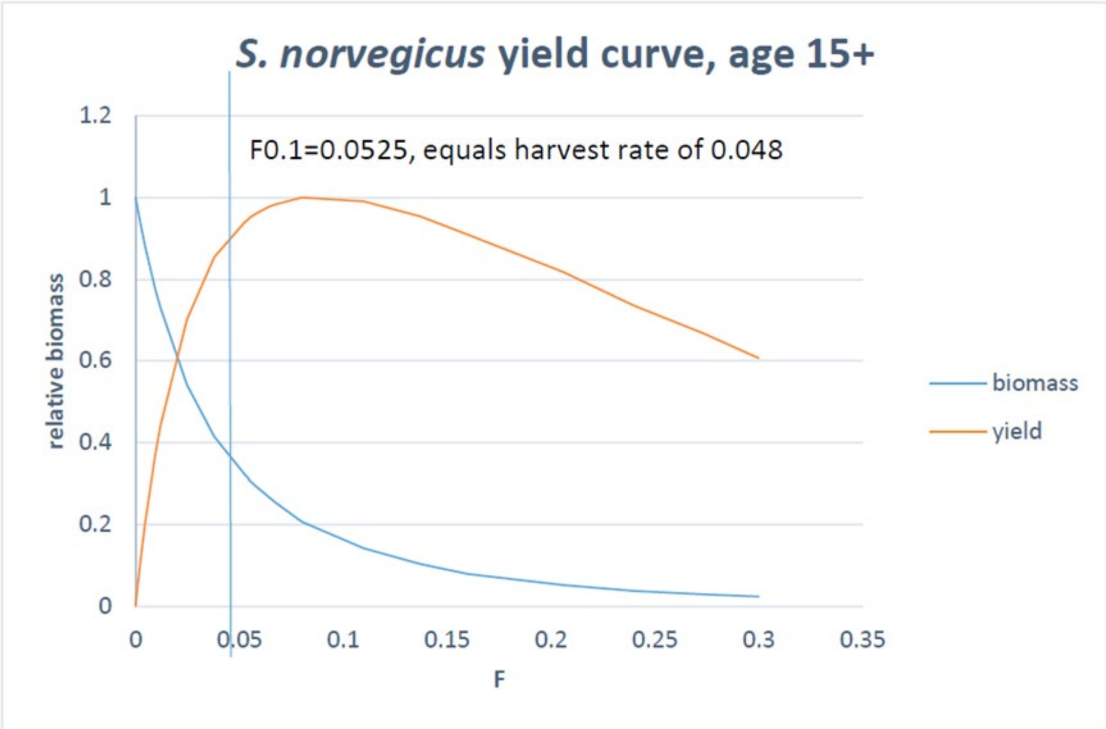


Figure E2. *S. norvegicus* in subareas 1 and 2. Yield-per-recruit for *S. norvegicus*, computed from the GADGET assessment model presented at the benchmark assessment in January 2018 (WKREDFISH, ICES 2018a).

8 Northeast Arctic Greenland halibut

ghl.27.1-2 – *Reinhardtius hippoglossoides* in subareas 1 and 2

On 30 March 2022, all Russian participation in ICES was suspended. Owing to this temporary suspension, it is not currently possible to run an ICES assessment for NEA cod. It is however critical for good ecosystem and fisheries management that such assessments be run and be used as the basis of management. An assessment for this stock has therefore been conducted in 2022 outside ICES by a bilateral Russian-Norwegian group, the "Joint Russian-Norwegian Arctic Fisheries Working Group" (JRN-AFWG). The assessments occur outside ICES but follow the stock annexes previously agreed within ICES, use the same data and models as previously, and are conducted by the same Russian and Norwegian scientists that were involved in the previous ICES assessments. The managing body in the Barents Sea (the Joint Norwegian Russian Fisheries Commission; JNRFC) has used the advice as the basis of management, following the same procedures previously used for ICES advice. JNRFC also endorsed this approach to be continued for the 2023 advice (52nd session[1], Appendix 10).

The report of the JRN-AFWG assessment and the associated advice sheets also follow closely the previous ICES reporting format and are published online by the Norwegian Institute of Marine Research. For NEA Greenland halibut the relevant information for 2023 can be found at:

2023 report:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-7

Advice on fishing opportunities in 2024:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-6

[1] https://www.jointfish.com/OM-FISKERIKOMMISJONEN/PROTOKOLLER.html

9 Northeast Arctic anglerfish

anf.27.1-2 – *Lophius budegassa, Lophius piscatorius* in subareas 1 and 2

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) should be considered a category 3 stock, for which survey or other indices (e.g. total mortality, recruitment, abundance) that provide reliable indications on stock trends are available.

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). 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 showed the likelihood that *Lophius* around Iceland (Solmundsson *et al.*, 2007), Faroe Islands (Ofstad, 2013) and Norwegian waters north of 62°N (i.e. subareas 1 and 2) were recruited from the area west of Scotland including Rockall. This finding was further supported by research survey data as a migration east-/north-eastwards with size was seen in the International Bottom Trawl Survey (IBTS) and other survey data (e.g. Dyb, 2003).

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 found no biological evidence to support the current separation of *Lophius* stocks in the Northeast Atlantic, but found substructures within the area.

Tagging studies neither revealed any advice on stock structure. 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 showed the tagging locations and the hitherto recaptures and suggested that there were migrations in all directions, i.e. anglerfish were recaptured in the southern North Sea, around Shetland/Faroes, up to Lofoten. Most of the recaptures happened at Møre, where most of the fish were also tagged. Additionally, 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 observation is of particular importance as it may indicate a wider mixing of stocks and validate the growth rate of anglerfish over several years.

In light of all these observations, 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 (L_{50}) 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 during the last year landings expanded 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 2.a 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 4.a, 6.a and 6.b), with the exception of the central and southern parts of Subarea 4 and the Skagerrak and Kattegat (Division 3.a). The survey began in 2005 and has more or less been 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, a decrease of 19% compared to 2019, and the lowest value since 2013. A large proportion of total population numbers consisted of individuals <30 cm in 2021, suggesting reasonably strong 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 (now back to the level before 2014) 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 and table H1) provide 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 1992–2022, 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 H3-H5. 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 and table 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 2007–2022.
- 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"[1]. 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, L_{50}, L_{95} (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 a target reference point of SPR=0.37 (with F/M=1) and SPR=0.23 (with F/M=1.85) and for a steepness value of 0.7 and 0.9, respectively. The stochastic LBSPR runs show a relatively stable annual estimates of SPR (between 0.15 and 0.5 (the IQ range)) and F/M (between 1.0 and

[1] https://github.com/AdrianHordyk/LBSPR

2.5 (the IQ range; Figure 9.7). This would suggest that while there is a lot of uncertainty, the population is fully exploited (estimated values of F/M and SPR included the target reference point ranges).

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 a major 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 tons 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

Based on plotting of raw data, catch weight and standardized effort were proportionally related. Therefore, all subsequent analysis on CPUE standardization was performed on the raw CPUE (per gillnet day). 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 2020) 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.

Like the last three assessments (AFWG 2020, 2021, 2022), data were filtered to keep only vessels that had more than 10 observations (as these rare vessel observations were causing deviations in the residual patterns due to difficulty in separating the vessel effect from other effects). However, the original model based on Tweedie distribution (AFWG 2020) showed a problematic residual pattern like the last assessment (AFWG 2022). In-depth investigation indicated that part of the problem was linked to the variability of vessel catchability per year.

Therefore, this year's final Tweedie model was configured using the following parameterization where the novelty lies in the use of the (1|vessel_year) random effect instead of (1|vessel). This enables capturing the variability of vessel catchability between years:

(eq 1)

$$"Presence = year + subarea + month + (1|vessel) + (1|subarea\neg\neg\_year) \\ + (1|month\_\neg year) + (1|month\_subarea)"$$

The expression (1|xxx) indicates that the variable xxx is considered as a random effect and acts on the intercept. The expression (1|xxx_yyy) indicates that the xxx and yyy variable were concatenated into a single variable and considered as a random effect. This is like modelling the interaction between xxx and yyy, but the approach only considers existing interaction as opposed to all combination of xxx and yyy when including as fixed interaction effect (which would be unestimable). The inclusion of (1|vessel_year) random effect helped reduce some residual pattern but did not fully eliminate it. Therefore, a delta model was developed like in the last assessment (AFWG 2022) in the aim of removing the 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. All variables were kept the same as in the Tweedie model except for the use of (1|vessel) random effect for the occurrence model as species occurrence did not vary much between year per vessel (the occurrence model with the (1|vessel_year) random effect had a poorer residual performance).

(eq 2)

$$"Presence = year + subarea + month + (1|vessel) + (1|subarea\neg\neg\_year) \\ + (1|month\_\neg year) + (1|month\_subarea)"$$

(eq 3)

$$"CPUE\_pos = year + subarea + month + (1|vessel\_year) + (1|subarea\neg\neg\_year) \\ + (1|month\_ - year) + (1|month\_subarea)"$$

Anglerfish occurrence was modelled using a binomial model with logit transform and positive CPUE was modelled using a Student-t distribution with log link where the degree of freedom was estimated within the model (d.f.~1.55. This suggests a highly skewed distribution). The delta model specification eliminated all the residual pattern (Figure 9.8).

For all subsequent analysis, we considered the delta model results as the new default but still included the original Tweedie model results as a sensitivity test.

As in all previous assessments, the standardized annual CPUE index was created by summing up all predictions based on all 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 2.a). In this process, we removed the "vessel_year" random effect (assuming it equals 0, the mean value) as we assumed it captured the variability of vessel catchability but not 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 with a confidence interval except that model predictions and uncertainty were manually calculated. 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 effects were kept at their MLE except for the vessel_year effect that was replaced by 0. These values were then used to predict the probability of occurrence and positive CPUE value for all combination of year, subarea, and month (as in the Tweedie model) for each of the 100.000 samples. The estimated probability of occurrence and positive CPUE were then multiplied together to calculate the expected CPUE. The final index was calculated by weighted average of the predictions by area (like for the Tweedie model) and the mean CPUE trajectory over time along with its SD was calculated across the 100.000 samples.

The trend in the estimated index between the delta (default) and Tweedie (sensitivity) models were similar except for the last three years where the delta model suggested a steeper yet highly uncertain decline in the anglerfish population in ICES Subarea 2.a (Figure 9.9). That said, the five (and only) RF vessels participating in the fishery between 2020–2022 also showed contrasting yet variable trends in the average raw CPUE. Moreover, one out of the five vessels only started in the RF program in 2020. All of this contributed to the increasing uncertainty in the estimated trend.

9.3.3 JABBA

JABBA stands for 'Just Another Bayesian Biomass Assessment' and is an 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 billfishes around the world (Winker *et al.*, 2018). JABBA requires at least two comma-separated value files as input (.csv): one for catch and another for abundance indices (with their SE) . 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 retrieved from Figure 9.14. 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 2 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 (e.g. 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 1990–2022 based on the 11 tested scenarios (Table 9.7). In general, population abundance seems to have fluctuated around B_{MSY} (at least the mean trajectory) over the last ten years while fishing mortality might have been slightly above F_{MSY} in more recent years (Figure 9.11). Figure 9.12 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 2022 estimates of biomass and fishing mortality. The percentage numbers at the top right indicate how much of the 2022 population estimates falls 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 colored quadrant). The model estimates that there is a 45.7% (15%) probability that the 2022 population estimate falls within the red zone, 15.6% (30%) in the orange, 3.4% (0.5%) in the yellow, and 35.2% (54.5%) in the green zone (numbers in parentheses show the 2021 values from previous assessment) suggesting a worse stock condition than last year. Finally, retrospective analysis on the base model run has improved compared to the previous assessment cycle (AFWG 2022) without any worrisome patterns (Figure 9.13, Table 9.7).

Management considerations and recommended advice

The abundance of anglerfish in subareas 1 and 2 seems to depend on the influx or migration of juveniles from ICES subareas 4 and 6. An effective discard ban on anglerfish in subareas 4 and 6 will hence have a positive effect on the abundance north of 62°N. A variable mean size of the landed anglerfish observed during the last 30 years, when fishing with the same large-meshed gillnets, is an indication of variable influx of recruitment to the ICES subareas 1 and 2. It is recommended that people involved in this Northeast arctic anglerfish assessment hence participate at the ICES benchmark assessment for anglerfish in ICES Subareas 3, 4 and 6 planned for autumn 2023-spring 2024.

The three distinct assessment approaches tested in this report offer corroborative evidence that the anglerfish population has declined over time and that population might be at or below B_{MSY} in 2022 but with a slightly high effort level (probably above F_{MSY}).

The spawning potential ratio and F/M values calculated by the LBSPR method suggests that while there is a lot of uncertainty, the population is fully exploited (estimated values of F/M and SPR included the target reference point ranges).

An increase in effort and CPUE after 2016 coincided with a sudden fall in mean size of the anglerfish caught with the standard large-meshed gillnets. This seems also to coincide with these year classes seen in the North Sea anglerfish survey as juveniles some years before. Since new recruits into ICES Subarea 2.a may temporarily reduce the overall mean weight of the anglerfish population in Subarea 2.a, and hence also the CPUE which is measured in weight or biomass, the fishing effort and mean length development may indicate recruitment immigration sooner and when it happens. The standardized CPUE analysis shows that anglerfish population in ICES Subarea 2.a has declined over the three most recent years but with a large uncertainty around the final year (2022) estimate. And since this CPUE decrease happens some years after the immigration of new recruits, it indicates a stock biomass reduction that only partly will be compensated by individual growth (mean length).

The relative population stock status in 2022 is around B_{MSY}, though fishing intensity could be close or slightly higher than F_{MSY}. Therefore, effort should be decreased at the risk of the population falling below the biomass and SPR targets.

Candidate advice

Following the ICES technical guidance for harvest control rules and stock assessment for stocks in category 2 (ICES 2022), the "fractile rules" based on the 35th percentile of the predicted catch distribution given a target fishing mortality was applied to the JABBA base-case scenario model. Due to the lack of official harvest control rule for assessment using JABBA, slight modification was made to the ICES "fractile rules" and the posterior distribution of the estimated MSY was used as basis for the catch recommendation.

The recommended TAC was estimated at 1930 t (Figure 9.15) and population projections were made for 2023–2025 using the base case model and assuming a constant annual catch of 1930, 2000, 2100, and 2200 t, respectively (Figure 9.16).

Figure 9.16 indicates that at the recommended TAC of 1930 t, the mean anglerfish population is expected to get back to B_{MSY} and F_{MSY} level by 2023.

9.4 Tables and figures

Table 9.1. Nominal catch (t) of anglerfish in ICES subareas 1 and 2, 2009–2022, as officially reported to ICES.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Denmark	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Faroes	2	1	+	+	1	+	+	1	1	+	+	1	-	+
France	-	-	1	3	2	-	4	2	4	3	8	5	4	4
Germany	+	82	70	0	-	+	+	+	1	1	50	-	-	-
Iceland	-	-	7	-	-	-	-	-	-	-	-	-	-	-
Norway	4298	5391	5030	3758	2988	1655	933	1355	1473	1884	2750	2258	2584	2288
Portugal	6	1	+	-	-	-	-	-	-	-	-	-	-	-
UK	152	40	3	3	111	2	105	76	5	15	+	16	13	-
Others	-	-	-	1	1	-	-	+	-	+	-	-	-	-
Total	4458	5515	5112	3765	3103	1657	1043	1435	1484	1903	2809	2280	2601	2293

***Preliminary per 24 March 2023**

Table 9.2. Anglerfish in ICES subareas 1 and 2. Norwegian landings (tonnes) by fishery in 2008–2022. 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	2022*
Coastal gillnet	3574	3934	4806	4573	3521	2758	1506	829	1231	1320	1727	2502	1939	2236	1977
Offshore gillnet	240	171	391	323	115	158	95	52	62	87	68	153	168	229	151
Danish seine	75	68	40	30	16	19	11	12	17	23	28	26	35	78	89
Demersal trawl	34	36	48	22	11	8	7	3	5	6	10	5	3	2	4
Other gears	84	89	106	82	96	45	36	37	40	31	51	64	113	39	67
Total	4007	4298	5391	5030	3759	2988	1655	934	1355	1468	1884	2750	2258	2584	2288

***Preliminary per 24 March 2023.**

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 (L_{50}; mean)	82
Length at 95% maturity (L_{95}; mean)	100

Basic input parameters	**Value**
ΔMat = L_{95} - L_{50} (mean)	18
Length at first capture	40
Length at full selection	60
M (mean)	0.2
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(L_{50})	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	83	221
2022	7		74	73	154

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	78
2022	43

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	1649
2022	1250

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 0 to 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}	procB	MSY
RE_peel1(2021)	0.09	−0.08	0.16	−0.22	0.01	0.1
RE_peel2(2020)	−0.03	0.04	−0.07	0.01	0.01	0.07
RE_peel3(2019)	0.04	−0.04	−0.16	0.36	−0.01	−0.12
RE_peel4(2018)	0.15	−0.13	0.15	−0.11	0	−0.01
RE_peel5(2017)	−0.04	0.04	−0.02	0.09	0	−0.07
Mohn's rho	0.04	−0.04	0.01	0.03	0	−0.01

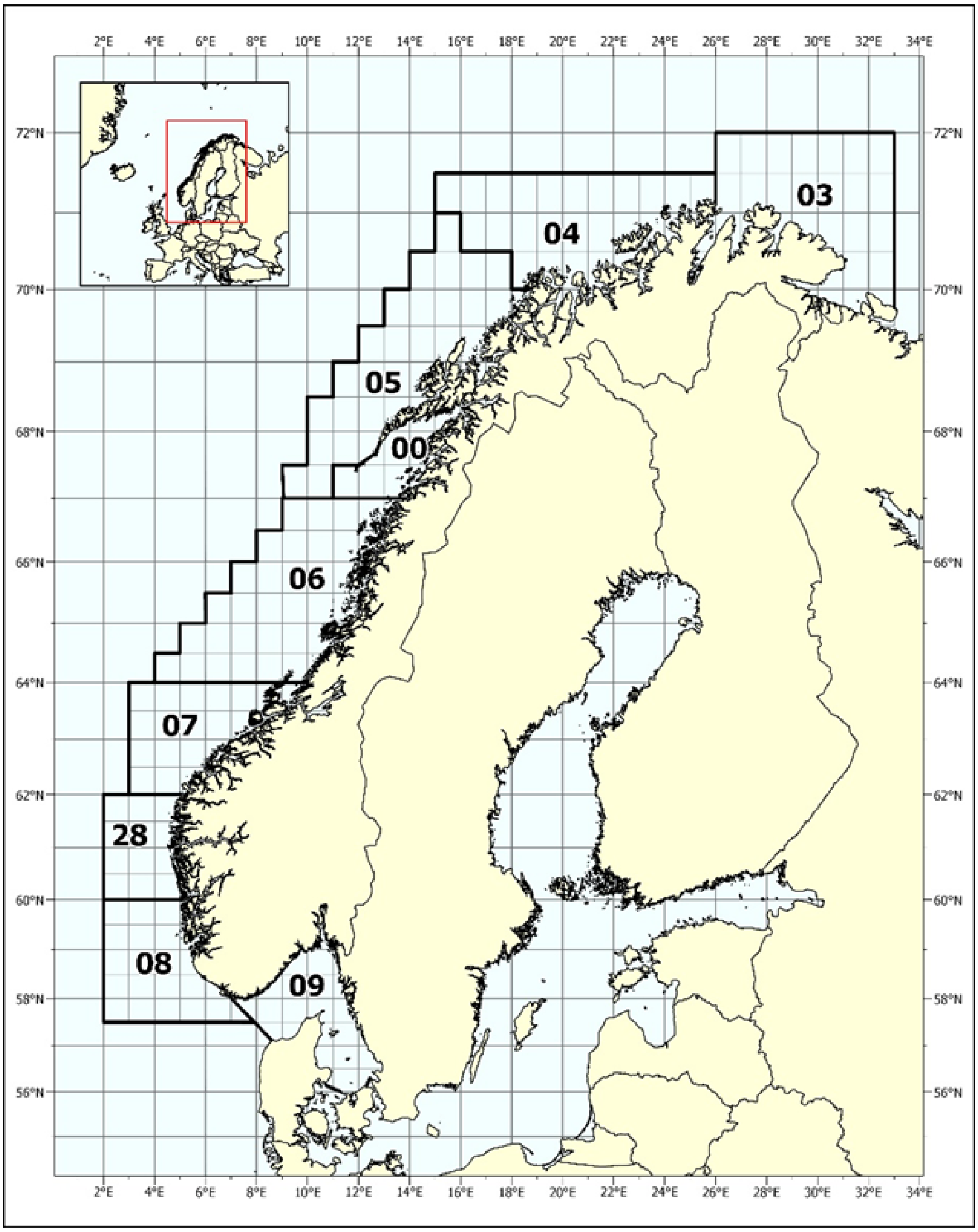


Figure 9.1. Map showing the Norwegian statistical coastal areas. Area 03 is part of ICES Subarea 1; areas 04, 05, 00, 06, and 07 are part of ICES Subarea 2; Areas 28 and 08 are part of ICES Subarea 4, and Area 09 corresponds roughly with ICES Subarea 3.

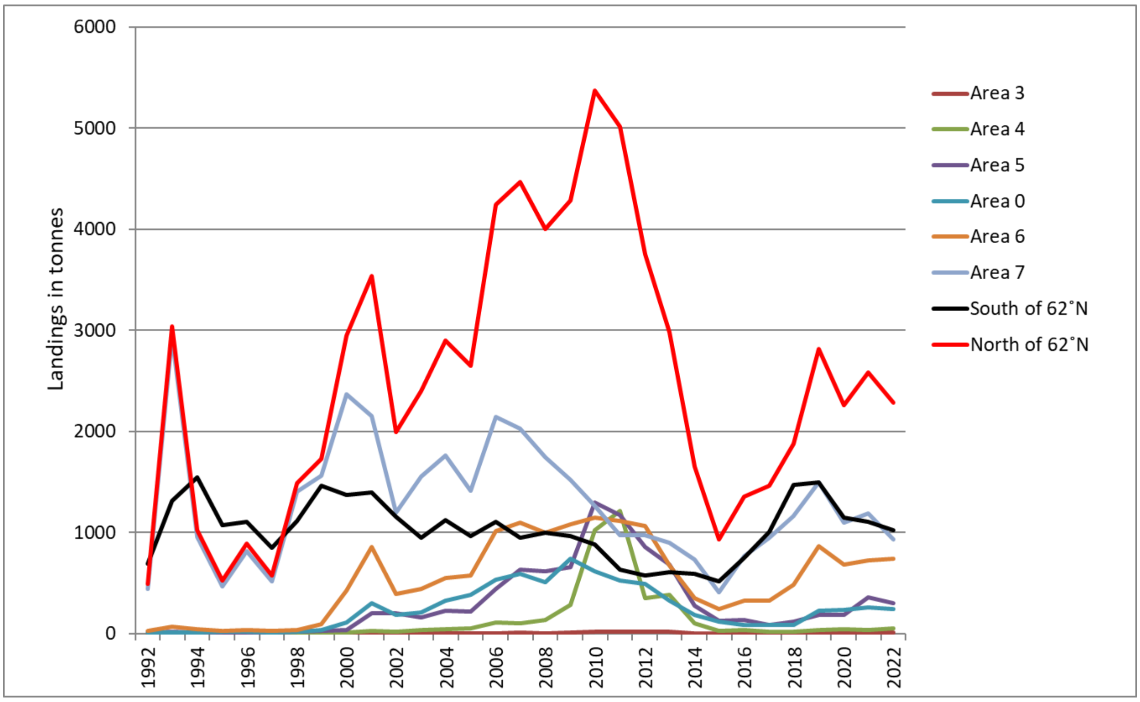


Figure 9.2. Norwegian official landings (in tonnes) of anglerfish (*Lophius piscatorius*) per statistical area (see Figure 9.1) within ICES areas 1 and 2 during 1992–2022. Norwegian landings from the area south of 62°N (ICES 4 and 3) are shown for comparison.

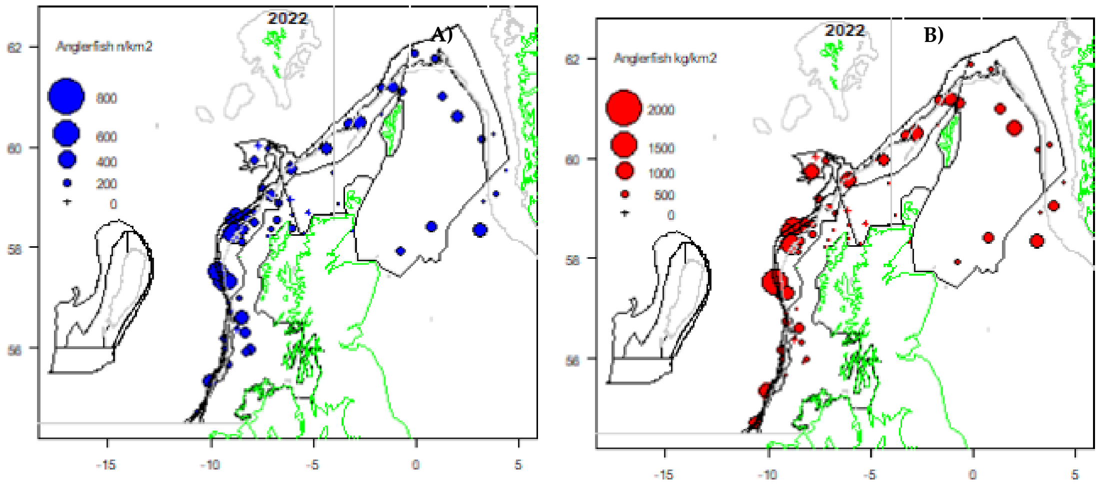


Figure 9.3. Excerpt from WGCSE 2022: A) WGCSE 2022 figure 4.16 - Numbers of anglerfish per km2 observed by SIAMISS surveys 2022. B) WGCSE 2022 figure 4.17 - Weight of anglerfish (kg) per km2 observed by SIAMISS surveys 2022.

