ARCTIC FISHERIES WORKING GROUP (AFWG)

Please note:
Section 9 Barents Sea Capelin was added to this report on 11 October 2019

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Contents

i Executive summary

Assessments run at AFWG provide the scientific basis for the management of cod, haddock, saith, redfish, Greenland halibut and capelin in subareas 1 and 2. Taking the catch values provided by the Norwegian fisheries ministry for Norwegian catches (https://fiskeridir.no/Yrkesfiske/Statistikk-yrkesfiske/Statistiske-publikasjoner/Noekkeltall-for-de-norske-fiskeriene) and raising the total landed value to the total catches gives an approximate nominal first-hand landed value for the combined AFWG stocks of ca. 20 billion NOK in 2018 (ca. 2 billion EUR).

At AFWG 2019 a revision to the NEA cod model was proposed, involving changing the assumed variance-at-age structure of the SAM model in light of the increasing numbers of older fish. This was reviewed at a rapid inter-benchmark IBPNEACod and presented to the Advice Drafting Group (ADGANW 2019). The proposed change was rejected as lacking sufficient rationale for the details of way the variance structure was changed. However, the reviewers did accept the need for a change in the model to account for the changing age structure, and AFWG is therefore proposing this stock for a benchmark in 2021 to deal with the issue in a more thorough and considered manner.

Haddock is currently working towards a benchmark in early 2020, and there are no other planned benchmarks in AFWG. However, given issues relating to the increasing age range of NEA cod and the lack of HCR for Greenland halibut, AFWG strongly recommends a benchmark for NEA cod in 2021 ready for AFWG 2021, followed by a benchmark and subsequent MSE for Greenland halibut in 2022 ready for the Green-land halibut assessment in 2023. Furthermore, the failure of the management plan for coastal cod indicates the need for a revised management plan, and scientific work to support this. A tentative target date of a benchmark in 2021 (with the NEA cod is proposed), although it is not yet clear if this is feasible. There is ongoing discussion about conducting a benchmark for capelin, but no firm conclusions.

Stock by stock summaries

Cod in subareas 1 and 2 (Norwegian coastal waters) The cod in subareas 1 and 2, Norwegian coastal waters was assessed on the basis of a survey time-series 1995–2019 as well as catch-at-age data (including recreational and tourist fisheries). This is a category 3 stock. For the years 2012–2019 the advice has been based on the Norwegian rebuilding plan. Although the ADG has felt that this plan has not been successful, advice is currently given on this basis until a revised plan can be devised. The current advice for 2020 and 2021 is based on the recent trend in the survey.

- The stock has varied without a clear trend since 2002. Both the stock biomass and the recruitment are at a low level compared to the first years in the survey time-series. Fishing pressure (F) increased in the three recent years, after a declining trend over the period 2000–2014.

Cod in subareas 1 and 2 (Northeast Arctic) was assessed using the SAM model following the outcome of the inter-benchmark meeting (IBP cod 2017). A proposed change in the variance structure was not accepted at IBPNEACod 2019, and is not used in this assessment.

- The biomass is declining, but still at a high level, and SSB is well above B_{pa}, although it is considerably lower than the peak in 2013. A significant portion of the catch and stock is now age 12+.

- The TAC advice for 2019 is 689 672 tonnes, corresponding to F = 0.47. This is 5% down on the TAC in 2019 and 2% up on the advice for 2019. F is above F_{pa}, because in the harvest control rule adopted in 2016, fishing mortality is increased at high SSB values.

Haddock in subareas 1 and 2 (Northeast Arctic) was assessed using SAM, following the recommendations from WKARCT in 2015. Work towards a new benchmark is underway, with the benchmark due to be completed in time for AFWG 2020. The stock status is as follows:

- The abundant cohorts 2004–2006 are still in the catches but is not a high proportion of the total haddock biomass.
- The total stock peaked in 2009 while SSB reached an all-time high in 2012–2015. SSB is now decreasing rapidly but recent signs of good recruitment suggest that the stock should start to increase again in coming years.
- A large proportion of the catches in recent years has been from age groups outside the reference age range (older than 7 years).
- The evaluated and agreed HCR gives a catch in 2020 of no more than 215 000 tonnes, corresponding to a 25% increase from the TAC in 2019. This corresponds to a fishing mortality of 0.32.

Saithe in subareas 1 and 2 (Northeast Arctic) was assessed using SAM, following the recommendations from the inter-benchmark meeting for this stock held in early 2014.

- The spawning-stock biomass (SSB) has shown wide fluctuations and has been above B_{pa} since 1996. The fishing pressure (F) has been close to or below the F management plan (FMP) since 1997. Recruitment (R) has fluctuated with no clear trend.
- Corresponding to the evaluated and implemented HCR, the catch in 2020 should be no more than 171 982 tonnes. This is a 15% increase compared to the TAC for 2018 and corresponds to a fishing mortality of 0.26.

Beaked redfish (*Sebastes mentella*) and Golden redfish (*Sebastes norvegicus*) in subareas 1 and 2 (Northeast Arctic). These stocks are on a multiannual advice cycle and new advice was not provided in 2019. Catch and survey data for both stocks have been updated and presented in this report. An assessment (but no new advice) was run for beaked redfish, no assessment was conducted for golden redfish.

Greenland halibut in subareas 1 and 2 (Northeast Arctic). The stock is assessed by a new GADGET length-based model approved at WKBUT benchmark in 2015, and there is as yet no HCR. AFWG is proposing a timetable for a benchmark and MSE in 2022–2023 to rectify this. The stock has a two-year advice cycle, with advice being provided for 2020 and 2021. There was one change to the assessment model in 2019 compared to 2017. Reduced sampling of the tuning survey resulted in the need for a simplified time-averaged method to split the data into males and females. This change increased the assessed stock by ca. 10%, but did not affect the overall trend. The revised splitting methodology is compatible with the stock annex, and the annex has therefore not been revised. The stock reached a peak in 2013 and has declined slightly since then. A five-year forecast indicates that status quo fishing will maintain the stock above B_{pa} over that period, and hence a status quo quota of 25 130 tonnes is advised for 2020 and 2021.

Anglerfish in subareas 1 and 2 (Northeast Arctic) There is currently no assessment for this stock, although the stock has been benchmarked in 2018, which recommended work towards a future potential analytic assessment for this stock. The stock structure of anglerfish is unclear, and anglerfish in this area seems to be dependent on influx or migration from ICES subareas 4 and 6. There are no survey data available. Age readings are not available, but the mean length in the catches, which has been increasing since 2003, is decreasing in recent years, indicating some recruitment to the area. Catches have been in the range 4000–5000 tonnes, mainly from a directed gillnet fishery. However, since 2012 catches declined rapidly, reaching a minimum of

1043 tonnes in 2015, the lowest level since 1997. Since then the catches have been slightly higher (1903 tonnes in 2018), but there is no indication of returns to the catch levels prior to 2012. The fishery is managed by technical regulations. The exploitation pattern seems to be sound, but the exploitation rate may well be too high.

Barents Sea capelin. Following ToR b), the data on Barents Sea capelin were updated in this report. No assessment is conducted during AFWG. There is ongoing discussion about the possibility of conducting a benchmark over a number of different capelin stocks, including the Barents Sea stock.

ii Expert group information

Expert group name	Arctic Fisheries Working Group (AFWG)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Daniel Howell, Norway
Meeting venue and dates	24-30 April 2019, Lisbon, Portugal (XX participants)

iii Term of reference

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

0 Introduction

0.1 Terms of reference

2018/2/FRSG02 The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell, Norway, will meet in Lisbon, Portugal, 24–30 April 2019 to:

a) Address generic ToRs for Regional and Species Working Groups, for relevant stocks except the Barents Sea capelin, which will be addressed at a meeting in the autumn;

b) For Barents Sea capelin oversee the process of providing intersessional assessment;

c) Address generic ToRs for Regional and Species Working Groups for the Barents Sea capelin stock.

d) Conduct reviews as required of any new time-series computed using the STOX and ECA open source software for use in assessments in the Barents Sea.

The assessments will be carried out on the basis of the Stock Annexes. 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 2019 ICES data call.

AFWG will report by 14 May 2019 and in October 2019 for Barents Sea capelin for the attention of ACOM

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

Generic ToRs for Regional and Species Working Groups

2018/2/ACOM05 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment for the fisheries relevant to the working group on:

  i) descriptions of ecosystem impacts of fisheries

  ii) descriptions of developments and recent changes to the fisheries

  iii) mixed fisheries considerations, and

  iv) emerging issues of relevance for the management of the fisheries;

c) Conduct an assessment on the stock(s) to be addressed in 2019 using the method (analytical, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, summarizing where the item is relevant:

i) Input data and examination of data quality;

ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

iii) 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 2018.

iv) Estimate MSY proxy reference points for the category 3 and 4 stocks

v) The developments in spawning-stock biomass, total-stock biomass, fishing mortality, catches (wanted and unwanted landings and discards) using the method described in the stock annex;

vi) The state of the stocks against relevant reference points;

vii) Catch scenarios for next year(s) for the stocks for which ICES has been requested to provide advice on fishing opportunities;

viii)Historical and analytical performance of the assessment and catch options and brief description of quality issues with these;

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

e) Review progress on benchmark processes of relevance to the Expert Group;

f) Prepare the data calls for the next year update assessment and for planned data evaluation workshops;

g) Identify research needs of relevance for the work of the Expert Group.

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

0.2 Additional requests

At its 47th meeting in October 2017, the Joint Norwegian-Russian Fisheries Commission (JNRFC) made the following request to ICES (Annex 17 to the protocol, request I was answered in 2018).

"JNRFC asks ICES to evaluate the impact of bycatch regulations for shrimp in the Barents Sea on the stocks of Sebastes mentella and Sebastes norvegicus in ICES subareas 1 and 2. This evaluation should be carried out for different levels of bycatch limitations and different levels of shrimp catch. It is suggested that this is added to the terms of reference for the ICES benchmark meeting for redfish (WKREDFISH) which will be held in February 2018. "

This request was considered both during AFWG 2018 and 2019. At AFWG 2019 it was concluded that for *S. mentella*, it is possible to evaluate the effect of such bycatch given the present criterion, for given redfish recruitment and shrimp catch levels. It is planned to provide such advice during 2019. However, evaluating the effect of changing the criterion would require further work, including simulation studies taking into account both biology and knowledge of behaviour of fishers and of the surveillance service. Also uncertainties in all quantities included in the calculations has to be accommodated. Spatial approaches and spatially varying criteria should be investigated in particular for *S.norvegicus*, for which also genetic studies may improve estimates of *norvegicus/mentella* ratio in different areas.

0.3 Responses to Terms of Reference

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

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

0.4 Benchmarks

No benchmarks were conducted prior to AFWG 2019. A benchmark is planned for haddock prior to the 2020 AFWG. A tentative plan to propose future benchmarks for AFWG was disused at AFWG 2019. NEA cod (and possibly coastal cod) in 2021, and Greenland Halibut in 2022 (following the next assessment in 2021). Then work for a first HCR for GHL prior to the advice in 2023. For NEA cod and haddock work for a revised HCR in 2022 was suggested. These dates should be discussed with Icelandic researchers to see if there can be international cooperation there. Capelin will need a benchmark at some point, as work is underway to revise the assessment methodology, however no data were proposed at this meeting, and cooperation with Iceland was thought advisable.

0.5 Unreported landings, discards, bycatch, and uncertainties in the catch data

0.5.1 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.

As previous years, a report from the Norwegian-Russian Analysis group dealing with estimation of total catch of cod and haddock in the Barents Sea in 2018 was available to AFWG. The report presents estimated catches made by Norwegian, Russian and third countries separately. According to that report the total catches of both cod and haddock reported to AFWG are very close (within 1%) to the estimates made by the analysis group. Thus, it was decided to set the IUU catches for 2017 to zero.

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

Discards estimates (1994–2018) 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 new compared to previous AFWG reports, and are obtained with a spatio-temporal model based 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 work in progress regarding improving the new estimates.

The new time-series in Figure 0.1 are obtained by scaling the estimated bycatch in the Norwegian fishery with the international fishery in each ICES area. The scaling procedure assumes that the Norwegian fishery is representative for 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.
It was observed during AFWG2019 that scaling the fishery logbooks with the landing statistics in year 2016 and 2017 resulted in a large difference between the obtained shrimp catch and the reported shrimp catch from NIPAG (ICES CM 2018/ACOM:08). Because of this inconsistency, only logbooks and *not* the landing statistics are used in year 2016 and 2017 when estimating the bycatch. Before AFWG2020, this inconsistency should be further investigated.

0.5.2 Uncertainty in catch data

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

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

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

We note that the SToX survey methodology reviewed by the group is able to produce uncertainty estimates for the survey time-series. The XSAM model can utilize such estimates, and work is ongoing to explore to consequences of utilizing such estimates.

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

0.5.3 Sampling effort– commercial fishery

Concerns about commercial sampling: The main Norwegian sampling program for demersal fish in ICES subareas 1 and 2 has been port sampling, carried out on board 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, but this improved the basis for the 2011–2017 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 1st, 2nd and 4th quarters, altogether up to 120 days. This is a reduction compared to about 180 days a year prior to 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 2008–2018. 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.

Cod, haddock and saithe: Previous concerns regarding poor biological sampling from the fishery were less of an issue in 2018, as available catch-at-age and length data covered the largest portion of catches by the respective fisheries. 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 2016–2018, the number of samples should be increased in coming years, with the aim of covering all quarters and areas contributing highest catches.

S. mentella

Data issues: 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.

S. norvegicus

Data issues: 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.

NeA Greenland halibut

Data issues: There is still a concern about the biological sampling from the fishery that may have become critically low. Age information is not available, due to disagreements on age reading method, and may affect precision in the assessment which at the moment is length based. NOR landings are split on Greenland halibut by sex for area, gear groups and Quarters. Annual sample level has decreased in the last years and may affect the precision of the catch distribution.

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

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

0.6 Uncertainties in survey data

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

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

The area coverage in the winter survey was extended from 2014 onwards (Mehl *et al.*, 2014; WD01), Figure 0.2. With the recent expansion of the cod distribution it is likely that in recent years the coverage in the February survey (BS-NoRu-Q1 (BTr) and BS-NoRu-Q1 (Aco)) has been incomplete, in particular for the younger ages. This could cause a bias in the assessment, but the magnitude is unknown. The 2014–2018 surveys covered considerably larger areas than earlier winter surveys, and showed that cod, haddock and Greenland halibut was distributed far outside the standard survey area. The 2017 and 2018 surveys were restricted by ice Northeast of Hopen Island, and the survey did not extend quite as far as in the years 2014–2016. In 2019 the coverage was almost as extensive as in 2014. The proportion of the total survey biomass (swept-area estimates) found in this new northern area by year and species in shown in Figure 0.3. For all stocks except Greenland halibut, mainly younger age groups are found in the northern area. It should however be noted that the survey index from this survey is currently not used in the assessment of Greenland halibut. The proportion by age of cod and haddock found in the northern area is shown in Figures 3.8 and 4.7.

The survey estimates within the standard area were used for the tuning data. If a wider coverage is continued in coming years, improved tuning data might be obtained.

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

From 2004 onwards, a joint Norwegian-Russian survey has been conducted in August-September. This is a multi-purpose survey termed an "ecosystem survey" because most part of the ecosystem is covered; including an acoustic survey for the pelagic species, which is used for capelin assessment, and a bottom-trawl survey which includes non-commercial species. The ecosystem survey is now included in both cod and haddock assessments. The survey is also utilized in the assessment of redfish and Greenland halibut. There is ongoing work on recalculation of the bottom-trawl series using the StoX framework, for inclusion in the assessment of cod and haddock (WD03).

In 2018, a large area in the eastern Barents Sea was not covered due to technical problems with one vessel (Figure 0.4). It is very important that this survey should be continued with complete spatial coverage. In addition to being the only survey used in capelin assessment and being used in assessment of demersal stocks, it has been shown to be valuable for sampling of synoptic ecosystem information, cover the entire area of fish distribution in the Barents Sea, and provide additional data on geographical distribution of demersal fish, which could prove valuable in future inclusion of more ecosystem information in the fish stock assessments.

0.7 Age reading

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

From 2009 onwards it was decided to have meetings between cod and haddock otolith readers only every second year. The overall percentage agreement for the 2015–2016 exchange was 88.7% for cod (WD 10), which was a little higher than at the previous meeting. The general trend is that the Russian readers assign slightly lower ages than the Norwegian readers compared to the modal age for all age groups. This is opposite of what we have seen in previous readings, where the Russian readers has tended to be slightly overestimating the age compared to the Norwegian readers.

It is not completely clear what are the main reasons for cod ageing discrepancies between Russian and Norwegian readers, as the interpretation of false zones, edge and centre seemed to be the same. Some increase in the percentage agreement in 2015–2016 is likely to be connected with less old fish present in catches and in the samples in later years. It is observed that the percent agreement between age readers decreases as fish age increases.

For haddock, the main reason of discrepancies between PINRO and IMR readers is different interpretation of the latest increments that were very thin in some years.

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

A positive development is seen for haddock age readings showing that the frequency of a different reading (usually ±1 year) has decreased from above 25% in 1996–1997 to about 10% at present. The discrepancies are always discussed and a final agreement on the exchanged cod and haddock otoliths is at present achieved for all otoliths except ca. 2–5%. For haddock, the overall percentage agreement for recent data (2015–2016) was 93.0% and the precision CV was 2.0% and considered to be satisfactory.

The next workshop on cod and haddock otolith reading will be held in Murmansk in May-June 2019.

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

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

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

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

It was concluded that experts from all laboratories normally interpret capelin otoliths equally. Difficult otoliths are sometimes interpreted differently, but these samples are few, and should not cause large problems for common work on capelin biology and stock assessment. All participants noted the great value of conducting joint work on otolith reading, and it was decided to continue the programme of capelin otolith exchange and to involve the labs at Iceland and Newfoundland in the exchange program. Readers from Norway and Russia should continue to meet at Workshops every second year. A capelin age reading Workshop was held in Murmansk in April 2016, and the report from that meeting was presented to the capelin assessment meeting in October 2016. The next age reading Workshop for capelin will be held in Murmansk in October 2019.

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

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

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

0.8 Assessment method issues

Following an IBP for NEA cod (ICES C. M. 2017/ACOM:29), the assessment method for NEA cod has been altered to the SAM model. In addition, the age range of the data (both catch and survey) has been extended as recommended by the benchmark. However, due to the increasing age structure of the cod, the settings for these older fish recommended by the benchmark were found to be problematic. In the SAM model, the variances for the oldest age categories in each tuning series (survey or commercial catch) were the same as for the youngest ages. This is unrealistic, but was a reasonable simplification when there were too few fish in these categories to allow for separate estimation of variances and too few to significantly affect the model tuning. These oldest age categories now represent a significant fraction of the stock (and catch), and AFWG 2019 therefore proposed allowing the SAM model to estimate these variances directly. This had the effect of increasing the assessed SSB by ca. 10%, and were proposed for review at IBPNEACOD 2019. The outcome of the review was that although the problem was real and re-evaluating the variance structure was a viable solution, the exact formulation chosen was considered to be too ad-hoc and lacking a solid justification. The result of the review was therefore to keep the previous model settings, and re-evaluate the issue in a full benchmark, likely in 2021. More details of the proposed solution are provided in the NEA cod chapter.

For coastal cod, the issues around the difficulties with the assessment model and management implementation of the management plan were noted. Work is ongoing to attempt to address these, and will lead to a benchmark in due course – although it is too early to set a timetable for this.

Greenland halibut largely followed the benchmark and stock annex. However, reduced sampling led to the sex splitting of the survey having to be done based on time-averaged values rather than annual samples. This affected the fraction of the stock in the 45 cm+ category used for reporting, and increased the assessed biomass by around 10% (although without changing the trends). This unavoidable described in the Greenland halibut section.

Work is in progress on revising the capelin assessment methodologies. However, it was considered that this would not be ready for a planned benchmark in 2020, and this has now been postponed to an unspecified future date.

0.9 Environmental information included in advice of NEA cod

For the twelfth time environmental information has been applied in the advice from AFWG. In this year's assessment ecosystem information was directly used in the projection of NEA cod. A combination of regression models, which is based on both climate and stock parameters, were used for prediction of recruitment-at-age 3, see section 1.4.

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

0.10 Proposals for status of assessments in 2018–2019

For anglerfish there is currently no assessment, however following the benchmark in 2018, work is being conducted with a view to a potential future assessment. AFWG proposes to set the following status for assessments for each stock. The redfish species, which were not assessed in 2019 will receive an update assessment in 2020.

Fish Stock	Stock Name	Advice in 2019	Previous benchmarks	Next bench-mark
cod.27.1-2	Cod in subareas 1 and 2 (Northeast Arctic)	Update	WKARCT 2015, IBP cod 2017	-
cod.27.1-2coast	Cod in subareas 1 and 2 (Norwegian coastal waters)	Update	WKARCT 2015	-
had.27.1-2	Haddock in subareas 1 and 2 (Northeast Arctic)	Update	WKARCT 2015 WKBENCH 2011	2020
pok.27.1-2	Saithe in subareas 1 and 2 (Northeast Arctic)	Update	IBP saithe 2014 WKROUND 2010	-
cap.27.1-2	Capelin in subareas 1 and 2 (Barents Sea), excluding Division 2.a west of 5°W	Update	WKARCT 2015 WKSHORT 2009	?
ghl.27.1-2	Greenland halibut in subareas 1 and 2	Update	WKBUT 2013 (finished in 2015)	-
reb.27.1-2	Redfish *Sebastes mentella* subareas 1 and 2	None (next in 2020)	WKREDFISH 2018 (WKREDMP 2014)	
reg.27.1-2	Redfish *Sebastes norvegicus* subareas 1 and 2	None (next in 2020)	WKREDFISH 2018	
anf.27.1-2	Anglerfish in subareas 1 and 2 (Northeast Arctic)	None	WKANGLERFISH 2018	

0.11 Stock annexes

There were no relevant benchmarks between AFWG 2018 and AFWG 2019, and no changes in the stock annexes. There has been a slight change in how sex splitting was conducted in one Greenland halibut series, but this change is within the description in the stock annex and therefore no changes have been made. For NEA cod a revision was proposed and reviewed at an interbenchmark following AFWG 2019. The revision was rejected, and no changes were made to the stock annex.

0.12 Audit reports

Audit reports were made for the 4 stocks for which updated advice is provided this year: north-east Arctic cod, haddock and saithe, and Greenland halibut. All audits reports except Norwegian Coastal cod were provided and available at the end of this report (Annex 5).

0.13 InterCatch

The assessment of NEA cod, haddock and saithe was partly based on output from InterCatch.

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

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

	ICES 1.a	ICES 2.a.1	ICES 2.b.1	Total	%NEAFC
2018					
NEA cod	1724	2	0	778627	0.22%
Coastal cod	0	0	0	36375	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%
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 %

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

	ICES 1.a	ICES 2.a.1	ICES 2.b.1	Total	%NEAFC
Anglerfish	0	0	0	1657	0.0 %

0.15 Relationship with WGIBAR

The WGIBAR group (Working Group on Integrated Assessments of the Barents Sea) met for the sixth time in February 2019 (ICES C. M. 2019/SSGIEA:04). Most of the ecosystem information which was previously found in Chapter 1 in the AFWG report was from 2017 onwards moved to the WGIBAR report. Chapter 1 in AFWG now only contains ecosystem-related information and data directly relevant to the assessment of AFWG stocks.

0.16 Research needs of relevance for the Working Group

Agreeing on method for calculation of bottom-trawl indices from ecosystem survey.

Agreeing on an age-reading method for Greenland Halibut

Extending Greenland Halibut data back in time

Routine methods for species and stock identification for *Sebastes norvegicus* and *S. mentella*

0.17 Time and place of Next Meeting

The Working Group proposes to meet next time in the period 17–23 April 2020 at a location to be decided. A one-day review of changes to the redfish time-series will be conducted on the 16 April 2020 at the same location.

In the absence of any other candidates, Daniel Howell was proposed by the group to be chair for a second three-year term (2020-2022).

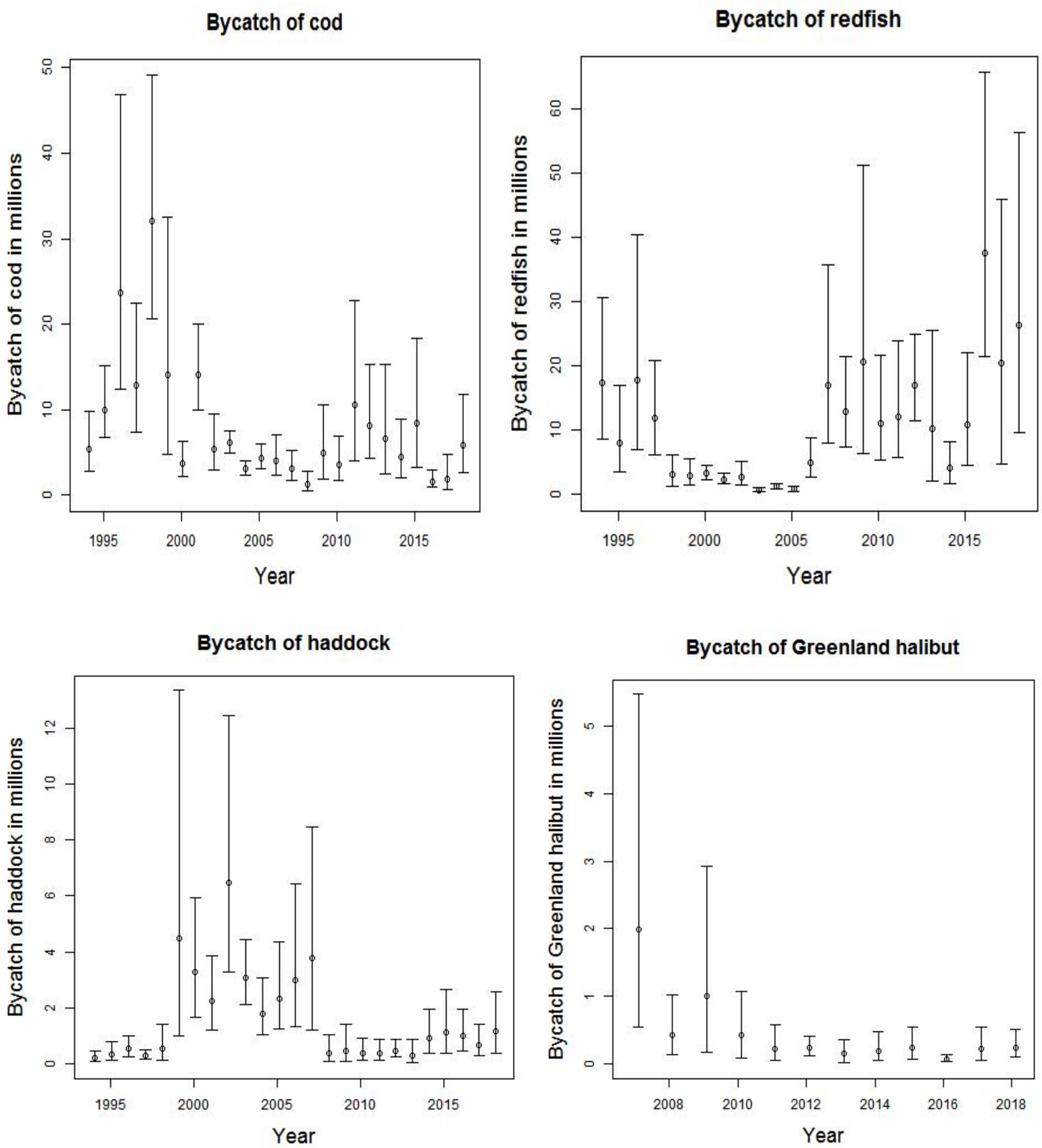

Figure 0.1. Estimated bycatch of cod, redfish, haddock, and Greenland Halibut in the Barents Sea shrimp fishery. Intervals are 90% confidence intervals.

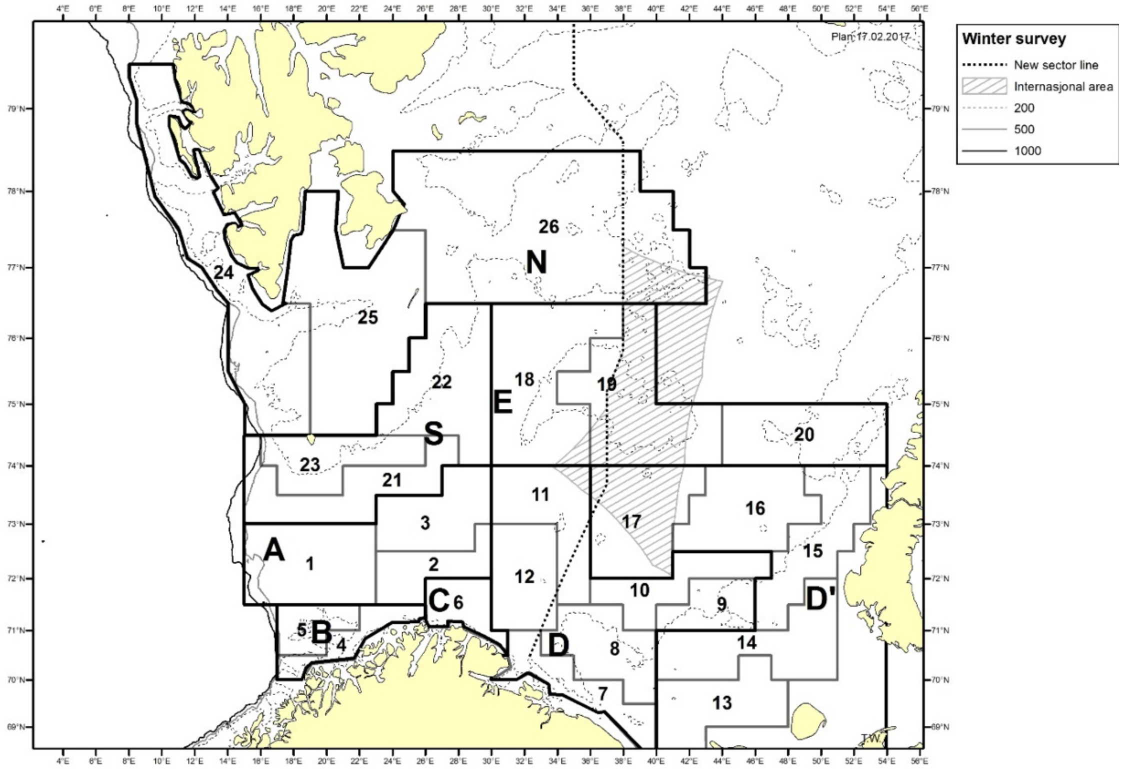

Figure 0.2. Strata (1–23) and main areas (A,B,C,D,D',E and S) used for swept-area estimations and acoustic estimations with StoX. Additional strata (24–26, main area N) are covered since 2014, but not included in the standard time-series.

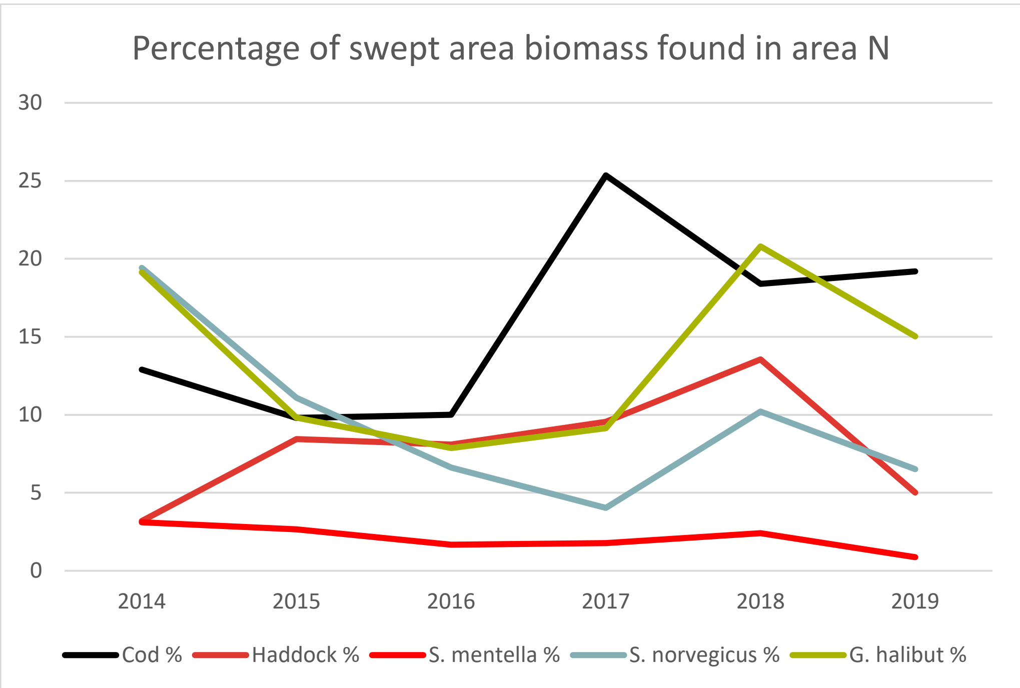

Figure 0.3. Proportion of swept-area biomass in the Joint winter survey found in the new northern area (N), by year and species.

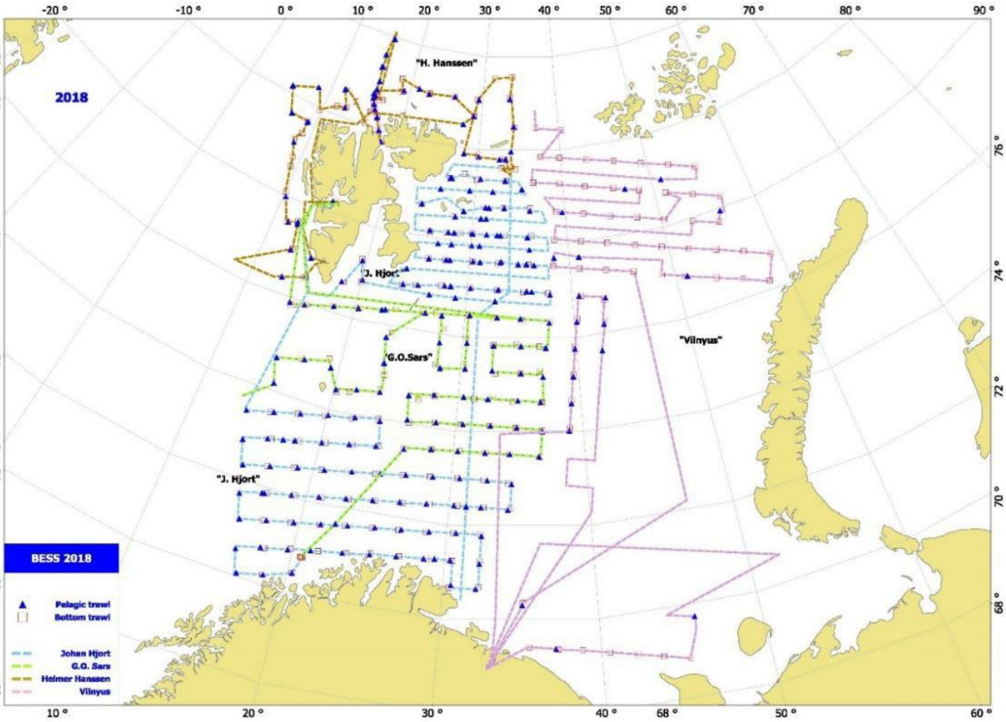

Figure 0.4 Barents Sea Ecosystem survey (BESS) 2018, realized vessel tracks with pelagic and bottom-trawl sampling stations.

Table 0.1. Age and length sampling by Norway of commercial catches in 2008-2018. 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.

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 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

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 1000 t	Age-samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
NEA-haddock	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
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

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 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
S. Norvegicus	2008	104	1093	18305		98	2281	6180	176.9	15.9	369.1	125
	2009	66	1131	17386		96	2302	6215	182.0	15.4	370.4	125
	2010	49	1050	19339		97	2164	6515	161.2	14.9	332.2	125
	2011	75	1064	16347		106	2310	4645	229.1	22.8	497.3	125
	2012	78	993	12994		76	1297	4250	39.1	3.1	56.7	125
	2013	35	654	627	17	74	1122	4244	154.1	17.4	264.4	125

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 1000 t	Age-samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
	2014	24	66	919	24	24	365	3053	21.6	7.9	119.6	125
	2015	28	121	3497	22	405	1281	2492	48.6	162.5	514.0	125
	2016	54	642	2376	36	517	1585	4606	139.4	112.2	344.1	125
	2017	69	695	6177	44	571	1633	3354	207.2	170.2	486.9	125
	2018	64	778	7354	32	629	1252	4275	182.0	147.1	292.8	125
S. mentella **)	2008	13	178	1038		0	0	2214	80.4	0.0	0.0	125
	2009	12	319	1841		2	40	2567	124.3	0.8	15.6	125
	2010	11	284	3664		11	320	2245	126.5	4.9	142.5	125
	2011	9	255	3210		11	298	2690	94.8	4.1	110.8	125
	2012	13	166	2187		13	241	2098	79.1	6.2	114.9	125
	2013	14	184	383	5	13	390	1361	135.2	9.6	286.6	125
	2014	11	36	4664	12	49	5	13402	2.7	3.7	0.4	125
	2015	21	166	23794	10	227		19700	8.4	11.5	0.0	125
	2016	26	271	3127	20	206	9	17631	15.4	11.7	0.5	125

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 1000 t	Age-samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
	2017	30	256	3196	24	211	24	17280	14.8	12.2	1.4	125
	2018	39	409	8782	20	364	25	19294	21.2	18.9	1.3	125
Greenland halibut	2008	53	580	9074		0	0	7394	78.4	0.0	0.0	125
	2009	36	922	12853		0	0	8446	109.2	0.0	0.0	125
	2010	26	519	8395		0	0	7685	67.5	0.0	0.0	125
	2011	29	463	8204		0	0	8273	56.0	0.0	0.0	125
	2012	34	610	7716		0	0	10074	60.6	0.0	0.0	125
	2013	26	597	4930		0	0	12613	47.3	0.0	0.0	125
	2014	33	236	2559	10	0	0	10876	21.7	0.0	0.0	125
	2015	31	273	8769	11	0	0	10704	25.5	0.0	0.0	125
	2016	83	384	2304	60	0	0	12573	30.5	0.0	0.0	125
	2017	67	556	10022	43	317	0	13194	42.1	24.0	0.0	125
	2018	96	582	11720	63	342	0	14876	39.1	23.0	0.0	125

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 1000 t	Age-samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
Anglerfish (Monk)	2013	14	126	636	12	109	0	2989	42.2	36.5	0.0	125
	2014	10	53	224	10	30	0	1655	32.0	18.1	24.8	125
	2015	10	105	518	10	33	0	934	112.4	35.3	0.0	125
	2016	22	161	489	10	38	0	2117	76.1	17.9	0.0	125
	2017	28	220	977	12	35	1	1468	149.9	23.8	0.7	125
	2018	24	229	907	12	46	2	1884	121.5	24.4	1.1	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

Stock	Year	No of unique vessels	No of length samples	No of lenght-measured individuals	No of unique vessels (***)	No of age samples	No of aged individuals	Landings, tonnes	Length-samples pr 1000 t	Age-samples per 1000 t	Aged individuals per 1000 t	EU DCF for comparison, per 1000 t
	2016	7	27	1863	7	27	649					125
	2017	21	43	2294	14	25	305					125
	2018	68	207	15022	33	76	823	123461	1.7	0.6	6.7	125

*) 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 splitted by length and age samples

Table 0.2. Age and length sampling by Russia of commercial catches and age sampling of surveys in 2008–2018. Also length-measured individuals and aged individuals per 1000 t caught. For comparison also the EU DCF requirements are shown.

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-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
NEA-haddock	2008	216959	2498	5677	8175	68792	3154	36,3	118,8	125

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-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
	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
NEA-saithe	2008	8865	479	175	654	11577	766	41,4	56,5	125
	2009	5279	7	68	75	11899	444	0,6	6,3	125
	2010	422	112	249	361	14664	29	7,6	24,6	125
	2011	88	9	27	36	10007	9	0,9	3,6	125

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison, per 1000 t
	2012	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
S. marinus	2008	1196	45	17	62	749	1597	60,1	82,8	125
(*norvegicus*)	2009	241	2	27	29	698	345	2,9	41,5	125
	2010	486	25	199	224	806	603	31,0	277,9	125
	2011	885	77	62	139	919	963	83,8	151,3	125
	2012	1564	58	54	112	681	2297	85,2	164,5	125
	2013	770	22	142	164	797	966	27,6	205,8	125
	2014	589	25	33	58	806	731	31,0	72,0	125

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison, per 1000 t
	2015	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
S. mentella	2008	21446	471	3379	3850	7117	3013	66,2	541,0	125
	2009	29435	761	1447	2208	3843	7659	198,0	574,6	125
	2010	2776	100	2295	2395	6414	433	15,6	373,4	125
	2011	917	7	640	647	5037	182	1,4	128,4	125
	2012	7802	422	1146	1568	4101	1902	102,9	382,3	125
	2013	19092	1253	1625	2878	3677	5192	340,8	782,7	125
	2014	817	25	1297	1322	1704	479	14,7	775,8	125
	2015	771		1818	1818	1142	675	0,0	1591,9	125
	2016	27765	1076	85	1161	8419	3298	127,8	137,9	125
	2017	958	99	1000	1099	4952	193	20,0	221,9	125

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-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
	2018	21004	845	39	884	10497	2001	80,5	84,2	125
G. halibut	2008	106411	1519	3366	4885	5294	20100	286,9	922,7	125
	2009	77554	819	2282	3101	3335	23255	245,6	929,8	125
	2010	32090	416	2784	3200	6888	4659	60,4	464,6	125
	2011	9892	115	1541	1656	7053	1403	16,3	234,8	125
	2012	82943	2140	2506	4646	10041	8260	213,1	462,7	125
	2013	12608	555	2756	3311	10310	1223	53,8	321,1	125
	2014	24346	633	2106	2739	10061	2420	62,9	272,2	125
	2015	22116	575	2489	3064	12953	1707	44,4	236,5	125
	2016	11818	574	221	795	10576	1117	54,3	75,2	125
	2017	24061	1205	1579	2784	10713	2246	112,5	259,9	125
	2018	21893	954	308	1262	12072	1814	79,0	104,5	125
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

Stock	Year	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-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
	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

***) 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 and 2015**

Table 0.3. Age and length sampling by Spain of commercial catches and length sampling of surveys in 2008-2018. 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 lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison, per 1000 t
NEA-cod	2008	2	10108	610		610	9658	1047	63	63	125
	2009	2	8733	1834		1834	12013	727	153	153	125
	2010	2	28297	1735		1735	12657	2236	137	137	125
	2011	2	11633	964		964	13291	875	73	73	125
	2012	2	9849	998		998	12814	769	78	78	125
	2013	2	30295	2381		2381	15041	2014	158	158	125
	2014	2	27828	2306		2306	16479	1689	140	140	125
	2015	2	18568	1445		1445	18772	989	77	77	125
	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

Stock	Year	No of vessels	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-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-haddock*	2009	1	2561				240				
	2010	1	3243				379				
	2011	1	1796				408				
	2012	2	3198				647				
	2013	1	660				413				
	2014	1	2460				370				
	2015	1	702				418				
	2016	2	701				357				
	2017	1	710				156				
	2018	1	154				169				
NEA-saithe*	2009	1	123				2				
	2013	1					5				
	2014	1					13				

Stock	Year	No of vessels	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-measured individuals per 1000 t	Aged individuals per 1000 t (commercial catches)	Total aged individuals per 1000 t	EU DCF for comparison, per 1000 t
	2015	1					33				
	2016						25				
	2017						85				
	2018						60				
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			

Stock	Year	No of vessels	No of lenght-measured individuals (commercial catches)	No of aged individuals (commercial catches)	No of aged individuals (surveys)	Total No of aged individuals	Landings, tonnes	Lenght-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
G. 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			

***) sampling from bycatch in cod fishery**
****) sampling from pelagic redfish fishery**
*****) sampling from Spanish Greenland halibut survey**

Table 0.4. German Catch sampling.

Stock	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged indi-viduals	Landings (t)	Length-measured indi-viuals per 1000 t	Age-sampled individu-als per 1000 t	EU DCF for com-parison
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
	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
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

Stock	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings (t)	Length-measured indiviuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
	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
	2018	4	2	4345	497	391	11113	1271	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

Stock	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged indi-viduals	Landings (t)	Length-measured indi-viuals per 1000 t	Age-sampled individu-als per 1000 t	EU DCF for com-parison
	2018	4	1	19718	473	1651	11943	286	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
G. 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

Stock	Year	No of unique vessels	No of length samples	No of length-measured individuals	No of aged individuals	Landings (t)	Length-measured indiviuals per 1000 t	Age-sampled individuals per 1000 t	EU DCF for comparison
	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

1 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 (ICES CM 2019/SSGIEA:04), here we only provide information that is directly relevant to assessment of the AFWG stocks as well as information that is updated after the 2019 WGIBAR report was finished.

1.1 0-group abundance

The recruitment of the Barents Sea fish species measured as 0-group has shown a large year-to-year variability (Tables 1.1–1.2). 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, 0-group indices could not be calculated due to incomplete area coverage in the southeastern Barents Sea (section 0.7).

1.2 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 1.3–1.7). Cod prefer capelin as a prey, and fluctuations of the capelin stock may have a strong effect on growth, maturation and fecundity of cod, as well as on cod recruitment because of cannibalism. The role of euphausiids for cod feeding increases in the years when capelin stock is at a low level (Ponomarenko and Yaragina, 1990). Also, according to Ponomarenko (1973; 1984) interannual changes of euphausiid abundance are important for the survival rate of cod during the first year of life.

The food consumption by NEA cod in 1984–2018, based on data from the Joint Russian-Norwegian stomach content database, is presented in Tables 1.3–1.4. The Norwegian calculations are based on the method described by (Bogstad and Mehl, 1997). The main prey items in 2018 were capelin, krill, haddock, polar cod, amphipods, cod, herring, and shrimp. The consumption calculations made by IMR show that the total consumption by age 1 and older cod in 2018 was 5.8 million tonnes, while PINRO estimates give a corresponding figure of 6.1 million tonnes. The consumption per cod by cod age groups is shown in Tables 1.5–1.6 (IMR and PINRO estimates), while the proportion of cod and haddock in the diet by cod age group (IMR estimates) is given in Tables 1.7 and 1.8. Consumption per cod and individual growth of cod has been stable in recent years.

One direct application for management of results from the trophic investigations in the Barents Sea is 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 1.3, 1.5 and 1.7, 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 although it is now decreasing, it is still at a high level for both stocks. There are a limited number of predators on such large fish. As predation is a likely to be a major source of natural mortality, it could thus be considered whether the natural mortality on 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 in recent years 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).

1.3 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 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 has 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 which 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.

1.4 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.

1.4.1 Historic overview

Several statistical models, which use multiple linear regressions, have been developed for recruitment of northeast Arctic cod. All models try to predict recruitment-at-age 3 (at 1 January), as calculated from the VPA, 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 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 numbers 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 relatively 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 have 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_{cod3-6} /$ABM_{capelin}$(-2,-1)
H2: log(R3)~ Temp(-2) +I(surv)+ Age1(-2) + BM_{cod3-6} /$ABM_{capelin}$ (-2,-1)
H3: log(R3)~ Temp(-1) + Age2(-1) + BM_{cod3-6} /$ABM_{capelin}$ (-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_{cod3-6} 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.

1.4.2 Models used in 2019

In 2018 at the meeting of the AFWG, the correction and simplification of models was continued. Due to the fact that 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 of 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: $R3^2 \sim DOxSat^2(t-13) + ITw(t-43) + expIce(t-40) + Ice(t-15)$
TitovEL: $R3^4 \sim OxSat(t-39) + ITw(t-43)$

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 2019.

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. It can be seen that 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 2 models (TitovES, TitovEL) will be used only to account for the effect of environmental conditions on NEA cod recruitment.

In AFWG-2018 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.

In summary, the SAM for age 3 from the AFWG 2019 assessment was used as historical R3. The recruitment forecast for 2019–2022 are based on a hybrid model with weighting estimated on AFWG-2018. The weights and forecasts for the 2019 AFWG assessment can be found in Tables 1.9a–b.

1.5 Biomass and exploitation levels of AFWG stocks.

Figure 1.2 shows the biomass development for northeast Arctic cod, haddock, and saithe. The combined biomass of these three stocks peaked in 2013, but is still at a high level. These three stocks have in recent years been harvested below or at the target fishing mortalities in the management plans (Figure 1.3), except for the fishing mortality on haddock in 2017–2018 which was above the target F.

Table 1.1. 0-group abundance indices (in millions) with 95% confidence limits, not corrected for catching efficiency.

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	197278	131674	262883	72	38	105	59	38	81	4	1	8	277873	0	701273
1981	123870	71852	175888	48	33	64	15	7	22	3	0	8	153279	0	363283
1982	168128	35275	300982	651	466	835	649	486	812	202	0	506	106140	63753	148528
1983	100042	56325	143759	3924	1749	6099	1356	904	1809	40557	19526	61589	172392	33352	311432
1984	68051	43308	92794	5284	2889	7679	1295	937	1653	6313	1930	10697	83182	36137	130227
1985	21267	1638	40896	15484	7603	23365	695	397	992	7237	646	13827	412777	40510	785044
1986	11409	98	22721	2054	1509	2599	592	367	817	7	0	15	91621	0	184194
1987	1209	435	1983	167	86	249	126	76	176	2	0	5	23747	12740	34755
1988	19624	3821	35427	507	296	718	387	157	618	8686	3325	14048	107027	23378	190675
1989	251485	201110	301861	717	404	1030	173	117	228	4196	1396	6996	16092	7589	24595
1990	36475	24372	48578	6612	3573	9651	1148	847	1450	9508	0	23943	94790	52658	136922
1991	57390	24772	90007	10874	7860	13888	3857	2907	4807	81175	43230	119121	41499	0	83751
1992	970	105	1835	44583	24730	64437	1617	1150	2083	37183	21675	52690	13782	0	36494
1993	330	125	534	38015	15944	60086	1502	911	2092	61508	2885	120131	5458	0	13543
1994	5386	0	10915	21677	11980	31375	1695	825	2566	14884	0	31270	52258	0	121547

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1995	862	0	1812	74930	38459	111401	472	269	675	1308	434	2182	11816	3386	20246
1996	44268	22447	66089	66047	42607	89488	1049	782	1316	57169	28040	86299	28	8	47
1997	54802	22682	86922	67061	49487	84634	600	420	780	45808	21160	70455	132	0	272
1998	33841	21406	46277	7050	4209	9890	5964	3800	8128	79492	44207	114778	755	23	1487
1999	85306	45266	125346	1289	135	2442	1137	368	1906	15931	1632	30229	46	14	79
2000	39813	1069	78556	26177	14287	38068	2907	1851	3962	49614	3246	95982	7530	0	16826
2001	33646	0	85901	908	152	1663	1706	1113	2299	844	177	1511	6	1	10
2002	19426	10648	28205	19157	11015	27300	1843	1276	2410	23354	12144	34564	130	20	241
2003	94902	41128	148676	17304	10225	24383	7910	3757	12063	28579	15504	41653	216	0	495
2004	16901	2619	31183	19408	14119	24696	19372	12727	26016	**136053**	97442	174664	862	0	1779
2005	42354	12517	72192	21789	14947	28631	**33637**	24645	42630	26531	1288	51774	12676	511	24841
2006	168059	103577	232540	7801	3605	11996	11209	7413	15005	68531	22418	114644	20403	9439	31367
2007	161594	87683	235504	9896	5993	13799	2873	1820	3925	22319	4517	40122	156548	46433	266663
2008	288799	178860	398738	52975	31839	74111	2742	830	4655	15915	4477	27353	9962	0	20827
2009	189747	113135	266360	54579	37311	71846	13040	7988	18093	18916	8249	29582	49939	23435	76443
2010	91730	57545	125914	40635	20307	60962	7268	4530	10006	20367	4099	36636	66392	3114	129669
2011	175836	3876	347796	**119736**	66423	173048	7441	5251	9631	13674	7737	19610	7026	0	17885

Year	Capelin			Cod			Haddock			Herring			Redfish		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2012	**310519**	225728	395311	105176	37917	172435	1814	762	2866	26480	299	316769	58535	0	128715
2013	94673	28224	161122	90108	62788	117428	7235	4721	9749	70972	8393	133550	928	310	1547
2014	48933	5599	92267	102977	72975	132980	4185	2217	6153	16674	5671	27677	77658	35010	120306
2015	147961	87971	207951	8744	3008	14479	6005	2816	9194	11207	0	25819	101653	40258	163048
2016	274050	157185	390915	16872	9942	23801	4029	1952	6107	32956	15793	50119	12941	1713	24168
2017	72486	36535	108438	69371	46841	91901	9205	6081	12329	32112	11180	53045	43561	0	97558
Mean	93511			30280			4442			28586			60307		
Median	62721			17088			1760			19641			22075		

Table 1.1. (cont.). 0-group abundance indices (in millions) with 95% confidence limits, not corrected for catching efficiency.

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	3	0	6	111	35	187	1273	883	1664	28958	9784	48132	9650	0	20622
1981	0	0	0	74	46	101	556	300	813	595	226	963	5150	1956	8345
1982	143	0	371	39	11	68	1013	698	1328	1435	144	2725	1187	0	3298
1983	239	83	394	41	22	59	420	264	577	1246	0	2501	9693	0	20851
1984	1339	407	2271	31	18	45	60	43	77	127	0	303	3182	737	5628
1985	12	1	23	48	29	67	265	110	420	19220	4989	33451	809	0	1628
1986	1	0	2	112	60	164	6846	4941	8752	12938	2355	23521	2130	180	4081
1987	1	0	1	35	23	47	804	411	1197	7694	0	17552	74	31	117
1988	17	4	30	8	3	13	205	113	297	383	9	757	4634	0	9889
1989	1	0	3	1	0	3	180	100	260	199	0	423	18056	2182	33931
1990	11	2	20	1	0	2	55	26	84	399	129	669	31939	0	70847
1991	4	2	6	1	0	2	90	49	131	88292	39856	136727	38709	0	110568
1992	159	86	233	9	0	17	121	25	218	7539	0	15873	9978	1591	18365
1993	366	0	913	4	2	7	56	25	87	41207	0	96068	8254	1359	15148
1994	2	0	5	39	0	93	1696	1083	2309	267997	151917	384078	5455	0	12032
1995	148	68	229	15	5	24	229	39	419	1	0	2	25	1	49

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1996	131	57	204	6	3	9	41	2	79	70134	43196	97072	4902	0	12235
1997	78	37	120	5	3	7	97	44	150	33580	18788	48371	7593	623	14563
1998	86	39	133	8	3	12	27	13	42	11223	6849	15597	10311	0	23358
1999	136	68	204	14	8	21	105	1	210	129980	82936	177023	2848	407	5288
2000	206	111	301	43	17	69	233	120	346	116121	67589	164652	22740	14924	30556
2001	20	0	46	51	20	83	162	78	246	3697	658	6736	13490	0	28796
2002	553	108	998	51	0	112	731	342	1121	96954	57530	136378	27753	4184	51322
2003	65	0	146	13	0	34	78	45	110	11211	6100	16323	1627	0	3643
2004	1395	860	1930	70	28	113	36	20	52	37156	19040	55271	367	125	610
2005	55	36	73	9	4	14	200	109	292	6540	3196	9884	3216	1269	5162
2006	142	60	224	11	1	20	710	437	983	26016	9996	42036	2078	464	3693
2007	51	6	96	1	1	0	262	45	478	25883	8494	43273	2532	0	5134
2008	45	22	69	6	0	13	956	410	1502	6649	845	12453	91	0	183
2009	22	0	46	7	4	10	115	51	179	23570	9661	37479	21433	5642	37223
2010	402	126	678	14	8	20	128	18	238	31338	13644	49032	1306	0	3580
2011	27	0	59	20	11	29	58	23	93	37431	15083	59780	627	26	1228

Year	Saithe			Gr halibut			Long rough dab			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2012	69	2	135	30	16	43	173	0	416	4173	48	8298	17281	0	49258
2013	3	1	5	21	13	28	5	0	14	1634	0	4167	148	28	268
2014	1	0	2	10	3	16	309	89	528	2779	737	4820	746	79	1414
2015	47	0	101	27	2	52	575	361	789	128	18	237	6074	2001	10146
2016	3	0	7	6	1	12	601	0	1267	258	0	624	1180	128	2231
2017	127	2	252	8	1	14	72	27	117	43	0	106	1009	0	2795
Mean	161			26			514			30388			7850		
Median	54			14			190			9453			3932		

Table 1.2. 0-group abundance indices (in millions) with 95% confidence limits, corrected for catching efficiency.

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	740289	495187	985391	276	131	421	265	169	361	77	12	142
1981	477260	273493	681026	289	201	377	75	34	117	37	0	86
1982	599596	145299	1053893	3480	2540	4421	2927	2200	3655	2519	0	5992
1983	340200	191122	489278	19299	9538	29061	6217	3978	8456	195446	69415	321477
1984	275233	161408	389057	24326	14489	34164	5512	3981	7043	27354	3425	51284
1985	63771	5893	121648	66630	32914	100346	2457	1520	3393	20081	3933	36228
1986	41814	642	82986	10509	7719	13299	2579	1621	3537	93	27	160
1987	4032	1458	6607	1035	504	1565	708	432	984	49	0	111
1988	65127	12101	118153	2570	1519	3622	1661	630	2693	60782	20877	100687
1989	862394	690983	1033806	2775	1624	3925	650	448	852	17956	8252	27661
1990	115636	77306	153966	23593	13426	33759	3122	2318	3926	15172	0	36389
1991	169455	74078	264832	40631	29843	51419	13713	10530	16897	267644	107990	427299
1992	2337	250	4423	166276	92113	240438	4739	3217	6262	83909	48399	119419
1993	952	289	1616	133046	58312	207779	3785	2335	5236	291468	1429	581506
1994	13898	70	27725	70761	39933	101589	4470	2354	6586	103891	0	212765
1995	2869	0	6032	233885	114258	353512	1203	686	1720	11018	4409	17627

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1996	136674	69801	203546	280916	188630	373203	2632	1999	3265	549608	256160	843055
1997	189372	80734	298011	294607	218967	370247	1983	1391	2575	463243	176669	749817
1998	113390	70516	156263	24951	15827	34076	14116	9524	18707	476065	277542	674589
1999	287760	143243	432278	4150	944	7355	2740	1018	4463	35932	13017	58848
2000	140837	6551	275123	108093	58416	157770	10906	6837	14975	469626	22507	916746
2001	90181	0	217345	4150	798	7502	4649	3189	6109	10008	2021	17996
2002	67130	36971	97288	76146	42253	110040	4381	2998	5764	151514	58954	244073
2003	340877	146178	535575	81977	47715	116240	30792	15352	46232	177676	52699	302653
2004	53950	11999	95900	65969	47743	84195	39303	26359	52246	773891	544964	1002819
2005	148466	51669	245263	72137	50662	93611	91606	67869	115343	125927	20407	231447
2006	515770	325776	705764	25061	11469	38653	28505	18754	38256	294649	102788	486511
2007	480069	272313	687825	42628	26652	58605	8401	5587	11214	144002	25099	262905
2008	995101	627202	1362999	234144	131081	337208	9864	1144	18585	201046	68778	333313
2009	673027	423386	922668	185457	123375	247540	33339	19707	46970	104233	31009	177458
2010	318569	201973	435166	135355	68199	202511	23669	14503	32834	117087	32045	202129
2011	594248	58009	1130487	448005	251499	644511	19114	14209	24018	83051	48024	118078
2012	988600	728754	1248445	410757	170242	651273	5281	2626	7936	177189	35046	2111493

Year	Capelin			Cod			Haddock			Herring		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2013	316020	127310	504731	385430	269640	501219	16665	11161	22169	289391	67718	511064
2014	163630	31980	295280	464124	323330	604919	11765	6160	17371	136305	42164	230447
2015	457481	274631	640331	37474	17244	57704	15089	6204	23973	82749	0	160973
2016	778784	479130	1078348	53796	30790	76622	5504	2791	8216	79439	38415	120464
2017	213787	112459	315115	233275	150239	316310	19484	12902	26067	153763	34713	272813
LTM	311542			117579	117579		11944			162997		

Table 1.2 (cont.). 0-group abundance indices (in millions) with 95% confidence limits, corrected for catching efficiency.

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1980	21	0	47	203226	69898	336554	82871	0	176632
1981	0	0	0	4882	1842	7922	46155	17810	74500
1982	296	0	699	1443	154	2731	10565	0	29314
1983	562	211	912	1246	0	2501	87272	0	190005
1984	2577	725	4430	871	0	2118	26316	6097	46534
1985	30	7	53	143257	39633	246881	6670	0	13613
1986	4	0	9	102869	16336	189403	18644	125	37164
1987	4	0	10	64171	0	144389	631	265	996
1988	32	11	52	2588	59	5117	41133	0	89068
1989	10	0	23	1391	0	2934	164058	15439	312678
1990	29	4	55	2862	879	4846	246819	0	545410
1991	9	4	14	823828	366924	1280732	281434	0	799822
1992	326	156	495	49757	0	104634	80747	12984	148509
1993	1033	0	2512	297397	0	690030	70019	12321	127716
1994	7	1	12	2139223	1230225	3048220	49237	0	109432
1995	415	196	634	6	0	14	195	0	390

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
1996	430	180	679	588020	368361	807678	46671	0	116324
1997	341	162	521	297828	164107	431550	62084	6037	118131
1998	182	91	272	96874	59118	134630	95609	0	220926
1999	275	139	411	1154149	728616	1579682	24015	3768	44262
2000	851	446	1256	916625	530966	1302284	190661	133249	248072
2001	47	0	106	29087	5648	52526	119023	0	252146
2002	2112	134	4090	829216	496352	1162079	215572	36403	394741
2003	286	0	631	82315	42707	121923	12998	0	30565
2004	4779	2810	6749	290686	147492	433879	2892	989	4796
2005	176	115	237	44663	22890	66436	25970	9987	41953
2006	280	116	443	182713	73645	291781	15965	3414	28517
2007	286	3	568	191111	57403	324819	22803	0	46521
2008	142	68	216	42657	5936	79378	619	25	1212
2009	62	0	132	168990	70509	267471	154687	37022	272351
2010	1066	362	1769	267430	111697	423162	12045	0	33370
2011	96	0	225	249269	100355	398183	4924	218	9629
2012	229	5	453	25026	1132	48920	125306	0	357381

Year	Saithe			Polar cod (east)			Polar cod (west)		
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit	
2013	11	4	18	11382	0	29002	1011	262	1760
2014	4	0	9	17349	5184	29515	5298	500	10096
2015	406	0	930	795	107	1484	49584	15385	83784
2016	10	0	21	1544	0	3718	9288	459	18117
2017	379	18	740	64390	48	256	6580	0	18044
Mean	469			247135			63589		

Table 1.3. The Northeast arctic COD stock's consumption of various prey species in 1984–2018 (1000 tonnes) based on Norwegian consumption calculations.

Table 1.3. The North-east arctic COD stock's consumption of various prey species in 1984-2018 (1000 tonnes)															
Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whiting	Long rough c	Snow crab	Total
1984	486	28	119	439	724	78	15	22	51	364	0	0	26	0	2352
1985	1115	173	60	155	1617	183	3	31	47	224	0	1	44	0	3654
1986	595	1213	112	139	823	131	137	81	109	311	0	0	59	0	3711
1987	662	1067	66	189	226	32	202	25	4	318	1	0	9	0	2800
1988	399	1230	301	127	337	8	92	9	3	222	0	4	6	0	2738
1989	650	793	237	131	570	3	32	8	10	227	0	0	62	0	2723
1990	1341	137	85	195	1608	7	6	19	15	243	0	87	104	0	3849
1991	761	66	76	188	2890	8	12	26	20	312	8	10	296	0	4672
1992	893	98	151	370	2450	330	96	54	106	187	22	2	101	0	4860
1993	737	247	671	313	3025	162	276	283	70	100	2	2	28	0	5918
1994	611	548	692	501	1082	145	566	215	48	78	0	1	42	0	4529
1995	811	951	500	351	606	113	242	358	111	189	1	0	37	0	4271
1996	588	623	1138	334	530	46	101	520	67	96	0	10	38	0	4093
1997	427	372	502	302	875	5	111	331	40	36	0	32	16	0	3050
1998	401	348	448	314	690	82	144	152	31	9	0	13	17	0	2649
1999	377	143	271	246	1697	127	217	61	26	16	1	31	8	0	3218
2000	380	164	452	444	1706	53	191	75	50	8	0	37	20	0	3579
2001	693	172	375	278	1739	72	253	69	50	6	1	154	33	0	3894
2002	378	96	259	242	2012	87	282	110	128	1	0	240	16	0	3850
2003	561	291	548	243	2196	219	282	116	172	3	0	76	55	0	4763
2004	633	568	345	249	1265	212	357	129	202	3	12	57	66	1	4099
2005	776	577	525	268	1377	129	382	117	318	2	5	116	54	0	4646
2006	901	228	1102	371	1770	168	112	81	364	12	2	160	135	0	5405
2007	1358	326	1192	474	2333	293	281	90	395	51	0	44	79	0	6917
2008	1739	178	1024	432	3167	114	558	205	315	66	13	19	101	0	7932
2009	1690	273	681	302	4481	137	827	223	288	33	3	6	130	2	9076
2010	1816	464	1128	320	4412	60	374	280	308	159	12	16	150	8	9506
2011	1758	283	976	253	4657	93	484	330	325	131	0	29	141	10	9470
2012	2294	345	875	397	4240	56	608	436	260	59	41	10	146	8	9776
2013	2019	283	581	299	4210	58	162	457	245	140	1	25	207	17	8704
2014	1606	331	482	218	4183	78	36	408	102	36	14	21	125	10	7649
2015	1743	658	638	247	3530	135	169	243	196	147	55	62	101	36	7961
2016	1754	536	730	304	2338	104	371	228	229	59	7	92	142	12	6906
2017	961	90	531	232	2798	189	51	338	276	41	4	24	138	43	5715
2018	947	246	603	164	2685	186	247	224	260	33	79	46	51	48	5819

Table 1.4. The North-east arctic COD stock's consumption of various prey species in 1984-2018 (1000 tonnes) (Dolgov, WD 23)

Year	Other	Amphipods	Krill	Shrimp	Capelin	Herring	Polar cod	Cod	Haddock	Redfish	G. halibut	Blue whitin	Long rough dab		Total
1984	560	31	94	353	593	34	18	14	50	196	0	5	52		2000
1985	766	440	31	210	1039	26	0	89	35	100	0	18	22		2775
1986	615	948	66	159	855	51	169	26	99	166	1	3	26		3183
1987	541	592	79	233	175	9	117	23	2	120	1	10	5		1906
1988	545	196	239	146	348	21	0	21	77	133	0	0	22		1746
1989	497	324	191	117	768	4	37	35	2	178	0	0	64		2217
1990	278	31	105	266	1264	65	8	24	15	237	0	39	79		2410
1991	289	81	55	277	3205	26	45	52	22	142	5	6	46		4249
1992	787	38	211	257	2018	335	196	82	37	117	1	0	42		4119
1993	562	173	184	220	2739	170	170	144	148	40	5	4	47		4605
1994	447	296	358	458	1275	102	485	383	72	55	0	1	40		3972
1995	502	455	396	533	670	193	191	541	130	110	3	0	52		3775
1996	673	346	957	195	470	74	74	451	57	67	0	9	45		3416
1997	463	134	509	257	511	51	112	383	35	29	2	16	17		2518
1998	311	219	644	285	913	73	134	131	23	15	0	24	20		2791
1999	179	81	458	267	1536	80	176	49	16	14	0	27	9		2891
2000	242	122	437	393	1798	53	167	59	32	4	0	28	21		3356
2001	383	75	410	322	1521	93	147	62	52	4	2	145	31		3247
2002	225	45	286	201	2399	55	301	100	80	4	0	110	17		3823
2003	400	171	547	227	1219	153	221	132	331	2	0	28	52		3480
2004	496	393	477	256	1097	129	369	86	144	7	16	48	62		3579
2005	619	163	687	244	1022	168	320	113	271	7	2	67	47		3729
2006	785	86	1544	274	1340	268	125	96	286	17	1	103	149		5071
2007	829	192	1334	419	1875	275	289	68	330	29	1	32	73		5746
2008	1017	51	999	343	3264	122	662	157	333	60	13	17	122		7160
2009	1045	189	937	283	3349	229	827	142	348	28	0	8	285		7670
2010	973	329	1839	255	4116	143	513	181	248	163	1	16	137		8914
2011	1254	202	830	226	4469	85	423	260	362	143	2	58	172		8484
2012	1771	164	599	272	2984	97	440	291	419	41	7	33	134		7252
2013	1364	209	642	332	3652	45	146	450	277	178	2	39	218		7554
2014	1383	119	736	206	3297	55	96	390	171	20	7	27	156		6663
2015	1110	294	1135	426	2622	68	157	175	180	86	14	38	118		6421
2016	1508	643	750	205	2144	83	235	239	155	46	3	49	332		6393
2017	1000	81	649	297	2587	92	70	264	305	186	3	24	249		5807
2018	1153	149	1578	184	1614	271	114	353	484	43	43	38	121		6144
Sum	**25571**	**8062**	**20989**	**9595**	**64746**	**3793**	**7553**	**6063**	**5625**	**2786**	**135**	**1067**	**3079**		**159063**

Table 1.5. Consumption per cod by cod age group (kg/year), based on Norwegian consumption calculations.

Year/Age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.247	0.814	1.685	2.521	3.951	5.208	8.009	8.524	9.181	9.912	9.985
1985	0.304	0.761	1.831	3.107	4.675	7.361	11.247	11.971	12.498	13.751	13.865
1986	0.161	0.488	1.348	3.163	5.617	6.834	11.030	11.943	12.749	13.513	13.745
1987	0.219	0.601	1.275	2.055	3.537	5.462	7.044	8.111	8.922	9.344	9.295
1988	0.164	0.703	1.149	2.148	3.744	5.877	10.100	11.222	12.575	13.127	13.351
1989	0.223	0.716	1.609	2.713	3.981	5.612	7.680	8.499	9.599	10.199	10.643
1990	0.363	0.906	1.904	3.038	4.166	5.331	6.262	6.679	6.711	7.053	7.753
1991	0.293	0.972	2.178	3.536	5.318	7.073	9.470	10.238	11.292	12.339	11.983
1992	0.215	0.665	2.100	3.135	4.142	5.093	7.868	9.023	9.402	10.124	10.169
1993	0.112	0.528	1.547	3.045	4.811	6.288	9.422	11.268	11.793	12.284	12.909
1994	0.130	0.408	0.922	2.521	3.508	4.528	6.404	8.889	9.723	10.030	10.229
1995	0.103	0.296	0.921	1.841	3.362	5.263	7.718	10.435	12.383	12.787	13.235
1996	0.108	0.356	0.929	1.847	3.070	4.434	7.412	11.206	14.918	15.097	15.492
1997	0.140	0.319	0.940	1.768	2.710	3.537	5.257	8.185	12.672	13.578	13.182
1998	0.117	0.398	0.984	1.942	2.924	4.188	5.748	8.071	11.471	11.990	12.045
1999	0.163	0.505	1.093	2.718	3.719	5.446	6.968	9.185	11.019	12.023	12.125
2000	0.170	0.499	1.243	2.461	4.253	5.654	7.967	9.401	12.634	13.416	13.458
2001	0.171	0.456	1.309	2.440	3.684	5.300	7.541	11.221	13.604	14.310	14.641
2002	0.199	0.551	1.167	2.441	3.381	4.721	6.363	9.064	10.350	11.681	11.082
2003	0.207	0.653	1.313	2.390	3.999	5.958	8.433	10.430	12.907	13.523	14.549
2004	0.222	0.478	1.307	2.297	3.361	5.581	7.442	11.470	17.415	19.399	18.835
2005	0.203	0.661	1.387	2.744	4.255	6.414	7.677	10.289	13.935	14.916	15.709
2006	0.204	0.628	1.593	2.810	4.252	6.365	7.877	11.631	14.102	15.126	16.041
2007	0.256	0.653	1.748	3.087	4.461	6.222	8.246	10.249	12.705	13.296	13.933
2008	0.204	0.717	1.464	2.876	4.081	7.086	8.398	11.388	15.565	16.104	16.330
2009	0.192	0.618	1.479	2.755	4.446	5.798	8.432	11.562	12.719	13.671	13.711
2010	0.203	0.634	1.352	2.493	3.977	5.694	8.447	12.040	15.385	16.043	16.460
2011	0.219	0.653	1.421	2.594	4.003	5.331	7.230	9.659	15.165	16.320	16.332
2012	0.231	0.768	1.499	2.697	4.084	5.074	7.309	10.047	15.397	16.580	16.567
2013	0.182	0.682	1.457	2.539	3.926	5.019	5.960	7.564	11.498	12.422	13.451
2014	0.224	0.649	1.318	2.565	3.767	4.286	5.815	7.991	10.694	11.509	12.006
2015	0.218	0.674	1.424	2.546	4.262	5.693	7.405	8.575	13.071	13.851	15.093
2016	0.252	0.726	1.576	2.792	3.955	5.546	7.335	8.108	11.939	12.708	14.582
2017	0.237	0.755	1.445	2.541	3.764	5.380	6.636	7.582	10.684	12.596	16.259
2018	0.194	0.796	1.586	2.859	4.447	5.228	6.827	10.607	12.886	17.087	16.143
Average	**0.201**	**0.620**	**1.414**	**2.601**	**3.988**	**5.540**	**7.685**	**9.781**	**12.273**	**13.192**	**13.577**

Table 1.6		**Consumption per cod by cod age group (kg/year), based on Russian consumption calculations.**											
Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1984	0.262	0.895	1.611	2.748	3.848	5.486	6.992	8.561	10.572	13.166	13.200	15.547	17.153
1985	0.295	0.753	1.658	2.681	4.264	6.599	8.241	9.745	10.974	14.448	17.327	17.391	19.186
1986	0.179	0.526	1.455	3.455	5.001	5.991	6.458	8.157	9.766	11.457	13.188	14.621	16.134
1987	0.145	0.432	0.852	1.558	3.073	4.380	7.357	9.667	12.705	14.481	15.899	16.616	18.318
1988	0.183	0.704	1.075	1.628	2.391	4.386	8.207	9.978	10.868	16.536	14.639	16.046	17.000
1989	0.282	0.909	1.465	2.207	3.243	4.798	6.578	8.725	11.134	15.798	16.313	18.436	18.041
1990	0.288	1.006	1.694	2.693	3.278	3.833	5.583	6.870	10.715	11.426	13.555	15.964	17.595
1991	0.241	0.936	2.670	4.472	6.037	7.844	9.590	11.543	14.969	19.292	18.590	21.720	23.960
1992	0.178	0.969	2.475	2.866	3.995	5.137	6.723	7.414	8.755	12.303	14.288	15.184	16.745
1993	0.133	0.476	1.512	2.865	3.944	5.108	7.372	8.945	10.343	11.600	14.835	16.536	18.249
1994	0.180	0.512	1.212	2.402	3.517	5.359	7.560	10.001	11.818	12.896	14.499	17.656	19.469
1995	0.194	0.497	0.962	1.801	3.204	4.847	7.332	9.688	13.835	15.247	16.899	19.273	21.254
1996	0.170	0.498	1.028	1.916	3.059	4.189	6.987	10.212	12.185	13.614	14.529	16.275	17.945
1997	0.119	0.341	0.992	1.908	2.668	3.503	4.954	7.980	12.174	16.762	16.710	18.410	20.308
1998	0.232	0.528	1.081	2.016	2.823	4.089	5.469	7.346	9.586	13.012	14.404	15.640	17.243
1999	0.261	0.431	1.128	2.490	3.676	5.222	6.398	8.220	9.194	13.364	15.268	16.990	18.727
2000	0.186	0.545	1.288	2.551	4.387	6.559	8.833	10.483	11.522	15.132	17.090	19.793	21.822
2001	0.150	0.413	1.163	2.110	3.430	5.571	6.835	10.233	12.457	15.130	17.341	19.307	21.345
2002	0.252	0.677	1.303	2.699	3.847	5.591	7.846	10.796	13.238	18.787	17.836	20.278	22.359
2003	0.228	0.618	1.296	2.028	3.547	4.716	6.684	8.905	13.418	14.492	19.480	19.309	21.292
2004	0.250	0.654	1.412	2.567	3.857	5.660	7.730	11.126	15.907	20.770	21.607	24.940	27.503
2005	0.255	0.687	1.514	2.504	3.896	5.264	7.192	9.395	13.163	15.981	20.628	21.448	23.639
2006	0.354	0.925	1.881	2.813	4.019	5.332	7.450	10.328	13.111	17.759	19.488	22.322	24.609
2007	0.234	0.681	1.874	3.128	4.459	5.893	7.563	9.178	12.032	15.919	19.961	21.644	23.863
2008	0.223	0.719	1.697	2.959	4.194	6.073	7.809	10.464	13.627	17.254	21.590	23.373	25.779
2009	0.217	0.624	1.495	2.526	4.304	5.623	7.855	11.490	13.341	15.988	18.770	21.866	24.111
2010	0.235	0.651	1.401	2.577	4.065	5.757	8.312	11.805	16.090	16.844	20.129	23.023	25.387
2011	0.248	0.721	1.497	2.513	3.859	4.963	6.848	9.213	13.799	19.074	20.784	23.791	26.241
2012	0.207	0.588	1.203	2.292	3.266	4.461	5.862	7.629	11.713	16.211	19.345	21.032	23.190
2013	0.190	0.656	1.641	2.552	3.809	4.952	5.791	7.757	10.881	14.989	19.785	22.386	24.691
2014	0.242	0.622	1.321	2.340	3.608	4.387	5.560	7.447	9.017	12.547	16.044	18.854	20.781
2015	0.234	0.745	1.390	2.406	3.915	4.922	5.960	7.505	10.265	12.116	16.245	19.978	22.023
2016	0.307	0.870	1.722	2.813	3.474	4.740	6.754	9.117	10.665	14.810	19.921	24.195	26.683
2017	0.244	0.779	1.582	2.531	3.748	4.943	6.601	9.180	11.302	16.016	20.086	23.464	25.870
2018	0.316	0.867	1.846	2.699	3.736	5.000	6.489	9.170	11.166	14.577	18.672	21.848	24.091
Average	**0.226**	**0.670**	**1.468**	**2.523**	**3.755**	**5.177**	**7.022**	**9.265**	**11.894**	**15.137**	**17.398**	**19.576**	**21.503**

Table 1.7 Proportion of cod in cod diet, based on Norwegian consumption calculations

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0000	0.0000	0.0032	0.0000	0.0436	0.0263	0.0327	0.0358	0.0365	0.0388	0.0372
1985	0.0015	0.0009	0.0014	0.0017	0.0312	0.0076	0.0822	0.0828	0.0837	0.0841	0.0847
1986	0.0000	0.0022	0.0015	0.0004	0.0129	0.1755	0.1761	0.1760	0.1756	0.1751	0.1744
1987	0.0000	0.0000	0.0007	0.0051	0.0102	0.0250	0.0377	0.0400	0.0418	0.0405	0.0440
1988	0.0000	0.0000	0.0000	0.0002	0.0059	0.0014	0.0038	0.0036	0.0032	0.0038	0.0036
1989	0.0000	0.0006	0.0016	0.0019	0.0027	0.0040	0.0035	0.0035	0.0039	0.0038	0.0041
1990	0.0000	0.0000	0.0000	0.0007	0.0010	0.0010	0.0170	0.0175	0.0188	0.0187	0.0181
1991	0.0000	0.0005	0.0000	0.0003	0.0032	0.0020	0.0222	0.0230	0.0233	0.0236	0.0239
1992	0.0000	0.0021	0.0037	0.0128	0.0250	0.0476	0.0119	0.0158	0.0231	0.0231	0.0229
1993	0.0000	0.0409	0.0364	0.0515	0.0534	0.1156	0.0498	0.0799	0.0799	0.0799	0.0802
1994	0.0000	0.0037	0.0884	0.0344	0.0284	0.0776	0.1246	0.1333	0.2603	0.2620	0.2592
1995	0.0069	0.0813	0.0741	0.0800	0.0923	0.1121	0.1385	0.2525	0.2543	0.2550	0.2571
1996	0.0000	0.1502	0.2504	0.2070	0.1323	0.1265	0.1842	0.2071	0.2426	0.2436	0.2431
1997	0.0000	0.0690	0.0779	0.1142	0.1551	0.1554	0.2327	0.2257	0.2862	0.2796	0.2813
1998	0.0000	0.0135	0.0271	0.0417	0.1042	0.0985	0.1081	0.1490	0.2725	0.2734	0.2745
1999	0.0000	0.0000	0.0050	0.0137	0.0148	0.0338	0.0620	0.1117	0.1934	0.1937	0.1838
2000	0.0000	0.0000	0.0283	0.0147	0.0134	0.0266	0.0498	0.0564	0.2725	0.2694	0.2706
2001	0.0000	0.0159	0.0116	0.0082	0.0131	0.0240	0.0493	0.0383	0.3279	0.3286	0.3303
2002	0.0000	0.0385	0.0594	0.0143	0.0187	0.0284	0.0357	0.0622	0.1581	0.1557	0.1548
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.0081	0.0235	0.0280	0.0269	0.0297	0.0319	0.0380	0.0661	0.1064	0.1067	0.1071
2005	0.0000	0.0266	0.0230	0.0265	0.0144	0.0276	0.0439	0.0786	0.1482	0.1464	0.1463
2006	0.0000	0.0103	0.0007	0.0128	0.0288	0.0158	0.0390	0.0368	0.0807	0.0818	0.0804
2007	0.0000	0.0000	0.0011	0.0117	0.0119	0.0306	0.0282	0.0901	0.1412	0.1414	0.1396
2008	0.0000	0.0558	0.0256	0.0101	0.0157	0.0098	0.0766	0.0873	0.0966	0.0952	0.0958
2009	0.0116	0.0225	0.0262	0.0251	0.0152	0.0140	0.0219	0.0947	0.1082	0.1084	0.1080
2010	0.0000	0.0327	0.0580	0.0270	0.0243	0.0243	0.0205	0.0386	0.1370	0.1373	0.1354
2011	0.0129	0.0152	0.0493	0.0170	0.0361	0.0300	0.0238	0.0571	0.1281	0.1281	0.1280
2012	0.0274	0.0608	0.0639	0.0618	0.0274	0.0431	0.0412	0.0373	0.0685	0.0691	0.0684
2013	0.0214	0.0303	0.0458	0.0388	0.0276	0.0225	0.0478	0.0539	0.1174	0.1185	0.1347
2014	0.0824	0.0363	0.0447	0.0341	0.0213	0.0457	0.0662	0.0789	0.0660	0.0664	0.0755
2015	0.0000	0.0088	0.0308	0.0283	0.0266	0.0192	0.0233	0.0283	0.0556	0.0562	0.0559
2016	0.0157	0.0192	0.0063	0.0393	0.0145	0.0172	0.0267	0.0138	0.0906	0.0924	0.0936
2017	0.0464	0.0394	0.0373	0.0500	0.0414	0.0416	0.0613	0.1102	0.0825	0.1403	0.1444
2018	0.0000	0.0185	0.0679	0.0480	0.0351	0.0378	0.0562	0.0308	0.0246	0.0076	0.0254
Average	**0.0067**	**0.0234**	**0.0337**	**0.0303**	**0.0323**	**0.0429**	**0.0582**	**0.0748**	**0.1203**	**0.1214**	**0.1225**

Table 1.8 Proportion of haddock in cod diet, based on Norwegian consumption calculations

Year/age	1	2	3	4	5	6	7	8	9	10	11+
1984	0.0443	0.0175	0.0053	0.0225	0.0457	0.0214	0.0022	0.0020	0.0019	0.0018	0.0019
1985	0.0205	0.0227	0.0052	0.0076	0.0207	0.0111	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0188	0.0015	0.0860	0.0005	0.0534	0.0246	0.0251	0.0264	0.0281	0.0302
1987	0.0000	0.0052	0.0003	0.0025	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0003	0.0033	0.0033	0.0035	0.0038	0.0032	0.0035
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0337	0.0336	0.0352	0.0348	0.0360
1990	0.0000	0.0000	0.0000	0.0024	0.0021	0.0007	0.0125	0.0121	0.0111	0.0112	0.0116
1991	0.0000	0.0000	0.0098	0.0079	0.0045	0.0051	0.0031	0.0029	0.0028	0.0026	0.0025
1992	0.0000	0.0000	0.0014	0.0681	0.0206	0.0272	0.0278	0.0316	0.0460	0.0460	0.0455
1993	0.0000	0.0000	0.0204	0.0073	0.0148	0.0143	0.0281	0.0262	0.0262	0.0262	0.0263
1994	0.0000	0.0000	0.0064	0.0133	0.0069	0.0142	0.0305	0.0499	0.0473	0.0468	0.0476
1995	0.0000	0.0355	0.0034	0.0438	0.0260	0.0239	0.0387	0.0954	0.1618	0.1623	0.1636
1996	0.0000	0.0000	0.0655	0.0150	0.0098	0.0168	0.0359	0.0473	0.0891	0.0977	0.0959
1997	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	0.0000	0.0000	0.0112	0.0116	0.0227	0.0192	0.0107	0.0324	0.0162	0.0164	0.0166
1999	0.0000	0.0000	0.0029	0.0078	0.0157	0.0124	0.0120	0.0139	0.0228	0.0229	0.0216
2000	0.0000	0.0000	0.0230	0.0102	0.0178	0.0116	0.0158	0.0517	0.0285	0.0285	0.0285
2001	0.0000	0.0081	0.0052	0.0163	0.0148	0.0172	0.0194	0.0199	0.0349	0.0352	0.0359
2002	0.0000	0.0000	0.0185	0.0339	0.0353	0.0470	0.0746	0.0761	0.1827	0.1788	0.1774
2003	0.0000	0.0000	0.0145	0.0311	0.0594	0.0436	0.0552	0.1215	0.1078	0.1077	0.1077
2004	0.0044	0.0419	0.0745	0.0389	0.0577	0.0501	0.0564	0.0997	0.0912	0.0915	0.0919
2005	0.0000	0.0853	0.1047	0.0596	0.0622	0.0647	0.1046	0.1088	0.1114	0.1102	0.1101
2006	0.0000	0.0409	0.0829	0.0871	0.0605	0.0900	0.0718	0.1064	0.0964	0.0959	0.0965
2007	0.0000	0.0035	0.0463	0.0417	0.0833	0.0984	0.1334	0.1151	0.1627	0.1626	0.1639
2008	0.0000	0.0045	0.0106	0.0156	0.0383	0.0753	0.1149	0.1328	0.2339	0.2355	0.2348
2009	0.0000	0.0218	0.0241	0.0182	0.0142	0.0363	0.1088	0.0597	0.1865	0.1860	0.1876
2010	0.0000	0.0031	0.0279	0.0181	0.0178	0.0217	0.0359	0.1426	0.1819	0.1805	0.1810
2011	0.0000	0.0049	0.0362	0.0284	0.0087	0.0205	0.0408	0.0917	0.1645	0.1647	0.1639
2012	0.0000	0.0000	0.0113	0.0282	0.0338	0.0273	0.0368	0.0335	0.0860	0.0847	0.0866
2013	0.0000	0.0074	0.0309	0.0112	0.0314	0.0234	0.0147	0.0363	0.0615	0.0615	0.0893
2014	0.0000	0.0090	0.0038	0.0255	0.0080	0.0047	0.0022	0.0339	0.0142	0.0140	0.0183
2015	0.0000	0.0175	0.0406	0.0253	0.0171	0.0166	0.0258	0.0197	0.0383	0.0381	0.0389
2016	0.0000	0.0051	0.0797	0.0769	0.0264	0.0259	0.0324	0.0420	0.0342	0.0345	0.0343
2017	0.0000	0.0450	0.0166	0.0447	0.0475	0.0594	0.0503	0.0635	0.0855	0.0809	0.0894
2018	0.0000	0.0000	0.0434	0.0365	0.0591	0.0661	0.0557	0.0592	0.0823	0.0300	0.1117
Average	**0.0020**	**0.0114**	**0.0237**	**0.0269**	**0.0252**	**0.0292**	**0.0375**	**0.0511**	**0.0707**	**0.0692**	**0.0729**

Table 1.9a. Overview of available prognoses of NEA cod recruitment (in million individuals of age 3) from different models (Section 1.4.2).