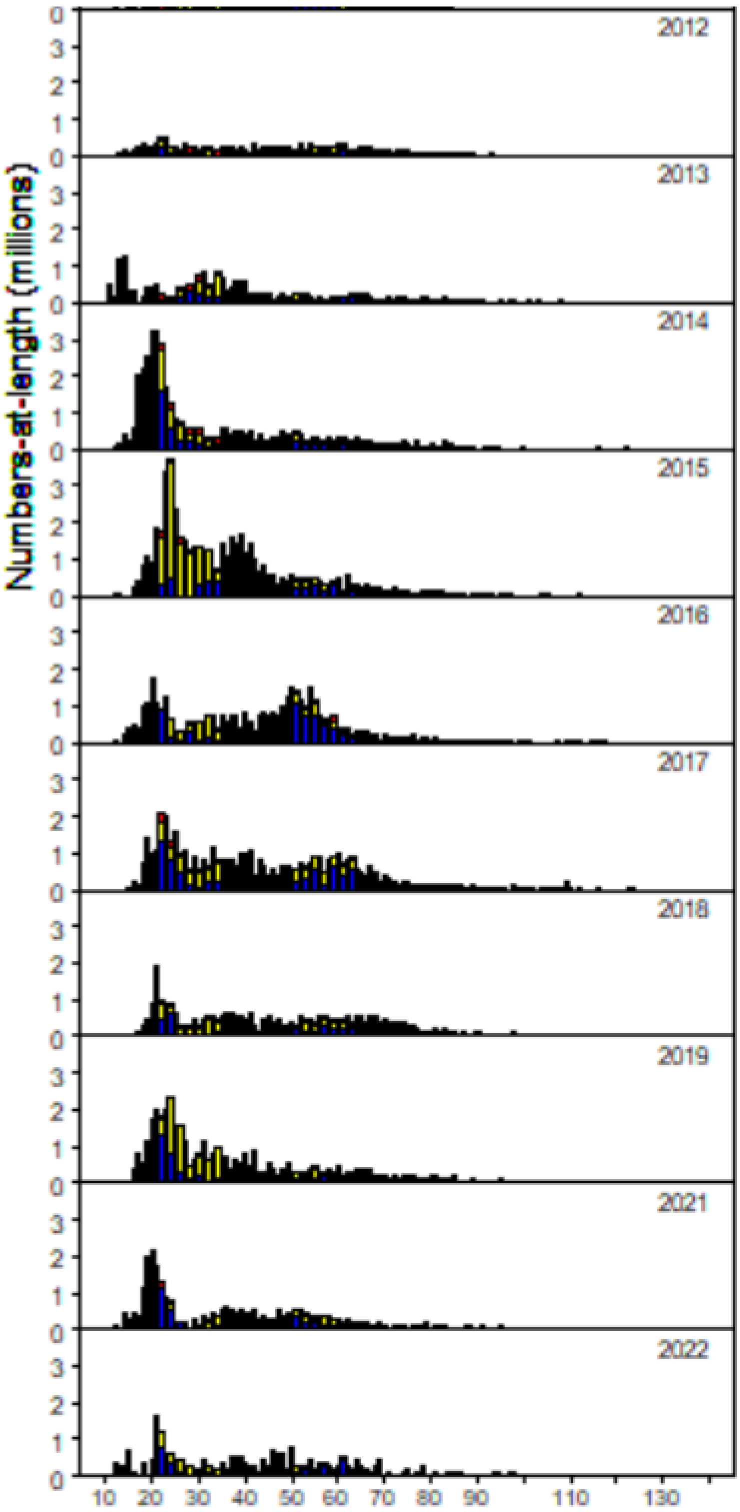


Figure 9.4. Excerpt from WGCSE 2022: Figure 4.8. SIAMISS-Q2 estimates of total numbers (millions) at-length (cm) for subareas 4.a (blue)–c and 6.a (yellow)–b (red) combined, 2012–2022.

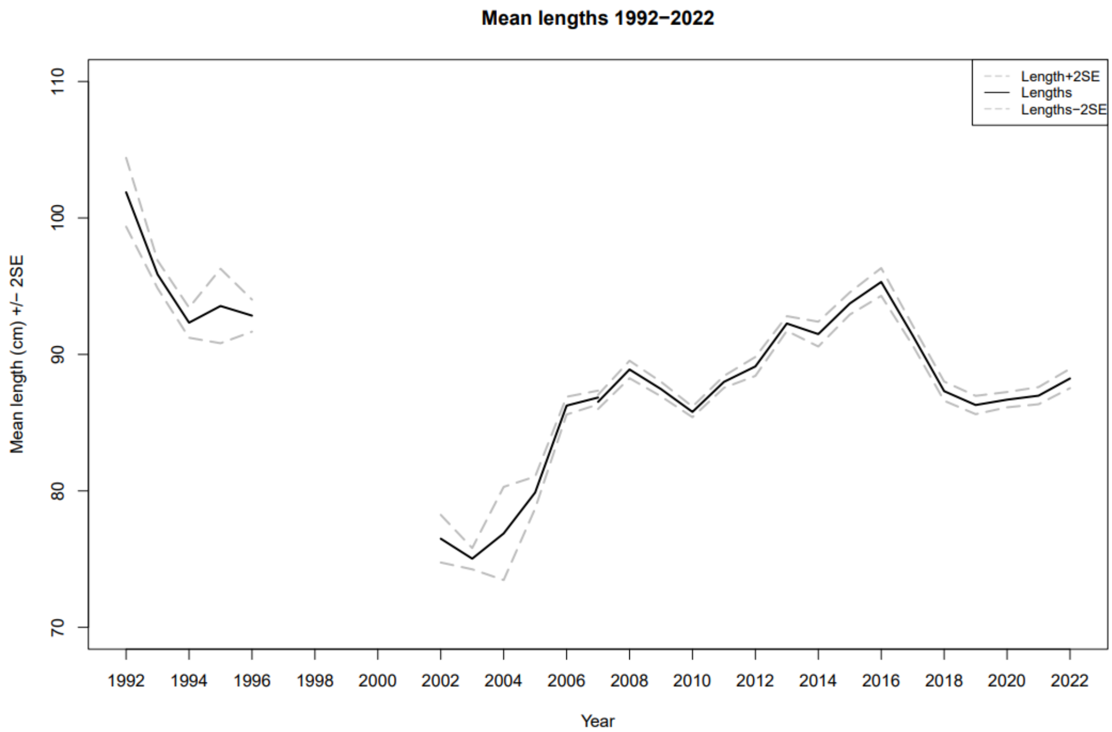


Figure 9.5. Anglerfish (*Lophius piscatorius*) in ICES Subareas 1 and 2. Mean lengths for anglerfish caught in the directed coastal gillnetting in Division 2.a during 1992–2022, dotted lines represent ±2SE of the mean. Note that data are lacking for 1997–2001. This illustrates pulses of new recruitment entering Division 2.a from ICES subareas 4 and 6; last time during 2002–2003, and to a lesser extent in 2017–2019.

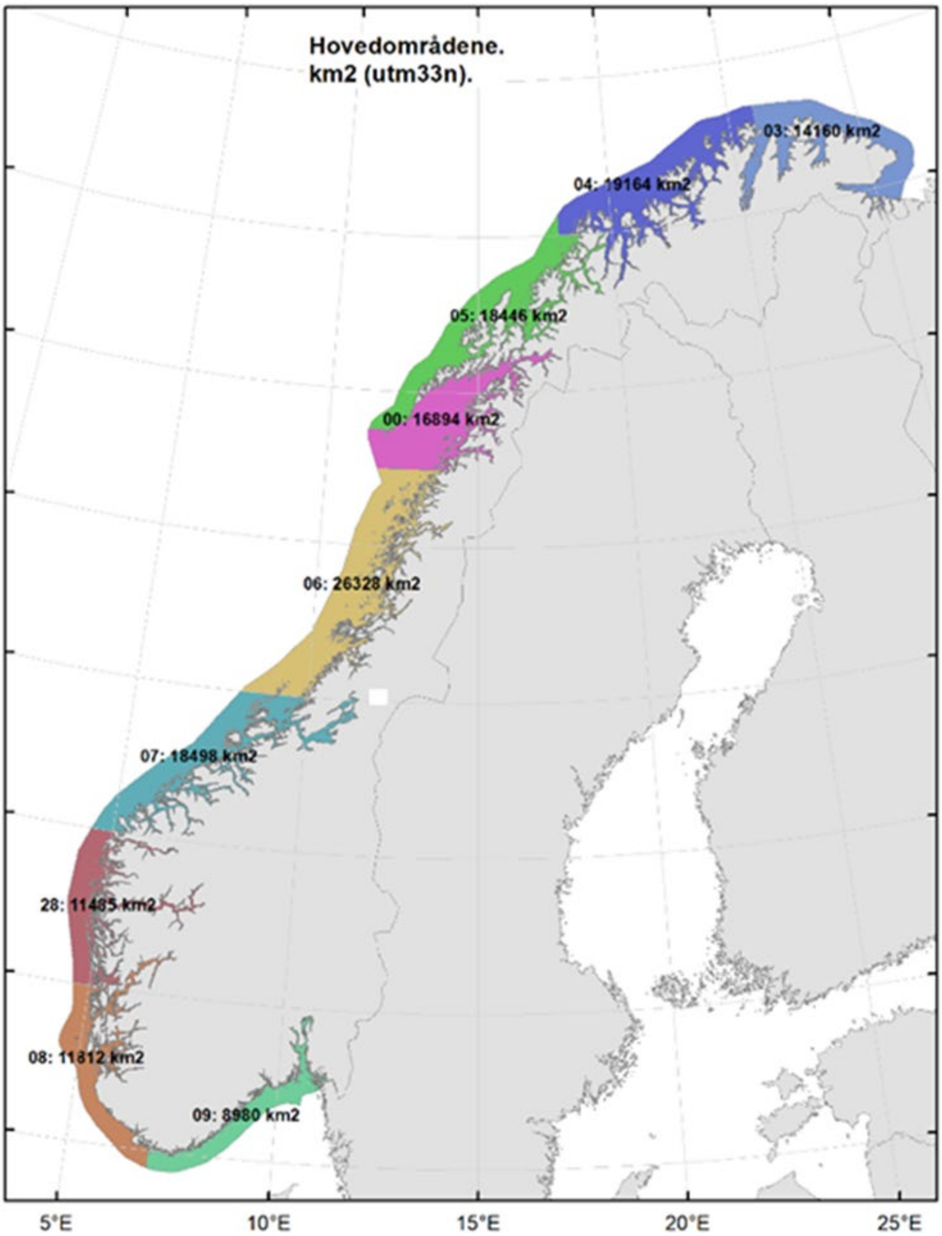


Figure 9.6. Map showing the area (km2) of each Norwegian statistical subarea inside 12 nautical miles. The subareas 4, 5, 0, 6, and 7 belong to the ICES Division 2.a.

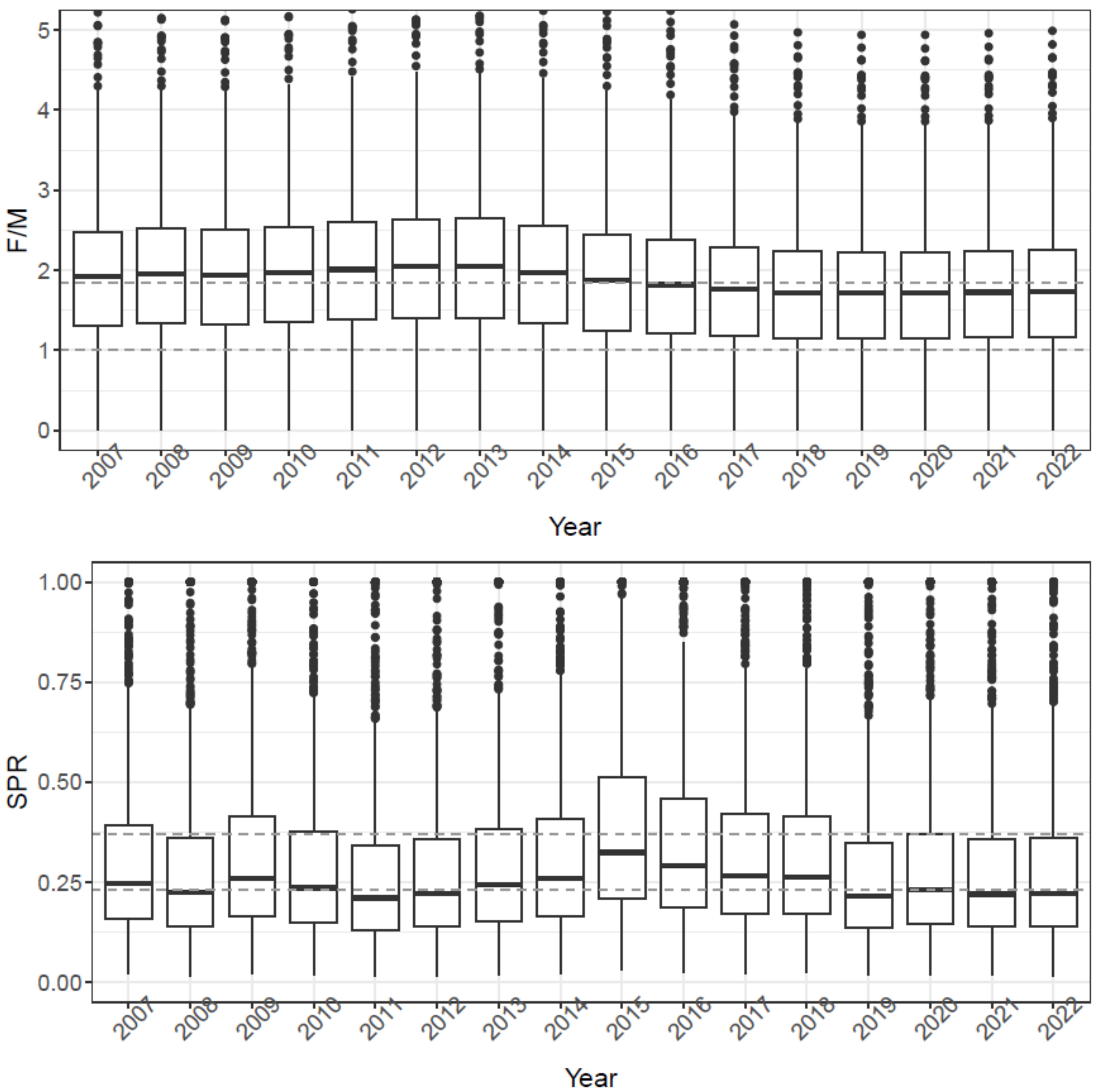


Figure 9.7. Annual estimates of F/M (above) and SPR (below) from the stochastic LBSPR approach using the length composition data from 2007–2022.

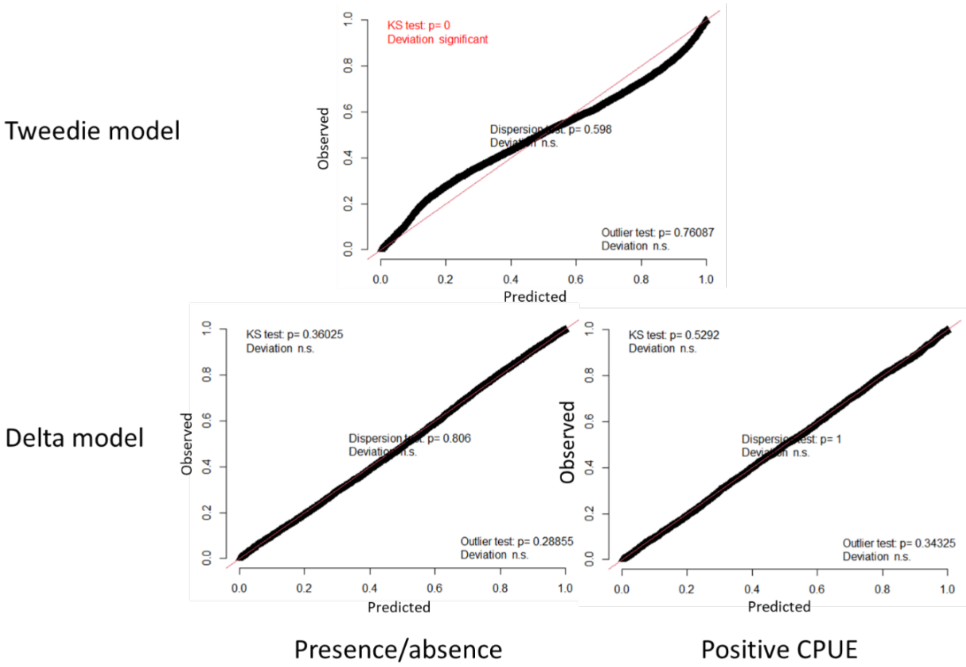


Figure 9.8. CPUE model residual diagnostics. Top panel shows the residual pattern in the Tweedie model using the latest data and with the (1|vessel_year) random effect. Bottom panel shows the results from the delta model with the specification mentioned in the text.

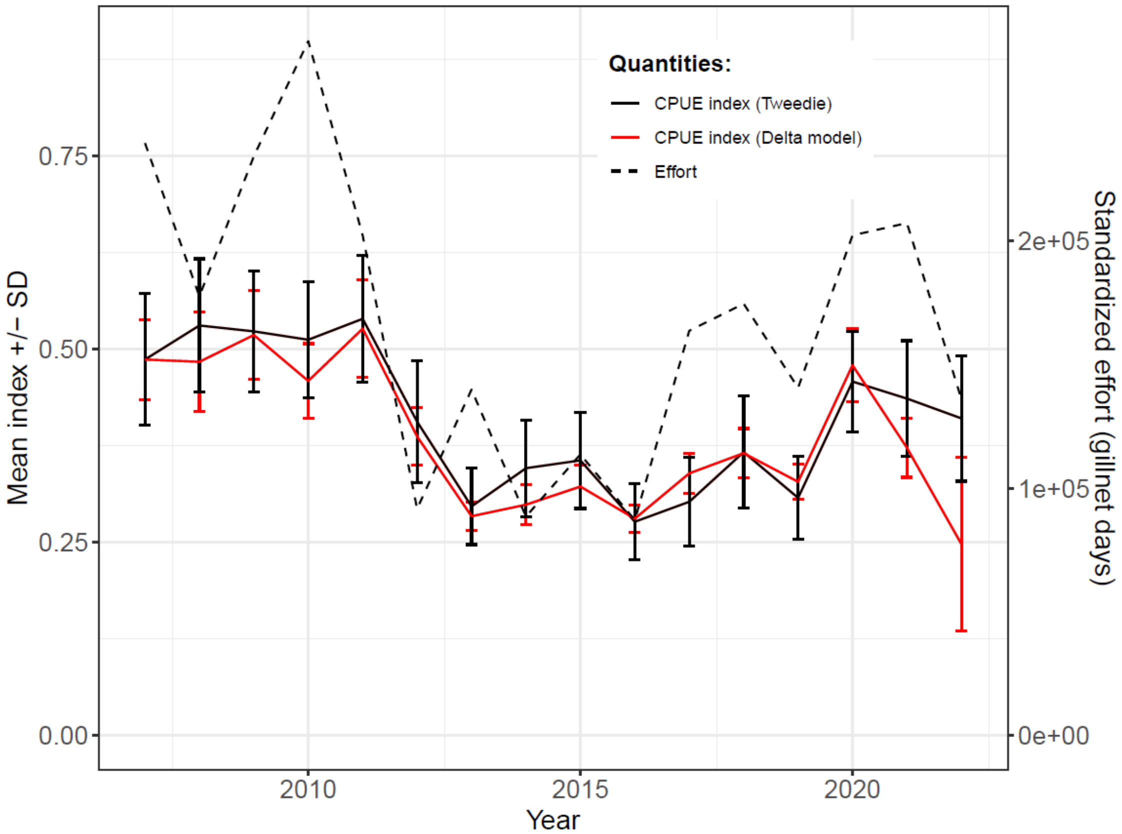


Figure 9.9. Standardized CPUE (kg per gillnet day) +/- SD (solid black line with error bars for the original Tweedie model, and solid red line with error bars for the new delta model) and the corresponding standardized effort (dash line) for anglerfish based on the data from the Norwegian coastal reference fleet in ICES Subarea 2a, from vessels targeting anglerfish with large meshed gillnets.

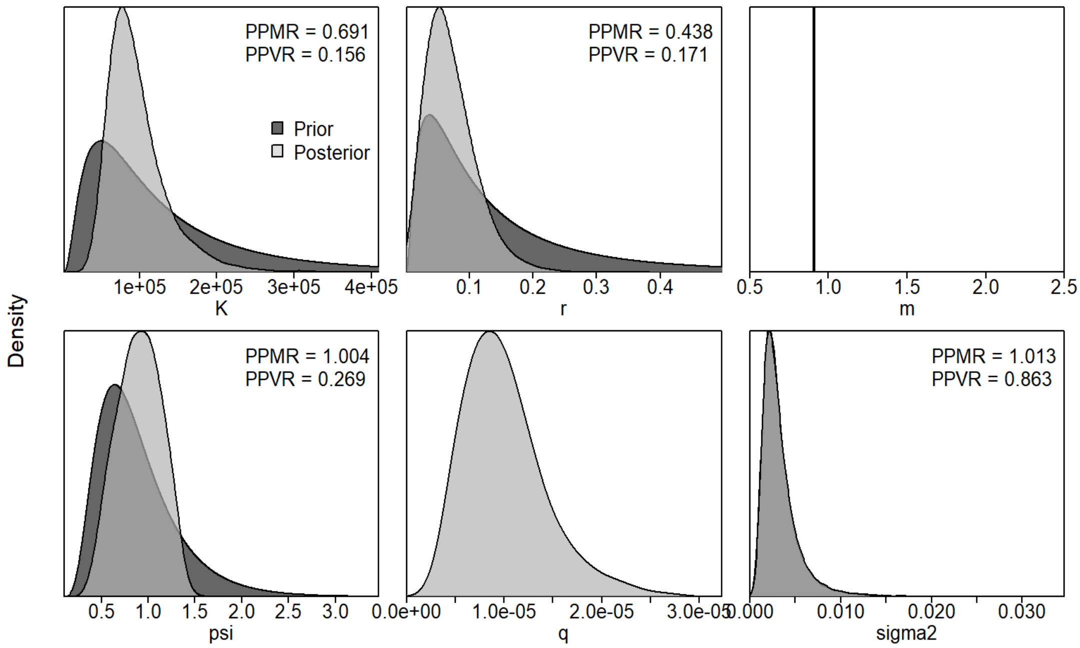


Figure 9.10. Prior and posterior distributions of the JABBA model parameters for the anglerfish assessment.

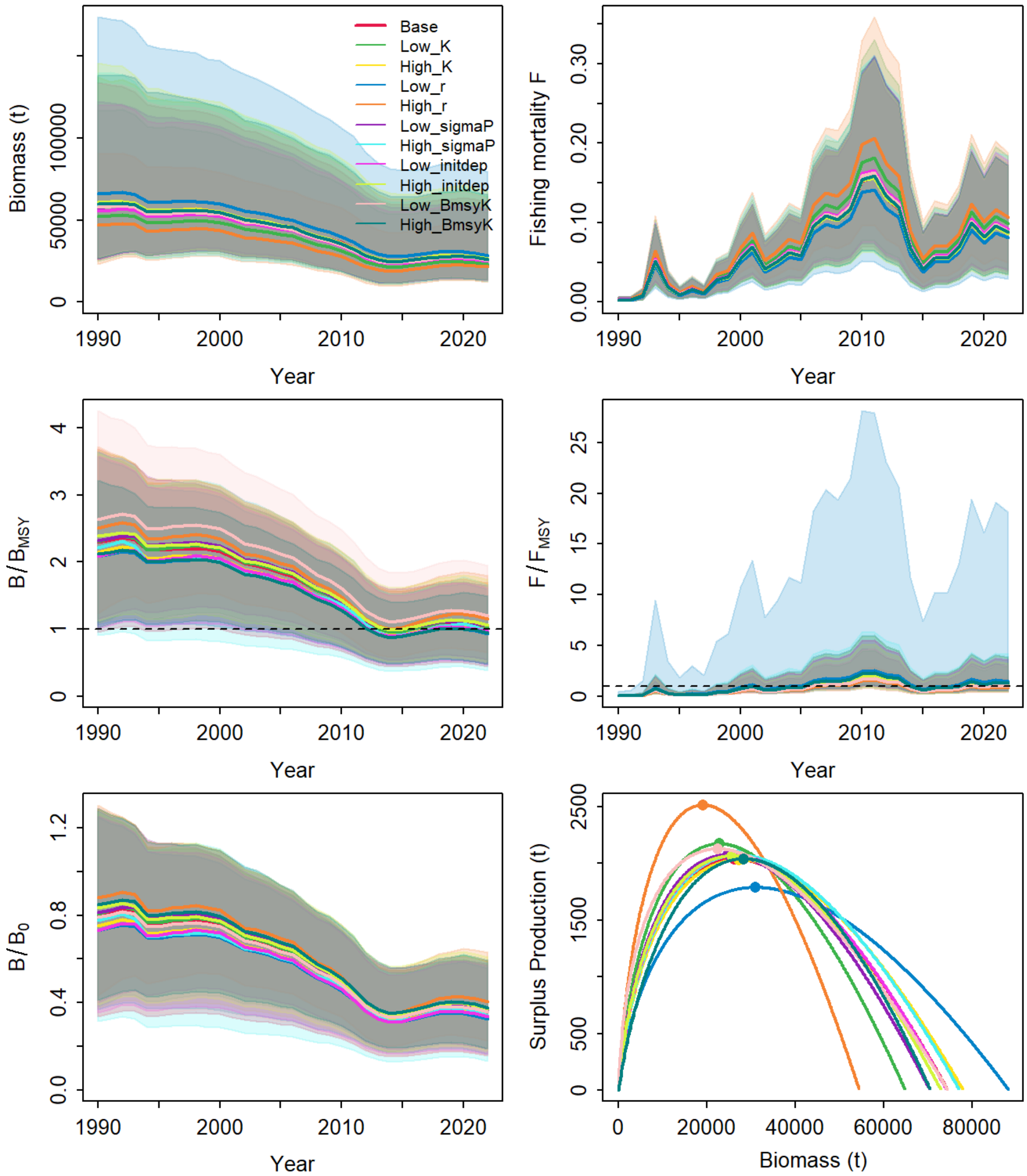
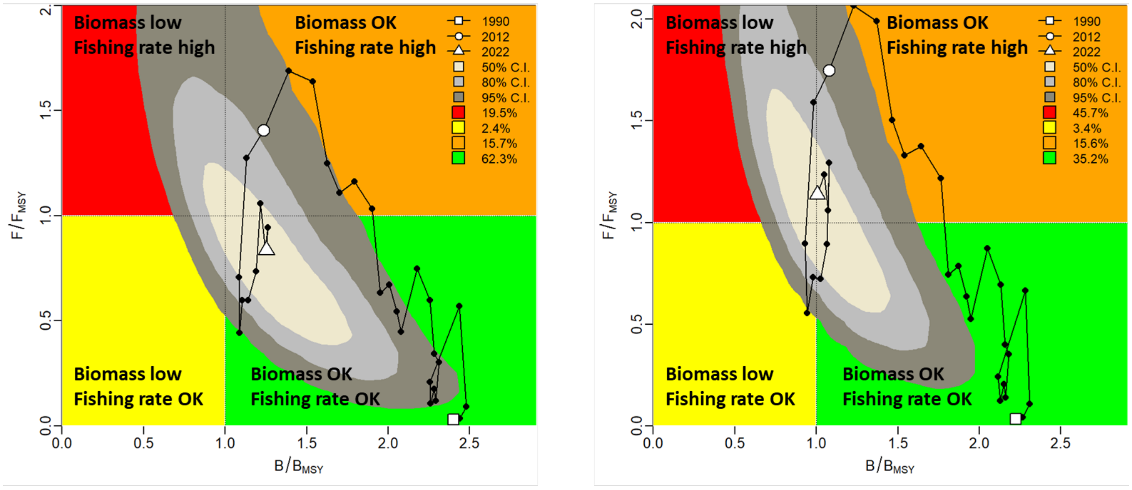


Figure 9.11. Estimated trajectories for biomass, fishing mortality, B/BMSY, F/FMSY, B/B0, and surplus production for the ICES Subarea 1–2 anglerfish based on 11 JABBA scenarios (the name of scenario and the associated color is indicated in the figure). The lines show the mean trajectory, and the shaded areas denote 95% credibility intervals.



Using CPUE from Tweedie model **Using CPUE from delta model**

9.12. 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.

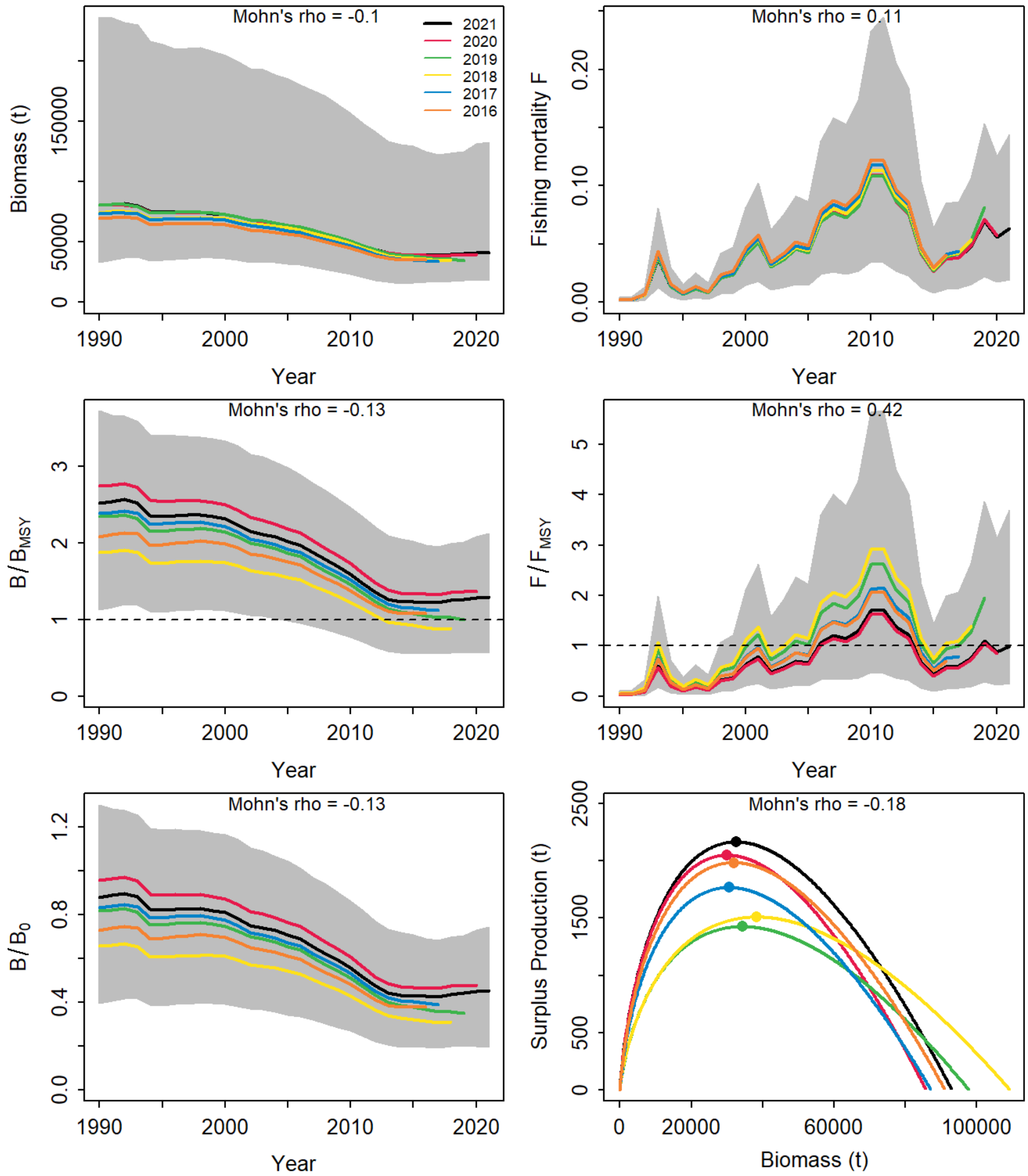


Figure 9.13. Retrospective analysis from the JABBA base case scenario. Different colours illustrate the results from different peels (ref. Table 9.7).

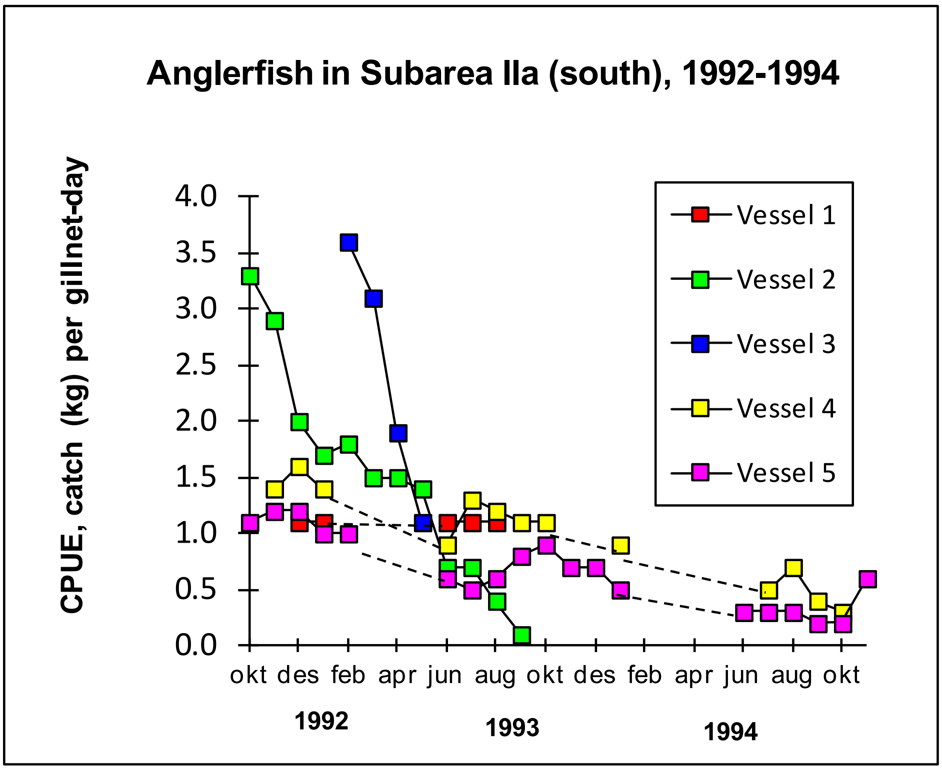


Figure 9.14. Catch per unit effort for five boats in the gillnet fishery for anglerfish in Møre and Romsdal (between 62–63˚N) in the period October 1992 to October 1994. Boat 1 > 25m; Boat 2 ca. 20 m; Boat 3 ca. 10 m; Boat 4 and 5 ca. 16 m. Boats 1–4 were fishing with gillnet 360 mm nesh size, boat 5 with 300 mm mesh size. These data have been used as input to the JABBA assessment.

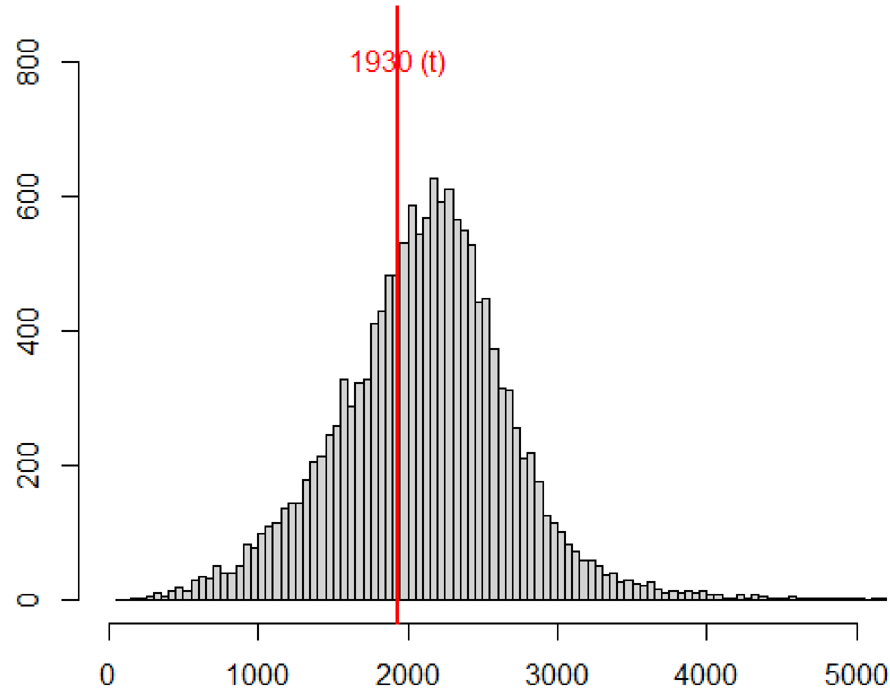


Figure 9.15 Posterior distribution of the MSY from the base-case scenario along with the 35th quantile of the distribution highlighted with a red line.

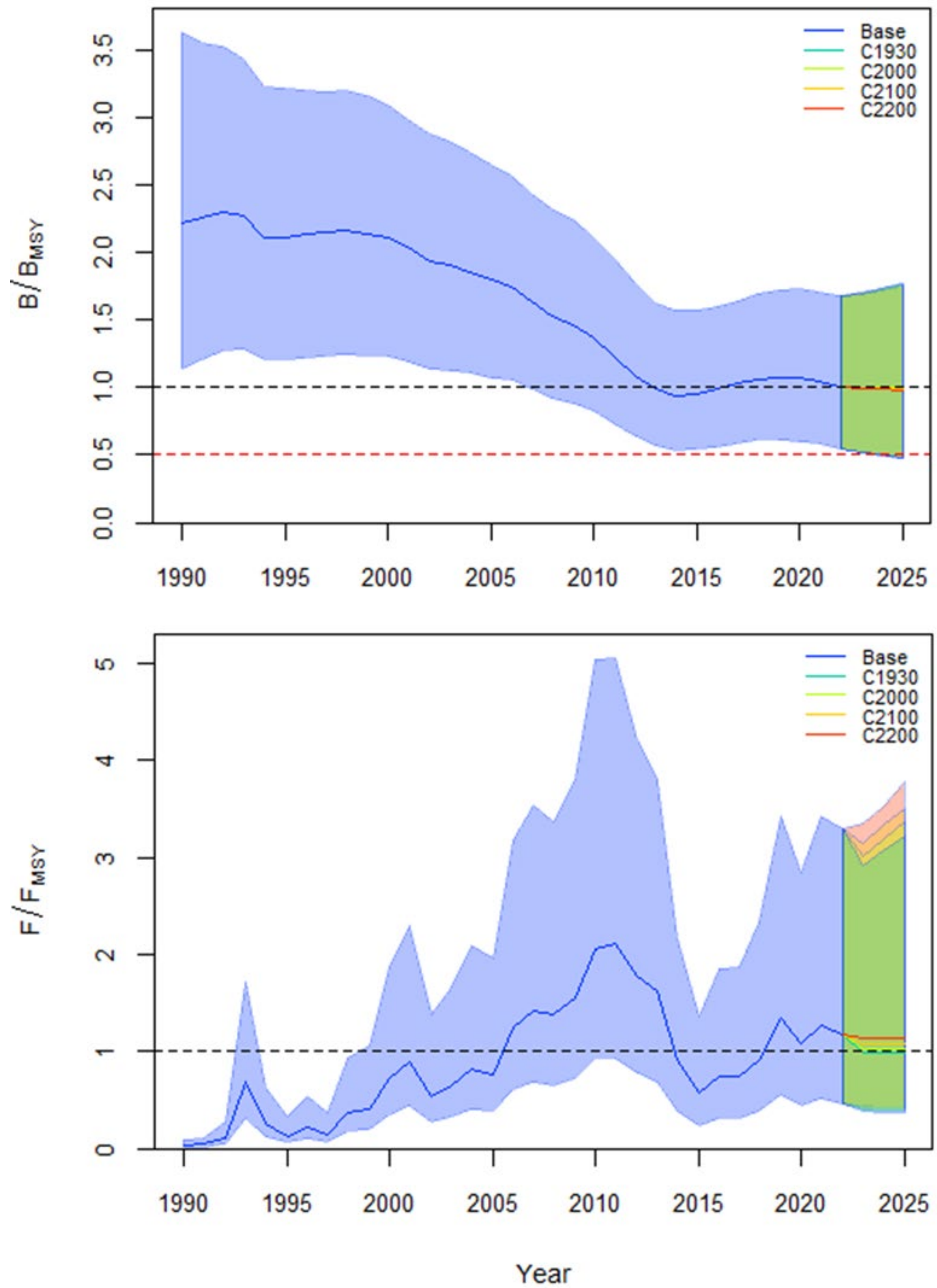
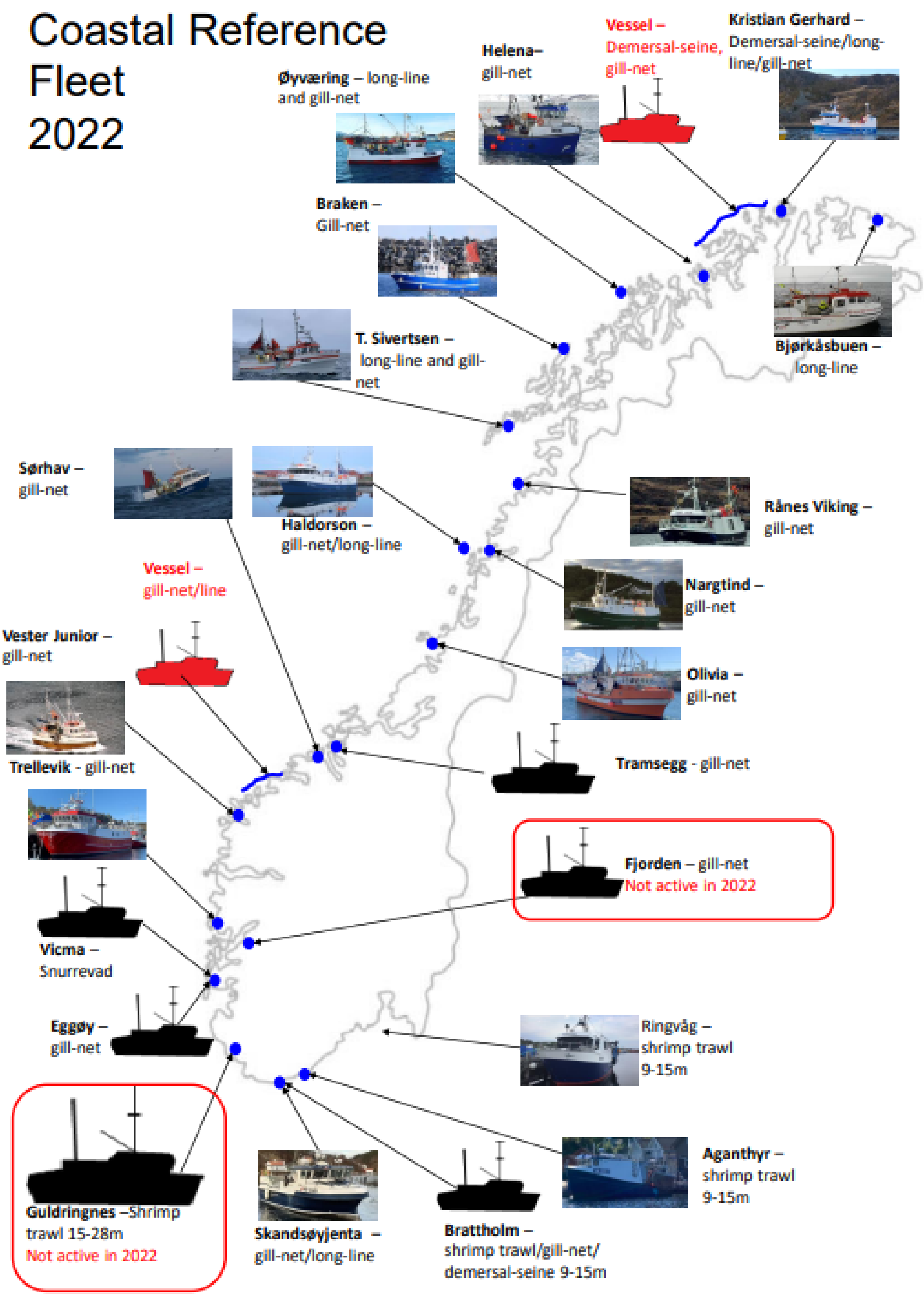
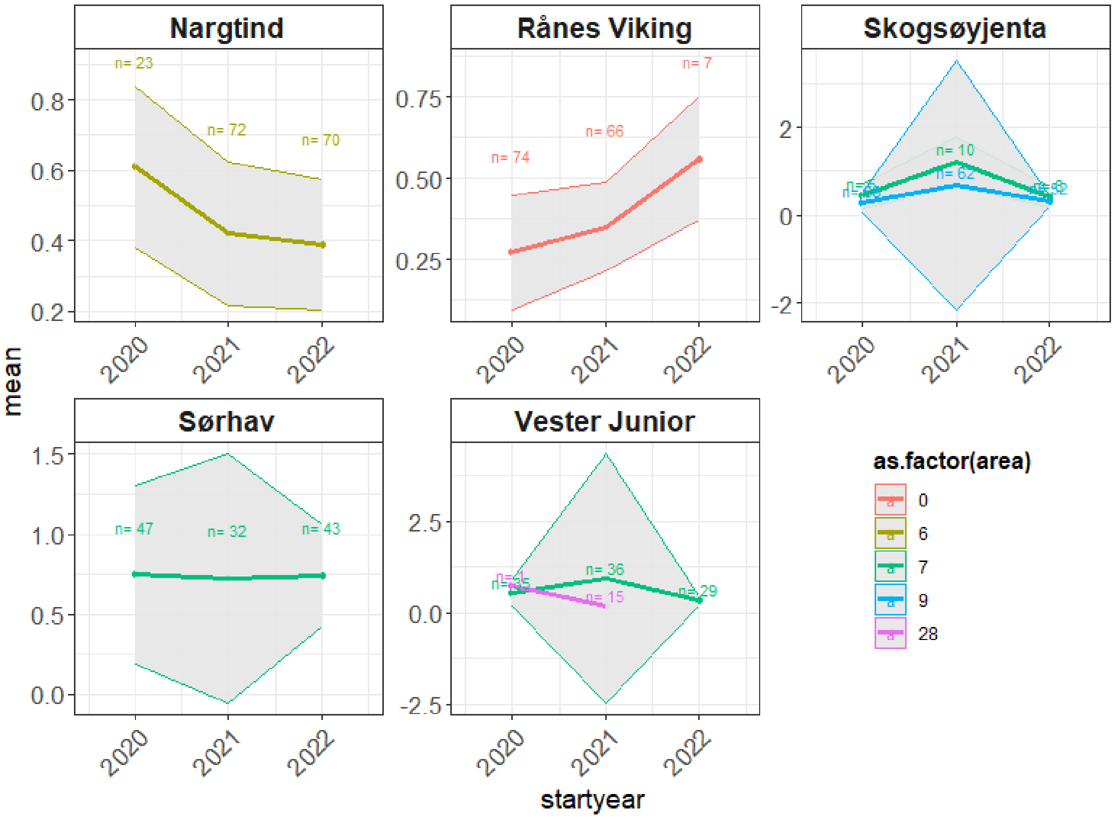


Figure 9.16. Projected (2023–2025) biomass (B/B_{MSY} - upper panel) and fishing mortality (F/F_{MSY} - lower panel) trajectories for different levels of catch (color coded) using the base-case model.

Appendix figure H1.



Appendix figure H2. Mean +/- SD in the raw CPUE for the five vessels participating in the RF program during 2020–2022.



Appendix table H1. Data contribution (i.e. fishing events) from the various vessels participating into the coastal reference fleet program from 2007 to 2022.

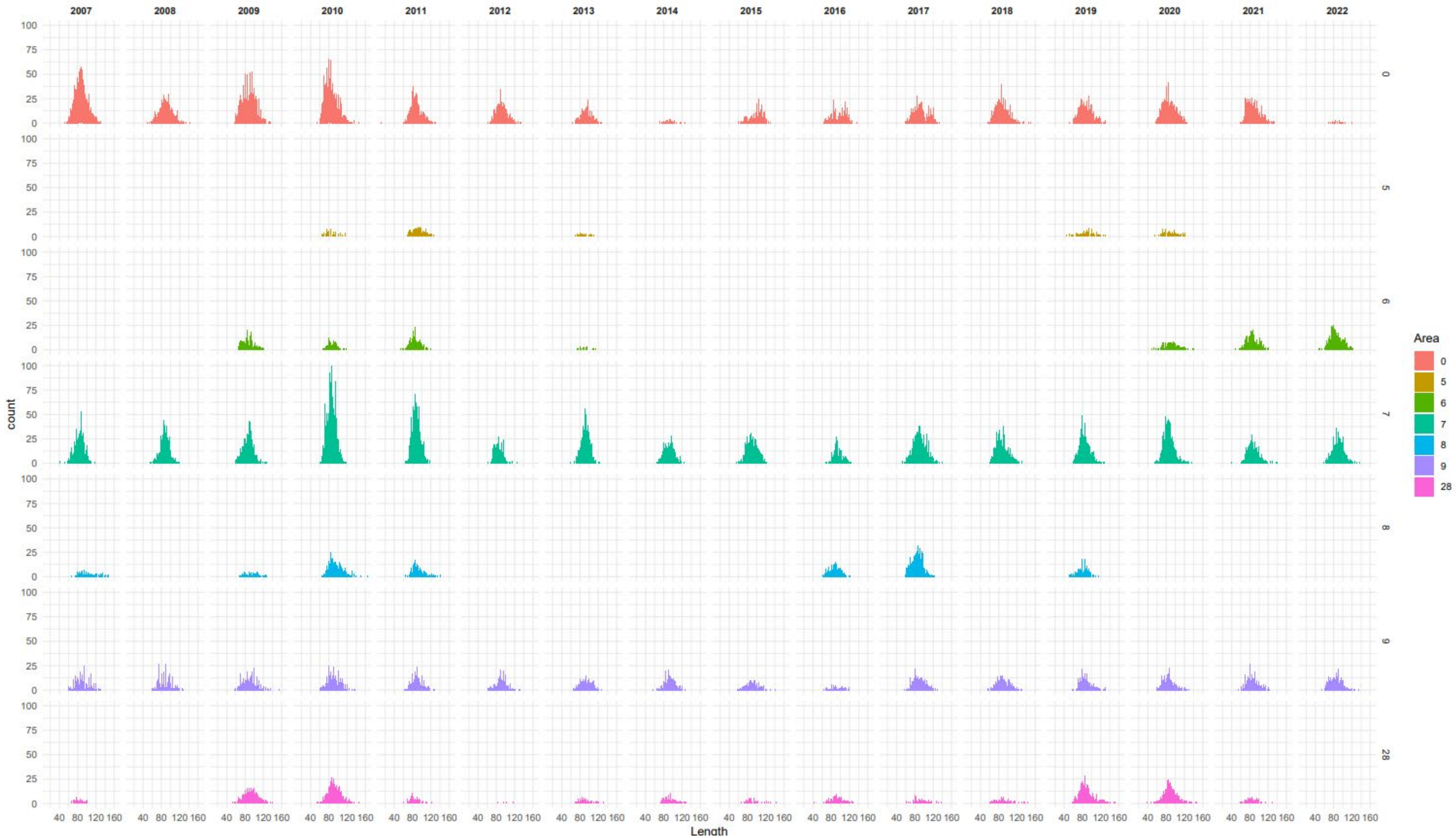
Vessel	Year															
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ben Hur	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Braken	0	0	0	0	0	0	0	0	0	0	0	0	34	28	0	0
Britt Evelyn	0	0	0	0	0	10	23	32	17	20	37	26	33	36	0	0
Eggøy	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0
Eggumsværin	0	0	22	27	0	0	0	0	0	0	0	0	0	0	0	0
Elias	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fanøyvåg	0	0	0	3	8	0	0	0	0	0	0	0	0	0	0	0
Fjorden	0	0	0	0	0	0	0	0	0	0	0	0	1	34	0	0
Haaværbuen	158	135	102	92	69	0	42	22	41	26	0	0	0	0	0	0
Haldorson	0	0	12	0	35	24	0	8	5	22	0	0	0	29	0	0
Heimdal	32	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hellskjær	0	0	0	0	0	12	20	0	0	0	0	0	0	0	0	0
Nargtind	0	0	0	0	0	0	0	0	0	0	0	0	0	23	72	70
Nimrod	74	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Økssund	0	0	0	0	0	0	0	0	113	90	82	56	25	0	0	0
Øygutt	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Ramona	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Rånes Viking	32	49	86	87	68	49	65	0	66	55	69	90	71	74	66	7
Skogsøyjenta	33	23	53	28	33	31	52	51	57	15	85	69	94	63	72	58
Snarsetværin	26	72	18	30	17	0	0	0	0	0	0	0	0	0	0	0
Solgløtt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sommarøybue	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Sørhav	0	0	0	0	0	0	0	0	0	0	48	40	51	47	32	43
Stording	0	0	18	27	10	0	0	0	0	0	0	0	0	0	0	0
T.Sivertsen	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Thema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tom-Robert	128	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tramsegg	122	37	73	51	48	21	39	55	35	1	1	3	4	24	21	0
Trellevik	0	0	0	0	0	0	0	0	0	0	0	8	16	0	0	0
Vågøybuen	0	6	24	35	16	0	0	0	0	0	0	0	0	0	0	0
Vandsøyvåg	0	0	0	0	0	0	18	13	0	0	0	0	0	0	0	0
Vester Junior	0	0	0	0	0	0	0	43	20	18	43	41	12	36	51	29
Vicma	0	0	0	0	0	0	0	0	0	53	151	0	0	0	0	0

Appendix table H2. Input data to the JABBA assessment in the form of catch and abundance indices of anglerfish (L. piscatorius) in ICES subareas 1 and 2.