Model	Prognostic years (counting this year's assessment as first year	Updated	2019 Prognoses	2020 Prognoses	2021 Prognoses	2022 prognoses
TitovES	2	At assessment	598	504		
TitovEL	4	At assessment	543	460	570	585
RCT3	3	At assessment	977	742	728	
Hybrid model (Assessment 2019) *		At assessment	667 (660)	537 (524)	644 (644)	585 (582)

* The results corresponding SPALY run are presented in brackets

Table 1.9b. Related weights to the models used in the hybrid model

Model	Model weight 2019	Model weight 2020	Model weight 2021
TitovES	0.54	0.59	
TitovEL	0.25	0.23	0.53
RCT3	0.22	0.18	0.47

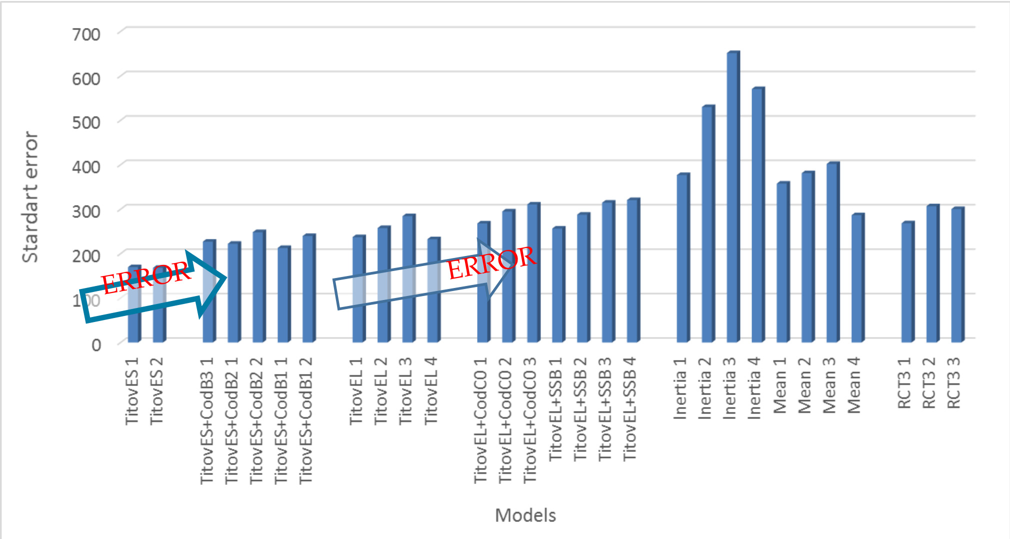

Figure 1.1. Standard errors of the NEA cod recruitment predicted values from the SAM values.

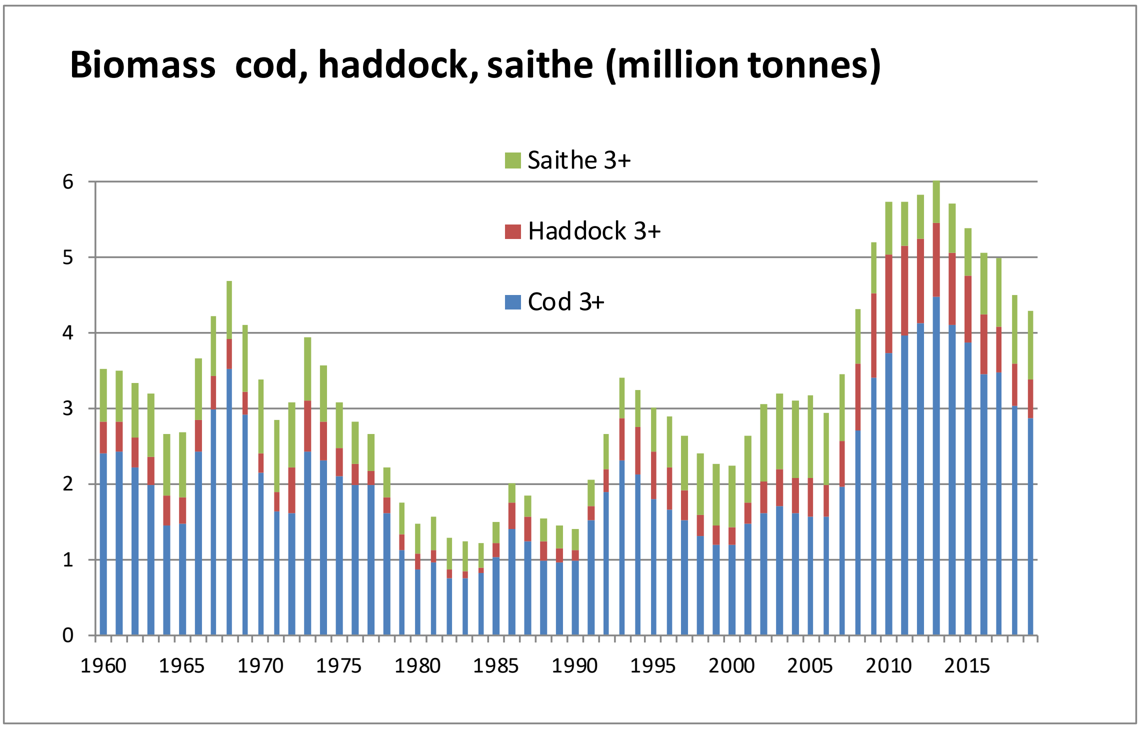

Figure 1.2. Biomass of northeast Arctic cod, haddock and saithe, from 2019 AFWG assessment.

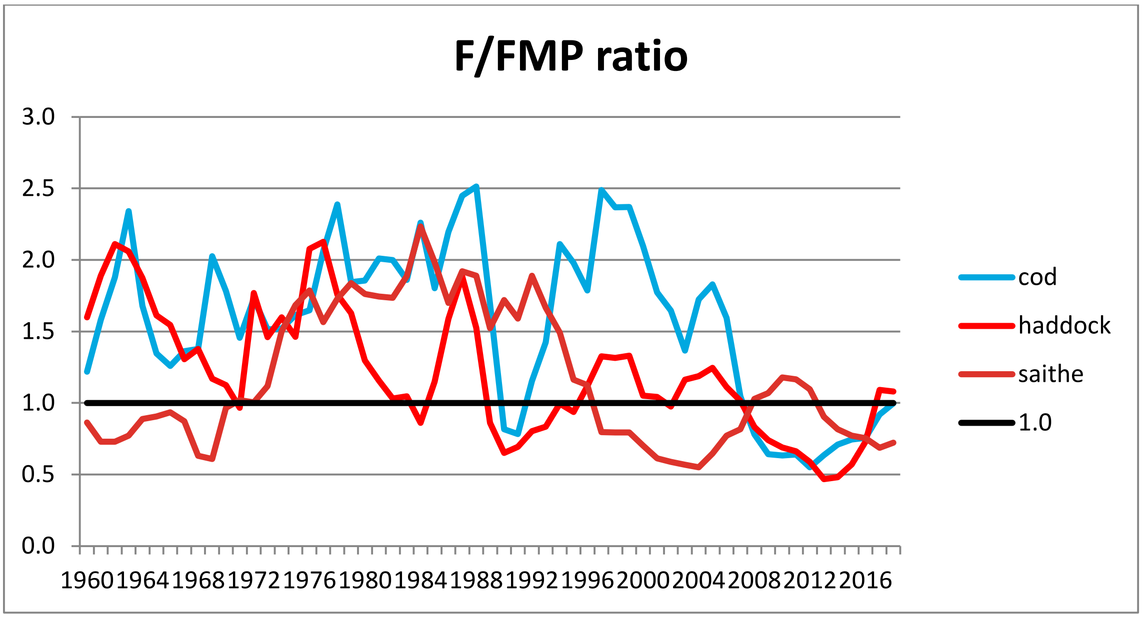

Figure 1.3. Annual fishing mortalities of the northeast Arctic cod, haddock and saithe stocks relative to F_{MP}, i.e. the level used in the management plans for these stocks when SSB > B_{pa}. For cod F_{MP} is not well-defined, as there is a two-step HCR. In this figure, the lower plateau (F = 0.40) is used in calculating the ratio. Harvest control rules were introduced for cod and haddock in 2004 onwards and for saithe in 2007.

2 Cod in subareas 1 and 2 (Norwegian coastal waters) AFWG 2019

Spaly assessment procedure, new catch-at-age time-series
Need for benchmark

The stock was a part of the WKARCT benchmark meeting in January 2015 (ICES 2015/ACOM: 31). There is high uncertainty in the estimation of commercial catch, and useful information about recreational fishing and tourist fishing is largely lacking. A new time-series for commercial catch numbers-at-age with uncertainty estimates was presented to the benchmark by using the ECA-model (Hirst *et al.*, 2012). The corresponding catches in tonnes are presented in Table 2.1a. The benchmark meeting accepted the new catch estimates, but noticed that the differences compared to the old method should be further explored. Work after the benchmark has revealed some years with problematic sampling data in some areas (see section 2.2.1). This has now been partly resolved, and results with the new catch-at-age series are presented and compared to the results from the old series for the years 1984–2018 (section 2.2.1, Figures 2.5b and 2.5.c.)

There is a need for a new Benchmark to be set up (preferably in 2021) to deal with:

- Consider a split of the assessment area in two or three regions. There are genetic analysis indicating reasons for splitting the stock in two or more units (Dahle *et al.*, 2018), and more studies are ongoing. Both survey data and catch sampling data have better quality north of 67 than south of 67. About 80% of the annual catches of coastal cod are taken north of 67;
- A new fyke net/gillnet-survey series in shallow areas has been initiated south of 67, alternating one year between 67 and 65°N (2013, 2016, and 2018), and next year between 65 and 62°N (2015,2017,2019).
- Ongoing work aims at using the software StoX (Johnsen *et al.*, 2016) for producing a swept-area time-series based on bottom-trawl hauls in the coastal survey (NOcoast-Aco-4Q), as well as re-estimating the acoustic time-series by use of StoX, and an improved strata system;
- Evaluate new information from the recreational fishery;
- Choice of assessment model.

2.1 Stock status summary

Both the coastal acoustic survey in autumn (Figure 2.14) and the current assessment (Figure 2.17) show a considerable decline in SSB in the late 1990s. The current assessment indicates some increased SSB in the years 2001–2016 and a decline in 2017 and 2018. The highest recruitments occurred in the two first years of the time-series (1984, 1985). Since then there seem to be a long-term declining trend in recruitment. Fishing mortality was very high at the beginning of the time-series (1984–1989) and rather high during 1997–1999. F shows a declining trend over the period 1998–2015, then higher again in the latest three years. The Fs in 2016–2018 are above the target in the rebuilding plan. The abundance indices from the coastal surveys in autumn 2013 and 2014 showed some increase compared to previous years. Later surveys have showed rather low indices, like those in the 2002–2012 period.

2.2 Fisheries

Coastal cod is fished throughout the year and within nearly all the distribution area in the Norwegian statistical areas 03, 04, 05, 00, 06, 07, Figures 2.1–2.3). Most of the coastal cod catches are taken as a bycatch during fisheries aimed at NEA cod during its spawning migration or feeding migration to coastal waters. The main fishery for coastal cod, therefore, takes place in the first half of the year. The main fishing areas are along the coast from Varangerfjord to Lofoten (areas 03, 04, 05, 00).

Except for the open fjords in eastern Finnmark, the quantities fished inside fjords are quite low. In the period 2011–2015 the average % share between gear types in the estimated coastal cod commercial landings was around 46% for gillnet, 26% for Danish seine, 26% for longline/handline and 2% for bottom trawl. In 2017, there was some increase for Danish seine (35%) and longline (25%), and a decrease for gillnet (38%). Table 2.1b. shows catches in 2018 by gear groups for coastal cod plus NEA cod in statistical areas 00, 03, 04, 05, and 06+07, and table 2.1c show the ECA-estimated catches of coastal cod for gillnet, trawl and others.

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. There is no reporting system for coastal cod (NCC) taken by recreational or tourist fishers in Norway. However, there are a few reports trying to assess the amount in certain years. In 2010, these reports were used to construct a time-series (ICES CM 2010/ACOM:05) of recreational catches. These catch estimates are rather uncertain. No additional information has been included in later years, and the annual recreational catch since 2010 has been assumed equal to the one estimated for 2009 (12 700 t). For those years, the total catch numbers-at-age (Table 2.1c) have been upscaled from the estimated catch-at-age in the commercial landings, according to the added amount in tonnes. There are some ongoing research projects on recreational fishing. There is a need for synthesising the results from those.

2.2.1 Sampling fisheries and estimating catches (Tables 2.1–2.4, Figures 2.1–2.5)

Catch numbers-at-age are estimated by the ECA model. The commercial catches of Norwegian Coastal cod (NCC) have been calculated back to 1984 (Table 2.1a). For this period, the estimated annual landings have been between 27 kt and 65 kt. The commercial landings of NCC in 2018 were estimated to 36.4 kt t (Table 2.1a, Figure 2.3). Table 2.1b shows the estimated catch by gears, area and quarters in 2018. Figure 2.5e compares the ECA-estimates and the results of the "traditional calculation method".

Commercial catches of cod are separated to types of cod by the structure of the otoliths in commercial samples. Figure 2.4 illustrates the main difference between the two types: The figure and the following text is from (Berg *et al*., 2005): *Coastal cod has a smaller and more circular first translucent zone than northeast Arctic cod, and the distance between the first and the second translucent zone is larger* (Figure 2.4). *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 has been investigated by comparison of different otolith readers and results from genetic investigation of cod. The results indicate high accuracy using in the otolith method (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.

Sampling and landings

The basis for estimating coastal cod catches is the total landings of cod in the Norwegian statistical areas 03, 04, 05, 00, 06, 07 (Figures 2.1—2.2), combined with the sampling of these fisheries. Since the catches are separated to type of cod by the structure of the otoliths, the numbers of age samples are critical for the estimated catch of coastal cod. Table 2.2a shows the sampling of the cod fishery by quarters and areas in 2017, and in Tables 2.2b for 2016 and 2015. The sampling level in 2018 was somewhat improved compared to 2016 and 2017. Table 2.3 compares the numbers of fish sampled by quarters for the period 1985–2018. A total of 16 062 fish were aged. 5196 of these otoliths were classified as coastal cod. (Table 2.2a, b). This represents 40% of all cod otoliths sampled within the coastal cod area. This percentage is similar to 2016, but well above the time-series average (Table 2.3).

The Norwegian sampling program was changed in 2010. This led to poor sampling in that year. The sampling in later years has gradually improved, and the number of samples (but not the number of otoliths) is now well above the level prior to 2010. Still there are too few samples in area 05 in quarter 3 (Table 2.2a).

Table 2.4 shows the total cod catch by area and quarters within the 12 n-mile and the estimated catches of coastal cod by statistical area and quarter for the years 2017 and 2016. The corresponding fractions of coastal cod in cod catches are also shown. The total cod catch within 12 n-mile was lower in 2017 than 2016, while the coastal cod catch (and fraction costal cod) was higher in 2017.

The ECA-estimate of coastal cod in 2017 is close the traditional estimate. For the period 2003–2014 the ECA estimates were consistently above the traditional (Figure 2.5e).

2.2.2 Regulations

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

Since the coastal cod is fished under a merged coastal cod/northeast Arctic cod quota, the main objective of these regulations is to move the traditional coastal fishery from areas with high fractions of coastal cod to areas where the proportion of NEA cod is higher.

Most regulation measures for northeast Arctic cod also applies to coastal cod; minimum catch size, minimum mesh size, maximum bycatch of undersized fish, closure of areas having high densities of juveniles, and some seasonal and area restrictions.

A number of regulations contribute to some protection of coastal cod: Trawl fishing for cod is not allowed inside the 6-nautical mile line (in the years 2006–2010 about 10 fresh fish trawlers had a dispensation to fish between the 4 and 6-mile line in a few areas in the period 15 April–15 September). Since the mid-1990s the fjords in Finnmark and northern Troms (areas 03 and 04) have been closed for fishing with Danish seine. Since 2000, the large longliners have been restricted to fish outside the 4 nautical mile line.

Regulations introduced 2004–2010

To achieve a reduction in landings of coastal cod additional technical regulations in coastal areas were introduced in May 2004 (after the main fishing season) and continued with small modifications in 2005 and 2006. In those regulations "fjord-lines" were drawn along the coast to close the fjords for direct cod fishing with vessels larger than 15 metres. In 2005 also a box closed to all fishing gears except handline and fishing rod was defined in the Henningsvær-Svolvær area. This is an area where spawning concentrations of coastal cod are usually observed and where the catches of coastal cod have been high. Since the coastal cod is fished under a merged coastal cod/northeast Arctic cod quota, these regulations are aimed at moving parts of the traditional coastal fishery from the catching of coastal cod in the fjords to a cod fishery outside the fjords, where the proportion of northeast Arctic cod is higher.

The regulations for the closed spawning area near Henningsvær-Svolvær were during the 2012 spring fishery relaxed by allowing vessels less than 11 m to fish. This was continued in 2013–2017. The openings of this area were based on "real-time" genetic monitoring of catches, started in 2007 (Dahle *et al.*, 2018). The area was closed in the seasons 2005–2010, and for the first time opened late in the 2011-season, based on the monitoring showing high percentage of NEA cod (>70%). In the spawning season in 2011–2016 large concentrations of NEA cod were observed in this area, and the fraction of coastal cod in the catches was low.

Further restrictions were introduced in 2007 by not allowing pelagic gillnet fishing for cod and by reducing the allowed bycatch of cod when fishing for other species inside fjord lines from 25–5%, and outside fjord lines from 25–20%. The regulations were maintained in 2008.

Since 2009 the most important coastal cod spawning area in the southern part of the stock distribution area (Borgundfjorden near Ålesund) has been closed to fishing (except for handline and fishing rod) during the spawning season. A similar real-time monitoring was set up for monitoring the fraction of NEA cod during the spring fishery (Johansen *et al.*, 2017). No samples during the years 2009–2015 showed fractions of NEA cod above 70%, and the areas has been kept closed in all the yeas 2009–2018.

7000 t of the Norwegian cod quota has since 2010 been set aside to cover the catches taken in the recreational and tourist fisheries and catches taken by young fishers (to motivate young people to become fishers).

<u>Additional regulations in 2011</u>: No dispensations for fresh fish trawlers to fish inside 6 n-mile. In the recreational fishery, the maximum gillnet length per person was reduced from 210 m to 165 m, and the allowance for selling cod per person is reduced from 2000 kg to 1000 kg per year. Minimum landing size now also applies to recreational and tourist fishing. For cod this is set to 44 cm in the area north of 62°N. A reallocation of unfished quotas towards the end of 2011 lead to some increased fishing effort aimed at cod in coastal areas. This reallocation has contributed to the increase in coastal cod catch in 2011.

<u>Additional regulations in 2012 and later</u>: The rebuilding plan (Annex 3.4.2) was put into operation in 2011. Since the spawning biomass index in the 2011 autumn survey was higher than the 2010 value, the rebuilding plan, implied that the 2011 regulation could be unchanged in 2012. A minimum mesh size (126 mm full mesh) for gillnets in recreational fisheries was activated from 1 January 2012. This had been announced more than a year in advance to allow people to prepare for the change.

The 2012 survey index for spawning biomass was lower than the previous, and the same was the case with the 2015 survey. According to the rebuilding plan additional measures for reducing catches of coastal cod should apply both for 2013 and 2016. For 2013–2016 no regulations in addition to those in place in 2011 and 2012 have been communicated to ICES.

In 2017, the Norwegian Directorate of Fisheries has extended the Fjord Lines to give more protection for some coastal cod spawning areas. In addition, a maximum number of hooks per day is introduced for the longline fishery within Fjord Lines. It will also be a more restrictive practice for dispensations for purse-seine fishing targeting herring and mackerel inside Fjord Lines.

From 28 November 2017 vessels less than 11 m length (and less than 4.5 m width and less than 20 m^3 container volume) have been allowed catch cod with Danish seine inside the fjord lines, except for some fjords in Finnmark and Troms where local regulations applies. Special restrictions on the gear also applies. The regulation is valid until 31 December 2018. IMR and the Norwegian Directorate of Fisheries (NFD) have evaluated the effects of this new regulation. 12 vessels participated, and the estimated total catches from this fishery inside fjord lines in the period 1 November 2017-14. October 2018 was 146 t (0.4% of the total catch of coastal cod in 2018)

2.3 Survey data

A trawl-acoustic survey along the Norwegian coast from the Russian border to 62°N was started in autumn 1995. In 2003 the survey was somewhat modified by being combined with the former saithe survey at the coastal banks and the survey (ICES acronym: NOcoast-Aco-Q4) was moved from September to October–November.

2.3.1 Indices of abundance and biomass (Tables 2.5-2.13, Figures 2.6-2.12)

The results of the 2018 survey (Staby *et al.,* 2018) are presented in Tables 2.6–2.12 for the area inside the 12 n.-miles border in the Norwegian statistical areas 03, 04, 05, 00, 06, and 07 (Figures 2.1 and 2.2). The survey time-series of estimated numbers of NCC per age group is given in Table 2.6 and in Figure 2.6. The 2018 estimate of spawning biomass is around 30% higher than the 2017 estimate. The uncertainty of the survey estimates is rather large.

Figures 2.7–2.12 show the survey series of stock number within each statistical area.

2.3.2 Age reading and stock separation (Tables 2.4, 2.5, 2.8-2.12)

A total of 1887 cod otoliths were sampled during the 2016 survey. As in previous years, NCC was found throughout the survey area (Table 2.5).

It must be emphasized that the Norwegian coastal surveys are conducted in October-November, and there is usually more NEA cod in the coastal areas at other times of the year, especially during the spawning season in the late winter. This is reflected in the commercial sampling as shown in Table 2.12.

2.3.3 Weights-at-age (Table 2.8, Figure 2.13)

Table 2.8 and Figure 2.13 show the time-series of mean weights at age for the whole survey. For age 8 and older the mean weights show large variations, probably caused by few fish sampled in some years.

There are large growth differences between areas (Berg and Albert, 2003); there is a general tendency for coastal cod to have higher weights-at-age in the southernmost area. The overall mean weights-at-age are therefore influenced by the sampling level relative to the abundance in the various areas.

2.3.4 Maturity-at-age (Table 2.10, Figure 2.13b)

The fraction of mature fish in the autumn survey (Table 2.10) show rather large variation between years. Parts of this variation could be caused by the difficulty of distinguishing mature and immature cod in autumn. Based on the records of spawning zones in the otoliths a back-calculation of proportion mature at age (Gulland, 1964) was considered at the 2010 AFWG. The analysis was based on samples from the spawning fisheries in March-April. The results are shown in Figure 2.13b. This does not confirm the amount of year-to-year variation seen in the survey observation, and thereby gives some support for rather using a fixed maturation as introduced by the 2010 WG.

Since the age at maturation is higher in northern areas compared to southern areas (Berg and Albert, 2003), the back-calculation analysis should be refined by ensuring a reasonable balance in the amount of data from northern and southern areas.

2.4 Data available for the catch-at-age Assessment (XSA and SVPA)

2.4.1 Catch-at-age (Table 2.1a-e, and table 2.14)

The estimated commercial catch-at-age (2–10+) for the period 1984–2017 is given in Table 2.1a. Table 2.1c shows the total catch numbers-at-age when recreational and tourist fishing is included.

There have been conducted two investigations trying to estimate the level of discarding and misreporting from the coastal vessels in two periods (2000 and 2002–2003, WD 14 at 2002 WG). The amount of discard was calculated, and the report from the 2000-investigation concluded there was both discard and misreporting by species in 2000. In the gillnet fishery for cod this represents approximately 8–10% relative to reported catch. 1/3 of this is probably coastal cod. The last report concluded that misreporting in the Norwegian coastal gillnet fisheries have been reduced significantly since 2000.

2.4.2 Weights-at-age (Tables 2.8 and 2.13)

Weight-at-age in catches is derived from the commercial sampling and is shown in Table 2.13. The same weight-at-age is assumed for the recreational and tourist catches.

The weight-at-age in the stock is obtained from the Norwegian coastal survey (Table 2.8). The survey is covering the distribution area of the stock. Weight-at-age from the survey is therefore assumed to be a relevant measure of the weight-at-age in the stock at survey time (October). These weights (Table 2.13) will, however, overestimate the stock biomass at the start of the year.

2.4.3 Natural mortality

A fixed natural mortality of 0.2 has been assumed in the assessment. However, in the Barents Sea 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 been observed to consume postlarvae and 0-group cod during summer/autumn (Aas, 2007).

2.4.4 Maturity-at-age (Tables 2.10, 2.13, Figure 2.13)

The average maturity-at-age observed over the survey period 1995–2009 has been used in the assessment (Table 2.13), since there are uncertainties related to the annual variations seen in the survey observations of maturity (Figure 2.13b). The analyses based on back-calculation of spawning zones (Figure 2.13b) are relevant, but still preliminary.

2.5 Methods used for assessing trends in stock size and mortality (Table 2.13-2.18, Figure 2.16-2.18)

Earlier attempts to assess the stock using XSA analysis have shown retrospective problems. For several years the main basis for assessing the stock was the survey time-series (plotted in Figures 2.6–2.13), and SURBA was used for further analysing the survey trends.

In the 2010 WG mortality signals from the survey and from the catch-at-age data were analysed and an SVPA ("user-defined VPA" in the Lowestoft VPA95-menu) were run using the survey based estimate of F_{2009} (details described in Annex 10 in ICES CM 2010/ACOM:05) as terminal F. The same procedure was used this year: By using the survey indices for ages 2 to 8 (Table 2.6) a trial XSA (Tables 2.13–2.15) was run to obtain historic values of $F_{(4–7)}$. Calculated survey mortalities (Table 2.16 and Figure 2.15) were regressed with XSA F_s for the years 1996–2007 (Figure 2.15). This regression was used for converting the 2017 survey mortality to a VPA $F_{(4–7)}$ (Table 2.16). A selection pattern for 2018 was estimated as the average pattern over the years 2015–2017 in the trial XSA, and Fs on oldest true age was taken from the trial XSA. The SVPA, which is considered as the final assessment, was run by using the survey based $F_{(4–7)}$ for 2018 combined with the selection pattern and oldest true F_s described above. The same procedure was repeated for catch-at-age data including estimates of recreational catches, but the trial XSA for that dataset is not shown here.

The results are shown in Tables 2.17–2.18 and in Figures 2.16–2.18.

2.6 Results of the Assessment

2.6.1 Comparing trends with last year's assessment (Table 2.6, 2.15—2.18, Figures 2.6, 2.13–2.14, 2.16–2.18)

The 2018 survey estimate of spawning biomass (18.4 kt) is above the 2017 Tables 2.9 and 2.11, Figure 2.17).

The survey based estimate of the F_{2018} is 0.27 when relating to commercial catch and 0.23 when relating to total catch data. The text table below compares those with corresponding values earlier years (see also Figure 2.16). The table also compares the SSB-results of SVPA-runs aimed at those F_s used as terminal F_s. The high catches in 2015–2017 (containing reasonable amounts of old fish) has in the current assessment caused some upward stock revision for several years back in time. Corresponding downward revisions of F is observed. The "F on oldest true age" in the SVPA is derived from a trial XSA with a 20 year tuning window with time taper. The effect of the high survey estimates at the beginning of the time-series has thereby been reduced in the later assessments compared to the earlier. This has further contributed to upward revisions of SSB, and downward revisions of F seen in the text table below (also visible in Figure 2.17 for the years 2015–2017). **Note that the results of the 2019 assessment are based on a revised catch number-at-age series.**

Ass Yr	F 09	F 10	F 11	F 12	F 13	F 14	F 15	F 16	F 17	F 18
2010	0.37									
2011	0.38	0.38								
2012	0.28	0.26	0.33							
2013	0.29	0.23	0.33	0.37						
2014	0.31	0.26	0.34	0.36	0.27					
2015	0.31	0.27	0.36	0.37	0.29	0.27				
2016	0.29	0.25	0.32	0.29	0.21	0.19	0.35			
2017	0.28	0.24	0.30	0.26	0.18	0.15	0.25	0.30		
2018	0.26	0.22	0.28	0.23	0.16	0.14	0.22	0.25	0.35	
2019	0.22	0.30	0.27	0.19	0.15	0..16	0.17	0.26	0.31	0.27

Ass Yr	SSB 09	SSB 10	SSB 11	SSB 12	SSB 13	SSB 14	SSB 15	SSB 16	SSB 17	SSB 18
2010	46									
2011	50	44								
2012	59	58	70							
2013	60	60	68	66						
2014	59	58	64	59	51					
2015	59	57	63	57	47	49				
2016	63	62	69	67	61	70	75			
2017	66	65	73	73	70	84	99	100		
2018	75	74	83	82	78	95	114	114	109	
2019	88	101	97	101	100	133	129	135	113	95

The recruitment estimate for the final year is highly uncertain in all assessments (Figures 2.16). Figure 2.17 shows the SSB-series from VPA and survey, both scaled to their average over the years 1995–2017. Figure 2.18 compares the various time-series of F. The SVPA is fixed at the survey-derived F for the terminal year, but for most of the years 2001–2016 the SVPA give lower F than the one derived from the survey. For the SVPA based on commercial catch this happened in 13 of those 16 years, and for the SVPA based on total catch this was the case in 11 of the 16 years. This pattern seems to indicate some conflicts between the annual catch-at-age and the annual numbers-at-age in the survey-

2.6.2 Recruitment (Table 2.6, Figure 2.16)

The younger ages are poorly represented both in the survey and in the catch data. The VPA-estimates of recruits in latest data year, therefore, show large retrospective revisions (Figure 2.16). The survey estimate for age 2 is somewhat higher in the three recent years compared to the period 2002–2013. It is worth to notice that the recruitment started to decline a few years before the spawning stock, indicating that the recruitment failure is an important cause for the stock decline in the late 1990s.

2.6.3 Catches in 2019

No catch prediction for 2019 have been made.

2.7 Comments to the Assessment

Uncertain estimates of catch-at-age and limited information about the recreational fishery and the tourist fishery leads to high uncertainty in the catch-at-age based analysis. The series with recreational and tourist fisheries included may be said to scale the stock size to a more realistic level, but at the same time brings in additional uncertainty.

The acoustic survey has a rather large uncertainty. This is because cod contributes to a low fraction of the total observed acoustic values. The cod estimate is thus vulnerable to allocation error. The Norwegian coastal survey is the only survey covering the main distribution area of the stock.

The survey is conducted in the period October/November. In this period, the maturity stage can be variable and difficult to define, and a survey index of SSB based on the long-term mean (currently 1995–2009) maturity-at-age is considered to reduce some annual variation caused by staging uncertainty.

2.8 Reference points

No biological reference points are established.

2.9 Management considerations

Estimated catches were rather stable in the period 2004–2014, while they were considerably higher in the years 2015–2017. For most years in the period 2004–2014 the regulations seem to have reduced the catches and fishing mortality compared to pre-2004 level, but have not been sufficient to cause persistent further reductions. Since 2013 the quotas for NEA cod has been very high. This has likely contributed to increased catches of coastal cod. In 2015, 2016 and 2017 catches of coastal cod were exceptionally high in January in southern Troms and northern Nordland (Figure 1.16), where coastal cod where feeding on aggregations of herring. This fishery occurred before the NEA cod spawning migration reached those areas. Such concentrations of coastal cod were in 2015 rather unexpected, and illustrates a need for considering flexible regulations that on short notice may move fisheries from coastal cod to Northeast arctic cod.

The time-series of estimated recreational catch presumes rather stable catches, and they represent thereby a higher fraction (about 35%) during the period 2004–2014 when the commercial catch was low.

The rebuilding plan (Annex 3.4.2) was put into operation in 2011. The plan specifies the following plan for reducing the fishing mortality in every year when the latest survey shows a reduced SSB-index:

Action year	1	2	3	4	5	6	7
Reduction relative to F_{2009}	15%	30%	45%	60%	75%	90%	100%

The spawning biomass index in the 2010 survey was below the index in the 2009 survey. This means that the regulation in 2011 was aimed at a 15% reduction of F relative to 2009. The 2011 survey gave a higher spawning biomass index than in 2010. The 2012 survey index for spawning biomass was lower than the previous, and according to the rebuilding plan additional measures for reducing F by 30% (relative to 2009) should apply for 2013. For 2013 and later years no regulations in addition to those in place in 2011 and 2012 have been communicated to ICES. The survey showed an increase both in 2013 and 2014. Therefore, the 30% reduction of F still applied for 2015. The 2015 survey showed a decline, and the regulations in 2016 should aim for 45% reduced F. The 45% also applies for 2017, since the latest survey gave a higher SSB-estimate then the previous. Since the 2017 survey was lower than in 2016, the forth step (60% reduction) should apply for 2018. Since the 2018 survey was above the 2017, the 60% also applies for 2019.

The VPA analysis presented indicate some reduction of F over the period 1999–2015, followed by increased F in 2016, 2017 and a possible decline in 2018.

2.10 Rebuilding plan for coastal cod

The following rebuilding plan was suggested by Norway in 2010:

"The overarching aim is to rebuild the stock complex to full reproductive capacity, as well as to give sufficient protection to local stock components. Until a biologically founded rebuilding target is defined, the stock complex will only be regarded as restored when the survey index of spawning stock in two successive years is observed to be above 60 000 tonnes[1]. Importantly, this rebuilding target will be redefined on the basis of relevant scientific information. Such information could, for instance, include a reliable stock assessment, as well as an estimate of the spawning stock corresponding to full reproductive capacity.

Given that the survey index for SSB does not increase, the regulations will aim to reduce F[2] by at least 15 per cent annually compared to the F estimated for 2009. If, however, the latest survey index of SSB is higher than the preceding one - or if the estimated F for the latest catch year is less than 0.1 - the regulations will be unchanged.

Special regulatory measures for local stock components will be viewed in the context of scientific advice. A system with stricter regulations inside fjords than outside fjords is currently in operation, and this particular system is likely to be continued in future.

The management regime employed is aiming for improved ecosystem monitoring in order to understand and possibly enhance the survival of coastal cod. Potential predators are - among others - cormorants, seals and saithe.

When the rebuilding target is reached, a thorough management plan is essential. In this regard, the aim will be to keep full reproductive capacity and high long-term yield."

The Evaluation of this plan made at the 2010 WG (Annex 10 in ICES, 2010/ACOM:05) was not reviewed by the review group and advice drafting group dealing with the rest of the AFWG report. ICES selected some experts who during summer 2010 reviewed the evaluation, and an advice group wrote the response to Norwegian Authorities, issued on 1 October 2010. The conclusions are:

Based on simulations, ICES conclude that the plan, if fully implemented, is expected to lead to significant rebuilding. Nonetheless, accounting for realistic uncertainties in the catches, surveys, and the assessment model, a rather long rebuilding period is required even if fishing mortality is markedly reduced within the next several years. Whereas not fully quantifiable, the needed reductions in fishing mortality will require accompanying reductions in the catches.

ICES consider the proposed rule to be provisionally consistent with the Precautionary Approach. The basis of this evaluation has been the precautionary approach, and not the new ICES MSY framework.

This rebuilding plan was in 2010 adopted by Norwegian authorities. Results from the coastal survey are available in early December, and management decisions for the following year will then be made according to the SSB index and the rebuilding plan.

Has the rebuilding plan worked?

According to the catch estimates, the commercial catch of coastal cod was quite high in the years 2015–2017, while the 2018 catch was somewhat lower. The high catches in 2015–2017 are mainly

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[1]The average survey index in the years 1995–1998

[2] Ages 4–7

caused by targeting aggregations of cod during the first quarter in southern Troms and northern Nordland, prior to arrival of the spawning NEA cod.

The rebuilding plan has now been in operation for 9 years. The plan implies that the fishing mortality in 2018 should be at least 60% lower than the 2009 value. The 2018 data indicate a fishing mortality similar to 2009, and the estimated catch in 2017 is well above the catch in 2009. The regulations have therefore not been sufficient for constraining the coastal cod catches in the years 2015–2018, and the most recent estimate of F is above the F in 2009.

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

Since coastal cod to a large extent is a bycatch in the fishery for northeast Arctic cod, the regulations should, in particular, aim for reducing catches in areas where the fraction of coastal cod is high. Stronger restrictions are required in all areas where coastal cod is distributed. These restriction requirements include coastal cod taken as bycatch in northeast Arctic cod, haddock, and saithe fisheries.

2.11 Recent ICES advice

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

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

Table 2.1a. 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**
1984	127	1251	3350	5629	5111	3412	359	93	175	63818
1985	72	4302	4794	5660	3377	1319	387	81	750	62954
1986	304	4192	5831	4801	2956	1913	610	223	621	56107
1987	22	177	3294	7016	3314	1153	505	171	281	48274
1988	17	280	836	6686	6222	2573	645	280	252	55065
1989	53	471	1162	1602	5779	2493	813	184	251	41242
1990	50	387	987	805	683	2022	603	91	135	20920
1991	9	273	913	1420	1226	937	1384	190	202	24837
1992	57	401	2156	3296	2477	1201	468	695	346	38195
1993	21	140	1793	2874	3120	2555	1190	355	889	50420
1994	32	117	1015	4266	3011	2709	1276	412	843	51664
1995	31	210	1098	2997	5013	3404	1876	1032	899	64964
1996	50	459	837	1583	2460	2759	1062	524	640	41672
1997	121	594	1804	1752	2152	3164	1970	502	669	51123
1998	105	723	2640	2164	1287	937	924	372	361	30472
1999	55	660	2578	3506	1981	933	539	462	489	35805
2000	20	796	2830	3614	1922	772	401	142	356	34815
2001	20	372	1985	2250	1769	1074	393	128	355	27253
2002	52	405	1763	2880	2610	1070	559	200	250	36405
2003	66	560	1183	2377	2242	1382	618	259	302	35381
2004	24	294	1042	1874	2264	1542	784	303	355	33650
2005	19	266	1179	1807	1904	1369	684	263	318	29255
2006	43	264	1327	2225	2652	1641	908	425	446	39343
2007	48	378	1382	1905	1450	1004	487	287	300	29227
2008	63	553	1955	2284	1857	1106	640	275	273	35552
2009	28	966	1500	1532	1573	902	433	187	288	29987
2010	118	728	1734	2712	2184	1002	815	277	474	40397

	Age									Tonnes
	2	3	4	5	6	7	8	9	10+	Landed
2011	74	702	1727	2917	1572	1002	523	287	508	36714
2012	408	1159	1376	1928	1660	918	458	254	503	35540
2013	131	571	1544	1609	1154	886	627	290	474	30144
2014	110	510	1020	1730	1440	1110	840	300	490	33660
2015	140	680	1470	1290	1950	1010	650	450	820	35843
2016	110	1630	1970	2220	1750	2130	1150	670	1070	54767
2017	190	860	1890	1980	2490	1580	1220	690	850	51053
2018	150	830	1580	1730	1600	1310	800	530	500	36375

Table 2.1b. Estimated commercial catch of coastal cod+NEA cod in 2018 by gear and area (t) within areas 00-07.

Year		2018					%
Area	03	04	00	05	06/07	Total	by gear
Gillnet	8 808	18 268	27 142	35 958	3 549	93 726	36.4
L.line/Jig	17 346	12 447	7 373	11 256	1 216	49 638	19.3
Danish seine	17 965	19 189	11 028	30 462	317	78 961	30.7
Trawl	12 722	16 958	0	4 454	717	34 851	13.5
Others	37	119	0	8	76	240	0.1
Total	56 879	66 981	45 544	82 138	5 875	257 416	

Table 2.1c. Estimated commercial catch of coastal cod in 2018 by gear and area (t) within areas 00-07

Year		2018			%
Area	03	04;05;00	06;07	Total	by gir
Gillnet	1 022	8 262	2 432	11 716	32.3
Trawl	881	2 364	519	3 764	10.4
Others	6 638	12 844	1 332	20 814	57.3
Total	8 541	23 470	4 283	36 294	

Table 2.1d. Norwegian coastal cod. Total estimated catch number ('000) at age, including recreational and tourist catches.

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
1984	1479	5209	9070	8945	7198	5561	2397	952	624	77118
1985	3558	10438	9733	10444	7732	3291	835	512	264	76354
1986	4722	7128	15330	10565	6889	4303	1521	481	407	69607
1987	278	2912	12244	14611	5076	3080	1236	351	149	61774
1988	744	3328	4910	8159	8714	5237	1590	591	333	68665
1989	459	1984	2917	4057	6610	3238	1057	270	86	54942
1990	408	1843	2485	2012	3838	3906	846	141	73	35420
1991	1308	3305	4448	4456	2681	1880	977	203	94	40137
1992	469	1946	5509	5913	3622	2459	1744	921	279	54295
1993	51	1645	2994	3156	3530	3768	2073	995	690	65220
1994	389	1274	3416	5017	3755	4008	1907	901	798	66364
1995	818	1228	3149	6639	7131	4050	1868	737	433	79664
1996	1214	2967	2989	5547	6144	5533	2543	1125	543	56172
1997	1377	4145	4173	3021	3225	5124	4000	1091	684	65623
1998	803	3956	7113	5339	2857	1956	2155	1230	343	45072
1999	301	1788	3791	6202	3693	1959	949	995	320	49705
2000	219	1525	4817	5322	3715	1448	453	241	152	48415
2001	44	848	2572	4020	2962	2282	740	321	119	40653
2002	248	1191	3161	3877	3681	2134	1250	490	377	50005
2003	166	1449	2758	3422	3076	1824	842	584	99	49281
2004	38	560	1407	2637	2919	2271	967	388	264	47050
2005	36	744	1957	2686	2289	1830	936	364	143	42455
2006	90	551	2672	2562	2678	1858	986	453	224	52343
2007	137	861	2155	2805	1858	1355	718	413	196	42227
2008	107	1065	2181	2473	1882	1262	701	349	170	48352
2009	3	322	1628	2007	2251	1665	825	262	276	42687
2010	21	1103	2512	2945	1616	1092	652	308	272	53097
2011	43	912	2754	2566	2203	1636	704	333	455	49414

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
2012	30	622	1509	2066	2425	1771	821	472	638	48240
2013	140	843	2526	1928	1803	1054	788	384	340	42844
2014	36	1265	1908	2537	1556	1036	662	567	296	46360
2015	291	1240	2311	2438	2777	1892	997	638	895	48543
2016	384	2071	2283	2666	2311	2374	1198	682	906	67467
2017	338	2233	3090	3181	2938	2117	1572	832	962	63753
2018	202	1120	2132	2334	2159	1767	1079	715	675	49075

Table 2.1e. Norwegian coastal cod. Total estimated catch number ('000) at-age, in recreational and tourist catches.

	AGE									Tonnes
	2	3	4	5	6	7	8	9	10+	landed
1984	650	1731	2116	1667	1194	597	236	133		13300
1985	3162	2590	2366	1745	647	225	130	79	0	13400
1986	627	3033	2668	1659	1139	435	251	139	0	13500
1987	108	1972	4008	2181	649	431	109	38	0	13500
1988	634	1407	1567	1708	2088	550	129	94	0	13600
1989	418	825	1483	1758	1413	518	108	34	0	13700
1990	401	1494	1252	682	2709	450	73	0	0	14500
1991	1183	2698	2996	1342	808	583	104	71	0	15300
1992	429	1281	2349	1491	630	514	846	84	0	16100
1993	47	1276	1288	813	846	696	202	368	0	14800
1994	57	701	1723	715	1288	671	393	124	0	14700
1995	8	332	804	1451	1585	780	413	180	0	14700
1996	21	591	509	617	1497	1373	461	227	0	14500
1997	51	707	1023	763	735	1189	688	132	0	14500
1998	249	1137	2327	1316	585	410	329	255	0	14600
1999	49	466	1445	1939	920	357	198	221	0	13900
2000	63	554	1153	1515	1044	344	127	109	0	13600
2001	0	343	735	1046	964	873	198	134	0	13400

					AGE					Tonnes
	2	3	4	5	6	7	8	9	10+	landed
2002	56	298	830	1055	939	596	335	165	0	13600
2003	85	342	664	916	918	450	244	326	0	13900
2004	26	254	483	924	1099	827	358	162	0	13400
2005	21	270	658	858	853	715	423	176	0	13200
2006	19	236	1016	867	983	612	315	127	0	13000
2007	49	346	759	959	606	531	327	157	0	13000
2008	15	395	743	838	650	400	261	134	0	12800
2009	0	84	576	727	863	600	280	90	0	12700
2010	8	393	896	1050	576	389	232	110	97	12700
2011	13	281	847	789	678	503	216	102	140	12700
2012	9	177	430	588	690	504	234	134	182	12700
2013	51	305	912	696	651	380	284	139	123	12700
2014	13	448	676	898	551	367	234	201	105	12700
2015	71	302	563	594	676	461	243	155	218	12700
2016	85	459	506	591	512	526	265	151	201	12700
2017	66	432	598	616	569	410	304	161	186	12700
2018	52	290	552	604	559	457	279	185	175	12700

Table 2.2. Sampling from cod fisheries in 2018 in the statistical areas 00, 03, 04, 05, 06+07. Number of age samples of cod by quarter, and total number of cod otoliths.

Samples 2018 Quarter	03	04	00	05	06+07	Tot
1	18	54	110	104	49	335
2	26	34	23	19	28	130
3	4	7	34	4	9	58
4	21	23	71	2	26	143
Total samples	69	118	238	129	112	666
Total otoliths	1696	2622	2787	3047	1768	11920
Coastal cod type otoliths	501	818	1147	671	1435	4572

Table 2.3. Sampling from cod fisheries in 2017and 2016in the statistical areas 00, 03, 04, 05, 06+07. Number of age samples of cod by quarter, and total number of cod otoliths.

Samples 2017 Quarter	03	04	00	05	06+07	Tot
1	30	55	107	86	58	336
2	17	60	30	31	26	164
3	17	5	24	2	21	69
4	25	22	60	8	11	125
Total samples	89	142	221	127	116	694
Total otoliths	3271	4527	2716	3693	1860	16067
Coastal cod type otoliths	915	1133	982	755	1491	5196

Samples 2016 Quarter	03	04	00	05	06+07	Tot
1	46	42	107	99	40	330
2	38	30	26	10	27	131
3	8	7	4	5	8	32
4	18	23	7	15	19	82
Total samples	91	88	126	101	119	574
Total otoliths	3068	2703	2728	4058	2058	14615
Coastal cod type otoliths	845	906	687	1430	1787	5655

Table 2.4 Number of otoliths sampled by quarter from commercial catches in the period 1985–2018. Cc = coastal cod, NEAc = northeast Arctic cod.

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

Year	Quart Cc	1 NEAc	Quart Cc	2 NEAc	Quart Cc	3 NEAc	Quart Cc	4 NEAc	TOTAL CC	Total NEAc	%Cc
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
Av85-18	***1064***	***4018***	***614***	***2102***	***521***	***489***	***796***	***880***	***2996***	***7521***	***28***

Table 2.5. Coastal cod. Acoustic abundance indices by subareas and in total in 2018 (in thousands). Age 1 is not split between coastal cod and NEA cod.

	Age (Year class)										
Area	1 **(17)**	2 **(16)**	3 **(15)**	4 **(14)**	5 **(13)**	6 **(12)**	7 **(11)**	8 **(10)**	9 **(09)**	10+ **(08+)**	**Sum**
03	3313	914	883	874	614	401	145	103	65	93	7405
04	3577	1324	753	1147	688	812	329	85	69	115	8900
05	434	304	264	361	414	488	248	153	84	135	2884
00	1572	127	318	308	74	150	32	79	-	28	2688
06	2264	326	302	192	168	31	14	3	-	-	3300
07	-	-	17	58	252	124	37	21	39	-	548
Tot	11160	2995	2537	2940	2209	2006	805	444	257	371	25725

Table 2.6. Coastal cod. Acoustic abundance indices by age 1995–2018 (in thousands). Age 1 is not split between coastal cod and NEA cod. Fjords in area 07 not covered in 2013.

					Age						
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Sum**
1995	28707	20191	13633	15636	16219	9550	3174	1158	781	579	109628
1996	1756	17378	22815	12382	12514	6817	3180	754	242	5	77843
1997	30694	18827	28913	17334	12379	10612	3928	1515	26	663	124891
1998	14455	13659	15003	13239	7415	3137	1578	315	169	128	69099
1999	6850	11309	12171	10123	7197	3052	850	242	112	54	51960
2000	9587	11528	11612	8974	7984	5451	1365	488	85	97	57171
2001	8366	6729	7994	7578	4751	2567	1493	487	189	116	40270
2002	1329	2990	4103	4940	3617	2593	1470	408	29	128	21607
2003	2084	2145	3545	3880	2788	2389	1144	589	364	80	19008

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
2004	3217	3541	3696	4320	2758	1940	783	448	98	110	20914
2005	1443	1843	3525	3198	3217	1700	1120	552	330	78	17006
2006	1929	2525	4049	3783	3472	2509	1811	399	229	13	20719
2007	2202	3300	4080	5518	3259	2447	1444	760	197	34	23241
2008	2128	2181	2475	2863	2101	1219	815	403	319	177	14681
2009	3442	2059	2722	3959	2536	1603	1259	793	443	141	18955
2010	7768	2513	2729	2820	2417	1098	501	426	260	305	20837
2011	9015	3266	3950	4571	3012	2185	448	478	171	339	27435
2012	4887	2292	3003	2993	1990	1125	814	339	144	430	18015
2013	10478	3222	2780	3545	2742	2072	1164	971	449	431	27854
2014	5104	5516	3425	2659	4514	2660	2053	1189	980	676	28776
2015	6939	5084	3695	3441	2053	1984	1029	601	529	404	25759
2016	4857	4214	4850	3760	3108	1455	1022	955	187	474	24881
2017	1712	3950	4402	2910	2220	1412	664	436	248	234	18186
2018	11160	2995	2537	2940	2209	2006	805	444	257	371	25725

Table 2.7. Coastal cod. Mean length (cm) at-age 1995–2018.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+
1995	21.5	33.0	43.0	52.0	59.1	64.1	76.0	87.4	89.0	108.3
1996	19.0	30.2	41.7	52.5	59.2	65.2	79.1	84.8	87.0	114.2
1997	16.8	28.7	40.8	51.6	58.1	65.9	73.6	80.8	102.0	110.7
1998	20.3	33.3	43.8	51.4	59.1	66.3	74.1	81.0	93.2	116.9
1999	21.5	32.6	43.8	54.6	59.6	65.8	77.9	90.8	99.4	118.0
2000	21.6	33.3	43.4	53.5	61.0	66.1	75.5	90.8	99.1	105.5
2001	21.1	33.3	44.5	53.6	62.9	64.7	88.7	84.2	85.7	102.1
2002	22.5	34.4	44.6	56.0	61.6	67.7	72.4	66.6	89.0	108.3
2003	18.9	33.8	42.1	51.6	60.0	67.2	72.7	76.9	84.9	94.8
2004	20.7	32.9	43.5	54.5	59.9	68.0	71.9	75.0	74.6	91.8
2005	22.5	32.8	42.2	57.9	60.6	64.0	71.3	69.9	73.5	108.4
2006	22.2	36.1	47.0	55.5	61.4	68.0	69.5	77.8	87.0	100.5
2007	21.6	36.0	48.0	57.9	62.2	66.8	71.8	86.6	100.2	106.3
2008	21.9	36.9	49.2	59.0	66.1	70.9	71.7	74.1	77.6	98.8
2009	20.9	34.5	47.8	57.8	65.8	70.5	77.9	78.4	85.1	73.5
2010	20.3	34.9	46.4	57.5	64.6	71.2	76.9	75.2	78.9	82.7
2011	20.6	32.9	47.2	59.5	66.1	71.5	79.9	82.0	81.1	83.9
2012	21.3	32.4	46.9	58.8	66.1	72.0	77.0	77.5	82.2	87.3
2013	21.5	33.6	44.5	56.7	66.2	71.3	74.2	84.2	84.6	88.1
2014	21.7	35.1	47.7	57.3	66.4	73.5	76.6	80.5	81.7	93.0
2015	19.9	33.5	46.9	58.0	66.5	70.3	77.8	77.7	80.5	85.5
2016	20.5	32.9	47.8	58.7	67.8	72.2	75.1	83.0	89.7	86.9
2017	23.5	35.6	47.2	58.3	66.1	72.6	75.2	82.4	82.6	91.2
2018	19.4	35.4	47.7	58.8	68.1	71.3	79.8	80.3	85.5	84.4

Table 2.8. Coastal cod. Mean weight (grammes) at-age 1995–2018.

	Age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1995	81	390	791	1525	2222	2881	4665	6979	6759	9897
1996	59	252	724	1433	2053	2748	4722	6685	6932	9723
1997	43	240	683	1364	1893	2816	4426	6406	7805	1827
1998	52	372	883	1456	2107	2950	4319	5625	8323	12468
1999	70	323	841	1675	2192	2857	4540	6579	9454	12902
2000	72	365	809	1554	2539	3049	4352	6203	8527	12066
2001	51	396	966	1524	2314	3320	3695	6144	8768	12468
2002	103	428	895	1741	2433	3133	4273	4397	7759	12992
2003	62	385	738	1353	2145	3103	3981	4921	6923	9956
2004	83	352	834	1690	2255	3312	4150	4594	4383	9733
2005	112	359	786	2168	2265	2756	4174	3373	4502	15887
2006	105	474	1080	1746	2430	3336	3684	5125	7028	14650
2007	103	518	1185	2011	2500	3160	4241	6806	11051	14931
2008	96	508	1208	2095	2987	3671	3976	4387	5415	11588
2009	85	434	1116	2003	2894	3632	4875	5400	6125	4719
2010	75	419	1026	1996	2839	3665	4868	4895	5685	6504
2011	77	343	1062	2119	2882	3761	5505	6336	6309	6570
2012	89	336	1038	2006	2998	3727	4783	5071	5851	7446
2013	88	365	851	1815	2856	3561	4122	6435	5974	7670
2014	93	423	1071	1845	2886	3905	4495	5249	5871	8762
2015	75	370	1045	1940	2910	3518	4927	4753	5868	7277
2016	77	344	1121	2033	3081	3734	4286	5895	7556	6980
2017	78	421	1026	1868	2687	3746	4419	6050	6887	7637
2018	69	392	1158	1948	3192	3705	5304	5354	6428	6038

Table 2.9. Coastal cod. Acoustic biomass indices (tonnes) in 1995–2018. Age 1 is not split between coastal cod and NEA cod. Fjords in area 07 not covered in 2013 and partly covered in 2016.

	Age										
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**	**Sum**
1995	2337	7868	10786	23846	36039	27515	14445	8761	4933	7779	144309
1996	145	4386	16521	17739	25687	18731	15562	4376	3130	46	106323
1997	1319	4518	19748	23644	23435	29884	15060	8860	249	8643	135360
1998	752	5078	13247	19274	15627	9255	6675	1646	1329	2083	74966
1999	477	3650	10233	16960	15774	8720	4723	2097	1220	567	64421
2000	688	4321	9824	14464	20482	17067	5936	4359	926	1232	79299
2001	425	2662	7724	11548	10993	8521	5517	3010	1705	1917	54022
2002	137	1279	3672	8600	8801	8124	6282	1794	225	1663	40577
2003	125	876	2569	5328	5788	6995	4201	2754	2674	1136	32446
2004	329	1269	3087	7394	6089	6901	3009	1779	454	1058	31405
2005	109	675	2947	6521	7167	4807	3648	1942	1315	1205	30336
2006	202	1197	4374	6605	8435	8367	6672	2045	1602	190	39689
2007	227	1709	4835	11097	8148	7733	6124	5173	2177	508	47731
2008	206	1212	3120	6085	6593	4203	3437	2014	1492	2066	30506
2009	294	893	3037	7933	7335	5821	6137	4282	2707	665	39107
2010	583	1053	2800	5629	6862	4024	2439	2085	1478	1984	28936
2011	695	1120	4195	9686	8681	8218	2466	3029	1079	2227	41396
2012	295	767	2974	5914	5574	4143	3820	1673	775	3265	29199
2013	519	1192	2767	6890	8067	7252	4756	5937	2797	3178	43355
2014	456	2218	3849	5026	13418	9994	9691	6367	7308	6608	64935
2015	424	1972	3872	6423	5646	6546	4587	2747	3172	2794	38183
2016	250	1364	5792	7746	10236	5409	4165	6091	1322	3657	46023
2017	133	1664	4517	5436	5965	5289	2934	2638	1708	1787	32070
2018	770	1173	2939	5726	7051	7433	4270	2377	1652	2240	35631

Table 2.10. Coastal cod. Maturity-at-age as determined from maturity stages observed in the surveys over the period 1995 – 2018. Age 1 is not split between coastal cod and NEA cod.

Year	AGE									
	1	2	3	4	5	6	7	8	9	10+
1995	0.00	0.00	0.01	0.21	0.48	0.71	0.87	0.87	1.00	1.00
1996	0.00	0.00	0.03	0.25	0.56	0.81	0.92	0.99	1.00	1.00
1997	0.00	0.00	0.06	0.29	0.45	0.76	0.97	1.00	1.00	1.00
1998	0.00	0.02	0.15	0.25	0.53	0.74	0.87	0.89	1.00	1.00
1999	0.00	0.02	0.03	0.21	0.43	0.66	0.74	1.00	1.00	1.00
2000	0.00	0.00	0.00	0.16	0.31	0.61	0.76	0.64	0.99	1.00
2001	0.00	0.00	0.00	0.04	0.37	0.78	0.98	0.99	0.97	1.00
2002	0.00	0.02	0.02	0.26	0.88	0.93	0.90	0.97	1.00	1.00
2003	0.00	0.00	0.00	0.05	0.29	0.49	0.90	0.98	0.96	1.00
2004	0.00	0.00	0.01	0.09	0.37	0.76	0.95	0.98	1.00	1.00
2005	0.00	0.00	0.00	0.07	0.40	0.56	0.89	0.98	1.00	1.00
2006	0.00	0.00	0.00	0.14	0.52	0.75	0.91	0.87	0.96	1.00
2007	0.00	0.00	0.00	0.14	0.54	0.76	0.96	0.83	1.00	1.00
2008	0.00	0.00	0.03	0.12	0.48	0.72	0.89	0.94	0.96	1.00
2009	0.00	0.00	0.02	0.06	0.26	0.35	0.59	0.74	0.60	0.92
2010	0.00	0.00	0.00	0.08	0.38	0.66	0.83	0.88	0.95	0.97
2011	0.00	0.01	0.00	0.06	0.42	0.73	0.81	0.53	0.92	0.85
2012	0.00	0.00	0.01	0.05	0.38	0.66	0.90	0.92	0.97	0.99
2013	0.00	0.00	0.00	0.01	0.32	0.65	0.86	0.94	0.99	0.96
2014	0.00	0.00	0.00	0.06	0.24	0.66	0.81	0.94	1.00	0.97
2015	0.00	0.00	0.00	0.07	0.23	0.57	0.75	0.88	0.89	0.94
2016	0.00	0.00	0.00	0.09	0.30	0.59	0.83	0.85	0.97	1.00
2017	0.00	0.00	0.00	0.07	0.30	0.65	0.88	0.94	0.97	0.97
2018	0.00	0.00	0.01	0.15	0.41	0.69	0.83	0.95	1.00	0.92

Table 2.11. Coastal cod. Acoustic spawning biomass indices (tonnes) 1995–2018, corresponding to maturities in Table 2.10. Age 1 is not split between coastal cod and NEA cod.

Year	Age										
	1	2	3	4	5	6	7	8	9	10+	Sum
1995	0	0	96	4925	17424	19614	12573	7648	4933	7779	74992
1996	0	0	468	4467	14320	15130	14365	4311	3130	46	56237
1997	0	0	1185	6857	10546	22712	14608	8860	249	8643	73660
1998	0	92	2026	4870	8252	6804	5774	1461	1329	2083	32691
1999	0	56	315	3544	6778	5716	3478	2097	1220	567	23771
2000	0	0	0	2366	6354	10426	4486	2798	916	1232	28579
2001	0	0	15	508	4102	6662	5398	2978	1650	1917	23230
2002	0	20	87	2240	7702	7551	5650	1747	225	1663	26885
2003	0	0	0	269	1670	3428	3778	2686	2554	1136	15521
2004	0	0	28	679	2252	5253	2853	1736	434	722	13959
2005	0	0	0	447	2844	2670	3247	1898	1315	288	12709
2006	0	0	0	925	4386	6275	6072	1779	1538	571	21546
2007	0	0	0	1554	4400	5877	5879	4294	2177	508	24689
2008	0	0	107	734	3189	3012	3049	1902	1434	2066	15493
2009	0	0	61	476	1907	2037	3621	3169	1624	612	13508
2010	0	0	0	450	2608	2656	2024	1835	1404	1924	12901
2011	0	11	0	581	3646	5999	1997	1605	993	1893	16725
2012	0	0	22	278	2126	2748	3457	1539	755	3219	14143
2013	0	0	0	56	2580	4713	4112	5576	2773	3046	22856
2014	0	0	0	314	3222	6593	7831	5958	7307	6433	37659
2015	0	0	0	457	1301	3719	3436	2414	2811	2627	16763
2016	0	0	0	725	3084	3196	3464	5190	1278	3657	20597
2017	0	0	0	734	1779	3464	2582	2489	1662	1729	14078
2018	0	0	29	859	2891	5129	3544	2258	1652	2061	18423

Table 2.12. Proportion coastal cod among sampled cod during the coastal survey by age and statistical areas in the years 2005–2018. Age 1 is not split between coastal cod and NEA cod.

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2005	3	0.63	0.54	0.54	0.45	0.35	0.30	0.20	0.48	0.03
2005	4	0.96	0.91	0.76	0.74	0.71	0.60	0.76	0.81	0.50
2005	5	0.00	0.54	0.65	0.68	0.52	1.00	1.00	0.67	
2005	0	0.11	0.39	0.70	0.61	0.70	0.85	0.50	1.00	
2005	6	1.00	1.00	0.93	0.87	0.81	0.81	0.59	0.96	
2005	7	1.00	1.00	1.00	1.00	1.00	0.86	0.67	0.00	
2006	3	0.79	0.77	0.63	0.59	0.45	0.37	0.30	0.39	0.00
2006	4	1.00	0.88	0.84	0.79	0.68	0.63	0.82	0.40	0.42
2006	5	1.00	0.98	0.81	0.88	0.77	0.63	0.80	0.00	0.50
2006	0	0.99	0.99	0.95	0.87	0.86	0.89	0.85	0.33	
2006	6	1.00	1.00	0.95	0.99	0.80	0.72	1.00	0.67	
2006	7	1.00	0.97	0.95	0.98	0.89	1.00	0.50		
2007	3	0.83	0.38	0.40	0.59	0.27	0.32	0.00	1.00	
2007	4	0.91	0.92	0.92	0.80	0.80	0.90	0.71	0.67	1.00
2007	5	0.97	1.00	0.97	0.94	0.94	0.95	0.86	0.67	0.00
2007	0	1.00	0.88	1.00	1.00	1.00	0.00	1.00	1.00	

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2007	6	1.00	1.00	0.95	0.87	0.91	0.81			
2007	7	1.00	1.00	1.00	0.89	0.86	0.86	1.00	1.00	1.00
2008	3	0.98	0.97	0.80	0.83	0.79	0.72	0.53	1.00	0.40
2008	4	1.00	0.99	0.80	0.88	0.84	0.78	0.88	0.88	0.86
2008	5	1.00	1.00	0.93	0.96	1.00	0.80	0.67	1.00	1.00
2008	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
2008	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2008	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2009	3	0.90	0.72	0.54	0.44	0.48	0.57	0.79	0.67	0.58
2009	4	0.95	0.89	0.78	0.62	0.69	0.92	0.72	0.78	0.79
2009	5	1.00	1.00	0.95	0.84	0.78	0.82	0.88	0.67	1.00
2009	0	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	
2009	6	1.00	1.00	1.00	1.00	0.82	1.00	1.00	1.00	0.50
2009	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
2010	3	0.86	0.78	0.56	0.47	0.36	0.37	0.81	0.89	0.95
2010	4	0.98	0.96	0.87	0.71	0.49	0.77	0.87	1.00	1.00
2010	5	1.00	0.98	1.00	1.00	0.84	0.88	1.00	0.73	1.00

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2010	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2010	6	1.00	1.00	1.00	1.00	1.00	1.00		1.00	1.00
2010	7	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
2011	3	0.83	0.83	0.78	0.67	0.44	0.28	0.70	0.73	0.67
2011	4	0.99	0.99	0.95	0.87	0.79	0.77	0.74	0.93	1.00
2011	5	0.97	1.00	1.00	0.93	0.75	0.71	0.75		0.83
2011	0	1.00	1.00	1.00	1.00	1.00		1.00		
2011	6	1.00	1.00	1.00	1.00	1.00		1.00		1.00
2011	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2012	3	0.50	0.83	0.65	0.67	0.51	0.51	0.49	0.78	0.64
2012	4	0.29	0.93	0.94	0.93	0.87	0.91	0.77	0.90	0.93
2012	5	0.84	0.91	0.92	0.89	0.72	0.83	0.75	0.80	0.89
2012	0	1.00	1.00	1.00	1.00	1.00		1.00	1.00	1.00
2012	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2012	7	1.00	1.00	1.00	1.00	1.00	1.00	0.50		
2013	3	0.87	0.79	0.58	0.54	0.73	0.59	057	0.58	1.00
2013	4	0.98	0.94	0.90	0.87	0.77	0.76	0.89	0.80	1.00

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2013	5	1.00	1.00	1.00	1.00	0.95	1.00	0.94	1.00	1.00
2013	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2013	7	1.00		1.00	1.00	1.00	1.00	0.50		
2014	3	0.99	0.98	0.92	0.84	0.76	0.85	0.68	0.73	0.70
2014	4	0.99	1.00	1.00	0.99	0.99	0.98	0.96	0.94	1.00
2014	5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	1.00
2014	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00
2014	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
2014	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2015	3	0.90	0.84	0.80	0.68	0.56	0.46	0.66	0.85	0.69
2015	4	0.93	0.89	0.89	0.77	0.81	0.68	0.68	0.71	0.86
2015	5	0.97	1.00	0.93	1.00	0.91	0.93	1.00	1.00	1.00
2015	0	1.00	1.00	1.00	1.00	1.00	0.92	0.75	1.00	1.00
2015	6	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	
2015	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
2016	3	0.95	0.97	0.85	0.74	0.47	0.53	0.50	0.32	0.19
2016	4	0.99	0.98	0.89	0.84	0.71	0.72	0.64	0.59	0.16
2016	5	0.92	0.90	0.89	0.86	0.75	0.71	0.62	0.21	0.25
2016	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00

Year	Area/Age	2	3	4	5	6	7	8	9	10+
2016	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2016	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2017	3	0.97	0.92	0.9	0.81	0.70	0.64	0.50	0.86	0.83
2017	4	0.98	0.97	0.94	0.82	0.64	0.76	0.87	0.75	0.88
2017	5	1.00	1.00	1.00	1.00	0.94	1.00	0.92	1.00	0.94
2017	0	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	
2017	6	1.00	1.00	0.94	0.94	1.00	1.00	1.00	1.00	
2017	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
2018	3	0.93	0.88	0.76	0.86	0.75	0.52	0.48	0.71	0.83
2018	4	0.99	0.95	0.93	0.87	0.81	0.71	0.85	1.00	0.83
2018	5	0.96	0.90	0.92	0.94	0.96	0.97	0.85	0.85	0.94
2018	0	0.97	1.00	1.00	1.00	1.00	1.00	1.00		
2018	6		1.00	1.00	1.00	1.00	1.00	1.00	1.00	
2018	7	0.93	0.88	0.76	0.86	0.75	0.52	0.48	0.71	0.83

Table 2.13. Norwegian Coastal Cod. Stock weight (SWT), catch weights (CWT) and proportion mature (MAT). Input data to all the VPA-analysis. Proportions of F and M before time of spawning was set to 0 for all ages and years.

SWT	2	3	4	5	6	7	8	9	10
1984	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1985	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1986	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1987	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1988	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1989	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1990	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1991	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1992	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1993	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1994	0.321	0.758	1.479	2.137	2.814	4.722	6.685	6.98	9.723
1995	0.298	0.7	1.338	1.973	2.649	4.164	7.051	6.41	14.326
1996	0.27	0.717	1.435	2.044	2.694	4.817	6.28	11.37	15.67
1997	0.232	0.677	1.363	1.903	2.816	3.833	5.849	9.60	13.037
1998	0.323	0.834	1.366	2.075	3.013	4.255	5.305	8.35	18.016
1999	0.318	0.804	1.559	2.042	2.798	4.678	7.151	8.96	18.340

SWT	2	3	4	5	6	7	8	9	10
2000	0.346	0.777	1.458	2.296	2.735	4.048	7.011	9.22	12.277
2001	0.347	0.878	1.543	2.213	2.862	3.321	4.849	7.339	11.542
2002	0.43	0.88	1.698	2.452	3.538	4.397	4.191	7.046	15.619
2003	0.308	0.686	1.299	2.149	3.135	4.048	5.008	5.789	10.069
2004	0.339	0.834	1.614	2.269	3.29	4.124	4.718	4.976	6.358
2005	0.407	0.846	1.748	2.2	2.693	3.817	3.797	5.344	14.829
2006	0.49	1.125	1.812	2.559	3.579	3.964	4.822	7.332	14.65
2007	0.518	1.185	2.011	2.5	3.16	4.241	6.806	11.051	14.931
2008	0.508	1.208	2.095	2.987	3.671	3.976	4.387	5.415	11.558
2009	0.434	1.116	2.003	2.894	3.632	4.875	5.4	6.125	4.719
2010	0.419	1.026	1.996	2.839	3.665	4.868	4.895	5.685	6.504
2011	0.343	1.062	2.119	2.882	3.761	5.505	6.336	6.309	6.57
2012	0.336	1.038	2.006	2.998	3.727	4.783	5.071	5.851	7.446
2013	0.365	0.851	1.815	2.856	3.561	4.122	6.435	5.974	7.67
2014	0.423	1.071	1.845	2.886	3.905	4.495	5.249	5.871	8.762
2015	0.37	1.045	1.94	2.91	3.518	4.927	4.753	5.864	7.277
2016	0.344	1.121	2.033	3.081	3.734	4.286	5.895	7.556	6.984

SWT	2	3	4	5	6	7	8	9	10
2017	0.421	1.026	1.868	2.687	3.746	4.419	6.05	6.887	7.637
2018	**0.392**	**1.158**	**1.948**	**3.192**	**3.705**	**5.305**	**5.354**	**6.428**	**6.038**
CWT	2	3	4	5	6	7	8	9	10
1984	0.832	1.262	1.873	2.608	3.52	5.202	6.23	7.186	14.435
1985	0.893	1.288	1.929	2.63	3.819	5.023	6.432	8.053	14.074
1986	0.225	0.539	1.531	2.393	3.354	4.72	6.13	7.309	14.555
1987	0.423	0.842	1.386	2.266	3.602	4.861	6.287	8.098	19.751
1988	0.349	0.741	1.299	1.878	3.074	4.493	5.898	7.219	18.64
1989	0.647	1.127	1.429	2.136	2.958	4.164	5.155	5.897	11.31
1990	0.779	1.294	1.796	2.5	3.354	4.326	5.326	6.379	13.051
1991	1.069	1.602	2.17	2.811	3.52	4.302	5.043	5.736	9.886
1992	1.009	1.481	2.081	2.748	3.466	4.397	5.16	5.972	10.286
1993	1.028	1.64	2.2	2.903	3.616	4.344	5.204	5.764	8.154
1994	0.882	1.396	1.912	2.567	3.412	4.239	5.017	6.175	9.328
1995	0.732	1.239	1.744	2.302	3.137	4.299	5.424	6.273	9.847
1996	0.845	1.432	2.122	2.93	3.454	4.176	5.135	6.016	9.25
1997	1.053	1.694	2.126	2.959	3.529	4.313	5.427	6.424	8.668

SWT	2	3	4	5	6	7	8	9	10
1998	0.789	1.335	1.779	2.556	3.55	4.24	5.066	5.761	10.589
1999	1	1.603	2.045	2.607	3.492	4.317	4.956	5.742	8.169
2000	1.075	1.551	2.205	2.75	3.587	4.483	5.607	6.187	10.939
2001	0.913	1.496	2.055	2.631	3.381	4.143	5.065	5.719	9.9
2002	0.973	1.733	2.352	2.972	3.98	4.877	5.646	6.883	11.221
2003	1.136	1.861	2.391	3.226	3.956	4.983	5.697	6.056	9.653
2004	1.063	1.857	2.308	2.883	3.79	4.769	5.644	6.239	8.494
2005	1.105	1.811	2.468	2.992	3.574	4.354	5.082	5.848	8.342
2006	1.326	1.737	2.244	3.094	3.794	4.522	5.375	6.296	8.802
2007	1.206	1.82	2.518	3.154	4.334	5.028	5.764	7.044	9.432
2008	1.27	1.76	2.693	3.239	4.137	5.264	5.97	6.69	9.77
2009	1.459	1.92	2.719	3.513	4.355	5.411	6.492	7.43	9.345
2010	1.232	1.903	2.703	3.441	4.31	5.127	5.503	6.654	8.374
2011	1.142	1.767	2.464	3.279	4.293	5.177	6.19	6.733	8.77
2012	1.091	1.736	2.549	3.493	4.571	5.635	6.724	7.532	10.09
2013	1.133	1.706	2.422	3.176	4.142	4.984	5.968	6.869	11.008
2014	1.214	1.915	2.609	3.385	4.302	5.336	6.048	6.725	9.785

SWT	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2015	1.095	1.633	2.272	3.195	3.977	4.952	5.881	6.722	9.119
2016	1.312	1.867	2.537	3.319	4.165	5.005	5.99	6.964	9.069
2017	**1.14**	**1.801**	**2.487**	**3.213**	**3.919**	**5.022**	**6**	**7.036**	**9.827**
2018	1.132	1.698	2.319	3.14	3.932	4.888	5.836	6.675	9.498
MAT	2	3	4	5	6	7	8	9	10
1984	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1985	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1986	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1987	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1988	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1989	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1990	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1991	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1992	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1993	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1994	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1995	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1

SWT	2	3	4	5	6	7	8	9	10
1996	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1997	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1998	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
1999	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2000	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2001	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2002	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2003	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2004	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2005	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2006	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2007	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2008	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2009	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2010	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2011	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2012	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1

SWT	2	3	4	5	6	7	8	9	10
2013	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2014	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1
2015	0	0.02	0.16	0.46	0.69	0.87	0.91	0.96	1

Table 2.14. Norwegian Coastal Cod. Diagnostic output from XSA trial run based on commercial catch-at-age and survey index at age (ages 2–8 in Table 2.6). Proportions of F and M before time of spawning has been set to 0 for all years and ages.