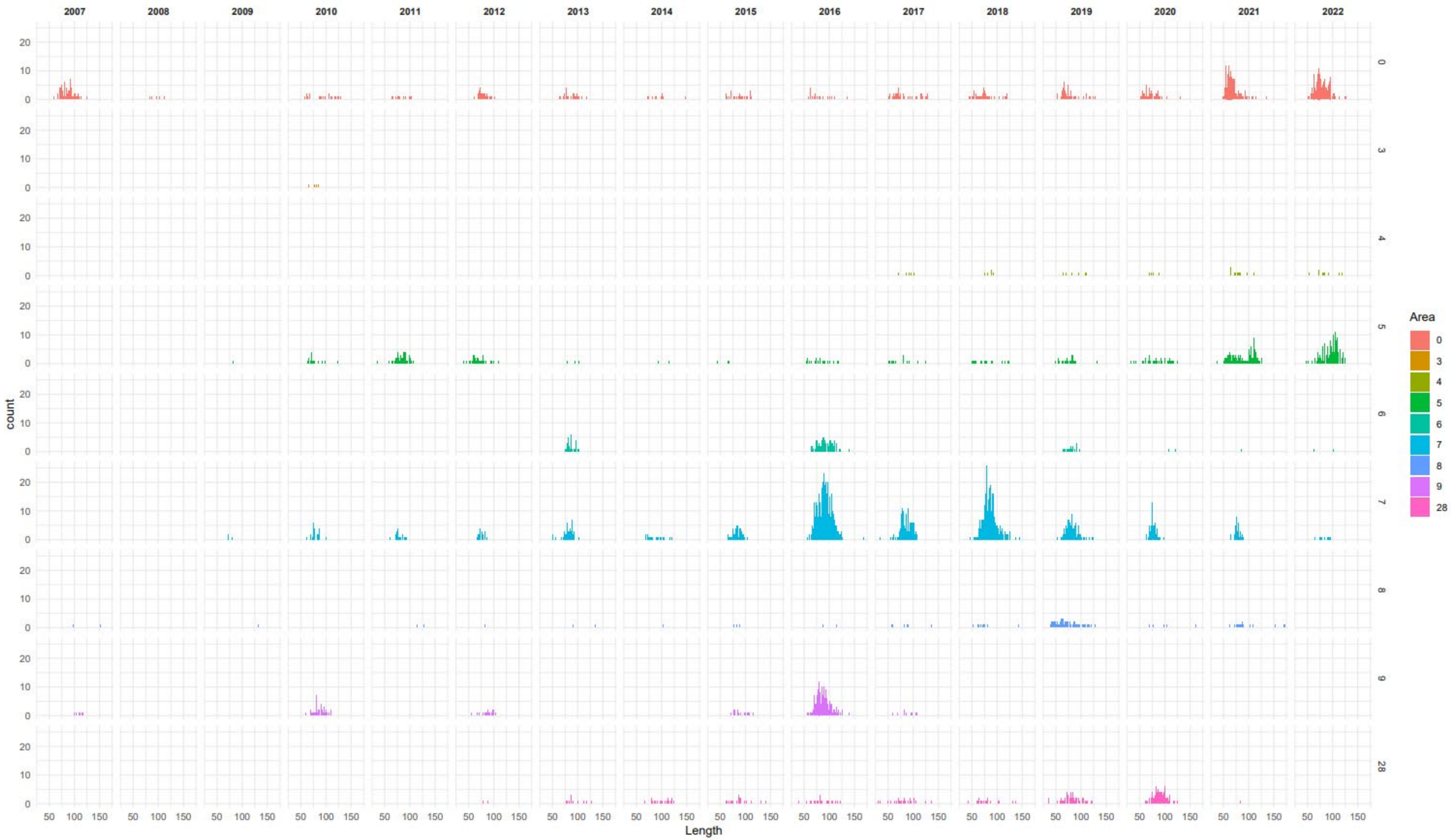
Year	Catch	CPUE (mean)	CPUE (SE)
1990	151		
1991	180		
1992	488	0.5	0.3
1993	3042	1	0.2
1994	1024	0.5	0.1
1995	526		
1996	887		
1997	601		
1998	1549		

Year	Catch	CPUE (mean)	CPUE (SE)
1999	1743		
2000	2999		
2001	3624		
2002	2071		
2003	2477		
2004	3001		
2005	2735		
2006	4348		
2007	4591	0.49	0.06
2008	4151	0.48	0.07
2009	4458	0.52	0.06
2010	5515	0.46	0.05
2011	5112	0.53	0.07
2012	3765	0.39	0.05
2013	3103	0.28	0.03
2014	1657	0.30	0.04
2015	1043	0.32	0.04
2016	1435	0.28	0.04
2017	1484	0.34	0.05
2018	1903	0.37	0.05
2019	2809	0.33	0.04
2020	2280	0.48	0.06
2021	2601	0.37	0.05
2022	2293	0.25	0.15

Appendix figure H3. 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 H3-H5.



Appendix figure H4. 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 H3-H5.



Appendix figure H5. 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 H3-H5.

10 Barents Sea capelin

cap.27.1-2 – *Mallotus villosus* in subareas 1 and 2, excluding Division 2.a west of 5°W

On 30 March 2022, all Russian participation in ICES was suspended. Owing to this temporary suspension, it is not currently possible to run an ICES assessment for NEA cod. It is however critical for good ecosystem and fisheries management that such assessments be run and be used as the basis of management. An assessment for this stock has therefore been conducted in 2022 outside ICES by a bilateral Russian-Norwegian group, the "Joint Russian-Norwegian Arctic Fisheries Working Group" (JRN-AFWG). The assessments occur outside ICES but follow the stock annexes previously agreed within ICES, use the same data and models as previously, and are conducted by the same Russian and Norwegian scientists that were involved in the previous ICES assessments. The managing body in the Barents Sea (the Joint Norwegian Russian Fisheries Commission; JNRFC) has used the advice as the basis of management, following the same procedures previously used for ICES advice. JNRFC also endorsed this approach to be continued for the 2023 advice (52nd session[1], Appendix 10).

The report of the JRN-AFWG assessment and the associated advice sheets also follow closely the previous ICES reporting format and are published online by the Norwegian Institute of Marine Research. For Barents Sea capelin the relevant information for 2023 can be found at:

2023 report:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-9

Advice on fishing opportunities in 2024:

https://www.hi.no/en/hi/nettrapporter/imr-pinro-en-2023-8

[1] https://www.jointfish.com/OM-FISKERIKOMMISJONEN/PROTOKOLLER.html

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Annex 1: List of participants

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Annex 2: Resolutions

2022/2/FRSG02

The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell, Norway, will meet at ICES Headquarters in Copenhagen, Denmark, 17–21 April 2023 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 any time-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 2023 ICES data call.

AFWG will report by 8 May 2023 and October 2023[1] 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.

Generic ToRs for Regional and Species Working Groups

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS. Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries Overviews with a focus on:
   1. identifying and correcting mistakes and errors (both in the text, tables, and figures);
   2. proposing concrete evidence-based input that is considered essential to the advice but is currently underdeveloped or missing (with references and Data Profiling Tool entries, as appropriate).

The input will feed into the annual updates of the overviews. Delivery of contributions other than those outlined above is also welcomed but will be utilized during the revision process (around every 5 years).

b) Conduct an assessment on the stock(s) to be addressed in 2023 using the method (assessment, forecast or trends indicators) as described in the stock annex; complete and document an audit of the calculations and results; and produce a brief report of the work carried out regarding the stock, providing summaries of the following where relevant:
   1. Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with missing data and the linked template that formulates how deviations from the stock annex are to be reported;

[1] Dates subject to final confirmation.

2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
3. For relevant stocks (i.e. all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2022;
4. For category 3 and 4 stocks requiring new advice in 2023, implement the methods recommended by WKLIFE X (e.g. SPiCT, rfb, chr, rb rules) to replace the former 2 over 3 advice rule (2 over 5 for elasmobranchs). MSY reference points or proxies for the category 3 and 4 stocks (ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3);
5. Evaluate spawning-stock biomass, total-stock biomass, fishing mortality, and catches (projected landings and discards) using the method described in the stock annex:
   1) For category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.
   2) If the assessment is deemed no longer suitable as basis for advice, provide advice using an appropriate Category 2–5 approach as described in ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3 or ICES.
   3) If the assessment has been moved to a Category 2–5 approach in the past year consider what is necessary to move back to a Category 1 and develop proposal for the appropriate benchmark process.
6. Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;
7. Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time-series of recruitment, spawning-stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR vii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

c) Produce a first draft of the advice on the stocks under consideration according to ACOM guidelines.

d) Review progress on benchmark issues and processes of relevance to the Expert Group:
   1. update the benchmark issues lists for the individual stocks in SID;
   2. review progress on benchmark issues and identify potential benchmarks to be initiated in 2024 for conclusion in 2025;
   3. determine the prioritization score for benchmarks proposed for 2024–2025;
   4. as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG).

e) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops.

f) Identify research needs of relevance to the work of the Expert Group.

g) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

h) If not completed previously, complete the audit spreadsheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate change, could be considered in the advice.

i) Deliver conservation status advice in accordance with the Technical guidelines on conservation status advice. The advice is only to be given when conservation aspects were identified and where clear, demonstrable management action can be recommended for any non-catch anthropogenic pressure. It can also be used to highlight clear demonstrable sensitivity to climate change. The qualification required to show clear, demonstratable management action is high. Avoid generic statements that are of no specific application to management.

j) Update SAG and SID with final assessment input and output.

Information on the stocks to be considered by each Expert Group is available here.

Annex 3: Working documents

WD #	WD Title	Authors
01	Estimating the status of anglerfish (*Lophius piscatorius*) in the north of 62˚N management unit (ICES subareas 1 and 2) using life history ratios, length compositions, and CPUE data	Kotaro Ono; Sofie Gundersen; Kjell Nedreaas
02	Report of the Portuguese fishery in 2021: ICES divisions 1, 2.a, and 2.b.	Ricardo Alpoim; Jorge Vargas
03	The Spanish NE Arctic Cod Fishery in 2022	José Miguel Casas Sánchez; Ane Iriondo
04	Data series on tourist- and resident recreational fisheries for Norwegian Coastal Cod north of 62˚N	Kjell Nedreaas

Working Document Submitted to AFWG 2023 WD_01
per 14 April 2023

Estimating the status of anglerfish (*Lophius piscatorius*) in the north of 62°N management unit (ICES Subareas 1 and 2) using life-history ratios, length compositions, and CPUE data

by
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Keywords: anglerfish, *Lophius piscatorius*, assessment, data limited, CPUE, LBSPR, JABBA

Introduction

The WKAngler (2018) assumed that most recruitment to the anglerfish population in Subarea 1 and 2 comes from the more southerly stock unit. The validation of this hypothesis requires further R&D work in collaboration with ICES 3a46 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) recommends a tagging program coordinated between all countries harvesting *Lophius*. Until there is more clarity in the true biological stock structure, WKAngler (2018) recommends keeping the anglerfish in Subareas 1 and 2 as a separate management unit.

A direct gillnet fishery, with large-meshed gillnets specially designed for anglerfish (*L. piscatorius*) started in autumn 1992 on the continental shelf in ICES Division 2a off the northwestern coast of Norway (Norwegian statistical area 07). Anglerfish had previously only been taken as bycatch in trawls and gillnets. Until 2010-2011 there was a geographical expansion of the fishery. The Norwegian management objective for the anglerfish in Norwegian waters is maximally sustainable long-term yield (Gullestad et al. 2017). The national harvest objective favors the large-meshed coastal and small-scaled gillnet fisheries, with stronger regulations on anglerfish bycatch in other fisheries (e.g., trawl, shrimp trawl and Danish seine).

At present, anglerfish in ICES Subareas 1 and 2 falls into ICES Category 3 – stocks for which landings and/or catch and reliable stock size indicator(s) exist. Includes stocks for which survey or other indices are available that provide reliable indications of trends in stock metrics, such as total mortality, recruitment, and biomass. (ICES 2018).

There are currently four methods approved by ICES for calculation of MSY reference points for category 3 and 4 stocks. These are:

- Length based indicators (LBI)
- Mean length Z (MLZ)
- Length based spawner per recruit (LBSPR)

- Surplus Production model in Continuous Time (SPiCT), or other similar models (e.g., JABBA).

The last assessment (AFWG 2022) was done using a combination of LBSPR, CPUE standardization and JABBA, and was approved (see also WD_16 at the AFWG 2022). This document is therefore just an assessment update using the same methodology but with new data from 2022 and some additional sensitivity analyses.

Material

Landings data

The official landings as reported to ICES for Subareas 1 and 2 for each country are shown in Table 1. Landings decreased rapidly from 2011 to 2015, to the lowest since 1997, but has since shown an increase. Norway has by far the largest reported catches of the anglerfish in Subareas 1 and 2, accounting for more than 96-99% of the official international landings. The coastal gillnetting accounts for more than 90% of the landings, of which about 90% is caught by the specially designed large-meshed gillnets (360 mm stretched meshes).

Table 1. Nominal catch (t) of Anglerfish in ICES Subareas I and II, 2009-2022, as officially reported to ICES.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*
Denmark	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Faroes	2	1	+	+	1	+	+	1	1	+	+	1	-	+
France	-	-	1	3	2	-	4	2	4	3	8	5	4	4
Germany	+	82	70	0	-	+	+	+	1	1	50	-	-	-
Iceland	-	-	7	-	-	-	-	-	-	-	-	-	-	-
Norway	4298	5391	5031	3758	2988	1655	933	1355	1473	1884	2750	2258	2584	2288
Portugal	6	1	+	-	-	-	-	-	-	-	-	-	-	-
UK	152	40	3	3	111	2	105	76	5	15	+	16	13	-
Others	-	-	-	1	1	-	-	+	-	+	-	-	-	-
Total	4458	5515	5112	3765	3103	1657	1043	1435	1484	1903	2809	2280	2601	2293

*Preliminary per 24 March 2023

The Norwegian coastal reference fleet (see Appendix figure 1) provide us with length measurements and catch per gillnet days from ICES Subareas 2, from 2007–present, and these have been presented for the AFWG in recent years (ICES 2019). The catch rates vary spatially and temporally, and the WKAngler (2018) recommended therefore to model and standardize the catch rates to better represent the general abundance trend of anglerfish in the entire ICES Subarea. The available material is shown in Tables 2 and 3 for the Norwegian statistical coastal areas (Figure 1) and total for ICES Subareas 1 and 2.

The absence of a TAC in Norwegian waters probably reduces the incentive to underreport landings. Berg and Nedreaas (2020) have estimated the annual discards of anglerfish by the Coastal reference fleet in Subareas 1 and 2 to vary between 11 and 32 tons during 2014-2018 (i.e., 1.5-2.5% of total gillnet catch). This discard is not included in the present analyses.

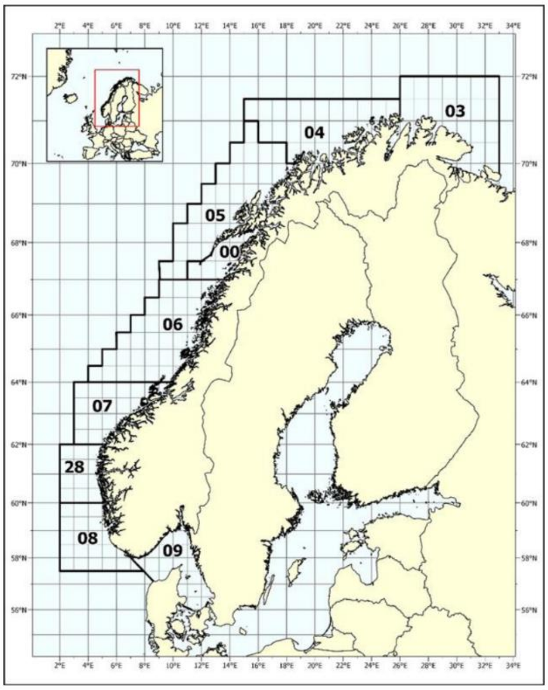

Figure 1. Map showing the Norwegian statistical coastal areas. Area 03 is part of ICES Subarea 1, Areas 04, 05, 00, 06 and 07 are part of ICES Subarea 2, Areas 28 and 08 are part of ICES Subarea 4, and Area 09 corresponds roughly with ICES Subarea 3.

Table 2. 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	83	221
2022	7		74	73	154

Table 3. 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	78
2022	43

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	1649
2022	1250

Length composition data

Length distributions of the retained anglerfish (*L. piscatorius*) caught as target species by the specially-designed-large-meshed gillnets, and as bycatch in other gillnets or other gears are shown in Appendix figures 2-4. All subsequent analyses (in the methods and results section) have only used the length distributions from the target fishery using the large-meshed gillnets which represent more than 80% of the international landings.

Catch per unit effort (CPUE) data

The Norwegian coastal reference fleet (see Appendix figure 1 and table 1) has reported catch per gillnet soaking time (CPUE) from their daily catch operations. The number of vessels reporting CPUE data has decreased in recent years, and only 5 of the 10 vessels reporting CPUE data in 2020 did target anglerfish in 2022. For the current modelling and hence standardization of the annual CPUE from Subarea 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=360mm)
- Years 2007-2022
- Discards excluded
- Adding zero catches where the large-meshed gillnets are used, but anglerfish not present
- All coastal areas (i.e. ICES 3a, 4a, 2a and 1) incl 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) are calculated and used as weighing factor when annual CPUEs are estimated for each subarea.

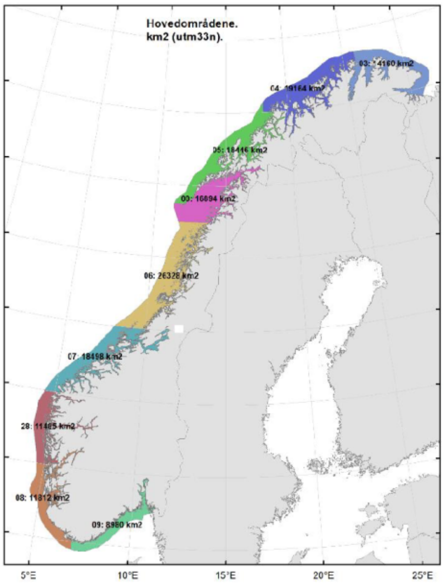

Figure 2. Map showing the area (km^2) of each Norwegian statistical subarea inside 12 nautical miles. The subareas 4, 5, 0, 6, and 7 belong to the ICES Division 2a.

Methods and results

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) though 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 is 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, b) used a conventional age-structured equilibrium population model and a size-base selectivity. Consequently, this approach could not account for "Lee's phenomenon" – the fact that larger specimen at age gets a higher 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 novel approach reduced bias related to the "Lee's phenomenon" (https://github.com/AdrianHordyk/LBSPR). 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 2022. Hordyk et al. (2015a,b) 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 Linf and K, and a univariate normal distribution for M, L50, L95 (see Table 4)) and rerun the model 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.

Table 4. Basic input parameters and parameters for resampling for the stochastic LBSPR analysis (as in AFWG 2022)

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
M/k (mean)	1.67
Parameters for resampling	
Nsamp	1000
CV(M)	0.15
Cor (Linf_K)	0.9
CV(K)	0.3
CV(Linf)	0.15
CV(L50)	0.05
CV(ΔMat)	0.05

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 was 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 a target reference point of SPR=0.37 (with F/M=1) and SPR=0.23 (with F/M=1.85) and for a steepness value of 0.7 and 0.9, respectively. What we obtained from the stochastic LBSPR runs instead is a relatively stable annual estimates of SPR (between 0.15 and 0.5 (the IQ range)) and F/M (between 1.0 and 2.5 (the IQ range) (Figure 4). This would suggest that while there is a lot of uncertainty, the population is fully exploited (estimated values of F/M and SPR included the target reference point ranges).

Stock-recruitment – the relationship between the biomass of reproductively mature individuals (spawning stock) and the resulting offspring added to the population (recruitment – 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 a constant recruitment and F over time) and violation of this assumption can lead to biased SPR estimates. However, some management strategy evaluation 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.

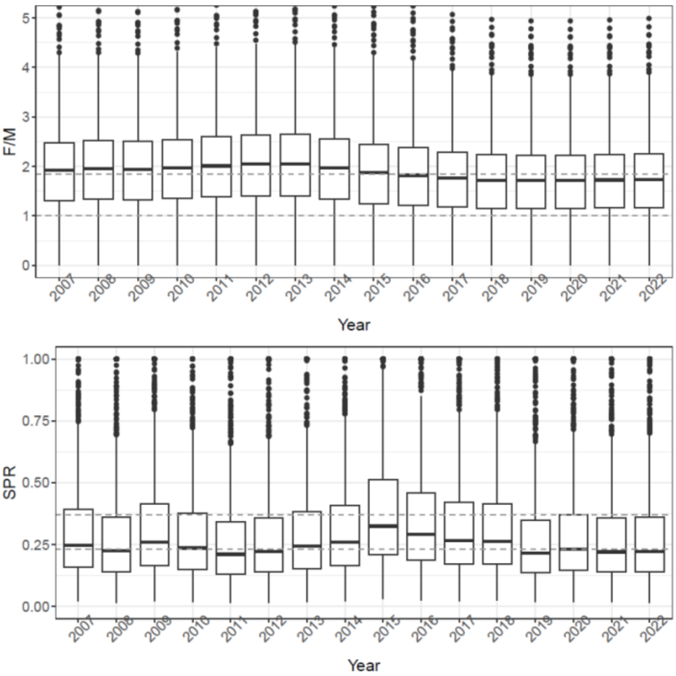

Figure 4. Annual estimates of F/M (above) and SPR (below) from the stochastic LBSPR approach using the length composition data from 2007 to 2022. The dotted lines give the target reference points for steepness values of 0.7 and 0.9.

CPUE standardization

Raw CPUE data is 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 a major 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 tons 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) / 24hours CPUE (per gillnet day) = catch weight/standardized effort

Based on plotting of raw data, catch weight and standardized effort were proportionally related. Therefore, all subsequent analysis on CPUE standardization was performed on the raw CPUE (per gillnet day). 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 2020) 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.

Like the last three assessments (AFWG 2020, 2021, 2022), data were filtered to keep only vessels that had more than 10 observations (as these rare vessel observations were causing deviations in the residual patterns due to difficulty in separating the vessel effect from other effects). However, the original model based on Tweedie distribution (AFWG 2020) showed a problematic residual pattern like the last assessment (AFWG 2022). In-depth investigation indicated that part of the problem was linked to the variability in vessel catchability per year. Therefore, this year's final Tweedie model was configured using the following parametrization where the novelty lies in the use of the (1|vessel_year) random effect instead of (1|vessel). This enables capturing the variability in vessel catchability between years:

CPUE = year + subarea + month + (1|vessel_year) + (1|subarea_year) + (1|month_year) + (1|month_subarea)

The expression (1|xxx) indicates that the variable *xxx* is considered as a random effect and acts on the intercept. The expression (1|xxx_yyy) indicates that the *xxx* and *yyy* variable were concatenated into a single variable and considered as a random effect. This is like modeling the interaction between *xxx* and *yyy*, but the approach only considers existing interaction as opposed to all combination of *xxx* and *yyy* when including as fixed interaction effect (which would be un-estimable). The inclusion of (1|vessel_year) random effect helped reduce some residual pattern but did not fully eliminate it. Therefore, a delta model was developed like in the last assessment (AFWG 2022) in the aim of removing the 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. All variables were kept the same as in the Tweedie model except for the use of (1|vessel) random effect for the occurrence model as species occurrence did not vary much between year per vessel (the occurrence model with the (1|vessel_year) random effect had a poorer residual performance).
Presence = year + subarea + month + (1|vessel) + (1|subarea_year) + (1|month_year) + (1|month_subarea)
CPUE_pos = year + subarea + month + (1|vessel_year) + (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 Student-t distribution with log link where the degree of freedom was estimated within the model (df~1.55. This suggests a highly skewed distribution). The delta model specification eliminated all the residual pattern (Figure 5).

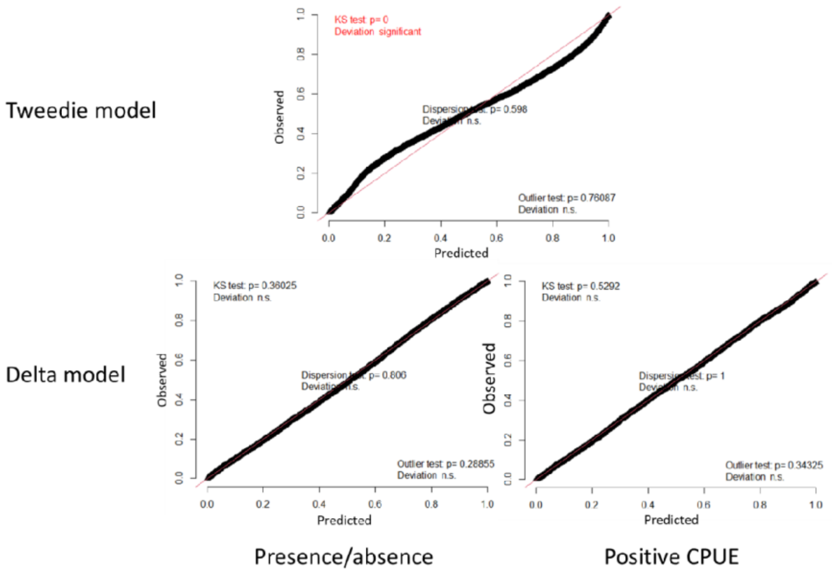

Figure 5. CPUE model residual diagnostics. Top panel shows the residual pattern in the Tweedie model using the latest data and with the (1|vessel_year) random effect. *Bottom panel shows the results from the delta model with the specification mentioned in the text.*

For all subsequent analysis, we considered the delta model results as the new default but still included the original Tweedie model results as a sensitivity test.

As in all previous assessments, the standardized annual CPUE index was created by summing up all predictions based on all combination of year (2007-2021), subarea (in ICES area 2a), 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 2) relative to the total surface (sum of all subarea surfaces in the ICES area 2a). In this process, we removed the "vessel_year" random effect (assuming it equals 0, the mean value) as we assumed it captured the variability in vessel catchability but not 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 with a confidence interval except that model predictions and uncertainty were manually calculated. 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 effects were kept at their MLE except for the vessel_year effect that was replaced by 0. These values were then used to predict the probability of occurrence and positive CPUE value for all combination of year, subarea, and month (as in the Tweedie model) for each of the 100.000 samples. The estimated probability of occurrence and positive CPUE were then multiplied together to calculate the expected CPUE. The final index was calculated by weighted average of the predictions by area (like for the Tweedie model) and the mean CPUE trajectory over time along with its SD was calculated across the 100.000 samples.

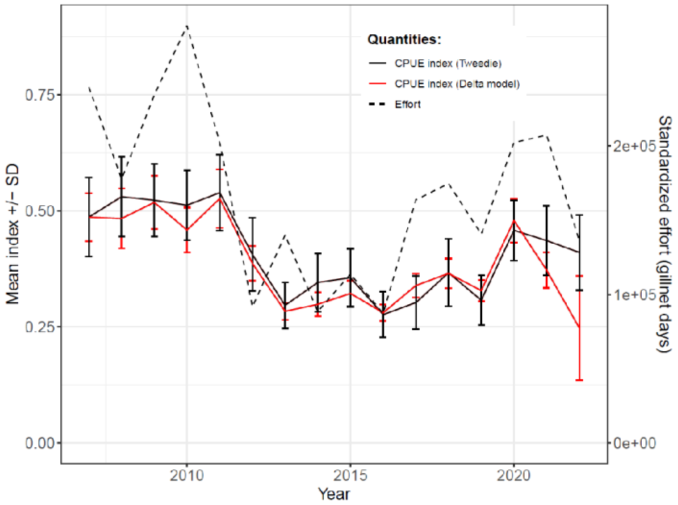

Figure 6. Standardized CPUE (kg per gillnet day) +/- SD (solid black line with error bars for the original Tweedie model, and solid red line with error bars for the new delta model) and the corresponding standardized effort (dash line) for anglerfish based on the data from the Norwegian coastal reference fleet in ICES Subarea 2a, from vessels targeting anglerfish with large-meshed gillnets.