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Lowestoft VPA Version 3.1

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 Extended Survivors Analysis

 Norwegian Coastal Cod,COMBSEX,PLUSGROUP

 CPUE data from file coast-9.txt

 Catch data for  35 years. 1984 to 2018. Ages  2 to  10.

    Fleet,           First, Last, First, Last, Alpha,  Beta
              ,    year, year,  age ,  age
 Norw. Coast. survey ,   1995, 2018,   0,     8,   .750,   .850


 Time-series weights :

    Tapered time weighting applied
    Power =    3 over  20 years


 Catchability analysis :

    Catchability dependent on stock size for ages <
4

      Regression type = C
      Minimum of   5 points used for regression
      Survivor estimates shrunk to the population mean for ages <  4


    Catchability independent of age for ages >=    7


 Terminal population estimation :

    Survivor estimates shrunk towards the mean F
    of the final   2 years or the   4 oldest ages.

    S.E. of the mean to which the estimates  are shrunk =   1.000

    Minimum standard error for
population
```

estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 60 iterations

Total absolute residual between iterations
59 and 60 = .00454

Final year F values
Age , 2, 3, 4, 5, 6, 7, 8, 9
Iteration 59, .0069, .0475, .1564, .2665, .2968, .4494, .5547, .5895
Iteration 60, .0069, .0475, .1564, .2671, .2977, .4498, .5538, .5911

1

Regression weights
, .751, .820, .877, .921, .954, .976, .990, .997, 1.000, 1.000

Fishing mortalities
Age, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018

2, .001, .005, .003, .021, .006, .005, .008, .006, .009, .007
3, .046, .038, .037, .056, .037, .028, .040, .115, .063, .048
4, .100, .110, .121, .096, .099, .087, .107, .156, .190, .156
5, .198, .265, .273, .192, .155, .154, .151, .234, .232, .267
6, .319, .480, .241, .246, .168, .202, .259, .314, .447, .298
7, .273, .345, .423, .216, .200, .243, .213, .503, .523, .450
8, .170, .426, .305, .348, .225, .297, .219, .400, .610, .554
9, .141, .157, .260, .238, .388, .160, .256, .368, .447, .591

1

XSA population numbers (Thousands)

	AGE							
YEAR ,	2,	3,	4,	5,	6,	7,	8,	9,
2009 ,	2.61E+04,	2.36E+04,	1.74E+04,	9.43E+03,	6.37E+03,	4.17E+03,	3.06E+03,	1.57E+03,
2010 ,	2.60E+04,	2.13E+04,	1.84E+04,	1.29E+04,	6.34E+03,	3.79E+03,	2.59E+03,	2.11E+03,
2011 ,	2.87E+04,	2.11E+04,	1.68E+04,	1.35E+04,	8.10E+03,	3.21E+03,	2.20E+03,	1.39E+03,
2012 ,	2.15E+04,	2.34E+04,	1.67E+04,	1.22E+04,	8.42E+03,	5.21E+03,	1.72E+03,	1.33E+03,
2013 ,	2.47E+04,	1.72E+04,	1.81E+04,	1.24E+04,	8.23E+03,	5.39E+03,	3.44E+03,	9.96E+02,
2014 ,	2.36E+04,	2.01E+04,	1.36E+04,	1.34E+04,	8.71E+03,	5.69E+03,	3.61E+03,	2.25E+03,
2015 ,	2.03E+04,	1.92E+04,	1.60E+04,	1.02E+04,	9.43E+03,	5.82E+03,	3.66E+03,	2.20E+03,
2016 ,	1.93E+04,	1.65E+04,	1.51E+04,	1.18E+04,	7.17E+03,	5.96E+03,	3.85E+03,	2.41E+03,
2017 ,	2.43E+04,	1.57E+04,	1.21E+04,	1.06E+04,	7.63E+03,	4.29E+03,	2.95E+03,	2.12E+03,
2018 ,	2.40E+04,	1.98E+04,	1.21E+04,	8.16E+03,	6.87E+03,	4.00E+03,	2.08E+03,	1.31E+03,

Estimated population abundance at 1st Jan 2019

, 0.00E+00, 1.95E+04, 1.54E+04, 8.44E+03, 5.11E+03, 4.17E+03, 2.09E+03, 9.80E+02,

Taper weighted geometric mean of the VPA populations:

, 2.38E+04, 1.94E+04, 1.52E+04, 1.14E+04, 7.76E+03, 4.72E+03, 2.79E+03, 1.65E+03,

Standard error of the weighted Log(VPA populations) :

, .1241, .1307, .1452, .1517, .1219, .1920, .2536, .3067,
1

Log catchability residuals.

Fleet : Norw. Coast. survey

Age ,	1995,	1996,	1997,	1998
2 ,	99.99,	99.99,	99.99,	99.99
3 ,	99.99,	99.99,	99.99,	99.99
4 ,	99.99,	99.99,	99.99,	99.99
5 ,	99.99,	99.99,	99.99,	99.99
6 ,	99.99,	99.99,	99.99,	99.99
7 ,	99.99,	99.99,	99.99,	99.99

8 , 99.99, 99.99, 99.99,
99.99

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2	-1.62	-1.55	-.93	.06	.45	-.04	.74	.40	-.15	.25
3	-1.41	-1.37	-.91	-.26	-.06	-.07	.05	-.04	-.03	.20
4	.91	.79	.58	.23	-.03	.15	-.13	.12	.54	-.03
5	1.07	1.09	.45	.16	-.06	-.14	.10	.23	.24	-.09
6	1.05	1.34	.44	.38	.25	.09	-.20	.41	.29	-.26
7	.73	.93	.72	.48	.26	-.18	.21	.51	.47	-.25
8	.32	.88	.44	-.02	.07	-.06	.03	-.16	.08	-.30

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	.41	.19	-.20	.47	-.04	-.60	-.36	-.10	-.26	.07
3	.02	.12	-.22	-.08	.32	-.03	-.06	-.23	-.05	.26
4	-.01	-.40	.19	-.25	-.16	-.17	-.06	.13	.12	.11
5	.12	-.19	-.01	-.39	-.11	.30	-.21	.13	-.10	.18
6	.12	-.13	.12	-.58	.00	.22	-.11	-.10	-.09	.25
7	.35	-.42	-.31	-.36	-.05	.50	-.24	-.04	-.12	.08
8	.11	-.14	.04	-.02	.24	.45	-.30	.25	-.10	.05

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	4	5	6	7	8
Mean Log q	-1.2323	-1.1121	-1.0807	-1.1661	-1.1661
S.E(Log q)	.2226	.2125	.2604	.3253	.2233

Regression statistics :

Ages with q dependent on year class strength

Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e, Mean Log q

2, -1.13, -2.320, 19.37, .11, 20, .38, -
1.84,

3, -.96, -4.185, 17.83, .31, 20, .20, -
1.54,

Ages with q independent of year class strength and constant w.r.t. time.

Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e, Mean Q

4, 2.56, -1.376, -11.90, .07, 20, .55, -
1.23,
5, 1.18, -.341, -.34, .27, 20, .26, -1.11,
6, 1.29, -.339, -1.23, .12, 20, .35, -1.08,
7, .77, .554, 2.81, .37, 20, .26, -1.17,
8, .82, .797, 2.33, .67, 20, .19, -1.14,
1

Terminal year survivor and F summaries :

Age 2 Catchability dependent on age and year class strength

Year class = 2016

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 20907., .395, .000, .00, 1, .097, .006

P shrinkage mean , 19388., .13,,,, .888,
.007

F shrinkage mean , 18008., 1.00,,,, .015,
.008

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
19508., .12, .05, 3, .422, .007

Age 3 Catchability dependent on age and year class strength

Year class = 2015

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 16611., .240, .249, 1.04, 2, .254, .044

P shrinkage mean , 15225., .15,,,, .731,
.048

F shrinkage mean , 8045., 1.00,,,, .015,
.089

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
15414., .12, .10, 4, .802, .048

1
Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2014

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 8486., .188, .061, .32, 3, .959, .156

F shrinkage mean , 7533., 1.00,,,, .041,
.174

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
8444., .18, .05, 4, .273, .156

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2013

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 5076., .162, .123, .76, 4, .961, .269

F shrinkage mean , 5941., 1.00,,,, .039,
.234

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,

5107., .16, .11, 5, .657, .267

1
Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 2012

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 4210., .144, .119, .82, 5, .966, .296

F shrinkage mean , 3099., 1.00,,,, .034,
.383

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
4166., .14, .11, 6, .747, .298

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 2011

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 2102., .137, .037, .27, 6, .956, .447

F shrinkage mean , 1751., 1.00,,,, .044,
.517

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
2085., .14, .04, 7, .264, .450

1
Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2010

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 974., .133, .076, .57, 7, .951, .556

F shrinkage mean , 1090., 1.00,,,, .049,
.509

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
980., .14, .07, 8, .508, .554

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2009

Fleet, Estimated, Int, Ext, Var, N, Scaled, Estimated
, Survivors, s.e, s.e, Ratio, , Weights, F
Norw. Coast. survey , 565., .133, .057, .43, 7, .914, .614

F shrinkage mean , 991., 1.00,,,, .086, .395

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
593., .15, .08, 8, .539, .591

Table 2.15. Norwegian Coastal Cod. Fishing mortalities from trial XSA run based on commercial catch-at-age and survey index at age (ages 2–8 in Table 2.6). (Proportions of F and M before time of spawning was set to 0 for all ages and years).

YR\AGE	2	3	4	5	6	7	8	9
1984	0.002	0.043	0.191	0.481	0.937	1.378	0.968	0.952
1985	0.001	0.104	0.231	0.568	0.602	0.673	0.530	0.598
1986	0.020	0.093	0.201	0.382	0.669	0.847	0.781	0.676
1987	0.001	0.015	0.098	0.396	0.498	0.605	0.562	0.519
1988	0.001	0.018	0.090	0.295	0.747	0.949	0.839	0.714
1989	0.002	0.019	0.097	0.248	0.449	0.785	0.943	0.612
1990	0.002	0.014	0.049	0.090	0.158	0.278	0.434	0.241
1991	0.000	0.010	0.041	0.093	0.192	0.339	0.311	0.235
1992	0.002	0.012	0.105	0.203	0.232	0.292	0.282	0.254
1993	0.001	0.006	0.070	0.200	0.301	0.400	0.529	0.360
1994	0.002	0.009	0.054	0.235	0.332	0.465	0.356	0.349
1995	0.002	0.019	0.113	0.225	0.477	0.785	0.694	0.550
1996	0.002	0.031	0.099	0.236	0.292	0.530	0.605	0.419
1997	0.005	0.030	0.164	0.309	0.583	0.762	0.939	0.654
1998	0.004	0.035	0.181	0.303	0.393	0.545	0.523	0.445
1999	0.002	0.031	0.166	0.388	0.504	0.556	0.713	0.545
2000	0.001	0.038	0.181	0.369	0.382	0.374	0.495	0.407
2001	0.001	0.019	0.124	0.215	0.311	0.383	0.332	0.288
2002	0.002	0.021	0.119	0.267	0.414	0.314	0.351	0.280
2003	0.003	0.032	0.079	0.232	0.344	0.403	0.301	0.272
2004	0.001	0.017	0.076	0.174	0.363	0.423	0.421	0.236
2005	0.001	0.016	0.087	0.182	0.269	0.390	0.336	0.242
2006	0.002	0.017	0.105	0.233	0.442	0.392	0.489	0.361
2007	0.002	0.025	0.115	0.216	0.235	0.297	0.191	0.279
2008	0.002	0.028	0.172	0.281	0.339	0.283	0.314	0.157
2009	0.001	0.046	0.100	0.198	0.319	0.274	0.170	0.141
2010	0.005	0.039	0.110	0.265	0.480	0.345	0.426	0.157
2011	0.003	0.037	0.121	0.273	0.241	0.423	0.305	0.260

YR\AGE	2	3	4	5	6	7	8	9
2012	0.021	0.056	0.096	0.192	0.246	0.217	0.348	0.238
2013	0.006	0.037	0.099	0.155	0.168	0.200	0.225	0.388
2014	0.005	0.028	0.087	0.154	0.202	0.243	0.297	0.160
2015	0.008	0.040	0.107	0.151	0.259	0.213	0.219	0.256
2016	0.006	0.115	0.156	0.234	0.314	0.503	0.400	0.368
2017	0.009	0.063	0.190	0.232	0.447	0.523	0.610	0.447
2018	0.007	0.048	0.156	0.267	0.298	0.450	0.554	0.591

Table 2.15 cont. Summary output from trial XSA run based on commercial catch

Run title	COMBSEX	PLUSGROUP : Norwegian Coastal Cod				
At 28/04/2019 19:43						
Table 16 Summary (without SOP correction)						
1984	58763	168477	68331	63818	0.934	0.7467
1985	63905	189068	74608	62954	0.8438	0.5184
1986	16661	194557	78130	56107	0.7181	0.5248
1987	21194	184102	80795	48274	0.5975	0.3993
1988	34526	178556	92634	55065	0.5944	0.5201
1989	38286	163910	84492	41242	0.4881	0.3947
1990	35982	171690	85300	20920	0.2453	0.1437
1991	44590	206187	105506	24837	0.2354	0.1661
1992	31836	231985	125158	38195	0.3052	0.2081
1993	17168	246138	145223	50420	0.3472	0.2423
1994	14963	238843	152812	51664	0.3381	0.2715
1995	20288	209496	145724	64964	0.4458	0.3999
1996	27146	182568	126726	41672	0.3288	0.2891
1997	28926	145668	91396	51123	0.5594	0.4545
1998	29144	138485	72312	30472	0.4214	0.3557
1999	29149	151398	78257	35805	0.4575	0.4037
2000	26519	140830	66391	34815	0.5244	0.3268
2001	26175	148583	72159	27253	0.3777	0.258

2002	24420	174306	89622	36405	0.4062	0.2783
2003	23934	150035	83663	35381	0.4229	0.2646
2004	22302	157880	84570	33650	0.3979	0.2588
2005	21435	161455	89268	29255	0.3277	0.2317
2006	20967	185880	104035	39343	0.3782	0.2932
2007	26768	187793	103227	29227	0.2831	0.2157
2008	28853	193179	99753	35552	0.3564	0.2687
2009	26055	180698	87904	29987	0.3411	0.2225
2010	25961	195902	101727	40397	0.3971	0.2998
2011	28669	193673	97573	36714	0.3763	0.2644
2012	21455	193760	100847	35540	0.3524	0.1875
2013	24716	183962	99639	30144	0.3025	0.1556
2014	23558	219055	129921	33660	0.2591	0.1712
2015	20335	209412	124053	35843	0.2889	0.1825
2016	19275	211948	127405	54767	0.4299	0.3016
2017	24342	176948	103159	51053	0.4949	0.3481
2018	23998	155424	77816	36375	0.4675	0.2928

Table 2.16. Calculated survey mortalities (Z) and vpa- values of F(4–7) predicted from survey mortalities, both for the vpa using commercial catch and the vpa using all catch.

year	av. survey Z	com. Catch	all catch
	ages 4–9	Predict F(4–7)	Predict F(4–7)
1996	0.881	0.3132	0.3404
1997	0.850	0.3103	0.3365
1998	1.604	0.3785	0.4301
1999	1.018	0.3255	0.3573
2000	0.538	0.2821	0.2977
2001	0.912	0.3159	0.3442
2002	1.084	0.3315	0.3655
2003	0.482	0.2770	0.2907
2004	0.725	0.2991	0.3210
2005	0.355	0.2656	0.2750
2006	0.324	0.2628	0.2711
2007	0.386	0.2684	0.2788
2008	0.925	0.3171	0.3457
2009	-0.030	0.2308	0.2272
2010	0.776	0.3037	0.3273
2011	0.229	0.2542	0.2594
2012	0.760	0.3022	0.3253
2013	-0.102	0.2243	0.2183
2014	-0.031	0.2307	0.2270
2015	0.677	0.2947	0.3150
2016	0.389	0.2687	0.2792
2017	0.802	0.3060	0.2903
2018	0.379	0.2678	0.2309

Table 2.17. Norwegian Coastal Cod. Stock summary for SVPA based on commercial catch-at-age and survey derived F in terminal year (2018)

At 07/05/2019 14:50

Table 16 Summary (without SOP correction)

Traditional vpa using file input for terminal F

	RECRUITS Age 2	TOTBIO	TOTSPBIO	LANDI	YIELD/SSB	F(4–7)
1984	58745	168380	68262	63818	0.9349	0.748
1985	63842	188814	74419	62954	0.8459	0.519
1986	16632	194344	77973	56107	0.7196	0.526
1987	21161	183864	80657	48274	0.5985	0.400
1988	34458	178286	92482	55065	0.5954	0.521
1989	38247	163621	84324	41242	0.4891	0.396
1990	35951	171348	85086	20920	0.2459	0.144
1991	44563	205780	105216	24837	0.2361	0.167
1992	31806	231554	124821	38195	0.306	0.209
1993	17158	245658	144821	50420	0.3482	0.243
1994	14952	238375	152407	51664	0.339	0.272
1995	20270	208984	145272	64964	0.4472	0.401
1996	27123	182155	126353	41672	0.3298	0.290
1997	28897	145355	91124	51123	0.561	0.455
1998	29119	138199	72078	30472	0.4228	0.356
1999	29115	151105	78013	35805	0.459	0.404
2000	26494	140572	66209	34815	0.5258	0.328
2001	26144	148353	71988	27253	0.3786	0.259
2002	24400	173980	89392	36405	0.4073	0.279
2003	23905	149760	83459	35381	0.4239	0.265
2004	22275	157607	84374	33650	0.3988	0.259
2005	21410	161132	89027	29255	0.3286	0.232
2006	20945	185477	103733	39343	0.3793	0.294
2007	26734	187398	102936	29227	0.2839	0.216
2008	28813	192835	99522	35552	0.3572	0.269
2009	26002	180403	87725	29987	0.3418	0.223
2010	25912	195488	101474	40397	0.3981	0.300
2011	31970	194401	97316	36714	0.3773	0.265
2012	23907	197019	100636	35540	0.3532	0.188
2013	25933	189893	100089	30144	0.3012	0.153
2014	22688	227762	132562	33660	0.2539	0.164
2015	23051	220258	129490	35843	0.2768	0.167
2016	20790	224844	135272	54767	0.4049	0.262
2017	15654	188550	113310	51053	0.4506	0.307
2018	21298	167844	94611	36375	0.3845	0.269

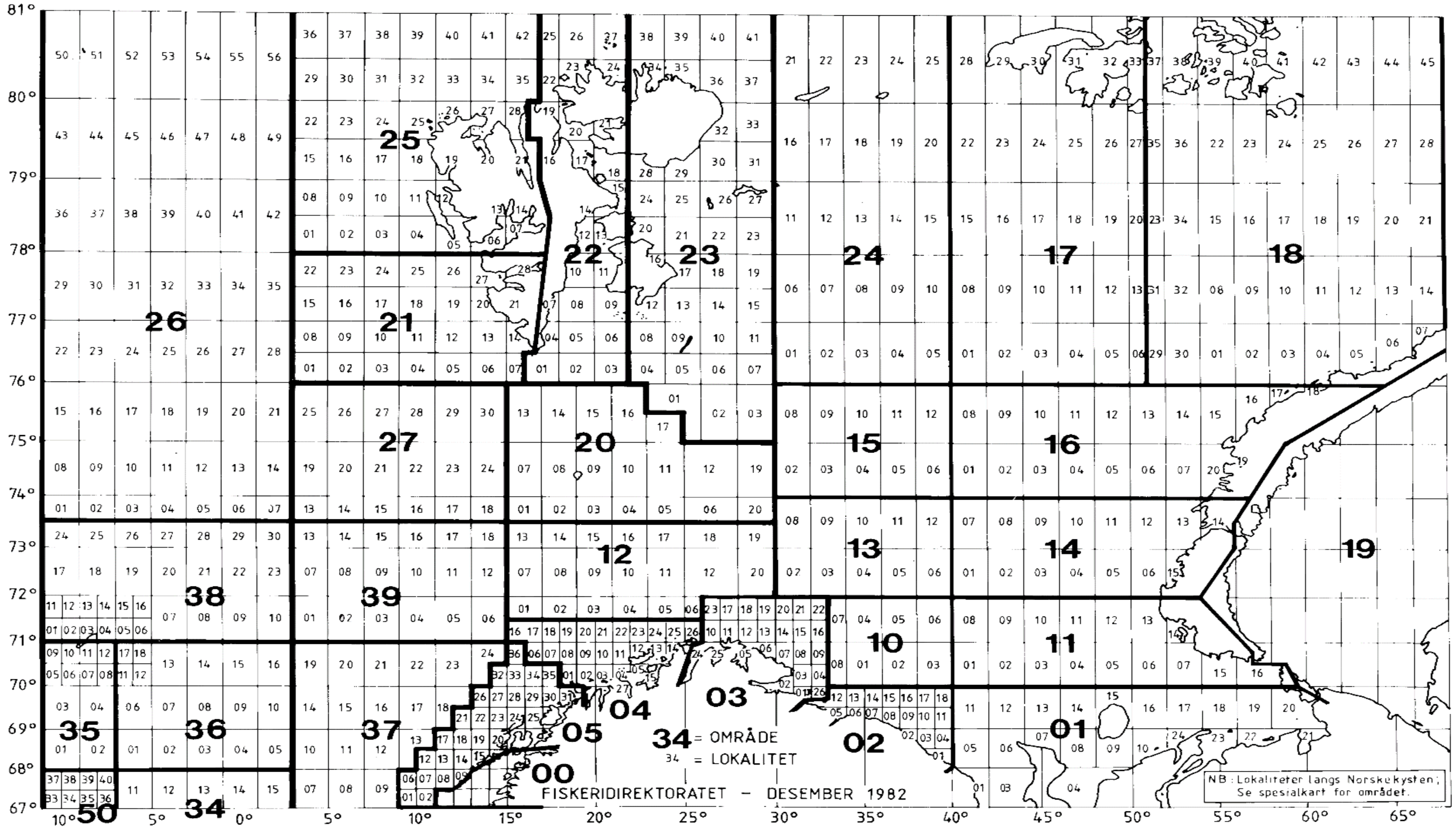


Figure 2.1a. Norwegian statistical rectangles in the Barents Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 03 and 04. The same areas are also referred to in the survey results (sec. 2.3).

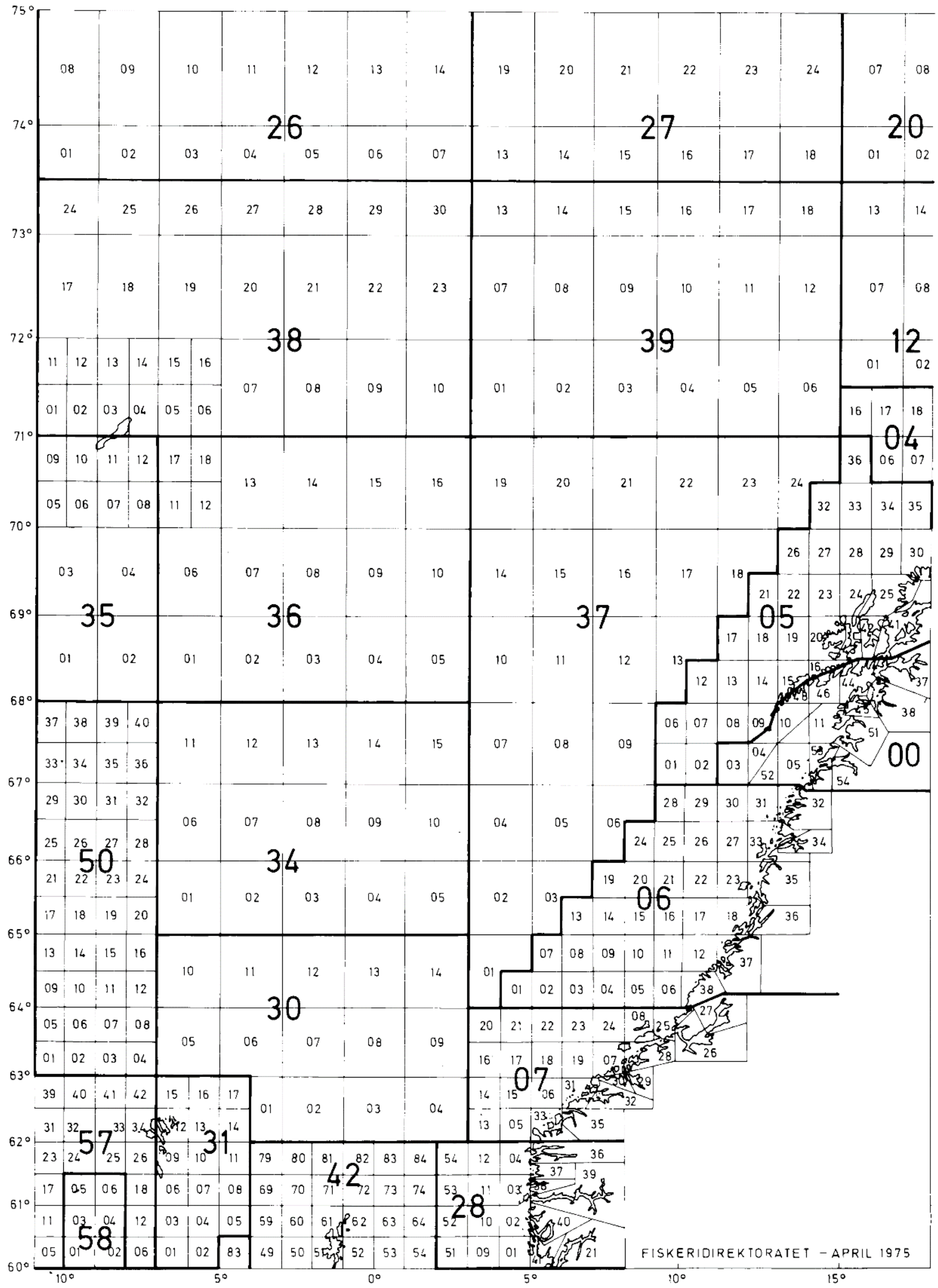


Figure 2.1b. Norwegian statistical rectangles in the Norwegian Sea. Coastal cod catches are estimated from the total cod catch taken inside 12 n.mile in areas 05, 00, 06 and 07. The same areas are also referred to in the survey results (sec. 2.3).

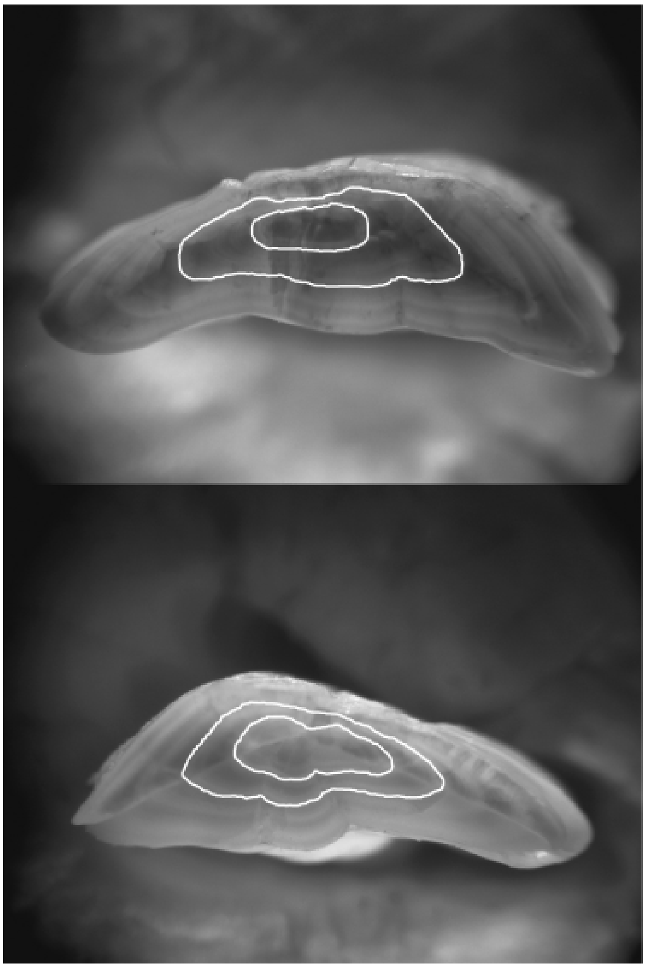


Figure 2.2. An image of a coastal cod otolith (top) and a northeast Arctic cod otolith (bottom). The two first translucent zones are highlighted. (from Berg *et al*., 2005).

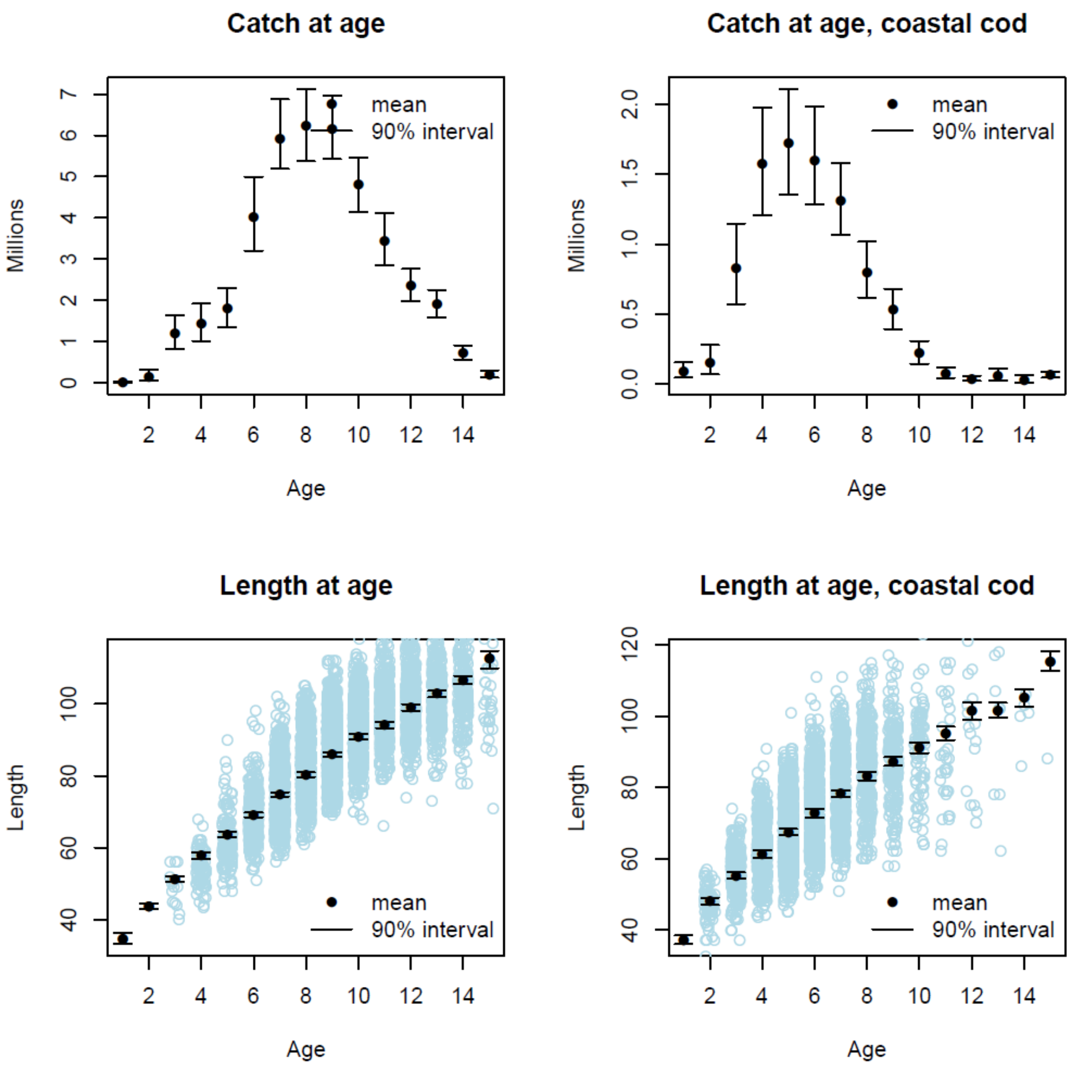


Figure 2.3a. ECA-output for 2018 commercial catches by Norway in the coastal statistical areas (Figure 2.5c). Left panels NEA cod. Right panels coastal cod.

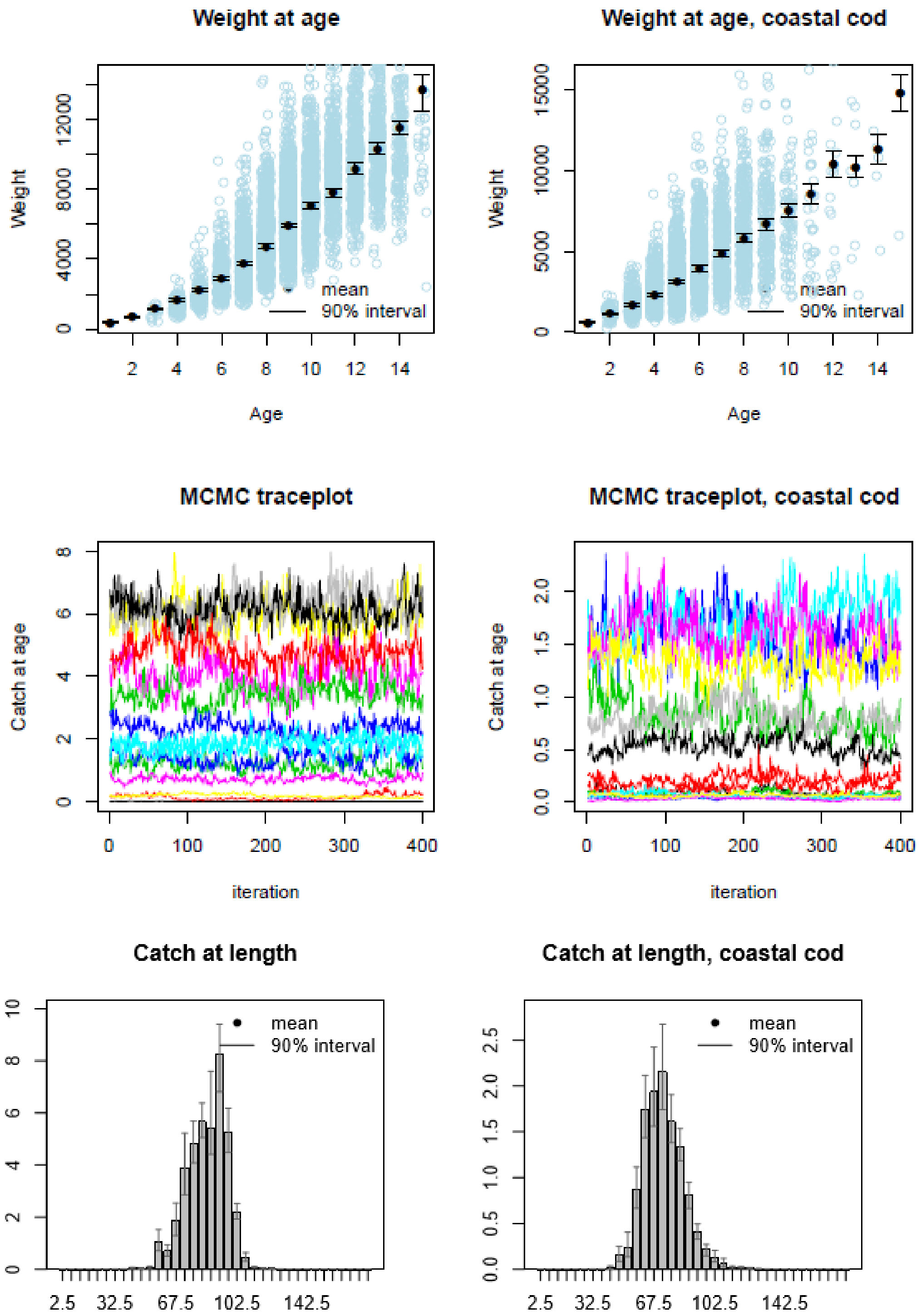


Figure 2.3b. ECA-output for 2018 commercial catches by Norway in the coastal statistical areas (Figure 2.5c). Left panels NEA cod. Right panels coastal cod.

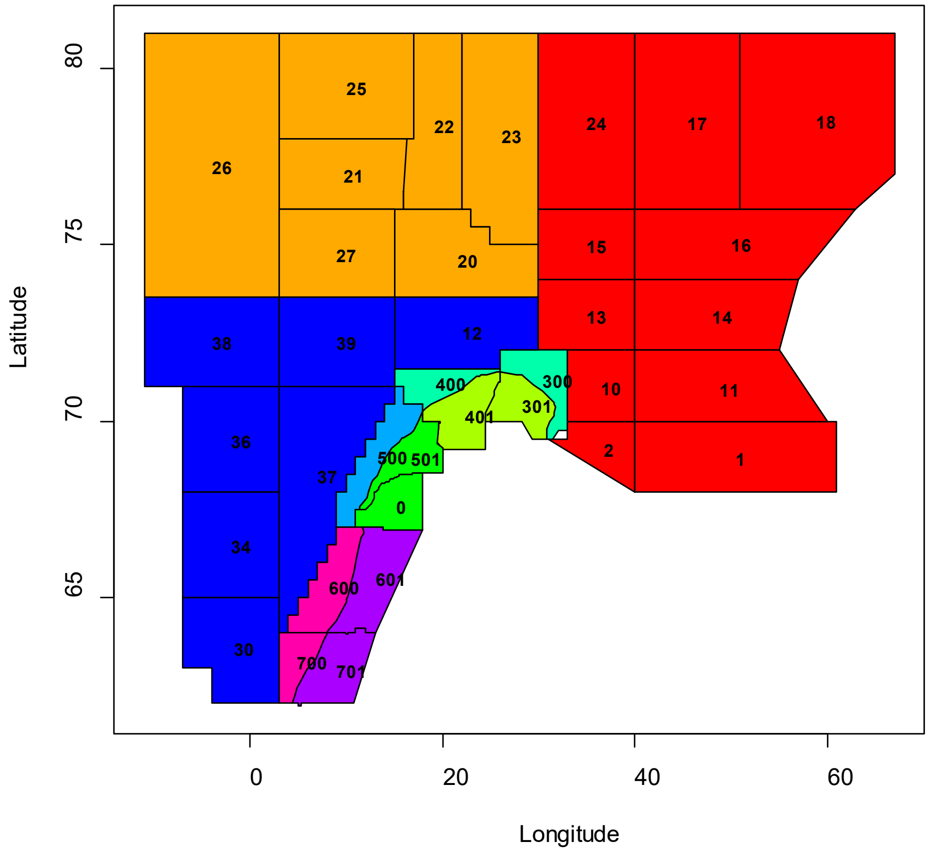


Figure 2.4. Norwegian statistical rectangles. The colors indicate area units used by the ECA-model for combining cod samples. Coastal cod are only estimated in coastal areas (0 and 300–701).

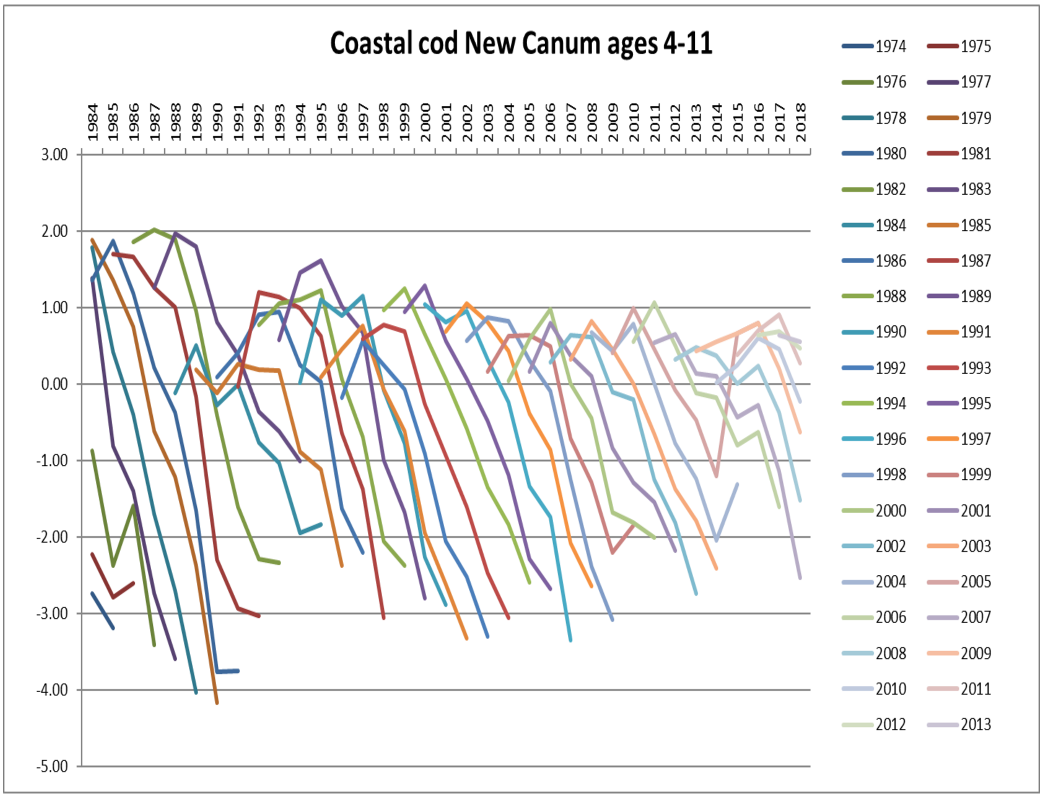


Figure 2.5a. Log catch numbers-at-age by cohort (series names) and catch years (x-axis). ECA estimates.

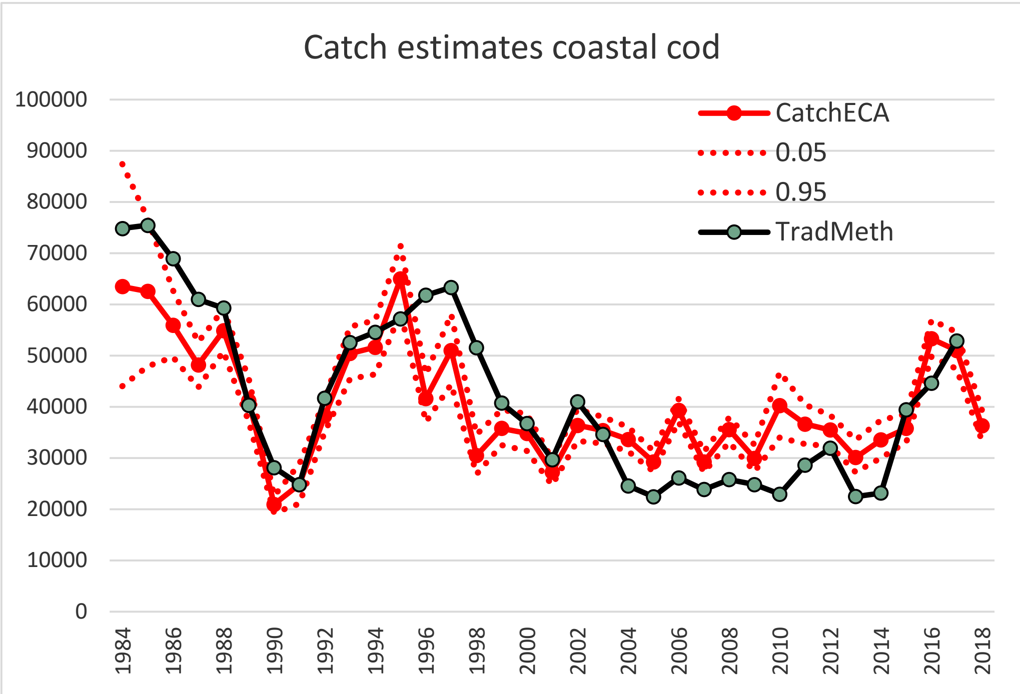


Figure 2.5b. Catches (tonnes) of coastal cod from the ECA analysis (with 5 and 95-percentiles), compared to the traditional estimates.

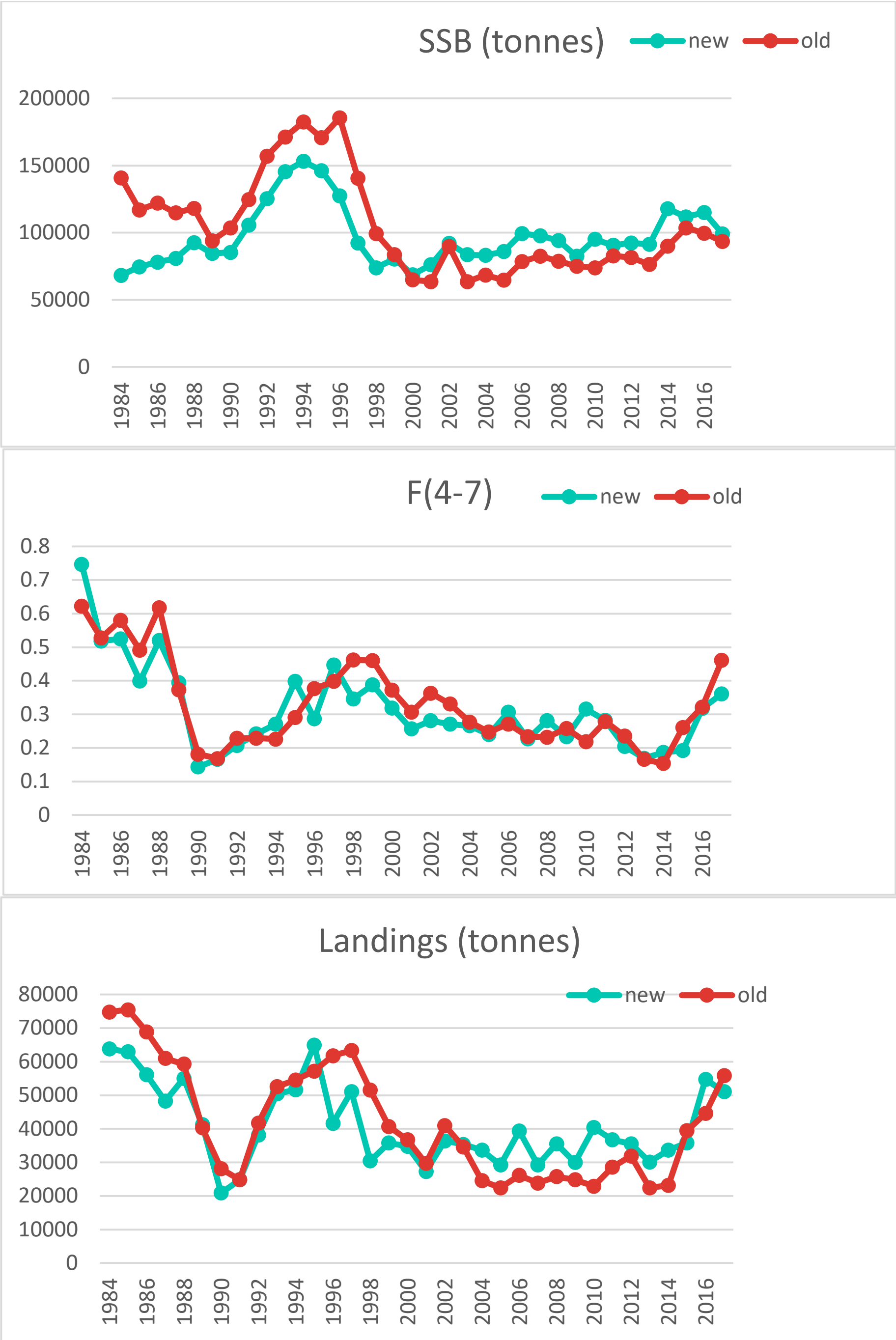
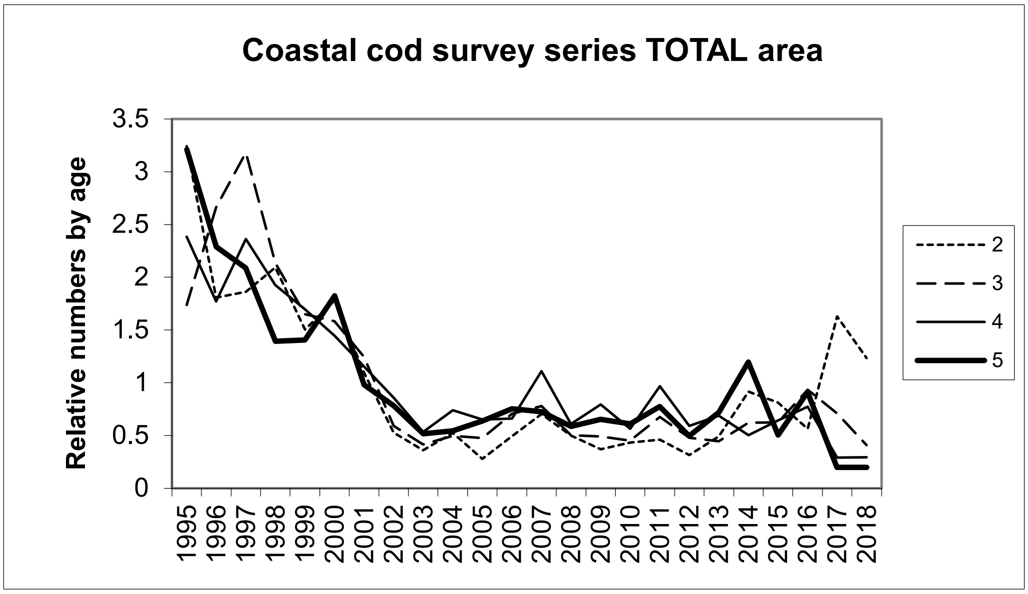


Figure 2.5c. XSA run (1984-2017) with Traditional estimates of catch-at-age as input (old), as used in 2018 AFWG, and run with ECA-estimates of catch-at-age as input (new), both runs tuned by the coastal survey data 1995-2017, ages 2-10+ (NOcoast-Aco-4Q).



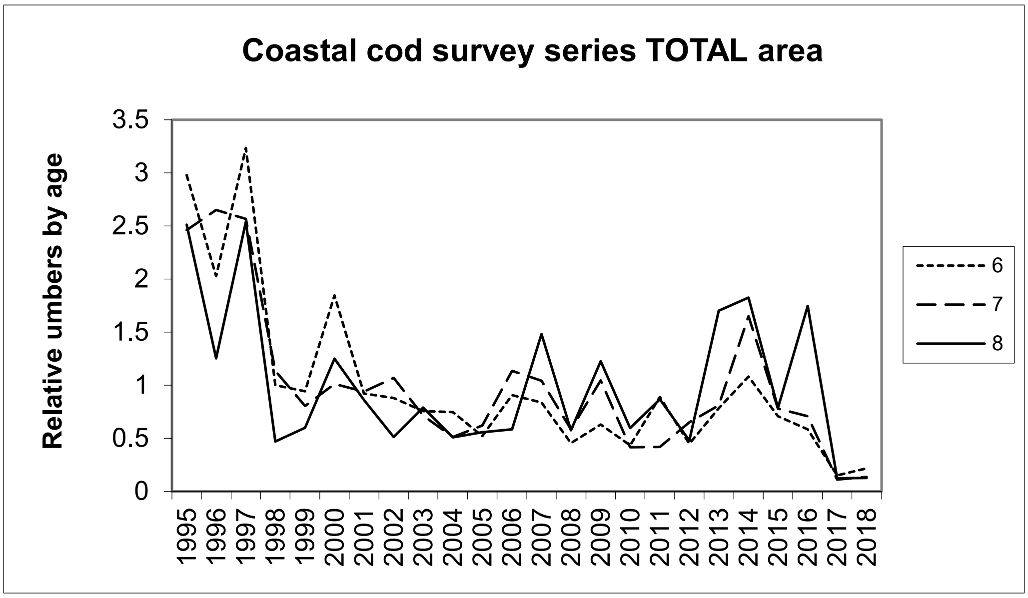
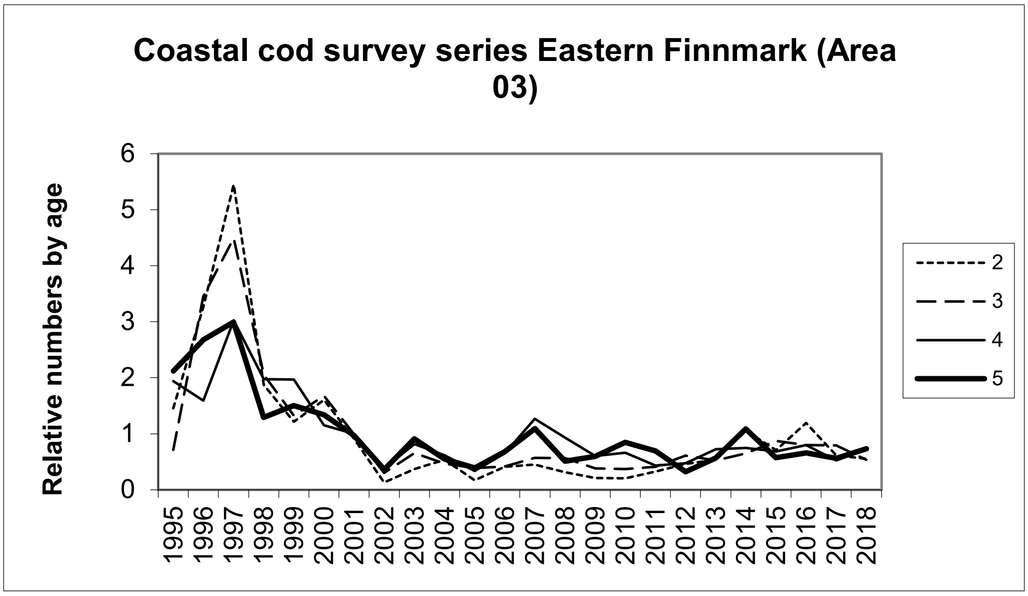


Figure 2.6. Coastal cod survey. Abundance at age relative to time-series average in total survey. Upper: ages 2–5, Lower: ages 6–8.



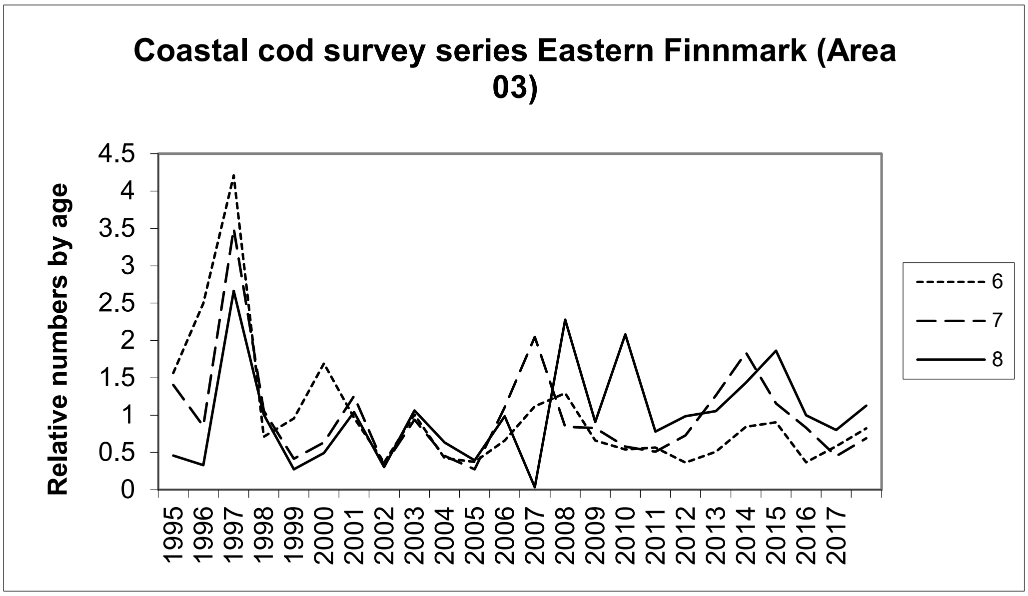
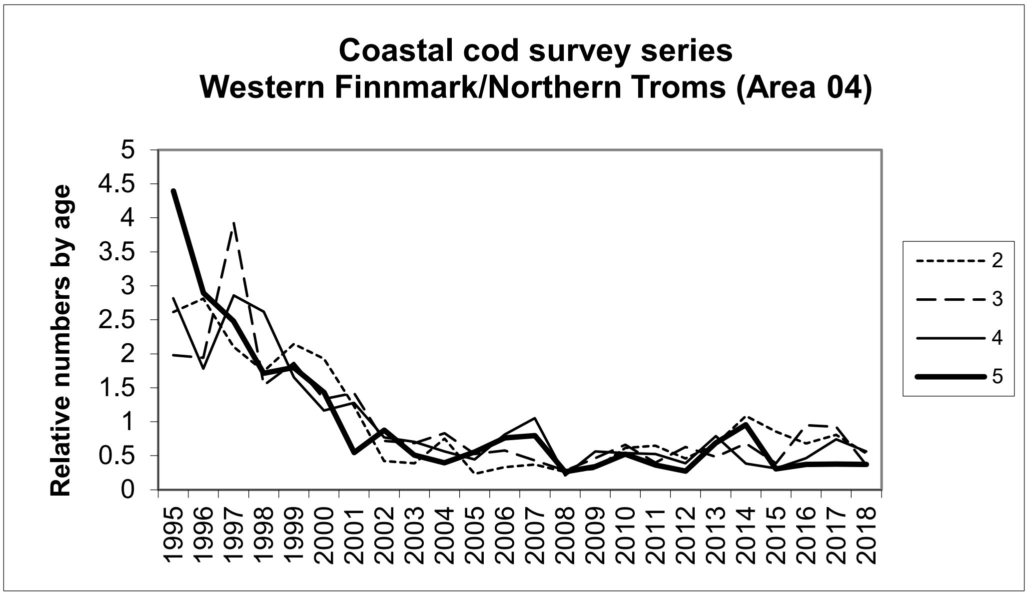


Figure 2.7. Coastal cod survey. Abundance at age relative to time-series average in statistical area 03. Upper: ages 2–5, Lower: ages 6–8.



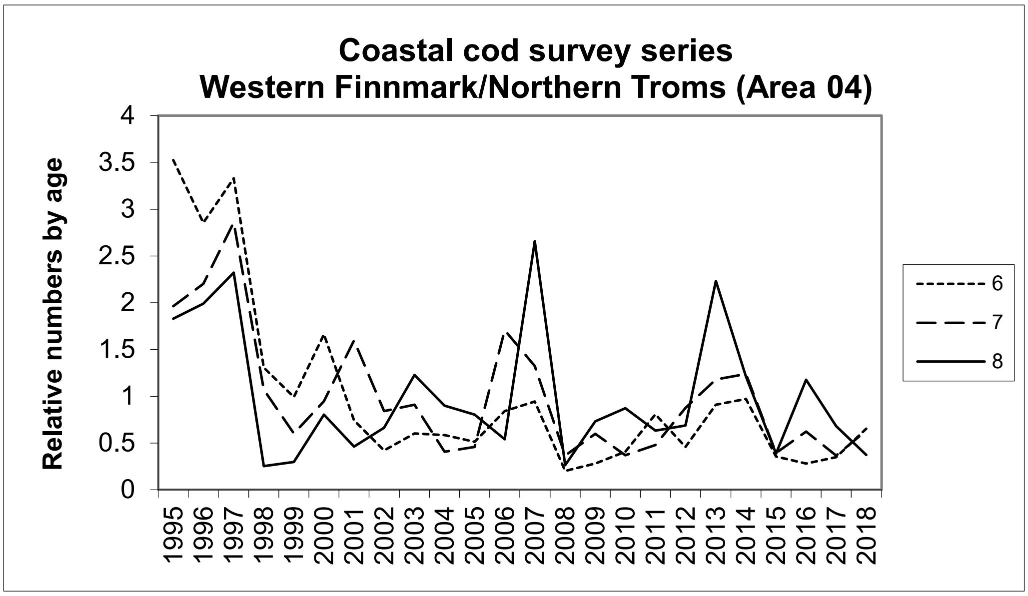
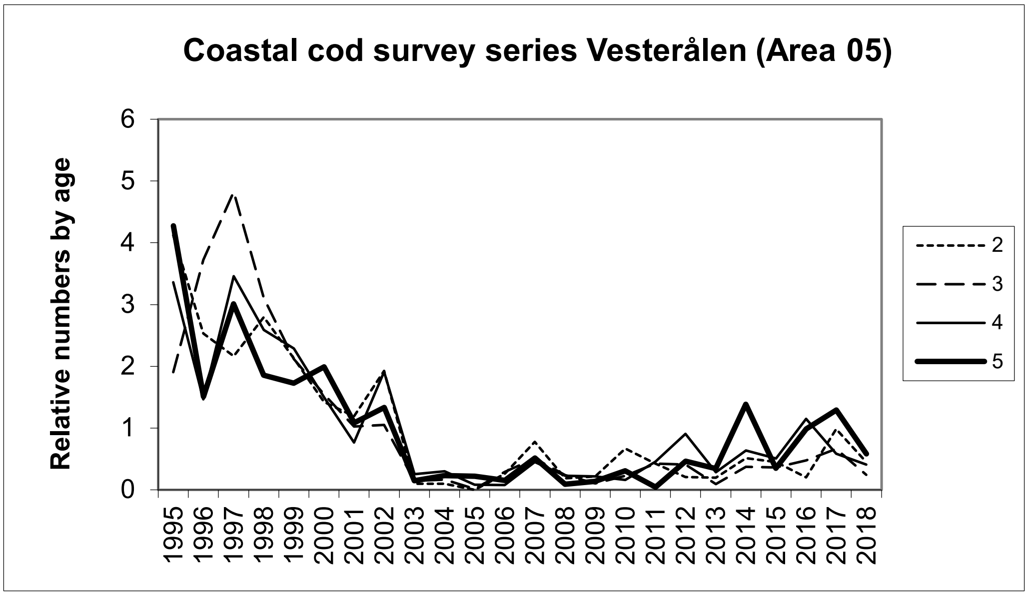


Figure 2.8. Coastal cod survey. Abundance at age relative to time-series average in statistical area 04. Upper: ages 2–5, Lower: ages 6–8



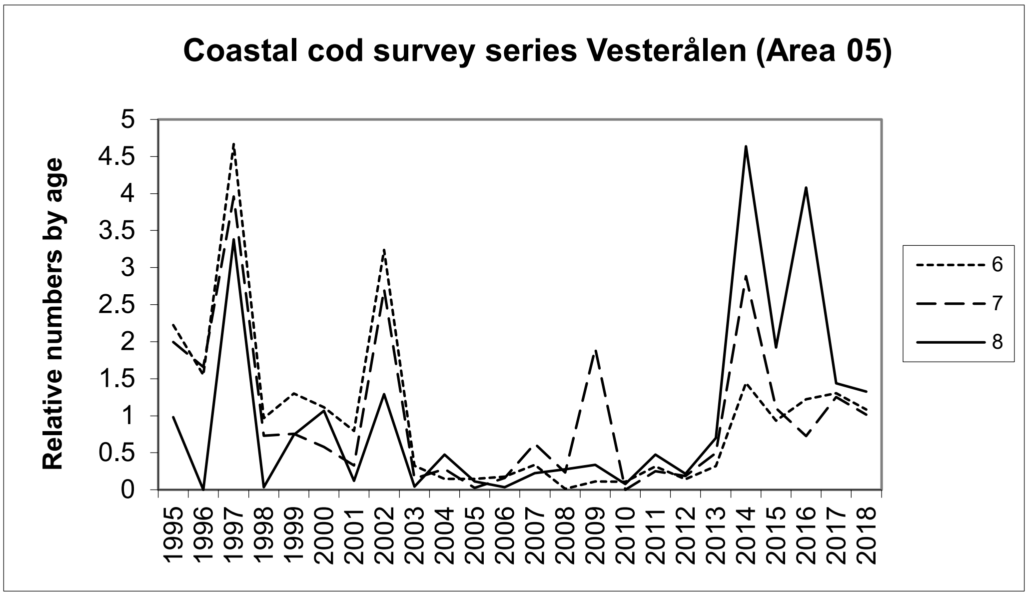


Figure 2.9. Coastal cod survey. Abundance at age relative to time-series average in statistical area 05. Upper: ages 2–5, Lower: ages 6–8.

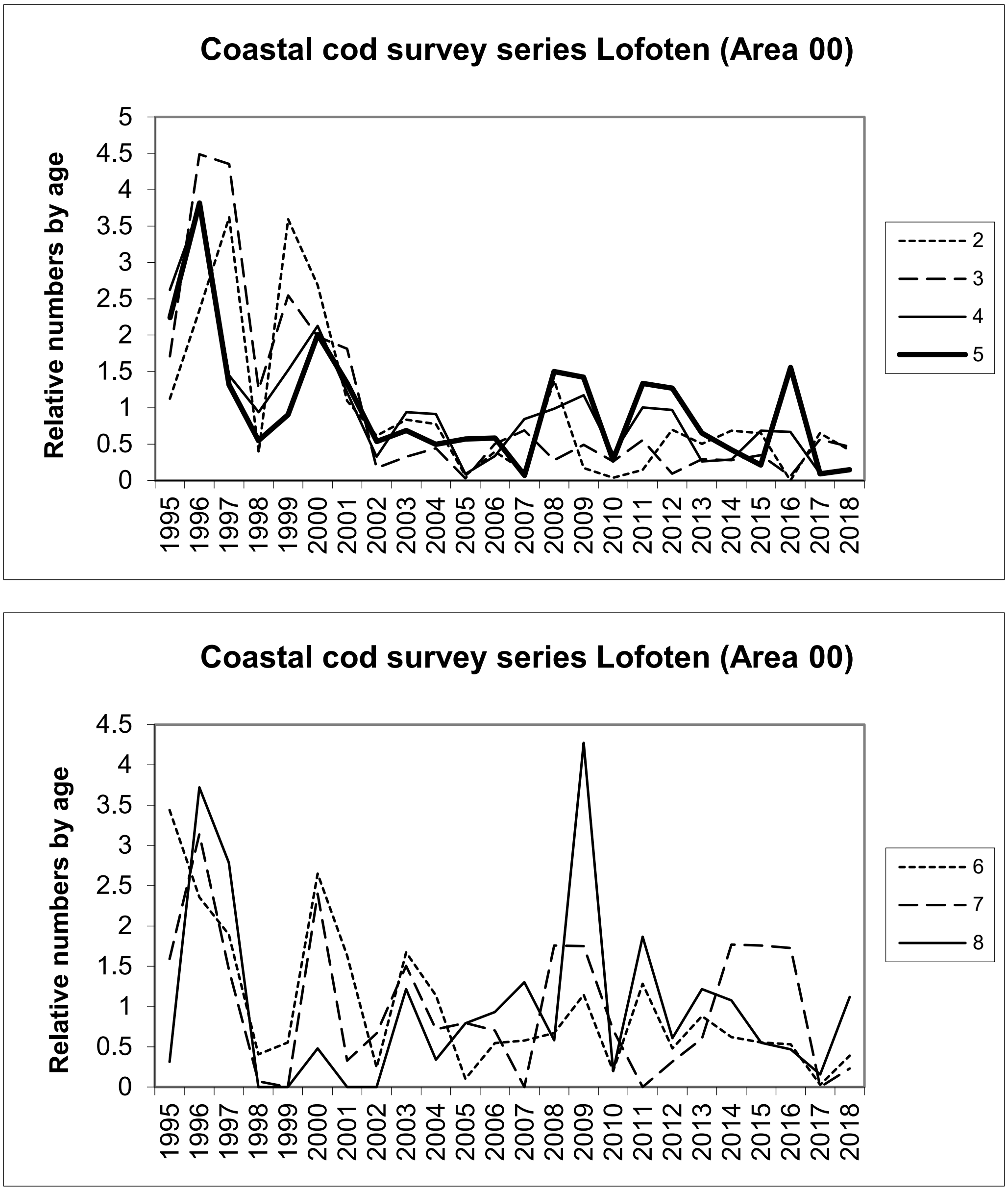


Figure 2.10. Coastal cod survey. Abundance at age relative to time-series average in statistical area 00. Upper: ages 2–5, Lower: ages 6–8.

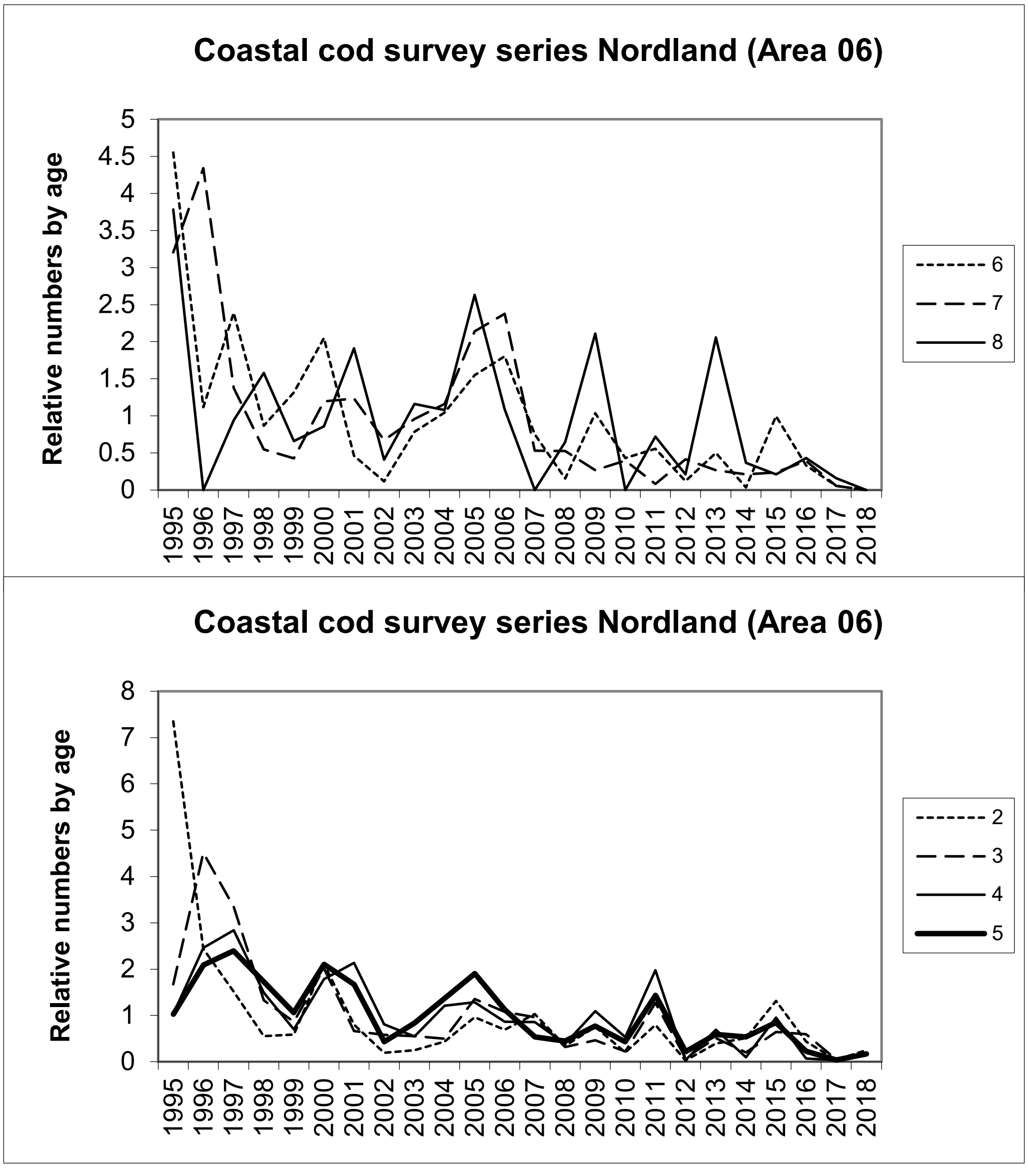
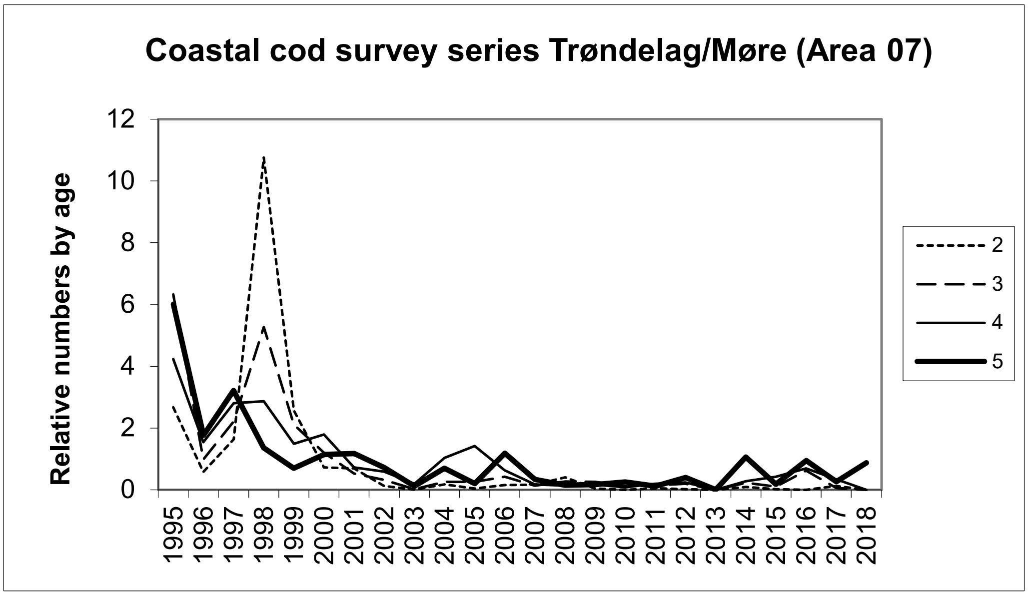


Figure 2.11 Coastal cod survey. Abundance at age relative to time-series average in statistical area 06. Upper: ages 2–5, Lower: ages 6–8.



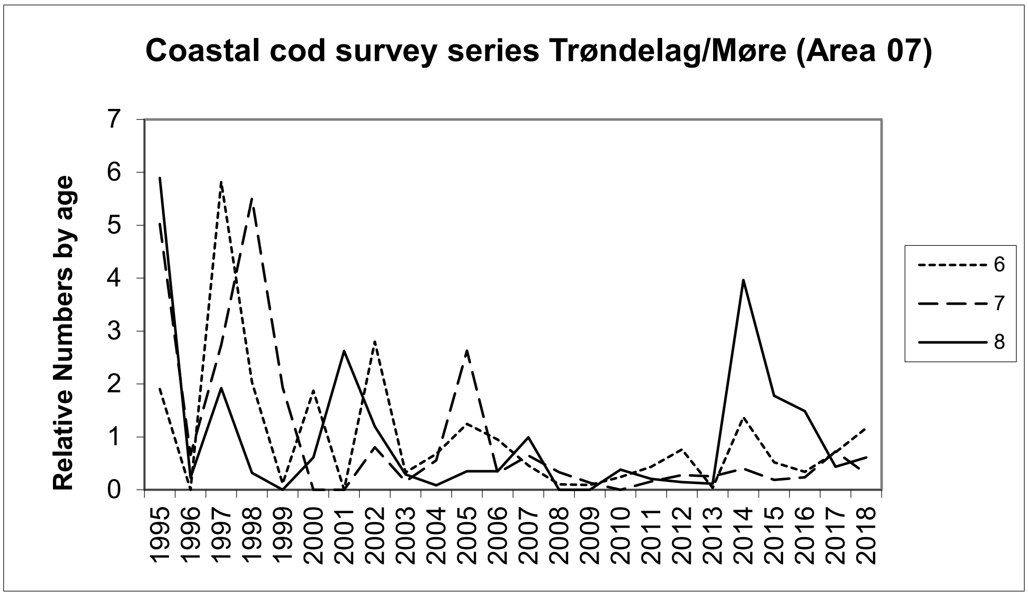


Figure 2.12. Coastal cod survey. Abundance-at-age relative to time-series average in statistical area 07. Some important areas at Møre was not covered in 2013. Upper: ages 2–5, Lower: ages 6–8.

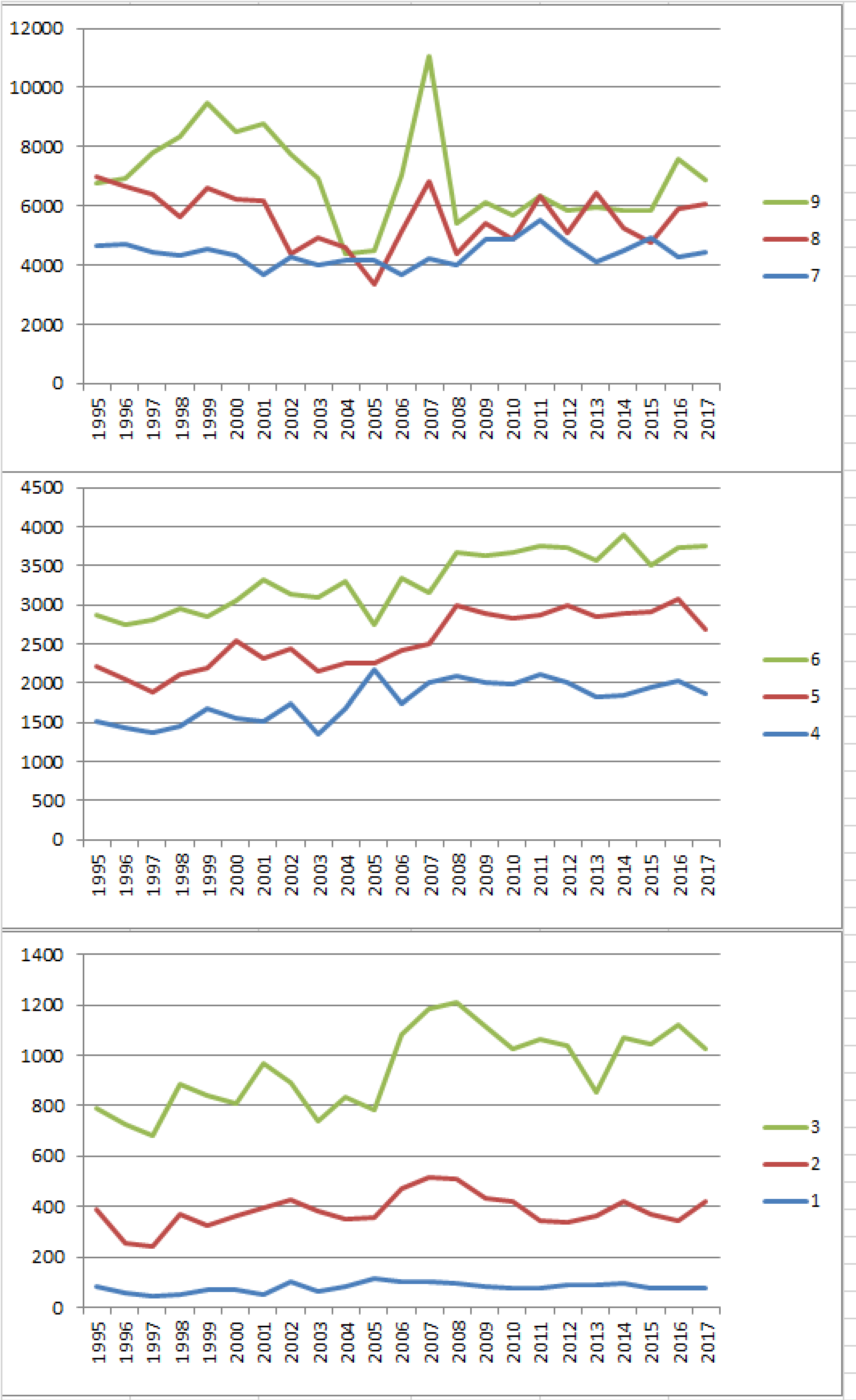


Figure 2.13a. Mean weights at age in the coastal survey

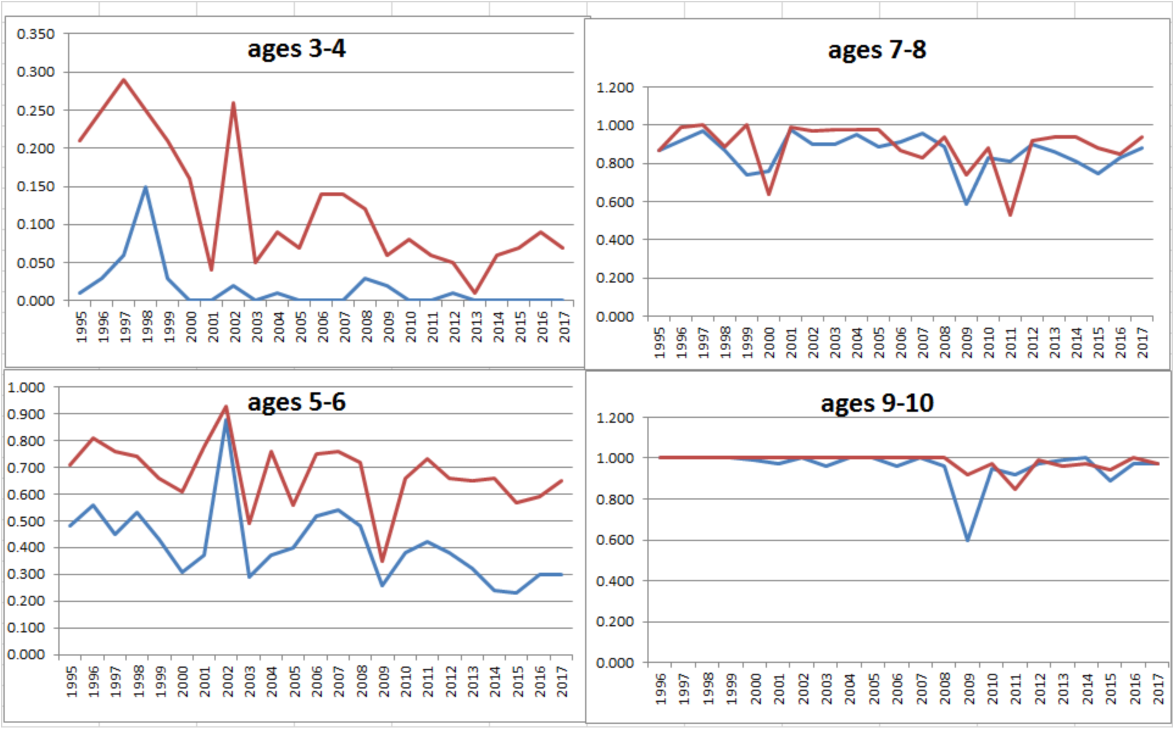


Figure 2.13b. Proportions mature-at-age as observed in the surveys. Ages 3, 5, 7 and 9 in blue, ages 4, 6, 8, and 10 in red.

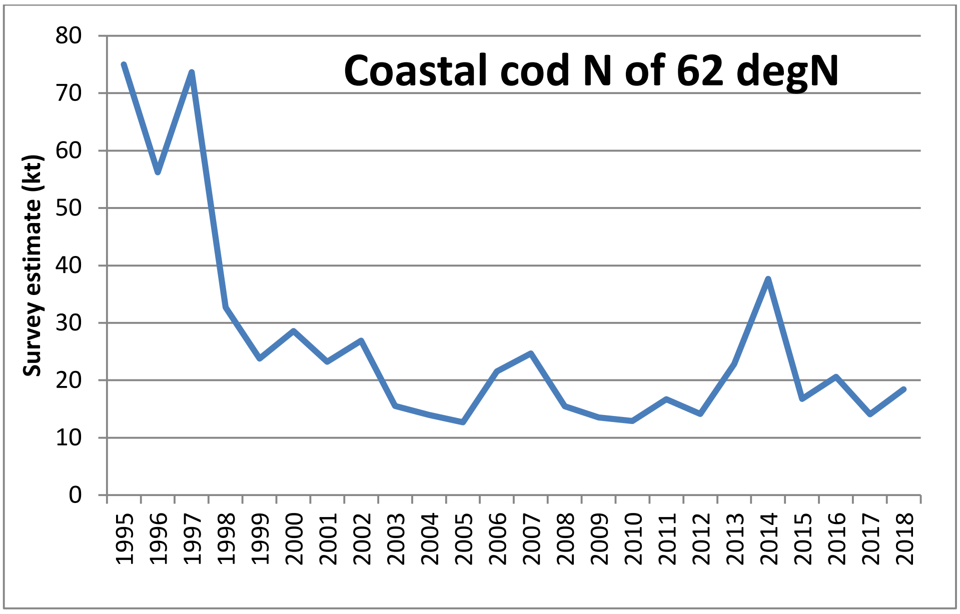


Figure 2.14. Survey SSB calculated by maturity observed in the surveys (red) and by maturity used in the VPA.

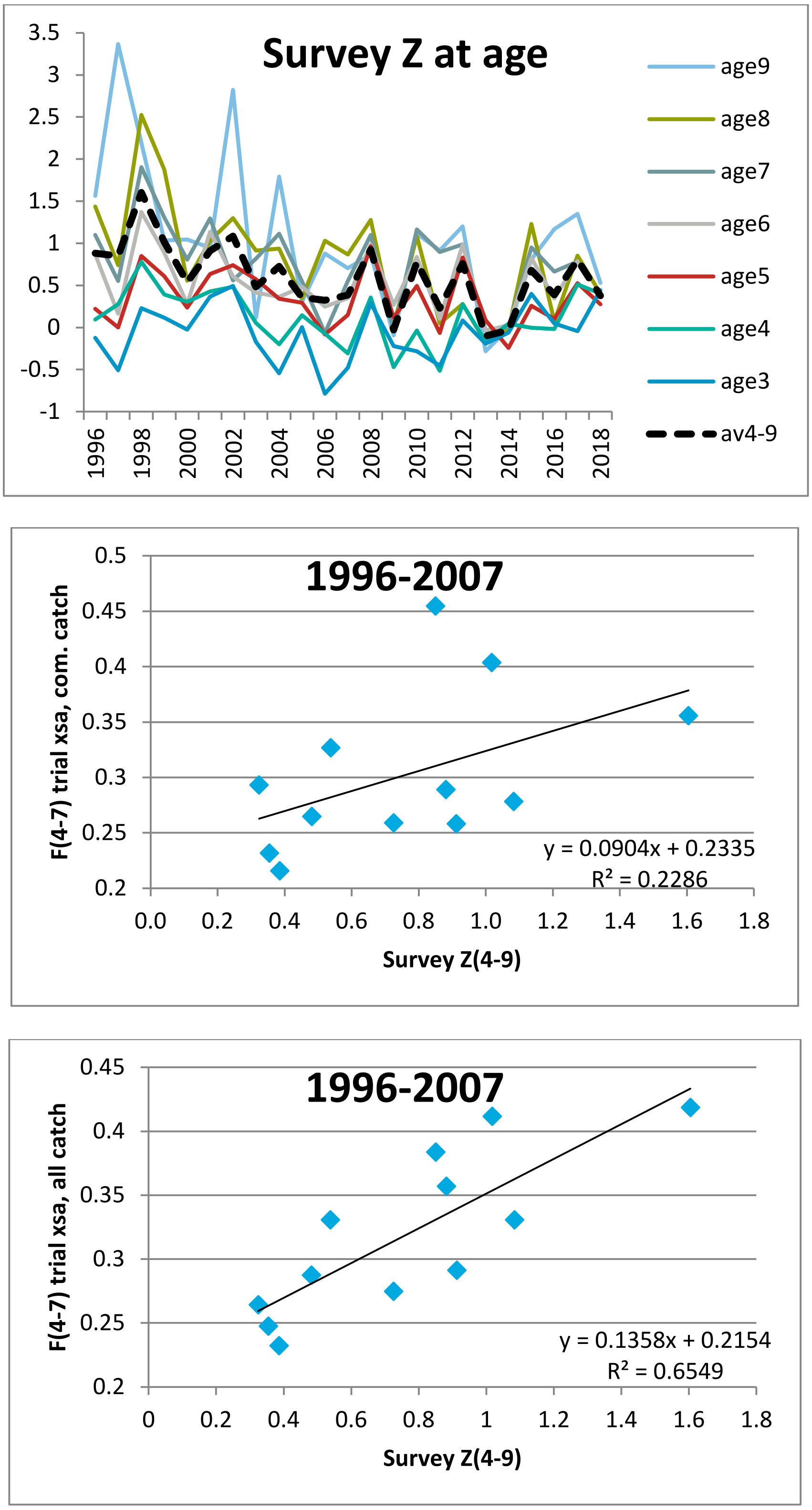


Figure 2.15. Survey mortality Z (upper) and relation to VPA values of $F_{(4–7)}$ over the period 1996–2007 for a trial XSA based on commercial catch (middle) and a trial XSA based on all catch (bottom).

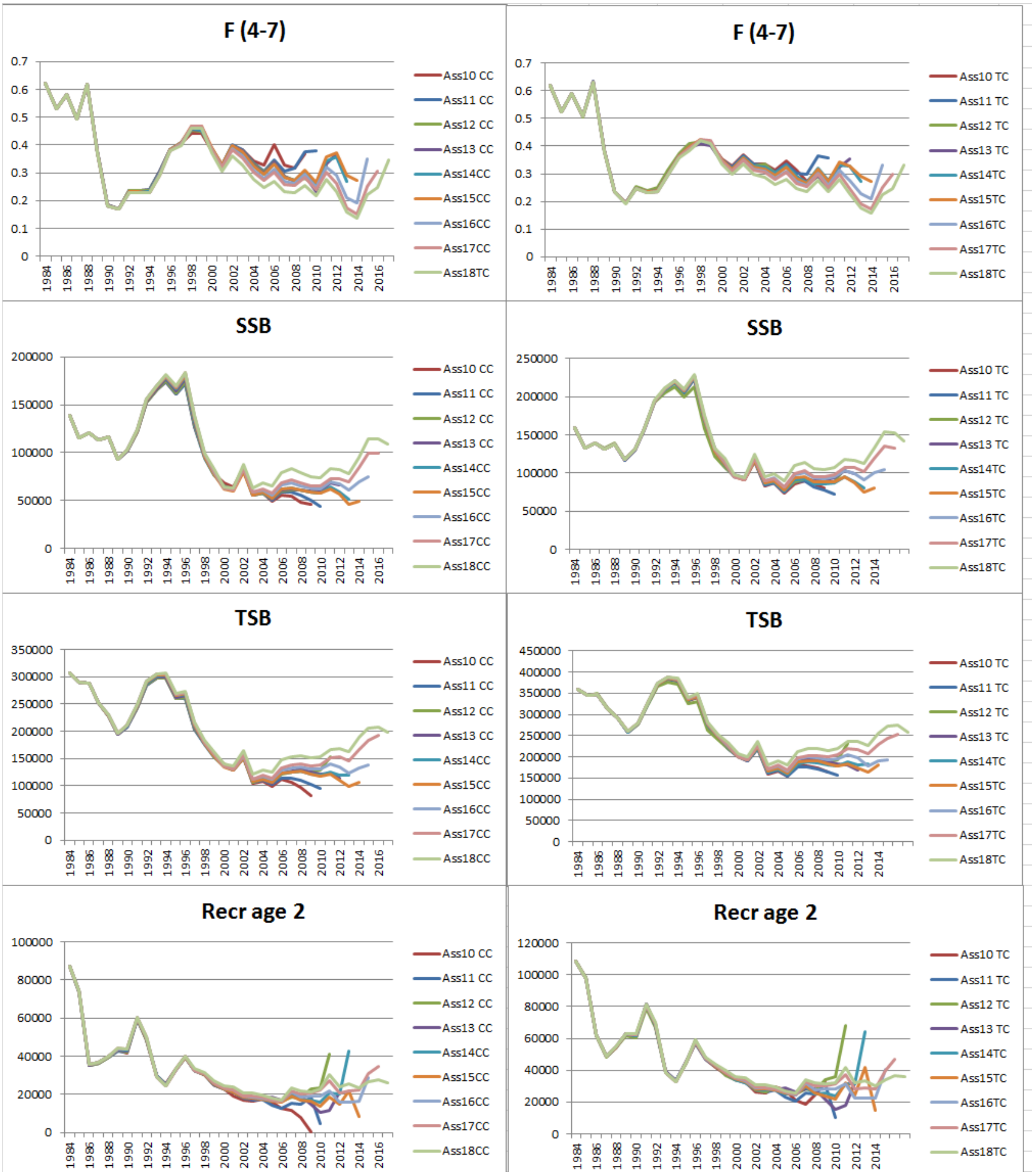


Figure 2.16. Comparisons of SVPA outputs in current assessment (Ass18) with the assessments in the years 2010-2017, for analyses based on commercial catch (left) and total catch (right). In all assessments the recruit estimate for the final year is highly uncertain. (2019 assessment not included).

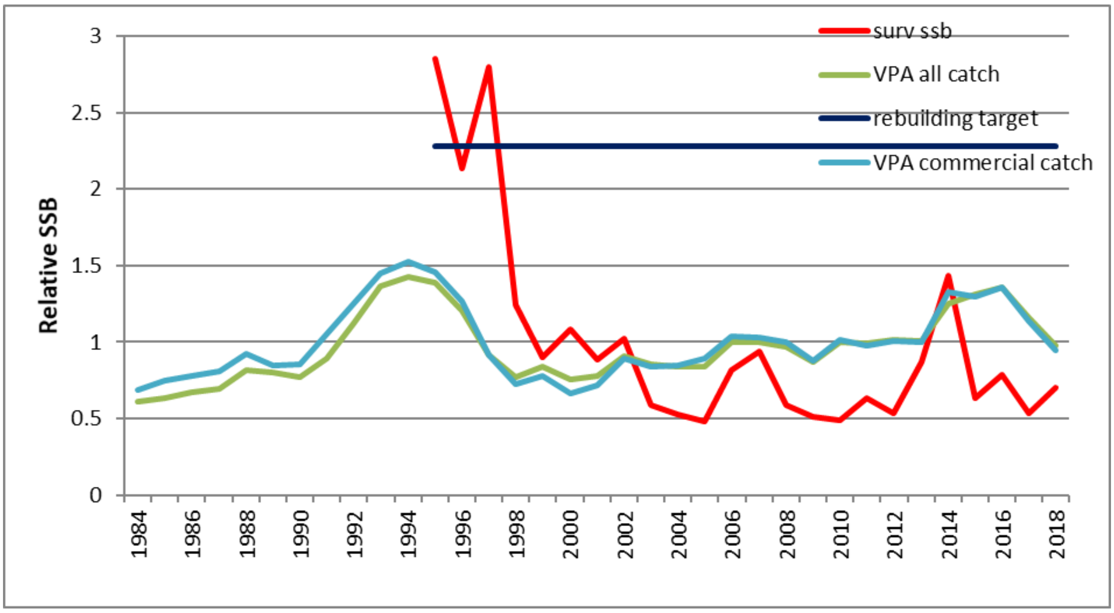


Figure 2.17. Coastal cod. Trends in spawning biomass. Each series are shown relative to its 1995–2017 average. The red line is survey SSB calculated with the same maturity ogive as in the VPA.

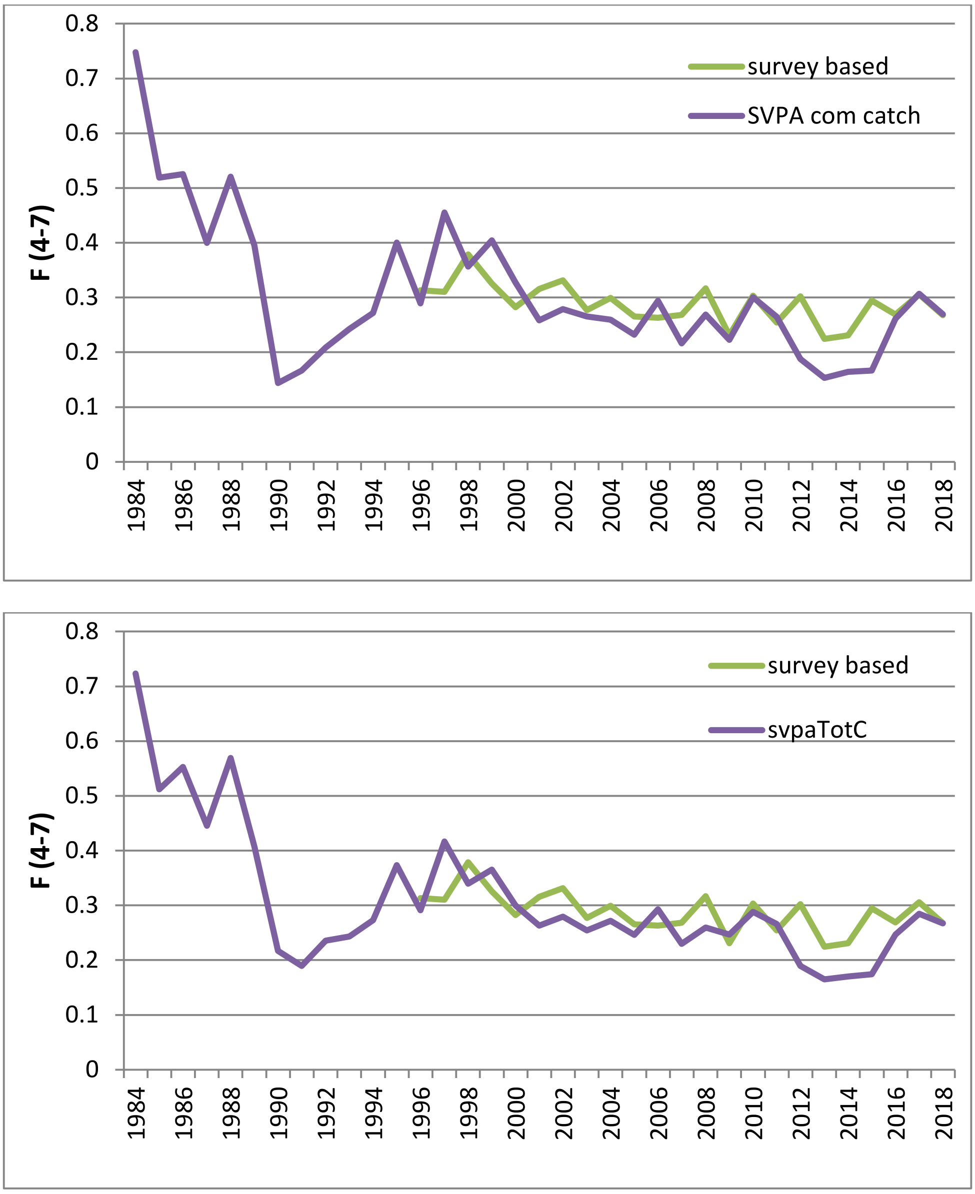


Figure 2.18. Time-series of F-estimates corresponding to commercial catch-at-age (upper) and total catch-at-age (lower). SVPA is in both cases a traditional VPA using the 2018 estimate of survey F as terminal F.

3 Northeast Arctic Cod (subareas 1 and 2)

General statement

This year AFWG made two alternative assessments for NEA cod based on the SAM model: SPALY – with the Same model Parameters As Last Year and final run with some changes in the model parameters (see sec. 3.5.1 for details). The final run is proposed by the group to be the basis for advice. Tables in the report with input data and observations are the same for the both runs. The other tables are presented in two parts:

- in the main body of the report section 3 there are tables with final run results;
- in section Annex there are assessment and prediction tables for the SPALY run.

The group notes that following a review (IBPNEACOD 2019) the Advice Drafting Group chose to reject the proposed changes in the "final" run, and that the advice given in 2019 is therefore based on the "SPALY" run described in the Section 3.13.

3.1 Status of the fisheries

3.1.1 Historical development of the fisheries (Table 3.1)

From a level of about 900 000 t in the mid-1970s, total catch declined steadily to around 300 000 t in 1983–1985 (Table 3.1). Catches increased to above 500 000 t in 1987 before dropping to 212 000 t in 1990, the lowest level recorded in the post-war period. The catches increased rapidly from 1991 onwards, stabilized around 750 000 t in 1994—1997 but decreased to about 414 000 t in 2000. From 2000—2009, the reported catches were between 400 000 and 520 000 t, in addition there were unreported catches (see below). Catches have been above the long-term average since 2011 and were 778 627 tonnes in 2018. The fishery is conducted both with an international trawler fleet and with coastal vessels using traditional fishing gears. Quotas were introduced in 1978 for the trawler fleets and in 1989 for the coastal fleets. In addition to quotas, the fishery is regulated by a minimum catch size, a minimum mesh size in trawls and Danish seines, a maximum bycatch of undersized fish, closure of areas having high densities of juveniles and by seasonal and area restrictions.

3.1.2 Reported catches prior to 2019 (Tables 3.1-3.4, Figure 3.1)

Reported catch of cod in Subarea 1 and Divisions 2.a and 2.b:

The provisional catch for 2018 reported to the working group is 778 627 t.

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

The historical practice (considering catches between 62°N and 67°N for the whole year and catches between 67°N and 69°N for the second half of the year to be Norwegian coastal cod) has been used for estimating the Norwegian landings of Northeast Arctic cod up to and including 2011 (Table 3.2). The catches of coastal cod calculated this way for the period 1960—2018 are given in Table 3.2 together with the coastal cod catches calculated based on otolith types (used in the coastal cod assessment as described in Section 2). For 2012–2018 the Norwegian catches have been analysed by an ECA-version designed for simultaneously providing estimates of catch numbers-at-age for each of the two stocks. By this procedure the amount of Norwegian catches calculated to be coastal cod in 2012, 2013, 2014, 2015, 2016, 2017 and 2018 is 35.2, 25.7, 33.6, 35.8, 54.9, 51.0, and 36.3 thousand tonnes. Table 3.2 includes ECA estimates of coastal cod for the whole period 1984—2018. The plan at the 2015 benchmark was for both stocks to use the ECA estimates for this whole period. As described in the coastal cod section (section 2) these tabulated ECA-results are still considered preliminary, and there is a need for further work on this before the whole time-series is applied. The catch by area, are shown in Table 3.1, and further split into trawl and other gears in Table 3.3. The distribution of catches by areas and gears in 2018 was similar to 2017. The nominal landings by country are given in Table 3.4.

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

In summer/autumn 2018, a Norwegian vessel caught 450 t of cod in the Jan Mayen EEZ, which is a part of ICES Area 2.a, mostly by long-line. Cod is known to occur in this area, but rarely in densities which are suitable for commercial fisheries. The cod caught in this area in 2018 was large (65–110 cm), and otolith readings and genetics both showed this cod to be a mix of Northeast Arctic and Icelandic cod. Norway will in 2019 carry out an experimental fishery during four different periods in order to investigate further the occurrence of cod in this area in space and time as well as stock identity. Two Norwegian vessels will participate in this fishery, and a TAC of 400 t has been set aside for each vessel. The 2018 catches in this area were counted against the Norwegian TAC for cod north of 62°N, while the 2019 TAC for this area comes in addition to the Norwegian TAC for cod as agreed by JNRFC.

3.1.3 Unreported catches of Northeast Arctic cod (Tables 3.1)

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

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

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

3.1.4 TACs and advised catches for 2018 and 2019

The Joint Norwegian-Russian Fisheries Commission (JNRFC) agreed on a cod TAC of 775 000 t for 2018, and in addition 21 000 t Norwegian coastal cod. The total reported catch of 814 985 t in 2018 was 18 985 t above the agreed TAC. Since 2015 JNRFC has decided that Norway and Russia can transfer to next year or borrow from last year 10% of the cod country's quota. That may lead to some deviation between agreed TAC and reported catch. Norwegian catches in 2018 were about 18 000 t above the TAC, while Russian and third country catches were very close to the TAC (differences of less than 3000 tonnes).

The advice for 2019 given by ACOM in 2018 was 675 000 t based on the agreed harvest control rule. The quota established by JNRFC for 2019 was equal to 725 000 tonnes. Thus, the TAC was not set according to the agreed HCR. In addition, the TAC for Norwegian Coastal Cod was set to the same value for 2019 as for 2018: 21 000 t.

3.2 Status of research

3.2.1 Fishing effort and CPUE (Table A1)

CPUE series of the Norwegian and Russian trawl fisheries are given in Table A1. The data reflect the total trawl effort, both for Norway and Russia. The Norwegian series is given as a total for all areas. Norwegian data for 2011–2018 are not necessarily compatible with data for 2007 and previous years.

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

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

The preliminary swept area estimates and acoustic estimates from the Joint winter survey on demersal fish in the Barents Sea in winter 2019 are given in Tables A2 and A3. More details on this survey are given in WD 04. The total area covered was about the same as in 2014 which is the most extensive coverage in the time series.

Before 2000 this survey was made without participation from Russian vessels, while in 2001—2005, 2008—2016 and 2018–2019 Russian vessels have covered important parts of the Russian zone. In 2006—2007 the survey was carried out only by Norwegian vessels. In 2007 and 2016 the Norwegian vessels were not allowed to cover the Russian EEZ. The method for adjustment for incomplete area coverage in 2007 is described in the 2007 report. Table 3.5 shows areas covered in the time-series and the additional areas implied in the method used to adjust for missing coverage in the Russian Economic Zone. In 5 of the 6 adjusted years (including 2017) the adjustments were not based on area ratios, but the "index ratio by age" was used. This means that the index by age for the covered area was scaled by the observed ratio between total index and the index for the same area observed in the years prior to the survey. The adjustments for 2017 were based on average index rations by age for 2014–2016.

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

The new method for calculating bottom trawl indices is described in Mehl *et al*. (2017b) and revised acoustic indices are given in Mehl *et al*. (2018). Time-series for weight-at-age and maturity-at-age for the years prior to 2018 should be revised accordingly.

With the recent expansion of the cod distribution it is likely that in recent years the coverage in the February survey (BS-NoRu-Q1 (BTr) and BS-NoRu-Q1 (Aco)) has been incomplete, in particular for the younger ages. This could cause a bias in the assessment, but the magnitude is unknown. The 2014–2019 surveys covered considerably larger areas than earlier winter surveys, and showed that most age groups of cod (particularly ages 1 and 2) were distributed far outside the standard survey area. The survey estimates within the standard area were used for the tuning data. If a wider coverage is continued in coming years, improved data for tuning and recruitment predictions might be obtained. Figure 3.7 shows the proportion by age of the swept area index which was found in the new northern area (see also Section 0.4).

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

The estimated abundance indices from the Norwegian acoustic survey off Lofoten and Vesterålen (the main spawning area for this stock) in March/April are given in Table A4. A description of the survey, sampling effort and details of the estimation procedure can be found in Korsbrekke (1997). The 2019 survey results in biomass terms was 663 thousand tonnes, this is almost twice the 2018 level and close to the 2017 level.

Russian autumn survey Acronym: RU-BTr-Q4

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

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

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

Swept area bottom trawl estimates from the joint Norwegian-Russian ecosystem survey in August-September for the period 2004–2018 are given in Table A14. This survey normally covers the entire distribution area of cod at that time of the year.

In 2014 this survey had an essential problem with area coverage in the north-west region because of difficult ice conditions. In the area covered by ice in 2014 a substantial part of population was distributed during 2013 survey. So, based on those observations AFWG decided in 2015 to exclude 2014 year from that tuning series in current assessment. In 2016 there was incomplete coverage in the international waters and close to the Murman coast. An adjustment for this incomplete coverage was made based on interpolation from adjacent areas (Kovalev *et al* 2017, WD 12). At this time of the year, usually a relatively small part of the cod stock is found in the area which was not covered in 2016. In 2017 the coverage was very close to complete.

In 2018, a large area in the eastern part of the Barents Sea was not covered (https://www.imr.no/tokt/okosystemtokt_i_barentshavet/survey_reports/nb-no). It was attempted to adjust for this lack of coverage based on historical data, but those attempts were considered unsuccessful. Thus it was decided not to include 2018 data from this survey, given in WD 01, in the assessment.

Revision of this time-series using the StoX calculation method is in progress (WD 03).

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

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

The Joint winter survey in 2019 shows stable size-at-age values (Table A6).

3.2.3 Age reading

The joint Norwegian-Russian work on cod otolith reading has continued, with regular exchanges of otoliths and age readers (see chapter 0.5). The results of fifteen years of annual comparative age readings are described in Yaragina *et al*. (2009). Zuykova *et al*. (2009) re-read old otoliths and found no significant difference in contemporary and historical age determination and subsequent length-at-age. However, age at first maturation in the historical material as determined by contemporary readers is younger than that determined by historical readers. Taking this difference into account would thus have effect on the spawning stock-recruitment relationship and thus on the biological reference points. The overall percentage agreement for the 2015–2016 exchange was 88.7% (Mjanger and Godiksen, 2018, WD 10). The main reason for cod ageing discrepancies between Russian and Norwegian specialists remains the same, representing the latest summer growth zone, and different interpretations of the false zones. The general trend is that the Russian readers assign slightly lower ages than the Norwegian readers compared to the modal age for all age groups. This is opposite of what we have seen in previous readings, where the Russian readers has tended to be slightly overestimating the age compared to the Norwegian readers.

The trend with bias in NEA cod age determination registered for some years of the period 1992–2016 between experts of both countries is a solid argument to continue comparative cod age reading between PINRO and IMR to monitor the situation. The German participant has expressed an intention to join the age reading cooperation in future.

3.3 Data used in the assessment

3.3.1 Catch-at-age (Tables 3.6)

For 2018, age compositions from all areas were available from Russia, Norway, Spain, Germany and Poland (Division 1 and 2b only). Unsampled catches were distributed on age by using data from Russian trawl in Subarea 1 and Division 2.a, and by using data from Norwegian trawl in Division 2.b. The catch-at-age data were calculated using InterCatch (Table 3.6).

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

Length distributions from the Russian fishery were made by observers on board fishing vessels in reasonably sufficient quantity in all areas. Also, length samples of cod taken by Norwegian Coast Guard on board Russian fishing vessels in Norwegian economic zone (NEZ) in first quarter of 2018 were used in calculations of length/age distributions. These data were combined with Russian observers' data. An advantage of adding the Norwegian Coast Guard data is that they were taken in all months of the first quarter and over the whole NEZ area. However, biological sampling from the trawl fishery has been relatively low, especially in Division 2a.

It should be noted that for ages 14 and 15, the catch-at-age in 2018 is the highest since the early 1950s (Table 3.6).

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

Catch weights

For 2018, the mean weight-at-age in the catch (Table 3.8) was obtained from InterCatch as a weighted average of the weight-at-age in the catch for Norway, Russia, Spain, Poland, and Germany (Table 3.7). The weight-at-age in the catch for all countries is given in Table 3.9. From 2000 to 2016, AFWG working group applied 13 as plus group. The weight-at-age 13, 14, and 15 in the catch for 1946–1982, needed due to extended age range, was as last year taken from AFWG 2001 (ICES CM 2001/ACFM:19). For the 2019 assessment, it was decided to use the same, as in the last year, procedure for weight-at-age calculations for the recent period (1983-onwards): Observations were used for ages up to 11. However, because of very noisy values observed for older fish, weight-at-age 12–15 was set to constant values in this period. Weight-at-age 12 was equal to the mean for 1983–2015; the mean increment for ages 12–13, 13–14 and 14–15+ groups in the 1983–2015 period were used to calculate weight-at-age 13, 14, and 15.

Stock weights

For ages 1—11 stock weights-at-age at the start of year y ($W_{a,y}$) for 1983—2018 (Table 3.9) were calculated as follows:

$$W_{a,y} = 0.5(W_{rus,a-1,y-1} + (\frac{N_{nbar,a},_y W_{nbar,a},_y + N_{lof,a,y} W_{lof,a,y}}{N_{nbar,a},_y + N_{lof,a},_y}))$$

where

$W_{rus,a-1,y-1}$: Weight-at-age a-1 in the Russian survey in year y-1 (Table A12)

$N_{nbar,a,y}$: Abundance-at-age a in the Norwegian Barents Sea acoustic survey in year y (Table A2)

$W_{nbar,a,y}$: Weight-at-age a in the Norwegian Barents Sea bottom trawl survey in year y (Table A6)

$N_{lof,a,y}$: Abundance-at-age a in the Lofoten survey in year y (Table A4)

$W_{lof,a,y}$: Weight-at-age a in the Lofoten survey in year y (Table A8)

Ecosystem survey data on length and weight-at-age are not used because of longer distance between survey time and beginning of the year (assessment using numbers at 1 January).

This year, the same procedure was used for weight-at-age in stock calculations for retro period (1946—1982) assuming that weight-at-age in stock was equal to weight-at-age in catch. Weight-at-age 12—15 was fixed for recent period (1983-onwards). Average values of Fleet 15 (BS-NoRu-Q1 (BTr)) data available at the moment for older age groups (12—15) were used for calculations of average weight-at-age in stock in this period.

Russian data for weight and maturity-at-age in autumn 2018 were not available as the survey was not conducted. In WD 15 to AFWG 2019, correction factors to allow for this when calculating the weight and maturity-at-age in 2019 were updated, based on historical differences between Norwegian and Russian data in the same way as in the 2017 (Yaragina and Bogstad, 2017, WD 10). These correction factors were then applied to the Norwegian data for 2019.

3.3.3 Natural mortality including cannibalism (Table 3.12)

A natural mortality (M) of 0.2 + cannibalism was used. Cannibalism is assumed to only affect natural mortality of ages 3-6. In addition, cannibalism was taken into account.

The method used for calculation of the prey consumption by cod described by Bogstad and Mehl (1997) is used to calculate the consumption of cod by cod (Table 3.12) for use in cod stock assessment. The consumption is calculated based on cod stomach content data taken from the joint

PINRO-IMR stomach content database (methods described in Mehl and Yaragina 1992). On average about 9000 cod stomachs from the Barents Sea have been analysed annually in the period 1984—2018.

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

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

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

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

3.3.4 Maturity-at-age (Tables 3.10 and 3.11)

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

Since 1982 Russian and Norwegian survey data have been used (Table 3.10). For the years 1985—2018, Norwegian maturity-at-age ogives have been obtained by combining the Barents Sea winter survey and the Lofoten survey. Russian maturity ogives from the autumn survey as well as from commercial fishery for November-February are available from 1984 until present. The Norwegian maturity ogives tend to give a higher percent mature-at-age compared to the Russian ogives, which is consistent with the generally higher growth rates observed in cod sampled by the Norwegian surveys. The approach used is consistent with the approach used to estimate the weight-at-age in the stock (described in Section 3.3.2). The percent mature-at-age for the Russian and Norwegian surveys have been arithmetically averaged for all years, except 1982—1983 when only Norwegian observations were used and 1984 when only Russian observations were used.

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

Maturity-at-age for cod has been variable the last five years, particularly for ages 6–9. According to the combined data, maturation at age decreased in 2015–2016 but has now returned to a level close to that in 2010 and previous years.

The proportions of mature cod for age 13–15 was set to 1 for the period 1984–present, while for the period 1946–1983 data were taken from the AFWG 2001 report (ICES CM 2001/ACFM:19).

3.4 Changes of assessment model and data at the latest benchmark

The range of ages in the stock has been expanding and this has caused some problems with the age range used in the stock assessment. One of the basic goals of the Inter-Benchmark meeting in April 2017 (ICES 2017/ ACOM:29) was to investigate if and how information on stock dynamics at older ages (biological, survey, and fishery data) may be included into the analytical stock assessment.

At the inter-benchmark meeting it was decided to use SAM as the main assessment model for this stock and to use an extended age range in the tuning series.

3.5 Assessment using SAM (Tables 3.13, A13)

The following survey dataseries were used:

Fleet code	Name	Place	Season	Age	Years
Fleet 15	Joint bottom-trawl survey	Barents Sea	Feb-Mar	4–12	1981–2019
Fleet 16	Joint acoustic survey	Barents Sea+Lofoten	Feb-Mar	4–12	1985–2019
Fleet 18	Russian bottom-trawl survey	Total area	Oct-Dec	3–12	1982–2017
Fleet 007	Ecosystem survey	Total area	Aug-Sep	3–12	2004–2017

Note that the surveys that are conducted during winter (FLT 15 and 16) are allocated to the time of the year when they are carried out, previously they were allocated the end of the previous year, as that was the only possibility for using them when running XSA.

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

Survey indices for Fleet 15 have been multiplied by a factor 100, while survey indices for Fleets 007, 16, and 18 have been multiplied by a factor 10. This was done to keep the dynamics of the surveys even for very low indices, because some models (e.g. XSA) adds 1.0 to the indices before the logarithm is taken. The Fleet 16 index (Table A13), which is a sum of the index from the Lofoten survey and acoustic index from the winter survey, has not yet been updated for years before 2018 with new data from StoX estimates for the acoustic index from the winter survey (Mehl *et al*., 2018a). For 2018 onwards StoX estimates have been used in the calculations.

3.5.1 Model adjustment and settings (Table 3.14)

At the inter-benchmark it was decided to have the same observation variance at age within each of the 4 tuning series and in the commercial catches, i.e. the simplest possible structure. At the time this seemed reasonable since there were very few fish in the oldest age groups (and note that time at the interbenchmark for checking settings was limited). Since the IBP however, the proportion of the stock and catch in the oldest age groups has increased and can no longer be treated as insignificant (36% of the catch in biomass in 2018 was from age 10+ fish and 14+ from age 12+). The last interbenchmark was held prior to the 2017 stock assessment and thus used 2015 as the last data year for catches. Thus this year’s assessment had three more years of available data and the two strong year classes were age 13 and 14 in the last data year compared to age 10 and 11 in the data set used at the inter-benchmark. At the same time the model diagnostics were indicating that the variance in the data for these oldest fish was (unsurprisingly) different from the younger fish.

The variance structure was thus adjusted at the assessment meeting compared to the benchmark settings. Investigating the residuals (WD 2) proposed age groups which needed separate variance parameters. These parameters were added to the model

The final adjusted variance structure, which is almost identical to the one proposed in WD 2 (the only change is that age 13 was added to the block with ages 14 and 15 for catch data), prescribes the following parameters: Two variance parameters for catches (ages >12 and age 12 and above), three variance parameters for fleet 15 (separate for age four, separate for age 11, and one common for the remaining ages), two variance parameters for fleet 16 (separate for age 11, one common for remaining ages), two variance parameters for fleet 18 (one for ages 9, 11, and 12, and one common for the remaining ages), finally two parameters for fleet 07 (one for age 12 and one common for the remaining ages). These new SAM settings, as well as the SPALY ones, are shown in Table 3.14.

The model diagnostics improved, as shown in the text tables below, as the estimated SD for residuals in the chosen blocks became closer to 1.0 and model diagnostics (AIC values and retrospective measures) were improved.

A comparison of model residuals and retrospective patterns is presented in Figures 3.2a, 3.2b and the influence on assessment results is shown in Figures 3.9a-d.

Standard deviations of residuals by fleets and age groups as a results of SPALY run

Age / Fleet	3	4	5	6	7	8	9	10	11	12	13	14	15
Catch	1.00	0.71	0.68	0.62	0.64	0.55	0.52	0.85	0.79	1.18	1.34	1.69	2.26
Fleet 15		0.38	1.08	0.95	0.91	1.06	0.99	0.90	1.44	1.14			
Fleet 16		0.83	0.81	0.90	0.86	0.92	0.97	0.75	1.27	1.03			
Fleet 18	0.54	0.98	1.00	0.86	0.66	0.70	1.39	0.97	1.35	1.27			
Fleet007	0.92	0.79	0.94	0.96	1.04	1.06	0.56	0.64	1.02	1.61			

Standard deviations of residuals by fleets and age groups as a result of FINAL run, dealing with SD for ages marked in blue as a separate parameters

Age / Fleet	3	4	5	6	7	8	9	10	11	12	13	14	15
Catch	1.02	0.83	0.79	0.72	0.87	0.76	0.72	1.01	1.04	1.51	0.95	1.10	1.46
Fleet 15		0.64	0.84	0.99	0.89	1.06	1.14	1.05	0.95	1.25			
Fleet 16		0.89	0.95	0.80	0.89	0.97	1.06	0.86	1.06	1.04			
Fleet 18	0.76	1.16	1.02	0.82	0.80	0.84	1.01	1.49	1.05	1.11			
Fleet007	1.02	0.83	0.95	1.00	1.04	0.99	0.66	0.76	1.29	1.04			

This adjusted model variance parameterization adds 6 model parameters, but improves the retrospective pattern, and improves the AIC score by 336.

Some criteria for diagnostic of fitting quality (Akaike criteria, Rho for F, R and SSB) for SAM runs with different assumption regarding ages with different variance of observations

	SPALY	WD-09	final run
AIC	2845	2568	2509
Rho(ssb)	8	10	8
Rho R	-27	-19	-20
Rho (F)	-3	-1	-1

3.5.2 SAM diagnostics (Figure 3.2a,b,c)

Residuals for the final SAM run are shown in Fig 3.2a, while retrospective plots of F, SSB and recruitment are shown in Figure 3.2b. The same results from SPALY run are presented in these figures for comparison. Figure 3.2c shows the catchability by survey and age group.

3.5.3 Results (Table 3.15-3.18, Figure 3.1)

The fishing mortalities and population numbers are given in Tables 3.15 and 3.16. M values (M = 0.2+cannibalism mortality) are given in Table 3.17. For ages 3—5 the M matrix in 1946—1983 also includes M2 since the benchmark meeting in 2015 (WKARCT 2015).

Summaries of landings, fishing mortality, stock biomass, spawning-stock-biomass, and recruitment since 1946 are given in Table 3.18 and Figure 3.1.

3.5.4 SPALY run

For comparison settings and diagnostics are presented together with final run on the same figures and tables. Tables with results and predictions from the SPALY run are given in section 3.13.

3.6 Results of the assessment

3.6.1 Fishing mortalities and stock biomass (Tables 3.18, 3.20, Figure 3.9d)

The estimated $F_{5\text{-}10}$ in 2018 is 0.3992, which is equal to F_{pa} (Table 3.18). Fishing mortality has increased in recent years. The spawning-stock-biomass in 2019 is estimated to be 1755 kt (Table 3.20), which is high but lower than the peak in 2013 (2737 kt). One should bear in mind that in the early part of the time-series the fraction at age of mature fish was considerably lower.

Total stock biomass in 2019 is estimated to 2905 kt which is somewhat above the long-term mean and well below the highest level observed (4478 kt in 2013).