The trend in the estimated index between the delta (default) and Tweedie (sensitivity) models were similar except for the last three years where the delta model suggested a steeper yet highly uncertain decline in the anglerfish population in ICES Subarea 2a (Figure 6). That said, the five (and only) RF vessels participating in the fishery between 2020-2022 also showed contrasting yet variable trends in the average raw CPUE (Appendix figure 2). Moreover, one out of the five vessels only started in the RF program in 2020. All of this contributed to the increasing uncertainty in the estimated trend.

JABBA

JABBA stands for 'Just Another Bayesian Biomass Assessment' and is an 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 billfishes around the world (Winker et al. 2018). JABBA requires at least two comma-separated value files as input (.csv): one for catch and another for abundance indices (with their SE) (see Appendix table 1). 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 1) and the CPUE data (along with its standard deviation) comes from the CPUE standardization process described above with values in 1992-1994 retrieved from Figure 9.13 in AFWG (2021). We assumed that the CPUE index from ICES Subarea 2a calculated using data from the anglerfish targeted fishery is representative of the stock status in ICES areas 1 and 2 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 (e.g., Figure 7). 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 5).

Table 5. Base case and 10 additional scenarios 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. Bmsy/K value controls for the position of the inflection point of the surplus production curve with respect to K (a value from 0 to 1).*

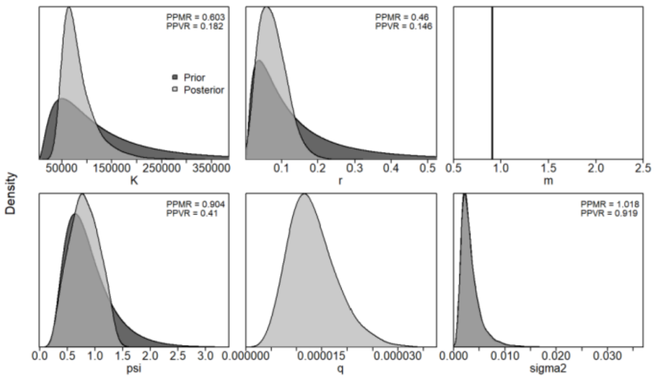

Figure 7. Prior and posterior distribution of the base model parameters for the anglerfish assessment.

Figure 8 shows the trajectory of the population estimates from 1990-2022 based on the 11 tested scenarios (Table 5). In general, population abundance seems to have fluctuated around B_{MSY} (at least the mean trajectory) over the last ten years while fishing mortality might have been slightly above F_{MSY} in more recent years (Figure 8). Figure 9 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 2022 estimates of biomass and fishing mortality. The percentage numbers at the top right indicate how much of the 2022 population estimates falls 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 colored quadrant). The model estimates that there is a 45.7% (15%) probability that the 2022 population estimate falls within the red zone, 15.6% (30%) in the orange, 3.4% (0.5%) in the yellow, and 35.2% (54.5%) in the green zone (numbers in parenthesis show the 2021 values from previous assessment) suggesting a worse stock condition than last year. Finally, retrospective analysis on the base model run has improved compared to the previous assessment cycle (AFWG 2022) without any worrisome patterns (Figure 10, Table 6).

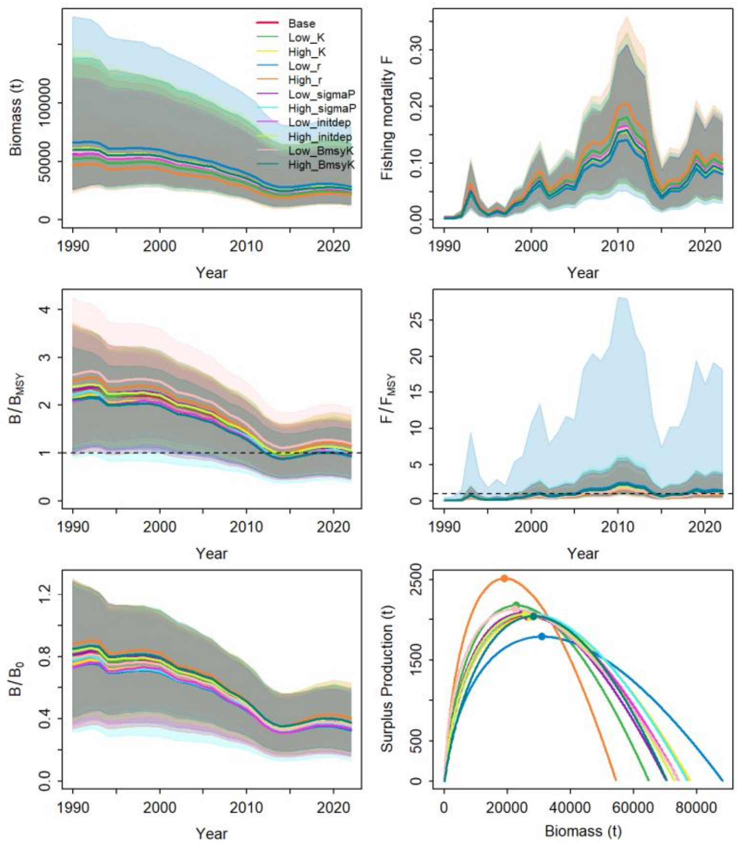

Figure 8. Estimated trajectories for biomass, fishing mortality, B/B_{MSY}, F/F_{MSY}, B/B_0, and surplus production for the ICES Subarea 1-2 anglerfish based on 11 JABBA scenarios (the name of scenario and the associated color is indicated in the figure). The lines show the mean trajectory, and the shaded areas denote 95% credibility intervals

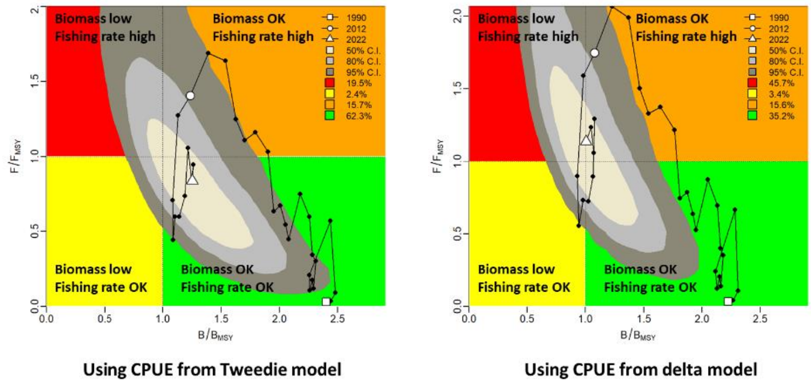

Figure 9. Kobe plot for the JABBA base case scenario showing the estimated trajectories (1990-2021) of B/B_{MSY} and F/F_{MSY}. Different grey shaded areas denote the 50%, 80%, and 95% credibility interval for the terminal assessment year. The probability of terminal year points falling within each quadrant is indicated in the figure legend. 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.

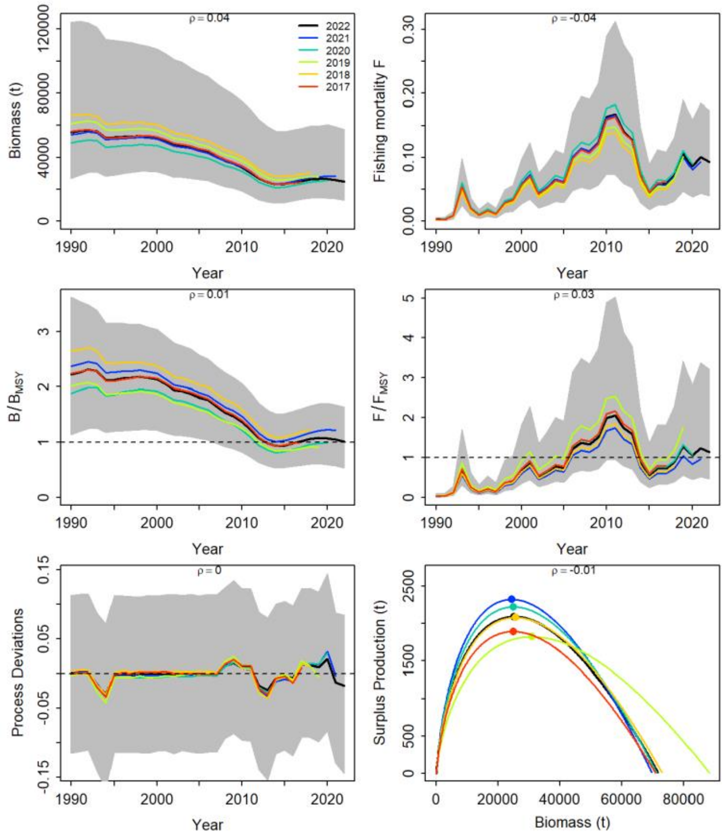

Figure 10. Retrospective analysis from the JABBA base case scenario. Distinct colors illustrate the results from different peels.

Table 6. Relative error (RE) in parameter estimates between the base run with full dataset (ref) 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/BM_{SY}	F/F_{MSY}	procB	MSY
RE_peel1(2021)	0.09	-0.08	0.16	-0.22	0.01	0.1
RE_peel2(2020)	-0.03	0.04	-0.07	0.01	0.01	0.07
RE_peel3(2019)	0.04	-0.04	-0.16	0.36	-0.01	-0.12
RE_peel4(2018)	0.15	-0.13	0.15	-0.11	0	-0.01
RE_peel5(2017)	-0.04	0.04	-0.02	0.09	0	-0.07
Mohn's rho	0.04	-0.04	0.01	0.03	0	-0.01

Discussion and recommendation

The three distinct approaches tested in this report offer corroborative evidence that the anglerfish population has declined over time and that population might be at or below B_{MSY} in 2022 but with a slightly high effort level (probably above F_{MSY}).

The spawning potential ratio and F/M values calculated by the LBSPR method suggests that while there is a lot of uncertainty, the population is fully exploited (estimated values of F/M and SPR included the target reference point ranges).

The standardized CPUE analysis shows that anglerfish population in ICES Subarea 2a has declined over the three most recent years but with a large uncertainty around the final year (2022) estimate.

The relative population stock status in 2022 is around BMSY, though fishing intensity could be close or slightly higher than FMSY. Therefore, effort should be decreased at the risk of the population falling below the biomass and SPR targets.

Recommended advice

Following the ICES technical guidance for harvest control rules and stock assessment for stocks in category 2 (ICES 2022), the "fractile rules" based on the 35th percentile of the predicted catch distribution given a target fishing mortality was applied to the JABBA base-case scenario model. Due to the lack of official harvest control rule for assessment using JABBA, slight modification was made to the ICES "fractile rules" and we used the posterior distribution of the estimated MSY to base the catch recommendation on.

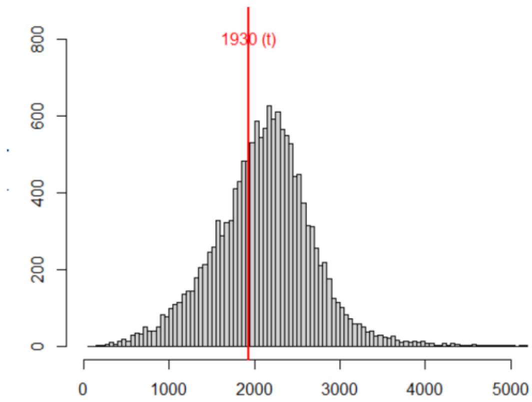

Figure 11. Posterior distribution of the MSY from the base-case scenario along with the 35th quantile of the distribution highlighted with a red line.

The recommended TAC was estimated at 1930 t (Figure 11) and population projections were made for 2023-2025 using the base case model and assuming a constant annual catch of 1930, 2000, 2100, and 2200 t, respectively (Figure 12).

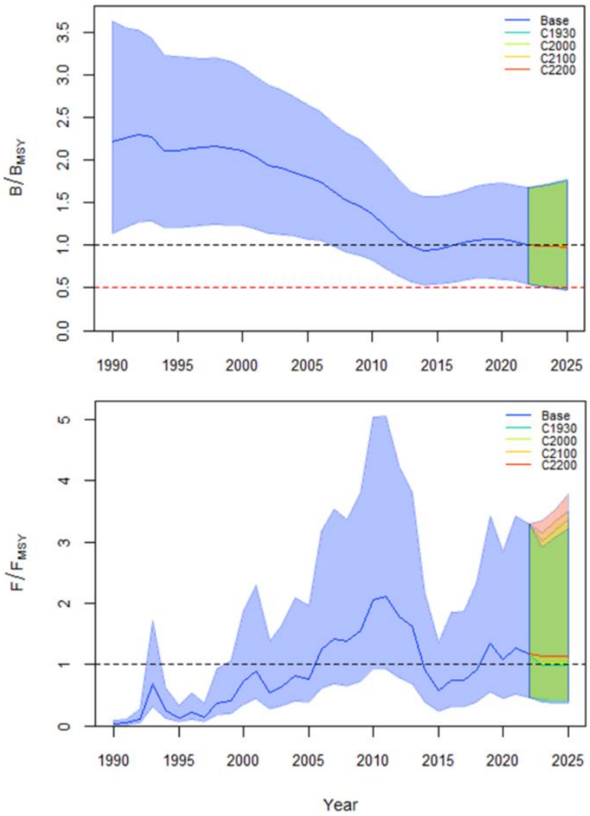

Figure 12. Projected (2023-2025) biomass (B/B_{MSY} - upper panel) and fishing mortality (F/F_{MSY} - lower panel) trajectories for different levels of catch (color coded) using the base-case model.

Figure 12 indicates that at the recommended TAC of 1930 t, the mean anglerfish population is expected to get back to BMSY and FMSY level by 2023.

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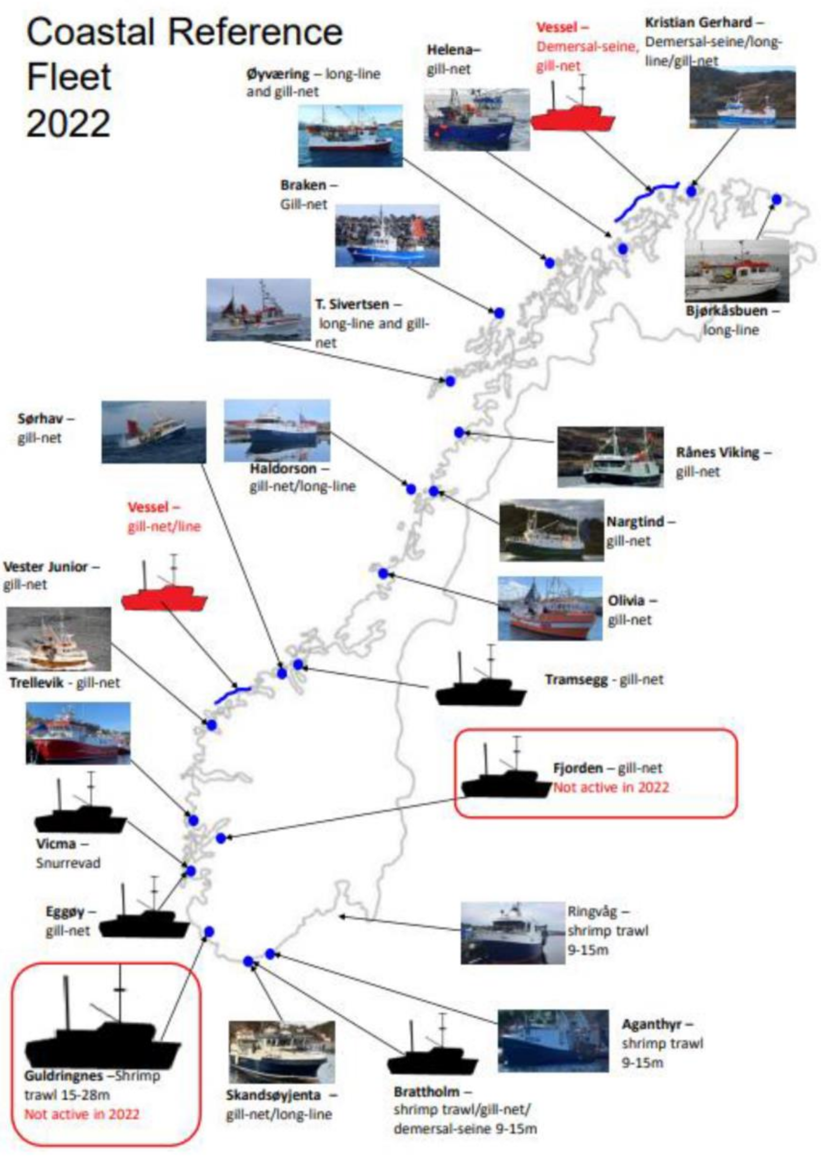
__Appendix figure 1.__ Coastal reference fleet 2022.



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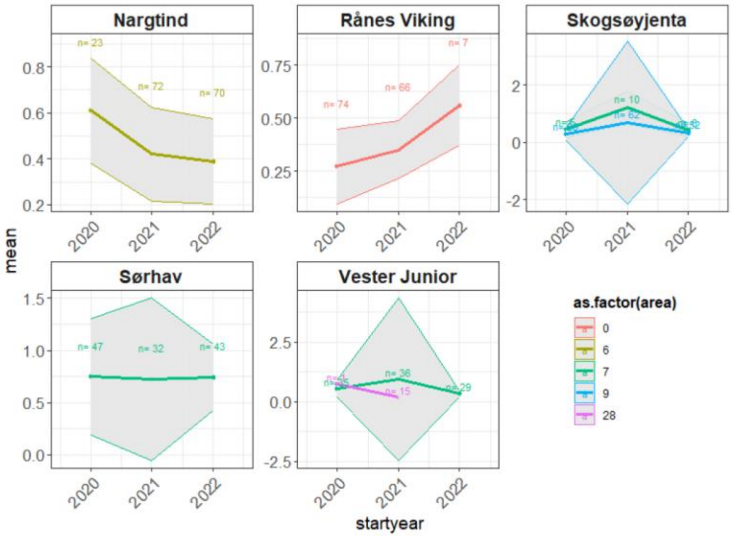
Appendix table 1. *Data contribution (i.e. fishing events) from the various vessels participating into the coastal reference fleet program from 2007 to 2022.*

Vessel	Year															
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ben Hur	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Braken	0	0	0	0	0	0	0	0	0	0	0	0	34	28	0	0
Britt Evelyn	0	0	0	0	0	10	23	32	17	20	37	26	33	36	0	0
Eggøy	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0
Eggumsværin	0	0	22	27	0	0	0	0	0	0	0	0	0	0	0	0
Elias	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fanøyvåg	0	0	0	3	8	0	0	0	0	0	0	0	0	0	0	0
Fjorden	0	0	0	0	0	0	0	0	0	0	0	0	1	34	0	0
Haaværbuen	158	135	102	92	69	0	42	22	41	26	0	0	0	0	0	0
Haldorson	0	0	12	0	35	24	0	8	5	22	0	0	0	29	0	0
Heimdal	32	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hellskjær	0	0	0	0	0	12	20	0	0	0	0	0	0	0	0	0
Nargtind	0	0	0	0	0	0	0	0	0	0	0	0	0	23	72	70
Nimrod	74	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Økssund	0	0	0	0	0	0	0	0	113	90	82	56	25	0	0	0
Øygutt	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Ramona	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Rånes Viking	32	49	86	87	68	49	65	0	66	55	69	90	71	74	66	7
Skogsøyjenta	33	23	53	28	33	31	52	51	57	15	85	69	94	63	72	58
Snarsetværin	26	72	18	30	17	0	0	0	0	0	0	0	0	0	0	0
Solgløtt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sommarøybu	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Sørhav	0	0	0	0	0	0	0	0	0	0	48	40	51	47	32	43
Stording	0	0	18	27	10	0	0	0	0	0	0	0	0	0	0	0
T.Sivertsen	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Thema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tom-Robert	128	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tramsegg	122	37	73	51	48	21	39	55	35	1	1	3	4	24	21	0
Trellevik	0	0	0	0	0	0	0	0	0	0	0	8	16	0	0	0
Vågøybuen	0	6	24	35	16	0	0	0	0	0	0	0	0	0	0	0
Vandsøyvåg	0	0	0	0	0	0	18	13	0	0	0	0	0	0	0	0
Vester Junior	0	0	0	0	0	0	0	43	20	18	43	41	12	36	51	29
Vicma	0	0	0	0	0	0	0	0	0	53	151	0	0	0	0	0

Appendix figure 2. Mean +/- SD in the raw CPUE for the five vessels participating in the RF program during 2020-2022.

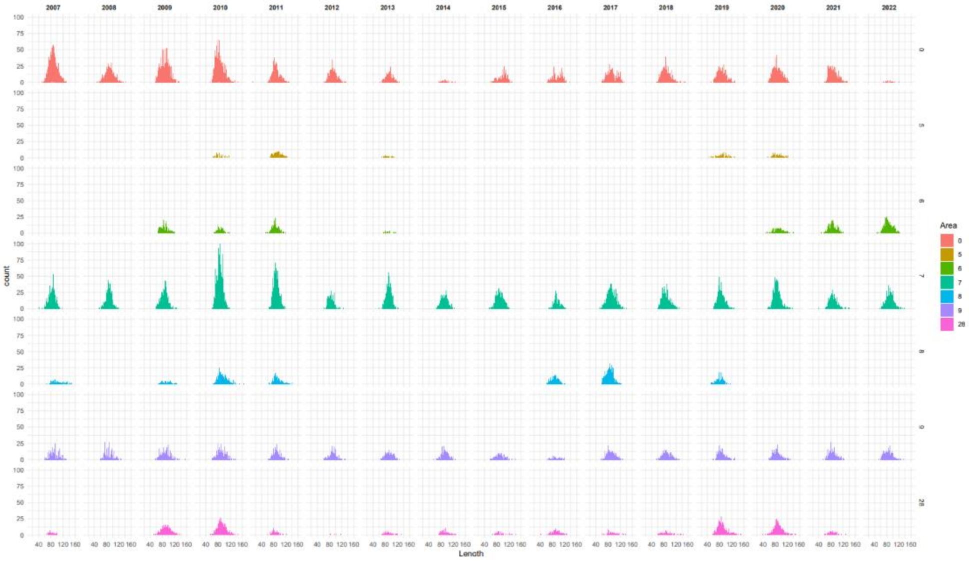


Appendix table 2. *Input data to the JABBA assessment in the form of catch and abundance indices of anglerfish (L. piscatorius) in ICES Subarea 1 and 2.*

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	0.49	0.06
2008	4151	0.48	0.07
2009	4458	0.52	0.06
2010	5515	0.46	0.05
2011	5112	0.53	0.07
2012	3765	0.39	0.05
2013	3103	0.28	0.03
2014	1657	0.30	0.04
2015	1043	0.32	0.04
2016	1435	0.28	0.04
2017	1484	0.34	0.05
2018	1903	0.37	0.05
2019	2809	0.33	0.04
2020	2280	0.48	0.06
2021	2601	0.37	0.05
2022	2293	0.25	0.15

Appendix figure 3. *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 2-4.*



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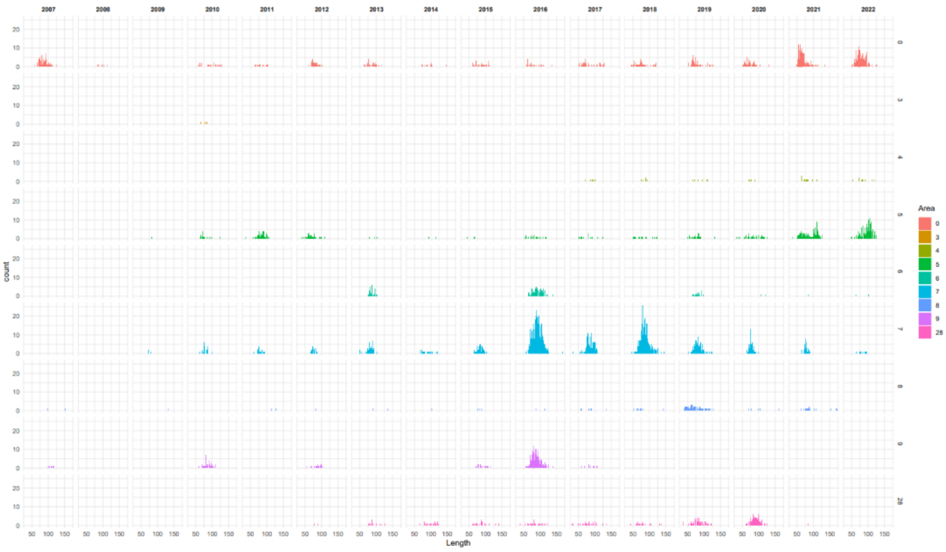
Appendix figure 4. *Length distributions of anglerfish (L. piscatorius) caught as bycatch and retained in* ***other gillnets*** *per year and Norwegian statistical areas. Note the different scale of the y-axis in App. figs 2-4.*



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Appendix figure 5. *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 2-4.*

Working Document Submitted to AFWG 2023 **WD 02**

Report of the Portuguese fishery in 2021: ICES Div. 1, 2a and 2b.

by

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A. Status of the fisheries

In 2022, the Portuguese nominal catches recorded 4,500 tons proceeding from the traditional grounds of both ICES Divisions 1 and 2 (Norway and Svalbard) and 88 tons proceeding from the redfish pelagic fishery in the "Banana Hole" zone (international waters of Div. 2a) (Tab. I). In the traditional grounds, the nominal catches increased from 1993 (4,036 tons) to 1997 (8,661 tons) followed by a decline till 2003 (4,250 tons). In 2004 total catches increased and were maintained between 5,300 and 5,900 tons till 2010. From 2011 to 2022 catches decreased to an interval amongst 3,200 and 5,600 tons, exception for 2015 (1754 ton - the lowest value since 1993).

In the traditional grounds, fishing effort increased till 1998 (1118 fishing days) but decreased gradually afterwards, reaching 277 fishing days in 2003. Between 2004 and 2007, the trend of fishing effort in the traditional grounds shows an increase, from 486 to 558 fishing days but since then effort decreased gradually reaching a minimum in 2015 (100 fishing days). Despite the increase fishing effort in 2016 and 2017 (197 and 192 fishing days respectively) the effort fell again in 2018-2019 to around 140 days. Effort from 2020 to 2022 was slightly above 200 fishing days (Table I).