The main difference between this year’s assessment and the results from the SPALY run is an increase in abundance of older age groups (Figure 3.9d). The difference in TSB in 2018 is 309 kt of which the difference in SSB accounts for 284 kt. F in 2018 in the SPALY run is 0.02 higher than in this year’s assessment.

3.6.2 Recruitment (Table 1.9a)

At the 2008 AFWG meeting it was decided to use a hybrid model, which is a weighted arithmetic mean of different recruitment models (Section 1.4). It was agreed to use the same approach this year. The input data for those models are the following time-series; ice coverage, intensity of interaction between the arctic and boreal oceanic systems on the shelf of the Barents Sea, temperature, and oxygen saturation at the Kola section. Prognosis from all the models, including the hybrid is presented in Table 1.9a. Since 2014 the hybrid model is based on objective weighting of different submodels and includes the RCT3 model (see section 1.4 for details). The numbers-at-age 3 calculated by the hybrid method were: 667 million for the 2016 year class, 537 million for the 2017 year class, 644 million for the 2018 year class, and 585 million for the 2019 year class. The same estimates for SPALY SAM were as follows: 660 million for the 2016 year class, 524 million for the 2017 year class, 644 million for the 2018 year class, and 582 million for the 2019 year class.

3.7 Reference points and harvest control rules

The current reference points for Northeast Arctic cod were estimated by SGBRP (ICES CM 2003/ACFM:11) and adopted by ACFM at the May 2003 meeting.

At the 46th session of JRNFC a new version of the management rule was adopted (see section 3.7.3). The TAC advice for 2020 is based on the agreed harvest control rule.

3.7.1 Biomass reference points

The values adopted by ACFM in 2003 are B_{lim} = 220 000 t, B_{pa} = 460 000 t. (ICES CM 2003/ACFM:11).

3.7.2 Fishing mortality reference points

The values adopted by ACFM in 2003 are F_{lim} = 0.74 and F_{pa} = 0.40. (ICES CM 2003/ACFM:11).

3.7.3 Harvest control rule

The history of how the harvest control rule has developed is given in the 2017 AFWG report. JNRFC in 2015 asked ICES to explore the consequences of 10 different harvest control rules. This was done by WKNEAMP (ICES 2015, 2016). JNRFC in 2016 adopted one of the rules explored by WKNEAMP (Rule 6 in that report).

The current rule reads as follows:

The TAC is calculated as the average catch predicted for the coming 3 years using the target level of exploitation (F_{tr}).

The target level of exploitation is calculated according to the spawning stock biomass (SSB) in the first year of the forecast as follows:

- *if $SSB < B_{pa}$, then $F_{tr} = SSB / B_{pa} \times F_{msy}$;*
- *if $B_{pa} \leq SSB \leq 2 \times B_{pa}$, then $F_{tr} = F_{msy}$;*
- *if $2 \times B_{pa} < SSB < 3 \times B_{pa}$, then $F_{tr} = F_{msy} \times (1 + 0.5 \times (SSB - 2 \times B_{pa}) / B_{pa})$;*
- *if $SSB \geq 3 \times B_{pa}$, then $F_{tr} = 1.5 \times F_{msy}$;*

where F_{msy}=0.40 and B_{pa}=460 000 tonnes.

If the spawning stock biomass in the present year, the previous year and each of the three years of prediction is above B_{pa}, the TAC should not be changed by more than +/-20% compared with the previous year's TAC. In this case, F_{tr} should however not be below 0.30.

3.8 Prediction

3.8.1 Prediction input (Table 3.19, Figure 3.3-3.6)

The input data to the short-term prediction with management option table (2019—2022) are given in Table 3.19. For 2019 stock weights and maturity were taken from surveys as described in Sections 3.3.2 and 3.3.4, applying the correction factors for missing Russian data in autumn 2018 given in WD15.

Catch weights in 2019 onwards and stock weights in 2020 and onwards for age 3–11 are predicted by the method described by Brander (2002), where the latest observation of weights by cohort are used together with average annual increments to predict the weight of the cohort the following year. The method is given by the equation

W(a+1,y+1)=W(a,y) + Incr(a), where Incr(a) is a "medium term" average of Incr(a,y)= W(a+1,y+1)-W(a,y)

For age 12 and older constant weights at age in the stock and the catch were used, based on 1983–2015 averages as described in Section 3.3.2.

This method was introduced in the cod prediction in the 2003 working group. Since 2005 working group the 3 most recent values of annual increments have been used for predicting stock weights. For catch weights the last 10-year period for averaging the increments is used. Weight increment for ages older than 9 are fixed to the value calculated for age 9 because of low sampling and high variability observed for older ages. Figures 3.3 and 3.4 show how these predictions perform back in history.

The maturity ogive for the years 2020—2022 was predicted by using the 2017—2019 average. The exploitation pattern in 2019 and later years was set equal to the previous 3 years average according to the benchmark decision (WKARCT 2015).

The method for prediction of weight-at-age in stock and catch and selection pattern for the oldest age groups (10+) should be reviewed at a benchmark, as we have more reliable data for those age groups in recent years and thus long time-series averages are not necessarily the most relevant to use.

The stock number-at-age in 2019 was taken from the final SAM run (Table 3.16) for ages 4 and older. The recruitment at age 3 in the years 2019—2022 was estimated as described in section 3.6.2. Figure 3.5 shows the development in natural mortality due to cannibalism for cod (prey) age groups 1-3 together with the abundance of capelin in the period 1984—2018. There was no clear trend in natural mortality, and the average M values for the last 3 years are used to predict natural mortality of age groups 3—6 for years 2019—2022 (based on benchmark decision, WKARCT 2015).

The assessment shows an increasing trend in F from 2012 to 2018. The fishing effort also increased, and CPUE decreased, but stabilised in 2016–2018 at a lower level than in previous years (Figure 3.6a,b, Table A1). In accordance with the benchmark decision (WKARCT 2015) and with support from WD 11, the last year's assessment F in terminal year 2018 (*status quo*) is used for F in the intermediate year (2019). Table 3.19 shows input data to the predictions. The results of prediction show that the catch in 2019 predicted using F_{sq} is 4% less than the agreed TAC.

3.8.2 Prediction results (Tables 3.20 - 3.21)

The catches corresponding to F_{sq} in 2019 is 697 kt (Table 3.20). This is somewhat below the TAC for 2019 (725 kt). The resulting SSB in 2020 is 1458 kt, lower than in 2019 but still at a high level.

Table 3.20 shows the short-term consequences over a range of F-values in 2020. The detailed outputs corresponding to F_{sq} in 2019 and the F corresponding to the HCR and F_{pa} in 2020 is given in Table 3.21. Summarised results are shown in the text table below.

Since SSB in 2020 is above 3 × B_{pa} = 1 380 000 t, F = 0.60 is used in the 3-year prediction, giving catches of 886 291, 745 207, and 668 696 tonnes in 2020, 2021, and 2022, respectively. The average of this is 766 732 tonnes.

Basis	Total catch (2020)	F_{total} (2020)	SSB(2021)	% SSB change **	% TAC change ***
ICES advice basis					
Management plan*	766 732	0.50	1 209 867	-17	6
Other options					
MSY approach: F_{MSY}	640 378	0.40	1 312 839	-10	-12
F = 0	0	0	1 860 296	28	-100
F = F_{2018}	639 358	0.3992	1 313 678	-10	-12
F_{pa}	640 378	0.40	1 312 839	-10	-12
F_{lim}	1 035 777	0.74	997 575	-32	43

Weights in tonnes.

*** 3 years (2020-2022) average catch**

**** SSB 2021 relative to SSB 2020.**

***** Catch 2020 relative to TAC 2019.**

SPALY SAM run

Since SSB in 2020 is between 2 × B_{pa} = 920 000 t and 3 × B_{pa} = 1 380 000 t, F = 0.4 × (1+0.5 × (1227–920)/460) = 0.533 is used in the 3-year prediction, giving catches of 761 080, 674 767, and 633 166 tonnes in 2020, 2021, and 2022, respectively. The average of this is 689 672 tonnes.

Basis	Total catch (2020)	F_{total} (2020)	SSB(2021)	% SSB change **	% TAC change ***
ICES advice basis					
Management plan*	689 672	0.47	1 056 392	-14	-5
Other options					
MSY approach: F_{MSY}	603 541	0.40	1 127 500	-8	-17
F = 0	0	0	1 652 231	35	-100
F = F_{2018}	630 101	0.4215	1 105 457	-10	-13
F_{pa}	603 541	0.40	1 127 500	-8	-17
F_{lim}	971 521	0.74	831 987	-32	34

Weights in tonnes.

*** 3 years (2020-2022) average catch**

**** SSB 2021 relative to SSB 2020.**

***** Catch 2020 relative to TAC 2019.**

This catch forecast covers all catches. It is then implied that all types of catches are to be counted against this TAC. It also means that if any overfishing is expected to take place, the above calculated TAC should be reduced by the expected amount of overfishing.

3.9 Comparison with last year's assessment

The text tables below compare this year's estimates with last year's estimates for the year 2018 of numbers-at-age (millions), total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2017.

AFWG 2019
FINAL SAM run

		N(2018)														
Assessment year (specification)	F(2017)	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14	TSB (2018)	SSB (2018)	F (2018)
2018 WG	0.4005	691*	406	130	135	141	80	39	25	11	13	12	7	2624	1486	0.4005**
2019 WG	0.368	498	462	161	146	168	87	46	27	14	15	16	10	3036	1810	0.3992
Ratio 2019 WG/ 2018 WG	0.92	0.72	1.14	1.24	1.08	1.19	1.08	1.18	1.06	1.27	1.20	1.35	1.59	1.16	1.22	1.00

***estimated by recruitment models **assuming F_{sq}**

The number-at-age 3 in 2018 from this year's assessment (FINAL SAM) is considerably below (28%) last year assessment, while the number-at-age 4–12 are above (6–27%) the assessment last year, and ages 13-14 are even further above (35 and 59%). The changes resulted from new SAM settings (Figure 3.9b,d).

AFWG 2019 SPALY SAM run

		N(2018)														
Assessment year (specification)	F(2017)	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14	TSB (2018)	SSB (2018)	F (2018)
2018 WG	0.4005	691*	406	130	135	141	80	39	25	11	13	12	7	2624	1486	0.4005**
2019 WG	0.387	432	461	159	149	164	87	44	24	11	12	11	6	2727	1526	0.4215
Ratio 2019 WG/ 2018 WG	0.97	0.63	1.14	1.22	1.10	1.16	1.09	1.13	0.96	1.01	0.93	0.95	0.99	1.04	1.03	1.05

***estimated by recruitment models **assuming F_{sq}**

The number-at-age 3 in 2018 from this year's assessment by SPALY SAM shows considerable reduction (37%) in comparison with assessment last year. The number-at-age 4–9 are all above (9–22%) assessment last year, while the number-at-age 10-14 is very close to last year's assessment (7% or less difference). The changes correspond to the observed retrospective pattern of SPALY SAM (Figure 3.2b).

The retrospective patterns for the final run are better and historic stock underestimation is reduced (Figure 3.2b).

3.10 Concerns with the assessment

Since the choice of which age groups should be linked by common parameters will be strongly affected by the changing age structure in a recovering stock, the group believes that this needs evaluating and updating more frequently than at the benchmarks. AFWG (in common with many other groups) used to do something similar with the stock-size dependent catchability in XSA, and for much the same reason. There was considerable debate at the group with some concern raised that this increased the modelled stock size for ages without survey data. However, the final consensus was that the forced linked variances was clearly wrong, and that we should move away from this. This will be examined in more detail at the next benchmark.

The change in assessment settings resulted in an increase in the assessed stock biomass, especially for the oldest ages (13+) for which no tuning data were available. This change is being proposed for the 2019 assessment, with the rationale that this improved the model fitting (including on AIC), reduced most retros and misfits.

The estimated stock numbers for age groups 14 and 15+ in 2019 are the highest in the time series and the 15+ value is twice the previous maximum for that age group. Of the SSB in 2019, 31% consists of age 13+. The model results show that the fishing mortality on these age groups in recent years is much lower than experienced in the late 1940s and early 1950s when catches of these age groups were high (i.e. higher than in recent years). The low recent average selectivity for those age groups used in the prediction implies that the in the years to come, a considerable proportion of the 15+ group will be fish older than 15 years, a situation which has not been experienced before. Stock and fishery dynamics (mortality, selectivity, growth) for older cod, in particular age 15+, is largely unknown.

The model uses single commercial fleet which is estimated to have a dome shaped selectivity, and no survey data on the oldest fish. This leads to the possibility that the model could estimate an artificially low selectivity and artificially high stock for these oldest fish. A simulation study indicates that the model does reliably estimate the fishing mortality at age over time in the current data situation. The estimation accuracy does naturally decrease for at ages where less data are available. This simulation did not study the potential effect of conflicting data sources.

It was noted that model estimates for age 15+ for the proposed final run are going up faster in the recent years than the 15+ catch data (Table 3.1) suggest, and the short available series of survey estimates for ages 13+ from FLT16 (Table A13, not included in the tuning) also indicates less of an increase in age groups 13+ in 2017–2019 than the assessment indicates. FLT 16 includes coverage of the spawning area and is the one of the two surveys with data from the last year which is considered to cover the largest part of the 10+ and 12+ stock. However, the model results reflect the proportion of age 12+ fish found in the catches of the Norwegian conventional fleet, which catches the major part of those age groups, also in these years. Thus, the data sources show different trends in the last three years.

The WG realizes that imprecise input data, in particular the catch-at-age matrix, and discontinuation of some surveys as far as incomplete spatial coverage in other surveys could be a main obstacle to producing precise stock assessments, regardless of which model is used.

There are some conflicting signals from the different surveys and catch-at-age data. This increases the uncertainty of assessment.

3.11 Additional assessment methods

All models use the same tuning data, but FLT 15 and FLT 16 are shifted one year and one age group in XSA, but not in SAM and TISVPA.

3.11.1 XSA

The same settings as last year used to run XSA this year. The model is run for ages 3–13+, while other models are runs for 3–15+.

3.11.2 TISVPA (Tables 3.22-3.24, Figure 3.8a-c)

The TISVPA (Triple Instantaneous Separable VPA) model (Vasilyev, 2005; 2006) represents fishing mortality coefficients (more precisely – exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). The generation-dependent parameters, which are estimated within the model, are intended to adapt traditional separable representation of fishing mortality to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishers, or by some other reasons.

The model was first presented and tested at the ICES Working Group on Methods of Fish Stock Assessments (WGMG 2006) and was used for data exploration and stock assessment for several ICES stocks, including Northeast Atlantic mackerel, blue whiting, Norwegian spring-spawning herring.

To NEA cod stock TISVPA model was applied at AFWG in 1998 and at benchmark group for arctic stocks (WKARCT) in 2015. At Inter-Benchmark protocol working group (IBPArcticCod) in 2017 it was decided to continue to use TISVPA as a supplementary model.

This year the TISVPA model was applied to NEA cod using the same data as SAM except that natural mortality values from cannibalism were taken from the SAM runs. During AFWG 2019 the results of exploratory runs using the TISVPA model were discussed (WD 09). The residuals of the model approximation of catch-at-age and "fleets" data are presented in Figure 3.8a. Likelihood profiles for different data source are presented in Figure 3.8b. Retrospective run results are shown in Figure 3.8c. The results generally support the results of SAM model giving an estimate of SSB in 2019 of about 1.72 million tonnes.

3.11.3 XSAM

The XSAM (Aanes, 2016) functionality on variances (allowing variances to vary through time, and setting external variance estimates) has now been incorporated into SAM. Work was presented showing that this had the possibility to produce significantly better model fitting. Note that this method of allowing variances to change through time may be a better way of handling the variance-at-age issue outlined above. This could in particular be the case for older age groups which in part of the time series have very low abundance and thus data for those groups are likely to be more uncertain in those periods.

During the meeting SAM was fitted with several XSAM options. Best fit among these runs with respect to likelihood was obtained with usage of external variance structures and with the current benchmark settings. The likelihood increased from -1358.7 to -1132.0 by including external variance estimates. This large increase in the likelihood indicates that model fit is improved by including the external variances. When using all XSAM-options given in Aanes (2016), the likelihood increased to -1213.3.

Leave-out-one residuals obtained using external variance structures and benchmark configurations are shown in Figure 3.10a. Note that there seems to be less structure in the residuals for later years for older ages. Retrospective plots obtained with the same settings are given in Figure 3.10b. Figure 3.10c shows the catch plots with use of both the benchmark configurations and with usage of external covariance structures. We see that the point estimate of the catch is much closer to the observed catch when using the external variance estimates, indicating that the catch observations are given a larger weight. SSB estimates are further given in Figure 3.10d

3.11.4 Model comparisons (Figure 3.9a-d)

Figure 3.9a compares the results of SAM (both runs), XSA and TISVPA, showing F, SSB, TSB, and recruitment. F and TSB is very similar for all models but deviate from each other for the most recent years. TSB and SSB in 2019 is quite similar in all models except SPALY SAM which is lower, around 10% lower TSB than the final SAM run. Recruitment in recent years is higher in XSA than in the other models. TISVPA and SAM demonstrate opposite patterns in catch residuals. TISVPA has a block of negative residuals at the end of time-series for younger age groups, while for older ages residuals are mostly positive (Figure 3.8a). At the same time SAM demonstrates the opposite pattern (Figure 3.2a).

The relatively small difference in total stock and SSB estimation for 2019 between two SAM models do have an effect on the predicted catch calculating according to the management plan. The predictions done using the same settings as for SAM (three years' average fishing pattern, F_{2019} = F_{2018}, starting abundance N taken for beginning of 2019) for Final SAM data gives a catch advice for 2020 according to the HCR equal to 767 kt, compared to 690 kt using SPALY SAM data. Such a difference compared to the difference in assessed biomass could be explained by different stock composition in 2019 in the two model sets and differences in fishing pattern (Figures 3.9c-d). In addition, some difference is caused by the fact that in accordance to the HCR the F value used for SPALY SAM in the 3-year prediction (0.53) becomes smaller than for Final SAM (0.60) as SSB for SPALY SAM in 2020 is below $3*B_{pa}$, but for final SAM it is above. For TISVPA SSB in 2020 is also above $3*B_{pa}$ and the catch advice for 2020 according to the HCR is estimated to 866 kt.

3.12 New and revised data sources

This section describes some data sources, which could be included in the assessment in the future.

3.12.1 Consistency between NEA cod and coastal cod catch data (Table 3.2)

Consistency between the catch data used for NEA cod and coastal cod should also be ensured. The catch figures used in the coastal cod assessment are not equal to the difference between the total cod catch and the catch used in the NEA cod assessment (Table 3.2). These discrepancies will be adjusted when the ECA-results for the period 1984—2018 are re-evaluated (Table 3.2, and section 2.2.1).

3.12.2 Discard and bycatch data (Tables 3.25-3.26)

Work on updating discard and bycatch data series (Tables 3.25, 3.26) is ongoing, new data on age groups were not available in time for AFWG 2019. Revised bycatch estimates in numbers for the period 2005-2018 are described in Section 0.6. At WKARCT in 2015 it was, however, decided not to include those data in the catch-at-age matrix.

Table 3.26 (taken from Ajiad *et al*., WD2, 2008) presents bycatch in the Norwegian shrimp fishery by cod age (previously this has been given by cod length). The bycatch mainly consists of age 1 and 2 fish, but the bycatch is generally small compared to other reported sources of mortality: catches, discards and the number of cod eaten by cod. From 1992 onwards, bycatches of age 3 and older fish are negligible, because use of sorting grids was made mandatory. However, in 1985, bycatches of age 5 and 6 cod were about one third of the reported catches for those age groups. The year class for which the bycatches were highest, was the 1983 year class (total bycatch of age 2 and older fish of about 60 million, compared to a stock estimate of about 1000 million at age 3.

Table 3.1. Northeast Arctic COD. Total catch (t) by fishing areas and unreported catch

Year	Subarea 1	Division 2.a	Division 2.b	Unreported catches	Total catch
1961	409 694	153 019	220 508		783 221
1962	548 621	139 848	220 797		909 266
1963	547 469	117 100	111 768		776 337
1964	206 883	104 698	126 114		437 695
1965	241 489	100 011	103 430		444 983
1966	292 253	134 805	56 653		483 711
1967	322 798	128 747	121 060		572 605
1968	642 452	162 472	269 254		1 074 084
1969	679 373	255 599	262 254		1 197 226
1970	603 855	243 835	85 556		933 246
1971	312 505	319 623	56 920		689 048
1972	197 015	335 257	32 982		565 254
1973	492 716	211 762	88 207		792 685
1974	723 489	124 214	254 730		1 102 433
1975	561 701	120 276	147 400		829 377
1976	526 685	237 245	103 533		867 463
1977	538 231	257 073	109 997		905 301
1978	418 265	263 157	17 293		698 715
1979	195 166	235 449	9 923		440 538
1980	168 671	199 313	12 450		380 434
1981	137 033	245 167	16 837		399 037
1982	96 576	236 125	31 029		363 730
1983	64 803	200 279	24 910		289 992
1984	54 317	197 573	25 761		277 651
1985	112 605	173 559	21 756		307 920
1986	157 631	202 688	69 794		430 113
1987	146 106	245 387	131 578		523 071
1988	166 649	209 930	58 360		434 939
1989	164 512	149 360	18 609		332 481
1990	62 272	99 465	25 263	25 000	212 000
1991	70 970	156 966	41 222	50 000	319 158
1992	124 219	172 532	86 483	130 000	513 234

Year	Subarea 1	Division 2.a	Division 2.b	Unreported catches	Total catch
1993	195 771	269 383	66 457	50 000	581 611
1994	353 425	306 417	86 244	25 000	771 086
1995	251 448	317 585	170 966		739 999
1996	278 364	297 237	156 627		732 228
1997	273 376	326 689	162 338		762 403
1998	250 815	257 398	84 411		592 624
1999	159 021	216 898	108 991		484 910
2000	137 197	204 167	73 506		414 870
2001	142 628	185 890	97 953		426 471
2002	184 789	189 013	71 242	90 000	535 045
2003	163 109	222 052	51 829	115 000	551 990
2004	177 888	219 261	92 296	117 000	606 445
2005	159 573	194 644	121 059	166 000	641 276
2006	159 851	204 603	104 743	67 100	537 642
2007	152 522	195 383	97 891	41 087	486 883
2008	144 905	203 244	101 022	15 000	464 171
2009	161 602	207 205	154 623		523 431
2010	183 988	271 337	154 657		609 983
2011	198 333	328 598	192 898		719 829
2012	247 938	331087	148 638		727 663
2013	360 673	421678	183 858		966 209
2014	320 347	468 934	197 168		986 449
2015	272 405	375 328	216 651		864 384
2016	321 347	351 468	176 607		849 422
2017	309 902	360 477	197 898		868 276
2018[1]	249397	321548	207681		778627

Data provided by Working Group members

[1] **Provisional figures**

Table 3.2. Landings of Norwegian Coastal Cod in subareas 1 and 2, 10^3 tonnes

Year	Coastal cod catch used in NCC-assess	Coastal cod catch from ECA-model	Norwegian catches of cod in areas 06+07 whole yr plus q3&4 in areas 00+05	Norwegian catches of cod removed from the NEAC-assessment
Av1960–70			38.6	38.6
1971–79			no data	no data
1980			40	40
1981			49	49
1982			42	42
1983			38	38
1984	74.8	63.5	33	33
1985	75.5	62.5	28	28
1986	68.9	56.0	26	26
1987	61	48.2	31	31
1988	59.3	54.9	22	22
1989	40.3	41.2	17	17
1990	28.1	20.9	24	24
1991	24.8	24.8	25	25
1992	41.7	38.2	35	35
1993	52.6	50.4	44	44
1994	54.6	51.6	48	48
1995	57.2	65.0	39	39
1996	61.8	41.6	32	32
1997	63.3	51.0	36	36
1998	51.6	30.5	29	29
1999	40.7	35.8	23	23
2000	36.7	34.8	19	19
2001	29.7	27.2	14	14
2002	41	36.4	20	20
2003	34.6	35.4	19	19
2004	24.5	33.6	14	14
2005	22.4	29.3	13	13

Year	Coastal cod catch used in NCC-assess	Coastal cod catch from ECA-model	Norwegian catches of cod in areas 06+07 whole yr plus q3&4 in areas 00+05	Norwegian catches of cod removed from the NEAC-assessment
2006	26.1	39.3	15	15
2007	23.8	29.2	13	13
2008	25.8	35.5	13	13
2009	24.8	30.0	15	15
2010	22.9	40.2	13.5	13.5
2011	28.6	36.6	18.8	18.8
2012	31.9	35.5	17.7	35.5
2013	22.5	30.1	16.8	30.1
2014	23.2	33.6	15.5	33.6
2015	39.4	35.8	13.2	35.8
2016	44.6	54.9	10.0	54.9
2017	52.9	51.0	7.6	51.0
2018	-	36.3	7.3	36.3

Table 3.3. Northeast Arctic COD. Total nominal catch ('000 t) by trawl and other gear for each area, data provided by Working Group members.

	Subarea 1		Division 2.a		Division 2.b	
Year	Trawl	Others	Trawl	Others	Trawl	Others
1967	238	84.8	38.7	90	121.1	-
1968	588.1	54.4	44.2	118.3	269.2	-
1969	633.5	45.9	119.7	135.9	262.3	-
1970	524.5	79.4	90.5	153.3	85.6	-
1971	253.1	59.4	74.5	245.1	56.9	-
1972	158.1	38.9	49.9	285.4	33	-
1973	459	33.7	39.4	172.4	88.2	-
1974	677	46.5	41	83.2	254.7	-
1975	526.3	35.4	33.7	86.6	147.4	-
1976	466.5	60.2	112.3	124.9	103.5	-
1977	471.5	66.7	100.9	156.2	110	-
1978	360.4	57.9	117	146.2	17.3	-
1979	161.5	33.7	114.9	120.5	8.1	-
1980	133.3	35.4	83.7	115.6	12.5	-
1981	91.5	45.1	77.2	167.9	17.2	-
1982	44.8	51.8	65.1	171	21	-
1983	36.6	28.2	56.6	143.7	24.9	-
1984	24.5	29.8	46.9	150.7	25.6	-
1985	72.4	40.2	60.7	112.8	21.5	-
1986	109.5	48.1	116.3	86.4	69.8	-
1987	126.3	19.8	167.9	77.5	129.9	1.7
1988	149.1	17.6	122	88	58.2	0.2
1989	144.4	19.5	68.9	81.2	19.1	0.1
1990	51.4	10.9	47.4	52.1	24.5	0.8
1991	58.9	12.1	73	84	40	1.2
1992	103.7	20.5	79.7	92.8	85.6	0.9
1993	165.1	30.7	155.5	113.9	66.3	0.2

1994	312.1	41.3	165.8	140.6	84.3	1.9
1995	218.1	33.3	174.3	143.3	160.3	10.7
1996	248.9	32.7	137.1	159	147.7	6.8
1997	235.6	37.7	150.5	176.2	154.7	7.6
1998	219.8	31	127	130.4	82.7	1.7
1999	133.3	25.7	101.9	115	107.2	1.8
2000	111.7	25.5	105.4	98.8	72.2	1.3
2001	119.1	23.5	83.1	102.8	95.4	2.5
2002	147.4	37.4	83.4	105.6	69.9	1.3
2003	146	17.1	107.8	114.2	50.1	1.8
2004	154.4	23.5	100.3	118.9	88.8	3.5
2005	132.4	27.2	87	107.7	115.4	5.6
2006	141.8	18.1	91.2	113.4	100.1	4.6
2007	129.6	22.9	84.8	110.6	91.6	6.3
2008	123.8	21.1	94.8	108.4	95.3	5.7
2009	130.1	31.5	102	105.2	142.1	11.4
2010	151.1	32.9	130	141.4	149.2	5.4
2011	158.1	38.4	163.5	167	181	11.9
2012	212.1	35.9	172.7	158.4	133.8	14.9
2013	308.5	52.2	216.9	204.7	159.7	24.1
2014	268.8	51.5	246.8	222.1	177.9	19.3
2015	224.3	48.1	192.2	183.2	197.7	19.0
2016	285.5	35.8	181.7	169.8	156.3	20.3
2017	265.4	44.5	189.5	171.0	180.0	17.9
2018[1]	204.7	44.7	156.7	164.9	192.0	15.6

Data provided by Working Group members

[1] **Provisional figures**

Table 3.4. Northeast Arctic COD. Nominal catch(t) by countries. (Subarea 1 and divisions 2.a and 2.b combined, data provided by Working group members

Year	Faroe Islands	France	German Dem.Rep.	Fed.Rep. Germany	Norway	Poland	United Kingdom	Russia[2]		Others	Total all countries
1961	3 934	13 755	3 921	8 129	268 377	-	158 113	325 780		1 212	783 221
1962	3 109	20 482	1 532	6 503	225 615	-	175 020	476 760		245	909 266
1963	-	18 318	129	4 223	205 056	108	129 779	417 964		-	775 577
1964	-	8 634	297	3 202	149 878	-	94 549	180 550		585	437 695
1965	-	526	91	3 670	197 085	-	89 962	152 780		816	444 930
1966	-	2 967	228	4 284	203 792	-	103 012	169 300		121	483 704
1967	-	664	45	3 632	218 910	-	87 008	262 340		6	572 605
1968	-	-	225	1 073	255 611	-	140 387	676 758		-	1 074 084
1969	29 374	-	5 907	5 543	305 241	7 856	231 066	612 215		133	1 197 226
1970	26 265	44 245	12 413	9 451	377 606	5 153	181 481	276 632		-	933 246
1971	5 877	34 772	4 998	9 726	407 044	1 512	80 102	144 802		215	689 048
1972	1 393	8 915	1 300	3 405	394 181	892	58 382	96 653		166	565 287
1973	1 916	17 028	4 684	16 751	285 184	843	78 808	387 196		276	792 686
1974	5 717	46 028	4 860	78 507	287 276	9 898	90 894	540 801		38 453	1 102 434
1975	11 309	28 734	9 981	30 037	277 099	7 435	101 843	343 580		19 368	829 377
1976	11 511	20 941	8 946	24 369	344 502	6 986	89 061	343 057		18 090	867 463
1977	9 167	15 414	3 463	12 763	388 982	1 084	86 781	369 876		17 771	905 301
1978	9 092	9 394	3 029	5 434	363 088	566	35 449	267 138		5 525	698 715
1979	6 320	3 046	547	2 513	294 821	15	17 991	105 846		9 439	440 538
1980	9 981	1 705	233	1 921	232 242	3	10 366	115 194		8 789	380 434
						Spain					
1981	12 825	3 106	298	2 228	277 818	14 500	5 262	83 000		-	399 037
1982	11 998	761	302	1 717	287 525	14 515	6 601	40 311		-	363 730
1983	11 106	126	473	1 243	234 000	14 229	5 840	22 975		-	289 992
1984	10 674	11	686	1 010	230 743	8 608	3 663	22 256		-	277 651
1985	13 418	23	1 019	4 395	211 065	7 846	3 335	62 489		4 330	307 920
1986	18 667	591	1 543	10 092	232 096	5 497	7 581	150 541		3 505	430 113
1987	15 036	1	986	7 035	268 004	16 223	10 957	202 314		2 515	523 071
1988	15 329	2 551	605	2 803	223 412	10 905	8 107	169 365		1 862	434 939
1989	15 625	3 231	326	3 291	158 684	7 802	7 056	134 593		1 273	332 481
1990	9 584	592	169	1 437	88 737	7 950	3 412	74 609		510	187 000
1991	8 981	975	**Greenland**	2 613	126 226	3 677	3 981	119 427 [3]		3 278	269 158
1992	11 663	2	3 337	3 911	168 460	6 217	6 120	182 315	**Iceland**	1 209	383 234
1993	17 435	3 572	5 389	5 887	221 051	8 800	11 336	244 860	9 374	3 907	531 611
1994	22 826	1 962	6 882	8 283	318 395	14 929	15 579	291 925	36 737	28 568	746 086
1995	22 262	4 912	7 462	7 428	319 987	15 505	16 329	296 158	34 214	15 742	739 999
1996	17 758	5 352	6 529	8 326	319 158	15 871	16 061	305 317	23 005	14 851	732 228
1997	20 076	5 353	6 426	6 680	357 825	17 130	18 066	313 344	4 200	13 303	762 403
1998	14 290	1 197	6 388	3 841	284 647	14 212	14 294	244 115	1 423	8 217	592 624
1999	13 700	2 137	4 093	3 019	223 390	8 994	11 315	210 379	1 985	5 898	484 910
2000	13 350	2 621	5 787	3 513	192 860	8 695	9 165	166 202	7 562	5 115	414 870
2001	12 500	2 681	5 727	4 524	188 431	9 196	8 698	183 572	5 917	5 225	426 471
2002	15 693	2 934	6 419	4 517	202 559	8 414	8 977	184 072	5 975	5 484	445 045
2003	19 427	2 921	7 026	4 732	191 977	7 924	8 711	182 160	5 963	6 149	436 990
2004	19 226	3 621	8 196	6 187	212 117	11 285	14 004	201 525	7 201	6 082	489 445
2005	16 273	3 491	8 135	5 848	207 825	9 349	10 744	200 077	5 874	7 660	475 276
2006	16 327	4 376	8 164	3 837	201 987	9 219	10 594	203 782	5 972	6 271	470 527
2007	14 788	3 190	5951	4619	199 809	9 496	9298	186 229	7316	5 101	445 796
2008	15 812	3 149	5 617	4 955	196 598	9 658	8 287	190 225	7 535	7 336	449 171
2009	16 905	3 908	4 977	8 585	224 298	12 013	8 632	229 291	7 380	7 442	523 431
2010	15 977	4 499	6 584	8 442	264 701	12 657	9 091	267 547	11 299	9 185	609 983
2011	13 429	1 173	7 155	4 621	331 535	13 291	8 210	310 326	12 734	17 354 [4]	719 829
2012 [5]	17523	2841	8520	8 500	315 739	12814	11166	329 943	9536	11 081	727 663
2013	13833	7858	7885	8 010	438 734	15042	12536	432 314	14734	15 263	966 209
2014	33298	8149	10864	6 225	431 846	16378	14762	433 479	18205	13 243	986 449
2015	26568	7480	7055	6 427	377 983	19905	11778	381 188	16120	9 880	864 384
2016	24084	7946	8607	6 336	348 949	14640	13583	394 107	16031	15 139	849 422
2017	28637	9554	13638	5 977	357 419	14414	16731	396 180	11925	13 802	868 276
2018 [1]	26152	6605	12743	9 768	333 539	13143	11533	340 364	10708	14 071	778 627

[1] Provisional figures.
[2] USSR prior to 1991.
[3] Includes Baltic countries.
[4] Includes unspecified EU catches.
[5] Revised figures.

Table 3.5. Barents Sea winter survey. Area covered ('000 square nautical miles) and areas implied in the method used to adjust for missing coverage in Russian Economic Zone. In 4 of the 5 adjusted years the adjustments were not based on area ratios, but the "index ratio by age" was used. This means that the index by age (for the area outside REZ) was scaled by the observed ratio between total index and the index outside REZ observed in the years prior to the survey.

Year	Area covered	Additional area implied in adjustment	Adjustment method
1981–92	88.1		
1993	137.6		
1994	143.8		
1995	186.6		
1996	165.3		
1997	87.5	78.0	Index ratio by age
1998	99.2	78.0	Index ratio by age
1999	118.3		
2000	162.4		
2001	164.1		
2002	156.7		
2003	146.6		
2004	164.6		
2005	178.9		
2006	169.1	18.1	Partly covered strata raised to full strata area
2007	122.2	56.7	Index ratio by age
2008	164.4		
2009	170.9		
2010	159.9		
2011	173.1		
2012	150.5	16.7	Index ratio by age
2013	202.1		
2014	207.8		
2015	195.7		
2016	172.8		
2017	146.9	37.5	Index ratio by age
2018	192.1		
2019	207.1		

Table 3.6. Northeast Arctic cod. Catch numbers-at-age (Thous)
SAM
Sun Apr 28 18:53:18 2019

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTALNUM
1946	4008	10387	18906	16596	13843	15370	59845	22618	10093	9573	5460	1927	750	189376
1947	710	13192	43890	52017	45501	13075	19718	47678	31392	9348	9330	4622	4103	294576
1948	140	3872	31054	55983	77375	21482	15237	9815	30041	7945	4491	3899	4205	265539
1949	991	6808	35214	100497	83283	29727	13207	5606	8617	13154	3657	1895	2167	304823
1950	1281	10954	29045	45233	62579	30037	19481	9172	6019	4133	6750	1662	1450	227796
1951	24687	77924	64013	46867	37535	33673	23510	10589	4221	1288	1002	3322	611	329242
1952	24099	120704	113203	73827	49389	20562	24367	15651	8327	3565	647	467	1044	455852
1953	47413	107659	112040	55500	22742	16863	10559	10553	5637	1752	468	173	156	391515
1954	11473	155171	146395	100751	40635	10713	11791	8557	6751	2370	896	268	123	495894
1955	3902	37652	201834	161336	84031	30451	13713	9481	4140	2406	867	355	128	550296
1956	10614	24172	129803	250472	86784	51091	14987	7465	3952	1655	1292	448	166	582901
1957	17321	33931	27182	70702	87033	39213	17747	6219	3232	1220	347	299	173	304619
1958	31219	133576	71051	40737	38380	35786	13338	10475	3289	1070	252	40	141	379354
1959	32308	77942	148285	53480	18498	17735	23118	9483	3748	997	254	161	98	386107
1960	37882	97865	64222	67425	23117	8429	7240	11675	4504	1843	354	102	226	324884
1961	45478	132655	123458	51167	38740	17376	5791	6778	5560	1682	910	280	108	429983
1962	42416	170566	167241	89460	28297	21996	7956	2728	2603	1647	392	280	103	535685
1963	13196	106984	205549	95498	35518	16221	11894	3884	1021	1025	498	129	157	491574
1964	5298	45912	97950	58575	19642	9162	6196	3553	783	172	387	264	131	248025
1965	15725	25999	78299	68511	25444	8438	3569	1467	1161	131	61	79	197	229081
1966	55937	55644	34676	42539	37169	18500	5077	1495	380	403	77	9	70	251976
1967	34467	160048	69235	22061	26295	25139	11323	2329	687	316	225	40	14	352179
1968	3709	174585	267961	107051	26701	16399	11597	3657	657	122	124	70	46	612679
1969	2307	24545	238511	181239	79363	26989	13463	5092	1913	414	121	23	46	574026
1970	7164	10792	25813	137829	96420	31920	8933	3249	1232	260	106	39	35	323792
1971	7754	13739	11831	9527	59290	52003	12093	2434	762	418	149	42	25	170067
1972	35536	45431	26832	12089	7918	34885	22315	4572	1215	353	315	121	40	191622
1973	294262	131493	61000	20569	7248	8328	19130	4499	677	195	81	59	55	547596

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTALNUM
1974	91855	437377	203772	47006	12630	4370	2523	5607	2127	322	151	83	62	807885
1975	45282	59798	226646	118567	29522	9353	2617	1555	1928	575	231	15	37	496126
1976	85337	114341	79993	118236	47872	13962	4051	936	558	442	139	26	53	465946
1977	39594	168609	136335	52925	61821	23338	5659	1521	610	271	122	92	54	490951
1978	78822	45400	88495	56823	25407	31821	9408	1227	913	446	748	48	51	339609
1979	8600	77484	43677	31943	16815	8274	10974	1785	427	103	59	38	45	200224
1980	3911	17086	81986	40061	17664	7442	3508	3196	678	79	24	26	8	175669
1981	3407	9466	20803	63433	21788	9933	4267	1311	882	109	37	3	1	135440
1982	8948	20933	19345	28084	42496	8395	2878	708	271	260	27	5	5	132355
1983	3108	19594	20473	17656	17004	18329	2545	646	229	74	58	20	5	99741
1984	6942	14240	18807	20086	15145	8287	5988	783	232	153	49	12	8	90732
1985	24634	45769	27806	19418	11369	3747	1557	768	137	36	31	32	8	135312
1986	28968	70993	78672	25215	11711	4063	976	726	557	136	28	34	14	222093
1987	13648	137106	98210	61407	13707	3866	910	455	187	227	21	59	20	329823
1988	9828	22774	135347	54379	21015	3304	1236	519	106	69	43	14	5	248639
1989	5085	17313	32165	81756	27854	5501	827	290	41	13	1	11	16	170873
1990	1911	7551	12999	17827	30007	6810	828	179	59	15	6	5	2	78199
1991	4963	10933	16467	20342	19479	25193	3888	428	48	12	1	1	2	101757
1992	21835	36015	27494	23392	18351	13541	18321	2529	264	82	3	9	1	161837
1993	10094	46182	63578	33623	14866	9449	6571	12593	1749	377	63	22	1	199168
1994	6531	59444	102548	59766	32504	10019	6163	3671	7528	995	121	19	4	289313
1995	4879	42587	115329	98485	32036	7334	3014	1725	1174	1920	222	41	1	308747
1996	7655	28782	80711	100509	54590	10545	2023	930	462	230	809	84	1	287331
1997	12827	36491	69633	83017	65768	28392	4651	1151	373	213	144	238	1	302899
1998	31887	88874	48972	40493	34513	26354	6583	965	197	69	42	22	53	279024
1999	7501	77714	92816	31139	15778	15851	8828	1837	195	40	34	8	30	251771
2000	4701	33094	93044	47210	12671	6677	4787	1647	321	71	11	1	14	204249
2001	5044	35019	62139	62456	22794	5266	1773	1163	343	85	6	7	22	196117
2002	2348	31033	76175	67656	42122	11527	1801	529	223	120	21	9	6	233570

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTALNUM
2003	7263	20885	64447	71109	36706	14002	2887	492	142	97	21	43	1	218095
2004	2090	38226	50826	68350	50838	18118	6239	1746	295	127	39	16	8	236918
2005	5815	19768	113144	61665	44777	20553	6285	2348	562	100	21	24	7	275069
2006	8548	47207	33625	78150	31770	15667	7245	1788	737	210	26	45	155	225173
2007	25473	43817	62877	26303	34392	11240	4080	1381	505	285	44	13	35	210445
2008	8459	51704	40656	35072	14037	20676	5503	1794	715	229	42	26	13	178926
2009	4866	38711	83998	46639	20789	8417	8920	1957	872	987	76	21	20	216273
2010	1778	16193	53855	75853	36797	17062	4784	4325	3034	913	189	49	35	214867
2011	1418	8033	32472	70938	73875	21116	11708	5058	3237	600	434	12	0	228901
2012	2695	10462	16646	40372	70014	48315	12326	5214	1926	1124	317	70	24	209505
2013	2903	13659	22752	21020	54231	74451	47124	9143	2963	694	449	89	145	249623
2014	5234	19226	38407	36633	29901	56109	47540	22738	3717	1169	313	210	157	261354
2015	4315	31383	41181	51209	33745	22530	23609	24553	16071	2510	468	134	254	251962
2016	2076	11291	50231	43609	35265	23417	14592	20105	15862	4781	871	249	308	222657
2017	6535	13128	28365	66504	46136	28507	15307	10073	12169	6465	1927	399	285	235800
2018	6120	28569	27128	33816	54328	28323	16208	9722	7132	3740	2295	840	271	218492

Table 3.7. Northeast Arctic COD. Weights-at-age (kg) in landings from various countries
Norway

Year	Age												
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.41	0.82	1.32	2.05	2.82	3.94	5.53	7.70	9.17	11.46	16.59	16.42	16.96	24.46
1984	1.16	1.47	1.97	2.53	3.13	3.82	4.81	5.95	7.19	7.86	8.46	7.99	9.78	10.64
1985	0.34	0.99	1.43	2.14	3.27	4.68	6.05	7.73	9.86	11.87	14.16	14.17	13.52	15.33
1986	0.30	0.67	1.34	2.04	3.14	4.60	5.78	6.70	7.52	9.74	10.68	12.86	9.59	16.31
1987	0.24	0.48	0.88	1.66	2.72	4.35	6.21	8.78	9.78	12.50	13.75	15.12	10.43	19.95
1988	0.36	0.56	0.83	1.31	2.34	3.84	6.50	8.76	9.97	11.06	14.43	19.02	12.89	10.16
1989	0.53	0.75	0.90	1.17	1.95	3.20	4.88	7.82	9.40	11.52	11.47		19.47	14.68
1990	0.40	0.81	1.22	1.59	2.14	3.29	4.99	7.83	10.54	14.21	17.63	7.97	14.64	
1991	0.63	1.37	1.77	2.31	3.01	3.68	4.63	6.06	8.98	12.89	17.00		14.17	16.63
1992	0.41	1.10	1.79	2.45	3.22	4.33	5.27	6.21	8.10	10.51	11.59		15.81	6.52
1993	0.30	0.83	1.70	2.41	3.35	4.27	5.45	6.28	7.10	7.82	10.10	16.03	19.51	17.68
1994	0.30	0.82	1.37	2.23	3.35	4.27	5.56	6.86	7.45	7.98	9.53	12.16	11.45	19.79
1995	0.44	0.78	1.26	1.87	2.80	4.12	5.15	5.96	7.90	8.67	9.20	11.53	17.77	21.11
1996	0.29	0.90	1.15	1.67	2.58	4.08	6.04	6.62	7.96	9.36	10.55	11.41	9.51	24.24
1997	0.35	0.78	1.14	1.56	2.25	3.48	5.35	7.38	7.55	8.30	11.15	8.64	12.80	
1998	0.38	0.68	1.03	1.64	2.23	3.24	4.85	6.88	9.18	9.84	15.78	14.37	13.77	15.58
1999	0.46	0.88	1.16	1.65	2.40	3.12	4.26	6.00	6.52	10.64	14.05	12.67	9.20	17.22
2000	0.31	0.65	1.23	1.80	2.54	3.58	4.49	5.71	7.54	7.86	12.71	14.71	15.40	20.26
2001	0.30	0.77	1.18	1.83	2.75	3.64	4.88	5.93	7.43	8.90	10.22	11.11	13.03	18.85
2002	0.31	0.90	1.40	1.90	2.60	3.55	4.60	5.80	7.40	9.56	8.71	12.92	8.42	17.61
2003	0.55	0.88	1.39	2.01	2.63	3.59	4.83	5.57	7.262	9.36	9.52	9.52	10.68	21.66
2004	0.54	1.08	1.41	1.95	2.69	3.46	4.77	6.72	7.90	8.66	12.21	14.02	16.50	11.37
2005	0.58	0.92	1.38	1.86	2.61	3.54	4.57	6.41	8.24	9.89	11.04	14.08	11.81	20.08
2006	0.51	0.97	1.45	2.06	2.71	3.56	4.57	5.53	6.61	7.53	8.55	8.44	9.82	12.31
2007	0.53	1.07	1.70	2.37	3.26	4.36	5.45	6.71	8.08	8.56	9.75	11.72	12.72	15.58
2008	0.65	1.12	1.70	2.44	3.32	4.41	5.61	6.84	8.25	9.31	10.54	12.45	13.59	21.15
2009	0.56	0.98	1.47	2.10	2.83	3.90	5.06	5.76	7.31	7.79	7.81	10.68	11.83	14.76

Year	Age													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2010	0.55	0.95	1.46	2.06	2.93	4.02	5.40	6.44	7.19	8.43	9.11	10.46	11.39	15.55
2011	0.53	1.09	1.50	2.06	2.85	3.70	5.01	6.26	7.33	8.34	9.87	13.23		
2012		0.83	1.32	1.92	2.65	3.52	4.71	6.34	8.11	9.92	11.31	13.45	15.75	
2013	0.43	0.95	1.40	2.00	2.64	3.44	4.51	5.67	7.29	8.80	10.33	11.38	12.56	
2014	0.59	1.07	1.55	2.15	2.80	3.70	4.57	5.78	6.97	8.35	9.46	10.99	12.28	15.49
2015	0.64	0.96	1.42	1.96	2.57	3.30	4.13	5.49	6.46	7.18	8.63	10.37	12.24	14.60
2016	0.59	0.96	1.46	1.99	2.71	3.57	4.56	5.78	6.82	8.08	9.33	10.01	11.68	14.79
2017	0.55	0.99	1.53	2.06	2.69	3.64	4.72	5.91	6.91	7.88	9.41	10.93	11.78	15.07
2018	0.62	1.05	1.51	2.11	2.80	3.48	4.54	5.80	6.97	7.64	9.11	10.29	11.35	14.05

Table 3.7. Northeast Arctic COD. Weights-at-age (kg) in landings from various countries (continued)
Russia (trawl only)

Year	Age												
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	0.65	1.05	1.58	2.31	3.39	4.87	6.86	8.72	10.40	12.07	14.43			
1984	0.53	0.88	1.45	2.22	3.21	4.73	6.05	8.43	10.34	12.61	14.95			
1985	0.33	0.77	1.31	1.84	2.96	4.17	5.94	6.38	8.58	10.28				
1986	0.29	0.61	1.14	1.75	2.45	4.17	6.18	8.04	9.48	11.33	12.35	14.13		
1987	0.24	0.52	0.88	1.42	2.07	2.96	5.07	7.56	8.93	10.80	13.05	18.16		
1988	0.27	0.49	0.88	1.32	2.06	3.02	4.40	6.91	9.15	11.65	12.53	14.68		
1989	0.50	0.73	1.00	1.39	1.88	2.67	4.06	6.09	7.76	9.88				
1990	0.45	0.83	1.21	1.70	2.27	3.16	4.35	6.25	8.73	10.85	13.52			
1991	0.36	0.64	1.05	2.03	2.85	3.77	4.92	6.13	8.36	10.44	15.84	19.33		
1992	0.55	1.20	1.44	2.07	3.04	4.24	5.14	5.97	7.25	9.28	11.36			
1993	0.48	0.78	1.39	2.06	2.62	4.07	5.72	6.79	7.59	11.26	14.79	17.71		
1994	0.41	0.81	1.24	1.80	2.55	2.88	4.96	6.91	8.12	10.28	12.42	16.93		
1995	0.37	0.77	1.21	1.74	2.37	3.40	4.71	6.73	8.47	9.58	12.03	16.99		
1996	0.30	0.64	1.09	1.60	2.37	3.42	5.30	7.86	8.86	10.87	11.80			
1997	0.30	0.57	1.00	1.52	2.18	3.30	4.94	7.15	10.08	11.87	13.54			
1998	0.33	0.68	1.06	1.60	2.34	3.39	5.03	6.89	10.76	12.39	13.61	14.72		
1999	0.24	0.58	0.98	1.41	2.17	3.26	4.42	5.70	7.27	10.24	14.12			
2000	0.18	0.48	0.85	1.44	2.16	3.12	4.44	5.79	7.49	9.66	10.36			
2001	0.12	0.31	0.62	1.00	1.53	2.30	3.31	4.57	6.55	8.11	9.52	11.99		
2002	0.20	0.60	1.05	1.46	2.14	3.27	4.47	6.23	8.37	10.06	12.37			
2003	0.23	0.63	1.06	1.78	2.40	3.41	4.86	6.28	7.55	11.10	13.41	12.12	14.51	
2004	0.30	0.57	1.09	1.55	2.37	3.20	4.73	6.92	8.41	9.77	11.08			
2005	0.33	0.65	0.98	1.50	2.10	3.08	4.31	5.81	8.42	10.37	13.56	14.13		
2006	0.27	0.68	1.05	1.49	2.25	3.16	4.54	5.90	8.59	10.31	12.31			
2007	0.23	0.67	1.12	1.66	2.25	3.31	4.57	6.27	8.20	10.02	12.36	12.4		
2008	0.28	0.64	1.16	1.74	2.65	3.58	4.74	5.73	7.32	8.07	9.52	12.5		
2009	0.31	0.64	1.09	1.58	2.11	3.19	4.80	6.58	7.97	9.84	11.51			

Year	Age													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2010	0.25	0.57	1.00	1.64	2.28	3.14	4.53	5.98	8.03	9.71	10.70	13.5		
2011	0.25	0.62	1.05	1.56	2.18	2.95	4.33	6.21	8.04	10.13	12.25	15.2		
2012	0.29	0.60	1.07	1.66	2.25	2.95	4.17	6.23	8.58	11.08	12.24	14.1	15.2	16.39
2013	0.33	0.63	1.05	1.54	2.26	3.09	4.08	5.47	7.37	9.59	12.57	15.5	17.1	
2014	0.32	0.61	1.05	1.61	2.26	3.15	4.00	5.24	7.13	9.46	11.18	14.5		
2015	0.30	0.60	0.97	1.49	2.11	3.13	4.64	5.78	7.13	9.53	12.12	16.7	17.4	
2016	0.26	0.55	0.97	1.53	2.20	3.19	4.50	6.12	7.97	9.55	10.95	14.3	14.7	17.25
2017	0.33	0.63	1.03	1.56	2.24	3.24	4.67	6.34	7.74	9.40	11.12	14.4	16.7	11.91
2018	0.33	0.68	1.06	1.62	2.40	3.22	4.66	6.23	7.79	8.91	10.26	11.26	13.41	10.14

Germany (Divisions 2.a and 2.b)

Year	Age													
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994		0.68	1.04	2.24	3.49	4.51	5.79	6.93	8.16	8.46	8.74	9.48	15.25	
1995		0.44	0.84	1.50	2.72	3.81	4.46	4.81	7.37	7.69	8.25	9.47		
1996		0.84	1.15	1.64	2.53	3.58	4.13	3.90	4.68	6.98	6.43	11.32		
1997		0.43	0.92	1.42	2.01	3.15	4.04	5.16	4.82	3.96	7.04	8.80		
1998	0.23	0.73	1.17	1.89	2.72	3.25	4.13	5.63	6.50	8.57	8.42	11.45	8.79	
1999 [1]		0.85	1.45	2.00	2.65	3.47	4.16	5.45	6.82	5.90		8.01		
2000 [2]	0.26	0.73	1.36	2.04	2.87	3.67	4.88	5.78	7.05	8.45	8.67	9.33	6.88	
2001	0.38	0.80	1.21	1.90	2.74	3.90	4.99	5.69	7.15	7.32	11.72	9.11	6.60	
2002	0.35	1.00	1.31	1.80	2.53	3.64	4.38	5.07	6.82	9.21	7.59	13.18	19.17	19.20
2003	0.22	0.44	1.04	1.71	2.31	3.27	4.93	6.17	7.773	9.61	9.99	12.29	13.59	
2004 [2]	0.22	0.73	1.01	1.75	2.58	3.33	4.73	6.32	7.20	8.45	9.20	11.99	10.14	13.11
2005 [3]	0.57	0.77	1.13	1.66	2.33	3.36	4.38	5.92	6.65	7.26	10.01	11.14		
2006 [2]	0.71	0.91	1.39	1.88	2.56	3.77	5.33	6.68	9.14	10.89	11.51	16.83	18.77	
2007 [3]	0.59	1.35	1.79	2.51	3.53	4	4.95	6.55	7.54	9.71	11.40	11.57	23.34	15.61
2008 [3]	0.23	0.51	1.14	1.76	2.57	3.15	4.4	5.43	7.18	8.39	10.15	10.03	10.99	14.26
2009 [3]	0.35	0.6	1.19	1.83	2.96	4.08	5.61	6.97	8.55	9.13	10.54	13.34	10.30	17.06