For the period 1993-2022, cod (*Gadus morhua*) was the most important species in the catches in Divisions 1 and 2, exception for 1993 in Division 2a. Cod catches more than doubled from 2015 to 2016 but decreased in the next two years to 2,672 tons. From 2019 to 2020 cod catches raised again, but in 2021and 2022 cod catches decreased to the level of 2019 (around 3,500 tons).

Redfish (*Sebastes mentella*) catches and effort in the international waters of Div. 2a decreased from 1697 ton in 2006 to values around 600-700 tons in 2008-2009, and from 175 days to 88 days, respectively. In 2010 the fishing effort was only 16 days and the redfish catches were 244 tons. Both catch and effort increased in the two following years to 600 tons and 42 days in 2011 and 1038 tons and 139 days in 2012. In 2013-2015 effort was only 59 days but catches were 852 tons in 2013, 544 tons in 2014 and 678 tons in 2015. In 2016 although only 35 days were spent the catches increased to 822 tons, but in 2017 it was need 79 days to catch the same amount. In 2018 both catches and effort fell to half of the values in 2017 (356 tons and 31 days) (Tab. I). In 2019, catches and effort increased considerably (1093 tons and 140 days), decreasing later in 2020 (480 tons and 74 days), and in 2021 were only 84 tons and 9 days. 2022 was similar to 2021 (88 tons and 11 days).

The Portuguese fleet operating in the traditional grounds of both Divisions 1 and 2, was composed by 3 trawler using a bottom trawl gear. The fishery in the international waters of Div. 2a was carried out by 1 trawler fishing with a pelagic trawl gear.

B. Portuguese Annual Sampling Program

1. Catch and effort sampling.

Effort and CPUE data for 2022 Portuguese trawl fishery on ICES Div. 1, 2 were obtained from one trawler, through the revision of the skipper logbook kindly supplied by the owner. All the information (round weight of the catch by species, fishing effort, positions and depths) has been recorded on a tow-by-tow basis. The vessel conversion factors were used to convert its processed landings in catches.

The daily catch and effort data from the logbook were used to estimate the target species, directed effort and CPUE, as well as the main by-catch species on a monthly basis (Tab. II).

In Division 1b and 2b, all fishing effort was directed to cod with a small by-catches of American plaice/ long rough dab (*Hippoglossoides platessoides*) and wolffish (*Anarhichas spp.*). In the "Banana Hole" zone (Div. 2a international waters – outside Norwegian EEZ), all pelagic fishing effort was directed to redfish.

1.1. Comments on redfish catch rate data.

Based on the observed vessel, the cod catch rates were high (over 0.440 tons/h) in September and November in Div. 1b (Table II) and between 0.335 and 0.377 tons/h in the rest of the months/Divisions. In Div. 2a international waters, the redfish catch rate in September 2022 (0.365 tons/h) decreased compared to the previous two years (> 0.480 tons/h) (Table II).

2. Biological Sampling

In 2022, biological sampling was obtained from one stern trawler fishing in ICES Div. 1b and 2b, since September to December, with a bottom trawl gear operating from 143 m to 438 m depths. In Div. 2a international waters, redfish (*S. mentella*) sampling data was obtained from one trawler, fishing in September, with a pelagic trawl gear operating from 198 m to 430 m depths (Tab III).

All commercial information is representative of the catch as a whole. When sampling was carried out by sex, mean length and weight is the mean of mean lengths and weights by sex, weighted by the abundance in the sampled catches of males and females. The mean weights in the catch are derived from the calculated 2022 length-weight relationships, exception for Greenland halibut (Tab. IV).

2.1. Comments on length composition of the 2022 trawl catches.

2.1.1 - Cod (*G. morhua*)

In Div. 1b (Tab. V, Fig. 1), lengths between 66 cm and 75 cm dominated catches, with a modal class at 69 cm (mean length and weight of 74.3 cm and 3958 g).

In Div. 2b (Tab. VI, Fig. 2), lengths between 57 cm and 69 cm dominated catches, with a modal class at 63 cm (mean length and weight of 68.2 cm and 3075 g).

2.1.2 – Redfish (*S. mentella*)

In Div. 2a international waters (Tab. VII, Fig. 3), lengths between 36 cm and 39 cm dominated catches, with a modal class at 37 cm (mean length and weight of 37.8 cm and 678 g).

2.1.3 – American plaice / long rough dab (*Hippoglossoides platessoides*)

In Div. 1b (Tab. VIII, Fig. 4), lengths between 36 cm and 42 cm dominated bycatches, with a modal class at 40 cm (mean length and weight of 40.7 cm and 711 g).
37 cm (mean length and weight of 37.8 cm and 678 g).

2.1.4 – Greenland halibut (*Reinhardtius hippoglossoides)*

In Div. 2b (Tab. IX, Fig. 5), lengths between 44 cm and 64 cm dominated bycatches, with two modal classes at 50 and 62 cm (mean length and weight of 55.3 cm and 1591 g).

2.1.5 – Haddock (*Melanogrammus aeglefinus*)

In Div. 2b (Tab. X, Fig. 6), lengths between 53 cm and 56 cm dominated bycatches, with a modal class at 53 cm (mean length and weight of 53.2 cm and 1607 g).

Acknowledgements

This study was supported by the European Commission (Programme for the Collection of Data in Fisheries Sector) and IPMA.

TABLE I - A: Portuguese provisional nominal trawl catches (ton) in Norway (Div.1 and 2a), Svalbard (Div.1 and 2b) and International waters (Div. 2a) regions, 2022.

SPECIES \ AREA	1 and 2a Norway	1 and 2b Svalbard	2a International waters (Banana hole)	SUBTOTAL Norway + Svalbard	TOTAL 2022
Cod	1667.0	2030.0		3697.0	3697.0
Redfish	425.0	24.0	88.0	449.0	537.0
American plaice	20.5	56.2		76.7	76.7
Greenland halibut	16.0	44.0		60.0	60.0
Atlantic halibut	3.0			3.0	3.0
Anarhichas spp.	20.1	64.6		84.7	84.7
Hadocck	40.0	10.0		50.0	50.0
Skates		4.0		4.0	4.0
Pollock	103.0	1.00		104.0	104.0
Shrimp					
Monkfish					
Unidentified					
TOTAL	2294.6	2233.9	88.0	4528.5	4616.5
Fishing Days	103	129	11	232	243

[illegible]

SPECIES / YEAR	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Cod	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Redfish	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
American plaice	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Greenland halibut	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Atlantic halibut	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Haddock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Skates														[illegible]				[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pollock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shrimp																													
[illegible]											[illegible]	[illegible]	[illegible]	[illegible]															
Unidentified	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]		[illegible]								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fishing Days	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-

[illegible]

SPECIES / YEAR	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Cod	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Redfish	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
American plaice	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Greenland halibut	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Atlantic halibut	[illegible]		[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Haddock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Skates												[illegible]			[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pollock	[illegible]		[illegible]		[illegible]			[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	[illegible]
Shrimp															[illegible]			[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]																													
Unidentified			[illegible]																						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fishing Days	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-

[illegible]

SPECIES / YEAR	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Cod	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Redfish	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
American plaice	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Greenland halibut	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Atlantic halibut	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Haddock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Skates												[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pollock	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shrimp															[illegible]			[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]											[illegible]	[illegible]	[illegible]	[illegible]															
Unidentified	[illegible]	[illegible]	[illegible]	[illegible]											[illegible]		[illegible]								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fishing Days	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-

TABLE II: Portuguese trawl fishery cpue's and bycatch by month and division for 2022.

DIVISION	TARGET SPECIES	MONTH	DEPTH RANGE (m) MIN.	MAX.	CPUE (ton/hour)	MAIN BYCATCH SPECIES	%	TOTAL BYCATCH (%)
1b	COD	SEP	176	298	0.440	PLA	3.6	5.6
1b	COD	NOV	363	383	0.618	PLA	5.1	9.9
2b	COD	SEP	203	295	0.373	PLA	4.9	6.8
2b	COD	OCT	143	381	0.335	CAT	8.0	16.9
2b	COD	NOV	179	438	0.377	PLA	6.4	20.0
2b	COD	DEC	255	338	0.336	PLA	11.3	16.3
2a (*)	RED	SEP	198	430	0.365	-	-	-

(*) - Banana Hole (International waters of division 2a)

TABLE III: Intensity of the trawl sampling during 2022, by species, division and month.

SPECIES	DIV.	MONTH	Nº OF SAMPLES	Nº FISH MEASURED	SAMPLING WEIGHT(Kg)	OTOLITHS Nº	LENGTH RANGE (cm)
COD	1b	SEP	6	610	2477	46	60-100
COD	1b	NOV	4	374	1348	85	55-103
COD	2b	SEP	2	188	687	18	60-96
COD	2b	OCT	27	2243	7477	169	60-112
COD	2b	NOV	25	2410	6966	62	49-97
COD	2b	DEC	11	1134	3270	3	49-97
REDFISH (*S. mentella*)	2c	SEP	11	1410	854	90	30-43
AMERICAN PLAICE	1b	SEP	1	104	54	30	36-45
GREENLAND HALIBUT	2b	NOV	2	119	232	-	-
HADDOCK	2b	OCT	3	66	103	6	45-58
HADDOCK	2b	NOV	1	15	25	-	-

(*) - Banana Hole (International waters of division 2a)

TABLE IV: Length-weight relationship by species, stock and sex in 2022.

Species	Stock	Sex	a	b	n	r^2	Length interval (cm)
COD	1, 2	T	0.0048	3.1458	6934	0.993	42-115
PLA	1, 2	T	0.0013	3.5686	30	0.954	36-45
REB	2a (*)	F	0.0066	3.1705	43	0.949	33-43
REB	2a (*)	M	0.0308	2.7466	59	0.973	30-42
REB	2a (*)	T	0.0240	2.8176	102	0.987	30-43
HAD	1, 2	F	0.0576	2.5709	5	0.974	44-60
HAD	1, 2	M	0.1085	2.4176	4	0.859	45-58
HAD	1, 2	T	0.0838	2.4784	9	0.924	44-60
GHL	1, 2	F	0.0025	3.2992		From 2011 report	
GHL	1, 2	M	0.0023	3.3174		From 2011 report	
GHL	1, 2	M+F	0.0026	3.2902		From 2011 report	

(*) - Banana Hole (International waters of division 2a)

TABLE V: COD, DIV. 1b, 2022: length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP =3rd Q.	NOV =4th Q.	YEAR	LENGTH GROUP
45		5.9	3.0	45
48		7.3	3.7	48
51	5.0	16.3	10.7	51
54	17.7	45.0	31.4	54
57	32.5	50.9	41.8	57
60	51.3	67.3	59.4	60
63	77.0	74.1	75.5	63
66	82.9	112.2	97.7	66
69	109.8	117.0	113.4	69
72	109.9	110.1	110.0	72
75	102.1	98.2	100.1	75
78	80.0	89.6	84.8	78
81	84.1	84.1	84.1	81
84	60.9	42.5	51.7	84
87	78.5	35.0	56.7	87
90	30.0	19.6	24.8	90
93	28.8	4.3	16.5	93
96	35.3	11.6	23.4	96
99	14.2	3.0	8.6	99
102		2.9	1.5	102
105		2.9	1.5	105
TOTAL	1000	1000	1000	
No. SAMPLES	6	4	10	
SAMPLING WEIGHT(kg)	2477	1348	3825	
No. F.MEASURED	610	374	984	
MEAN LENGTH(cm)	76.3	72.4	74.3	
MEAN WEIGHT (g)	4281	3638	3958	
DEPTH RANGE (m)	212/298	365/378	212/378	

TABLE VI: COD, DIV. 2b, 2022: length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP	OCT	NOV	DEC	3rd Q.	4th Q.	YEAR	LENGTH GROUP
42		2.3	1.4	4.4		2.2	2.2	42
45		7.9	16.3	10.1		12.2	12.1	45
48		14.1	26.8	34.5		23.5	23.3	48
51		43.2	51.0	46.6		47.4	46.9	51
54		61.1	80.2	61.0		70.0	69.3	54
57	21.3	90.0	95.9	78.1	21.3	90.8	90.1	57
60	82.0	104.1	105.5	95.1	82.0	103.2	103.0	60
63	119.9	107.7	115.2	113.5	119.9	112.2	112.2	63
66	139.8	85.7	122.6	128.1	139.8	110.1	110.4	66
69	167.8	81.6	85.9	101.4	167.8	87.0	87.7	69
72	118.4	77.6	80.5	98.1	118.4	82.4	82.8	72
75	139.8	69.0	68.4	70.2	139.8	68.9	69.6	75
78	44.5	65.7	45.7	54.5	44.5	54.5	54.4	78
81	23.2	47.6	40.8	45.8	23.2	44.1	43.9	81
84	75.7	47.9	27.1	23.1	75.7	34.0	34.4	84
87	24.7	34.7	14.3	15.3	24.7	21.9	21.9	87
90	14.8	28.9	10.6	9.4	14.8	17.0	17.0	90
93	16.5	14.8	7.4	1.9	16.5	9.2	9.2	93
96	1.7	9.5	2.3	1.1	1.7	4.7	4.7	96
99	9.8	3.6	1.4	6.2	9.8	3.0	3.1	99
102		0.9	0.1	1.5		0.6	0.6	102
105		1.4	0.1			0.6	0.6	105
108		0.2	0.1			0.1	0.1	108
111		0.4				0.1	0.1	111
114			0.3			0.1	0.1	114
TOTAL	1000	1000	1000	1000	1000	1000	1000	
No. SAMPLES	2	27	25	11	2	63	65	
SAMPLING WEIGHT(kg)	687	7477	6966	3270	687	17713	18401	
No. F.MEASURED	188	2243	2410	1134	188	5787	5975	
MEAN LENGTH(cm)	72.9	69.9	67.0	67.7	72.9	68.2	68.2	
MEAN WEIGHT (g)	3641	3349	2885	2975	3641	3069	3075	
DEPTH RANGE (m)	239/295	153/334	187/416	255/338	239/295	153/416	153/416	

TABLE VII: REDFISH (*S. mentella*),
International waters of DIV. 2a, 2022:
length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP =YEAR	LENGTH GROUP
30	0.4	30
31		31
32	7.4	32
33	5.1	33
34	38.8	34
35	76.8	35
36	178.5	36
37	237.1	37
38	214.4	38
39	150.7	39
40	56.7	40
41	30.8	41
42	3.0	42
43	0.3	43
TOTAL	1000	
No. SAMPLES	11	
SAMPLING WEIGHT(kg)	854	
No. F.MEASURED	1410	
MEAN LENGTH(cm)	37.8	
MEAN WEIGHT (g)	678	
DEPTH RANGE (m)	198/430	

TABLE VIII: AMERICAN PLAICE, DIV. 1b, 2022:
length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP =YEAR	LENGTH GROUP
30	9.6	30
32		32
34	19.2	34
36	144.2	36
38	240.4	38
40	269.2	40
42	211.5	42
44	76.9	44
46	19.2	46
48	9.6	48
TOTAL	1000	
No. SAMPLES	1	
SAMPLING WEIGHT(kg)	54	
No. F.MEASURED	104	
MEAN LENGTH(cm)	40.7	
MEAN WEIGHT (g)	711	
DEPTH RANGE (m)	243/298	

TABLE IX: GREENLAND HALIBUT, DIV. 2b, 2022:
length composition (0/000) of the trawl catches.

LENGTH GROUP	NOV =YEAR	LENGTH GROUP
32	7.3	32
34	16.6	34
36	14.5	36
38		38
40	35.4	40
42	42.7	42
44	70.8	44
46	83.2	46
48	68.7	48
50	85.3	50
52	76.0	52
54	26.0	54
56	63.6	56
58	56.3	58
60	50.9	60
62	81.1	62
64	76.0	64
66	73.9	66
68		68
70	16.6	70
72	23.9	72
74	9.4	74
76	7.3	76
78	7.3	78
80	7.3	80
TOTAL	1000	
No. SAMPLES	2	
SAMPLING WEIGHT(kg)	232	
No. F.MEASURED	119	
MEAN LENGTH(cm)	55.3	
MEAN WEIGHT (g)	1591	
DEPTH RANGE (m)	238/365	

TABLE X: HADDOCK, DIV. 2b, 2022: length composition (0/000) of the trawl catches.

LENGTH GROUP	OCT	NOV	4th Q. =YEAR	LENGTH GROUP
44	7.9		3.4	44
45	60.5		26.1	45
46	52.6	133.3	98.5	46
47				47
48	43.0	66.7	56.4	48
49	76.8		33.2	49
50	122.7		53.0	50
51	125.2	66.7	91.9	51
52	169.8		73.3	52
53	79.4	200.0	147.9	53
54	43.0	200.0	132.2	54
55	59.3	66.7	63.5	55
56	35.0	200.0	128.8	56
57	29.7		12.8	57
58	33.3		14.4	58
59	29.7		12.8	59
60	20.0		8.7	60
61				61
62	12.1		5.2	62
63				63
64				64
65				65
66		66.7	37.9	66
TOTAL	1000	1000	1000	
No. SAMPLES	3	1	4	
SAMPLING WEIGHT(kg)	103	25	129	
No. F.MEASURED	66	15	81	
MEAN LENGTH(cm)	52.2	53.9	53.2	
MEAN WEIGHT (g)	1534	1663	1607	
DEPTH RANGE (m)	192/251	243/278	192/278	

Fig. 1 - Annual length composition of cod on Division 1b, bottom trawl fishery in 2022.

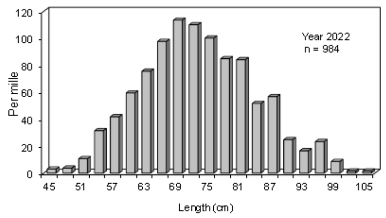

Fig. 2 - Annual length composition of cod on Division 2b, bottom trawl fishery in 2022.

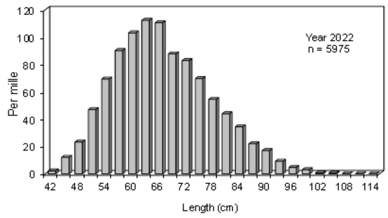

Fig. 3 - Annual length composition of redfish (*S. mentella*) International waters of Division 2a, pelagic trawl fishery in 2022.

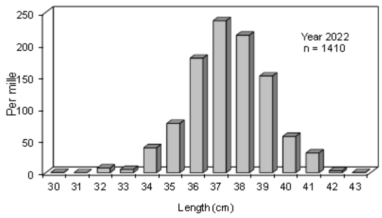

Fig. 4 - Annual length composition of American plaice on Division 1b, bottom trawl fishery in 2022.

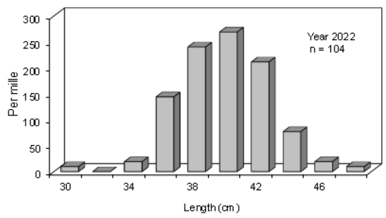

Fig. 5 - Annual length composition of Greenland halibut on Division 2b, bottom trawl fishery in 2022.

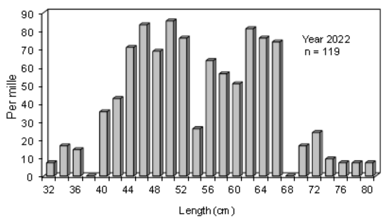

Fig. 6 - Annual length composition of haddock on Division 2b, bottom trawl fishery in 2022.

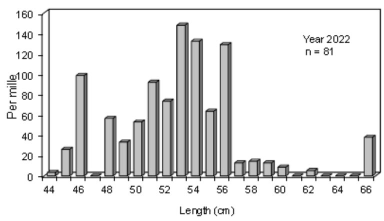

TABLE I - A: Portuguese provisional commercial trawl catches (ton) in Norway (Div. 1 and 2a), Svalbard (Div. 1 and 2b) and international waters (Div. 2a) regions, 2022.

SPECIES \ AREA	1 and 2a Norway	1 and 2b Svalbard	2a International waters (Banana hole)	SUBTOTAL Norway + Svalbard	TOTAL 2022
Cod	1667.0	2030.0		3697.0	3697.0
Redfish	425.0	24.0	88.0	449.0	537.0
American plaice	20.5	56.2		76.7	76.7
Greenland halibut	16.0	44.0		60.0	60.0
Atlantic halibut	3.0			3.0	3.0
Anarhichas spp.	20.1	64.6		84.7	84.7
Haddock	40.0	10.0		50.0	50.0
Skates		4.0		4.0	4.0
Pollock	103.0	1.00		104.0	104.0
Shrimp					
Monkfish					
Unidentified					
TOTAL	2294.6	2233.9	88.0	4528.5	4616.5
Fishing Days	103	129	11	232	243

TABLE I - B: Portuguese commercial trawl catches (ton) in Norway/ZEE (Div. 1 and 2a, not including international waters of Div. 2a.

SPECIES / YEAR	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Cod	1104.2	3444.2	1784.6	2649.9	2770.1	2522.0	1182.0	1813.9	2630.0	1515.0	1106.1	2559.7	3340.4	2967.2	2269.3	2598.2	2529.7	2610.6	2204	2205.1	2198.7	2184.4	2230.4	3494.6	4906.0	4380.9	3817.1	3253.5	27.3
Redfish	368.0	476.7	394.4	391.5	369.3	244.8	0.1	1.6	8.0	4.4	4.6	27.8	92.5	112.7	89.7	92.5	126.9	91.3	23	142.1	110.2	114.3	68.9	124.2	470.6	479.5	740.3	777.4	724.7
American plaice	10.7	9.2	0.2	0.1			0.2					0.7	10.6	2.5	0.4	3.6	8	12.5	21.8	14.4	23.9	36.5	28.4	192.0	29.4	70.2	27.2	16.0	
Greenland halibut	12.7	9.4	4.1	6.3	1.2	18.6	3.7		0.86	0.06	0.2	0.1	9.2	1.3	1.8	7.6	13.4	24.2	9.6	4.6	12.6	18.1	33.1	80.0	40.9	65.1	75.2	26.1	16.6
Atlantic halibut	1.3	3.4	1.6	6.6	2.3	2.0	1.0	1.1	0.4	0.7	0.6	2.4	6.3	8.9	11.5	11	3.8	1	1.1	0.3	0.6	0.8		0.3		0.3	0.2		
Anarhichas spp.	4.7	6.3	1.6	8.1	3.2	10.2	3.4		1.4		2.0	0.03	6.0	2.9	0.4	3.6	19.7	48.4	46.8	69.7	87.5	117.8	51.6	344.7	94.4	94.9	82.5	80.5	3.2
Haddock	26.3	60.7	28.6	70.3	87.1	122.3	34.8	27.4	34.0	22.2	30.0	137.8	406.1	407.8	372.3	286.2	223.1	184.6	144.5	85.4	78.7	109.6	19.5	34.9	119.3	69.8	33.4	34.0	10.8
Skates														2.0				1.5	3.1		0.6	6.2	2.9	38.4	14.7	7.6	9.8	3.5	0.1
Pollock	21.2	131.6	122.2	60.7	86.5	63.0	9.7	11.7	17.0	7.3	41.0	93.3	209.0	346.9	397	333.9	343.4	98.2	143.6	110.9	72.3	45.7	17.4	47.3	12.0	23.8	4.2	0.6	0.6
Shrimp																													
Monkfish											0.02	1.5	6.4	2.0															
Unidentified	0.1	0.7	0.6	0.7											0.6		0.1								0.1	0.5	3.5	6.3	2.9
TOTAL	1539.2	4141.3	2337.7	3082.2	3308.8	2912.9	1244.9	1861.7	2691.7	1549.6	1183.5	2823.2	4086.4	3454.2	3142.9	3296.6	3368.1	3132.2	2597.4	2632.5	2585.9	2633.4	2442.2	4356.4	5687.4	5172.5	4793.3	4197.9	786.1
Fishing Days	69	136	89	130	99	121	51	56	74	62	76	132	274	271	218	333	298	284	179	169	267	399	327	748	494	393	306	-	-

TABLE I - C: Portuguese commercial trawl catches (ton) in Svalbard (Div. 1 and 2b).

SPECIES / YEAR	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Cod	2419.5	1415.5	1686.2	122.0	1208.0	1948.6	505.5	1539.2	2117.0	1940.4	1871.1	2094.7	1366.7	1554.7	1490.3	1649	1686.2	1714.5	1424.1	1424.8	1424.3	1403.0	1654.9	1967.4	2622.3	2384.4	2378.1	2390.4	1761.1
Redfish	4.9	0.7	1.8	0.0	0.460	0.004		5.5	31.0	18.8	38.8	48.8	41.8	47.8	166.9	83.4	68.5	148.7	27.2	134.0	74.9	16.9	8.6	6.8	63.6	42.8	219.0	208.2	316.3
American plaice	137.1	27.8	6.8	0.1	2.5	4.3	0.0	6.2	12.6	3.8	1.3	10.7	8.7	22.7	34.1	38.7	37.1	32.9	27	79.6	44.9	74.4	42.3	66.3	27.6	14.8	21.9	10.6	29.0
Greenland halibut	33.4	18.2	3.2	0.1	4.6	2.8	0.8	0.0	3.0	1.6	21.4	10.8	19.5	45.4	27.6	16.4	12.3	26.3	9.9	10.8	21.9	18.9	15.7	18.9	8.6	24.4	24.1	10.1	25.6
Atlantic halibut	0.2		0.1	0.1	0.1					0.3	0.8	1.3	1.5	1.1	4.8	3.6	1.4	0.1									0.1		
Anarhichas spp.	33.3	34.0	2.7	1.0	19.4	3.8	2.2	9.6	8.6	9.3	7.2	32.4	74.9	66.7	97.8	49.1	47.8	47.3	30.9	37.2	63.7	43.6	39.7	123.6	122.4	69.6	424.8	511.0	623.2
Haddock	26.0	1.4	6.3	10.7	21.3	18.1		24.4	53.0	120.9	962.7	349.7	250.5	204.9	550	193.8	219	170.7	120.1	75.6	22.0	21.4	18.0	10.2	48.4	148.2	573.7	720.7	571.6
Skates												0.9			13.2	7.9	1.3		5.1		1.9	0.4	6.6	7.8	12.8	2.3	5.9	6.9	22.1
Pollock	0.02		8.3		3.1			0.2	0.3		1.8		0.2	1.2	9.2	6.2	11.1	6.6	3	10.7	2.9	0.1					0.8	1.3	0.3
Shrimp															0.6			24.1			219.3	264.0	826.7	168.4	67.9				
Monkfish																													
Unidentified			0.1																						0.1	1.9	1.8	1.7	2.2
TOTAL	2654.6	1497.6	1714.6	134.1	1259.5	1977.6	508.6	1585.1	2225.3	2096	2896.0	2549.4	1763.7	1944.5	2384.5	2047.1	2086.7	2171.2	1647.3	1772.7	1815.8	1842.7	2612.5	2369.4	2973.6	2688.3	3690.3	3861.0	3292.3
Fishing Days	130	75	59	5	90	76	15	65	40	85	130	130	106	150	280	213	145	202	98	125	188	236	404	370	326	137	262	-	-

TABLE I - D: Portuguese commercial trawl catches (ton) in Div. 1 and 2, not including international waters of Div. 2a.