Year		Age													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2010	3	0.36	0.67	0.93	1.71	2.46	3.21	4.93	6.75	7.80	8.70	8.53	10.17	12.36	14.11
2011	1			1.75	3.09	3.3	3.28	4.13	4.99	6.61	7.91	9.38	10.79	14.67	14.91
2013	3			1.03	1.37	1.87	2.65	3.45	4.49	7.26	11.42	12.86	13.07		
2014	4		0.68	0.96	1.39	1.69	3.06	4.07	5.65	8.15	10.36	13.07	13.52		
2015	4	0.82	1.05	1.67	2.33	3.56	4.5	5.41	6.2	6.39					
2016	1		1.38	2.6	3.55	4.81	6.33	7.61	8.9	9.26	10.83	13.41	16.84	17.03	17.76
2017	1		1.58	2.79	3.93	3.93	4.77	6.35	8.16	9.09	10.39	11.24	12.48	14.39	13.04
2018	3	0.58	1.16	1.76	2.45	3.34	4.13	5.81	7.16	8.99	9.96	10.85	11.73	14.01	17.79

[1] **Division 2.a only**

[2] **2.a and 2.b combined**

[3] **1,2.a and 2.b combined**

[4] **Division 2.b only**

Table 3.7. Northeast Arctic COD. Weights at age (kg) in landings from various countries (continued)
Spain (Division 2.b)

Year		Age													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994		0.43	1.08	1.38	2.32	2.47	2.68	3.46	5.20	7.04	6.79	7.20	8.04	10.46	15.35
1995		0.42	0.51	0.98	1.99	3.41	4.95	5.52	8.62	9.21	11.42	9.78	8.08		
1996			0.66	1.12	1.57	2.43	3.17	3.59	4.44	5.48	6.79	8.10			
1997	1	0.51	0.65	1.22	1.68	2.60	3.39	4.27	6.67	7.88	11.34	13.33	10.03	8.69	
1998		0.47	0.74	1.15	1.82	2.44	3.32	3.71	5.00	7.26					
1999	1	0.21	0.69	1.06	1.69	2.50	3.32	4.72	5.76	6.77	7.24	7.63			
2000	1	0.23	0.61	1.24	1.75	2.47	3.12	4.65	6.06	7.66	10.94	11.40	7.20		
2001		0.23	0.64	1.25	1.95	2.86	3.55	4.95	6.46	8.50	11.07	13.09			
2002		0.16	0.55	1.00	1.48	2.17	3.29	4.47	5.35	8.29	12.23	9.01	12.16	15.2	
2003			0.58	1.05	1.70	2.33	3.33	4.92	6.24	9.98	13.07	14.74	14.17		
2004	1	0.31	0.56	0.80	1.28	1.96	2.59	3.72	5.36	5.28	7.41		11.43		
2005	1		0.63	1.14	1.85	2.48	3.43	4.25	5.38	8.41	11.19	15.04	16.93		
2006		0.30	0.61	0.99	1.46	2.04	2.55	3.39	3.50	4.70	6.36				
2007		0.42	0.60	1.20	1.76	2.40	3.18	3.96	5.19	6.61	9.48	7.65	12.65	15.74	19.66

Year	Age												
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2009 [1]	0.12	0.45	0.95	1.60	2.18	3.36	4.52	6.04	7.30	9.42	10.35	11.47	12.54	
2010 [2]	0.18	0.56	1.11	1.73	2.36	3.36	5.14	6.88	8.64	9.65	6.83			
2011 [1]		0.45	0.90	1.26	1.84	2.55	4.08	5.61	8.17	8.14	7.31	8.91		
2012 [2]		0.40	0.84	1.29	1.96	2.78	3.71	4.99	7.42		7.19	9.32		
2013	0.17	0.72	1.06	1.63	2.36	3.14	3.90	4.36	6.55					
2014	0.24	0.43	0.74	1.27	1.85	2.60	3.56	4.51	5.52	7.18	9.42	9.26	13.16	15.05
2015 [2]		0.40	0.80	1.19	1.79	2.45	3.38	4.41	5.85	6.64	7.48	6.77		
2016 [3]	0.11	0.38	0.76	1.20	1.72	2.50	3.39	4.96	7.11	8.56				
2017 [2]	0.12	0.42	0.75	1.17	1.69	2.50	3.39	4.47	5.69	5.93	6.00	10.91	13.57	10.52
2018 [2]	0.19	0.45	0.83	1.30	1.86	2.57	3.55	4.92	5.51	7.84	7.08	7.28		

[1] 2.a and 2.b combined

[2] 1,2.a and 2.b combined

[3] 1 and 2.b combined

Iceland (Subarea 1)

Year	Age												
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994	0.42	0.85	1.44	2.77	3.54	4.08	5.84	6.37	7.02	7.48	7.37			
1995		1.17	0.91	1.60	2.28	3.61	4.73	6.27			6.26			
1996		0.36	0.99	1.55	2.83	3.79	4.81	5.34	7.25	7.68	9.08	8.98	10.52	
1997	0.42	0.43	0.76	1.60	2.40	3.45	4.40	5.74	6.15		8.28	10.52	9.89	

UK (England & Wales)

Year	Age												
	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1995 [1]			1.47	2.11	3.47	5.57	6.43	7.17	8.12	8.05	10.2	10.1		
1996 [2]			1.55	1.81	2.42	3.61	6.3	6.47	7.83	7.91	8.93	9.38	10.9	
1997 [2]			1.93	2.17	3.07	4.17	4.89	6.46		12.3	8.44			

[1] Divisions 2.a and 2.b

[2] Division 2.a

Poland (Division 2.b)

Year	Age													
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
2006	0.18	0.51	0.89	1.55	2.23	3.6	5.28	6.95	8.478	11	10.8	15.6	18.9	
2008		0.49	0.90	1.45	2.24	2.79	3.82	4.68	5.015	6.45	7.02	7.22	5.99	6.91
2009			1.02	1.72	2.65	3.81	5.23	6.91	8.862	11.1	13.6	16.5		
2010			1.39	1.66	2.29	2.98	3.92	5.18	6.313	6.66	8.72	9.05		
2011			0.99	1.50	2.17	3.15	4.43	7.45	7.28					
2016 [1]		0.84	1.59	2.29	2.81	3.91	4.78	5.61	6.709	7.89	8.54	11.6	13.7	16.09
2017 [2]		0.71	1.23	1.52	2.47	3.52	4.78	6.97	9.193	9.95	10.9	14.1		
2018 [3]		0.74	1.15	1.66	2.45	3.55	4.48	6.06	6.31	7.59	7.91	8.28	8.52	9.40

[1] **Division 2.a**

[2] **Divisions 2.a and 2.b**

[3] **1 and 2.b combined**

Table 3.8. Northeast Arctic COD. Catch weights-at-age (kg)
SAM
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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1946	0.35	0.59	1.11	1.69	2.37	3.17	3.98	5.05	5.92	7.2	8.15	8.13	9.25
1947	0.32	0.56	0.95	1.5	2.14	2.92	3.65	4.56	5.84	7.42	8.85	8.79	10
1948	0.34	0.53	1.26	1.93	2.46	3.36	4.22	5.31	5.92	7.09	8.43	8.18	9.43
1949	0.37	0.67	1.11	1.66	2.5	3.23	4.07	5.27	5.99	7.08	8.22	8.26	8.7
1950	0.39	0.64	1.29	1.7	2.36	3.48	4.52	5.62	6.4	7.96	8.89	9.07	10.27
1951	0.4	0.83	1.39	1.88	2.54	3.46	4.88	5.2	7.14	8.22	9.39	9.5	9.52
1952	0.44	0.8	1.33	1.92	2.64	3.71	5.06	6.05	7.42	8.43	10.19	10.13	10.56
1953	0.4	0.76	1.28	1.93	2.81	3.72	5.06	6.34	7.4	8.67	10.24	11.41	11.93
1954	0.44	0.77	1.26	1.97	3.03	4.33	5.4	6.75	7.79	10.67	9.68	9.56	11.11
1955	0.32	0.57	1.13	1.73	2.75	3.94	4.9	7.04	7.2	8.78	10.08	11.02	12.11
1956	0.33	0.58	1.07	1.83	2.89	4.25	5.55	7.28	8	8.35	9.94	10.25	11.56
1957	0.33	0.59	1.02	1.82	2.89	4.28	5.49	7.51	8.24	9.25	10.61	10.82	12.07
1958	0.34	0.52	0.95	1.92	2.94	4.21	5.61	7.35	8.67	9.58	11.63	11	13.83
1959	0.35	0.72	1.47	2.68	3.59	4.32	5.45	6.44	7.17	8.63	11.62	11.95	13
1960	0.34	0.51	1.09	2.13	3.38	4.87	6.12	8.49	7.79	8.3	11.42	11.72	13.42
1961	0.31	0.55	1.05	2.2	3.23	5.11	6.15	8.15	8.68	9.6	11.95	13.18	13.42
1962	0.32	0.55	0.93	1.7	3.03	5.03	6.55	7.7	9.27	10.56	12.72	13.48	14.44
1963	0.32	0.61	0.96	1.73	3.04	4.96	6.44	7.91	9.62	11.31	12.74	13.19	14.29
1964	0.33	0.55	0.95	1.86	3.25	4.97	6.41	8.07	9.34	10.16	12.89	13.25	14
1965	0.38	0.68	1.03	1.49	2.41	3.52	5.73	7.54	8.47	11.17	13.72	13.46	14.12
1966	0.44	0.74	1.18	1.78	2.46	3.82	5.36	7.27	8.63	10.66	14.15	14	15
1967	0.29	0.81	1.35	2.04	2.81	3.48	4.89	7.11	9.03	10.59	13.83	14.15	16.76
1968	0.33	0.7	1.48	2.12	3.14	4.21	5.27	6.65	9.01	9.66	14.85	16.3	17
1969	0.44	0.79	1.23	2.03	2.9	3.81	5.02	6.43	8.33	10.71	14.21	15	17
1970	0.37	0.91	1.34	2	3	4.15	5.59	7.6	8.97	10.99	14.07	14.61	16
1971	0.45	0.88	1.38	2.16	3.07	4.22	5.81	7.13	8.62	10.83	12.95	14.25	15.97
1972	0.38	0.77	1.43	2.12	3.23	4.38	5.83	7.62	9.52	12.09	13.67	13.85	16
1973	0.38	0.91	1.54	2.26	3.29	4.61	6.57	8.37	10.54	11.62	13.9	14	15.84

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1974	0.32	0.66	1.17	2.22	3.21	4.39	5.52	7.86	9.82	11.41	13.24	13.7	14.29
1975	0.41	0.64	1.11	1.9	2.95	4.37	5.74	8.77	9.92	11.81	13.11	14	14.29
1976	0.35	0.73	1.19	2.01	2.76	4.22	5.88	9.3	10.28	11.86	13.54	14.31	14.28
1977	0.49	0.9	1.43	2.05	3.3	4.56	6.46	8.63	9.93	10.9	13.67	14.26	14.91
1978	0.49	0.81	1.45	2.15	3.04	4.46	6.54	7.98	10.15	10.85	13.18	14	15
1979	0.35	0.7	1.24	2.14	3.15	4.29	6.58	8.61	9.22	10.89	14.34	14.5	15.31
1980	0.27	0.56	1.02	1.72	3.02	4.2	5.84	7.26	8.84	9.28	14.45	15	15.5
1981	0.49	0.98	1.44	2.09	2.98	4.85	6.57	9.16	10.82	10.77	13.93	15	16
1982	0.37	0.66	1.35	1.99	2.93	4.24	6.46	8.51	12.24	10.78	14.04	15	16
1983	0.84	1.37	2.09	2.86	3.99	5.58	7.77	9.29	11.55	11.42	12.8	14.18	15.55
1984	1.42	1.93	2.49	3.14	3.91	4.91	6.02	7.4	8.13	11.42	12.8	14.18	15.55
1985	0.94	1.37	2.02	3.22	4.63	6.04	7.66	9.81	11.8	11.42	12.8	14.18	15.55
1986	0.64	1.27	1.88	2.79	4.49	5.84	6.83	7.69	9.81	11.42	12.8	14.18	15.55
1987	0.49	0.88	1.55	2.33	3.44	5.92	8.6	9.6	12.17	11.42	12.8	14.18	15.55
1988	0.54	0.85	1.32	2.24	3.52	5.35	8.06	9.51	11.36	11.42	12.8	14.18	15.55
1989	0.74	0.96	1.31	1.92	2.93	4.64	7.52	9.12	11.08	11.42	12.8	14.18	15.55
1990	0.81	1.22	1.64	2.22	3.24	4.68	7.3	9.84	13.25	11.42	12.8	14.18	15.55
1991	1.05	1.45	2.15	2.89	3.75	4.71	6.08	8.82	11.8	11.42	12.8	14.18	15.55
1992	1.16	1.57	2.21	3.1	4.27	5.19	6.14	7.77	10.12	11.42	12.8	14.18	15.55
1993	0.81	1.52	2.16	2.79	4.07	5.53	6.47	7.19	7.98	11.42	12.8	14.18	15.55
1994	0.82	1.3	2.06	2.89	3.21	5.2	6.8	7.57	8.01	11.42	12.8	14.18	15.55
1995	0.77	1.2	1.78	2.59	3.81	4.99	6.23	8.05	8.74	11.42	12.8	14.18	15.55
1996	0.79	1.11	1.61	2.46	3.82	5.72	6.74	8.04	9.28	11.42	12.8	14.18	15.55
1997	0.67	1.04	1.53	2.22	3.42	5.2	7.19	7.73	8.61	11.42	12.8	14.18	15.55
1998	0.68	1.05	1.62	2.3	3.3	4.86	6.87	9.3	10.3	11.42	12.8	14.18	15.55
1999	0.63	1.01	1.54	2.34	3.21	4.29	6	6.73	10.08	11.42	12.8	14.18	15.55
2000	0.57	1.04	1.61	2.34	3.34	4.48	5.72	7.52	8.02	11.42	12.8	14.18	15.55
2001	0.66	1.05	1.62	2.51	3.51	4.78	6.04	7.54	9	11.42	12.8	14.18	15.55
2002	0.72	1.13	1.56	2.31	3.52	4.78	6.2	7.66	9.14	11.42	12.8	14.18	15.55

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2003	0.67	1.12	1.83	2.5	3.58	5.04	6.36	8.2	10.71	11.42	12.8	14.18	15.55
2004	0.72	1.13	1.61	2.43	3.27	4.72	6.71	7.98	9.19	11.42	12.8	14.18	15.55
2005	0.69	1.08	1.57	2.21	3.26	4.44	6.23	8.19	9.72	11.42	12.8	14.18	15.55
2006	0.72	1.16	1.6	2.39	3.32	4.54	5.47	6.78	7.7	11.42	12.8	14.18	15.55
2007	0.74	1.21	1.83	2.51	3.82	5.04	6.58	8.08	8.94	11.42	12.8	14.18	15.55
2008	0.77	1.27	1.87	2.82	3.79	5.12	6.22	7.75	8.4	11.42	12.8	14.18	15.55
2009	0.75	1.17	1.74	2.42	3.86	5.35	6.43	8.01	8.67	11.42	12.8	14.18	15.55
2010	0.78	1.2	1.74	2.44	3.4	5.04	6.25	7.32	8.53	11.42	12.8	14.18	15.55
2011	0.78	1.31	1.72	2.37	3.2	4.62	6.18	7.47	8.57	11.42	12.8	14.18	15.55
2012	0.67	1.14	1.73	2.34	3.12	4.4	6.28	8.24	10.35	11.42	12.8	14.18	15.55
2013	0.71	1.17	1.67	2.36	3.19	4.22	5.58	7.31	9.08	11.42	12.8	14.18	15.55
2014	0.79	1.2	1.73	2.34	3.28	4.21	5.49	6.98	8.67	11.42	12.8	14.18	15.55
2015	0.78	1.09	1.55	2.18	3.14	4.46	5.61	6.62	7.34	11.42	12.8	14.18	15.55
2016	0.78	1.14	1.66	2.26	3.25	4.5	5.98	7.31	8.54	11.42	12.8	14.18	15.55
2017	0.71	1.15	1.66	2.32	3.32	4.67	6.13	7.15	8.14	11.42	12.8	14.18	15.55
2018	0.86	1.17	1.71	2.5	3.31	4.61	6.03	7.32	8.06	11.42	12.8	14.18	15.55

Table 3.9. Northeast Arctic COD. Stock weights at age (kg)
SAM Sun Apr 28 18:53:18 2019

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1946	0.35	0.59	1.11	1.69	2.37	3.17	3.98	5.05	5.92	7.2	8.146	8.133	9.253
1947	0.32	0.56	0.95	1.5	2.14	2.92	3.65	4.56	5.84	7.42	8.848	8.789	9.998
1948	0.34	0.53	1.26	1.93	2.46	3.36	4.22	5.31	5.92	7.09	8.43	8.181	9.433
1949	0.37	0.67	1.11	1.66	2.5	3.23	4.07	5.27	5.99	7.08	8.218	8.259	8.701
1950	0.39	0.64	1.29	1.7	2.36	3.48	4.52	5.62	6.4	7.96	8.891	9.07	10.271
1951	0.4	0.83	1.39	1.88	2.54	3.46	4.88	5.2	7.14	8.22	9.389	9.502	9.517
1952	0.44	0.8	1.33	1.92	2.64	3.71	5.06	6.05	7.42	8.43	10.185	10.134	10.563
1953	0.4	0.76	1.28	1.93	2.81	3.72	5.06	6.34	7.4	8.67	10.238	11.409	11.926
1954	0.44	0.77	1.26	1.97	3.03	4.33	5.4	6.75	7.79	10.67	9.68	9.557	11.106
1955	0.32	0.57	1.13	1.73	2.75	3.94	4.9	7.04	7.2	8.78	10.077	11.023	12.105
1956	0.33	0.58	1.07	1.83	2.89	4.25	5.55	7.28	8	8.35	9.944	10.248	11.564

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1957	0.33	0.59	1.02	1.82	2.89	4.28	5.49	7.51	8.24	9.25	10.605	10.825	12.075
1958	0.34	0.52	0.95	1.92	2.94	4.21	5.61	7.35	8.67	9.58	11.631	11	13.832
1959	0.35	0.72	1.47	2.68	3.59	4.32	5.45	6.44	7.17	8.63	11.621	11.95	13
1960	0.34	0.51	1.09	2.13	3.38	4.87	6.12	8.49	7.79	8.3	11.422	11.719	13.424
1961	0.31	0.55	1.05	2.2	3.23	5.11	6.15	8.15	8.68	9.6	11.952	13.181	13.422
1962	0.32	0.55	0.93	1.7	3.03	5.03	6.55	7.7	9.27	10.56	12.717	13.482	14.44
1963	0.32	0.61	0.96	1.73	3.04	4.96	6.44	7.91	9.62	11.31	12.737	13.193	14.287
1964	0.33	0.55	0.95	1.86	3.25	4.97	6.41	8.07	9.34	10.16	12.886	13.251	14
1965	0.38	0.68	1.03	1.49	2.41	3.52	5.73	7.54	8.47	11.17	13.722	13.465	14.118
1966	0.44	0.74	1.18	1.78	2.46	3.82	5.36	7.27	8.63	10.66	14.148	14	15
1967	0.29	0.81	1.35	2.04	2.81	3.48	4.89	7.11	9.03	10.59	13.829	14.146	16.756
1968	0.33	0.7	1.48	2.12	3.14	4.21	5.27	6.65	9.01	9.66	14.848	16.3	17
1969	0.44	0.79	1.23	2.03	2.9	3.81	5.02	6.43	8.33	10.71	14.211	15	17
1970	0.37	0.91	1.34	2	3	4.15	5.59	7.6	8.97	10.99	14.074	14.611	16
1971	0.45	0.88	1.38	2.16	3.07	4.22	5.81	7.13	8.62	10.83	12.945	14.25	15.973
1972	0.38	0.77	1.43	2.12	3.23	4.38	5.83	7.62	9.52	12.09	13.673	13.852	16
1973	0.38	0.91	1.54	2.26	3.29	4.61	6.57	8.37	10.54	11.62	13.904	14	15.841
1974	0.32	0.66	1.17	2.22	3.21	4.39	5.52	7.86	9.82	11.41	13.242	13.704	14.291
1975	0.41	0.64	1.11	1.9	2.95	4.37	5.74	8.77	9.92	11.81	13.107	14	14.293
1976	0.35	0.73	1.19	2.01	2.76	4.22	5.88	9.3	10.28	11.86	13.544	14.311	14.284
1977	0.49	0.9	1.43	2.05	3.3	4.56	6.46	8.63	9.93	10.9	13.668	14.255	14.906
1978	0.49	0.81	1.45	2.15	3.04	4.46	6.54	7.98	10.15	10.85	13.177	14	15
1979	0.35	0.7	1.24	2.14	3.15	4.29	6.58	8.61	9.22	10.89	14.344	14.5	15.315
1980	0.27	0.56	1.02	1.72	3.02	4.2	5.84	7.26	8.84	9.28	14.448	15	15.5
1981	0.49	0.98	1.44	2.09	2.98	4.85	6.57	9.16	10.82	10.77	13.932	15	16
1982	0.37	0.66	1.35	1.99	2.93	4.24	6.46	8.51	12.24	10.78	14.041	15	16
1983	0.37	0.92	1.6	2.44	3.82	4.76	6.17	7.7	9.25	12.621	14.544	16.466	18.388
1984	0.42	1.16	1.81	2.79	3.78	4.57	6.17	7.7	9.25	12.621	14.544	16.466	18.388
1985	0.413	0.875	1.603	2.81	4.059	5.833	7.685	10.117	14.29	12.621	14.544	16.466	18.388

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1986	0.311	0.88	1.47	2.467	3.915	5.81	6.58	6.833	11.004	12.621	14.544	16.466	18.388
1987	0.211	0.498	1.254	2.047	3.431	5.137	6.523	9.3	13.15	12.621	14.544	16.466	18.388
1988	0.212	0.404	0.79	1.903	2.977	4.392	7.812	12.112	13.107	12.621	14.544	16.466	18.388
1989	0.299	0.52	0.868	1.477	2.686	4.628	7.048	9.98	9.25	12.621	14.544	16.466	18.388
1990	0.398	0.705	1.182	1.719	2.458	3.565	4.71	7.801	8.956	12.621	14.544	16.466	18.388
1991	0.518	1.136	1.743	2.428	3.214	4.538	6.88	10.719	9.445	12.621	14.544	16.466	18.388
1992	0.44	0.931	1.812	2.716	3.895	5.176	6.774	9.598	12.427	12.621	14.544	16.466	18.388
1993	0.344	1.172	1.82	2.823	4.031	5.497	6.765	8.571	10.847	12.621	14.544	16.466	18.388
1994	0.235	0.753	1.42	2.413	3.825	5.416	6.631	7.63	8.112	12.621	14.544	16.466	18.388
1995	0.201	0.485	1.14	2.118	3.47	4.938	7.16	9.119	10.101	12.621	14.544	16.466	18.388
1996	0.195	0.487	0.971	2.054	3.527	5.503	7.767	10.159	10.669	12.621	14.544	16.466	18.388
1997	0.202	0.521	1.079	1.878	3.369	5.263	8.927	12.154	11.204	12.621	14.544	16.466	18.388
1998	0.217	0.533	1.161	1.939	2.945	4.574	7.423	10.367	11.738	12.621	14.544	16.466	18.388
1999	0.203	0.52	1.174	2.031	3.034	4.464	6.482	10.269	10.882	12.621	14.544	16.466	18.388
2000	0.194	0.465	1.208	1.972	3.048	4.096	5.724	7.457	9.582	12.621	14.544	16.466	18.388
2001	0.285	0.522	1.196	2.239	3.313	5.118	6.376	9.241	11.322	12.621	14.544	16.466	18.388
2002	0.251	0.605	1.189	2.138	3.333	4.766	6.859	9.333	10.186	12.621	14.544	16.466	18.388
2003	0.23	0.537	1.31	2.009	3.241	4.971	6.739	8.706	15.026	12.621	14.544	16.466	18.388
2004	0.25	0.546	1.087	2.035	2.921	4.384	6.254	8.543	9.735	12.621	14.544	16.466	18.388
2005	0.231	0.624	1.118	1.932	3.046	3.955	5.811	8.289	13.44	12.621	14.544	16.466	18.388
2006	0.256	0.602	1.201	2.009	3.114	4.427	6.03	8.037	9.928	12.621	14.544	16.466	18.388
2007	0.262	0.699	1.341	2.121	3.167	4.64	6.495	9.123	11.78	12.621	14.544	16.466	18.388
2008	0.286	0.734	1.37	2.367	3.29	4.82	6.548	8.483	8.902	12.621	14.544	16.466	18.388
2009	0.26	0.641	1.343	2.36	3.763	5.111	6.554	9.098	9.432	12.621	14.544	16.466	18.388
2010	0.257	0.589	1.183	2.052	3.181	4.8	6.759	7.859	10.008	12.621	14.544	16.466	18.388
2011	0.224	0.589	1.088	1.915	2.776	4.319	6.495	8.489	10.016	12.621	14.544	16.466	18.388
2012	0.21	0.561	1.108	1.76	2.775	4.056	6.117	8.718	11.676	12.621	14.544	16.466	18.388
2013	0.256	0.589	1.151	2.019	2.857	4.049	5.631	8.146	10.378	12.621	14.544	16.466	18.388
2014	0.22	0.588	1.146	1.827	2.835	3.828	5.142	6.953	9.015	12.621	14.544	16.466	18.388

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2015	0.231	0.546	1.165	1.938	2.853	3.946	5.258	6.821	8.957	12.621	14.544	16.466	18.388
2016	0.229	0.53	1.037	1.805	2.712	3.964	5.537	7.073	8.648	12.621	14.544	16.466	18.388
2017	0.261	0.649	1.168	1.966	2.93	4.627	5.966	7.279	9.3	12.621	14.544	16.466	18.388
2018	0.277	0.631	1.21	1.943	2.742	4.041	5.701	7.485	9.406	12.621	14.544	16.466	18.388
2019	0.274	0.659	1.188	1.95	3.101	4.381	5.928	7.361	9.632	12.621	14.544	16.466	18.388

Table 3.10. Northeast Arctic COD. Basis for maturity ogives (percent) used in the assessment. Norwegian and Russian data.

Norway

	Percentage mature							
	Age							
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1982	0	5	10	34	65	82	92	100
1983	5	8	10	30	73	88	97	100

Russia

	Percentage mature							
	Age							
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1984	0	5	18	31	56	90	99	100
1985	0	1	10	33	59	85	92	100
1986	0	2	9	19	56	76	89	100
1987	0	1	9	23	27	61	81	80
1988	0	1	3	25	53	79	100	100
1989	0	0	2	15	39	59	83	100
1990	0	2	6	20	47	62	81	95
1991	0	3	1	23	66	82	96	100
1992	0	1	8	31	73	92	95	100
1993	0	3	7	21	56	89	95	99
1994	0	1	8	30	55	84	95	98
1995	0	0	4	23	61	75	94	97

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1996	0	0	1	22	56	82	95	100
1997	0	0	1	10	48	73	90	100
1998	0	0	2	15	47	87	97	96
1999	0	0.2	1.3	9.9	38.4	74.9	94	100
2000	0	0	6	19.2	51.4	84	95.5	100
2001	0.1	0.1	3.9	27.9	62.3	89.4	96.3	100
2002	0.1	1.9	10.9	34.4	68.1	82.8	97.6	100
2003	0.2	0	11	29.2	65.9	89.6	95.1	100
2004	0	0.7	8	33.8	63.3	83.4	96.4	96.4
2005	0	0.6	4.6	24.2	61.5	84.9	95.3	98.1
2006	0	0	6.1	29.6	59.6	89.5	96.4	100
2007	0	0.4	5.7	20.8	60.4	83.5	96	100
2008	0	0.5	4	24.6	48.3	84.4	94.7	98.7
2009	0	0	6	28	66	85	97	100
2010	0	0.2	1.5	22.8	47	77.4	90.2	95.5
2011	0	0	2.2	20.7	50.4	73.7	90.6	95.6
2012	0.2	0	1.5	10.8	43.9	76.1	90.8	96.4
2013	0	0	0.6	10.6	41.8	70.6	89.8	96.9
2014	0	0	1.9	14.1	45.9	76	92	97.5
2015	0	0.2	0.2	7.9	27	60.8	83.4	93.7
2016	0	0	0.2	5.2	22.4	44.1	74.8	92.5
2017*	0	0	0.8	6.3	20.8	51.6	80.4	98.6
2018	0	0.5	2.5	23.6	53.9	79.4	92.5	96.0
2019**	0	0	4.5	11.9	56.4	91.8	95.1	100.0

***Not used in inputs (instead ratios presented in WD 10, 2017 used for further calculations)**

****Not used in inputs (instead ratios presented in WD 15, 2019 used for further calculations)**

Norway

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
1985	0.31	1.36	8.94	38.33	51.27	85.13	100	79.2
1986	2.92	7	7.85	18.85	49.72	66.52	35.59	80.09
1987	0	0.07	4.49	12.42	16.28	31.23	19.32	
1988	0	2.35	6.16	40.54	53.63	45.36	100	100
1989	1.52	0.67	3.88	30.65	70.36	82.02	100	100
1990	1.52	0.67	4.18	22	57.45	80.95	100	100
1991	0.1	3.4	13.93	38.03	75.52	90.12	95.39	100
1992	0.22	1.85	21.04	52.83	86.95	96.52	99.83	100
1993	0	2.6	10.37	52.6	84.8	97.25	99.3	99.73
1994	0.51	0.33	15.78	36.92	62.84	88.44	97.56	100
1995	0	0.62	8.19	51.48	63.75	81.11	98.01	99.34
1996	0.03	0	2.82	29.56	70.22	82.06	100	100
1997	0	0	1.48	17.91	73.31	93.01	99.12	100
1998	0.12	0.68	3.17	15.42	47.31	75.73	94.3	100
1999	0.42	0.16	1.6	27.46	70.48	94.57	98.99	100
2000	0	0.11	8.15	30.23	77.3	81.95	100	100
2001	0.49	0.51	9.03	43.81	62.52	74.36	94.13	100
2002	0.27	0.73	5.94	43.22	68.4	85.31	92.52	100
2003	0.02	0.18	6.5	35.97	68.56	87.97	96.3	100
2004	0.24	1.36	10.23	54.56	81.84	90.94	98.76	98.91
2005	0	0.27	9	55.16	81.77	93.51	98.03	100
2006	0	0.22	5.92	44.25	69.85	89.89	96.65	100
2007	0.12	0.33	8.7	47.88	84.29	91.68	99.11	100
2008	0	0.27	9.27	34.13	61.39	88.04	91.17	100
2009	0	0	9	46	85	86	98	99
2010	0	0.36	7.5	41.75	67.7	90.1	95.29	98.55
2011	0	0.2	5.2	48	77.7	89.7	97.3	97.2

	Percentage mature							
	Age							
Year	3	4	5	6	7	8	9	10
2012	0	0	7.7	32.2	67.5	81	90.9	96.3
2013	0	0.3	1	20.2	55.3	80	91.8	99.3
2014	0	0.4	2	13.3	56.7	85	93.8	98.7
2015	0	0	1.9	10.9	29.2	79.1	93.1	99.6
2016	0.07	0.19	1.05	6.4	28.53	71.3	86.06	98.56
2017	0	0.2	0.5	18	54.8	81.4	95.9	100
2018	0	0.1	3.0	16.2	38.3	61.0	93.7	98.9
2019	0.0	0.3	4.0	24.0	68.6	93.1	96.7	99.8

Table 3.11. Northeast Arctic cod. Proportion mature-at-age
SAM
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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1946	0	0	0.01	0.03	0.06	0.11	0.18	0.44	0.65	0.86	0.96	0.96	1
1947	0	0	0.01	0.03	0.06	0.13	0.16	0.42	0.75	0.91	0.95	1	1
1948	0	0	0.01	0.03	0.07	0.13	0.25	0.47	0.73	0.91	0.97	1	1
1949	0	0	0.01	0.03	0.09	0.17	0.29	0.54	0.79	0.88	0.97	1	1
1950	0	0	0.01	0.03	0.09	0.23	0.35	0.52	0.79	0.95	0.97	1	1
1951	0	0	0.01	0.03	0.1	0.24	0.4	0.58	0.72	0.85	0.96	1	1
1952	0	0	0.01	0.03	0.08	0.22	0.41	0.63	0.82	0.92	0.97	1	1
1953	0	0	0.01	0.03	0.07	0.19	0.4	0.64	0.84	0.94	0.97	1	1
1954	0	0	0.01	0.03	0.08	0.16	0.37	0.68	0.87	0.93	0.96	1	1
1955	0	0	0.01	0.03	0.07	0.13	0.26	0.53	0.83	0.92	0.97	1	1
1956	0	0	0.01	0.03	0.06	0.12	0.14	0.41	0.67	0.91	0.96	1	1
1957	0	0	0.01	0.03	0.06	0.09	0.12	0.22	0.6	0.82	0.97	1	1
1958	0	0	0.01	0.03	0.06	0.1	0.1	0.3	0.5	0.82	0.97	1	1
1959	0	0	0.01	0.04	0.12	0.34	0.49	0.67	0.84	0.87	1	1	1
1960	0	0.01	0.03	0.06	0.1	0.19	0.45	0.69	0.77	0.85	0.99	1	1
1961	0	0	0.01	0.06	0.12	0.31	0.65	0.91	0.98	0.98	1	0.96	1
1962	0	0	0.01	0.05	0.15	0.34	0.61	0.81	0.92	0.97	1	0.932	1
1963	0	0.01	0.01	0.03	0.07	0.28	0.42	0.81	0.98	0.98	1	0.966	1
1964	0	0	0	0.03	0.13	0.37	0.66	0.89	0.95	0.99	1	1	1
1965	0	0	0	0.01	0.06	0.2	0.55	0.73	0.99	0.98	1	1	1
1966	0	0	0.01	0.02	0.06	0.22	0.35	0.74	0.94	0.94	1	1	1
1967	0	0	0	0.03	0.07	0.14	0.38	0.64	0.89	0.9	1	1	1
1968	0	0	0.03	0.05	0.09	0.19	0.39	0.58	0.82	1	1	1	1
1969	0	0	0	0.02	0.04	0.12	0.34	0.55	0.74	0.95	1	1	1
1970	0	0.01	0	0.01	0.07	0.23	0.58	0.81	0.89	0.91	1	1	1
1971	0	0	0.01	0.05	0.11	0.3	0.59	0.79	0.86	0.88	1	1	1
1972	0.01	0.02	0.02	0.01	0.1	0.34	0.64	0.81	0.94	1	1	1	1
1973	0	0	0	0.02	0.16	0.53	0.81	0.92	0.95	0.98	1	1	1

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1974	0	0	0	0.01	0.03	0.21	0.5	0.96	1	0.96	1	1	1
1975	0	0	0.01	0.02	0.09	0.21	0.56	0.78	0.79	0.95	1	1	1
1976	0	0	0	0.05	0.12	0.29	0.45	0.84	0.83	1	0.9	1	1
1977	0	0	0.02	0.08	0.26	0.54	0.76	0.87	0.93	0.94	0.9	1	1
1978	0	0	0	0.02	0.13	0.44	0.71	0.77	0.81	0.89	0.8	1	1
1979	0	0	0	0.03	0.13	0.39	0.77	0.89	0.83	0.78	0.9	1	1
1980	0	0	0	0.02	0.13	0.35	0.65	0.82	1	0.9	0.9	1	1
1981	0	0	0.02	0.07	0.2	0.54	0.8	0.97	1	1	1	1	1
1982	0	0.05	0.1	0.34	0.65	0.82	0.92	1	1	1	1	1	1
1983	0.01	0.08	0.1	0.3	0.73	0.88	0.97	1	1	1	1	1	1
1984	0	0.05	0.18	0.31	0.56	0.9	0.99	1	1	1	1	1	1
1985	0	0.01	0.09	0.36	0.55	0.85	0.96	0.9	1	1	1	1	1
1986	0	0.05	0.08	0.19	0.53	0.71	0.62	0.9	1	1	1	1	1
1987	0	0.01	0.07	0.18	0.22	0.46	0.5	0.75	1	1	1	1	1
1988	0	0.02	0.05	0.33	0.53	0.62	1	1	1	1	1	1	1
1989	0.008	0.003	0.029	0.228	0.547	0.705	0.915	1	1	1	1	1	1
1990	0.008	0.013	0.051	0.21	0.522	0.715	0.905	0.975	1	1	1	1	1
1991	0.001	0.032	0.075	0.305	0.708	0.861	0.957	1	1	1	1	1	1
1992	0.001	0.014	0.145	0.419	0.8	0.943	0.974	1	1	1	1	1	1
1993	0	0.028	0.087	0.368	0.704	0.931	0.972	0.994	1	1	1	1	1
1994	0.003	0.007	0.119	0.335	0.589	0.862	0.963	0.99	1	1	1	1	1
1995	0	0.003	0.061	0.372	0.624	0.781	0.96	0.979	1	1	1	1	1
1996	0	0	0.019	0.258	0.631	0.82	0.975	1	1	1	1	1	1
1997	0	0	0.012	0.14	0.607	0.83	0.946	1	1	1	1	1	1
1998	0.001	0.003	0.026	0.152	0.472	0.814	0.957	0.98	1	1	1	1	1
1999	0.002	0.002	0.014	0.187	0.544	0.847	0.965	1	1	1	1	1	1
2000	0	0.001	0.071	0.247	0.643	0.83	0.978	1	1	1	1	1	1
2001	0.003	0.003	0.065	0.359	0.624	0.819	0.952	1	1	1	1	1	1
2002	0.002	0.013	0.084	0.388	0.683	0.841	0.951	1	1	1	1	1	1

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2003	0.001	0.001	0.088	0.326	0.672	0.888	0.957	1	1	1	1	1	1
2004	0.001	0.01	0.091	0.442	0.726	0.872	0.976	0.977	1	1	1	1	1
2005	0	0.004	0.068	0.397	0.716	0.892	0.967	0.991	1	1	1	1	1
2006	0	0.001	0.06	0.369	0.647	0.897	0.965	1	1	1	1	1	1
2007	0	0.004	0.072	0.343	0.723	0.876	0.976	1	1	1	1	1	1
2008	0	0.004	0.062	0.282	0.538	0.863	0.928	0.994	1	1	1	1	1
2009	0	0	0.076	0.372	0.755	0.857	0.977	0.997	0.981	1	1	1	1
2010	0	0.003	0.045	0.323	0.573	0.838	0.927	0.97	0.974	0.986	1	1	1
2011	0	0.001	0.037	0.343	0.64	0.817	0.94	0.964	0.991	0.989	1	1	1
2012	0.001	0	0.046	0.215	0.557	0.786	0.909	0.964	0.99	0.989	1	1	1
2013	0	0.002	0.008	0.154	0.486	0.753	0.908	0.981	0.989	1	1	1	1
2014	0	0.002	0.019	0.137	0.513	0.805	0.929	0.981	0.998	1	1	1	1
2015	0	0.001	0.011	0.094	0.281	0.7	0.883	0.967	0.988	0.994	1	1	1
2016	0	0.001	0.006	0.058	0.255	0.577	0.804	0.955	0.986	1	1	1	1
2017	0	0.002	0.004	0.148	0.493	0.781	0.94	0.99	1	0.996	1	1	1
2018	0	0.003	0.027	0.199	0.461	0.702	0.931	0.974	1	0.989	0.991	1	1
2019	0	0.003	0.033	0.199	0.624	0.894	0.947	0.988	0.997	1	1	1	1

Table 3.12. The Northeast Arctic cod stock's consumption of cod in million individuals

Age	0	1	2	3	4	5	6
1984	0.000	415.758	21.198	0.228	0.000	0.000	0.000
1985	1555.101	373.360	66.359	0.184	0.000	0.000	0.000
1986	51.176	939.536	385.612	97.691	0.000	0.000	0.000
1987	671.998	180.218	278.630	14.187	0.000	0.000	0.000
1988	29.018	410.532	22.269	1.570	0.000	0.000	0.000
1989	909.916	143.714	0.000	0.000	0.000	0.000	0.000
1990	0.000	126.168	28.076	0.000	0.000	0.000	0.000
1991	122.993	151.311	214.867	1.819	0.000	0.000	0.000
1992	4303.581	1025.534	154.334	4.301	0.000	0.000	0.000
1993	3787.746	20185.712	508.876	51.439	1.382	0.440	0.000

Age	0	1	2	3	4	5	6
1994	7736.962	6682.587	617.760	128.034	51.139	8.178	0.415
1995	8144.974	14913.968	743.249	204.751	64.068	3.608	0.217
1996	9191.479	21039.477	1478.360	142.101	55.525	19.830	1.126
1997	2884.053	15228.549	1827.552	174.311	16.543	1.288	0.228
1998	76.338	4681.534	522.125	210.279	24.735	1.586	0.502
1999	577.347	1797.176	289.814	51.534	4.344	0.005	0.000
2000	1639.380	2183.268	169.731	36.721	14.070	3.953	0.044
2001	90.668	2268.248	114.758	24.467	13.128	2.031	1.131
2002	7628.686	464.289	408.431	42.097	5.555	0.852	0.018
2003	5547.393	4373.454	110.336	24.884	0.000	0.000	0.000
2004	6574.460	2390.806	579.402	21.247	11.460	1.563	0.266
2005	2473.400	2972.940	133.751	82.210	4.691	5.725	0.531
2006	3732.433	2092.722	147.744	6.243	2.032	0.075	0.000
2007	2381.832	1163.180	191.766	75.687	3.503	0.130	0.000
2008	16134.226	789.146	92.849	102.062	33.633	4.472	0.000
2009	10929.329	8222.379	159.788	77.236	23.548	5.801	0.258
2010	4902.355	8230.604	335.563	61.660	32.670	20.380	2.703
2011	14662.972	5083.121	509.812	195.020	48.800	13.444	6.284
2012	24126.530	13957.457	1172.312	121.224	37.904	5.413	0.000
2013	30964.597	5637.282	1858.536	218.117	21.799	9.905	1.502
2014	36435.919	6438.967	867.706	239.532	65.930	6.495	0.080
2015	1671.597	10709.437	345.639	81.164	51.819	22.196	2.188
2016	11920.413	2696.465	521.293	15.201	25.395	37.392	8.826
2017	15905.809	1915.877	465.450	152.035	9.594	4.909	3.581
2018	7565.160	11822.180	207.086	50.267	3.018	0.099	0.000

Table 3.13. Northeast Arctic COD. Tuning data

North-East Arctic cod (Sub-areas I and II) (run name: XSAASA01)									
104									
FLT15: NorBarTrSur									
1981	2019								
1	1	0.085	0.189						
4	12								
1	2330	4000	3840	480	100	30	NA	NA	NA
1	2770	2360	1550	1600	140	20	NA	NA	NA
1	5234	4333	1696	582	321	97	NA	NA	NA
1	2828	2144	1174	407	40	8	NA	NA	NA
1	12598	1992	767	334	21	7	NA	NA	NA
1	14393	6414	830	191	34	4	NA	NA	NA
1	39115	5435	1570	200	45	3	NA	NA	NA
1	8049	17331	2048	358	53	3	NA	NA	NA
1	7586	3779	9019	982	94	10	NA	NA	NA
1	3487	3459	2056	2723	161	38	NA	NA	NA
1	3367	2565	2149	1215	1267	61	NA	NA	NA
1	5771	1782	1283	767	429	272	NA	NA	NA
1	14013	7248	1583	624	389	223	NA	NA	NA
1	30760	15260	4680	813	259	132	55	52	11
1	24210	25230	7710	1790	233	113	55	59	19
1	11670	14070	11120	2480	279	37	16	8	8
1	6920	7500	6070	2680	495	63	68	46	0
1	16740	3170	2640	1750	826	79	52	65	0
1	18190	6130	1280	683	519	98	27	2	3
1	13000	11200	2700	473	182	123	36	10	3
1	19450	8160	3800	958	119	45	19	4	0
1	13770	10860	4650	1450	219	34	19	5	0
1	12540	9520	6660	1790	472	102	16	4	0
1	18610	5360	4320	3090	692	166	29	8	1
1	5480	10270	2240	1640	380	88	30	4	2
1	11400	2810	4330	1400	519	134	22	21	8
1	12730	6890	1370	2360	685	220	40	31	8
1	30000	11560	4080	1800	829	186	35	2	2
1	19610	21800	5820	1750	844	527	50	18	3
1	11490	15550	14450	3980	1120	370	164	57	5
1	5070	12990	13800	10310	1670	434	117	79	20
1	7030	3640	9390	13630	4960	938	233	87	60
1	11980	6400	4100	6500	7620	3360	221	283	41
1	8510	6790	4780	3260	4690	3170	936	101	97
1	17020	13570	9980	7120	2740	5280	1700	286	72
1	11230	15130	10900	6610	2660	1280	1500	643	96
1	3970	4870	5660	2780	1890	763	301	222	349
1	14870	4610	5570	5340	2390	748	541	113	224
1	13200	18860	6640	2700	2880	760	172	34	17
FLT16: NorBarLofAcSur									
1985	2019								
1	1	0.085	0.26						
4	12								
1	1416	204	151	157	33	13	10	5	NA
1	1343	684	116	77	31	3	NA	4	NA
1	2049	502	174	14	30	7	NA	NA	NA
1	355	578	109	40	3	NA	1	NA	NA
1	344	214	670	166	32	5	2	NA	NA
1	206	262	269	668	73	6	3	NA	NA
1	346	293	339	367	500	37	2	2	NA
1	658	215	184	284	254	824	43	17	NA
1	1911	1131	354	255	252	277	442	49	NA
1	4045	2175	895	225	119	94	39	180	NA
1	1598	2166	1040	290	44	43	30	26	NA
1	705	872	891	446	65	11	4	9	NA
1	517	497	422	499	205	22	5	NA	NA
1	1826	424	338	340	247	49	7	2	NA
1	964	454	122	112	187	92	10	2	NA
1	1589	1457	493	129	69	52	12	6	NA
1	1716	816	573	198	24	8	6	3	NA
1	1122	1043	661	345	95	12	5	6	NA
1	1144	1315	1445	643	212	38	5	1	NA
1	928	327	451	468	222	88	22	2	NA
1	337	661	299	432	172	75	18	1	NA
1	591	157	381	169	155	88	24	3	NA
1	371	318	130	427	138	75	33	8	NA
1	3061	1410	754	246	329	58	28	17	NA
1	1783	1405	495	401	133	260	37	17	NA
1	1219	1759	1949	709	375	111	88	17	NA
1	291	824	1587	2843	656	226	61	78	5
1	527	381	828	2244	1547	309	108	48	20
1	850	710	575	1194	2249	1756	209	126	49
1	1178	918	679	529	1354	1751	977	142	66
1	1542	1193	996	965	362	1112	663	300	68
1	583	969	646	587	339	341	481	292	170
1	404	486	766	498	503	285	180	147	172
1	1361	473	546	678	462	186	143	59	59
1	977	1248	563	480	677	264	212	65	29

Table 3.13. Northeast Arctic COD. Tuning data (continued)

FLT18: RusSweptArea										
1982	2018									
1	1	0.9	1							
3	12									
1	1413	1525	721	198	551	174	37	19	15	1
1	520	642	506	358	179	252	94	NA	NA	NA
1	1189	700	489	357	154	69	61	17	15	6
1	1188	1592	1068	365	165	37	8	16	1	21
1	1622	1532	1493	481	189	42	2	6	NA	NA
1	557	3076	900	701	184	60	25	4	1	3
1	993	938	2879	583	260	47	24	NA	NA	NA
1	490	978	1062	1454	1167	299	112	47	18	7
1	167	487	627	972	1538	673	153	49	9	2
1	1077	484	532	583	685	747	98	14	3	NA
1	675	308	239	273	218	175	25	25	4	NA
1	1604	1135	681	416	354	87	3	7	1	1
1	1363	1309	1019	354	128	49	21	11	6	2
1	589	1065	1395	849	251	83	19	18	9	6
1	733	784	1035	773	348	132	19	5	12	2
1	1342	835	613	602	348	116	32	30	NA	NA
1	2028	1363	788	470	259	130	48	5	NA	1
1	1587	2072	980	301	123	94	42	4	NA	NA
1	1839	1286	1786	773	114	52	23	9	4	NA
1	1224	1557	1290	1061	304	50	14	5	25	13
1	980	1473	1473	896	600	182	29	8	1	1
1	1246	1057	1166	1203	535	241	40	9	3	NA
1	329	1576	880	1111	776	279	93	23	4	2
1	1408	631	1832	744	605	244	88	28	6	1
1	927	1613	777	1801	662	342	161	43	17	7
1	2579	1617	1903	846	1525	553	226	86	49	11
1	2203	3088	1635	1472	830	863	291	115	33	17
1	974	2317	3687	2016	1175	620	413	205	65	32
1	334	1070	2505	3715	1817	789	395	299	156	55
1	882	508	1432	3065	3300	917	439	176	175	70
1	815	1114	839	2122	3358	1878	432	195	46	57
1	747	1174	1177	884	2349	3132	1367	306	92	54
1	1399	1368	1725	1483	1111	1929	1297	383	93	35
1	657	1583	1742	1932	1610	925	1158	761	242	65
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	1456	884	1063	1952	1231	567	266	120	120	75
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
FLT007: Ecosystem_2018										
2004	2018									
1	1	0.65	0.75							
3	12									
1	1477	4215	1502	798	402	101	22	5	1	1
1	2166	558	1009	280	156	57	12	5	1	NA
1	1861	2056	599	698	176	81	26	6	2	NA
1	5862	1592	791	246	269	60	22	9	1	2
1	6526	4834	1323	511	128	175	33	9	2	2
1	2023	2806	2896	1017	319	127	73	26	8	3
1	568	1770	3972	4249	1427	385	105	68	16	3
1	1236	1015	2402	3004	1784	323	77	18	13	6
1	2291	1464	700	1508	1652	845	127	44	16	14
1	2491	1836	1257	632	1182	1302	538	91	33	15
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1	1744	2252	1413	726	486	262	353	266	79	17
1	772	937	1216	701	444	272	138	132	54	17
1	3750	1415	1049	1209	626	280	112	64	44	45
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 3.14. SAM model parameter settings used in the Final run and their variant used in the SPALY run (highlighted in grey)

Min Age (should not be modified unless data are modified accordingly)

3

Max Age (should not be modified unless data are modified accordingly)

15

Max Age considered a plus group (0=No, 1=Yes)

1

Coupling of correlation in observations

(NA NA NA NA NA NA NA NA NA NA NA NA)

(-1 0 1 2 3 4 4 4 4 -1 -1 -1)

(-1 5 6 7 8 9 10 10 10 -1 -1 -1)

(11 12 13 14 14 14 14 14 14 -1 -1 -1)

(15 16 17 18 19 20 20 20 20 -1 -1 -1)

Coupling of OBSERVATION VARIANCES

Variant used in the Final SAM run (ages pick upped to be estimated separately highlighted by cyan)

(0 0 0 0 0 0 0 0 0 0 1 1 1)

(-1 2 3 3 3 3 3 3 4 3 -1 -1 -1)

(-1 5 5 5 5 5 5 5 6 5 -1 -1 -1)

(7 7 7 7 7 7 8 7 8 8 -1 -1 -1)

(9 9 9 9 9 9 9 9 9 10 -1 -1 -1)

Variant used in the SPALY SAM run

(0 0 0 0 0 0 0 0 0 0 0 0 0)

(-1 1 1 1 1 1 1 1 1 1 -1 -1 -1)

(-1 2 2 2 2 2 2 2 2 2 -1 -1 -1)

(3 3 3 3 3 3 3 3 3 3 -1 -1 -1)

(4 4 4 4 4 4 4 4 4 4 -1 -1 -1)

Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)

0

Years in which catch data are to be scaled by an estimated parameter

0

Define Fbar range

5 10

Table 3.15. Northeast Arctic cod. Fishing mortality
SAM
Sun Apr 28 18:53:19 2019

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1946	0.0021	0.0177	0.062	0.119	0.23	0.2	0.3089	0.2953	0.4381	0.4077	0.4222	0.4997	0.4997	0.2025
1947	0.0015	0.0177	0.0849	0.1959	0.3997	0.3227	0.4826	0.4851	0.7952	0.7259	0.7356	0.8535	0.8535	0.3285
1948	8e-04	0.012	0.0668	0.1847	0.4102	0.3456	0.4842	0.4461	0.7025	0.6656	0.7151	0.8792	0.8792	0.3229
1949	0.0019	0.029	0.1355	0.2987	0.4895	0.3739	0.4656	0.4605	0.742	0.7349	0.7907	0.9854	0.9854	0.3706
1950	0.0025	0.0351	0.1403	0.2712	0.4032	0.3489	0.4828	0.5627	0.9243	0.9556	0.9937	1.2299	1.2299	0.3682
1951	0.0108	0.1128	0.2831	0.3871	0.4562	0.3754	0.471	0.5153	0.695	0.7511	0.8128	1.0376	1.0376	0.4147
1952	0.0159	0.1433	0.353	0.5065	0.5537	0.4667	0.602	0.7562	1.053	1.1392	1.1446	1.3769	1.3769	0.5397
1953	0.0173	0.1212	0.2556	0.3475	0.372	0.3342	0.422	0.5484	0.7178	0.733	0.7374	0.8806	0.8806	0.3799
1954	0.0162	0.111	0.2541	0.3647	0.3829	0.3448	0.4471	0.6228	0.7879	0.7768	0.7531	0.8532	0.8532	0.4027
1955	0.0141	0.0969	0.2691	0.4709	0.5165	0.5198	0.5868	0.7491	0.8867	0.8634	0.7998	0.8538	0.8538	0.5187
1956	0.0198	0.1353	0.3724	0.6316	0.649	0.6542	0.6596	0.804	0.9853	1.0391	0.9273	0.9222	0.9222	0.6285
1957	0.0181	0.1143	0.2699	0.4677	0.5145	0.5451	0.5422	0.6888	0.861	0.9039	0.8057	0.7735	0.7735	0.5047
1958	0.0356	0.2085	0.4038	0.5576	0.5316	0.5067	0.5065	0.6834	0.8064	0.8082	0.6797	0.6305	0.6305	0.5316
1959	0.0359	0.2169	0.4342	0.5477	0.5225	0.5221	0.5302	0.6709	0.717	0.6997	0.6153	0.5828	0.5828	0.5379
1960	0.0333	0.1972	0.3783	0.4634	0.444	0.4742	0.4917	0.6751	0.7733	0.747	0.6742	0.6476	0.6476	0.4878
1961	0.0378	0.2368	0.4903	0.5851	0.5538	0.628	0.6873	0.851	0.926	0.867	0.7965	0.7491	0.7491	0.6326
1962	0.0393	0.2681	0.6333	0.7773	0.6728	0.6988	0.7882	0.9389	0.9381	0.8208	0.7701	0.7119	0.7119	0.7515
1963	0.0276	0.2169	0.6396	0.9017	0.8736	0.9108	1.0437	1.252	1.2951	1.0553	0.9672	0.8516	0.8516	0.9369
1964	0.0187	0.1356	0.3693	0.518	0.5694	0.7016	0.9073	0.965	1.0439	0.8885	0.9077	0.8169	0.8169	0.6718
1965	0.0222	0.1364	0.3346	0.4247	0.4488	0.5539	0.7177	0.7504	0.7212	0.6312	0.7213	0.6808	0.6808	0.5384
1966	0.0255	0.132	0.2792	0.3604	0.4306	0.5568	0.7006	0.6953	0.6096	0.5644	0.6315	0.58	0.58	0.5038
1967	0.0243	0.1275	0.244	0.3071	0.4157	0.6068	0.8315	0.8634	0.8562	0.7447	0.7888	0.6737	0.6737	0.5448
1968	0.0276	0.168	0.3489	0.4163	0.4714	0.5937	0.7559	0.7212	0.6474	0.5187	0.5982	0.5403	0.5403	0.5513
1969	0.0321	0.1971	0.4438	0.5582	0.7013	0.9184	1.1442	1.0945	1.0427	0.7776	0.8201	0.6996	0.6996	0.8101
1970	0.0351	0.1726	0.3925	0.4971	0.619	0.8491	1.0018	0.9156	0.7609	0.5419	0.5993	0.5419	0.5419	0.7125
1971	0.0268	0.1109	0.2436	0.3166	0.4424	0.7205	0.9246	0.8457	0.7329	0.5499	0.5933	0.5322	0.5322	0.5822
1972	0.0504	0.1655	0.3082	0.3718	0.4423	0.7482	1.1111	1.1693	1.082	0.8023	0.8376	0.7217	0.7217	0.6918
1973	0.1148	0.2646	0.4028	0.4308	0.458	0.6754	0.8541	0.8115	0.764	0.6083	0.6554	0.583	0.583	0.6054

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1974	0.1655	0.3751	0.5406	0.5363	0.4969	0.5956	0.6881	0.7924	0.9044	0.761	0.8339	0.7237	0.7237	0.6083
1975	0.1066	0.2636	0.4787	0.5942	0.6211	0.713	0.738	0.7304	0.8874	0.7645	0.8248	0.7104	0.7104	0.6459
1976	0.1329	0.3281	0.5351	0.6146	0.6577	0.7799	0.7753	0.5905	0.6712	0.6145	0.6951	0.6609	0.6609	0.6589
1977	0.1501	0.4206	0.6992	0.754	0.7583	0.9128	1.0551	0.7684	0.8367	0.7684	0.882	0.8901	0.8901	0.8246
1978	0.1105	0.3129	0.6183	0.8018	0.8509	1.0027	1.3069	1.1531	1.6095	1.4921	1.5899	1.5944	1.5944	0.9556
1979	0.0551	0.1841	0.3823	0.5726	0.6649	0.7823	1.0327	0.9904	1.3363	1.2395	1.3699	1.5722	1.5722	0.7375
1980	0.0377	0.1442	0.326	0.5712	0.7033	0.8045	1.0213	1.0278	1.2766	1.1467	1.2225	1.4726	1.4726	0.7424
1981	0.0283	0.1198	0.2694	0.5387	0.7947	0.9976	1.1875	1.0387	1.0535	0.9338	0.8728	1.0098	1.0098	0.8044
1982	0.0408	0.1777	0.3465	0.639	0.8808	1.0005	1.0813	0.8499	0.8295	0.8585	0.7648	0.9519	0.9519	0.7997
1983	0.0268	0.1414	0.2974	0.5448	0.8575	1.0121	0.9835	0.7706	0.6375	0.6278	0.5847	0.819	0.819	0.7443
1984	0.0241	0.13	0.312	0.6124	1.0731	1.2602	1.1944	0.9749	0.817	0.7595	0.6387	0.9304	0.9304	0.9045
1985	0.0362	0.1637	0.3746	0.6445	0.9261	1.0061	0.7755	0.6007	0.471	0.4145	0.3582	0.6007	0.6007	0.7213
1986	0.037	0.1755	0.438	0.7511	0.9957	1.117	0.9492	1.0198	0.8836	0.8646	0.6295	1.0234	1.0234	0.8785
1987	0.0464	0.196	0.5153	0.8806	1.1238	1.1223	0.9777	1.2554	1.1564	1.2301	0.8304	1.3653	1.3653	0.9792
1988	0.0353	0.1367	0.3522	0.668	1.0289	1.1551	1.1651	1.6626	1.5375	1.6828	1.0533	1.6494	1.6494	1.0053
1989	0.0267	0.1044	0.2503	0.4498	0.7014	0.8733	0.8176	0.9698	0.8562	0.9537	0.6751	1.2919	1.2919	0.677
1990	0.0136	0.0579	0.1269	0.2158	0.3099	0.3961	0.4153	0.4956	0.5234	0.6593	0.5292	1.0974	1.0974	0.3266
1991	0.016	0.0805	0.1776	0.2795	0.3577	0.3771	0.3561	0.3317	0.2618	0.3243	0.2881	0.6835	0.6835	0.3133
1992	0.0241	0.1288	0.2904	0.4372	0.5258	0.5285	0.5035	0.4855	0.4041	0.5424	0.481	1.1087	1.1087	0.4618
1993	0.0146	0.0999	0.2879	0.4894	0.6146	0.6273	0.6657	0.7349	0.7202	0.9489	0.8822	1.8371	1.8371	0.57
1994	0.013	0.1024	0.3338	0.6553	0.9831	0.9965	1.0059	1.0903	1.1445	1.4179	1.4324	2.9386	2.9386	0.8441
1995	0.0139	0.1059	0.3226	0.6052	0.8863	0.943	0.96	1.0334	1.0801	1.2367	1.3739	2.8181	2.8181	0.7918
1996	0.0189	0.1308	0.3526	0.576	0.767	0.8579	0.8215	0.9128	0.8482	0.9037	0.9628	1.8908	1.8908	0.7146
1997	0.0249	0.19	0.4979	0.747	0.9309	1.204	1.2595	1.3316	1.2002	1.1188	0.9476	1.379	1.379	0.9952
1998	0.0304	0.2314	0.5507	0.7614	0.8483	1.0806	1.1782	1.2646	1.0501	0.9628	0.7631	0.9746	0.9746	0.9473
1999	0.0175	0.1607	0.479	0.7265	0.8596	1.0931	1.2466	1.2818	0.9139	0.8252	0.6321	0.7477	0.7477	0.9478
2000	0.01	0.0995	0.3367	0.5831	0.7848	1.0124	1.1383	1.1809	0.8597	0.8178	0.5513	0.6258	0.6258	0.8393
2001	0.009	0.0843	0.2798	0.5054	0.7056	0.8731	0.9096	0.9847	0.7004	0.6636	0.4512	0.5606	0.5606	0.7097
2002	0.0081	0.079	0.2721	0.5136	0.7491	0.8586	0.7958	0.7597	0.5733	0.5835	0.3755	0.4656	0.4656	0.6582

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
2003	0.0096	0.082	0.2655	0.4571	0.6468	0.7004	0.6258	0.5823	0.455	0.4621	0.2768	0.3231	0.3231	0.5463
2004	0.0097	0.0839	0.2799	0.508	0.7498	0.8781	0.8641	0.8562	0.7188	0.6842	0.3602	0.373	0.373	0.6893
2005	0.0127	0.111	0.3372	0.5676	0.7821	0.9077	0.9314	0.8623	0.7488	0.7023	0.3612	0.3555	0.3555	0.7314
2006	0.0164	0.1208	0.3103	0.4882	0.6514	0.7729	0.8276	0.7779	0.7546	0.8001	0.4535	0.4575	0.4575	0.638
2007	0.0167	0.1085	0.2529	0.3614	0.4366	0.4955	0.5025	0.4656	0.5473	0.6585	0.3842	0.3665	0.3665	0.4191
2008	0.0089	0.0585	0.1438	0.2426	0.3301	0.3932	0.4042	0.3592	0.4259	0.5483	0.3226	0.2822	0.2822	0.3122
2009	0.0079	0.0501	0.1184	0.1945	0.2693	0.3153	0.3338	0.3082	0.4273	0.6402	0.3687	0.2835	0.2835	0.2566
2010	0.0062	0.0396	0.0934	0.1557	0.24	0.314	0.3399	0.3753	0.5497	0.6266	0.3778	0.2685	0.2685	0.253
2011	0.0048	0.0359	0.0879	0.1417	0.2204	0.3055	0.3698	0.4105	0.4441	0.3747	0.2354	0.1603	0.1603	0.256
2012	0.0055	0.038	0.095	0.1382	0.1946	0.255	0.3027	0.3324	0.3364	0.2638	0.1738	0.1209	0.1209	0.2197
2013	0.0059	0.0404	0.1054	0.1661	0.2342	0.3072	0.3474	0.3641	0.3266	0.2286	0.154	0.1103	0.1103	0.2541
2014	0.0083	0.0539	0.1402	0.2225	0.2908	0.3492	0.3431	0.3536	0.3232	0.2165	0.1414	0.0992	0.0992	0.2832
2015	0.0108	0.0649	0.162	0.2618	0.3096	0.3475	0.3246	0.3799	0.4247	0.2745	0.1632	0.1059	0.1059	0.2976
2016	0.009	0.0525	0.1441	0.2422	0.3076	0.3581	0.3507	0.4101	0.452	0.2648	0.1521	0.0949	0.0949	0.3022
2017	0.0114	0.066	0.1751	0.2965	0.3794	0.441	0.4235	0.4902	0.5641	0.3026	0.162	0.0946	0.0946	0.3676
2018	0.0136	0.0737	0.1928	0.3173	0.4099	0.4661	0.4635	0.5457	0.6762	0.3318	0.1684	0.0934	0.0934	0.3992
FBAR	0.0113	0.064	0.1707	0.2853	0.3656	0.4218	0.4126	0.482	0.5641	0.2997	0.1609	0.0943		

Table 3.16. Northeast Arctic COD Stock number-at-age (Thous)
SAM
Sun Apr 28 18:53:19 2019

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
1946	1755794	715330	387863	180013	81351	91103	235341	94459	33749	31570	18669	7951	2344	3635537
1947	656369	928281	529645	306706	138005	55641	60312	137813	56716	18604	17262	10045	5203	2920603
1948	351078	385738	586427	368065	212297	76060	35953	31201	68206	19644	7450	6772	5374	2154264
1949	605332	258667	288587	408032	239760	108235	42889	17866	17135	27883	8154	2990	4110	2029640
1950	815919	383269	222365	200116	225518	116255	58305	22613	9445	6833	11107	2998	2165	2076909
1951	2583494	682927	297361	174298	120833	117622	66226	28868	10648	2917	2126	3410	1227	4091956
1952	2233088	1134739	413394	180084	112861	63083	62974	32788	13861	4752	1126	765	1338	4254853
1953	2957209	1089682	622852	224473	85714	58090	33365	27867	12335	3886	1236	294	428	5117432
1954	832260	1596761	705447	382197	133910	48334	35033	18383	13146	4893	1546	485	245	3772638
1955	359397	540791	1004881	438566	223242	75288	30861	18650	7888	4814	1853	599	254	2707082
1956	725560	234630	395101	583112	215053	110809	35230	14745	7148	2641	1689	687	298	2326705
1957	1454003	397280	147906	208242	239657	92126	46739	14639	5677	2214	739	550	322	2610093
1958	1005575	737698	246645	96426	103607	111464	41463	22146	6138	1988	741	262	331	2374483
1959	1317191	503738	430942	137500	47426	48816	55814	20695	8912	2224	713	313	260	2574545
1960	1550867	634409	256521	208684	68263	23559	23509	25935	8658	3677	911	312	267	2805573
1961	1589071	730335	354289	136795	105411	36919	12045	12589	10422	3181	1443	385	247	2993132
1962	1292322	823748	396661	171420	64791	50137	15772	4836	4651	3331	1069	535	244	2829517
1963	828474	709577	450412	164180	62856	28523	21180	5718	1505	1576	1208	400	313	2275920
1964	428596	402970	372977	173626	51722	20343	9721	6549	1284	326	455	382	250	1469203
1965	873400	237438	265078	208026	83669	23267	7929	3069	2249	351	108	150	232	1704967
1966	2240060	560063	164066	150781	111308	45149	11035	3111	1142	939	156	42	156	3288006
1967	1511690	1454905	400505	106899	84214	57815	21315	4529	1219	552	439	69	88	3644239
1968	169339	1126391	965274	286590	74570	44363	24606	7550	1608	393	213	164	67	2701126
1969	95436	134020	739888	512350	157453	43158	20665	9178	2942	734	195	94	110	1716221
1970	221996	79434	86098	371898	233245	62112	14957	5449	2575	794	274	71	83	1078987
1971	383445	154793	57651	44738	174030	101105	21397	4708	1733	1020	385	123	73	945200
1972	941651	308997	112203	38921	27384	84072	37776	6770	1746	690	484	177	94	1560966
1973	2231117	687328	211599	67095	22110	15768	32452	9793	1625	476	255	171	109	3279898

1974	579419	1440677	483524	121736	36687	11667	6602	10623	3623	638	211	111	129	2695647
1975	570561	354579	705665	244491	60812	19169	5636	3000	3603	1177	247	74	96	1969110
1976	686700	434037	224442	323944	107276	25952	7887	2400	1248	1118	441	88	70	1815602
1977	336354	464436	268213	112001	140365	43927	9060	2990	1214	551	471	179	68	1379828
1978	717515	223555	220251	108058	45668	55631	14206	2353	1121	489	221	155	83	1389306
1979	188057	491187	145637	88594	38673	16413	17448	3130	614	173	90	37	40	990092
1980	120993	145728	317863	87251	39483	16069	6278	5149	954	132	41	19	13	739974
1981	152874	95642	106362	176847	40124	15728	6098	1946	1489	211	35	10	6	597371
1982	200438	129975	77048	62863	83390	15036	4572	1520	555	423	69	12	5	575905
1983	153254	142126	88623	47548	28880	28328	4606	1246	563	193	141	27	5	495540
1984	392799	125732	85914	52556	23269	10898	8347	1382	451	266	87	61	12	701774
1985	623486	359591	89807	47164	23392	5980	2725	2086	417	154	102	38	23	1154966
1986	1046035	462051	256220	48633	20609	7098	1697	1090	977	226	84	59	28	1844805
1987	315985	912262	273483	115143	18258	6661	1764	597	309	334	77	38	25	1644937
1988	293648	225738	575983	119330	33935	5126	1809	570	140	81	78	28	13	1256479
1989	193461	212786	149295	307312	53871	9370	1439	480	86	24	12	22	7	928162
1990	159980	147625	137365	101049	149477	22089	2874	558	138	31	8	5	6	721203
1991	383103	140238	110052	95109	66948	91326	12413	1546	278	59	13	4	3	901091
1992	798991	315197	114772	76275	53775	36569	51869	7040	970	187	34	8	3	1455688
1993	888841	550242	257276	78102	38687	25092	16387	26041	3581	580	88	18	3	1884936
1994	699632	706529	400312	149537	41732	17202	11059	6516	10913	1420	183	29	3	2045066
1995	488242	491444	499216	225636	60002	12663	5266	3248	1839	2915	275	36	1	1790785
1996	445026	293398	317074	277936	102594	19716	4175	1581	958	488	741	56	2	1463745
1997	677708	238263	195708	173577	123367	40360	6566	1647	530	335	165	243	7	1458477
1998	1052482	455261	134970	92174	68905	42204	9912	1524	343	125	89	53	53	1858095
1999	529765	600276	261464	62013	32295	26144	12191	2537	358	94	38	33	34	1527242
2000	629642	391345	375752	119297	24424	11324	7383	2738	595	123	33	16	27	1562698
2001	578837	505977	288612	184237	52219	9335	3386	1864	715	207	42	16	19	1625465
2002	394623	429331	363108	183715	83710	21023	3313	1148	575	288	89	21	16	1480961
2003	743330	306365	295985	233312	83846	31416	7144	1250	445	278	128	52	18	1703569

2004	252623	580469	220931	187626	114735	34911	12517	3142	586	247	148	78	41	1408055
2005	606471	193167	416007	139945	95467	40229	11502	4406	1076	227	104	88	67	1508755
2006	545107	454952	140342	233216	68927	34222	13573	3555	1529	429	91	61	94	1496098
2007	1470329	452623	301006	89736	118930	30894	12517	4646	1248	616	159	47	81	2482833
2008	1185542	1054628	361374	170500	53104	65178	16591	6213	2319	618	254	89	72	2916484
2009	678599	880606	827224	270213	96920	35693	33525	9232	3484	1447	295	148	99	2837485
2010	293867	508187	707088	607260	185761	62471	21706	17929	6104	1939	599	168	153	2413231
2011	448443	226328	437832	588192	424425	97571	38140	13252	10106	2529	896	321	201	2288236
2012	572835	329221	177947	356589	449842	258395	54513	20757	7370	5257	1450	594	363	2235132
2013	625805	395664	251865	148494	274806	311437	166902	30848	12360	4158	3311	1002	715	2227367
2014	771499	426873	310675	198920	118574	193054	180029	87592	16792	7121	2676	2324	1274	2317404
2015	447415	525580	327945	217830	143696	78649	113081	95741	47443	10362	4593	1881	2660	2016875
2016	268554	285807	395649	228740	143053	86286	50417	65468	50642	23738	6406	3155	3319	1611234
2017	750022	215920	205313	269364	152237	85614	49317	28937	32792	26935	14890	4467	4715	1840524
2018	498154	461995	161216	146304	167548	86915	45810	26725	14345	15054	16295	10368	6681	1657410
2019		338158	348666	122712	79018	95191	44464	24333	12504	5742	8845	11273	12714	1601775

Table 3.17. Northeast Arctic COD. Natural mortality used in final run
SAM
Sun Apr 28 18:53:18 2019

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1946	0.4901	0.3038	0.226	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1947	0.5438	0.3246	0.2309	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1948	0.4928	0.3048	0.2263	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1949	0.4338	0.2819	0.2209	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1950	0.3164	0.2364	0.2103	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1951	0.7235	0.3943	0.2471	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1952	0.7148	0.3909	0.2463	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1953	0.5367	0.3219	0.2302	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1954	0.3878	0.264	0.2168	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1955	0.4056	0.271	0.2184	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1956	0.5899	0.3425	0.235	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1957	0.7252	0.395	0.2473	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1958	0.5616	0.3315	0.2325	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1959	0.7131	0.3903	0.2462	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1960	0.7036	0.3866	0.2453	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1961	0.6094	0.35	0.2368	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1962	0.5201	0.3154	0.2287	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.7882	0.4194	0.253	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.6027	0.3475	0.2362	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1965	0.4164	0.2752	0.2194	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1966	0.3529	0.2505	0.2136	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1967	0.2707	0.2186	0.2062	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1968	0.2242	0.2006	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1969	0.206	0.2	0.2003	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1970	0.2927	0.2272	0.2082	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1971	0.2562	0.213	0.2049	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1972	0.3234	0.2391	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1973	0.2172	0.2	0.2014	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1974	0.2168	0.2	0.2013	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.2317	0.2035	0.2027	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.2238	0.2004	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.2487	0.2101	0.2042	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.2342	0.2045	0.2029	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.2081	0.2	0.2005	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1980	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1981	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1982	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1983	0.2031	0.2	0.2001	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.2	0.2028	0.2174	0.2029	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.2071	0.2075	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.2627	0.226	0.2521	0.2152	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2524	0.2188	0.2238	0.2608	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.2174	0.2033	0.2262	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2021	0.2203	0.2	0.2219	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.2	0.2022	0.2106	0.2002	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2	0.2	0.2012	0.2196	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2107	0.2	0.2	0.2135	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.2442	0.2024	0.2151	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.349	0.2621	0.2171	0.2245	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.5236	0.3174	0.22	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.4973	0.3256	0.2353	0.2157	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.412	0.2699	0.2242	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.4312	0.2626	0.212	0.2372	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.262	0.2358	0.2355	0.2067	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2489	0.2117	0.2492	0.2172	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.2372	0.2186	0.2039	0.2318	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.279	0.2114	0.2	0.2239	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2003	0.2386	0.2	0.2	0.217	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.2494	0.2139	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.2942	0.2117	0.2117	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.202	0.224	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.2464	0.2	0.2384	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.2577	0.2149	0.2	0.2236	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.2797	0.213	0.2055	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.2959	0.2402	0.2128	0.2054	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.424	0.3232	0.2053	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.3754	0.3228	0.2218	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.4122	0.2461	0.2165	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.3975	0.3106	0.217	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.3904	0.278	0.2487	0.203	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.2244	0.287	0.3093	0.2369	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.4907	0.2383	0.2053	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.3286	0.2082	0.2	0.2234	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 3.18. Northeast Arctic COD. Summary table
SAM
Sun Apr 28 18:53:19 2019

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1946	1755794	4332127	990363	706000	0.7129	0.2025
1947	656369	3761772	1016274	882017	0.8679	0.3285
1948	351078	3580230	802790	774295	0.9645	0.3229
1949	605332	3040175	618632	800122	1.2934	0.3706
1950	815919	2780989	556998	731982	1.3142	0.3682
1951	2583494	3692461	497024	827180	1.6643	0.4147
1952	2233088	4011190	501009	876795	1.7501	0.5397
1953	2957209	4190074	388578	695546	1.79	0.3799
1954	832260	4342709	411153	826021	2.009	0.4027
1955	359397	3637959	338366	1147841	3.3923	0.5187
1956	725560	3367213	286427	1343068	4.689	0.6285
1957	1454003	2782457	207204	792557	3.825	0.5047
1958	1005575	2402528	203231	769313	3.7854	0.5316
1959	1317191	2742807	437340	744607	1.7026	0.5379
1960	1550867	2400088	395257	622042	1.5738	0.4878
1961	1589071	2419705	406656	783221	1.926	0.6326
1962	1292322	2218580	324252	909266	2.8042	0.7515
1963	828474	1985989	220684	776337	3.5179	0.9369
1964	428596	1454456	186227	437695	2.3503	0.6718
1965	873400	1458203	102937	444930	4.3224	0.5384
1966	2240060	2415105	122919	483711	3.9352	0.5038
1967	1511690	2975263	135070	572605	4.2393	0.5448
1968	169339	3506567	232121	1074084	4.6273	0.5513
1969	95436	2920202	158166	1197226	7.5694	0.8101
1970	221996	2134168	233195	933246	4.002	0.7125
1971	383445	1637663	322729	689048	2.1351	0.5822
1972	941651	1602778	363707	565254	1.5541	0.6918
1973	2231117	2421731	330673	792685	2.3972	0.6054

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1974	579419	2310174	164090	1102433	6.7185	0.6083
1975	570561	2085787	136580	829377	6.0725	0.6459
1976	686700	1984013	170998	867463	5.0729	0.6589
1977	336354	1971847	347774	905301	2.6031	0.8246
1978	717515	1605995	231975	698715	3.012	0.9556
1979	188057	1123803	169849	440538	2.5937	0.7375
1980	120993	860070	107153	380434	3.5504	0.7424
1981	152874	964259	162493	399038	2.4557	0.8044
1982	200438	752180	320991	363730	1.1331	0.7997
1983	153254	738680	306597	289992	0.9458	0.7443
1984	392799	822886	246469	277651	1.1265	0.9045
1985	623486	1030952	195226	307920	1.5773	0.7213
1986	1046035	1385368	175215	430113	2.4548	0.8785
1987	315985	1224033	120903	523071	4.3264	0.9792
1988	293648	984827	192741	434939	2.2566	1.0053
1989	193461	956726	233586	332481	1.4234	0.677
1990	159980	969795	313138	212000	0.677	0.3266
1991	383103	1515745	701247	319158	0.4551	0.3133
1992	798991	1892878	892347	513234	0.5752	0.4618
1993	888841	2315085	755527	581611	0.7698	0.57
1994	699632	2111183	596545	771086	1.2926	0.8441
1995	488242	1781545	517153	739999	1.4309	0.7918
1996	445026	1655372	546222	732228	1.3405	0.7146
1997	677708	1521544	568920	762403	1.3401	0.9952
1998	1052482	1300557	379755	592624	1.5605	0.9473
1999	529765	1179159	289954	484910	1.6724	0.9478
2000	629642	1185278	247116	414868	1.6788	0.8393
2001	578837	1458292	368598	426471	1.157	0.7097
2002	394623	1607397	510834	535045	1.0474	0.6582

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
2003	743330	1692137	578756	551990	0.9538	0.5463
2004	252623	1608404	686276	606445	0.8837	0.6893
2005	606471	1570869	611913	641276	1.048	0.7314
2006	545107	1551724	590253	537642	0.9109	0.638
2007	1470329	1966329	642292	486883	0.758	0.4191
2008	1185542	2696970	700855	464171	0.6623	0.3122
2009	678599	3400092	1110811	523430	0.4712	0.2566
2010	293867	3735660	1401499	609983	0.4352	0.253
2011	448443	3951490	1997645	719830	0.3603	0.256
2012	572835	4130452	2329091	727663	0.3124	0.2197
2013	625805	4478757	2737085	966209	0.353	0.2541
2014	771499	4091963	2623413	986449	0.376	0.2832
2015	447415	3864872	2229644	864384	0.3877	0.2976
2016	268554	3452059	1927084	849422	0.4408	0.3022
2017	750022	3474026	2114354	868276	0.4107	0.3676
2018	498154	3036166	1810295	778627	0.4301	0.3992
Arith. Mean	773518	2331679	614401	671921	2.0305	0.5905

Table 3.19. Northeast Arctic COD. Input for the short-term prediction

2019								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
3	667000	0.3479	0	0	0	0.274	0.0113	0.834
4	338158	0.2445	0.003	0	0	0.659	0.0641	1.282
5	348666	0.2382	0.033	0	0	1.188	0.1707	1.671
6	122712	0.2201	0.199	0	0	1.95	0.2853	2.355
7	79018	0.2	0.624	0	0	3.101	0.3656	3.42
8	95191	0.2	0.894	0	0	4.381	0.4217	4.558
9	44464	0.2	0.947	0	0	5.928	0.4126	5.943
10	24333	0.2	0.988	0	0	7.361	0.4820	7.365
11	12504	0.2	0.997	0	0	9.632	0.5641	8.65
12	5742	0.2	1	0	0	12.621	0.2997	11.42
13	8845	0.2	1	0	0	14.544	0.1608	12.8
14	11273	0.2	1	0	0	16.466	0.0943	14.18
15	12714	0.2	1	0	0	18.388	0.0943	15.55

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
3	537000	0.3479	0	0	0	0.244	0.0113	0.834
4		0.2445	0.003	0	0	0.665	0.0641	1.256
5		0.2382	0.021	0	0	1.244	0.1707	1.789
6		0.2201	0.182	0	0	2.003	0.2853	2.317
7		0.2	0.526	0	0	2.97	0.3656	3.276
8		0.2	0.792	0	0	4.656	0.4217	4.674
9		0.2	0.939	0	0	6.035	0.4126	5.894
10		0.2	0.984	0	0	7.568	0.4820	7.279
11		0.2	0.999	0	0	9.528	0.5641	8.701
12		0.2	0.995	0	0	12.621	0.2997	11.42
13		0.2	1	0	0	14.544	0.1608	12.8
14		0.2	1	0	0	16.466	0.0943	14.18

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
15		0.2	1	0	0	18.388	0.0943	15.55

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
3	644000	0.3479	0	0	0	0.262	0.0113	0.834
4		0.2445	0.003	0	0	0.635	0.0641	1.256
5		0.2382	0.021	0	0	1.25	0.1707	1.789
6		0.2201	0.182	0	0	2.059	0.2853	2.317
7		0.2	0.526	0	0	3.022	0.3656	3.276
8		0.2	0.792	0	0	4.525	0.4217	4.674
9		0.2	0.939	0	0	6.31	0.4126	5.894
10		0.2	0.984	0	0	7.676	0.4820	7.279
11		0.2	0.999	0	0	9.735	0.5641	8.701
12		0.2	0.995	0	0	12.621	0.2997	11.42
13		0.2	1	0	0	14.544	0.1608	12.8
14		0.2	1	0	0	16.466	0.0943	14.18
15		0.2	1	0	0	18.388	0.0943	15.55

Table 3.20. Northeast Arctic COD. Management option table.

2019				
Biomass (t)	**SSB (t)**	**F_{Mult}**	**F_{Bar}**	**Landings (t)**
2904828	1754858	1	0.399	697412

2020				2021	
Biomass	**SSB**	**F_{Bar}**	**Landings**	**Biomass**	**SSB**
2733266	1458491	0.00	0	3377091	1860296
		0.05	93143	3268939	1778361
		0.10	182139	3165928	1700742
		0.15	267205	3067780	1627194
		0.20	348546	2974232	1557484
		0.25	426356	2885038	1491392
		0.30	500818	2799964	1428714
		0.35	572104	2718791	1369257
		0.40	640378	2641312	1312839
		0.45	705792	2567333	1259289
		0.50	768492	2496670	1208446
		0.55	828615	2429148	1160160
		0.60	886291	2364604	1114287
		0.65	941641	2302885	1070694
		0.70	994782	2243844	1029255
		0.75	1045822	2187343	989851
		0.80	1094864	2133254	952371
		0.85	1142007	2081452	916708
		0.90	1187342	2031823	882765
		0.95	1230958	1984257	850447
		1.00	1272936	1938651	819666
Tonnes	Tonnes		Tonnes	Tonnes	Tonnes

Table 3.21. Northeast Arctic COD. Detailed prediction output assuming Fsq in 2019 and HCR in 2020.

F_{bar}	age	
range:	5-10	
Year:	2019	
F	multiplier:	1
F_{bar}:	0.3992	

Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos(Jan)**	**SSB(Jan)**
3	0.013	7111	6	667000	183	0	0
4	0.072	20810	27	338158	223	1014	1
5	0.191	54204	91	348666	414	11506	14
6	0.320	30316	71	122712	239	24420	48
7	0.410	24237	83	79018	245	49307	153
8	0.473	32745	149	95191	417	85101	373
9	0.462	15031	89	44464	264	42107	250
10	0.540	9285	68	24333	179	24041	177
11	0.632	5365	46	12504	120	12466	120
12	0.336	1493	17	5742	72	5742	72
13	0.180	1326	17	8845	129	8845	129
14	0.106	1026	15	11273	186	11273	186
15+	0.106	1157	18	12714	234	12714	234
Total	NA	204106	697	1770620	2905	288537	1755
		Thous	Thou.	Thous	Thou.	Thous	Thou.
			tonnes		tonnes		tonnes

F_{bar}	age	
range:	5-10	
Year:	2020	
F	multiplier:	1.25
F_{bar}:	0.4986	

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.016	7139	6	537000	131	0	0
4	0.090	35440	45	465072	309	1395	1
5	0.239	46808	84	246468	307	5176	6
6	0.399	67543	156	226942	455	41303	83
7	0.512	26181	86	71525	212	37622	112
8	0.590	17520	82	42949	200	34015	158
9	0.577	19498	115	48587	293	45623	275
10	0.674	10308	75	22929	174	22563	171
11	0.789	5818	51	11609	111	11597	111
12	0.419	1701	19	5441	69	5414	68
13	0.225	616	8	3360	49	3360	49
14	0.132	679	10	6048	100	6048	100
15+	0.132	1984	31	17670	325	17670	325
Total	NA	241235	767	1705599	2733	231787	1458
		Thous	Thou.	Thous	Thou.	Thous	Thou.
			tonnes		tonnes		tonnes

Table 3.22. Northeast Arctic COD. Assessments results by means of TISVPA

Year	B(3+)	SSB	R(3)	F(5-10)
1984	813202	251608	411969	0.812
1985	990156	199707	583047	0.639
1986	1363640	182247	1015891	0.785
1987	1223679	135359	284049	1.017
1988	1005886	225779	215992	0.987
1989	913903	237312	182324	0.467
1990	996937	334589	211590	0.311
1991	1569125	721825	408357	0.228
1992	1965822	964711	688971	0.411
1993	2455778	853206	1000433	0.624
1994	2232270	643641	728736	0.826
1995	1922693	579860	435074	0.756
1996	1856793	658311	394762	0.719
1997	1718566	721898	608997	1.048
1998	1287720	440631	793938	1.058
1999	1090944	286921	446610	0.97
2000	1062428	230196	557965	0.675
2001	1293487	351235	457530	0.536
2002	1425295	473949	409553	0.522
2003	1516577	532778	654027	0.515
2004	1481568	623001	276911	0.619
2005	1485127	580451	531612	0.625
2006	1523745	597826	552067	0.653
2007	1881561	625058	1368644	0.513
2008	2619874	633097	1360508	0.368
2009	3347953	987173	913069	0.355
2010	3695017	1196468	566554	0.393
2011	3802508	1690494	661291	0.334
2012	3879741	1949245	694998	0.288

Year	B(3+)	SSB	R(3)	F(5-10)
2013	4132734	2220948	801536	0.283
2014	3843732	2171555	990962	0.294
2015	3671185	1850850	447642	0.301
2016	3325412	1638149	307976	0.278
2017	3420527	1958815	760154	0.321
2018	3060426	1731796	668649	0.368

Table 3.23. NEA cod TISVPA estimates of abundance at age (thousands)

	3	4	5	6	7	8	9	10	11	12	13	14	15
1984	411969	139061	72716	41672	24693	12142	9031	1477	697	457	216	39	26
1985	583047	330380	99084	42263	18172	7060	3359	2485	476	404	185	123	31
1986	1015891	459773	230876	56920	20067	6805	2325	1317	1063	223	282	115	47
1987	284049	770659	311592	115323	23465	7158	2196	715	431	371	80	176	60
1988	215992	213745	519539	155444	36581	6232	2088	716	145	146	115	43	15
1989	182324	167846	150484	283707	59066	9080	1504	619	189	34	54	58	85
1990	211590	145761	121659	95349	156221	25788	3483	630	292	109	17	38	15
1991	408357	171671	112179	85629	60730	96049	14419	2020	361	184	72	10	20
1992	688971	330643	132991	79454	54531	35758	58492	8621	1267	243	133	55	6
1993	1000433	546892	245909	88345	44936	28326	17170	30413	4387	716	132	97	4
1994	728736	773315	408791	148380	45562	20319	11546	6693	12358	1781	289	68	14
1995	435074	510456	541471	243402	66668	14633	6112	3263	1805	3862	572	149	4
1996	394762	254975	336244	325503	118830	25532	5192	1897	944	506	1430	302	4
1997	608997	232904	164250	196273	159688	49521	9286	2006	585	307	179	659	3
1998	793938	390105	147310	81142	78757	47764	12972	2097	465	109	61	61	147
1999	446610	498114	237003	71986	31013	24240	10433	3675	496	140	25	24	88
2000	557965	337286	326568	111180	25495	10413	5833	2040	1146	159	55	4	55
2001	457530	429821	242950	172082	48475	9058	3672	1694	590	564	69	34	106
2002	409553	356582	312497	148332	80361	20298	3288	1653	632	246	337	47	31
2003	654027	305973	263507	191691	70741	31541	7725	1294	860	324	116	235	5
2004	276911	507948	231246	166165	97114	30891	12732	3537	596	515	179	76	38
2005	531612	212848	373710	146092	82715	37363	11203	4468	1362	243	287	112	33
2006	552067	388863	155248	218840	72806	33573	12813	4139	1507	580	109	195	673
2007	1368644	443401	272777	96627	108305	31457	12850	4080	1597	523	256	66	179
2008	1360508	1054614	328478	164233	54580	53275	14848	6134	1780	779	208	167	83
2009	913069	1045014	803297	228447	98346	31036	26307	7646	3286	868	432	137	131
2010	566554	684848	806110	567748	142615	57314	17060	13598	4282	1846	209	290	207
2011	661291	417158	516246	583683	365706	79198	29461	9041	6868	1685	877	77	0
2012	694998	426781	293097	379790	399285	219117	43412	14649	4033	3292	915	472	162
2013	801536	472156	297971	217208	265209	257380	128105	24020	7640	1989	1796	552	899
2014	990962	528033	354238	217297	156168	166721	148935	66554	12131	3883	1073	1144	855
2015	447642	658834	367932	247867	145615	102018	91610	82161	33714	6317	2058	654	1239
2016	307976	301749	469848	246795	155035	89009	63312	51657	44562	15285	3051	1285	1589
2017	760154	244223	217284	301657	154696	93021	52840	39519	27109	24123	8170	1852	1323
2018	668649	471549	180507	147182	183834	86526	50168	30203	23854	13510	13745	5031	1623
2019	0	472611	357359	123240	86972	101352	45214	26408	15931	13077	7677	9177	3359

Table 3.24. NEA cod TISVPA estimates of fishing mortality coefficients

F(a,y)	3	4	5	6	7	8	9	10	11	12	13	14	15	F(5-10)
1984	0.0226	0.1381	0.3244	0.5624	1.0246	0.9882	1.0190	0.9539	0.2674	0.8280	0.4149	0.4149	0.4149	0.8121
1985	0.0202	0.1250	0.3151	0.4531	0.6211	0.9217	0.7453	0.7764	0.6621	0.2036	0.3397	0.3397	0.3397	0.6388
1986	0.0211	0.1526	0.4014	0.6484	0.7466	0.8757	1.1290	0.9064	0.8463	0.7143	0.3973	0.3973	0.3973	0.7846
1987	0.0257	0.1585	0.5043	0.8684	1.1553	1.0779	1.0555	1.4410	0.9857	0.9128	0.4640	0.4640	0.4640	1.0171
1988	0.0243	0.1662	0.4333	0.9068	1.2536	1.3342	0.9999	0.9959	1.1657	0.8288	0.4469	0.4469	0.4469	0.9873
1989	0.0135	0.0900	0.2461	0.3775	0.5728	0.6096	0.5435	0.4513	0.4122	0.4582	0.2330	0.2330	0.2330	0.4668
1990	0.0081	0.0593	0.1591	0.2664	0.3225	0.4063	0.3732	0.3408	0.2656	0.2437	0.1551	0.1551	0.1551	0.3114
1991	0.0063	0.0386	0.1135	0.1887	0.2532	0.2617	0.2857	0.2666	0.2260	0.1777	0.1147	0.1147	0.1147	0.2282
1992	0.0094	0.0669	0.1684	0.3225	0.4486	0.5286	0.4726	0.5282	0.4466	0.3717	0.1979	0.1979	0.1979	0.4115
1993	0.0145	0.0847	0.2535	0.4103	0.6726	0.8228	0.8384	0.7457	0.7632	0.6295	0.2897	0.2897	0.2897	0.6239
1994	0.0173	0.1157	0.2812	0.5516	0.7365	1.0854	1.1267	1.1730	0.9067	0.9253	0.3670	0.3670	0.3670	0.8257
1995	0.0163	0.1114	0.3113	0.4726	0.7609	0.8487	1.0430	1.1003	1.0093	0.7917	0.3629	0.3629	0.3629	0.7561
1996	0.0209	0.1065	0.3051	0.5427	0.6584	0.9062	0.8443	1.0544	0.9832	0.9021	0.3672	0.3672	0.3672	0.7185
1997	0.0277	0.1825	0.3922	0.7547	1.1720	1.1850	1.4455	1.3402	1.5442	1.3987	0.5098	0.5098	0.5098	1.0483
1998	0.0308	0.1851	0.5295	0.6965	1.1092	1.4377	1.1501	1.4251	1.1515	1.2958	0.5081	0.5081	0.5081	1.0580
1999	0.0251	0.1958	0.5015	0.9215	0.9186	1.2077	1.2408	1.0303	1.0976	0.9115	0.4720	0.4720	0.4720	0.9701
2000	0.0206	0.1230	0.4004	0.6145	0.8515	0.6925	0.7329	0.7586	0.5950	0.6221	0.3319	0.3319	0.3319	0.6751
2001	0.0147	0.1083	0.2638	0.5360	0.6389	0.7234	0.5108	0.5443	0.5117	0.4106	0.2602	0.2602	0.2602	0.5362
2002	0.0131	0.0881	0.2699	0.4085	0.6748	0.6689	0.6424	0.4647	0.4520	0.4245	0.2403	0.2403	0.2403	0.5215
2003	0.0133	0.0795	0.2198	0.4269	0.5156	0.7234	0.6088	0.5930	0.3960	0.3841	0.2261	0.2261	0.2261	0.5146
2004	0.0144	0.0992	0.2446	0.4329	0.7055	0.7187	0.8765	0.7379	0.6488	0.4274	0.2646	0.2646	0.2646	0.6194
2005	0.0152	0.0945	0.2707	0.4183	0.6029	0.8431	0.7217	0.8939	0.6783	0.5961	0.2695	0.2695	0.2695	0.6251
2006	0.0157	0.1061	0.2746	0.5042	0.6291	0.7770	0.9303	0.8022	0.8946	0.6757	0.2936	0.2936	0.2936	0.6529
2007	0.0125	0.0859	0.2375	0.3804	0.5566	0.5790	0.6035	0.7190	0.5718	0.6259	0.2436	0.2436	0.2436	0.5127
2008	0.0080	0.0635	0.1768	0.3029	0.3855	0.4731	0.4244	0.4461	0.4775	0.3878	0.1892	0.1892	0.1892	0.3682
2009	0.0075	0.0495	0.1615	0.2830	0.3931	0.4269	0.4538	0.4124	0.3972	0.4228	0.1852	0.1852	0.1852	0.3551
2010	0.0060	0.0525	0.1414	0.2954	0.4241	0.5077	0.4769	0.5141	0.4264	0.4090	0.2070	0.2070	0.2070	0.3933
2011	0.0064	0.0346	0.1241	0.2094	0.3562	0.4364	0.4510	0.4294	0.4230	0.3522	0.1896	0.1896	0.0000	0.3344
2012	0.0071	0.0381	0.0832	0.1883	0.2578	0.3781	0.4022	0.4202	0.3676	0.3609	0.1789	0.1789	0.1789	0.2883
2013	0.0077	0.0489	0.1061	0.1447	0.2704	0.3202	0.4129	0.4449	0.4260	0.3711	0.1964	0.1964	0.1964	0.2832
2014	0.0095	0.0555	0.1441	0.1955	0.2162	0.3548	0.3679	0.4838	0.4775	0.4550	0.2268	0.2268	0.2268	0.2937
2015	0.0117	0.0679	0.1614	0.2644	0.2895	0.2750	0.3990	0.4191	0.5070	0.4982	0.2569	0.2569	0.2569	0.3014
2016	0.0105	0.0704	0.1666	0.2465	0.3265	0.3055	0.2541	0.3710	0.3576	0.4279	0.2410	0.2410	0.2410	0.2783
2017	0.0141	0.0749	0.2068	0.3072	0.3682	0.4201	0.3409	0.2857	0.3858	0.3703	0.2720	0.2720	0.2720	0.3215
2018	0.0109	0.0696	0.1816	0.2978	0.3954	0.4491	0.4417	0.4397	0.4011	0.3652	0.2040	0.2040	0.2040	0.3675

Table 3.25. North East arctic cod. Stock numbers-at-age (in thousands) estimated by VPA including discard estimates, and % increase in stock numbers relative to a VPA without discards. From Dingsør (2001). The discard numbers applied correspond to method II (1946–1982) and IIIb (1983–1998) mentioned in Dingsør (2001).

	Estimated stock numbers (thousands)			Percent increase		
Year	Age 3	Age 4	Age 5	Age 3	Age 4	Age 5
1946	875 346	602 579	407 163	20 %	4 %	1 %
1947	531 993	676 806	465 099	27 %	14 %	0 %
1948	570 356	392 309	497 476	29 %	14 %	5 %
1949	589 367	416 668	285 459	26 %	16 %	3 %
1950	799 732	414 016	291 200	13 %	9 %	1 %
1951	1 235 322	586 054	302 346	14 %	2 %	0 %
1952	1 388 731	889 509	401 768	17 %	3 %	0 %
1953	1 801 114	975 004	600 908	13 %	2 %	0 %
1954	830 653	1 321 053	684 303	29 %	5 %	0 %
1955	381 489	615 696	907 875	40 %	19 %	2 %
1956	567 555	274 235	399 344	29 %	25 %	3 %
1957	914 850	387 496	161 710	14 %	10 %	2 %
1958	552 600	672 221	262 135	11 %	4 %	2 %
1959	757 567	391 906	406 694	11 %	3 %	0 %
1960	855 470	534 350	240 047	8 %	1 %	0 %
1961	1 041 570	620 707	347 043	13 %	1 %	0 %
1962	894 728	739 196	382 556	23 %	4 %	0 %
1963	551 938	614 025	429 068	17 %	10 %	0 %
1964	389 151	396 165	361 790	15 %	5 %	0 %
1965	845 469	293 844	266 134	9 %	8 %	0 %
1966	1 618 188	647 435	203 168	2 %	4 %	2 %
1967	1 404 569	1 249 506	465 035	9 %	0 %	1 %
1968	210 875	1 088 071	876 095	24 %	6 %	0 %
1969	143 791	155 947	699 033	28 %	15 %	2 %
1970	222 635	104 415	92 541	13 %	17 %	4 %
1971	462 474	164 397	65 112	14 %	6 %	2 %
1972	1 221 559	358 357	115 892	20 %	10 %	1 %
1973	1 858 123	947 409	249 400	2 %	19 %	11 %
1974	598 555	1 246 499	583 612	14 %	2 %	9 %
1975	654 442	382 692	627 793	5 %	10 %	3 %
1976	622 230	477 390	233 608	1 %	2 %	1 %
1977	397 826	426 386	280 645	14 %	0 %	0 %
1978	653 256	277 410	198 204	2 %	11 %	0 %
1979	225 935	460 104	164 243	14 %	2 %	1 %
1980	152 937	171 954	300 312	11 %	11 %	0 %
1981	161 752	116 964	116 337	7 %	7 %	4 %
1982	151 642	125 307	81 780	0 %	4 %	1 %
1983	166 310	115 423	82 423	0 %	-1 %	3 %
1984	408 525	133 333	77 728	3 %	0 %	0 %
1985	543 828	324 072	96 327	4 %	2 %	0 %
1986	1 114 252	412 683	219 993	7 %	2 %	0 %
1987	307 425	767 656	268 642	7 %	4 %	0 %
1988	222 819	215 720	490 161	9 %	3 %	2 %
1989	180 066	166 955	151 576	4 %	6 %	0 %
1990	249 968	139 922	114 006	3 %	2 %	1 %
1991	418 955	200 700	105 559	2 %	2 %	0 %
1992	748 962	333 517	151 973	4 %	1 %	0 %
1993	1 002 933	576 112	238 980	10 %	2 %	0 %
1994	896 184	744 062	420 039	9 %	8 %	0 %
1995	733 664	584 808	476 048	10 %	6 %	3 %
1996	467 093	341 918	344 124	3 %	7 %	3 %
1997	765 234	238 202	193 102	3 %	0 %	4 %
1998	836 301	429 147	144 629	2 %	1 %	-1 %

Table 3.26. Northeast Arctic cod. Number (thousands) of cod by age groups taken as by-catch in the Norwegian shrimp fishery (1984–2006)

Age\Year	1984	1985	1986	1987	1988	1989	1990	1991
0	322	4537	28	1408	259	717	2971	11651
1	4913	19437	2339	3259	1719	668	13731	34450
2	1624	49334	6952	1961	1534	418	1518	2759
3	1073	2720	5245	499	1380	694	1019	87
4	2200	1891	716	2210	1882	2096	403	64
5	161	9306	737	1715	1124	2281	909	33
6	89	6374	520	411	269	1135	2913	293
7	144	266	92	79	186	184	1434	1138
8	38	1	93	28	178	13	185	316
9	1	2	165	6	1	0	3	29
10	0	3	88	1	0	0	9	0
11	0	0	0	0	0	0	0	0
Total('000)	10564	93872	16976	11576	8532	8206	25095	50819

Age\Year	1992	1993	1994	1995	1996	1997	1998	1999
0	6486	604	1042	1138	519	896	506	651
1	5236	6702	1628	1896	9084	17157	40314	7155
2	2922	4032	410	99	359	1805	5248	245
3	242	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
Total('000)	14886	11339	3080	3133	9962	19858	46068	8052

Age\Year	2000	2001	2002	2003	2004	2005	2006
0	66	1188	478	4253	713	945	1355
1	1572	7187	293	8805	1014	3411	2597
2	3152	1348	893	96	323	1628	218
3	218	0	190	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
Total('000)	5007	9723	1854	13154	2051	5984	4170

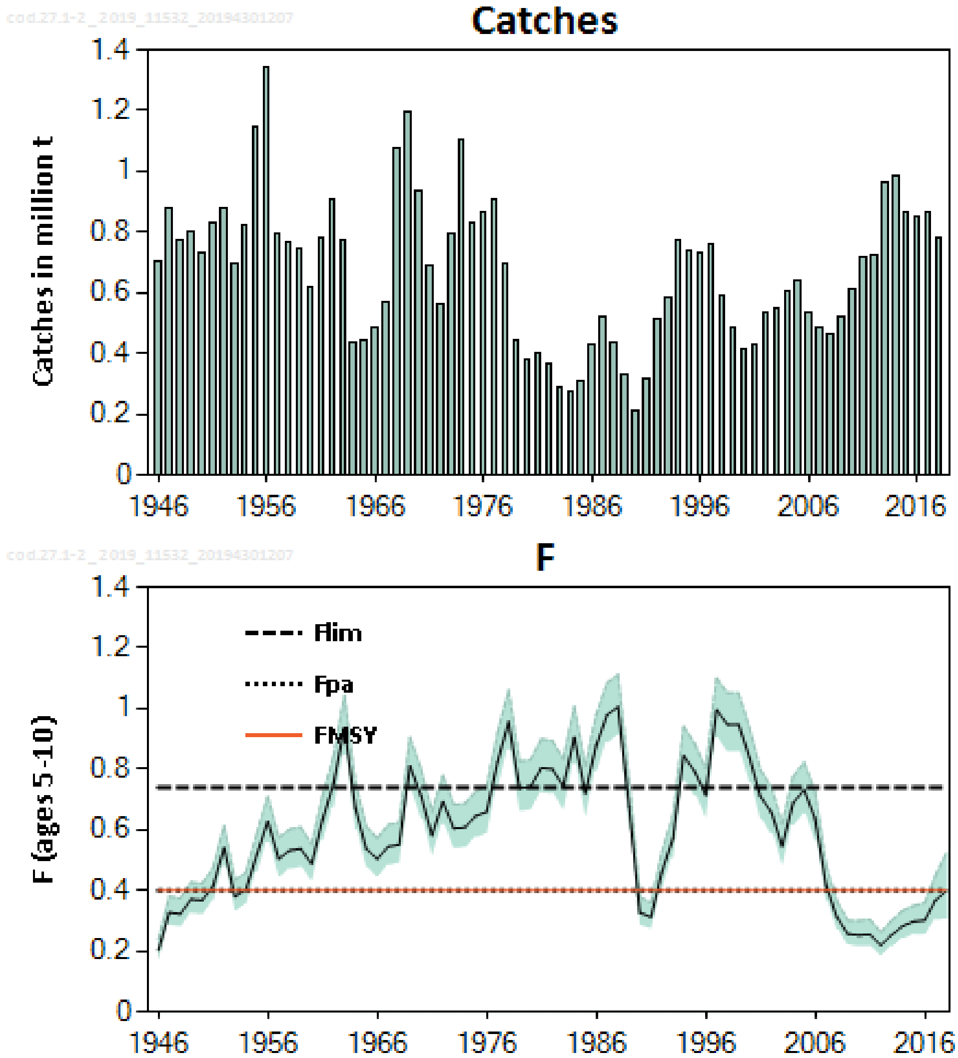

Figure 3.1. ICES Standard plots for Northeast Arctic cod (Subareas 1 and 2)

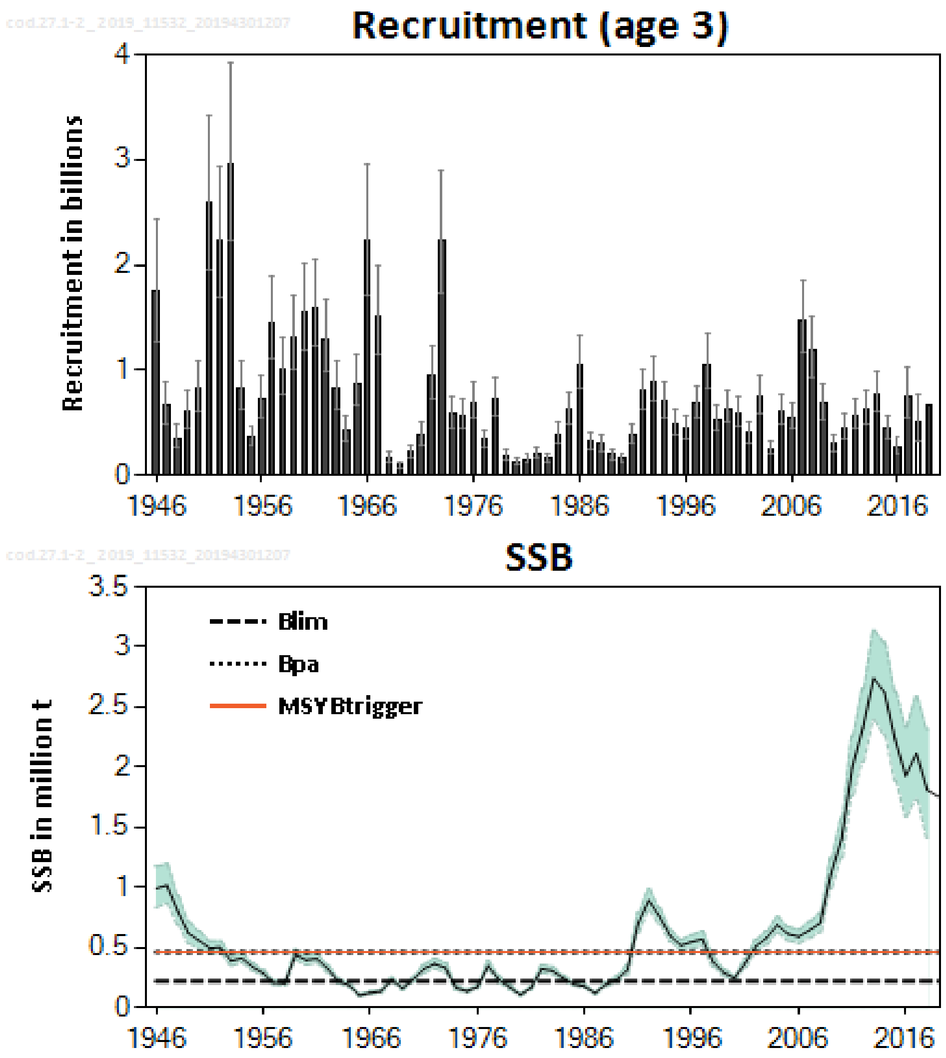

Figure 3.1 (continued). ICES Standard plots for Northeast Arctic cod (Subareas 1 and 2)

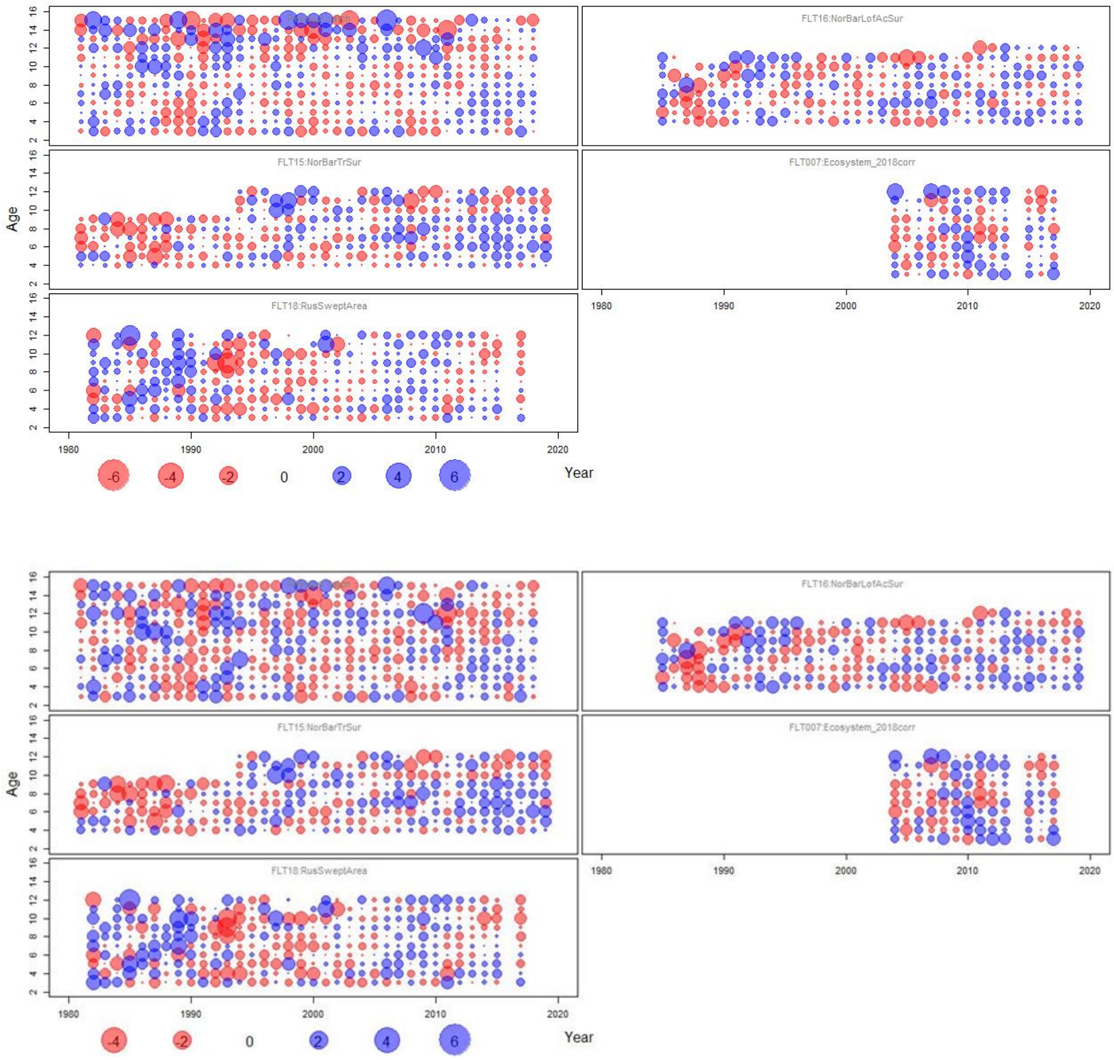

Figure 3.2a. Standardized one-observation-ahead residuals for log-catches and log-indices (Thygesen *et al.*, 2017) in the SPALY SAM run (upper panel) and the final SAM run (lower panel)

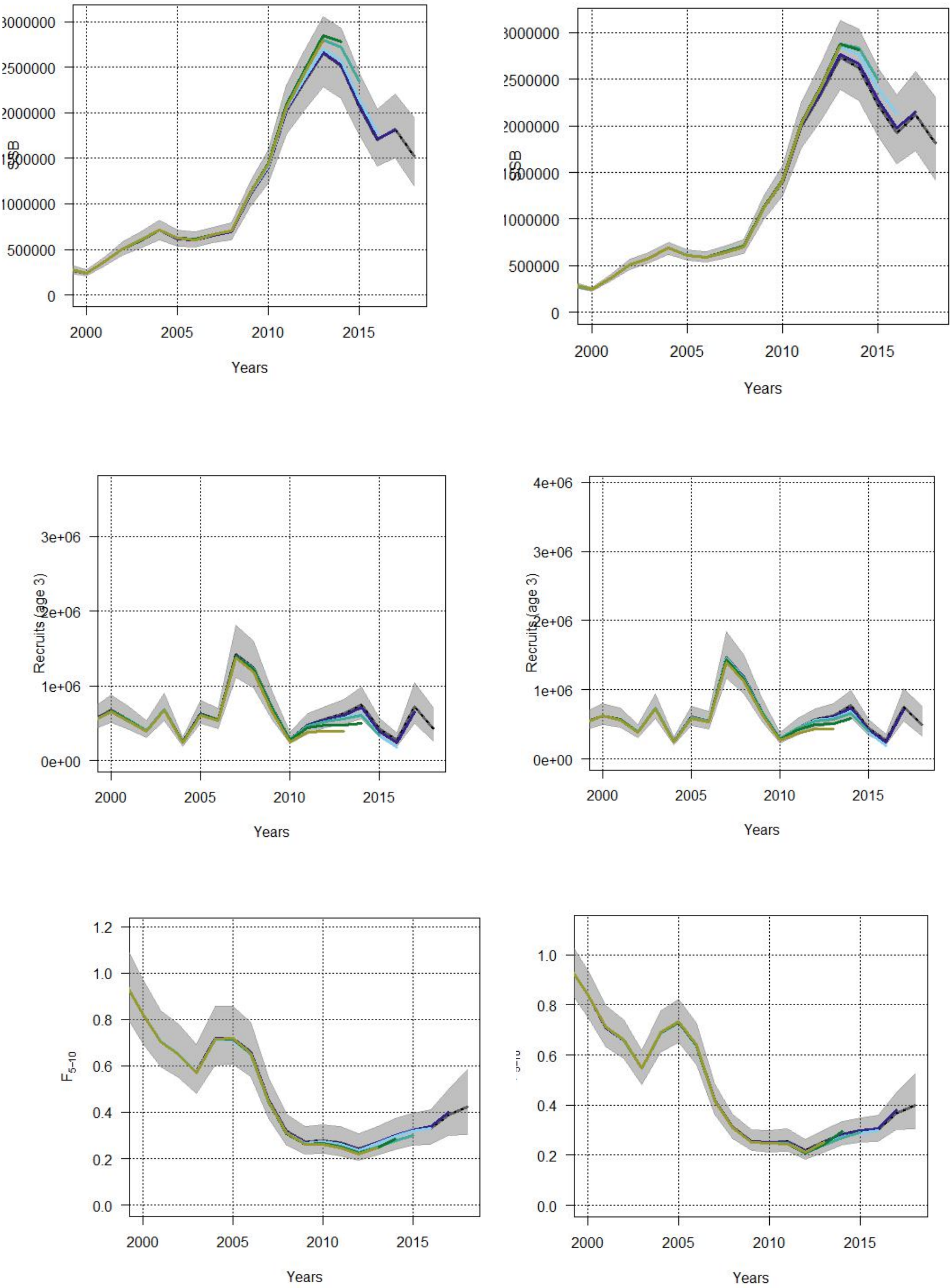

Figure 3.2b. NEA cod SSB, R and F_{bar} retrospective pattern for the SPALY SAM settings (left) and the final SAM run (right).

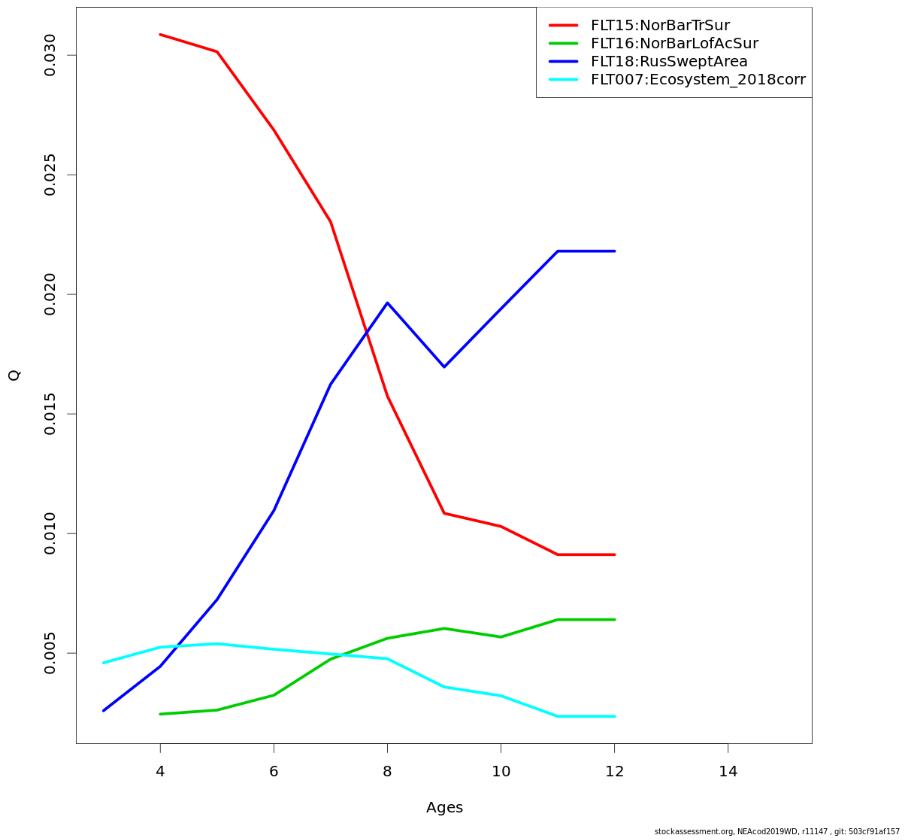

Figure 3.2c. NEA cod. Catchability of different fleets used for final SAM run fit.

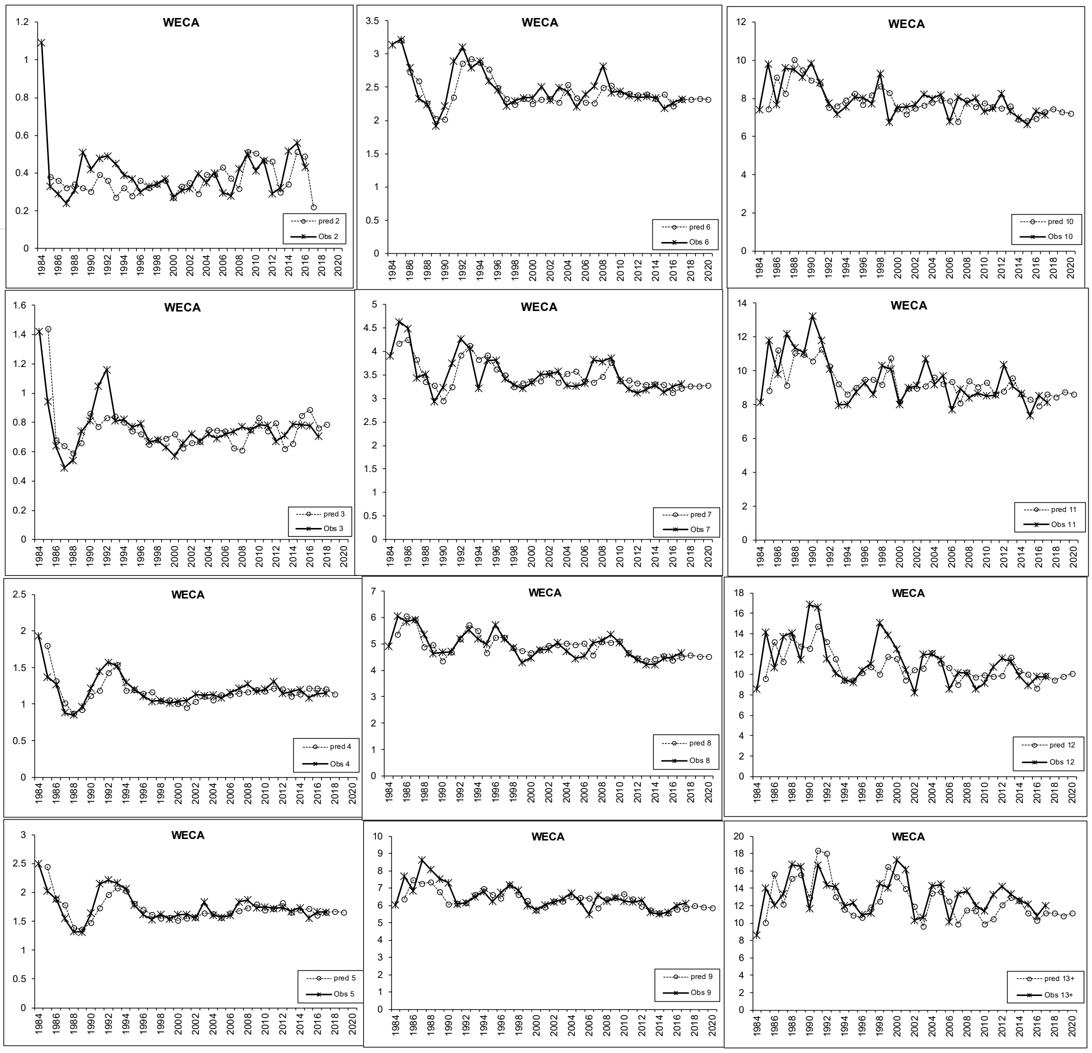

Figure 3.3. Northeast Arctic cod. Weight in catch predictions.

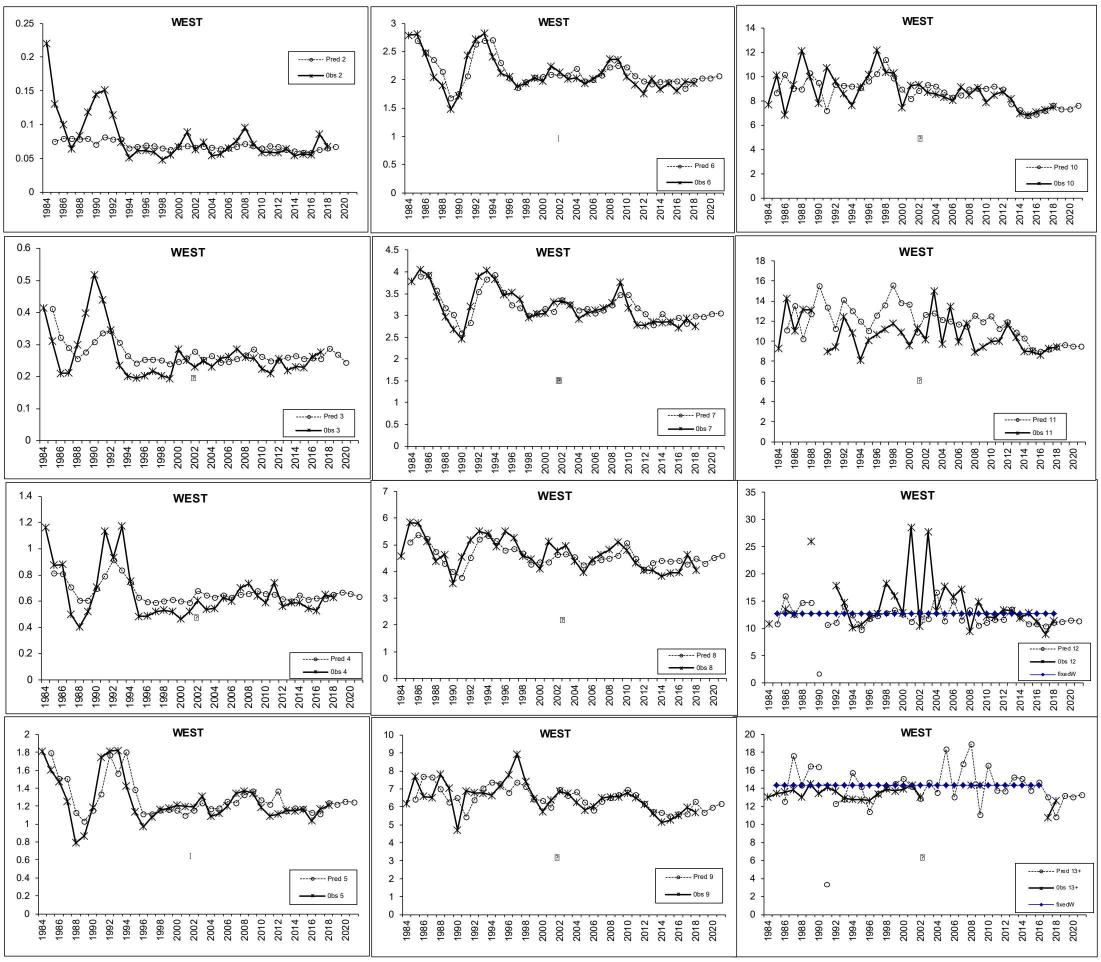

Figure 3.4. Northeast Arctic cod. Weight-in-stock projections.

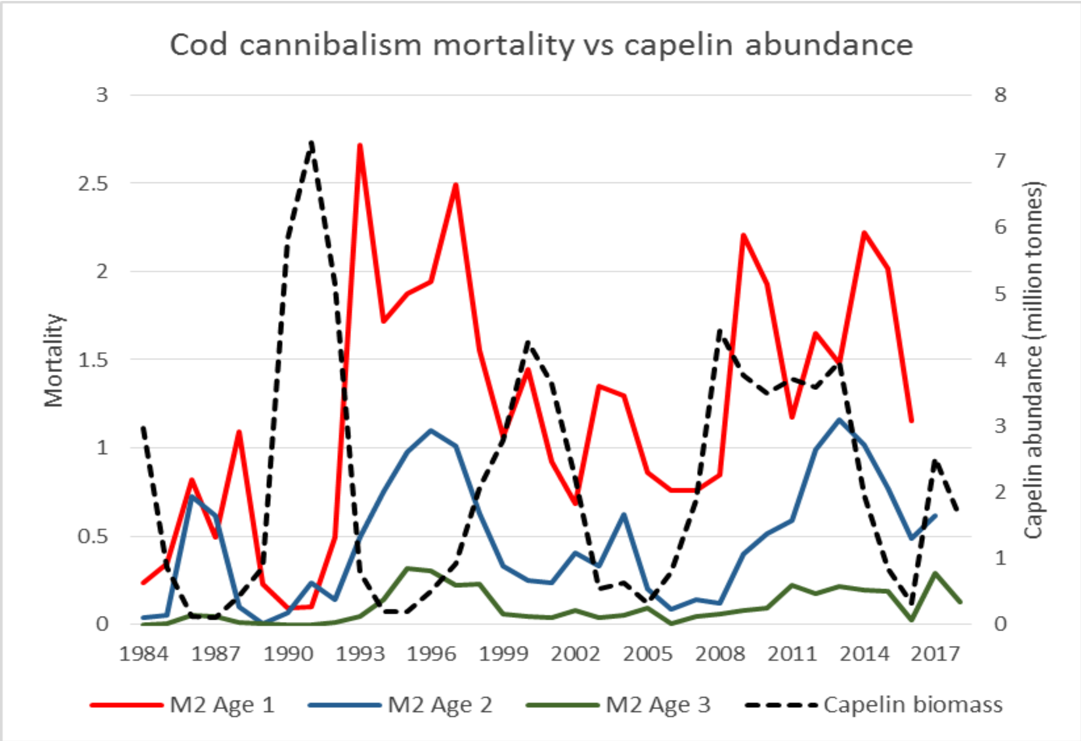

Figure 3.5. NEA cod cannibalism mortality vs. capelin abundance.

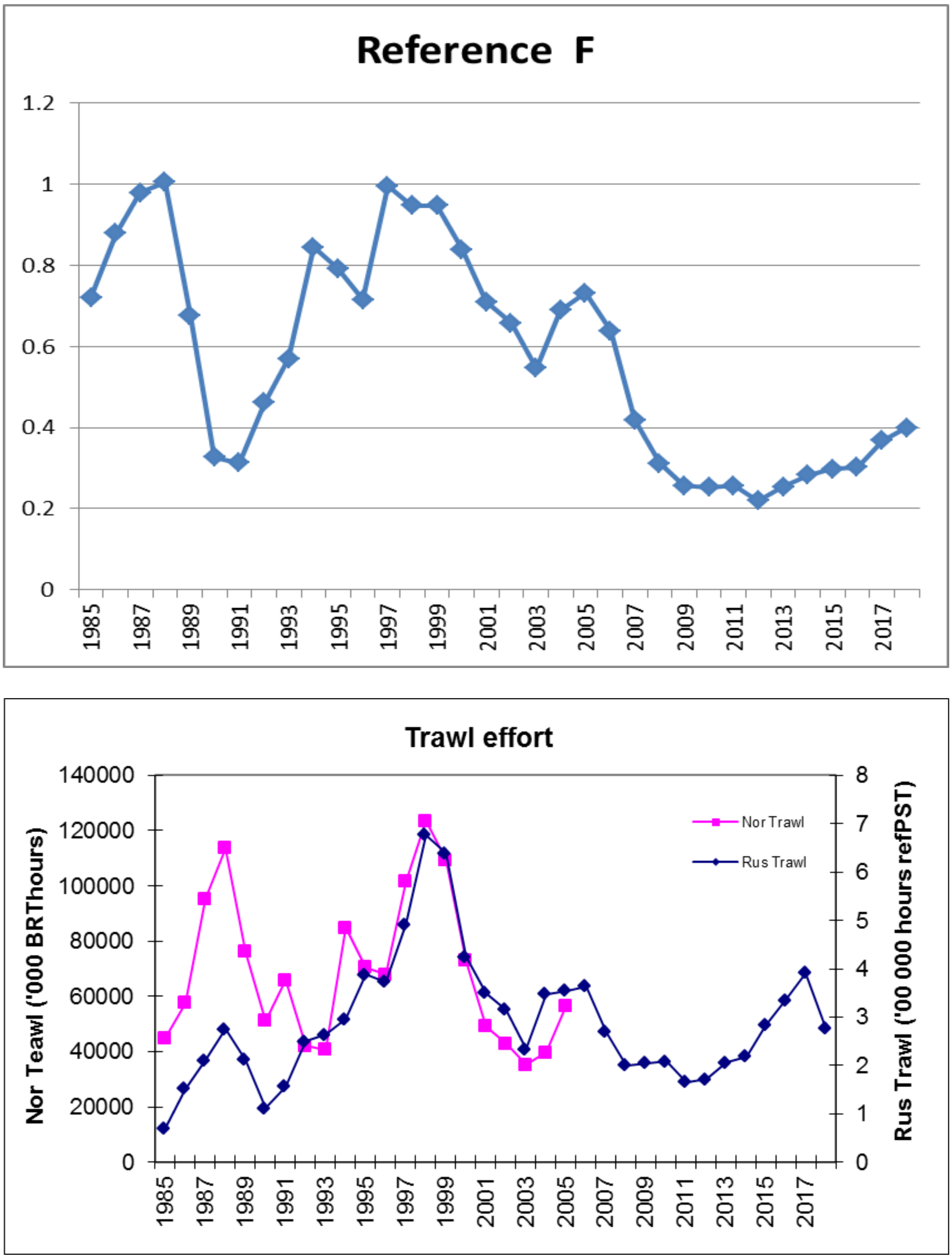

Figure 3.6a. Northeast Arctic cod. Fishing mortality (F5-10) (top panel) and trawl efforts in 1985–2018 (bottom panel).

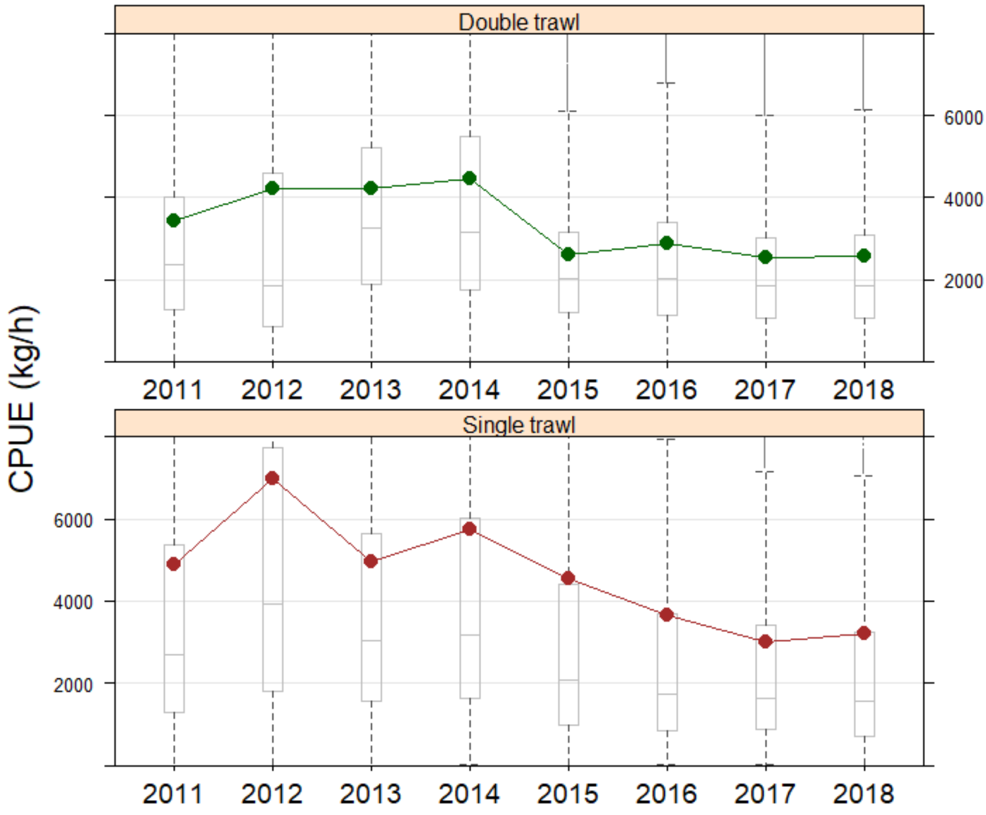

Figure 3.6b. Cod CPUE in Norwegian trawl catches where cod is the main species (double and single trawl). Connected line shows mean, line inside the box shows the median, and the box shows 25 and 75 percentiles.

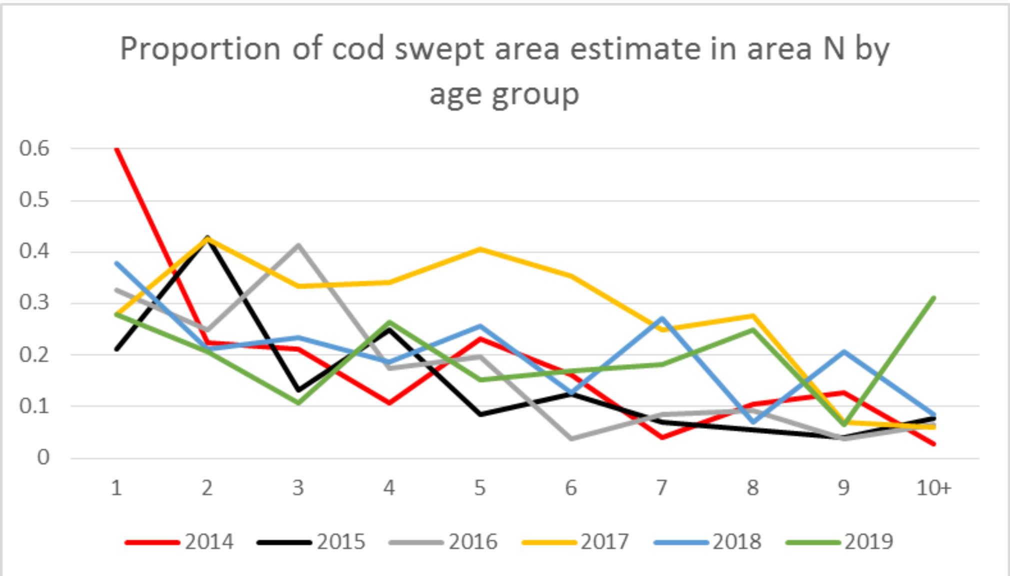

Figure 3.7. Proportion of NEA cod swept area estimate in area N during the Joint winter survey in 2014–2019, by age group.

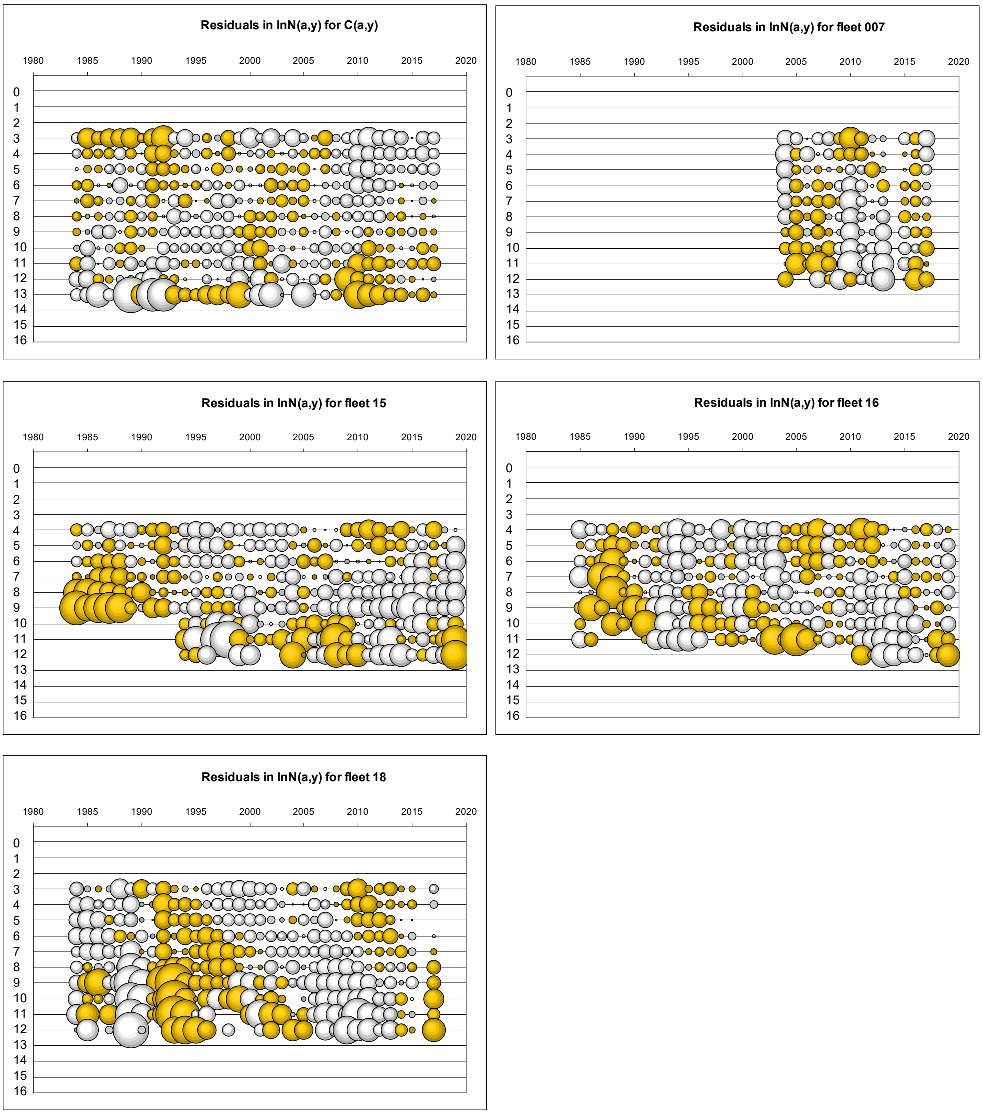

Figure 3.8a. Residuals of the TISVPA data approximation (yellow circles are positive residuals, white – negative, maximum bubble size corresponds to residual = 2.4).

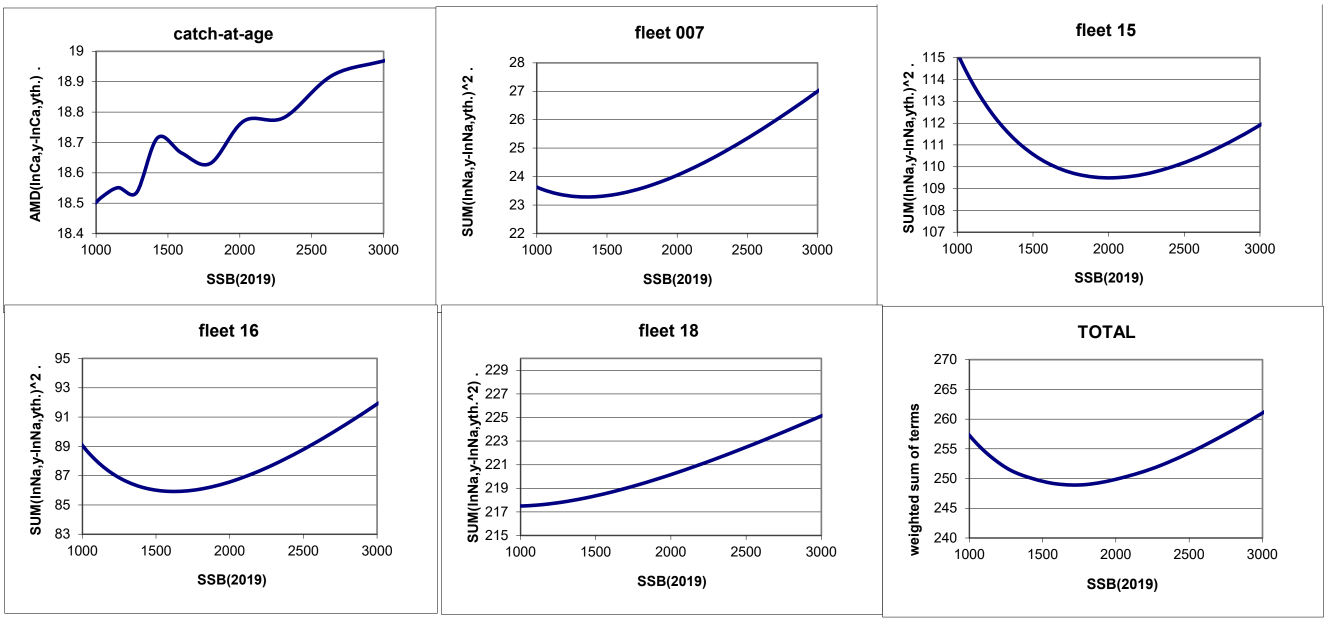

Figure 3.8b. Profiles of the components of the TISVPA objective function.

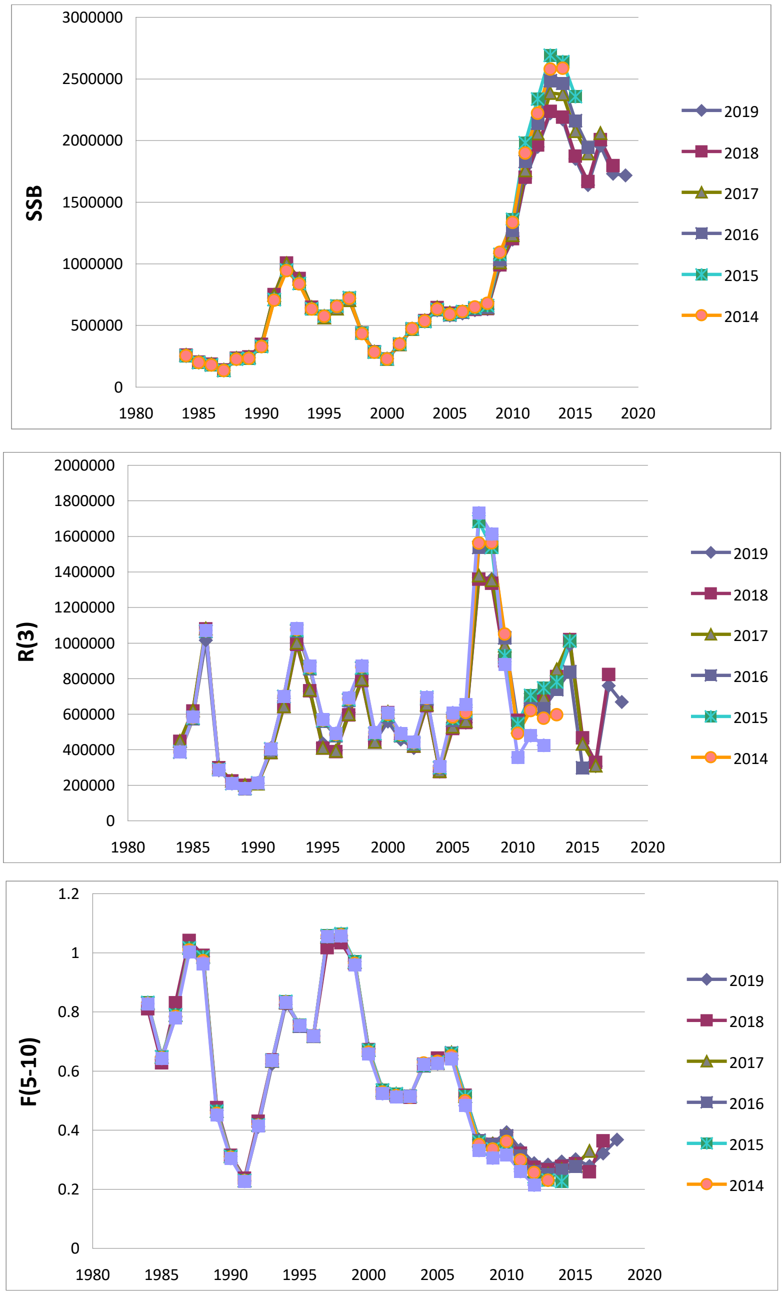

Figure 3.8c. TISVPA retrospective runs.

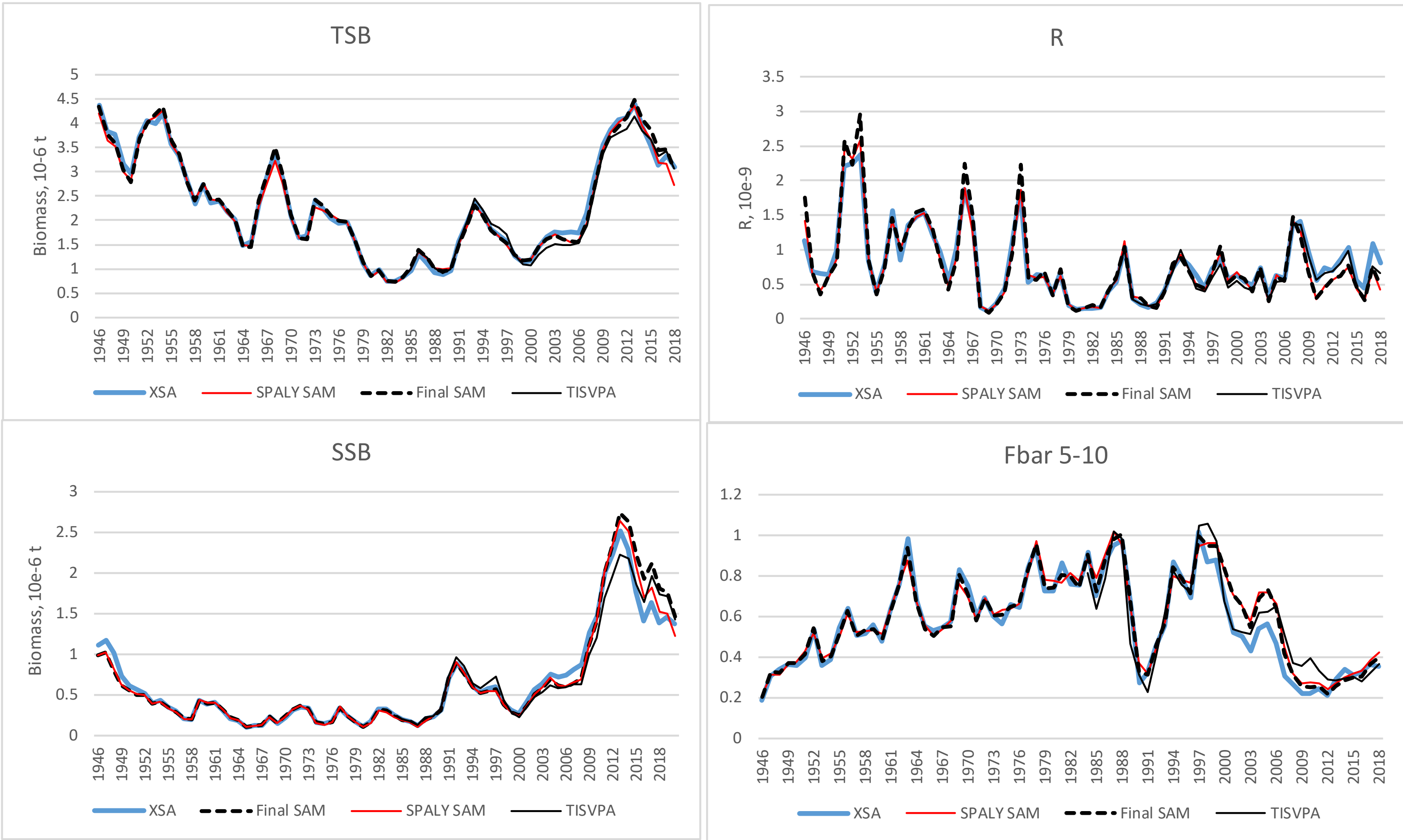

Figure 3.9a. Model comparison. F, SSB, TSB and recruitment in SAM, XSA and TISVPA.

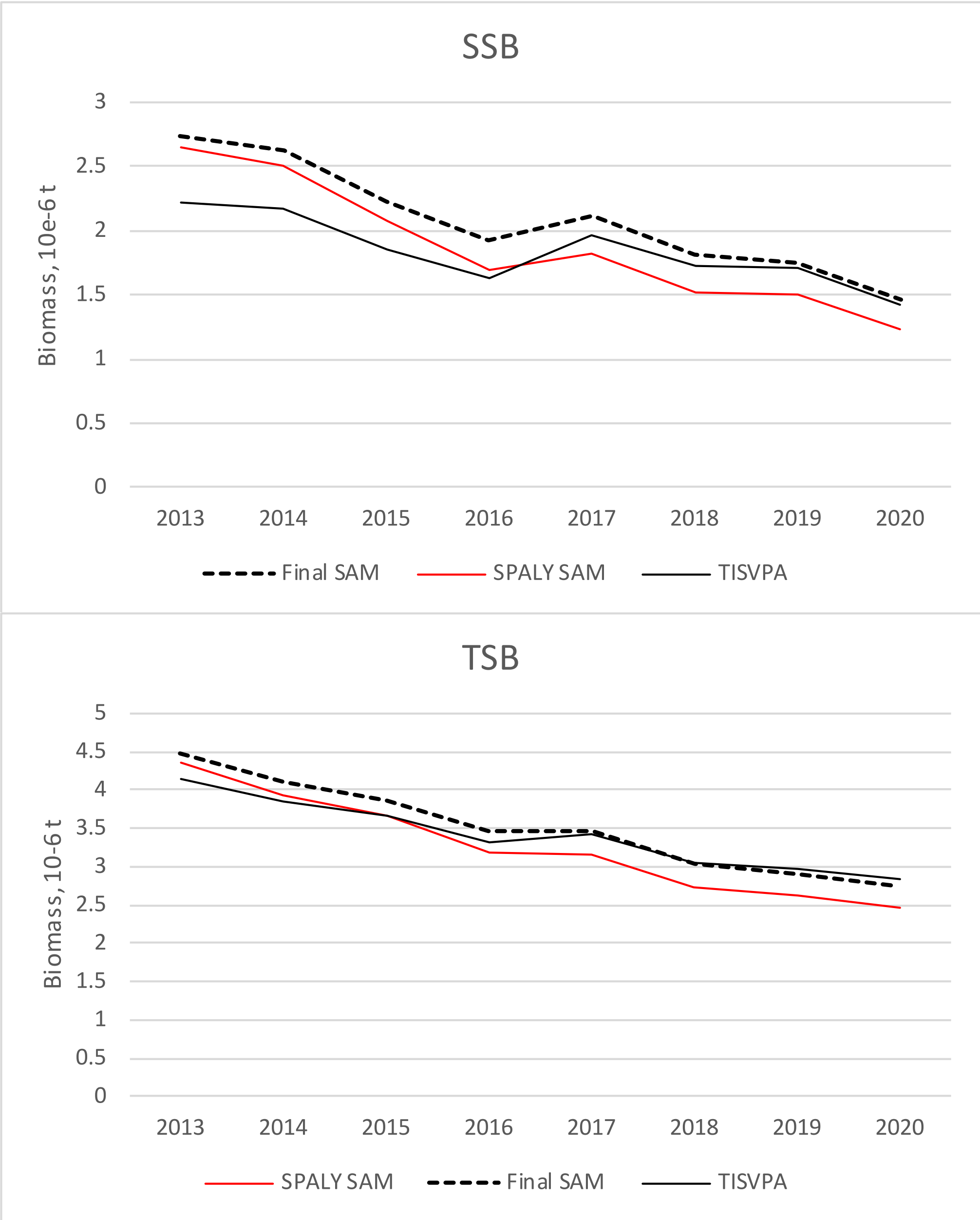

Figure 3.9b. NEA cod biomass dynamic assessed (2012–2018) and predicted (2019–2020) by SAM and TISVPA assuming F status quo in 2019.

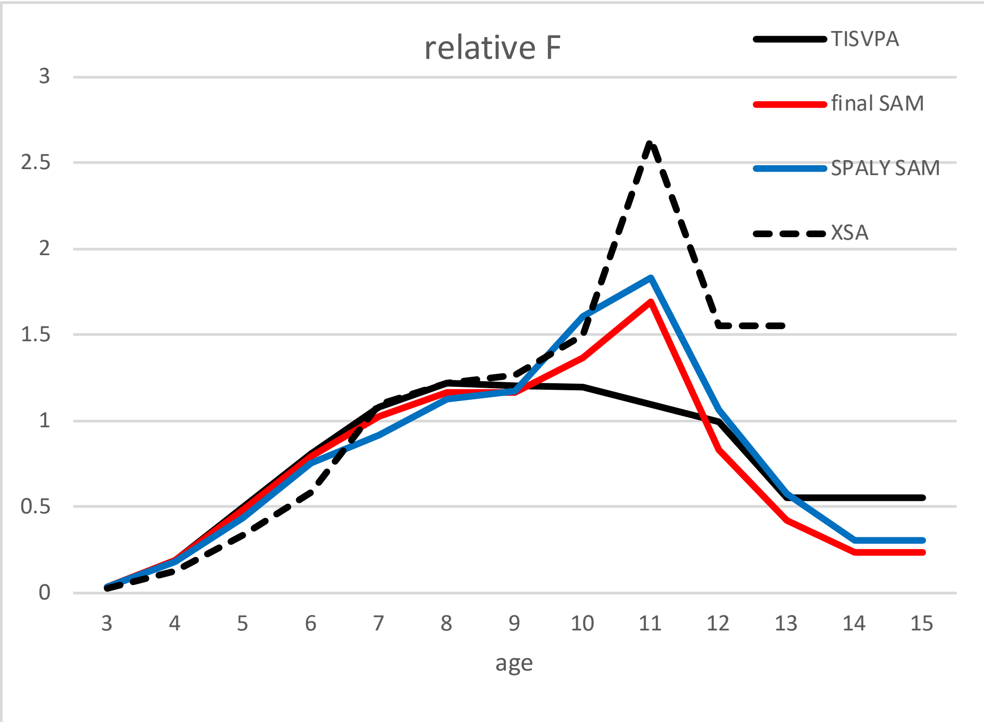

Figure 3.9c. NEA cod average fishing pattern for 2016–2018 from 4 models (SPALY SAM, Final SAM, XSA, and TISVPA).

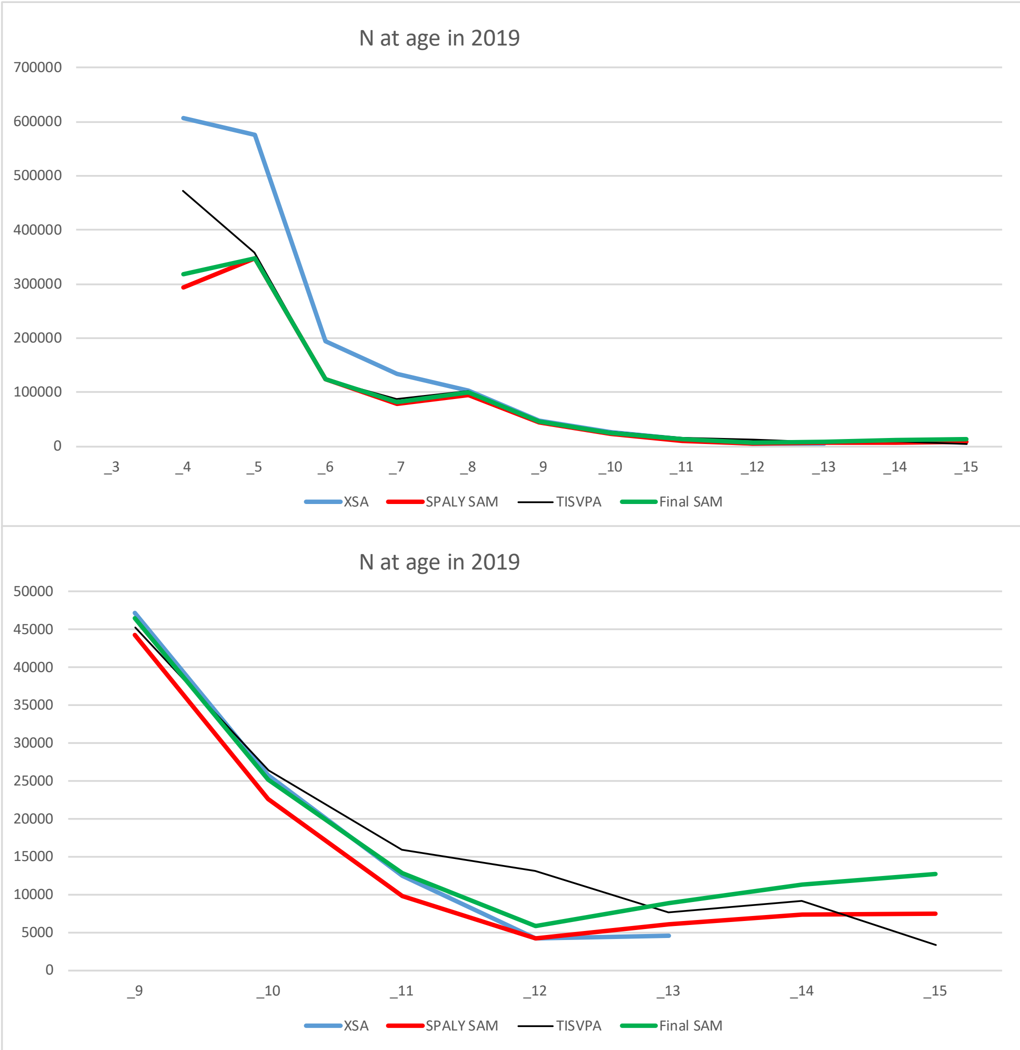

Figure 3.9d. NEA cod stock numbers (thousands) at the beginning of 2019 from 4 models (SPALY SAM, Final SAM, XSA, and TISVPA). Upper panel: Ages 3-15+, lower panel: Ages 9-15+.

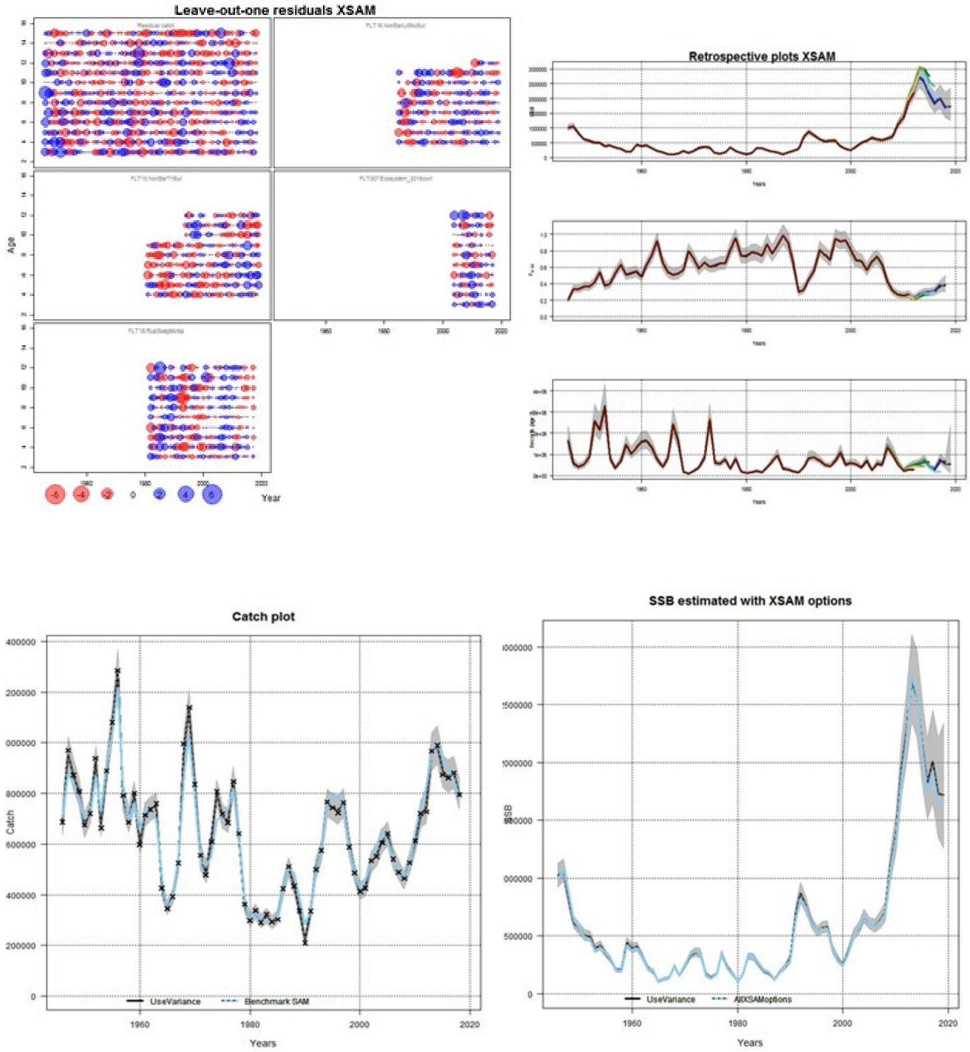

Figure 3.10: a) Leave-out-one residual plots, b) retrospective plots, c) catch plot and D) SSB plot using benchmark settings and variance structures for catch and FLT15. Note that the estimated catch is also provided for the benchmark (SPALY) setting in c), and the SSB estimates are also provided for a run with all XSAM options in d).

Table A1. Northeast Arctic COD. Catch per unit effort.

	Sub-area I			Division IIb			Division IIa		Total
Year	Norway[2]	UK[3]	Russia[4]	Norway[2]	UK[3]	Russia[4]	Norway[2]	UK[3]	Norway
1966	-	0.074	0.42	-	0.078	0.19	-	0.067	
1967	-	0.081	0.53	-	0.106	0.87	-	0.052	
1968	-	0.110	1.09	-	0.173	1.21	-	0.056	
1969	-	0.113	1.00	-	0.135	1.17	-	0.094	
1970	-	0.100	0.80	-	0.100	0.80	-	0.066	
1971	-	0.056	0.43	-	0.071	0.16	-	0.062	
1972	0.90	0.047	0.34	0.59	0.051	0.18	1.08	0.055	
1973	1.05	0.057	0.56	0.43	0.054	0.57	0.71	0.043	
1974	1.75	0.079	0.86	1.94	0.106	0.77	0.19	0.028	
1975	1.82	0.077	0.94	1.67	0.100	0.43	1.36	0.033	
1976	1.69	0.060	0.84	1.20	0.081	0.30	1.69	0.035	
1977	1.54	0.052	0.63	0.91	0.056	0.25	1.16	0.044	1.17
1978	1.37	0.062	0.52	0.56	0.044	0.08	1.12	0.037	0.94
1979	0.85	0.046	0.43	0.62	-	0.06	1.06	0.042	0.85
1980	1.47	-	0.49	0.41	-	0.16	1.27	-	1.23
					Spain[5]			**Russia[4]**	
1981	1.42	-	0.41	(0.96)	-	0.07	1.02	0.35	1.21
1982	1.30	-	0.35	-	0.86	0.26	1.01	0.34	1.09
1983	1.58	-	0.31	(1.31)	0.92	0.36	1.05	0.38	1.11
1984	1.40	-	0.45	1.20	0.78	0.35	0.73	0.27	0.96
1985	1.86	-	1.04	1.51	1.37	0.50	0.90	0.39	1.29
1986	1.97	-	1.00	2.39	1.73	0.84	1.36	1.14	1.70
1987	1.77	-	0.97	2.00	1.82	1.05	1.73	0.67	1.77
1988	1.58	-	0.66	1.61	(1.36)	0.54	0.97	0.55	1.03
1989	1.49	-	0.71	0.41	2.70	0.45	0.78	0.43	0.76
1990	1.35	-	0.70	0.39	2.69	0.80	0.38	0.60	0.49
1991	1.38	-	0.67	0.29	4.96	0.76	0.50	0.90	0.44
1992	2.19	-	0.79	3.06	2.47	0.23	0.98	0.65	1.29
1993	2.33	-	0.85	2.98	3.38	1.00	1.74	1.03	1.87
1994	2.50	-	1.01	2.82	1.44	1.14	1.27	0.86	1.59
1995	1.57	-	0.59	2.73	1.65	1.10	1.00	1.01	1.92
1996			0.74		1.11	0.85		0.99	1.81
1997			0.61			0.57		0.74	1.36
1998			0.37			0.29		0.40	0.83
1999			0.29			0.34		0.39	0.74
2000			0.34			0.37		0.53	0.92
2001			0.46			0.46		0.69	1.21
2002			0.58			0.66		0.57	1.35
2003			0.70			1.22		0.73	1.67
2004			0.48			0.78		0.84	1.67
2005			0.45			0.62		0.81	1.23
2006			0.49			0.54		0.84	0.88
2007			0.71			0.51		0.88	1.16
2008			0.93			0.79		1.21	
2009			1.33			1.16		0.83	
2010			1.47			1.18		1.16	
2011			1.77			1.69		2.46	4.87[6]
2012			2.25			1.44		2.11	6.97[6]
2013			2.30			1.46		2.60	4.96[6]
2014			2.07			1.54		2.38	5.75[6]
2015			1.06			1.38		1.93	4.54[6]
2016			1.15			1.06		1.39	3.64[6]
2017			1.00			1.00		1.05	3.01[6]
2018[1]			1.06			1.40		1.31	3.20[6]

[1]Preliminary figures.
[2]Norwegian data - t per 1,000 tonnage*hrs fishing.
[3]United Kingdom data - t per 100 tonnage*hrs fishing.
[4]Russian data - t per hr fishing.
[5]Spanish data - t per hr fishing.
[6] 2011-2018 Norwegian data on t per hr fishing are from single-trawl only, not comparable to data from previous years

Period	Sub-area I	Divisions IIa and IIb
1960–1973	RT	RT
1974–1980	PST	RT
1981–	PST	PST

Vessel type: RT = side trawlers, 800–1000 HP, PST = stern trawlers, up to 2000 HP.

Table A2. Northeast Arctic COD. Abundance indices (millions) from the Norwegian acoustic survey in the Barents Sea in January-March. New TS and rock-hopper gear (1981–1988 back-calculated from bobbins gear). Corrected for length-dependent effective spread of trawl. Data from 1994 onwards from Mehl *et al.*, 2018a.

Year				Age														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	10+	Total
1981		8.00	82.00	40.00	63.00	106.00	103.00	16.00	3.00	1.00							1.00	423.0
1982		4.00	5.00	49.00	43.00	40.00	26.00	28.00	2.00	+							0.00	197.0
1983		60.49	2.78	5.34	14.27	17.37	11.13	5.58	2.98	0.45							0.06	120.5
1984		745.44	146.11	39.13	13.59	11.26	7.44	2.81	0.19	0.02							0.00	966.0
1985		69.06	446.29	153.04	141.59	19.66	7.58	3.32	0.22	0.09							0.04	840.9
1986		353.63	243.90	499.61	134.27	65.90	8.28	2.15	0.37	0.06							0.02	1308.2
1987		1.62	34.07	62.80	204.93	41.41	10.40	1.22	0.19	0.66							0.00	357.3
1988		1.98	26.25	50.42	35.53	56.20	6.48	1.35	0.15	0.01							0.00	178.4
1989		7.53	7.98	17.00	34.39	21.38	53.82	6.88	0.97	0.10							0.05	150.1
1990		81.13	24.92	14.82	20.63	26.08	24.30	39.78	2.37	0.06							0.03	234.1
1991		181.04	219.51	50.23	34.64	29.33	28.87	16.89	17.33	0.86							0.03	578.7
1992		241.38	562.13	176.48	65.79	18.84	13.23	7.58	4.50	2.78							0.21	1092.9
1993		1074.04	494.68	357.24	191.05	108.24	20.84	8.12	4.98	2.25							2.51	2264.0
1994		823.50	586.90	307.20	384.40	207.00	68.00	12.10	3.53	2.55	0.81	1.11	0.11	0.12	0.00	0.00	2.15	2397.4
1995		2106.60	217.90	143.00	138.00	198.30	67.00	16.10	2.46	0.90	0.32	0.53	0.16	0.00	0.00	0.00	1.01	2891.2
1996		1748.90	261.10	110.00	89.50	115.00	83.30	23.00	2.20	0.27	0.08	0.05	0.05	0.06	0.01	0.00	0.25	2433.4
1997	[1]	2832.90	842.90	209.20	49.20	51.50	43.10	24.90	5.73	1.00	0.23	0.22	0.00	0.00	0.03	0.00	0.48	4060.9
1998	[1]	2633.10	555.80	444.50	210.80	46.60	44.40	28.60	16.90	1.85	0.46	0.16	0.00	0.02	0.00	0.07	0.71	3983.2
1999		351.10	227.00	151.60	133.30	51.80	12.00	7.02	3.98	1.54	0.32	0.02	0.01	0.01	0.00	0.00	0.36	939.6
2000		142.40	248.10	301.10	168.80	147.10	49.00	12.10	4.48	2.85	0.80	0.18	0.12	0.03	0.00	0.00	1.13	1077.0
2001		348.30	50.80	179.00	162.30	81.10	44.00	11.30	1.73	0.47	0.18	0.10	0.00	0.00	0.00	0.01	0.29	879.4
2002		18.40	208.80	62.40	105.50	98.00	53.40	20.20	2.96	0.30	0.53	0.12	0.00	0.00	0.00	0.02	0.67	570.6
2003		1399.70	52.00	307.00	120.60	121.80	118.70	39.10	9.32	1.84	0.33	0.07	0.00	0.07	0.05	0.00	0.52	2170.5
2004		147.10	111.20	33.30	85.20	33.50	28.50	18.00	5.35	1.15	0.36	0.06	0.01	+	0.00	0.00	0.43	463.8
2005		438.20	123.20	129.80	34.90	69.10	21.20	15.00	4.95	0.95	0.27	0.04	0.06	0.05	0.03	0.00	0.45	837.7
2006	[2]	369.50	158.30	64.40	54.50	18.60	29.70	9.57	4.83	1.22	0.19	0.11	0.22	0.00	0.00	0.00	0.52	711.2
2007	[1]	88.90	53.70	63.90	35.70	32.70	9.68	18.80	6.57	2.74	0.51	0.24	0.09	0.04	0.00	0.00	0.88	313.6
2008		48.50	91.90	196.10	292.00	116.00	73.70	21.10	14.10	2.62	0.72	0.05	0.02	0.01	0.00	0.00	0.80	856.8
2009		195.50	23.20	104.60	191.60	139.70	40.90	14.10	4.70	4.38	0.48	0.13	0.02	0.01	0.00	0.00	0.64	719.4
2010		696.10	41.80	21.80	86.90	161.80	153.80	46.20	14.40	3.87	2.86	0.91	0.11	0.14	0.09	0.01	4.12	1230.9
2011		248.50	88.70	39.10	28.70	65.40	106.60	102.40	19.40	6.71	1.49	1.07	0.28	0.13	0.10	0.02	3.09	708.5
2012	[2]	508.10	45.30	87.80	47.60	35.10	70.90	135.80	60.30	8.19	5.19	1.26	0.66	0.45	0.01	0.10	7.67	1006.7
2013		293.30	82.40	59.10	85.40	70.60	50.20	100.00	129.90	57.00	5.37	3.98	1.63	0.70	0.21	0.05	11.94	939.8
2014		582.20	154.20	234.00	115.90	96.00	68.40	37.70	84.70	55.30	24.10	2.46	1.51	0.17	0.04	0.16	28.44	1456.8
2015		1183.00	107.60	110.20	188.00	119.50	130.20	84.90	33.80	51.70	23.00	6.27	0.57	0.14	0.04	0.01	30.03	2038.9
2016		106.20	111.50	35.20	61.60	101.20	64.50	49.20	23.10	11.90	16.30	7.37	2.25	0.69	0.25	0.09	26.95	591.4
2017	[2]	381.50	42.80	80.60	33.00	37.60	58.00	33.00	22.30	10.30	3.81	3.00	3.15	0.59	0.20	0.10	10.85	710.0
2018		1492.00	221.20	93.30	134.00	46.70	51.90	56.10	35.10	10.00	6.65	1.38	2.14	1.55	0.14	0.25	12.11	2152.4
2019		1000.30	287.40	182.10	97.70	124.30	53.40	33.70	31.60	8.70	2.83	0.38	0.33	0.20	0.23	0.16	4.13	1823.3
	[1]	Survey covered a larger area																
	[2]	Adjusted indices																

Table A3. Northeast Arctic COD. Abundance indices (millions) from the Norwegian bottom-trawl survey in the Barents Sea in January-March. Rock-hopper gear (1981–1988 back-calculated from bobbins gear). Corrected for length-dependent effective spread of trawl. Data from 1994 and onwards from Mehl *et al*. 2017b.

				Age														
Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	10+	Total
1981		4.60	34.30	16.40	23.30	40.00	38.40	4.80	1.00	0.30							0.00	163.1
1982		0.80	2.90	28.30	27.70	23.60	15.50	16.00	1.40	0.20							0.00	116.4
1983		152.90	13.40	24.95	52.34	43.33	16.96	5.82	3.21	0.97							0.05	313.9
1984		2755.04	379.11	97.49	28.28	21.44	11.74	4.07	0.40	0.08							0.08	3297.7
1985		49.49	660.04	166.79	125.98	19.92	7.67	3.34	0.21	0.07							0.05	1033.6
1986		665.79	399.61	805.00	143.93	64.14	8.30	1.91	0.34	0.04							0.03	2089.1
1987		30.72	444.98	240.38	391.15	54.35	15.70	2.00	0.45	0.03							0.00	1179.8
1988		3.21	72.83	148.03	80.49	173.31	20.48	3.58	0.53	0.03							0.00	502.5
1989		8.24	15.62	46.36	75.86	37.79	90.19	9.82	0.94	0.10							0.07	285.0
1990		207.17	56.72	28.35	34.87	34.59	20.56	27.23	1.61	0.38							0.03	411.5
1991		460.45	220.14	45.85	33.67	25.65	21.49	12.15	12.67	0.61							0.02	832.7
1992		126.56	570.92	158.26	57.71	17.82	12.83	7.67	4.29	2.72							0.22	959.0
1993		534.48	420.40	273.89	140.13	72.48	15.83	6.24	3.89	2.23							2.36	1471.9
1994		1044.50	545.50	296.80	307.60	152.60	46.80	8.13	2.59	1.32	0.55	0.52	0.11	0.05	0.00	0.00	1.23	2407.0
1995		5343.80	540.20	280.40	242.10	252.30	77.10	17.90	2.33	1.13	0.55	0.59	0.19	0.00	0.00	0.00	1.33	6758.7
1996		5908.30	778.60	164.00	116.70	140.70	111.20	24.80	2.79	0.37	0.16	0.08	0.08	0.05	0.02	0.00	0.39	7247.9
1997	1	5122.80	1413.70	315.40	69.20	75.00	60.70	26.80	4.95	0.63	0.68	0.46	0.00	0.00	0.00	0.00	1.14	7090.2
1998	1	2512.10	492.50	355.20	167.40	31.70	26.40	17.50	8.26	0.79	0.52	0.65	0.00	0.35	0.00	0.04	1.56	3613.4
1999		479.70	353.60	189.60	181.90	61.30	12.80	6.83	5.19	0.98	0.27	0.02	0.03	0.02	0.00	0.00	0.34	1292.2
2000		128.20	242.80	247.50	130.00	112.00	27.00	4.73	1.82	1.23	0.36	0.10	0.03	0.02	0.00	0.00	0.51	895.8
2001		715.80	77.60	182.00	194.50	81.60	38.00	9.58	1.19	0.45	0.19	0.04	0.00	0.00	0.00	0.01	0.24	1300.9
2002		34.20	416.20	118.00	137.70	108.60	46.50	14.50	2.19	0.34	0.19	0.05	0.00	0.00	0.00	0.02	0.26	878.5
2003		3021.40	61.20	380.80	125.40	95.20	66.60	17.90	4.72	1.02	0.16	0.04	0.00	0.02	0.02	0.00	0.24	3774.3
2004		321.30	236.30	65.50	186.10	53.60	43.20	30.90	6.92	1.66	0.29	0.08	0.01	0.01	0.00	0.00	0.39	945.8
2005		846.80	216.40	244.80	54.80	102.70	22.40	16.40	3.80	0.88	0.30	0.04	0.02	0.03	0.04	0.00	0.43	1509.5
2006	2	676.90	283.80	115.60	114.00	28.10	43.30	14.00	5.19	1.34	0.22	0.21	0.08	0.00	0.00	0.00	0.51	1282.6
2007	1	584.20	369.90	365.80	127.30	68.90	13.70	23.60	6.85	2.20	0.40	0.31	0.08	0.00	0.00	0.00	0.79	1563.2
2008		69.00	103.30	192.50	300.00	115.60	40.80	18.00	8.29	1.86	0.35	0.02	0.02	0.01	0.00	0.00	0.40	850.0
2009		389.40	35.50	124.30	196.10	218.00	58.20	17.50	8.44	5.27	0.50	0.18	0.03	0.03	0.00	0.00	0.74	1053.4
2010		1031.50	96.50	37.00	114.90	155.50	144.50	39.80	11.20	3.70	1.64	0.57	0.05	0.02	0.03	0.02	2.33	1637.0
2011		615.30	225.60	85.40	50.70	129.90	138.00	103.10	16.70	4.34	1.17	0.79	0.20	0.17	0.04	0.02	2.39	1371.4
2012	3	728.40	124.80	83.10	70.30	36.40	93.90	136.30	49.60	9.38	2.33	0.87	0.60	0.47	0.02	0.05	4.34	1336.6
2013		439.10	147.20	70.30	119.80	64.00	41.00	65.00	76.20	33.60	2.21	2.83	0.41	0.35	0.06	0.03	5.89	1062.0
2014		499.80	148.80	180.60	85.10	67.90	47.80	32.60	46.90	31.70	9.36	1.01	0.97	0.15	0.04	0.07	11.60	1153.0
2015		1295.00	196.80	125.40	170.20	135.70	99.80	71.20	27.40	52.80	17.00	2.86	0.72	0.10	0.07	0.04	20.79	2194.8
2016		212.30	232.90	53.40	112.30	151.30	109.00	66.10	26.60	12.80	15.00	6.43	0.96	0.50	0.17	0.14	23.20	1000.0
2017	3	471.50	71.00	116.10	39.70	48.70	56.60	27.80	18.90	7.63	3.01	2.22	3.49	0.53	0.17	0.06	9.48	867.5
2018		1686.20	394.80	107.60	148.70	46.10	55.70	53.40	23.90	7.48	5.41	1.13	2.24	1.19	0.13	0.39	10.49	2529.3
2019		1291.70	446.00	253.70	132.00	188.60	66.40	27.00	28.80	7.60	1.72	0.34	0.17	0.14	0.13	0.10	2.60	2444.3

1Indices raised to also represent the Russian EEZ.

2 Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

3Indices raised to also represent uncovered parts of the Russian EEZ.

Table A4. North East Arctic COD. Abundance-at-age (millions) from the Norwegian acoustic survey on the spawning grounds off Lofoten in March-April.

Year	5	6	7	8	9	10	11	12	13	14+	12+	Sum
1985	0.68	7.45	12.36	3.11	1.15	1.01	0.45					26.21
1986	2.49	3.30	5.54	2.71	0.16		0.40				0.08	14.68
1987	8.77	7.04	0.23	2.83	0.04		0.03				0.03	18.97
1988	1.57	4.43	2.56	0.05	0.01	0.05						8.67
1989	0.04	13.20	9.73	2.20	0.38	0.12					0.06	25.73
1990	0.13	2.60	27.02	4.85	0.49	0.32						35.41
1991	0.00	5.00	19.83	32.67	2.75	0.19	0.17					60.61
1992	2.74	5.23	20.80	20.87	79.60	4.17	1.61				0.22	135.24
1993	4.87	14.58	17.35	20.22	25.44	41.95	4.74				0.71	129.86
1994	23.78	25.85	10.36	8.21	7.68	3.49	17.53				2.61	99.51
1995	6.49	35.24	12.34	2.27	3.60	2.56	2.15				7.96	72.61
1996	1.41	14.43	24.00	3.65	0.79	0.25	0.80				1.30	46.63
1997	0.40	4.95	27.56	16.50	1.50	0.42					0.75	52.08
1998	0.05	0.30	7.06	11.05	3.24	0.51	0.18				0.02	22.41
1999	0.25	1.92	4.84	14.58	8.42	0.75	0.19				0.10	31.05
2000	3.61	3.85	3.25	2.15	2.23	0.45	0.39				0.05	15.98
2001	4.33	17.61	8.03	0.96	0.33	0.36	0.26				0.09	31.97
2002	2.30	19.11	16.50	6.49	0.83	0.31	0.47				0.01	46.02
2003	2.49	29.56	30.01	13.46	1.90	0.11	0.04				0.02	77.59
2004	1.96	17.52	29.82	16.34	7.67	2.04	0.15				0.68	76.18
2005	3.33	12.93	28.75	13.06	6.51	1.55	0.06				0.16	66.35
2006	0.20	12.50	8.11	10.98	7.42	2.12	0.16				0.66	42.14
2007	1.46	3.88	28.52	8.69	5.35	2.80	0.68				0.36	51.72
2008	0.45	5.96	2.95	20.72	2.70	2.02	1.66				0.71	37.17
2009	3.42	14.48	27.64	8.10	22.31	3.07	1.56				0.37	80.95
2010	1.22	32.60	26.50	23.68	7.56	6.32	0.81				1.54	100.22
2011	2.02	51.01	178.92	48.47	18.10	4.58	6.98				0.44	310.50
2012	0.37	13.43	98.37	77.69	20.53	7.37	3.18				1.80	222.74
2013	0.22	5.84	33.44	101.10	105.50	15.91	7.01				6.38	275.40
2014	0.25	2.83	15.42	58.13	111.90	75.33	12.25				8.84	284.95
2015	0.96	1.58	16.09	15.66	42.91	44.45	26.80				11.01	159.46
2016	0.15	1.21	7.50	12.00	19.09	32.63	22.84	15.85	7.97	1.89	25.70	121.11
2017	0.18	8.94	12.86	24.07	14.76	12.58	11.58	12.01	3.72	3.51	19.24	104.20
2018	0.62	3.48	11.45	11.21	8.48	7.78	4.44	3.73	2.82	3.06	9.61	57.25
2019	0.54	2.88	14.33	36.09	17.67	18.41	6.10	2.54	2.44	5.03	10.01	106.02

Table A5. COD. Length (cm)-at-age in the Barents Sea from the investigations winter survey in February.

	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1981	17.0	26.1	35.5	44.7	52.0	61.3	69.6	77.9						
1982	14.8	25.8	37.6	46.3	54.7	63.1	70.8	82.9						
1983	12.8	27.6	34.8	45.9	54.5	62.7	73.1	78.6						
1984	14.2	28.4	35.8	48.6	56.6	66.2	74.1	79.7						
1985	16.5	23.7	40.3	48.7	61.3	71.1	81.2	85.7						
1986	11.9	21.6	34.4	49.9	59.8	69.4	80.3	93.8						
1987	13.9	21.0	31.8	41.3	56.3	66.3	77.6	87.9						
1988	15.3	23.3	29.7	38.7	47.6	56.8	71.7	79.4						
1989	12.5	25.4	34.7	39.9	46.8	56.2	67.0	83.3						
1990	14.4	27.9	39.4	47.1	53.8	60.6	68.2	79.2						
1991	13.6	27.2	41.6	51.7	59.5	67.1	72.3	77.6						
1992	13.2	23.9	41.3	49.9	60.2	68.4	76.1	82.8						
1993	11.3	20.3	35.9	50.8	59.0	68.2	76.8	85.8						
1994	11.3	17.9	30.2	44.6	55.1	65.5	73.8	78.5	87.5	97.9	97.7	100.8	122.1	-
1995	12.2	18.0	28.8	42.1	54.0	63.7	75.7	80.2	83.9	99.1	+	109.0	-	-
1996	12.1	18.9	28.7	40.6	49.3	60.9	71.7	84.8	92.2	92.2	99.5	104.6	108.7	121.0
1997	10.9	15.9	26.8	39.9	49.5	59.2	69.9	81.6	91.8	+	+	-	-	-
1998	9.8	18.0	29.3	40.0	50.9	58.9	67.7	76.7	87.4	+	+	-	+	-
1999	12.0	18.3	29.0	39.9	50.4	59.4	70.4	78.5	88.7	88.4	+	+	+	-
2000	12.9	20.7	28.4	39.7	51.5	61.4	70.5	76.2	84.8	81.8	99.7	+	+	-
2001	11.6	22.6	33.0	41.1	52.2	63.3	70.2	77.7	86.0	96.2	103.8	-	-	-
2002	12.0	19.5	28.6	43.6	52.1	62.0	71.3	79.5	91.0	89.3	102.3	-	-	-
2003	11.4	18.0	28.9	39.4	53.4	61.7	70.6	80.8	89.1	90.6	104.5	-	105.8	111.6
2004	10.6	18.4	31.7	40.6	51.7	61.6	68.6	79.7	90.9	88.5	91.7	+	+	-
2005	11.2	18.3	29.5	43.5	51.1	60.3	71.0	79.6	88.9	96.2	109.4	+	+	+
2006	12.0	19.5	30.9	42.1	53.6	60.2	66.4	76.5	84.5	98.8	93.2	96.3	-	-
2007	13.1	21.0	29.4	40.2	53.1	62.9	68.7	76.6	87.6	94.9	102.4	+	-	-
2008	12.1	22.4	33.1	43.2	51.7	64.1	69.0	81.3	88.4	94.6	108.9	+	+	-
2009	11.2	21.2	32.1	42.6	53.1	61.7	76.5	81.8	89.3	97.9	99.9	+	+	-
2010	11.2	18.2	31.5	42.7	52.4	60.7	70.6	80.4	88.5	96.2	102.7	+	+	+
2011	11.9	19.4	29.5	41.9	51.0	60.7	68.1	78.3	85.9	95.2	101.3	111.1	111.7	119.0
2012	10.6	18.4	29.7	41.0	52.4	58.0	66.5	75.7	86.0	91.4	106.2	113.4	119.7	+
2013	11.2	19.2	31.0	41.0	51.6	62.1	69.7	76.5	81.1	95.2	92.2	110.7	110.7	+
2014	9.8	17.3	29.1	40.1	51.8	59.5	70.3	77.0	81.9	87.1	96.7	98.1	110.5	+
2015	10.5	16.2	30.0	39.9	51.2	60.5	69.0	77.6	80.1	88.9	95.4	101.4	+	+
2016	12.2	18.5	29.9	40.6	50.0	60.6	68.3	76.7	85.6	86.0	90.0	92.6	111.8	122.2
2017	12.4	21.8	31.4	42.3	51.9	60.8	69.7	79.5	85.9	90.6	96.3	91.9	106.9	108.7
2018	11.2	18.6	31.9	42.2	51.1	61.5	68.9	77.6	83.7	87.9	97	98.8	100.1	105.8
2019	11.8	17.2	31.1	41.6	50.8	59.6	69.6	77	83.6	89.6	100.1	102.1	107.3	104.5

In 1997, 1998 and 2012 lengths were adjusted for missing coverage of Russian EEZ.

Table A6. COD. Weight (g) at-age in the Barents Sea from the investigations winter survey in February.

Year \ Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	20	190	372	923	1597	2442	3821	4758						
1984	23	219	421	1155	1806	2793	3777	4566						
1985	20	171	576	1003	2019	3353	5015	6154						
1986	20	119	377	997	1623	2926	3838	7385						
1987	21	65	230	490	1380	2300	3970	6000						
1988	24	114	241	492	892	1635	3040	4373						
1989	16	158	374	604	947	1535	2582	4906	10943	5226				
1990	26	217	580	1009	1435	1977	2829	4435	10772	11045	9615			
1991	18	196	805	1364	2067	2806	3557	4502	7404	13447				
1992	20	136	619	1118	1912	2792	3933	5127	6420	8103	17705	22060		
1993	9	71	415	1179	1743	2742	3977	5758	7068	7515	7521	10744		
1994	12	55	260	796	1463	2372	3477	4624	6782	8420	8530	13516	20786	-
1995	15	53	239	656	1341	2194	3628	4577	5315	8907	+	12176	-	-
1996	15	62	232	632	1079	1979	3327	5479	7655	8192	9760	13013	13614	14650
1997	13	46	181	592	1097	1785	2917	4928	7290	+	+	-	-	-
1998	8	50	256	608	1184	1749	2601	4040	6383	+	+	-	+	-
1999	14	58	231	588	1178	1827	2994	4123	6343	7326	+	+	+	-
2000	16	74	210	558	1210	1961	3042	3842	5384	5727	9960	+	+	-
2001	14	106	336	642	1288	2233	3090	4332	5727	8571	11022	-	-	-
2002	14	67	233	747	1225	2065	3189	4577	7472	6431	11645	-	-	-
2003	13	59	229	586	1313	2013	2982	4725	6511	7552	12467	-	12885	16112
2004	10	59	276	607	1142	1946	2618	4139	6684	6988	7957	+	+	-
2005	13	61	245	724	1145	1857	2953	4224	6418	8607	12488	+	+	+
2006	13	69	280	663	1413	1965	2599	4244	5783	10131	8620	10735	-	-
2007	17	71	226	638	1370	2270	2918	4254	6556	8727	11130	+	-	-
2008	15	90	336	799	1410	2449	3144	5218	6793	9494	12918	+	+	-