SPECIES / YEAR	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Cod	3523.7	4859.7	3469.8	2671.9	3978.1	4470.6	1687.5	3359.1	4647.0	3455.4	3576.2	4654.4	4707.1	4121.9	3759.6	4207.2	4315.9	4385	3628.1	3629.9	3624.0	3587.4	3885.3	5462.0	7528.3	6165.3	6195.2	5644.0	1788.4
Redfish	362.9	476.4	396.2	391.5	369.8	244.8	0.1	7.2	39.0	23.2	43.4	76.6	134.3	160.4	245.6	175.9	195.4	240	50.2	276.1	185.1	131.2	67.5	131.0	534.1	522.3	959.3	985.6	1040.0
American plaice	147.8	37.0	7.0	0.1	2.5	4.3	0.2	6.2	12.6	3.8	1.3	11.4	19.3	25.2	34.5	42.3	45.1	45.4	48.8	94.0	68.8	110.9	70.7	258.3	57.0	85.0	49.1	26.5	29.0
Greenland halibut	46.1	27.6	7.3	5.5	5.8	21.4	4.5	0.0	3.9	1.6	21.5	10.9	28.7	46.8	29.4	24	25.7	50.5	19.5	15.4	34.4	37.0	48.8	98.9	49.5	79.5	99.4	36.2	42.1
Atlantic halibut	1.5	3.4	1.6	6.6	2.5	2.0	1.0	1.1	0.4	1.0	1.5	3.6	7.7	10.0	16.3	14.6	5.2	1.1	1.1	0.3	0.6	0.8		0.3		0.3	0.3		
Anarhichas spp.	38.0	40.3	4.3	9.1	22.6	14.0	5.7	9.6	9.9	9.3	9.2	32.5	80.9	69.6	98.2	52.7	67.5	95.7	77.7	106.9	151.2	161.4	91.3	468.3	216.8	164.4	507.3	591.5	626.3
Haddock	52.3	62.1	34.8	81.1	108.3	140.4	34.8	51.7	87.0	143.1	992.7	481.5	656.6	612.7	922.3	480	442.1	355.3	264.6	161.0	100.7	131.0	37.5	45.1	167.7	217.9	607.1	754.7	582.5
Skates												0.9		2.0	13.2	7.9	1.3	1.5	8.2		2.4	6.6	9.5	45.2	27.5	9.9	15.8	10.4	22.2
Pollock	21.3	131.6	130.5	60.7	88.6	63.0	9.7	11.9	17.3	7.3	42.8	93.3	209.2	348.1	406.2	339.1	354.5	104.8	146.6	121.6	75.2	45.8	17.4	47.3	12.0	23.8	4.9	2.0	0.9
Shrimp															0.6			24.1			219.3	264.0	826.7	168.4	67.9				
Monkfish											0.02	1.5	6.4	2.0															
Unidentified	0.1	0.7	0.7	0.7											0.6		0.1								0.2	2.3	5.3	8.1	5.1
TOTAL	4193.7	5638.9	4052.3	3216.2	4568.3	4890.6	1753.5	3446.9	4817.0	3644.6	4678.6	6372.6	5850.1	5398.8	5527.4	5343.7	5452.8	5303.4	4244.7	4405.2	4461.7	4476.1	5054.7	6725.8	8661.0	7860.8	8443.6	8058.9	4036.4
Fishing Days	202	211	148	135	192	197	66	121	114	145	209	262	380	421	598	546	443	486	277	294	455	634	811	1118	819	487	568	-	-

TABLE II: Portuguese trawl fishery cpue's and bycatch by month and division for 2022.

DIVISION	TARGET SPECIES	MONTH	DEPTH RANGE (m) MIN.	MAX.	CPUE (ton/hour)	MAIN BYCATCH SPECIES	%	TOTAL BYCATCH (%)
1b	COD	SEP	176	298	0.440	PLA	3.6	5.6
1b	COD	NOV	363	383	0.618	PLA	5.1	9.9
2b	COD	SEP	203	295	0.373	PLA	4.9	6.8
2b	COD	OCT	143	381	0.335	CAT	8.0	16.9
2b	COD	NOV	179	438	0.377	PLA	6.4	20.0
2b	COD	DEC	255	338	0.336	PLA	11.3	16.3
2a (*)	RED	SEP	198	430	0.365	-	-	-

(*) - Banana Hole (International waters of division 2a)

TABLE III: Intensity of the trawl sampling during 2022, by species, division and month.

SPECIES	DIV.	MONTH	Nº OF SAMPLES	Nº FISH MEASURED	SAMPLING WEIGHT(Kg)	OTOLITHS Nº	LENGTH RANGE (cm)
COD	1b	SEP	6	610	2477	46	60-100
COD	1b	NOV	4	374	1348	85	55-103
COD	2b	SEP	2	188	687	18	60-96
COD	2b	OCT	27	2243	7477	169	60-112
COD	2b	NOV	25	2410	6966	62	49-97
COD	2b	DEC	11	1134	3270	3	49-97
REDFISH (*S. mentella*)	2c	SEP	11	1410	854	90	30-43
AMERICAN PLAICE	1b	SEP	1	104	54	30	36-45
GREENLAND HALIBUT	2b	NOV	2	119	232	-	-
HADDOCK	2b	OCT	3	66	103	6	45-58
HADDOCK	2b	NOV	1	15	25	-	-

(*) - Banana Hole (International waters of division 2a)

TABLE IV: Length-weight relationship by species, stock and sex in 2022.

Species	Stock	Sex	a	b	n	r^2	Length interval (cm)	n médias	
COD	1, 2	T	0.0048	3.1458	6934	0.993	42-115	66	
PLA	1, 2	T	0.0013	3.5686	30	0.954	36-45	10	
REB	2a (*)	F	0.0066	3.1705	43	0.949	33-43	10	
REB	2a (*)	M	0.0308	2.7466	59	0.973	30-42	12	
REB	2a (*)	T	0.0240	2.8176	102	0.987	30-43	13	
HAD	1, 2	F	0.0576	2.5709	5	0.974	44-60	5	
HAD	1, 2	M	0.1085	2.4176	4	0.859	45-58	4	
HAD	1, 2	T	0.0838	2.4784	9	0.924	44-60	8	
GHL	1, 2	F	0.0025	3.2992		From 2011 report			do relatorio de 2011
GHL	1, 2	M	0.0023	3.3174		From 2011 report			do relatorio de 2011
GHL	1, 2	M+F	0.0026	3.2902		From 2011 report			do relatorio de 2011

(*) - Banana Hole (International waters of division 2a)

TABLE V: COD, DIV. 1b, 2022: length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP =3rd Q.	NOV =4th Q.	YEAR	LENGTH GROUP
45		5.9	3.0	45
48		7.3	3.7	48
51	5.0	16.3	10.7	51
54	17.7	45.0	31.4	54
57	32.5	50.9	41.8	57
60	51.3	67.3	59.4	60
63	77.0	74.1	75.5	63
66	82.9	112.2	97.7	66
69	109.8	117.0	113.4	69
72	109.9	110.1	110.0	72
75	102.1	98.2	100.1	75
78	80.0	89.6	84.8	78
81	84.1	84.1	84.1	81
84	60.9	42.5	51.7	84
87	78.5	35.0	56.7	87
90	30.0	19.6	24.8	90
93	28.8	4.3	16.5	93
96	35.3	11.6	23.4	96
99	14.2	3.0	8.6	99
102		2.9	1.5	102
105		2.9	1.5	105
TOTAL	1000	1000	1000	
No. SAMPLES	6	4	10	
SAMPLING WEIGHT(kg)	2477	1348	3825	
No. F.MEASURED	610	374	984	
MEAN LENGTH(cm)	76.3	72.4	74.3	
MEAN WEIGHT (g)	4281	3638	3958	
DEPTH RANGE (m)	212/298	365/378	212/378	

TABLE VI: COD, DIV. 2b, 2022: length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP	OCT	NOV	DEC	3rd Q.	4th Q.	YEAR
42		2.3	1.4	4.4		2.2	2.2
45		7.9	16.3	10.1		12.2	12.1
48		14.1	26.8	34.5		23.5	23.3
51		43.2	51.0	46.6		47.4	46.9
54		61.1	80.2	61.0		70.0	69.3
57	21.3	90.0	95.9	78.1	21.3	90.8	90.1
60	82.0	104.1	105.5	95.1	82.0	103.2	103.0
63	119.9	107.7	115.2	113.5	119.9	112.2	112.2
66	139.8	85.7	122.6	128.1	139.8	110.1	110.4
69	167.8	81.6	85.9	101.4	167.8	87.0	87.7
72	118.4	77.6	80.5	98.1	118.4	82.4	82.8
75	139.8	69.0	68.4	70.2	139.8	68.9	69.6
78	44.5	65.7	45.7	54.5	44.5	54.5	54.4
81	23.2	47.6	40.8	45.8	23.2	44.1	43.9
84	75.7	47.9	27.1	23.1	75.7	34.0	34.4
87	24.7	34.7	14.3	15.3	24.7	21.9	21.9
90	14.8	28.9	10.6	9.4	14.8	17.0	17.0
93	16.5	14.8	7.4	1.9	16.5	9.2	9.2
96	1.7	9.5	2.3	1.1	1.7	4.7	4.7
99	9.8	3.6	1.4	6.2	9.8	3.0	3.1
102		0.9	0.1	1.5		0.6	0.6
105		1.4	0.1			0.6	0.6
108		0.2	0.1			0.1	0.1
111		0.4				0.1	0.1
114			0.3			0.1	0.1
TOTAL	1000	1000	1000	1000	1000	1000	1000
No. SAMPLES	2	27	25	11	2	63	65
SAMPLING WEIGHT(kg)	687	7477	6966	3270	687	17713	18401
No. F.MEASURED	188	2243	2410	1134	188	5787	5975
MEAN LENGTH(cm)	72.9	69.9	67.0	67.7	72.9	68.2	68.2
MEAN WEIGHT (g)	3641	3349	2885	2975	3641	3069	3075
DEPTH RANGE (m)	239/295	153/334	187/416	255/338	239/295	153/416	153/416

LENGTH GROUP
42
45
48
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93
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102
105
108
111
114

TABLE VII: REDFISH (*S. mentella*),
International waters of DIV. 2a, 2022:
length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP =YEAR	LENGTH GROUP
30	0.4	30
31		31
32	7.4	32
33	5.1	33
34	38.8	34
35	76.8	35
36	178.5	36
37	237.1	37
38	214.4	38
39	150.7	39
40	56.7	40
41	30.8	41
42	3.0	42
43	0.3	43
TOTAL	1000	
No. SAMPLES	11	
SAMPLING WEIGHT(kg)	854	
No. F.MEASURED	1410	
MEAN LENGTH(cm)	37.8	
MEAN WEIGHT (g)	678	
DEPTH RANGE (m)	198/430	

TABLE VIII: AMERICAN PLAICE, DIV. 1b, 2022:
length composition (0/000) of the trawl catches.

LENGTH GROUP	SEP =YEAR	LENGTH GROUP
30	9.6	30
32		32
34	19.2	34
36	144.2	36
38	240.4	38
40	269.2	40
42	211.5	42
44	76.9	44
46	19.2	46
48	9.6	48
TOTAL	1000	
No. SAMPLES	1	
SAMPLING WEIGHT(kg)	54	
No. F.MEASURED	104	
MEAN LENGTH(cm)	40.7	
MEAN WEIGHT (g)	711	
DEPTH RANGE (m)	243/298	

TABLE IX: GREENLAND HALIBUT, DIV. 2b, 2022:
length composition (0/000) of the trawl catches.

LENGTH GROUP	NOV =YEAR	LENGTH GROUP
32	7.3	32
34	16.6	34
36	14.5	36
38		38
40	35.4	40
42	42.7	42
44	70.8	44
46	83.2	46
48	68.7	48
50	85.3	50
52	76.0	52
54	26.0	54
56	63.6	56
58	56.3	58
60	50.9	60
62	81.1	62
64	76.0	64
66	73.9	66
68		68
70	16.6	70
72	23.9	72
74	9.4	74
76	7.3	76
78	7.3	78
80	7.3	80
TOTAL	1000	
No. SAMPLES	2	
SAMPLING WEIGHT(kg)	232	
No. F.MEASURED	119	
MEAN LENGTH(cm)	55.3	
MEAN WEIGHT (g)	1591	
DEPTH RANGE (m)	238/365	

TABLE X: HADDOCK, DIV. 2b, 2022: length composition (0/000) of the trawl catches.

LENGTH GROUP	OCT	NOV	4th Q. =YEAR	LENGTH GROUP
44	7.9		3.4	44
45	60.5		26.1	45
46	52.6	133.3	98.5	46
47				47
48	43.0	66.7	56.4	48
49	76.8		33.2	49
50	122.7		53.0	50
51	125.2	66.7	91.9	51
52	169.8		73.3	52
53	79.4	200.0	147.9	53
54	43.0	200.0	132.2	54
55	59.3	66.7	63.5	55
56	35.0	200.0	128.8	56
57	29.7		12.8	57
58	33.3		14.4	58
59	29.7		12.8	59
60	20.0		8.7	60
61				61
62	12.1		5.2	62
63				63
64				64
65				65
66		66.7	37.9	66
TOTAL	1000	1000	1000	
No. SAMPLES	3	1	4	
SAMPLING WEIGHT(kg)	103	25	129	
No. F.MEASURED	66	15	81	
MEAN LENGTH(cm)	52.2	53.9	53.2	
MEAN WEIGHT (g)	1534	1663	1607	
DEPTH RANGE (m)	192/251	243/278	192/278	

Fig. 1 - Annual length composition of cod on Division 1b, bottom trawl fishery in 2022.

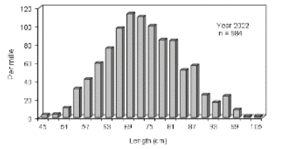


Fig. 2 - Annual length composition of cod on Division 2b, bottom trawl fishery in 2022.

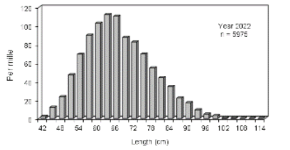


Fig. 3 - Annual length composition of redfish (*S. mentella*) international waters of Division 2a, pelagic trawl fishery in 2022.

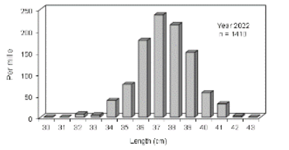


Fig. 4 - Annual length composition of American plaice on Division 1b, bottom trawl fishery in 2022.

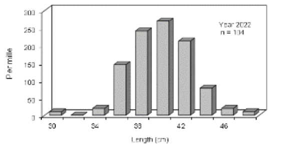


Fig. 5 - Annual length composition of Greenland halibut on Division 2b, bottom trawl fishery in 2022.

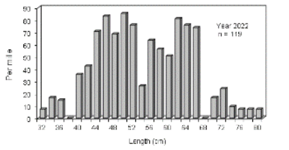
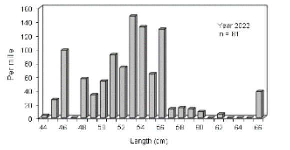


Fig. 6 - Annual length composition of haddock on Division 2b, bottom trawl fishery in 2022.



WD:
ICES AFWG 2023

The Spanish NE Arctic Cod Fishery in 2022

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In 2022 the Spanish fleet targeting for cod was composed by 4 single trawls. The activity of this fleet was carried out in ICES fishing areas 1, 2a and 2b throughout year.

Scientific sampling in 2022 was carried out on board of one vessel. The observer recorded catch, effort and biological data from May to June in ICES Division 2.a.2 and 2.b.2.

Table 1 shows catches of cod and by-catches by month, ICES divisions and effort distribution (number of otter trawls, number of hours of activity), and the overall monthly yield of the otter trawls for the target species. Catch per unit of effort (kg/hour) of cod for the whole fleet were estimated from the data provided by the Spanish General Secretary of Fisheries and the information gathered by the scientific observer on board. In Figure 1 the percentage of cod catches by each fishing ground are presented.

Tables 2 and 3 show the length and age distribution of cod catches by quarters from on-board sampling in ICES division 2b. When the length distribution for a specific area/quarter was not available, a summarised length frequency from neighbouring areas or quarters was used. In the same way, the gaps in age-length distributions in determined areas and quarters were filled with data from neighbouring areas or quarters. The rest of gaps were filled in with information from the age-length key produced for the long-term period (2001-2019). In Figure 2, cod length distribution as percentage by each fishing ground and quarter is shown.

Table 1.- Cod catches (kg) and by-catch of the Spanish fleet in ICES Subarea 1, Divisions 2a and 2b in 2022.

BARENTS SEA SUBAREA (1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gadus morhua							119,546	13,919	504,283	55,579	242,256		935,583
Anarhichas spp							223		2,153	18,101	4,189		24,667
Reinhardtius hippoglossoides							2,585	241	3,480	225	11,933		18,464
Hippoglossoides platessoides							1,915	488	1,869	474	1,403		6,149
Melanogrammus aeglefinus								238	121	1,443			1,802
Sebastes mentella										200	1,130		1,331
Anarhichas minor								454					454
Anarhichas lupus							49	80					130
Sebastes marinus										30			30
Number of **otter trawls**							3	2	1	1	1		4
Fishing hours (**otter trawls**)							64	84	249	43	191		632
CPUE COD (kg/h) (**otter trawls**)							1,856	165	2,024	1,308	1,267		1,482

NORWAY ZEE NORTH OF 62° (2A)	Jan	Feb[a]	Mar[a]	Apr	My[b]	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total[a]
Gadus morhua		40,351	266,292		703								307,346
Sebastes mentella		267	5,460		85,878								91,605
Pollachius virens		795	24,619										25,414
Melanogrammus aeglefinus		906	8,151										9,057
Hippoglossus hippoglossus		408	659										1,067
Sebastes marinus					540								540
Reinhardtius hippoglossoides					385								385
Hippoglossoides platessoides			56										56
Number of **otter trawls**		1	1		2								3
Fishing hours (**otter trawls**)		32	196		24								253
CPUE (kg/h) (otter trawls)		1,258[a]	1,357[a]		3,517[b]								1,216[b]

[a] direct fishery to Cod
[b] direct fishery to *S. mentella*

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Table 1 Cont.

SVALBARD (DIVISION 2B)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gadus morhua		119,349	501,013	629,410	736,207	2,498,521	3,219,415	956,159	1,349,250	57,781	499,742	403,861	10,970,707
Sebastes mentella		3,749	6,202	28,026	3,633	2,613	13,898	17,456	28	94,169	12,258	3,408	185,439
Reinhardtius hippoglossoides			16,835	19,768	26,959	31,366	23,826	9,827	193	1,819	9,982	4,196	144,769
Melanogrammus aeglefinus		3,008	8,917	12,873	9,604	13,066	13,778	26,184	482	361			88,273
Anarhichas spp						18,433	2,251	7,053	6,994	4,550	1,447	3,721	44,449
Hippoglossoides platessoides		329	2,485	3,510	2,778	9,491	16,772	4,977	805	460	1,622	951	44,180
Anarhichas lupus		473	1,884	4,594	2,808	2,510	4,091	1,480	327				18,167
Sebastes marinus						60		59	30	3,349	300	27	3,826
Anarhichas minor						159	1,402	1,030	124				2,715
Hippoglossus hippoglossus		272	40	906	35								1,253
Number of **otter trawls**		1	1	1	3	4	4	4	3	1	1	1	4
Fishing hours (**otter trawls**)		65	273	536	847	1,795	1,884	864	699	107	342	237	7,648
CPUE COD (kg/h) (**otter trawls**)		1,843	1,837	1,173	869	1,392	1,709	1,106	1,931	538	1,461	1,703	1,434

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Table 2: Length distribution of Spanish fleet cod catches in ICES division 2b, 2022.

Length group (cm)	1st Q.	2nd Q.	3rd Q.	4th Q.	ALL
28-30					
31-33					
34-36		164			164
37-39		606			606
40-42		2633			2633
43-45		6116			6116
46-48		11777			11777
49-51		20939			20939
52-54		34591			34591
55-57		47889			47889
58-60		62723			62723
61-63		62122			62122
64-66		48354			48354
67-69		33274			33274
70-72		20258			20258
73-75		13300			13300
76-78		9665			9665
79-81		5836			5836
82-84		3438			3438
85-87		1621			1621
88-90		981			981
91-93		498			498
94-96		346			346
97-99		160			160
100-102		151			151
103-105		162			162
106-108		87			87
109-111					
112-114		8			8
115-117					
118-120					
121-123		11			11
124-126		8			8
127-129					
130-132					
133-135					
136-138					
Total		387720			387720
No. Samples		136			136
No. F. Measured		22771			22771
[1]Sampling Weight (kg)		710055			710055
Mean Length (cm)		61.3			61.3

[1]Weights corresponding to the length distributions

Table 3: Age distribution of Spanish fleet cod catches in ICES Subarea 1, 2022.

BARENTS SEA SUBAREA (1)	*1st QUARTER*			*2nd QUARTER*			*3rd QUARTER[1]*			*4th QUARTER[1]*			*TOTAL[1]*		
AGE	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g
1															
2															
3							0.506	39.4	485	0.236	39.4	485	0.742	39.4	485
4							18.532	46.6	799	8.654	46.6	799	27.186	46.6	799
5							97.219	54.5	1248	45.402	54.5	1248	142.621	54.5	1248
6							169.109	62.2	1828	78.976	62.2	1828	248.085	62.2	1828
7							51.034	71.8	2766	23.834	71.8	2766	74.868	71.8	2766
8							10.101	82.0	4061	4.717	82.0	4061	14.818	82.0	4061
9							1.201	91.0	5521	0.561	91.0	5521	1.762	91.0	5521
10							0.291	102.3	7708	0.136	102.3	7708	0.427	102.3	7708
11							0.107	107.2	8874	0.050	107.2	8874	0.156	107.2	8874
12							0.014	119.5	12183	0.006	119.5	12183	0.020	119.5	12183
13															
14															
15															
16															
17															
T. NUMBER ('000)								348.113			162.572			510.685	
No. of fish measured								-[1]			-[1]			-[1]	
TOTAL CATCH (t)								637.748			297.835			935.583	
SAMPLED CATCH (t)								-[1]			-[1]			-[1]	
#OTOLITHS								-[1]			-[1]			-[1]	
MEAN WEIGHT (g)															

[1] length and otolith samples from 2b and 2nd quarter.

Table 3 (cont): Age distribution of Spanish fleet cod catches in ICES Division 2a, 2022.

NORWAY ZEE NORTH OF 62º (2A)	*1st QUARTER[1]*			*2nd QUARTER[1]*			*3rd QUARTER*			*4th QUARTER*			*TOTAL[1]*		
AGE	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g	Number '000	Mean Length cm	Mean Weight g
1															
2															
3	0.243	39.4	485	0.001	39.4	485							0.244	39.4	485
4	8.910	46.6	799	0.020	46.6	799							8.931	46.6	799
5	46.745	54.5	1248	0.107	54.5	1248							46.852	54.5	1248
6	81.311	62.2	1828	0.187	62.2	1828							81.498	62.2	1828
7	24.538	71.8	2766	0.056	71.8	2766							24.595	71.8	2766
8	4.857	82.0	4061	0.011	82.0	4061							4.868	82.0	4061
9	0.578	91.0	5521	0.001	91.0	5521							0.579	91.0	5521
10	0.140	102.3	7708	0.000	102.3	7708							0.140	102.3	7708
11	0.051	107.2	8874	0.000	107.2	8874							0.051	107.2	8874
12	0.007	119.5	12183	0.000	119.5	12183							0.007	119.5	12183
13															
14															
15+															
T. NUMBER ('000)		167.380			0.384									167.764	
No. of fish measured		-[1]			-[1]									-[1]	
TOTAL CATCH (t)		306.643			0.703									307.346	
SAMPLED CATCH (t)		-[1]			-[1]									-[1]	
#OTOLITHS		-[1]			-[1]									-[1]	
MEAN WEIGHT (g)															

[1] length and otolith samples from IIB 2nd quarter

Table 3 (cont): Age distribution of Spanish fleet cod catches in ICES Division 2b, 2022.

SVALBARD (2B)	*1st QUARTER[1]*			*2nd QUARTER*			*3rd QUARTER[1]*			*4th QUARTER[1]*			*TOTAL*		
AGE	Number ´000	Mean Length cm	Mean Weight g	Number ´000	Mean Length cm	Mean Weight g	Number ´000	Mean Length cm	Mean Weight g	Number ´000	Mean Length cm	Mean Weight g	Number ´000	Mean Length cm	Mean Weight g
1															
2															
3	0.492	39.4	485	3.066	39.4	485	4.383	39.4	485	0.763	39.4	485	8.704	39.4	485
4	18.026	46.6	799	112.284	46.6	799	160.540	46.6	799	27.936	46.6	799	318.786	46.6	799
5	94.568	54.5	1248	589.051	54.5	1248	842.207	54.5	1248	146.554	54.5	1248	1672.380	54.5	1248
6	164.499	62.2	1828	1024.639	62.2	1828	1464.997	62.2	1828	254.927	62.2	1828	2909.062	62.2	1828
7	49.643	71.8	2766	309.219	71.8	2766	442.112	71.8	2766	76.933	71.8	2766	877.907	71.8	2766
8	9.825	82.0	4061	61.200	82.0	4061	87.503	82.0	4061	15.226	82.0	4061	173.755	82.0	4061
9	1.168	91.0	5521	7.278	91.0	5521	10.405	91.0	5521	1.811	91.0	5521	20.662	91.0	5521
10	0.283	102.3	7708	1.762	102.3	7708	2.519	102.3	7708	0.438	102.3	7708	5.002	102.3	7708
11	0.104	107.2	8874	0.646	107.2	8874	0.923	107.2	8874	0.161	107.2	8874	1.833	107.2	8874
12	0.013	119.5	12183	0.082	119.5	12183	0.118	119.5	12183	0.020	119.5	12183	0.234	119.5	12183
13															
14															
15+															
T. NUMBER ('000)	338.622			2109.227			3015.707			524.768			5988.325		
No. of fish measured	-[1]			22,771			-[1]			-[1]			22,771		
TOTAL CATCH (t)	620.362			3864.37			5524.824			961.384			10970.707		
SAMPLED CATCH (t)	-[1]			710,055			-[1]			-[1]			710,055		
# OTOLITHS	-[1]			347			-[1]			-[1]			347		
MEAN WEIGHT (g)				1832									1832		

[1] length and otolith samples from 2b 2nd quarter

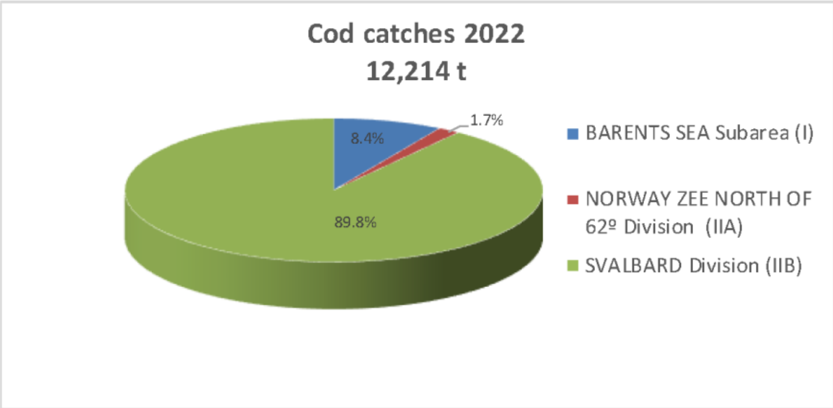

Figure 1: Catches of cod (%) by Spanish fleet in different fishing grounds during 2022.