2009	13	84	294	704	1293	2030	4061	5082	6884	9504	9614	+	+	-
2010	11	64	307	702	1297	2031	3165	4736	6501	9016	10417	+	+	+
2011	15	65	247	667	1129	1940	2725	4003	5914	8233	9888	13213	13814	+
2012	13	62	251	609	1278	1673	2480	3772	5923	7783	12298	14876	17868	+
2013	11	65	264	591	1201	2064	2804	3839	4814	8433	8759	15101	14729	+
2014	8	49	238	592	1234	1776	2849	3942	4946	6181	8368	9212	12578	+
2015	10	47	242	574	1250	1971	2760	4077	4621	6901	8096	11366	+	+
2016	13	54	239	602	1063	1952	2701	3855	5553	6034	6963	8061	15330	21950
2017	16	92	297	737	1253	2016	3091	4645	6088	7403	9186	8412	12416	14916
2018	12	66	305	687	1237	2074	2867	4180	5536	6793	9222	10497	11164	12268
2019	12	46	272	652	1157	1883	2916	3994	5303	6926	10034	11535	13243	11926

1987: Estimated weights

1997, 1998 and 2012: Adjusted weights due to missing coverage of Russian EEZ.

Table A7. Northeast Arctic COD. Length-at-age in cm in the Lofoten survey.

Year/age	5	6	7	8	9	10	11	12	13	14	12+
1985	59.6	71.1	79.0	88.2	97.3	105.2	114.0				
1986	62.7	70.0	80.0	89.4	86.6		105.8				115.0
1987	58.2	64.5	76.7	86.2	88.0		118.5				116.0
1988	53.1	67.1	71.6	94.0	97.0	119.6					
1989	54.0	59.0	69.8	80.8	96.6	103.0					125.0
1990	56.9	65.1	69.2	79.5	83.7	100.1					
1991	59.0	67.3	74.4	81.0	91.3	99.8	85.0				
1992	66.3	68.7	78.3	83.9	89.2	92.2	101.9				127.0
1993	58.3	66.1	72.8	83.6	87.4	92.7	95.4				111.2
1994	64.3	70.6	82.0	87.3	90.0	95.3	92.4				101.4
1995	61.5	69.7	77.8	84.4	92.6	96.7	100.3				99.5
1996	62.2	67.1	75.9	81.0	93.6	100.9	97.4				104.1
1997	63.7	68.6	74.2	83.8	99.9	108.4					109.0
1998	55.0	62.6	70.2	80.0	92.0	98.0	96.7				115.0
1999	52.7	67.0	69.4	78.6	85.8	100.3	102.0				125.0
2000	58.4	66.5	72.6	77.0	83.9	90.6	93.7				112.4
2001	59.3	66.9	73.2	87.1	88.7	102.8	98.5				128.2
2002	58.6	66.0	73.2	80.8	88.2	101.8	91.0				101.4
2003	62.3	65.0	73.2	80.9	88.9	86.4	120.0				122.0
2004	58.8	64.7	71.2	80.1	85.6	97.0	102.6				115.8
2005	56.3	65.4	72.3	76.0	85.3	95.5	110.5				117.8
2006	56.2	63.7	72.6	77.5	82.9	88.3	89.2				116.3
2007	63.0	66.4	72.4	82.5	88.2	99.8	103.7				115.0
2008	63.8	69.1	73.6	80.9	90.0	94.9	94.9				96.5
2009	60.5	69.3	76.5	82.7	88.7	98.8	92.9				111.6
2010	60.6	64.2	75.0	82.8	93.9	93.7	102.8				108.1
2011	56.8	64.5	70.0	79.9	91.1	96.7	101.1				104.8
2012	59.6	65.4	69.9	77.0	85.4	99.0	105.2				106.0
2013	63.6	68.8	73.1	78.2	83.5	90.9	99.1				96.6
2014	57.2	65.8	74.3	77.9	82.8	86.8	93.3				99.0
2015	60.4	67.8	73.0	78.3	83.0	88.3	94.7				99.2
2016	58.2	63.0	74.4	80.1	89.1	92.9	95.7				97.1
2017	57.6	64.9	70.7	80.9	87.3	94.7	98.6	99.3	102.6	106.6	
2018	67.9	66.8	72.8	79.5	89.4	93.6	99.3	104.9	104.3	109.2	
2019	58.8	68.6	74.7	81.4	87.9	93.9	98.1	106.2	111.1	109.6	

Table A8. Northeast Arctic COD. Mean weight-at-age (kg) in the Lofoten survey.

Year	5	6	7	8	9	10	11	12	13	14+	12+
1985	2.00	3.42	4.61	6.67	8.89	10.73	14.29				
1986	2.22	3.22	4.74	6.40	5.80		10.84				13.48
1987	1.44	1.94	3.61	5.40	5.64		13.15				12.55
1988	1.46	2.82	3.39	6.63	7.27	13.64					
1989	1.30	1.77	2.89	4.74	8.28	9.98					26.00
1990	1.54	2.32	2.55	3.78	4.77	8.80					
1991	2.21	2.52	3.51	5.18	7.40	11.36	5.35				
1992	2.56	2.85	3.99	5.43	6.35	8.03	9.50				17.80
1993	1.79	2.58	3.55	5.31	6.21	7.69	9.28				14.71
1994	2.31	3.27	5.06	6.39	6.64	7.92	7.73				10.10
1995	2.20	3.24	4.83	5.98	7.80	10.03	10.39				10.68
1996	2.22	2.75	4.11	5.63	7.92	10.53	10.58				12.08
1997	2.42	2.92	3.86	5.71	9.65	13.41					12.67
1998	1.88	2.09	2.98	4.85	7.92	9.91	11.05				18.34
1999	1.51	2.80	2.96	4.22	5.92	9.33	9.17				16.00
2000	1.71	2.50	3.16	3.85	5.32	7.07	7.62				12.84
2001	1.90	2.72	3.49	6.23	6.82	10.95	10.29				28.58
2002	1.87	2.57	3.52	4.71	6.18	10.56	8.70				10.48
2003	2.30	2.34	3.48	4.59	5.89	8.07	24.50				27.70
2004	1.74	2.30	3.02	4.50	5.77	7.81	9.95				13.25
2005	1.56	2.40	3.20	3.71	5.79	8.52	16.27				18.63
2006	1.54	2.35	3.44	4.19	5.43	6.57	6.19				18.15
2007	2.34	2.67	3.53	5.30	6.70	9.95	11.24				16.62
2008	2.21	2.97	3.63	4.88	6.74	8.18	7.70				9.07
2009	2.04	2.98	4.10	5.19	6.56	9.38	8.58				15.67
2010	1.91	2.28	3.60	4.70	7.03	7.11	9.09				12.50
2011	1.61	2.29	2.89	4.51	6.79	8.30	9.46				10.54
2012	2.34	2.46	2.93	3.93	5.39	8.91	11.68				12.56
2013	2.49	3.04	3.51	4.43	5.54	7.56	10.25				11.69
2014	2.00	2.45	3.76	4.05	5.06	5.97	7.34				10.37
2015	2.14	2.66	3.44	3.91	5.06	6.27	7.89				11.32
2016	2.55	2.23	3.65	4.80	6.67	7.74	8.68	8.83	12.63	18.02	10.68
2017	1.96	2.48	2.94	4.80	5.74	7.12	8.16	9.12	10.43	12.31	
2018	3.25	2.72	3.41	4.53	6.51	7.94	9.69	12.06	12.05	13.14	
2019	1.90	2.89	3.72	4.82	6.07	7.43	8.68	11.07	13.87	13.42	

Table A9. Northeast Arctic COD. Results from the Russian trawl-acoustic survey in the Barents Sea and adjacent waters in the autumn. Stock number in millions.

Year					Age							Total
		1	2	3	4	5	6	7	8	9	10+	1941
1985	1	77	569	400	568	244	51	20	8	1	3	1998
1986	1	25	129	899	612	238	69	20	3	2	1	1323
1987	2	2	58	103	855	198	82	19	4	1	1	602
1988	2	3	23	96	100	305	54	16	3	1	1	332
1989	1	1	3	17	45	57	91	75	25	13	5	377
1990	1	36	27	8	27	62	74	91	39	10	3	494
1991	1	63	65	96	45	50	54	66	49	5	1	1222
1992	1	133	399	380	121	56	58	33	29	11	2	783
1993	1	20	44	220	234	164	51	19	13	8	10	1335
1994	1	105	38	147	275	303	314	100	35	10	8	971
1995	1	242	42	111	219	229	97	21	6	2	2	2127
1996	1,3,5	424	275	189	316	449	314	126	27	3	4	900
1997	4,5	72	160	263	198	112	57	27	9	1	1	672
1998	1	26	86	279	186	57	23	10	4	1	0	658
1999	1	19	79	166	260	98	20	8	5	2	1	642
2000	1, rev	24	82	191	159	127	48	6	3	1	1	656
2001	1	38	59	148	204	120	70	14	2	1		672
2002	1,5,6	83	2	106	85	140	151	67	30	7	1	908
2003		69	36	25	218	142	167	163	60	23	4	1669
2004		375	35	170	85	345	194	229	167	49	19	803
2005		112	48	65	154	70	214	68	47	17	8	341
2006	7	12	20	39	49	78	32	64	23	13	8	1221
2007		13	35	165	372	208	189	74	113	32	20	

1 October-December
2 September-October
3 Area IIb not covered
4 Areas IIa, IIb covered in October-December, part of Area I covered in February-March 1998
5 Adjusted for incomplete area coverage
6 Area IIa not covered
7 Area I not fully covered

Table A10. Northeast Arctic COD. Abundance indices (millions) from the Russian bottom-trawl survey in the Barents Sea.

Year				Age												
		0	1	2	3	4	5	6	7	8	9	10	11	12	13+	Sum
				Total (Sub-area I and Division IIa and IIb)												
1982		849.3	1905.3	33.2	141.3	152.5	72.1	19.8	55.1	17.4	3.7	1.9	1.5	0.1	0.0	3253.3
1983		1872.2	2003.4	73.2	52.0	64.2	50.6	35.8	17.9	25.2	9.4	0	0	0	0	4203.9
1984		363.3	180.5	104.4	118.9	70.0	48.9	35.7	15.4	6.9	6.1	1.7	1.5	0.6	0.2	954.0
1985		284.6	15.6	129.0	118.8	159.2	106.8	36.5	16.5	3.7	0.8	1.6	0.1	2.1	0.0	875.3
1986		329.9	7.6	31.7	162.2	153.2	149.3	48.1	18.9	4.2	0.2	0.6	0.0	0.0	0.0	905.9
1987		7.7	1.3	46.9	55.7	307.6	90.0	70.1	18.4	6.0	2.5	0.4	0.1	0.3	0.0	607.0
1988		92.5	2.9	31.3	99.3	93.8	287.9	58.3	26.0	4.7	2.4	0.1	0.0	0.0	0.0	699.2
1989		355.8	3.0	14.7	49.0	97.8	106.2	145.4	116.7	29.9	11.2	4.7	1.8	0.7	0.5	937.4
1990		1248.4	31.1	51.0	16.7	48.7	62.7	97.2	153.8	67.3	15.3	4.9	0.9	0.2	0.0	1798.2
1991		974.0	64.0	91.1	107.7	48.4	53.2	58.3	68.5	74.7	9.8	1.4	0.3	0.0	0.0	1551.4
1992		1204.8	157.7	151.1	67.5	30.8	23.9	27.3	21.8	17.5	2.5	2.5	0.4	0.0	0.0	1707.8
1993		484.8	38.0	158.6	160.4	113.5	68.1	41.6	35.4	8.7	0.3	0.7	0.1	0.1	0.0	1110.3
1994		1606.6	833.2	69.9	136.3	130.9	101.9	35.4	12.8	4.9	2.1	1.1	0.6	0.2	0.0	2935.9
1995		5703.5	471.9	36.9	58.9	106.5	139.5	84.9	25.1	8.3	1.9	1.8	0.9	0.6	0.0	6640.8
1996		2660.3	396.5	128.5	73.3	78.4	103.5	77.3	34.8	13.2	1.9	0.5	1.2	0.2	0.0	3569.6
1997		1371.4	353.9	135.3	134.2	83.5	61.3	60.2	34.8	11.6	3.2	3.0	0.0	0.0	0.0	2252.4
1998		304.8	276.8	89.6	202.8	136.3	78.8	47.0	25.9	13.0	4.8	0.5	0.0	0.1	0.0	1180.4
1999		266.9	40.1	118.4	158.7	207.2	98.0	30.1	12.3	9.4	4.2	0.4	0.0	0.0	0.0	945.7
2000		1436.5	37.7	103.6	183.9	128.6	178.6	77.3	11.4	5.2	2.3	0.9	0.4	0.0	0.0	2166.4
2001		321.6	233.8	77.3	122.4	155.7	129.0	106.1	30.4	5.0	1.4	0.5	2.5	1.3	0.0	1187.1
2002		1797.9	26.7	135.6	98.0	147.3	147.3	89.6	60.0	18.2	2.9	0.8	0.1	0.1	0.0	2524.4
2003		489.5	517.5	26.8	124.6	105.7	116.6	120.3	53.5	24.1	4.0	0.9	0.3	0.0	0.1	1583.9
2004		1770.4	158.4	87.5	32.9	157.6	88.0	111.1	77.6	27.9	9.3	2.3	0.4	0.2	0.0	2523.6
2005		2298.0	323.9	61.7	140.8	63.1	183.2	74.4	60.5	24.4	8.8	2.8	0.6	0.1	0.0	3242.4
2006		427.4	52.4	63.2	92.7	161.3	77.7	180.1	66.2	34.2	16.1	4.3	1.7	0.7	0.0	1178.1
2007		177.5	37.0	148.6	257.9	161.7	190.3	84.6	152.5	55.3	22.6	8.6	4.9	1.1	0.7	1303.3
2008		1468.6	45.2	86.3	220.3	308.8	163.5	147.2	83.0	86.3	29.1	11.5	3.3	1.7	0.2	2654.9
2009		1877.7	287.8	21.9	97.4	231.7	368.7	201.6	117.5	62.0	41.3	20.5	6.5	3.2	0.9	3338.7
2010	*	2210.4	214.9	47.0	33.4	107.0	250.5	371.5	181.7	78.9	39.5	29.9	15.6	5.5	2.0	3587.7
2011		2296.1	125.9	80.0	88.2	50.8	143.2	306.5	330.0	91.7	43.9	17.6	17.5	7.0	3.5	3602.1
2012		1096.0	196.2	45.1	81.5	111.4	83.9	212.2	335.8	187.8	43.2	19.5	4.6	5.7	1.9	2424.8
2013		297.1	654.0	107.6	74.7	117.4	117.7	88.4	234.9	313.2	136.7	30.6	9.2	5.4	4.5	2191.5
2014		909.7	211.0	72.1	139.9	136.8	172.5	148.3	111.1	192.9	129.7	38.3	9.3	3.5	2.0	2277.1
2015		572.9	465.4	51.5	65.7	158.3	174.2	193.2	161.0	92.5	115.8	76.1	24.2	6.5	4.9	2162.0
2016		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
2017		4325.9	5257.4	94.5	145.6	88.4	106.3	195.2	123.1	56.7	26.6	12.0	12.0	7.5	2.8	10454.0
2018		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
*	corrected															

Table A11 Northeast Arctic COD. Length-at-age (cm) from Russian surveys in November-December.

Year	Age												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1984	15.7	22.3	30.7	44.3	51.7	63.6	73.4	82.5	88.4	97.0	-	-	-
1985	15.0	21.1	30.6	43.2	53.7	61.2	72.8	83.0	92.8	101.3	-	-	-
1986	15.2	19.7	28.3	39.0	51.8	62.2	70.9	83.0	91.3	104.0	-	-	-
1987	-	19.2	27.9	33.4	41.4	59.1	69.2	80.1	95.7	102.6	-	-	-
1988	11.3	21.3	28.7	36.2	43.9	53.3	65.3	79.5	85.0	-	-	-	-
1989	-	20.8	28.8	34.8	46.0	53.9	61.8	69.8	78.7	88.6	-	-	-
1990	16.0	24.0	30.4	46.5	54.9	62.5	69.7	77.6	87.8	102.0	-	-	-
1991	11.5	22.4	30.6	43.0	55.9	64.6	72.8	78.5	87.9	101.8	-	-	-
1992	11.3	21.3	31.9	50.1	59.8	69.1	78.6	84.0	90.8	97.5	-	-	-
1993	12.1	17.4	29.1	43.4	52.7	64.3	73.9	81.2	89.1	91.8	-	-	-
1994	12.2	20.3	26.3	33.7	47.4	58.7	70.6	80.8	90.1	96.1	-	-	-
1995	11.6	19.8	27.6	33.8	45.2	60.5	71.1	83.5	92.9	99.1	-	-	-
1996	10.2	20.0	28.1	36.7	48.7	58.9	70.5	80.0	93.6	102.7	-	-	-
1997	9.6	18.5	28.8	38.2	50.8	62.0	70.5	80.1	88.9	103.5	-	-	-
1998	11.4	19.0	28.0	36.4	50.5	61.0	70.7	80.3	91.1	102.5	-	-	-
1999	11.7	19.7	27.9	35.3	51.6	60.6	70.6	78.9	86.8	94.3	-	-	-
2000	10.7	20.8	30.1	34.7	49.8	61.1	71.6	82.0	88.3	85.7	104,2	-	-
2001	10.6	19.4	29.8	37.3	50.4	61.9	71.9	81.4	91.0	98.7	103,8	-	-
2002	10.7	19.2	29.9	38.2	52.5	60.4	70.6	82.2	91.3	97.2	104.1	-	-
2003	9.8	18.9	28.3	34.9	49.2	62.2	71.0	81.5	92.3	100.9	104.3	-	-
2004	9.8	19.6	29.3	38.4	49.1	60.0	70.5	80.0	91.0	98.0	106.0	-	-
2005	11.2	19.4	29.7	38.5	48.7	59.3	69.3	79.2	87.7	96.1	104.4	-	-
2006	13.0	21.9	31.6	42.7	53.2	60.1	70.2	79.1	88.3	95.2	107.7	-	-
2007	10.7	21.5	30.8	42.2	53.6	63.7	71.0	79.6	87.3	95.9	-	-	-
2008	10.2	20.0	30.3	40.2	53.7	64.5	74.6	82.7	89.5	98.2	102.3	110.2	111.9
2009	12.9	19.3	29.5	38.4	50.7	61.5	70.7	81.7	89.9	94.7	101.8	105.9	109.4
2010	11.1	19.3	28.7	38.5	48.9	59.1	68.0	78.4	88.2	97.3	102.5	108.4	117.7
2011	11.2	20.3	29.2	38.5	49.5	58.6	68.7	78.2	90.0	97.9	106.9	109.3	116.0
2012	11.0	20.3	31.1	40.8	50.8	60.7	68.4	77.6	87.4	97.7	105.2	111.7	116.6
2013	9.5	19.5	29.0	40.3	50.4	59.3	67.3	75.3	84.4	95.3	104.5	111.9	119.4
2014	10.1	20.1	29.8	39.2	50.7	60.9	69.4	77.9	85.1	93.6	102.7	113.3	122.8
2015	11.5	19.0	28.5	37.5	48.0	58.4	67.4	76.3	83.5	91.0	98,8	107,1	117,9
2016	-	-	-	-	-	-	-	-	-	-	-	-	-
2017	14.6	20.6	30.6	40.2	51.5	59.3	67.1	76.2	84.9	92.6	97.9	104	110.1
2018	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A12. Northeast Arctic COD. Weight (g) at age from Russian surveys in November-December.

Year	Age												
	0	1	2	3	4	5	6	7	8	9	10	11	12
1984	26	90	250	746	1187	2234	3422	5027	6479	9503	-	-	-
1985	26	80	245	762	1296	1924	3346	5094	7360	6833	11167	-	-
1986	25	63	191	506	1117	1940	2949	4942	7406	9300	-	-	-
1987	-	54	182	316	672	1691	2688	3959	8353	10583	13107	-	-
1988	15	78	223	435	789	1373	2609	4465	5816	-	-	-	-
1989	-	73	216	401	928	1427	2200	3133	4649	6801	8956	-	-
1990	28	106	230	908	1418	2092	2897	4131	6359	10078	13540	-	-
1991	26	93	260	743	1629	2623	3816	4975	7198	11165	15353	-	-
1992	10	76	273	1165	1895	2971	4377	5596	7319	9452	12414	-	-
1993	11	46	211	717	1280	2293	3509	4902	6621	7339	8494	-	-
1994	12	69	153	316	919	1670	2884	4505	6520	8207	9812	-	-
1995	11	61	180	337	861	1987	3298	5427	7614	9787	10757	-	-
1996	7	64	191	436	1035	1834	3329	5001	8203	10898	11358	-	-
1997	6	48	203	487	1176	2142	3220	4805	6925	10823	12426	-	-
1998	11	55	187	435	1186	2050	3096	4759	7044	11207	12593	-	-
1999	10	58	177	371	1214	1925	3064	4378	6128	7843	11543	-	-
2000	8	74	232	379	1101	2128	3341	5054	6560	8497	12353	-	-
2001	9	58	221	459	1125	2078	3329	4950	7270	9541	11672	-	-
2002	8	65	232	505	1299	1964	3271	5325	7249	9195	11389	-	-
2003	6	49	205	492	972	1993	2953	4393	6638	9319	11085	-	-
2004	6	55	231	543	1079	1798	2977	4110	5822	8061	12442	-	-
2005	10	59	223	521	1034	1910	3036	4619	6580	9106	12006	-	-
2006	13	72	270	707	1332	1953	2969	4340	6410	8622	12436	-	-
2007	10	96	252	669	1344	2277	3140	4691	6178	8567	10014	-	-
2008	7	58	228	558	1332	2305	3527	5001	6519	8848	10339	13276	15196
2009	15	54	214	495	1116	2024	3090	4876	6592	8087	10262	11472	13268
2010	9	54	191	794	989	1784	2719	4246	6384	8747	10499	12117	14199
2011	10	63	206	486	1037	1691	2827	4312	6698	8979	11557	12915	15694
2012	9	62	237	561	1087	1877	2688	3974	5930	8495	11000	13377	14826
2013	5	55	202	546	1062	1718	2541	3667	5258	7821	10509	13161	16581
2014	7	64	221	508	1079	1849	2734	3994	5418	7480	10100	14163	18404
2015	11	55	198	452	947	1735	2588	3728	5081	6827	8877	11623	15626
2016	-	-	-	-	-	-	-	-	-	-	-	-	-
2017	22	69	248	571	1150	1771	2539	3819	5426	7554	9236	11220	13536
2018	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A13. Northeast Arctic COD. Sum of acoustic abundance estimates (millions) in the Joint winter Barents Sea survey (Table A2) and the Norwegian Lofoten acoustic survey (Table A4).

					Age									
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	12+
1985	69.1	446.3	153.0	141.6	20.4	15.1	15.7	3.3	1.3	1.0	0.5	na	na	0.0
1986	353.6	243.9	499.6	134.3	68.4	11.6	7.7	3.1	0.3	0.0	0.4	na	na	0.1
1987	1.6	34.1	62.8	204.9	50.2	17.4	1.4	3.0	0.7	0.0	0.0	na	na	0.0
1988	2.0	26.3	50.4	35.5	57.8	10.9	4.0	0.3	0.0	0.1	0.0	na	na	0.0
1989	7.5	8.0	17.0	34.4	21.4	67.0	16.6	3.2	0.5	0.2	0.0	na	na	0.1
1990	81.1	24.9	14.8	20.6	26.2	26.9	66.8	7.3	0.6	0.3	0.0	na	na	0.0
1991	181.0	219.5	50.2	34.6	29.3	33.9	36.7	50.0	3.7	0.2	0.2	na	na	0.0
1992	241.4	562.1	176.5	65.8	21.5	18.4	28.4	25.4	82.4	4.3	1.7	na	na	0.2
1993	1074.0	494.7	357.2	191.1	113.1	35.4	25.5	25.2	27.7	44.2	4.9	na	na	0.8
1994	858.3	577.2	349.8	404.5	217.5	89.5	22.5	11.9	9.4	3.9	18.0	na	na	2.7
1995	2619.2	292.9	166.2	159.8	216.6	104.0	29.0	4.4	4.3	3.0	2.6	na	na	8.1
1996	2396.0	339.8	92.9	70.5	87.2	89.1	44.6	6.5	1.1	0.4	0.9	na	na	1.4
1997	1623.5	430.5	188.3	51.7	49.7	42.2	49.9	20.5	2.2	0.5	0.0	na	na	0.8
1998	3401.3	632.9	427.7	182.6	42.4	33.8	34.0	24.7	4.9	0.7	0.2	na	na	0.1
1999	358.3	304.3	150.0	96.4	45.4	12.2	11.2	18.7	9.2	1.0	0.2	na	na	0.2
2000	154.1	221.4	245.2	158.9	145.7	49.3	12.9	6.9	5.2	1.2	0.6	na	na	0.2
2001	629.9	63.9	138.2	171.6	81.6	57.3	19.8	2.4	0.8	0.6	0.3	na	na	0.1
2002	18.2	215.5	69.3	112.2	104.3	66.1	34.5	9.5	1.2	0.5	0.6	na	na	0.0
2003	1693.9	61.5	303.4	114.4	131.5	144.5	64.3	21.2	3.8	0.5	0.1	na	na	0.1
2004	157.7	105.2	33.6	92.8	32.7	45.1	46.8	22.2	8.8	2.2	0.2	na	na	0.7
2005	465.3	119.6	123.9	33.7	66.1	29.9	43.2	17.2	7.5	1.8	0.1	na	na	0.2
2006	544.6	216.6	79.8	59.1	15.7	38.1	16.9	15.5	8.8	2.4	0.3	na	na	0.8
2007	125.0	61.7	80.3	37.1	31.8	13.0	42.7	13.8	7.5	3.3	0.8	na	na	0.4
2008	68.8	97.6	210.2	306.1	141.0	75.4	24.6	32.9	5.8	2.8	1.7	na	na	0.8
2009	321.5	30.6	182.6	178.3	140.5	49.5	40.1	13.3	26.0	3.7	1.7	na	na	0.4
2010	485.4	59.4	34.7	121.9	175.9	194.9	70.9	37.5	11.1	8.8	1.7	na	na	1.7
2011	389.3	124.8	47.1	29.1	82.4	158.7	284.3	65.6	22.6	6.1	7.8	0.5	0.6	1.0
2012	950.6	72.7	133.9	52.7	38.1	82.8	224.4	154.7	30.9	10.8	4.8	2.0	0.8	2.7
2013	470.6	110.8	64.1	85.0	71.0	57.5	119.4	224.9	175.6	20.9	12.6	4.9	3.3	8.2
2014	630.1	139.1	220.0	117.8	91.8	67.9	52.9	135.4	175.1	97.7	14.2	6.6	4.0	10.6
2015	1141.0	127.0	94.9	154.2	119.3	99.6	96.5	36.2	111.2	66.3	30.0	6.8	5.2	12.0
2016	142.9	120.7	41.0	58.3	96.9	64.6	58.7	33.9	34.1	48.1	29.2	17.0	11.3	28.1
2017	396.6	48.5	91.2	40.4	48.6	76.6	49.8	50.3	28.5	18.0	14.7	17.2	8.5	25.6
2018	1492.4	221.3	90.0	136.1	47.3	54.6	67.8	46.2	18.6	14.3	5.9	5.9	7.8	13.7
2019	1000.3	287.4	182.1	97.7	124.8	56.3	48.0	67.7	26.4	21.2	6.5	2.9	8.1	10.9

Table A14. Swept area estimates (millions) of Northeast Arctic Cod from the Joint Norwegian- Russian ecosystem survey in August-September (2018 data are taken from WD 01 AFWG 2019).

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13+
2004	543.0	330.6	329.7	147.7	421.5	150.2	79.8	40.2	10.1	2.2	0.5	0.1	0.1	0.1
2005	180.2	440.7	146.6	216.6	55.8	100.9	28.0	15.6	5.7	1.2	0.5	0.1	0.0	0.1
2006	276.0	479.0	509.7	186.1	205.6	59.9	69.8	17.6	8.1	2.6	0.6	0.2	0.0	0.0
2007	101.0	333.3	505.4	586.2	159.2	79.1	24.6	26.9	6.0	2.2	0.9	0.1	0.2	0.0
2008	483.4	130.9	372.6	652.6	483.4	132.3	51.1	12.8	17.5	3.3	0.9	0.2	0.2	0.2
2009	903.3	569.7	93.5	202.3	280.6	289.6	101.7	31.9	12.7	7.3	2.6	0.8	0.3	0.2
2010	652.6	310.3	84.2	56.8	177.0	397.2	424.9	142.7	38.5	10.5	6.8	1.6	0.3	0.3
2011	2083.0	509.8	160.0	123.6	101.5	240.2	300.4	178.4	32.3	7.7	1.8	1.3	0.6	0.3
2012	1412.7	1454.3	255.9	229.1	146.4	70.0	150.8	165.2	84.5	12.7	4.4	1.6	1.4	0.6
2013	2281.8	914.2	659.0	249.1	183.6	125.7	63.2	118.2	130.2	53.8	9.1	3.3	1.5	0.9
2014	2445.2	308.2	155.1	190.0	108.6	93.9	52.8	30.4	50.2	36.3	12.1	3.4	1.0	1.4
2014 *	***2445.2***	***339.0***	***184.0***	***226.3***	***122.2***	***103.4***	***67.7***	***42.1***	***81.3***	***78.9***	***28.1***	***4.7***	***1.3***	***1.5***
2015	350.9	725.3	154.0	174.4	225.2	141.3	72.6	48.6	26.2	35.3	26.6	7.9	1.7	1.0
2016	1164.8	350.8	341.3	77.2	93.7	121.6	70.1	44.4	27.2	13.8	13.2	5.4	1.7	1.4
2017	2316.3	757.5	260.6	375.0	141.5	104.9	120.9	62.6	28.0	11.2	6.4	4.4	4.5	2.7
2018*	***1841.2***	***2100.3***	***413.8***	***183.6***	***148.9***	***60.0***	***37.6***	***57.1***	***20.2***	***14.4***	***5.8***	***3.6***	***3.5***	***2.8***

* not complete coverage, index adjusted but not used in assessment

3.13 Report tables related to SPALY SAM run which are different from the same tables related to the final run

Table S_3.15. Northeast Arctic cod. Fishing mortality from the SPALY SAM run
SAM
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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1946	0.0018	0.0183	0.0683	0.1389	0.2435	0.2152	0.2996	0.3105	0.4384	0.404	0.4062	0.4395	0.4395	0.2127
1947	0.0017	0.0196	0.0858	0.1955	0.3607	0.3203	0.4483	0.4784	0.7205	0.6802	0.703	0.7869	0.7869	0.3148
1948	0.0012	0.0162	0.077	0.1903	0.3623	0.3282	0.449	0.4746	0.7158	0.7209	0.7813	0.9514	0.9514	0.3136
1949	0.0022	0.0283	0.1223	0.2681	0.4379	0.3728	0.4742	0.5059	0.7553	0.7592	0.8182	1.0384	1.0384	0.3635
1950	0.0033	0.0387	0.1442	0.2794	0.4151	0.368	0.4852	0.5598	0.852	0.8948	0.9341	1.2322	1.2322	0.3753
1951	0.0086	0.0861	0.248	0.3802	0.4715	0.3995	0.4966	0.5621	0.7877	0.8412	0.8904	1.1959	1.1959	0.4263
1952	0.0137	0.1231	0.3249	0.4743	0.5382	0.4695	0.5922	0.7188	0.9987	1.0628	1.0761	1.4071	1.4071	0.5196
1953	0.0148	0.1144	0.2699	0.3729	0.4003	0.3531	0.4375	0.5392	0.7136	0.7252	0.7139	0.8952	0.8952	0.3955
1954	0.015	0.1121	0.2701	0.3864	0.4128	0.3731	0.46	0.5961	0.772	0.7752	0.7434	0.8686	0.8686	0.4164
1955	0.0152	0.1115	0.2923	0.4639	0.5099	0.4854	0.5598	0.6998	0.8899	0.8711	0.7902	0.8493	0.8493	0.5019
1956	0.0195	0.1391	0.3622	0.5822	0.6344	0.6122	0.6674	0.8213	1.0394	1.0976	0.9584	0.9204	0.9204	0.6133
1957	0.0198	0.1307	0.3104	0.4842	0.531	0.5335	0.5744	0.7161	0.9022	0.932	0.8256	0.748	0.748	0.5249
1958	0.0293	0.1843	0.3913	0.5338	0.5299	0.5107	0.5386	0.6579	0.767	0.7403	0.594	0.523	0.523	0.527
1959	0.0325	0.2019	0.4205	0.5346	0.517	0.5077	0.544	0.6656	0.7403	0.7012	0.5973	0.5475	0.5475	0.5316
1960	0.0322	0.1974	0.4048	0.4958	0.4731	0.4875	0.5341	0.6797	0.7881	0.7407	0.6609	0.6446	0.6446	0.5125
1961	0.0367	0.2345	0.5089	0.6189	0.581	0.6181	0.7024	0.8501	0.9583	0.9081	0.8279	0.7798	0.7798	0.6466
1962	0.0383	0.257	0.6099	0.7663	0.6995	0.716	0.8103	0.946	0.967	0.8459	0.7877	0.713	0.713	0.758
1963	0.0317	0.2241	0.5962	0.8261	0.8241	0.8758	0.9907	1.1287	1.1576	0.9364	0.8697	0.7497	0.7497	0.8736
1964	0.0223	0.1478	0.3833	0.541	0.5943	0.712	0.872	0.9495	1.0018	0.9027	0.9825	0.8432	0.8432	0.6753
1965	0.0224	0.1327	0.319	0.4278	0.4738	0.5882	0.7385	0.7831	0.7758	0.7099	0.9037	0.8208	0.8208	0.5551
1966	0.0245	0.1304	0.2825	0.369	0.4292	0.5532	0.6949	0.7061	0.6545	0.5713	0.6886	0.6082	0.6082	0.5058
1967	0.0259	0.1346	0.2766	0.3497	0.4282	0.5906	0.7771	0.7962	0.7503	0.6266	0.7225	0.574	0.574	0.5364
1968	0.0294	0.1592	0.3405	0.4212	0.4815	0.6317	0.8048	0.7917	0.7261	0.5928	0.7396	0.6076	0.6076	0.5786
1969	0.0346	0.1834	0.4158	0.5432	0.6514	0.8593	1.0692	1.0172	0.911	0.6876	0.7792	0.6177	0.6177	0.7594
1970	0.0361	0.1656	0.3635	0.4853	0.6016	0.8254	0.9944	0.9112	0.7765	0.5647	0.6494	0.5479	0.5479	0.6969

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
1971	0.0323	0.1281	0.2607	0.3423	0.456	0.7041	0.9086	0.8405	0.7324	0.5316	0.5888	0.4917	0.4917	0.5854
1972	0.051	0.1754	0.3198	0.3888	0.477	0.7723	1.0954	1.092	1.0136	0.7469	0.8221	0.6479	0.6479	0.6909
1973	0.0881	0.2543	0.4038	0.4356	0.4615	0.6413	0.8565	0.846	0.8085	0.6142	0.6728	0.5273	0.5273	0.6074
1974	0.1194	0.3361	0.5163	0.5359	0.5204	0.6265	0.7597	0.8488	0.959	0.7917	0.9303	0.6743	0.6743	0.6346
1975	0.1061	0.3016	0.509	0.5816	0.5899	0.6774	0.7322	0.7192	0.8845	0.7678	0.8699	0.5931	0.5931	0.6349
1976	0.1186	0.3367	0.554	0.6338	0.6483	0.7373	0.7556	0.6232	0.6868	0.6394	0.7563	0.5981	0.5981	0.6587
1977	0.1245	0.3815	0.6549	0.7517	0.7707	0.8915	0.9741	0.7936	0.8296	0.7264	0.9353	0.834	0.834	0.8061
1978	0.0998	0.3204	0.6249	0.8125	0.8717	1.0508	1.2792	1.1891	1.4351	1.2951	1.5993	1.4401	1.4401	0.9714
1979	0.0558	0.1949	0.4135	0.6177	0.7095	0.8386	1.0588	1.0524	1.2829	1.2344	1.5177	1.7312	1.7312	0.7818
1980	0.0394	0.1482	0.3477	0.5972	0.7462	0.8668	1.0314	1.0696	1.2554	1.1784	1.3838	1.6737	1.6737	0.7765
1981	0.0319	0.1276	0.3111	0.5857	0.7952	0.9355	1.0249	0.938	1.0138	0.9042	0.8525	0.8792	0.8792	0.7651
1982	0.0374	0.1565	0.3681	0.7036	0.9442	1.0195	1.0064	0.8435	0.8264	0.8371	0.7369	0.8613	0.8613	0.8142
1983	0.03	0.1377	0.3318	0.6208	0.9258	1.0371	0.9599	0.7825	0.6975	0.6918	0.651	0.8846	0.8846	0.7763
1984	0.0293	0.1416	0.3646	0.6893	1.093	1.2075	1.0657	0.9002	0.7533	0.6895	0.5656	0.8571	0.8571	0.8867
1985	0.0347	0.162	0.4036	0.7122	0.9827	1.0738	0.8514	0.7111	0.6149	0.5345	0.4085	0.7354	0.7354	0.7891
1986	0.0379	0.1851	0.4854	0.8129	1.0089	1.157	0.9868	0.9738	0.9178	0.851	0.5307	1.0003	1.0003	0.9041
1987	0.0418	0.2003	0.5419	0.9147	1.1016	1.2125	1.1033	1.2479	1.3169	1.3332	0.7448	1.4668	1.4668	1.0203
1988	0.0328	0.151	0.3915	0.7124	0.9873	1.1101	1.1156	1.4079	1.4334	1.5402	0.7702	1.3866	1.3866	0.9541
1989	0.0238	0.1081	0.2634	0.4795	0.6715	0.8002	0.7625	0.9177	0.9198	0.9782	0.5436	1.3392	1.3392	0.6491
1990	0.0146	0.0671	0.1558	0.267	0.3638	0.4389	0.4523	0.5322	0.6052	0.738	0.4803	1.2329	1.2329	0.3683
1991	0.0154	0.0777	0.1797	0.2894	0.3547	0.3756	0.3572	0.3434	0.3368	0.3929	0.2677	0.8304	0.8304	0.3167
1992	0.0199	0.1108	0.2679	0.429	0.5079	0.5188	0.5043	0.4602	0.4467	0.5177	0.3752	1.1811	1.1811	0.448
1993	0.0161	0.1045	0.2926	0.504	0.6253	0.6603	0.7048	0.6747	0.7207	0.8468	0.7059	1.8166	1.8166	0.5769
1994	0.0155	0.1122	0.3482	0.6602	0.8804	0.9411	0.996	0.9584	1.0497	1.2531	1.2249	3.1384	3.1384	0.7974
1995	0.0155	0.1144	0.3484	0.6356	0.853	0.9213	0.9767	0.9554	1.0046	1.1444	1.292	3.3308	3.3308	0.7817
1996	0.0186	0.1359	0.3871	0.6426	0.7977	0.9134	0.9119	0.9449	0.9657	1.1112	1.1719	2.7926	2.7926	0.7663
1997	0.0238	0.186	0.5114	0.7736	0.9123	1.1233	1.1841	1.1756	1.138	1.1875	0.9513	1.3287	1.3287	0.9467
1998	0.0256	0.2085	0.5529	0.8023	0.8802	1.0887	1.1777	1.2593	1.1141	1.176	0.87	0.9246	0.9246	0.9602
1999	0.0184	0.1652	0.4968	0.757	0.8904	1.1005	1.2333	1.2817	1.0767	1.1582	0.8644	0.8082	0.8082	0.96

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	FBAR5-10
2000	0.0119	0.1113	0.3633	0.61	0.7876	0.976	1.0829	1.1193	0.8428	0.8829	0.5728	0.5902	0.5902	0.8232
2001	0.0099	0.0904	0.2942	0.5281	0.7206	0.8587	0.8948	0.9464	0.7066	0.7261	0.5143	0.74	0.74	0.7072
2002	0.0092	0.0842	0.2742	0.5035	0.7218	0.8338	0.8021	0.7952	0.5971	0.6196	0.4225	0.6872	0.6872	0.6551
2003	0.0098	0.0841	0.26	0.4532	0.6578	0.7354	0.6917	0.658	0.4699	0.4367	0.2724	0.4059	0.4059	0.576
2004	0.0109	0.0932	0.2869	0.5083	0.7918	0.9277	0.9087	0.8956	0.6495	0.5372	0.2844	0.3601	0.3601	0.7198
2005	0.0131	0.1089	0.3136	0.5126	0.7743	0.9232	0.9188	0.877	0.661	0.5526	0.275	0.3108	0.3108	0.7199
2006	0.0149	0.1136	0.2977	0.4594	0.6608	0.8082	0.8622	0.8657	0.7559	0.7321	0.4396	0.5291	0.5291	0.659
2007	0.0137	0.0964	0.2381	0.3384	0.4598	0.5334	0.5635	0.5818	0.5642	0.5779	0.3594	0.3836	0.3836	0.4525
2008	0.009	0.0608	0.1508	0.2303	0.3249	0.3819	0.4056	0.4195	0.4445	0.4572	0.2898	0.2623	0.2623	0.3188
2009	0.0073	0.0479	0.1167	0.1822	0.2687	0.3247	0.3593	0.3803	0.443	0.4861	0.3139	0.2306	0.2306	0.272
2010	0.0061	0.0395	0.0965	0.1571	0.2488	0.3346	0.3828	0.442	0.529	0.5249	0.376	0.2358	0.2358	0.277
2011	0.0053	0.0355	0.088	0.1431	0.2289	0.3268	0.3841	0.4389	0.47	0.3908	0.2695	0.1461	0.1461	0.2683
2012	0.0056	0.0362	0.089	0.1388	0.2056	0.2875	0.3422	0.3927	0.4064	0.3171	0.2185	0.121	0.121	0.2426
2013	0.0064	0.0409	0.102	0.1623	0.2291	0.3146	0.375	0.4413	0.4426	0.3244	0.2218	0.1332	0.1332	0.2707
2014	0.0084	0.0521	0.1294	0.2049	0.2675	0.3397	0.3828	0.4676	0.4715	0.3333	0.2176	0.1327	0.1327	0.2986
2015	0.0102	0.061	0.1496	0.2405	0.2942	0.3516	0.3795	0.4953	0.5467	0.3697	0.2263	0.1345	0.1345	0.3184
2016	0.0097	0.0568	0.1438	0.2404	0.3005	0.3685	0.3943	0.5307	0.5941	0.3934	0.2374	0.1391	0.1391	0.3297
2017	0.0117	0.0669	0.1678	0.2849	0.3517	0.4402	0.4591	0.6157	0.6925	0.4279	0.2438	0.136	0.136	0.3866
2018	0.0135	0.075	0.1848	0.3161	0.3854	0.4731	0.4935	0.6761	0.7725	0.4493	0.2426	0.1276	0.1276	0.4215
FBAR	0.0116	0.0662	0.1654	0.2805	0.3459	0.4273	0.449	0.6075	0.6864	0.4235	0.2413	0.1342		

Table S_3.16. Northeast Arctic COD Stock number-at-age (Thous) from the SPALY SAM run

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Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
1946	1416931	680210	383865	180817	85157	89690	241917	85504	36563	32415	18295	8035	2542	3261942
1947	619134	821510	494142	291908	132478	55827	59394	146004	50839	19658	17771	10001	5834	2724499
1948	409903	359212	554131	353389	198426	75886	34137	31132	74202	19464	8253	7124	6007	2131266
1949	578971	275547	268236	396829	234656	109886	44383	17746	16056	30232	7569	3101	4095	1987308
1950	878251	375964	222209	190781	236531	120408	60543	22805	8850	6186	11946	2689	2083	2139246
1951	2464249	675369	291575	170022	117547	123878	67137	30104	10726	3035	2026	3958	1119	3960745
1952	2319857	1154680	417191	179143	104329	60253	66643	32994	14034	4125	1077	673	1257	4356258
1953	2577947	1106242	666739	232937	90210	53350	30955	29938	12971	4219	1158	303	376	4807345
1954	849308	1454583	702709	400710	132397	49889	32273	16324	14306	5168	1692	468	227	3660054
1955	388276	557244	963720	425580	224658	72354	29249	17385	7149	5444	1953	659	239	2693910
1956	745369	251019	386497	563666	213266	111019	36040	13947	7232	2317	1916	737	314	2333338
1957	1420132	406487	155052	211313	248630	90680	49017	15083	5097	2163	600	606	345	2605205
1958	1029039	702429	246389	91831	106463	116385	42016	22725	6099	1690	719	201	372	2366358
1959	1323764	541705	423578	135531	44803	51486	56679	19765	9645	2320	639	341	281	2610538
1960	1478093	625994	286615	216451	66426	21952	25613	26518	8121	3860	950	280	309	2761182
1961	1526684	700467	346204	147718	109092	34581	10973	12820	10864	2919	1545	413	248	2904527
1962	1250450	796560	383401	162994	65748	51210	15272	4360	4676	3407	925	559	246	2739808
1963	842509	707681	442953	161782	60790	27207	21210	5552	1342	1521	1207	337	324	2274416
1964	485216	386388	371506	183774	55760	21103	9328	6698	1450	327	500	430	258	1522737
1965	907526	263551	244644	201557	86699	24645	8262	3134	2220	433	104	152	250	1743177
1966	1899526	586335	179840	144118	107640	44535	11173	3187	1159	870	182	32	141	2978738
1967	1262674	1289825	407405	114183	81898	56888	20974	4558	1268	504	411	79	73	3240738
1968	186334	956300	888344	263049	71294	43820	25358	7822	1678	477	216	164	73	2444927
1969	111350	143418	656691	498619	143661	38714	19421	9231	2898	676	221	81	106	1625087
1970	213861	88637	95700	342946	230336	60742	13975	5474	2737	934	274	84	83	1055782
1971	389450	152690	61396	53054	164640	100238	21538	4360	1792	1044	442	117	78	950837
1972	994529	300452	109953	39887	31620	80720	38878	7010	1575	710	505	209	97	1606146
1973	1862348	703223	203172	65621	22831	17079	29275	10274	1886	464	277	179	132	2916762

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
1974	641060	1323978	463609	113656	35379	12236	7725	9532	3555	701	204	122	150	2611906
1975	598801	428966	727575	230318	55253	17597	5671	3247	3089	1092	267	63	115	2072054
1976	609951	434519	257167	341344	104454	24693	7345	2373	1418	950	403	89	85	1784792
1977	373618	423171	258054	122986	145184	44082	9348	2796	1117	650	371	156	81	1381614
1978	627373	249776	220684	108803	49010	54743	14627	2776	1016	425	291	114	84	1329721
1979	209981	449172	148615	91471	39253	17383	15653	3307	693	189	97	47	39	975900
1980	129936	161840	300282	81347	39113	15846	6438	4365	949	159	44	18	12	740350
1981	159985	102093	116849	171928	36336	14817	5544	1985	1179	221	42	9	4	610991
1982	174971	131463	81895	62845	78685	13802	4674	1618	660	328	74	14	5	551033
1983	156432	129911	93507	48169	25536	24719	4165	1404	583	238	109	30	7	484811
1984	413732	123273	85471	55217	21578	8558	7189	1247	533	248	102	43	13	717201
1985	558141	363254	83206	45624	23927	5420	2197	2065	393	207	102	49	19	1084605
1986	1118909	435551	246826	43463	18833	7057	1457	812	854	180	99	56	26	1874123
1987	327381	966880	264980	104606	14967	6071	1718	489	245	283	63	49	25	1687758
1988	297828	241634	624677	115547	29864	4401	1488	467	121	54	59	25	13	1316178
1989	188918	222377	154339	341162	49408	8545	1309	400	90	24	9	21	9	966612
1990	155641	147313	144148	105126	165419	20689	2951	534	126	29	8	4	6	741994
1991	396154	134061	108805	98156	66839	94514	11137	1529	266	53	11	3	3	911531
1992	735643	316583	106964	75309	57438	37875	53004	6500	954	163	29	7	2	1390472
1993	927910	533533	250952	70602	38043	28085	17572	27426	3339	526	80	18	2	1898089
1994	732611	719322	397739	146088	35373	16704	11826	7099	11688	1340	183	31	3	2080006
1995	500001	499327	524736	221745	57359	12108	5330	3527	2266	3512	304	43	1	1830259
1996	410747	297172	331787	290613	97569	18931	4167	1574	1104	650	1036	66	1	1455418
1997	671971	225740	202076	176384	121112	37154	5866	1509	507	333	181	291	3	1443128
1998	956873	438472	130119	94357	69608	41291	9945	1425	393	126	81	57	69	1742816
1999	544727	580878	253279	59312	32762	25564	11481	2580	320	105	30	27	44	1511108
2000	672798	398480	375830	115622	23022	11163	7065	2619	623	89	27	9	28	1607375
2001	551468	527108	293964	183211	50816	8773	3472	1899	690	229	28	12	18	1621687
2002	409501	419714	374943	187160	82000	19991	3127	1192	615	269	95	13	12	1498631

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp	TOTAL
2003	694292	304092	296560	244703	86942	32374	6951	1170	444	300	112	55	9	1668004
2004	247602	564525	213079	191287	122603	36494	12708	2824	495	248	172	68	34	1392139
2005	633125	189109	401335	134029	98410	41604	11759	4248	906	208	121	115	56	1515026
2006	542436	460446	136679	234288	70314	36152	13510	3770	1435	407	94	79	119	1499729
2007	1421853	451049	295538	86972	123770	31135	13006	4390	1302	582	164	49	96	2429907
2008	1248669	1059025	365329	165652	52964	65124	15857	6060	1885	666	251	96	79	2981657
2009	710394	925992	847071	264378	95300	35701	34258	8941	3343	1043	346	149	110	2927027
2010	289761	535682	737883	632542	183655	59732	21593	18266	5351	1882	485	211	169	2487212
2011	479622	221072	446817	600952	443711	98594	35488	12030	9474	2498	1025	244	243	2351770
2012	563238	333185	174168	352515	460378	265536	53737	19406	6483	4768	1405	668	337	2235823
2013	628109	388691	246150	146114	267192	311661	160225	28981	10790	3564	2795	914	775	2195961
2014	745585	427963	302272	192068	113175	187946	180526	82350	14774	5537	2035	1827	1223	2257280
2015	426911	501025	323581	211783	139377	75571	113569	95691	39005	7758	3123	1313	2166	1940875
2016	269656	280520	382321	224599	138838	84562	46947	61772	46466	17478	4392	2006	2442	1562000
2017	724455	214015	206656	263753	148082	82858	47227	26185	28242	21379	9846	2828	3017	1778543
2018	431988	461216	159245	148858	163708	87397	43920	24359	11395	11663	11440	6446	3966	1565602
2019		293269	346688	123576	78839	95026	44249	22628	9836	4259	6093	7348	7504	1471304

Table S_3.17 Northeast Arctic COD. Natural mortality from the SPALY SAM run
SAM, Fri Apr 26 22:22:51 2019

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1946	0.4901	0.3038	0.226	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1947	0.5438	0.3246	0.2309	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1948	0.4928	0.3048	0.2263	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1949	0.4338	0.2819	0.2209	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1950	0.3164	0.2364	0.2103	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1951	0.7235	0.3943	0.2471	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1952	0.7148	0.3909	0.2463	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1953	0.5367	0.3219	0.2302	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1954	0.3878	0.264	0.2168	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1955	0.4056	0.271	0.2184	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1956	0.5899	0.3425	0.235	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1957	0.7252	0.395	0.2473	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1958	0.5616	0.3315	0.2325	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1959	0.7131	0.3903	0.2462	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1960	0.7036	0.3866	0.2453	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1961	0.6094	0.35	0.2368	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1962	0.5201	0.3154	0.2287	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.7882	0.4194	0.253	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.6027	0.3475	0.2362	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1965	0.4164	0.2752	0.2194	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1966	0.3529	0.2505	0.2136	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1967	0.2707	0.2186	0.2062	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1968	0.2242	0.2006	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1969	0.206	0.2	0.2003	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1970	0.2927	0.2272	0.2082	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1971	0.2562	0.213	0.2049	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1972	0.3234	0.2391	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1973	0.2172	0.2	0.2014	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1974	0.2168	0.2	0.2013	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.2317	0.2035	0.2027	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.2238	0.2004	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.2487	0.2101	0.2042	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.2342	0.2045	0.2029	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.2081	0.2	0.2005	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1980	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1981	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1982	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1983	0.2031	0.2	0.2001	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
1984	0.2	0.209	0.2121	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.2037	0.2137	0.2145	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.2494	0.2197	0.258	0.2253	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2439	0.208	0.2185	0.2611	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.2143	0.2036	0.2088	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.2015	0.2166	0.2	0.2153	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.2	0.2027	0.2074	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2012	0.2	0.2019	0.2108	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.2085	0.2	0.2	0.2166	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.2445	0.2	0.215	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.342	0.2523	0.2174	0.2305	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.5189	0.3103	0.215	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.5046	0.3167	0.2296	0.2157	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.4184	0.2688	0.22	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.4255	0.2624	0.2122	0.2264	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.2585	0.228	0.2273	0.2013	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.2458	0.2087	0.245	0.2077	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.2357	0.2167	0.2004	0.2303	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.2817	0.208	0.2	0.2214	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.2398	0.201	0.2	0.2129	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.2516	0.2133	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.2987	0.214	0.2069	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.2027	0.2296	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.2438	0.2	0.2422	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.2563	0.2123	0.2	0.2228	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.2809	0.2137	0.2034	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.3014	0.2426	0.2118	0.2044	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.4334	0.3241	0.2075	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.3808	0.3255	0.2249	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Year_age	3	4	5	6	7	8	9	10	11	12	13	14	+gp
2013	0.4114	0.2461	0.2178	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.4002	0.3117	0.22	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.3829	0.2757	0.2499	0.2068	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.2235	0.2724	0.294	0.2325	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.4603	0.233	0.206	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.3357	0.2077	0.2	0.228	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table S_3.18. Northeast Arctic COD. Summary table from the SPALY SAM run
SAM, Fri Apr 26 22:22:51 2019

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1946	1416931	4197431	990849	706000	0.7125	0.2127
1947	619134	3640777	1021359	882017	0.8636	0.3148
1948	409903	3524263	837151	774295	0.9249	0.3136
1949	578971	3004710	624676	800122	1.2809	0.3635
1950	878251	2831042	561970	731982	1.3025	0.3753
1951	2464249	3651356	511078	827180	1.6185	0.4263
1952	2319857	4049077	499222	876795	1.7563	0.5196
1953	2577947	4125663	396048	695546	1.7562	0.3955
1954	849308	4260137	409556	826021	2.0169	0.4164
1955	388276	3564836	331358	1147841	3.4641	0.5019
1956	745369	3333777	284149	1343068	4.7266	0.6133
1957	1420132	2819340	206883	792557	3.8309	0.5249
1958	1029039	2416035	204280	769313	3.766	0.527
1959	1323764	2763014	442991	744607	1.6809	0.5316
1960	1478093	2422153	402990	622042	1.5436	0.5125
1961	1526684	2397619	406033	783221	1.929	0.6466
1962	1250450	2164483	320206	909266	2.8396	0.758
1963	842509	1961230	214441	776337	3.6203	0.8736
1964	485216	1499949	192096	437695	2.2785	0.6753
1965	907526	1473682	106528	444930	4.1767	0.5551
1966	1899526	2280806	121929	483711	3.9671	0.5058

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1967	1262674	2781737	133538	572605	4.288	0.5364
1968	186334	3224154	228937	1074084	4.6916	0.5786
1969	111350	2740734	151312	1197226	7.9123	0.7594
1970	213861	2077956	230628	933246	4.0465	0.6969
1971	389450	1628999	319334	689048	2.1578	0.5854
1972	994529	1621761	365182	565254	1.5479	0.6909
1973	1862348	2274713	324238	792685	2.4448	0.6074
1974	641060	2207965	159552	1102433	6.9096	0.6346
1975	598801	2115748	130574	829377	6.3518	0.6349
1976	609951	2014373	167876	867463	5.1673	0.6587
1977	373618	1976376	352518	905301	2.5681	0.8061
1978	627373	1596211	234824	698715	2.9755	0.9714
1979	209981	1108762	165128	440538	2.6679	0.7818
1980	129936	836842	102622	380434	3.7071	0.7765
1981	159985	956705	151677	399038	2.6308	0.7651
1982	174971	733087	310238	363730	1.1724	0.8142
1983	156432	706868	281458	289992	1.0303	0.7763
1984	413732	810628	227619	277651	1.2198	0.8867
1985	558141	987323	187504	307920	1.6422	0.7891
1986	1118909	1345711	162209	430113	2.6516	0.9041
1987	327381	1204270	110255	523071	4.7442	1.0203
1988	297828	1003447	179367	434939	2.4249	0.9541
1989	188918	997230	234248	332481	1.4194	0.6491
1990	155641	1017098	331888	212000	0.6388	0.3683
1991	396154	1525658	706539	319158	0.4517	0.3167
1992	735643	1872462	908683	513234	0.5648	0.448
1993	927910	2306583	775845	581611	0.7496	0.5769
1994	732611	2104405	591364	771086	1.3039	0.7974
1995	500001	1812051	523318	739999	1.4141	0.7817

Year	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 5-10
1996	410747	1676724	546404	732228	1.3401	0.7663
1997	671971	1494275	544203	762403	1.401	0.9467
1998	956873	1267417	377854	592624	1.5684	0.9602
1999	544727	1151382	283058	484910	1.7131	0.96
2000	672798	1181840	239037	414868	1.7356	0.8232
2001	551468	1458686	363501	426471	1.1732	0.7072
2002	409501	1615291	505998	535045	1.0574	0.6551
2003	694292	1715991	595218	551990	0.9274	0.576
2004	247602	1624920	709114	606445	0.8552	0.7198
2005	633125	1559230	615647	641276	1.0416	0.7199
2006	542436	1565894	602187	537642	0.8928	0.659
2007	1421853	1957213	653169	486883	0.7454	0.4525
2008	1248669	2702303	688680	464171	0.674	0.3188
2009	710394	3440984	1099774	523430	0.4759	0.272
2010	289761	3812243	1398250	609983	0.4362	0.277
2011	479622	4014603	2012786	719830	0.3576	0.2683
2012	563238	4144546	2334475	727663	0.3117	0.2426
2013	628109	4358560	2645872	966209	0.3652	0.2707
2014	745585	3939370	2507946	986449	0.3933	0.2986
2015	426911	3659453	2071319	864384	0.4173	0.3184
2016	269656	3185130	1700333	849422	0.4996	0.3297
2017	724455	3155230	1821497	868276	0.4767	0.3866
2018	431988	2727210	1525907	778627	0.5103	0.4215
Arith. Mean	749896	2292873	598308	671921	2.0674	0.5956

Table S_3.19. Northeast Arctic COD. Input for the short term prediction from the SPALY SAM run

2019								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
3	660000	0.3398	0	0	0	0.274	0.0116	0.834
4	293269	0.2377	0.003	0	0	0.659	0.0662	1.282
5	346688	0.2333	0.033	0	0	1.188	0.1655	1.671
6	123576	0.2202	0.199	0	0	1.95	0.2805	2.355
7	78839	0.2	0.624	0	0	3.101	0.3459	3.42
8	95026	0.2	0.894	0	0	4.381	0.4273	4.558
9	44249	0.2	0.947	0	0	5.928	0.4490	5.943
10	22628	0.2	0.988	0	0	7.361	0.6075	7.365
11	9836	0.2	0.997	0	0	9.632	0.6864	8.65
12	4259	0.2	1	0	0	12.621	0.4235	11.42
13	6093	0.2	1	0	0	14.544	0.2413	12.8
14	7348	0.2	1	0	0	16.466	0.1342	14.18
15	7504	0.2	1	0	0	18.388	0.1342	15.55

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
3	524000	0.3398	0	0	0	0.244	0.0116	0.834
4		0.2377	0.003	0	0	0.665	0.0662	1.256
5		0.2333	0.021	0	0	1.244	0.1655	1.789
6		0.2202	0.182	0	0	2.003	0.2805	2.317
7		0.2	0.526	0	0	2.97	0.3459	3.276
8		0.2	0.792	0	0	4.656	0.4273	4.674
9		0.2	0.939	0	0	6.035	0.4490	5.894
10		0.2	0.984	0	0	7.568	0.6075	7.279
11		0.2	0.999	0	0	9.528	0.6864	8.701
12		0.2	0.995	0	0	12.621	0.4235	11.42
13		0.2	1	0	0	14.544	0.2413	12.8

2020								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
14		0.2	1	0	0	16.466	0.1342	14.18
15		0.2	1	0	0	18.388	0.1342	15.55

2021								
Age	**N**	**M**	**Mat**	**PF**	**PM**	**SWT**	**Sel**	**CWT**
3	644000	0.3398	0	0	0	0.262	0.0116	0.834
4		0.2377	0.003	0	0	0.635	0.0662	1.256
5		0.2333	0.021	0	0	1.25	0.1655	1.789
6		0.2202	0.182	0	0	2.059	0.2805	2.317
7		0.2	0.526	0	0	3.022	0.3459	3.276
8		0.2	0.792	0	0	4.525	0.4273	4.674
9		0.2	0.939	0	0	6.31	0.4490	5.894
10		0.2	0.984	0	0	7.676	0.6075	7.279
11		0.2	0.999	0	0	9.735	0.6864	8.701
12		0.2	0.995	0	0	12.621	0.4235	11.42
13		0.2	1	0	0	14.544	0.2413	12.8
14		0.2	1	0	0	16.466	0.1342	14.18
15		0.2	1	0	0	18.388	0.1342	15.55

Table S_3.20. Northeast Arctic COD. Management option table from the SPALY SAM run.

2019				
Biomass (t)	**SSB (t)**	**FMult**	**FBar**	**Landings (t)**
2612690	1495633	1	0.421	687500

2020				2021	
Biomass	**SSB**	**FBar**	**Landings**	**Biomass**	**SSB**
2464216	1227387	0.00	0	3129014	1652231
		0.05	88412	3026060	1572831
		0.10	172683	2928249	1497886
		0.15	253049	2835280	1427120
		0.20	329729	2746871	1360274
		0.25	402931	2662757	1297107
		0.30	472848	2582693	1237394
		0.35	539661	2506447	1180924
		0.40	603541	2433803	1127500
		0.45	664648	2364557	1076938
		0.50	723131	2298519	1029068
		0.55	779131	2235512	983729
		0.60	832780	2175368	940770
		0.65	884203	2117931	900051
		0.70	933516	2063053	861440
		0.75	980829	2010595	824815
		0.80	1026245	1960429	790060
		0.85	1069861	1912432	757067
		0.90	1111769	1866489	725736
		0.95	1152054	1822493	695970
		1.00	1190798	1780343	667682
Tonnes	Tonnes		Tonnes	Tonnes	Tonnes

Table S_3.21. Northeast Arctic COD. Detailed prediction output assuming Fsq in 2019 and HCR in 2020 from the SPALY SAM run

Fbar	age	
range:	5-10	
Year:	2019	
F	multiplier:	1
Fbar:	0.4215	

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.013	7190	6	660000	181	0	0
4	0.074	18549	24	293269	193	880	1
5	0.184	52122	87	346688	412	11441	14
6	0.312	29872	70	123576	241	24592	48
7	0.384	22948	78	78839	244	49196	153
8	0.475	32813	150	95026	416	84953	372
9	0.499	15885	94	44249	262	41904	248
10	0.675	10180	75	22628	167	22356	165
11	0.763	4817	42	9836	95	9806	94
12	0.471	1460	17	4259	54	4259	54
13	0.268	1305	17	6093	89	6093	89
14	0.149	925	13	7348	121	7348	121
15+	0.149	945	15	7504	138	7504	138
Total	NA	199011	688	1699315	2613	270332	1496
		Thous	Thou.	Thous	Thou.	Thous	Thou.
			tonnes		tonnes		tonnes

Fbar	age	
range:	5-10	
Year:	2020	
F	multiplier:	1.12
Fbar:	0.4711	

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)
3	0.014	6376	5	524000	128	0	0
4	0.082	32658	41	463812	308	1391	1
5	0.206	35741	64	214817	267	4511	6
6	0.348	60702	141	228426	458	41573	83
7	0.430	23147	76	72603	216	38189	113
8	0.531	16550	77	43950	205	34808	162
9	0.558	18923	112	48392	292	45440	274
10	0.755	10695	78	21997	166	21645	164
11	0.853	4973	43	9432	90	9422	90
12	0.526	1405	16	3756	47	3737	47
13	0.300	514	7	2178	32	2178	32
14	0.167	533	8	3815	63	3815	63