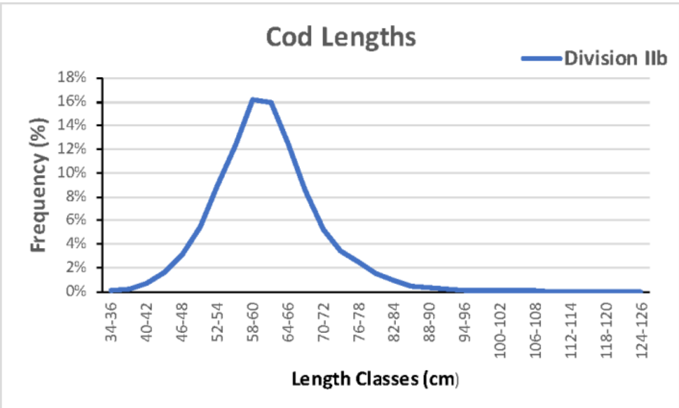

Figure 2: Length distributions of cod (%) in sampled fishing grounds (ICES Division 2b) during 2022.

Working Document for the ICES Arctic Fisheries Working Group 2023 WD_4

Data series on tourist- and resident recreational fisheries for Norwegian Coastal Cod north of 62°N

by

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1. Background

ICES Arctic Fisheries WG (AFWG) includes in its annual reports an estimate of the amount of coastal cod fished in the tourist fishery and the Norwegian recreational fishery north of 62N since 1994. For the years (1984)1994-2009 this is summarized in WD (no. 17) by Knut Sunnanå, IMR, to the AFWG in 2010 (AFWG 2010). Two fundamental works in Sunnanå's summary were Hallenstvedt and Wulff (2000) describing and estimating the foreign tourist fishing at that time, and Hallenstvedt and Wulff (2004) estimating the recreational fishery by Norwegian residents.

At the benchmark meeting WKBARFAR 2021, the data series on recreational and tourist fisheries for Norwegian Coastal Cod were updated with new information until and including 2019 (see Nedreaas et al. WD no. 13 submitted to WKBARFAR 2021). The main new information compared to AFWG 2010 was due to Vølstad et al. (2011) estimating what had been fished by tourists north of 62N associated with registered tourist businesses/ companies in 2009, and a new project 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 to develop cost-effective methods to map catches and socio-economic dimensions of marine recreational fisheries (MRF) in Norway from three study areas Troms, Hordaland, and Oslofjord. Results from this project has later been published in Ferter et al. (2023).

The data series on recreational and tourist fisheries for Norwegian Coastal Cod were updated and included as time series back to 1994 for both coastal cod stocks north of 62N for the first time in the ICES AFWG 2021, and advice related to the recreational catches has since been given for these stocks by ICES.

Recreational fishery categories:

i) Tourists in tourist businesses ✔
incl. few lengths 2018-2019, 2022

ii) Tourist outside tourist businesses (camping, private lodging) **?**
iii) Residents fishing with rod and line ✓
incl. few lengths 2018-2019, 2021-2022
iv) Residents fishing with fixed gears (gillnets, longline, traps etc) **?**

2. Tourist fishing - sampling and estimation

Based on Hallenstvedt and Wulff (2004), the consultant company Essens management (Anon, 2005), and an assumption of an 10% increase per year from 2004 to 2009 in sea fishing tourism, the estimated quantity fished by tourists in 2009 was 1,800 t cod, all assumed to be coastal cod (Sunnanå 2010). This estimate is not so different from the scientific estimate of Vølstad et al. (2011) of 1,586 t of cod fished by tourists north of 62N associated with registered tourist businesses/ companies in 2009. However, the total catch of coastal cod by tourists in 2009 north of 62N must have been higher due to the informal tourist fishing sector (eg private rental, camping etc). Hallenstvedt and Wulff (2000, table 10) estimated the informal sector to be larger than the formal business sector north of 62N (factor 1.13). Today we know little about how this informal tourist sector has developed since 2009, but since only tourist living at registered tourist businesses are allowed to bring fish out of Norway, it is reasonable to believe that this informal sector has decreased.

2.1 Tourist fishing – catch reporting in numbers

Historical there has been no reporting system for coastal cod (NCC) taken by recreational or tourist fishers in Norway. In 2019 the Norwegian Directorate for Fisheries established a web-portal for obligatory catch reportings (both kept and released fish) by all registered fishing camps. Registered fishing camps are obliged to report catches to the fisheries authorities. Each fishing trip and all catches, whether landed or released, of the five species cod, Atlantic halibut, redfish and wolffish are to be reported. Not all companies do report, and the reported catch has hence been raised to all active companies in the county and finally summed for all counties in the region. In 2022, 670 businesses (north of 62N) reported both retained and released number of the five obligatory species, while 205 active businesses did not report any species, either due to no catch or not following the obligations. The reported cod catches have hence been raised by a factor of 1.31 to include the not-reporting businesses. The national register of businesses has been quality checked and improved since 2019, thereby reducing the raising factor. Number kept cod was in 2022 about the same as in 2019 after a period of less activity in 2020-2021 (77% reduction in 2020) due to the Corona pandemic. However, since the raising factor due to a (hopefully) more correct business registry and fewer businesses not reporting, is lower in 2022 compared to 2019-2021, the estimated coastal cod catch caught by tourists north of 62N in 2022 was 1 462 tonnes compared to 3 455 tonnes in 2019. This includes a release percentage varying between 39-44% during 2019-2022. Based on investigations in other countries we anticipate 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). For all the reported released cod we have used a mortality rate of 20% because tourists in this region of Norway mainly fish from boats.

It is essential for correct tourist fishing catch statistics that the registries are correct and regularly updated, and that the obligatory reporting is controlled and checked.

2.2 Tourist catch-in-numbers-at-age and in tonnes

Foreign tourists are prohibited to fish with other gears than rod and line (e.g., handheld tackle). Hence it is necessary to handle the tourist fishing separate from the Norwegian resident fishery (allowed to use other gears) and to collect sufficient catch samples (species, length, age a.o) of the tourist catches per region to be able to distribute the reported number on age with sufficient precision. With a suitable length-weight relationship one will be able to estimate an average individual weight per age group and use the weighted average of these weight-at-ages to convert the reported catch in numbers to catch in tonnes. All cod catches assumed to be coastal cod.

Table 1 below illustrates this procedure with the available length- and age distributions for the two coastal cod stocks (north and south) in 2022. The only available length- and age data were from sampling the cod catches at the tourist fishing businesses in the Andfjord in June-July, only 132 coastal cods. This length and age distribution has been used for the tourist catches both north and south of 67˚N, but using slightly different l-w relationships. The length-weight relationships are estimated from the coastal cod caught during IMR's coastal survey in autumn 2003-2022.

The representativeness of summer samples given that there is also tourist fishing at some places at other times of year, particularly earlier in the year during the "skrei" (and coastal cod) spawning, is not satisfactory. The spawning season fishery would target larger fish, giving a different split by age, and samples should hence also be collected from this season to see how much coastal cod is being caught.

Table 1. Reported catches of cod caught by tourists in 2022 north and south of 67N. Age distribution according to available samples from the Andfjord in the northern area. Length-weight parameters ($w=al^b$) from coastal survey data during 2003-2022.

Tourist fishing (coastal cod only), all based on sampling in Andfjorden during June-July 2022						
Age	Sample numbers	Mean length (cm)	CAA total	L-w	CAA north	CAA south
2	4	38.8	18		9	9
3	31	51.3	138	north	68	66
4	19	61.2	84	a= 4.544814e-06	42	41
5	22	65.5	98	b= 3.111289	48	47
6	32	68.6	142		70	69
7	11	75.4	49	south	24	24
8	7	79.1	31	a= 4.487755e-06	15	15
9	2	93.5	9	b= 3.121863	4	4
10	2	94.5	9		4	4
11	1	75.0	4	length in mm	2	2
12	1	91.0	4	weight in grams	2	2
	132	64.2	587		290	283
	Average weight (kg)					
	North of 67N	**2.492**	587	numbers in 1000	290	283
			1 462	**tonnes**	**724**	**738**
	South of 67N	**2.607**				

3. Resident Norwegian recreational catches - sampling and estimation

3.1 Resident recreational catches in tonnes

In the 2010 AFWG report, the Norwegian resident recreational quantity of coastal cod was estimated to 10 900 t for 2009. Hence a total quantity of 12,700 t coastal cod (10,900 t by resident recreational fishers and 1,800 t by tourist fishers) was assumed to be taken by the tourist and recreational fishers in Norway in 2009 (Sunnanå 2010). This quantity was extrapolated to the years before using the product of population numbers and the fraction of the people during recreational sea fisheries (Statistics Norway), but was kept constant during 2009-2019. It was assumed that the amount of cod was 50% of the total recreational catch throughout all the years.

A project in 2019 aiming at estimating both the tourist fishing segment and the resident Norwegian recreational fishery in Troms county (Ferter et al. 2023), managed to document about 9,000 tonnes coastal cod fished by rod and handline if the results from Troms are valid for the rest of the coast north of 62N. This is clearly an underestimate (because of tourists outside registered tourist businesses and residents fishing with fixed gears are not included). Until a better quantification of these missing recreational segments, the ICES AFWG (2021) decided to keep the quantity of 12,700 tonnes recreational catch of Norwegian coastal cod on top of the commercial reported landings north of 62N.

With the new reporting system for the tourist fishing businesses starting in 2019, and no new information about the Norwegian resident recreational fishery since then, it has been decided to fix the resident recreational fishery to the 2019-level of **9,245 t** (12,700 t minus 3,455 t tourist catches that year) for later years. This is not unreasonable if we compare with the cod being reported landed and sold cod by Norwegian recreational fishers 2012-2022 (Table 2). The increased landings in 2018-2020 may well be due to more North-east Arctic cod fished and landed in the northern area these years, and not coastal cod.

An unknown informal tourist fishery segment, i.e. camping tourists, private (not registered) lodging, is at present included in the resident recreational catch figures. This total resident recreational catch has further been distributed with 3,510 t (38%) between 62-67N and 5,735 t (62%) north of 67N (Table 3). This percentage share between the two areas has been kept fixed since 2019 when the area split of the resident catches, in the absence of better data, was using the same area-percentages resulting from the reported tourist fishing catches. Finally, the annual and variable official reported tourist fishing numbers raised to the total business registry have been added on top of the resident catches to get a total recreational catch of coastal cod north of 62N.

Table 2. Reported landed and sold cod by Norwegian recreational fishers 2012-2022 (in tonnes). These landings are included in the official Norwegian landings statistics and hence not part of the estimated recreational catches.

Year/Area	North of 67˚N	Between 62-67˚N	Total
2012	1 425	239	1 665
2013	450	167	617
2014	774	229	1 003
2015	618	226	844
2016	810	332	1 142
2017	772	307	1 078
2018	1 206	340	1 546
2019	1 603	339	1 943
2020	1 785	347	2 132
2021	565	321	885
2022	524	244	768

Table 3. Total catches (in tonnes) of coastal cod in the tourist- and Norwegian resident recreational fishery north of 62N in 2022 in the two coastal cod stock areas north of 67N and between 62-67N. The tourist catches are based on the official daily reporting from 670 businesses raised to additional 205 active but not reporting businesses to the Norwegian Directorate of Fisheries. The Norwegian resident recreational catch includes an unknown fraction of the informal tourist fishery segment, i.e. camping tourists, private (not registered) lodging, and has been distributed on the two areas as it has ben since 2019.

Total catches (in tonnes) in the tourist- and Norw resident recreational coastal cod fishery north of 62N in 2022					
		Tourist	Norw. Resident	TOTAL	
North of 67N		724	5735	6459	
South of 67N		738	3510	4248	
		1462	9245	**10707**	

3.2 Resident recreational catch-at-age

The only available length (and age) sample of coastal cod from the Norwegian resident recreational fishery north of 62N in 2022 is from the seasonal spawning fishery in the Borgundfjord in April. Although the cod spawning season is the main season for traditional Norwegian subsistence and recreational fishery, the length- and age data from only 155 specimens from one particular area is too little to be used for converting 9,245 t coastal cod to catch-at-age (CAA) in numbers (Table 4).

The average weight of the sampled Borgundfjord coastal cod was 4.57 kg (Table 4), i.e., significantly different from the 2.5-2.6 kg average weight of the tourist samples (Table 1). It was therefore decided to keep these recreational segments separate regarding length- and age composition. It is reasonable to say that the Borgundfjord sample is composed of larger mature and spawning specimens than would be the average size if samples from several seasons and areas were available. The average commercial individual weight of the northern coastal cod was 3.89 kg, and 3.80 kg for the southern. It was therefore decided to raise the total commercial catch-at-age for each of the two areas to include the resident recreational catches of 5,735 t and 3,510 t, respectively.

Table 4. Estimated catch of cod (mostly coastal cod) caught by Norwegian resident recreational fishers in 2022 north of 62N. Age distribution according to available samples from the Borgundfjord in the southern area during spawning season. Length-weight parameters (w=alb) from coastal survey data during 2003-2022.

Norwegian recreational fishing (coastal cod only),			
all based on sampling in Borgundfjorden during April 2022			
Age	Sample num	Mean length (cm	CAA total
2	0		
3	11	59.6	
4	46	64.9	
5	19	72.8	
6	27	78.4	
7	19	86.5	
8	10	89.2	
9	12	91.0	
10	8	101.6	
11	3	107.0	
12	0		
	155	76.8	
Average weight (kg)			
Between 62-67N		**4.569**	
	9 245	**tonnes**	

4. Future needs

1) The status of tourist businesses in the national registry be checked/updated once per year.
2) In the priority listed below, data should be collected from both the tourist fishing/businesses and resident recreational sectors to estimate by stock area (i.e. 62-67˚N and north of 67˚N):
   i) Total catch,
   ii) Catch numbers- and weight- at age (i.e. at least representative length distributions, and ideally proportions-at-age), and
   iii) Otoliths or genetic samples to separate NCC from NEAC.
3) The Norwegian resident recreational (partly subsistence) fishery, responsible for most of the total recreational catches, should be regularly monitored by roving creel surveys including both hook-and-line and fixed gears. It is suggested to do this county by county

following the practice reported by Ferter et al. (2023), i.e., one new county each year, until all counties have been covered, and then start over again. Biological sampling should be part of the roving creel surveys.

5. Acknowledgement

My colleagues Keno Ferter, Jon Helge Vølstad, Håkon Otterå and Asgeir Aglen are thanked for running the recreational fishery projects in 2009 and 2017-2020 providing basis for current understanding and estimations. Despite a continuously need for quality checks and update of the obligatory reporting system from the tourist fishing businesses, the introduction of this system by the Directorate of Fisheries is crucial and should be made as good and reliable as possible. Thanks to Malin Pihlstrøm, Eskil Dahl Olaussen and Bernt Bertelsen, Directorate of Fisheries, for establishing good routines for this. And finally, many thanks to my colleagues, and coastal cod stock coordinators, Johanna Fall and Brian Stock, for good comments and edits.

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Table 5. Total catch-in-numbers-at-age of coastal cod north of 67N incl. recreational catch.

Coastal cod catch-in-numbers ('000)-at-age. Total north of 67N including recreational catch.												
AGE										Tonnes	Hereof	
	2	3	4	5	6	7	8	9	10+	fished	recreational	rec %
1994	13	115	1148	5158	4414	3235	1313	356	793	61723	9144	15
1995	24	264	945	3183	5567	3672	2106	1094	711	66051	9144	14
1996	50	934	1720	2473	3805	3752	1471	659	709	50840	9020	18
1997	68	1326	2514	2334	2797	3248	2215	674	890	55624	9020	16
1998	523	1957	7718	5268	3341	1002	935	452	471	54544	9082	17
1999	97	1116	4152	6040	2492	957	644	482	520	47390	8646	18
2000	38	670	3201	4929	2812	1037	472	141	342	41541	8460	20
2001	13	442	2497	3006	2199	1288	409	140	661	32806	8335	25
2002	53	389	1959	3265	3019	1335	796	231	459	40648	8460	21
2003	156	454	1234	2408	2815	1562	754	399	326	37900	8646	23
2004	30	227	1352	1926	2774	1989	993	415	470	39533	8335	21
2005	17	307	1176	2525	2550	1862	911	324	440	38308	8211	21
2006	28	271	1556	2410	3193	2115	1240	490	482	44970	8087	18
2007	47	492	1567	2181	1737	1423	624	362	365	34287	8087	24
2008	81	498	1284	2458	1994	1294	741	358	369	35674	7962	22
2009	28	612	896	1582	1605	1091	563	579	284	30888	7900	26
2010	35	651	925	3474	2388	1295	647	347	1051	42704	7900	18
2011	83	597	1550	1690	1588	1386	728	440	747	35882	7900	22
2012	484	1317	1458	1447	1666	984	471	229	772	34678	7900	23
2013	179	689	1403	1421	1245	965	655	300	466	29276	7900	27
2014	119	680	1110	1695	1130	911	704	400	534	30650	7900	26
2015	407	1360	1734	1537	2089	1278	785	537	1072	42383	7900	19
2016	86	1086	2305	1835	1998	2458	1362	743	1244	57403	7900	14
2017	969	1806	2373	2661	2391	1707	1525	802	1035	62173	7900	13
2018	210	691	1800	2007	1873	1740	918	637	611	42432	7900	19
2019	60	1163	1585	2167	1934	1537	1202	387	633	43761	7900	18
2020	45	612	2524	2422	2905	1849	1037	405	353	49366	6233	13
2021	190	479	2245	3545	2112	1490	755	207	294	44970	6623	15
2022	179	1193	1497	2530	3114	1633	884	273	182	43941	6459	15

Table 6. Total catch-in-numbers-at-age of coastal cod between 62-67N incl. recreational catch.

cod catch-in-numbers ('000)-at-age. Total between 62- 67N incl. recreational catches.												
E	2	3	4	5	6	7	8	9	10+	Tonnes landed	Hereof recreational	rec %
1994	2	14	207	538	676	523	296	132	210	11937	5556	47
1995	4	51	341	647	797	757	433	184	155	14492	5556	38
1996	3	120	455	723	572	476	245	68	82	11687	5480	47
1997	5	253	369	456	407	399	283	95	72	10226	5480	54
1998	38	334	842	937	628	207	155	42	43	11718	5518	47
1999	5	226	610	600	497	240	103	128	51	10776	5254	49
2000	3	456	1311	773	299	107	96	32	69	10979	5140	47
2001	3	184	832	897	598	293	101	34	169	10315	5065	49
2002	15	153	627	711	768	240	91	22	28	12077	5140	43
2003	36	325	377	907	633	605	178	35	85	14159	5254	37
2004	9	194	581	451	695	403	242	60	45	11931	5065	42
2005	3	105	619	848	722	426	197	61	31	12994	4989	38
2006	16	76	484	968	888	282	156	84	79	13525	4913	36
2007	18	252	597	814	620	185	83	38	47	12609	4913	39
2008	46	153	1330	990	290	395	103	56	71	14727	4838	33
2009	1	375	1109	433	519	178	124	70	34	11945	4800	40
2010	7	187	651	706	398	423	81	58	74	12434	4800	39
2011	5	98	518	811	447	325	109	59	58	11928	4800	40
2012	45	179	425	795	502	442	115	57	58	12987	4800	37
2013	9	105	463	414	480	327	154	52	31	9931	4800	48
2014	1	100	293	690	469	400	140	76	68	11044	4800	43
2015	41	293	503	449	515	234	135	72	80	9804	4800	49
2016	2	151	448	566	371	360	218	120	150	10762	4800	45
2017	28	158	592	600	337	208	152	51	73	8959	4800	54
2018	19	118	272	620	532	293	187	75	66	9236	4800	52
2019	12	88	223	265	336	316	201	54	63	7765	4800	62
2020	1	97	342	293	301	166	177	78	34	7287	3806	52
2021	72	361	414	477	239	163	104	56	70	7735	4039	52
2022	11	294	578	463	399	148	72	46	33	7075	4248	60

Annex 4: Audit reports

Audit of Northeast Arctic anglerfish (AFWG 2023)

Date: 07 May 2023

Reviewer: Erik Berg

Expert group Chair: Daniel Howell

Secretariat representative: Neil Campbell

General

The Northeast Arctic anglerfish report with several exploratory assessments have been presented to the AFWG.

For single-stock summary sheet advice

Northeast Arctic anglerfish (*Lophius* spp. in subareas 1 and 2; pok.27.1-2)

Short description of the assessment as follows:

1) **Assessment type:** exploratory runs
2) **Assessment:** exploratory
3) **Forecast:** JABBA 2023-2025 forecast with constant annual catch of 1 930 t, indicates that the mean anglerfish population is expected to get back to BMSY and FMSY level by 2023.
4) **Assessment model:** JABBA, LBSPR
5) **Consistency:** not relevant
6) **Stock status:** No reference points established for the stock. Exploratory assessment and estimated candidate to relative reference points, indicate relative stock size close to B_{MSY}, and relative F above F_{msy}.
7) **Management plan:** Not adopted

General comments

This was a well-documented and ordered section. It was easy to follow and interpret. Stock annex should perhaps be updated since new standardised CPUE is calculated?

Technical comments

No technical comments.

Conclusions

Exploratory assessment.

Audit of Northeast Arctic saithe (AFWG 2023)

Date: 27 April 2023

Reviewer: Matthias Bernreuther

Expert group Chair: Daniel Howell

Secretariat representative: Neil Campbell

General

The Northeast Arctic saithe assessment and draft advice have been approved by the Working Group.

For single-stock summary sheet advice

Northeast Arctic Saithe (*Pollachius virens* in subareas 1 and 2; pok.27.1-2)

Short description of the assessment as follows:

1) **Assessment type:** update
2) **Assessment:** accepted
3) **Forecast:** accepted
4) **Assessment model:** SAM – tuning by one acoustic survey (split in two time series)
5) **Consistency:** Last year´s assessment was accepted. The assessment, recruitment and forecast models have been applied as specified in the stock annex.
6) **Stock status:** The SSB has been above B_{pa} since 1996, declined considerably from 2007 to 2011, then increased again and is presently (2022/2023) 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.
7) **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.

The lack of reliable recruitment estimates is still a major problem for the short-term catch forecast.

Technical comments

No technical comments.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice.

Audit of Northern Norwegian coastal cod (AFWG 2023)

Date: 8 May 2023

Reviewer: Bjarte Bogstad

Expert group Chair: Daniel Howell

Secretariat representative: Neil Campbell

General

The Northern Norwegian coastal cod assessment and draft advice have been approved by the Working Group.

For single-stock summary sheet advice

Northern Norwegian coastal cod (*Gadus morhua* in subareas 1 and 2; cod.27.1-2coastN)

Short description of the assessment as follows:

An updated Stock Annex was not uploaded to the ICES Sharepoint directory where Stock Annexes are found at the time of the audit. This should only affect the management plan part which could be found elsewhere.

1) **Assessment type:** update
2) **Assessment:** accepted
3) **Forecast:** accepted except recruitment
4) **Assessment model:** SAM – tuning by one age-based swept area index and two acoustic indices (split in time)
5) **Consistency:** Last year´s assessment was accepted. The assessment and forecast models have this year been applied as specified in the stock annex except that the recruitment figure in 2023 does not seem to be resampled from 2013-2022 (2023 recruitment of 51286 as given in advice sheet is higher than any of the numbers given for the years 2013-2022). The use of age 2 in the model and reporting age 3 in Table 8 in the advice sheet, as well as natural mortality being variable by year confuses the picture a bit, the 2023 recruitment may be calculated correctly but at least an explanation is needed. Also I am sceptical to including a confidence interval in the advice sheet when resampling from a number of years is used – unclear how this is calculated.
6) **Stock status:** Fishing pressure on the stock is above F_{mgt}; spawning-stock size is above $SSB_{lowerbound}$.
7) **Management plan:** The current Norwegian management plan for this stock is as follows: The target level of exploitation is calculated by applying a fishing mortality of F_{mgt} = 0.176 for the advice year in the short-term forecast. This level of fishing mortality corresponds to $F_{0.1}$ and is valid for all spawning stock sizes at or above the minimum observed in the time-series (67 743 tonnes, estimated with 2003–2020 data). Should the spawning stock fall below this level, the HCR must be re-evaluated. ICES evaluated this harvest control rule as precautionary in 2022.

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.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice. The recruitment prediction (R age 3 in 2023) needs more explanation and reviewing but possible changes here will have a minor impact on the assessment.

Comments to the assessment report

A few minor comments to the text/tables/figures in the assessment report is given below:

2.1.1 paragraph starting with 'The number of otoliths' – 2022 numbers should be commented on.

Text Fig 2.1.3 – is this combined data for 2020 and 2021?

2.2.2 Section starting with 'catch at age' 2020 in third line should be 2021

Annex 5: Stock Annex updates

Stock code	Stock description	Last updated	DOI
anf.27.1-2	Anglerfish (*Lophius budegassa, Lophius piscatorius*) in subareas 1 and 2 (Northeast Arctic)		
cap.27.1-2	Capelin (*Mallotus villosus*) in subareas 1 and 2 (Northeast Arctic), excluding Division 2.a west of 5°W (Barents Sea capelin)		
cod.27.1-2	Cod (*Gadus morhua*) in subareas 1 and 2 (Northeast Arctic)		
cod.27.1-2.coastN	Cod (*Gadus morhua*) in subareas 1 and 2, north of 67°N (Norwegian Sea and Barents Sea), northern Norwegian coastal cod	12 September 2023	https://doi.org/10.17895/ices.pub.24411667
cod.27.2.coastS	Cod (*Gadus morhua*) in Subarea 2 between 62°N and 67°N (Norwegian Sea), southern Norwegian coastal cod		
ghl.27.1-2	Greenland halibut (*Reinhardtius hippoglossoides*) in subareas 1 and 2 (Northeast Arctic)		
had.27.1-2	Haddock (*Melanogrammus aeglefinus*) in subareas 1 and 2 (Northeast Arctic)		
pok.27.1-2	Saithe (*Pollachius virens*) in subareas 1 and 2 (Northeast Arctic)		
reb.27.1-2	Beaked redfish (*Sebastes mentella*) in subareas 1 and 2 (Northeast Arctic)		
reg.27.1-2	Golden redfish (*Sebastes norvegicus*) in subareas 1 and 2 (Northeast Arctic)		