15+	0.167	1462	23	10475	193	10475	193
Total	NA	213680	690	1647652	2464	217186	1227
		Thous	Thou.	Thous	Thou.	Thous	Thou.
			tonnes		tonnes		tonnes

4 Northeast Arctic Haddock (subareas 1 and 2)

4.1 Introductory note

The haddock assessment and advice include the effects of cod predation, and thus relies on the biomass in the NEA cod assessment. In AFWG 2019 there was a proposed revision of the NEA cod model (the "final" run described in Chapter 3). This revision was not accepted for advice, and the cod advice in 2019 was based on the SPALY NEA cod model. Consequently, the advice for NEA haddock is based on predation from the SPALY NEA cod model.

4.2 Status of the Fisheries

4.2.1 Historical development of the fisheries

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

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

The exceptionally strong year classes 2004—2006 have contributed to the strong in-crease to all-time high levels of stock size and SSB that we have seen in last decade. Their importance in the catches is now decreasing rapidly. The following year classes are at a much lower level. We are experiencing some years with a decreasing SSB, which again will result in lower catch advice. The 2016 year class is strong and if bycatch mortality and natural mortality is at a low level in the coming years, the catches are expected to increase when this year class enter the fishery.

4.2.2 Landings prior to 2019 (Tables 4.1–4.3, Figure 4.1)

The highest landing of haddock historically was 320 kt in 1973. Since 1973 the highest catches observed were about 316 kt in 2012. In 2013–2015 stock biomass started to decline and the level of landings decreased to below 200 kt (Figure 4.1). Provisional official landings for 2018 is about 191 kt which is 11% below the realized TAC (214 kt transfers included).

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

In 2006 it was decided to include reported Norwegian landings of haddock from the Norwegian statistical areas 06 and 07 (ICES CM 2006/ACFM:19; ICES CM 2006/ACFM:25) (i.e. between 62°N and Lofoten) not previously included in the total landings of NEA haddock used as input for this stock assessment (Tables 4.1—4.3). This practice is continued.

4.3 Catch advice and TAC for 2019

The catch advice for 2019 was 152 kt. However, the Joint Norwegian-Russian Fisheries Commission set aside the HCR and set the TAC to 172 kt so that the reduction in was 15% rather than 25%, and therefore total allowable catch was set 172 kt. Furthermore, Russia and Norway can transfer unused part of own quotas from 2018. Norway can transfer maximally 10% corresponding to 9.5 kt and Russian about 1.5 kt so the actual allowable catch in 2019 can reach about 183 kt.

4.4 Status of Research

4.4.1 Survey results (Tables B1-B5)

For this year's assessment only indices from the Joint Barents Sea winter survey could be used, since the Russian bottom-trawl survey was not conducted in 2018 and the joint ecosystem survey had a complete lack of coverage in southeast where most of the haddock is distributed. There was a slight difference in the Joint Barents Sea winter survey indices for the year 2018 compared to the estimates from 2018 presented and used in last year's report. This was due to data revisions after last year's AFWG meeting.

Joint Barents Sea winter survey (bottom trawl NoRu-BTr-Q1and acoustics NoRu-Aco-Q1)

The swept-area estimates and acoustic estimates from the Joint winter survey on demersal fish in the Barents Sea in winter 2019 are given in Mehl *et al.* (WD 04). The survey area has been extended the last years with additional northern areas (N) covered. The extended area is not included in total and standard survey index calculations. Almost all the haddock was found within the area used for the standard survey calculations. The survey indices are given in Tables B1 and B3.

Like in previous years, the distribution of haddock extends further to the north and to the east than what was common in the 1990s. Overall, this survey tracks both strong and poor year classes well. At the survey in 2019 young haddock was aggregated in the south-eastern Barents Sea (WD 04). These are from the year classes 2015–2017.

Russian bottom-trawl (RU-BTr-Q4) and acoustic survey

Russia provided indices for 1982–2015 and 2017 for the Barents Sea trawl and acoustic survey (TAS) which was carried out in October-December. In 2018 TAS was not conducted in the Barents Sea. Survey indices are given in Tables B2 and B4.

International 0-group survey and joint ecosystem survey (Eco-NoRu-Q3 (Btr))

The bottom-trawl estimates from the joint ecosystem survey in August-September started in 2004. This survey covers a larger proportion of the distribution area of haddock. At the benchmark assessment in 2011 it was decided to include this survey as tuning series (ages 3–8). Estimates of the abundance of age groups (indices) from the joint ecosystem survey are presented in Table B5. Estimates based on runs by StoX is presented in WD03. The abundance of age 6 and older in this survey in 2016 was unexpectedly high compared to the abundance of corresponding year classes in this survey in previous years. In 2017 the swept-area estimates of abundance of haddock 6 years and older was only 16% of the abundance estimates from 2016. The spatial coverage at this survey in 2018 was too poor to calculate meaningful estimates and was not included in the assessment this year.

4.5 Weight-at-age (Tables B6 – B9)

Length- and weight-at-age from the NoRu-BTr and RU-BTr-Q4 bottom-trawl surveys are given in Tables B6- B9. There was no Russian bottom-trawl survey in 2018 and therefore no new data added in Tables B7 and B9.

4.6 Data Used in the Assessment

4.6.1 Estimates of unreported catches (Tables 4.1-4.3)

We continue to include the estimates of IUU catches as in previous years (see Section 4.1.2), but the IUU is negligible for 2009–2018 and therefore set to zero.

4.6.2 Catch-at-age (Table 4.4)

Age and length compositions of the landings in 2018 were available from Norway and Russia in Subarea 1 and Division 2.b, from Norway, Russia, and Germany in Division 2.a. The biological sampling of NEA haddock catches is considered good for the most important ages in the fisheries.

Relevant data of estimated catch-at-age obtained from InterCatch for the period 2008–2018 and historical values from 1950 is listed in Table 4.4.

4.6.3 Weight-at-age (Tables 4.5–4.6)

The mean weight-at-age in the catch (Table 4.5) was obtained from InterCatch as a weighted average of the weight-at-age in the catch for Norway, Russia, and Germany.

Since 1983 the stock weights at age (Table 4.6) are calculated taking the average of the weight-at-age estimate from the Joint Barents Sea winter survey and the Russian bottom-trawl survey. These averages are assumed to give representative values for the beginning of the year (see stock annex for details). However, the Russian bottom-trawl survey was not conducted in 2018 and therefor stock weights-at-age was calculated using a correction factor (WD 14). The same correction was also applied when the Russian bottom-trawl survey was lacking in 2016.

Stock weights seem to be stable with only small year-to-year differences for the last years.

4.6.4 Maturity-at-age (Table 4.7)

The estimates of maturity-at-age are shown in Table 4.7. Smoothed estimates were produced separately for the Russian autumn survey and the joint winter survey are later combined using an arithmetic average. These averages are assumed to give representative values for the beginning of the year. Since there was no Russian autumn survey in 2018, a correction was applied (WD 14). The same correction was also applied in 2016. Values for year classes 1993 and onwards changed somewhat compared the values used in the assessment last year.

4.6.5 Natural mortality (Tables 4.8)

Natural mortality used in the assessment was 0.2 + mortality from predation by cod (see Stock annex). For the period from 1984 to 2018 actual estimates of predation by cod have been used (see Table 4.8).

For the previous years (1950–1983) the average natural mortality for 1984–2017 was used (age groups 3-6). The historic estimates of natural mortality have changed slightly with the change of assessment model.

Estimated mortality from predation by cod in this year's assessment is based on the 'final run' cod assessment.

The proportion of F and M before spawning was set to zero.

4.6.6 Changes in data from last year (Tables 4.6-4.7)

As stock weights and maturity are modelled (See above) the values of these variables have changed for 2019 and for 2020–2021.

At the benchmark in 2011 it was decided that these (weight, M, and maturity) historic values (1950–1979) should be kept constant from the 2011 assessment and onwards (ICES CM 2011/ACOM:38). M estimates have been updated after the change of assessment model.

4.7 Assessment models and settings

At the benchmark it was concluded that for stock assessment at the AFWG, the SAM model can be applied as the main model and XSA, with revised settings, will be used as additional model (WKARCT 2015). This year the TISVPA model also is used as additional model for comparison.

4.7.1 Data for tuning (Table 4.9)

The following survey series are included in the data for tuning both for SAM:

Name	ICES Acronym	Place	Season	Age	Year	prior weight
FLT01: Russian bottom trawl	RU-BTr-Q4	Barents Sea	October-December	3–7	1991–2017	1
FLT02: Joint Barents Sea survey – acoustic	BS-NoRU-Q1(Aco)	Barents Sea	February-March	4–8	1993–2019	1
FLT04: Joint Barents Sea survey - bottom trawl	BS-NoRu-Q1 (BTr)	Barents Sea	February-March	4–9	1994–2019	1
FLT007: Joint Russian-Norwegian ecosystem autumn survey in the Barents Sea -bottom trawl	Eco-NoRu-Q3 (Btr)	Barents Sea	August - September	3-8	2004-2017	1

Detailed information about index estimates are described in the Stock annex and in Mehl *et al* (WD 04).

4.7.2 SAM model settings (Table 4.10)

The configuration and tuning of SAM was decided on during the benchmark process (ICES CM 2015/ACOM:31). These settings were used in this assessment. The configuration file is given in Table 4.10 and in (www.stockassessment.org)

4.8 Results of the Assessments (Tables 4.11–4.14 and Figures 4.1-4.3)

The stock summary table estimated by SAM (predation included) is given in Table 4.11, the fishing mortality in Table 4.12, stock numbers-at-age in Table 4.13 and natural mortality M in Table 4.14.

Standard stock graphs are given in Figure 4.1 the retrospective plot in Figure 4.2 and the log-catchability residuals plot is presented in Figure 4.3.

The estimate of fishing mortality of main ages (4–7) in 2018 was the same as for 2017 (0.38) and above F_{MSY} = 0.35.

The dominating feature of this assessment is that the stock reached an all-time high level around 2010 (about 1300 kt) due to the strong 2004–2006 year classes. The total biomass has decreased since the all-time high in 2010.

SSB was at a record high level from 2012 to 2016 but is now decreasing rapidly.

Figures 4.2 a-c show that there has been a strong retrospective pattern the last years, especially for SSB, which has been adjusted downwards considerably. The assessment for this year is well in agreement with the results from last year on SSB.

4.9 Predictions, reference points and harvest control rules (Tables 4.16- 4.21)

4.9.1 Recruitment (Tables 4.16, 4.17)

The RCT3 program translation in R was used to estimate the recruiting year classes 2017–2019 with survey data for ages 0–2 as input data (Russian autumn survey (not for 2016 and 2018), joint winter survey and ecosystem survey (not for 2018). Input data and results are shown in Tables 4.16 and 4.17, respectively.

4.9.2 Prediction data (Table 4.18)

The input data for making the prediction are presented in Table 4.18:

Stock numbers for 2019–2021 at age 3 taken from RCT3, abundance at ages 4–13+ in 2019 from the SAM assessment. The average fishing pattern observed in 2016–2018, scaled to F status quo was used for distribution of fishing mortality-at-age for 2019–2021. The proportion of M and F before spawning was set to 0. Smoothed observed average weight in stock-at-age and maturity-at-age for 2019 are used for 2019–2021.

Russian data for weight and maturity-at-age in autumn 2016 and 2018 were not available as the survey was not conducted. In WD14 to AFWG 2019, correction factors to allow for this when calculating the weight and maturity-at-age in 2019 were calculated, based on historical differences between Norwegian and Russian data. These correction factors were then applied to the Norwegian data for 2019.

The average weights-at-age in catch for the year classes with similar abundance at age 3 (2016—2018) are used for 2019—2021. For natural mortality for 2019-2021 the average for the 3 last years (2016—2018) was used.

4.9.3 Biomass reference points (Figure 4.1)

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

4.9.4 Fishing mortality reference points (Figure 4.1)

Previous values were F_{lim} = 0.49 and F_{pa} = 0.35. There is no standard method of estimating F_{lim} nor F_{pa}, and ACOM accepted to use geometric mean recruitment (146 million) and B_{lim} as basis for the F_{lim} estimate. F_{lim} is then based on the slope of line from origin at SSB = 0 to the geometric mean recruitment (146 million) and SSB = B_{lim}. The SPR value of this slope give F_{lim} value on SPR curve; F_{lim} = 0.77 (found using Pasoft). Using the same approach as for B_{pa}; $F_{pa} = F_{lim}*\exp(-1.645*\sigma) = 0.47$.

F_{MSY} = 0.35 has been estimated by long-term stochastic simulation (WD 16, AFWG 2011, ICES 2016a). Values of reference points compared with current stock values are reflected in Figure 4.1.

4.9.5 Harvest control rule

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

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

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

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

4.9.6 Prediction results and catch options for 2020 (Tables 4.19 - 4.20)

The projection shows an increase in SSB in 2020 to 216 kt (Table 4.19). The TAC for 2020 is established using the current one-year HCR, in accordance of the management plan. F_{MSY} = 0.35 would give a quota for 2020 of 231 kt, this is a 35% increase from the quota advice for 2019. Therefore, the TAC constraint is used, giving a quota of 215 kt. F corresponding to the HCR in 2020 and 2021 is given in Table 4.20.

Catch options for 2020 are shown in the text table below (weights in tonnes).

Basis	Total catch (2020)	F ages 4-7 (2020)	SSB (2021)	% SSB change *	% TAC change **	% Advice change ***
ICES advice basis						
Management plan	215 000	0.32	268 486	24	25	41
Other scenarios						
MSY approach: F_{MSY}	231 352	0.35	261 810	21	35	52
F = 0	0	0	363 570	68	-100	-100
$F = F_{2018}$	247 231	0.38	255 407	18	44	63
F_{pa}	297 101	0.47	235 810	9	73	95
F_{lim}	438 518	0.77	184 630	-15	155	188

*** SSB 2021 relative to SSB 2020.**

**** Catch in 2020 relative to TAC in 2019 (172 000 t).**

***** Catch value for 2020 relative to advice value for 2019 (152 000 t).**

This catch forecast covers all catches. It is then implied that all types of catches are to be counted against this TAC. It also means that if any overfishing is expected to take place, the above calculated TAC should be reduced by the expected amount of overfishing.

4.10 Comparison with last year's assessment

The text table below compares this year's estimates with last year's estimates for 2018 of total biomass, spawning biomass (thousand tonnes), as well as reference F for the year 2017.

Compared to last year's assessment the current estimates by SAM model of the total stock (TSB), spawning stock (SSB) are higher for 2018. The F in 2018 estimated a bit lower.

Year of assessment, model	F (2017)	Numbers 2018 (ages)											TSB (2018)	SSB (2018)
		3	4	5	6	7	8	9	10	11	12	13+		
2018 SAM	0.39		113	106	18	39	13	14	7	9	8	4	505*	253*
2019 SAM	0.38	336	115	109	23	41	13	16	8	9	9	3	547	280
Changing,%	-3		2	3	27	5	0	16	15	0	11	-8	8	11

*** forecast in 2018 using RCT 3**

4.11 Additional assessment methods (Table 4.15, Figures 4.4-4.6)

4.11.1 XSA (Figure 4.4)

The Extended Survivors Analysis (XSA) was used to tune the VPA by available index series. As last years, FLR was used for the assessment of haddock (see stock annex), and thus all results concerning XSA are obtained using FLR. The settings used were as set in last benchmark (WKARCT 2015).

The estimated consumption of NEA haddock by NEA cod is incorporated into the XSA analysis by first constructing a catch number-at-age matrix, adding the numbers of haddock eaten by cod to the catches for the years where such data are available (1984–2018). The summary of XSA stock estimates are presented in Table 4.15. A retrospective plot for XSA is given in Figure 4.4.

4.11.2 TISVPA (Figure 4.5)

The TISVPA (Triple Instantaneous Separable VPA) model (Vasilyev, 2005; 2006) represents fishing mortality coefficients (more precisely – exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). The generation-dependent parameters, which are estimated within the model, are intended to adapt traditional separable representation of fishing mortality to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishers, or by some other reasons. To NEA haddock stock the TISVPA model was at benchmark group for arctic stocks (WKARCT) in 2015 and this year it was decided to apply to NEA haddock using the same data as SAM except that natural mortality values from cannibalism were taken from the SAM runs. All the input data, including catch-at-age, weight-at-age in stock and in catches, maturity-at-age were taken the same as for stock assessment by means of SAM. During AFWG 2019 the results of exploratory runs using the TISVPA model were presented. The results are presented in WD10. In generally biomass estimates of this model much higher than SAM, which can be explained different assumptions about indices catchability. A retrospective plot for TISVPA is given in Figure 4.5

4.11.3 Model comparisons (Figure 4.6)

Results from SAM, XSA and TISVPA are compared in Figure 4.6. Comparison of results of SAM, TISVPA and XSA with previous year settings shows that the models demonstrate similar trends. The TSVPA model is more flexible for settings than the others and taking in account a possible decreasing in survey data consistency, it was attempted to do tuning of surveys not at abundance but to age proportions because the probable change in effective survey catchability.

4.12 Comments to the assessment

The retrospective runs show rather large discrepancies (Figure 4.3), in particular of SSB, but the result for the assessment of this year is well in agreement with the result from last year in showing a strong decline in SSB. The decline is due to the disappearance the 2004–2006 year classes from the stock. The influence of different SAM settings on the retrospective patterns, in particular with respect to the selectivity of older ages will be explored in the benchmark scheduled in 2020.

The advised catch for 2020 is considerably higher than that advised for 2019 because the strong year classes of 2016–2017 will be 4 and 3-year-old in 2020. These year classes are estimated to contribute almost 60% of the total-stock biomass in 2020, and over 40% of the catches. A large proportion of the strong 2016 and 2017 year classes are still under fishing size in 2019 and 2020, furthermore the 2018 year class appear to be above average. Therefore, there is a likelihood of higher catch of undersized fish in the next year(s). The minimum size for haddock is 40 cm, and 15% bycatch by number of cod, haddock, and saithe combined below the respective minimum sizes for the species is allowed. The minimum mesh size is 130 mm. The mean length of age 3 haddock in February is about 30 cm, and at that mean length the upper part of the length distribution for age 3 fish would be large enough to be caught in trawl fisheries, although only few fish would be above 40 cm at that age. It is therefore important that the fishery is regulated by a relatively low TAC and spatial and temporal closures in the next couple of years as this will reduce the likelihood of high catch and possible discarding of undersized fish of the abundant 2016–2017 year classes.

Table 4.1. North-East Arctic HADDOCK. Total nominal catch (t) by fishing areas.

Year	Subarea 1	Division 2.a	Division 2.b	un-reported (2	Total (3	Norw. stat.areas 06 and 07(4
1960	125026	27781	1844	-	154651	6000
1961	165156	25641	2427	-	193224	4000
1962	160561	25125	1723	-	187409	3000
1963	124332	20956	936	-	146224	4000
1964	79262	18784	1112	-	99158	6000
1965	98921	18719	943	-	118583	6000
1966	125009	35143	1626	-	161778	5000
1967	107996	27962	440	-	136398	3000
1968	140970	40031	725	-	181726	3000
1969	89948	40306	566	-	130820	2000
1970	60631	27120	507	-	88258	-
1971	56989	21453	463	-	78905	-
1972	221880	42111	2162	-	266153	-
1973	285644	23506	13077	-	322227	-
1974	159051	47037	15069	-	221157	10000
1975	121692	44337	9729	-	175758	6000
1976	94054	37562	5648	-	137264	2000
1977	72159	28452	9547	-	110158	2000
1978	63965	30478	979	-	95422	2000
1979	63841	39167	615	-	103623	6000
1980	54205	33616	68	-	87889	5098
1981	36834	39864	455	-	77153	4767
1982	17948	29005	2	-	46955	3335
1983	5837	16859	1904	-	24600	3112
1984	2934	16683	1328	-	20945	3803
1985	27982	14340	2730	-	45052	3583
1986	61729	29771	9063	-	100563	4021
1987	97091	41084	16741	-	154916	3194
1988	45060	49564	631	-	95255	3756

Year	Subarea 1	Division 2.a	Division 2.b	un-reported (2	Total (3	Norw. stat.areas 06 and 07(4
1989	29723	28478	317	-	58518	4701
1990	13306	13275	601	-	27182	2912
1991	17985	17801	430	-	36216	3045
1992	30884	28064	974	-	59922	5634
1993	46918	32433	3028	-	82379	5559
1994	76748	50388	8050	-	135186	6311
1995	75860	53460	13128	-	142448	5444
1996	112749	61722	3657	-	178128	5126
1997	78128	73475	2756	-	154359	5987
1998	45640	53936	1054	-	100630	6338
1999	38291	40819	4085	-	83195	5743
2000	25931	39169	3844	-	68944	4536
2001	35072	47245	7323	-	89640	4542
2002	40721	42774	12567	18736/5310	114798/101372	6898
2003	53653	43564	8483	33226/9417	138926/115117	4279
2004	64873	47483	12146	33777/8661	158279/133163	3743
2005	53518	48081	16416	40283/9949	158298/127964	5538
2006	51124	47291	33291	21451/8949	153157/140655	5410
2007	62904	58141	25927	14553/3102	161525/150074	7110
2008	58379	60178	31219	5828/-	155604/149776	6629
2009	57723	66045	76293	0	200061	4498
2010	62604	86279	100318	0	249200	3661
2011	86931	99307	123546	0	309785	4169
2012	90141	96807	128679	0	315627	3869
2013	68416	64810	60520	0	193744	4000
2014	61537	58320	57665	0	177522	3433
2015	75195	61567	57993	0	194756	3902
2016	78714	95140	59561	0	233416	3233
2017	94772	75455	57362	0	227589	2987

Year	Subarea 1	Division 2.a	Division 2.b	un-reported (2	Total (3	Norw. stat.areas 06 and 07(4
2018 1)	80902	58522	51853	0	191276	4437

1) Provisional figures, Norwegian catches on Russian quotas are included.

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

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

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

Table 4.2. North-East Arctic Haddock. Total nominal catch ('000 t) by trawl and other gear for each area

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1967	73.7	34.3	20.5	7.5	0.4	-	-
1968	98.1	42.9	31.4	8.6	0.7	-	-
1969	41.4	47.8	33.2	7.1	1.3	-	-
1970	37.4	23.2	20.6	6.5	0.5	-	-
1971	27.5	29.2	15.1	6.7	0.4	-	-
1972	193.9	27.9	34.5	7.6	2.2	-	-
1973	242.9	42.8	14	9.5	13.1	-	-
1974	133.1	25.9	39.9	7.1	15.1	-	-
1975	103.5	18.2	34.6	9.7	9.7	-	-
1976	77.7	16.4	28.1	9.5	5.6	-	-
1977	57.6	14.6	19.9	8.6	9.5	-	-
1978	53.9	10.1	15.7	14.8	1	-	-
1979	47.8	16	20.3	18.9	0.6	-	-
1980	30.5	23.7	14.8	18.9	0.1	-	-
1981	18.8	17.7	21.6	18.5	0.5	-	-
1982	11.6	11.5	23.9	13.5	-	-	-
1983	3.6	2.2	8.7	8.2	0.2	1.7	-
1984	1.6	1.3	7.6	9.1	0.1	1.2	-
1985	24.4	3.5	6.2	8.1	0.1	2.6	-
1986	51.7	10.1	14	15.8	0.8	8.3	-
1987	79	18.1	23	18.1	3	13.8	-
1988	28.7	16.4	34.3	15.3	0.6	0	-
1989	20	9.7	13.5	15	0.3	0	-
1990	4.4	8.9	5.1	8.2	0.6	0	-
1991	9	8.9	8.9	8.9	0.2	0.2	-
1992	21.3	9.6	11.9	16.1	1	0	-
1993	35.3	11.6	14.5	17.9	3	0	-
1994	58.6	18.2	26.1	24.3	7.9	0.2	-

	Subarea 1		Division 2.a		Division 2.b		Unreported[2]
Year	Trawl	Others	Trawl	Others	Trawl	Others	
1995	63.9	12	29.6	23.8	12.1	1	-
1996	98.3	14.4	36.5	25.2	3.4	0.3	-
1997	57.4	20.7	44.9	28.6	2.5	0.3	-
1998	26	19.6	27.1	26.9	0.7	0.3	-
1999	29.4	8.9	19.1	21.8	4	0.1	-
2000	20.1	5.9	18.8	20.4	3.7	0.1	-
2001	28.4	6.7	23.4	23.8	7	0.3	-
2002	30.5	10.2	19.5	23.3	12.5	0.1	18.7/5.3
2003	42.7	10.9	21.9	21.7	8.1	0.4	33.2/9.4
2004	52.4	12.5	27	20.5	11.5	0.6	33.8/8.7
2005	38.5	15	24.9	20.9	13	1.6	40.3/9.9
2006	40.1	11	22	25.3	30.1	3.2	21.5/8.9
2007	51.8	11.1	30.5	27.7	20.4	5.5	14.6/3.1
2008	46.8	11.6	30.9	29.3	24.9	6.3	5.8/-
2009	49	8.8	40.1	25.3	67.1	7.8	0
2010	43.6	19	50	35.7	87	10.4	0
2011	55.8	31.1	61.1	38.9	107.7	14.3	0
2012	58.8	31.3	57.5	39.2	103.2	24.8	0
2013	40.1	28.3	37.7	26.9	52.1	8.1	0
2014	35.2	26.3	32.5	25.8	49	8.6	0
2015	49.1	26.1	34.6	27	48.5	9.4	0
2016	56.4	22.3	62.5	32.5	45.4	14.1	0
2017	65	29.8	50.7	24.7	47.1	10.3	0
2018 1)	51.7	29.2	36.9	21.6	43.2	8.6	0

1) Provisional.

2) Figures based on Norwegian/Russian IUU estimates.

Table 4.3 North-East Arctic Haddock. Nominal catch (t) by countries. Subarea 1 and Divisions 2.a and 2.b combined. (Data provided by Working Group members).

Year	Far Isl	France	GDR	FRG	Norway 4)	Poland	U K	Russia 2)	Others	Unrep 3)	Total 3)
1960	172	-	-	5597	46263	-	45469	57025	125	-	154651
1961	285	220	-	6304	60862	-	39650	85345	558	-	193224
1962	83	409	-	2895	54567	-	37486	91910	58	-	187408
1963	17	363	-	2554	59955	-	19809	63526	-	-	146224
1964	-	208	-	1482	38695	-	14653	43870	250	-	99158
1965	-	226	-	1568	60447	-	14345	41750	242	-	118578
1966	-	1072	11	2098	82090	-	27723	48710	74	-	161778
1967	-	1208	3	1705	51954	-	24158	57346	23	-	136397
1968	-	-	-	1867	64076	-	40129	75654	-	-	181726
1969	2	-	309	1490	67549	-	37234	24211	25	-	130820
1970	541	-	656	2119	37716	-	20423	26802	-	-	88257
1971	81	-	16	896	45715	43	16373	15778	3	-	78905
1972	137	-	829	1433	46700	1433	17166	196224	2231	-	266153
1973	1212	3214	22	9534	86767	34	32408	186534	2501	-	322226
1974	925	3601	454	23409	66164	3045	37663	78548	7348	-	221157
1975	299	5191	437	15930	55966	1080	28677	65015	3163	-	175758
1976	536	4459	348	16660	49492	986	16940	42485	5358	-	137264
1977	213	1510	144	4798	40118	-	10878	52210	287	-	110158
1978	466	1411	369	1521	39955	1	5766	45895	38	-	95422
1979	343	1198	10	1948	66849	2	6454	26365	454	-	103623
1980	497	226	15	1365	66501	-	2948	20706	246	-	92504
1981	381	414	22	2402	63435	Spain	1682	13400	-	-	81736
1982	496	53	-	1258	43702	-	827	2900	-	-	49236
1983	428	-	1	729	22364	139	259	680	-	-	24600
1984	297	15	4	400	18813	37	276	1103	-	-	20945
1985	424	21	20	395	21272	77	153	22690	-	-	45052
1986	893	12	75	1079	52313	22	431	45738	-	-	100563
1987	464	7	83	3105	72419	59	563	78211	5	-	154916
1988	1113	116	78	1323	60823	72	435	31293	2	-	95255
1989	1217	-	26	171	36451	1	590	20062	-	-	58518
1990	705	-	5	167	20621	-	494	5190	-	-	27182
1991	1117	-	Greenl	213	22178	-	514	12177	17	-	36216
1992	1093	151	1719	387	36238	38	596	19699	1	-	59922
1993	546	1215	880	1165	40978	76	1802	35071	646	-	82379
1994	2761	678	770	2412	71171	22	4673	51822	877	-	135186
1995	2833	598	1097	2675	76886	14	3111	54516	718	-	142448
1996	3743	6	1510	942	94527	669	2275	74239	217	-	178128
1997	3327	540	1877	972	103407	364	2340	41228	304	-	154359
1998	1903	241	854	385	75108	257	1229	20559	94	-	100630
1999	1913	64	437	641	48182	652	694	30520	92	-	83195
2000	631	178	432	880	42009	502	747	22738	827	-	68944
2001	1210	324	553	554	49067	1497	1068	34307	1060	-	89640
2002	1564	297	858	627	52247	1505	1125	37157	682	18736/5310	114798/101372
2003	1959	382	1363	918	56485	1330	1018	41142	1103	33226/9417	138926/115117
2004	2484	103	1680	823	62192	54	1250	54347	1569	33777/8661	158279/133163
2005	2138	333	15	996	60850	963	1899	50012	1262	40283/9949	158751/128417
2006	2390	883	1830	989	69272	703	1164	53313	1162	21451/8949	153157/140/655
2007	2307	277	1464	1123	71244	125	1351	66569	2511	14553/3102	161525/150074
2008	2687	311	1659	535	72779	283	971	68792	1759	5828/-	155604/149776
2009	2820	529	1410	1957	104354	317	1315	85514	1845	0	200061
2010	3173	764	1970	3539	123384	379	1758	111372	2862	0	249200
2011	1759	268	2110	1724	158202	502	1379	139912	4763	0	309785
2012	2055	322	3984	1111	159602	441	833	143886	3393	0	315627
2013	1886	342	1795	500	99215	439	639	85668	3260	0	193744
2014	1470	198	1150	340	91306	187	355	78725	3791	0	177522
2015	2459	145	1047	124	95094	246	450	91864	3327	0	194756
2016	2460	340	1401	170	108718	200	575	115710	3838	0	233416
2017	2776	108	1810	170	113132	228	372	106714	2279	0	227588
2018 1)	2333	183	1317	385	93839	107	453	90486	2173	0	191276

1) Provisional figures.

2) USSR prior to 1991.

3) Figures based on Norwegian/Russian IUU estimates

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

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

Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0	4446	3189	37949	35344	18849	28868	9199	1979	1093	853	867	1257
1951	4069	222	65643	9178	18014	13551	6808	6850	3322	1182	734	178	436
1952	0	13674	6012	151996	13634	9850	4693	3237	2434	606	534	185	161
1953	392	8031	64528	13013	70781	5431	2867	1080	424	315	393	202	410
1954	1726	493	6563	154696	5885	27590	3233	1302	712	319	126	68	349
1955	0	989	1154	10689	176678	4993	28273	1445	271	100	50	30	20
1956	97	3012	16437	5922	14713	127879	3182	8003	450	200	80	60	45
1957	828	243	2074	24704	7942	12535	46619	1087	1971	356	17	40	119
1958	153	2312	1727	5914	31438	5820	12748	17565	822	1072	226	79	296
1959	169	2425	20318	7826	7243	14040	3154	2237	5918	285	316	71	113
1960	2319	3613	39910	70912	13647	7101	6236	1579	2340	2005	497	70	42
1961	362	5531	15429	56855	63351	8706	3578	4407	788	527	1287	67	80
1962	0	4524	39503	30868	48903	33836	3201	1341	1773	242	247	483	28
1963	3	2143	28466	72736	18969	13579	9257	1239	559	409	80	84	212
1964	149	834	22363	49290	30672	5815	3527	2716	833	104	206	235	190
1965	0	3498	5936	46356	40201	12631	1679	974	897	123	204	123	471
1966	0	2577	26345	22631	63176	29048	5752	582	438	189	186	25	30
1967	0	53	15907	41346	13496	25719	8872	1616	218	175	155	75	41
1968	0	33	657	67632	41267	7748	15599	5292	655	182	101	115	70
1969	0	1061	1524	1968	44634	19002	3620	4937	1628	316	43	43	23
1970	480	281	23444	2454	1906	22417	8100	2012	2016	740	166	26	96
1971	15	3535	1978	24358	1257	918	9279	3056	826	1043	369	130	35
1972	133	9399	230942	22315	42981	3206	1611	6758	2638	900	989	538	120
1973	0	5956	70679	260520	24180	6919	422	426	1692	529	147	339	95
1974	281	3713	9685	41706	88120	5829	4138	382	618	2043	935	276	659
1975	1321	4355	10037	14088	33871	49711	2135	1236	92	131	500	147	287
1976	3475	7499	13994	13454	6810	20796	40057	1247	1350	193	280	652	671
1977	184	18456	55967	22043	7368	2586	7781	11043	311	388	96	101	182
1978	46	2033	47311	18812	4076	1389	1626	2596	6215	162	258	3	139
1979	0	48	17540	35290	10645	1429	812	546	1466	2310	181	87	55
1980	0	0	627	22878	21794	2971	250	504	230	842	1299	111	50
1981	1	68	486	2561	22124	10685	1034	162	162	72	330	564	69
1982	2	29	883	900	3372	12203	2625	344	75	80	91	321	238
1983	3	351	1173	2636	1360	2394	2506	1799	267	37	60	100	132
1984	7	754	1271	1019	1899	657	950	2619	352	87	2	22	53
1985	4	2952	29624	1695	564	1009	943	886	1763	588	124	64	93
1986	506	650	23113	68429	1565	783	896	393	702	1144	443	130	414
1987	9	83	5031	87170	64556	960	597	376	212	230	419	245	73
1988	7	139	1439	12478	47890	20429	397	178	74	88	168	198	80
1989	611	221	2157	4986	16071	25313	3198	147	1	28	28	53	96
1990	2	446	1015	2580	2142	4046	6221	840	134	42	14	13	44
1991	23	533	4421	3564	2416	3299	4633	3953	461	83	9	18	27
1992	49	2793	11571	11567	4099	2642	2894	3327	3498	486	35	32	18
1993	498	272	13487	19457	13704	4103	1747	1886	2105	1965	201	96	25
1994	95	187	3374	47821	36333	13264	2057	903	1453	2769	1802	259	49
1995	2	85	2003	16109	72644	19145	6417	746	361	770	655	804	116
1996	35	478	1662	6818	36473	73579	13426	2944	573	365	533	598	767
1997	70	94	2280	5633	12603	32832	49478	5636	778	245	126	158	463
1998	547	1476	1701	11304	9258	8633	13801	19469	2113	330	59	54	377
1999	104	568	16839	8039	15365	6073	4466	6355	6204	647	117	109	220
2000	46	692	1520	29986	6496	5149	2406	1657	1570	1744	183	70	184
2001	374	1758	12971	5230	32049	5279	2941	1137	1161	1169	747	169	288
2002	59	603	7132	46335	11084	21985	2602	1602	482	448	581	349	98
2003	123	611	6803	31448	56480	11736	14541	1637	2178	858	411	413	395
2004	58	1295	7993	21116	41310	41226	4939	4914	598	1252	296	139	465
2005	102	865	11452	19369	22887	37067	24461	2393	2997	990	201	263	1059
2006	271	2496	4539	35040	27571	15033	16023	8567	1259	1298	222	175	321
2007	575	3914	30707	15213	45992	18516	10642	7889	2570	678	605	197	185
2008	440	2089	14536	44192	15926	31173	9145	4520	2846	1181	274	214	166
2009	483	1364	15379	55013	52498	13679	15382	3800	1669	887	285	353	321
2010	457	620	6545	52006	80622	50306	9273	5324	1954	1114	533	242	621
2011	909	806	1277	8501	90394	100522	39496	4397	2340	668	437	269	708
2012	268	611	7814	4206	18007	93055	82721	14445	1325	448	217	216	568
2013	402	904	1778	12780	3805	12297	58024	29930	4976	957	331	212	535
2014	528	649	6948	4503	14563	6833	16304	39620	16439	2431	619	440	545
2015	303	1334	1645	27317	8526	16624	7950	20538	25534	6677	1556	295	312
2016	294	655	5774	3482	33177	9563	18045	12030	21875	13492	4757	876	248
2017	724	1898	30744	46463	16895	48927	10518	14992	9 485	8447	6 640	1872	317
2018	679	1438	9424	16291	34060	8466	18882	5123	8902	4125	3564	4504	1354

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

	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1951	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1952	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1953	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1954	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1955	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1956	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1957	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1958	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1959	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1960	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1961	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1962	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1963	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1964	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1965	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1966	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1967	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1968	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1969	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1970	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1971	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1972	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1973	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1974	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1975	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1976	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1977	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1978	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1979	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1980	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1981	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1982	0.299	0.519	0.75	1.038	1.321	1.617	1.873	2.147	2.418	2.698	2.931	3.094	3.461
1983	0.188	0.689	1.033	1.408	1.71	2.149	2.469	2.748	3.069	3.687	4.516	3.094	3.461
1984	0.408	0.805	1.218	1.632	2.038	2.852	2.845	3.218	3.605	4.065	4.407	4.734	5.099
1985	0.319	0.383	0.835	1.29	1.816	2.174	2.301	2.835	3.253	3.721	4.084	4.137	4.926
1986	0.218	0.325	0.612	1.064	1.539	1.944	2.362	2.794	3.25	3.643	4.14	4.559	5.927
1987	0.143	0.221	0.497	0.765	1.179	1.724	2.135	2.551	3.009	3.414	3.84	4.415	5.195
1988	0.279	0.551	0.55	0.908	1.097	1.357	1.537	1.704	2.403	2.403	2.486	2.531	2.834
1989	0.258	0.55	0.684	0.84	0.998	1.176	1.546	1.713	1.949	2.14	2.389	2.522	2.797
1990	0.319	0.601	0.793	1.172	1.397	1.624	1.885	2.112	2.653	3.102	3.18	3.438	3.319
1991	0.216	0.616	0.941	1.281	1.556	1.797	2.044	2.079	2.311	2.788	3.408	2.896	3.274
1992	0.055	0.458	0.906	1.263	1.535	1.747	2.043	2.2	2.298	2.494	2.49	2.673	2.923
1993	0.381	0.64	0.94	1.204	1.487	1.748	1.994	2.237	2.417	2.654	2.906	3.184	3.363
1994	0.278	0.521	0.614	0.906	1.287	1.602	1.968	2.059	2.39	2.545	2.881	2.918	3.222
1995	0.258	0.446	0.739	0.808	1.107	1.556	1.838	2.234	2.416	2.602	2.965	3.163	3.786
1996	0.287	0.427	0.683	0.868	1.045	1.363	1.71	1.886	2.214	2.37	2.438	2.707	2.896
1997	0.408	0.575	0.682	1.028	1.151	1.369	1.637	1.856	2.073	2.5	2.279	2.532	2.609
1998	0.409	0.593	0.748	0.974	1.262	1.433	1.641	1.863	2.069	2.335	2.511	2.8	2.849
1999	0.435	0.695	0.826	1.079	1.261	1.485	1.634	1.798	2.032	2.237	2.339	2.611	2.865
2000	0.378	0.577	0.853	1.186	1.395	1.588	1.808	1.989	2.264	2.415	2.587	2.647	3.098
2001	0.391	0.647	0.751	1.104	1.459	1.709	1.921	2.182	2.331	2.609	2.757	3.376	3.338
2002	0.159	0.407	0.687	1.001	1.363	1.643	1.975	2.086	2.294	2.487	2.612	2.847	3.501
2003	0.198	0.384	0.594	0.875	1.113	1.364	1.361	1.972	1.636	1.877	2.088	2.351	2.842
2004	0.328	0.429	0.636	0.886	1.183	1.508	1.821	2.075	2.339	2.58	2.527	3.153	3.197
2005	0.285	0.492	0.722	0.906	1.121	1.343	1.619	2.036	2.177	2.382	2.527	2.496	2.81
2006	0.311	0.567	0.745	1.041	1.287	1.504	1.72	2.082	2.377	2.738	3.082	3.02	3.43
2007	0.329	0.431	0.652	0.899	1.197	1.435	1.722	1.99	2.309	2.715	2.987	2.947	3.591
2008	0.383	0.484	0.658	0.901	1.242	1.515	1.781	2.18	2.33	2.664	3.019	3.326	3.829
2009	0.378	0.508	0.707	1.024	1.28	1.538	1.806	2.107	2.398	2.531	2.606	3.089	3.541
2010	0.317	0.499	0.642	0.887	1.137	1.396	1.702	1.907	2.095	2.404	2.534	3.064	3.249
2011	0.423	0.513	0.811	0.953	1.093	1.254	1.462	1.715	1.978	2.328	2.305	2.55	2.76
2012	0.271	0.506	0.756	1.004	1.174	1.371	1.514	1.715	2.051	2.444	2.414	2.615	2.932
2013	0.469	0.542	0.821	1.014	1.217	1.401	1.571	1.714	1.914	2.168	2.24	2.516	2.807
2014	0.469	0.645	0.792	1.033	1.253	1.417	1.625	1.793	1.941	2.081	2.479	2.703	3.011
2015	0.473	0.647	0.876	1.054	1.327	1.571	1.777	1.934	2.025	2.216	2.481	2.99	3.455
2016	0.497	0.743	0.882	1.115	1.369	1.662	1.917	2.089	2.301	2.567	3.076	3.286	3.331
2017	0.449	0.608	0.874	1.088	1.378	1.666	1.879	2.146	2.258	2.476	2.72	2.98	3.713
2018	0.443	0.663	0.820	1.051	1.339	1.629	1.927	2.156	2.372	2.588	2.728	2.773	3.175

Table 4.6. Northeast Arctic haddock. Stock weights-at-age (kg).

	1	2	3	4	5	6	7	8	9	10	11+
1950	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1951	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1952	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1953	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1954	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1955	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1956	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1957	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1958	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1959	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1960	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1961	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1962	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1963	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1964	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1965	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1966	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1967	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1968	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1969	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1970	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1971	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1972	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1973	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1974	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1975	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1976	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1977	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1978	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1979	0.031	0.145	0.354	0.653	1.016	1.427	1.867	2.327	2.771	3.195	3.597
1980	0.063	0.262	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792
1981	0.051	0.274	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904
1982	0.036	0.224	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016
1983	0.035	0.164	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165
1984	0.028	0.158	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878
1985	0.03	0.127	0.379	0.7	1.394	2.195	2.626	2.572	3.158	3.261	3.728
1986	0.035	0.136	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632
1987	0.042	0.161	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946
1988	0.039	0.189	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787
1989	0.037	0.175	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449
1990	0.031	0.169	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73
1991	0.025	0.141	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256
1992	0.023	0.114	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491
1993	0.025	0.107	0.279	0.616	1.1	1.537	2.08	2.308	2.54	2.831	3.531
1994	0.03	0.115	0.262	0.512	0.952	1.518	1.969	2.527	2.729	2.945	3.213
1995	0.036	0.131	0.282	0.484	0.8	1.327	1.952	2.401	2.959	3.135	3.335
1996	0.037	0.154	0.313	0.52	0.76	1.128	1.724	2.388	2.82	3.369	3.52
1997	0.036	0.158	0.363	0.567	0.816	1.076	1.481	2.127	2.814	3.22	3.751
1998	0.029	0.153	0.371	0.65	0.879	1.155	1.418	1.847	2.526	3.221	3.595
1999	0.028	0.128	0.361	0.662	0.998	1.225	1.523	1.775	2.215	2.911	3.604
2000	0.026	0.122	0.305	0.647	1.014	1.375	1.592	1.905	2.137	2.578	3.278
2001	0.031	0.113	0.292	0.553	0.993	1.396	1.77	1.969	2.292	2.495	2.929
2002	0.03	0.133	0.272	0.531	0.859	1.369	1.795	2.17	2.349	2.676	2.845
2003	0.028	0.13	0.318	0.497	0.827	1.199	1.763	2.197	2.567	2.727	3.049
2004	0.025	0.12	0.31	0.575	0.778	1.157	1.561	2.162	2.597	2.956	3.095
2005	0.022	0.109	0.289	0.562	0.891	1.094	1.511	1.934	2.559	2.988	3.332
2006	0.023	0.096	0.263	0.526	0.873	1.239	1.434	1.877	2.31	2.948	3.363
2007	0.025	0.101	0.234	0.483	0.821	1.216	1.609	1.789	2.248	2.686	3.323
2008	0.031	0.109	0.246	0.432	0.758	1.15	1.582	1.988	2.151	2.619	3.052
2009	0.029	0.132	0.264	0.454	0.684	1.067	1.502	1.958	2.37	2.514	2.983
2010	0.039	0.125	0.315	0.484	0.715	0.97	1.402	1.866	2.336	2.749	2.873
2011	0.034	0.167	0.3	0.571	0.76	1.012	1.283	1.751	2.236	2.713	3.118
2012	0.039	0.151	0.391	0.55	0.884	1.082	1.37	1.619	2.084	2.625	3.094
2013	0.032	0.166	0.358	0.693	0.861	1.236	1.418	1.718	1.961	2.446	2.985
2014	0.036	0.136	0.391	0.64	1.059	1.2	1.602	1.773	2.073	2.309	2.802
2015	0.032	0.157	0.324	0.698	0.988	1.461	1.568	1.987	2.136	2.435	2.664
2016	0.029	0.139	0.371	0.585	1.065	1.357	1.869	1.937	2.367	2.505	2.79
2017	0.03	0.127	0.333	0.664	0.908	1.461	1.755	2.283	2.322	2.749	2.867
2018	0.028	0.129	0.303	0.598	1.013	1.266	1.878	2.153	2.686	2.699	3.121
2019	0.037	0.124	0.309	0.554	0.926	1.397	1.638	2.294	2.553	3.089	3.066

Table 4.7. Northeast Arctic haddock. Proportion mature-at-age.

	1	2	3	4	5	6	7	8	9	10	11	12	13+
1950	0	0	0.026	0.076	0.243	0.649	0.860	0.950	0.984	0.995	1	1	1
1951	0	0	0.056	0.104	0.303	0.549	0.857	0.948	0.984	0.995	1	1	1
1952	0	0	0.053	0.161	0.332	0.577	0.770	0.947	0.983	0.995	1	1	1
1953	0	0	0.057	0.183	0.472	0.665	0.800	0.906	0.983	0.995	1	1	1
1954	0	0	0.044	0.196	0.510	0.801	0.862	0.921	0.967	0.995	1	1	1
1955	0	0	0.027	0.149	0.522	0.796	0.928	0.953	0.973	0.989	1	1	1
1956	0	0	0.021	0.103	0.454	0.758	0.928	0.977	0.984	0.991	1	1	1
1957	0	0	0.021	0.076	0.294	0.713	0.918	0.976	0.993	0.994	1	1	1
1958	0	0	0.025	0.074	0.240	0.576	0.898	0.975	0.993	0.998	1	1	1
1959	0	0	0.032	0.090	0.250	0.534	0.822	0.966	0.993	0.998	1	1	1
1960	0	0	0.046	0.127	0.305	0.578	0.798	0.937	0.990	0.997	1	1	1
1961	0	0	0.041	0.164	0.358	0.623	0.820	0.925	0.980	0.997	1	1	1
1962	0	0	0.030	0.147	0.449	0.704	0.855	0.936	0.976	0.994	1	1	1
1963	0	0	0.018	0.113	0.396	0.741	0.878	0.950	0.979	0.992	1	1	1
1964	0	0	0.016	0.073	0.329	0.702	0.903	0.960	0.984	0.993	1	1	1
1965	0	0	0.016	0.059	0.227	0.633	0.885	0.969	0.987	0.995	1	1	1
1966	0	0	0.023	0.069	0.213	0.497	0.855	0.964	0.991	0.996	1	1	1
1967	0	0	0.034	0.083	0.204	0.495	0.760	0.948	0.989	0.997	1	1	1
1968	0	0	0.041	0.116	0.247	0.502	0.750	0.907	0.984	0.997	1	1	1
1969	0	0	0.050	0.133	0.316	0.521	0.760	0.898	0.969	0.995	1	1	1
1970	0	0	0.033	0.154	0.352	0.600	0.771	0.900	0.966	0.990	1	1	1
1971	0	0	0.032	0.106	0.385	0.642	0.819	0.911	0.967	0.989	1	1	1
1972	0	0	0.024	0.103	0.291	0.674	0.848	0.930	0.968	0.989	1	1	1
1973	0	0	0.027	0.080	0.283	0.575	0.867	0.943	0.975	0.989	1	1	1
1974	0	0	0.029	0.092	0.232	0.565	0.809	0.951	0.980	0.991	1	1	1
1975	0	0	0.030	0.096	0.263	0.498	0.803	0.927	0.983	0.993	1	1	1
1976	0	0	0.027	0.098	0.272	0.539	0.754	0.925	0.974	0.994	1	1	1
1977	0	0	0.022	0.089	0.273	0.551	0.781	0.902	0.973	0.990	1	1	1
1978	0	0	0.019	0.071	0.248	0.553	0.791	0.913	0.964	0.990	1	1	1
1979	0	0	0.019	0.064	0.206	0.520	0.795	0.919	0.968	0.987	1	1	1
1980	0	0	0.026	0.076	0.243	0.649	0.86	0.95	0.984	0.995	1	1	1
1981	0	0	0.056	0.104	0.303	0.549	0.857	0.948	0.984	0.995	1	1	1
1982	0	0	0.053	0.161	0.332	0.577	0.77	0.947	0.983	0.995	1	1	1
1983	0	0	0.057	0.183	0.472	0.665	0.8	0.906	0.983	0.995	1	1	1
1984	0	0	0.044	0.196	0.51	0.801	0.862	0.921	0.967	0.995	1	1	1
1985	0	0	0.027	0.149	0.522	0.796	0.928	0.953	0.973	0.989	1	1	1
1986	0	0	0.021	0.103	0.454	0.758	0.928	0.977	0.984	0.991	1	1	1
1987	0	0	0.021	0.076	0.294	0.713	0.918	0.976	0.993	0.994	1	1	1
1988	0	0	0.025	0.074	0.24	0.576	0.898	0.975	0.993	0.998	1	1	1
1989	0	0	0.032	0.09	0.25	0.534	0.822	0.966	0.993	0.998	1	1	1
1990	0	0	0.046	0.127	0.305	0.578	0.798	0.937	0.99	0.997	1	1	1
1991	0	0	0.041	0.164	0.358	0.623	0.82	0.925	0.98	0.997	1	1	1
1992	0	0	0.03	0.147	0.449	0.704	0.855	0.936	0.976	0.994	1	1	1
1993	0	0	0.018	0.113	0.396	0.741	0.878	0.95	0.979	0.992	1	1	1
1994	0	0	0.016	0.073	0.329	0.702	0.903	0.96	0.984	0.993	1	1	1
1995	0	0	0.016	0.059	0.227	0.633	0.885	0.969	0.987	0.995	1	1	1
1996	0	0	0.032	0.069	0.213	0.497	0.855	0.964	0.991	0.996	1	1	1
1997	0	0	0.04	0.098	0.204	0.495	0.76	0.948	0.989	0.997	1	1	1
1998	0	0	0.041	0.125	0.264	0.502	0.75	0.907	0.984	0.997	1	1	1
1999	0	0	0.039	0.129	0.32	0.535	0.76	0.898	0.969	0.995	1	1	1
2000	0	0	0.03	0.124	0.328	0.594	0.775	0.9	0.966	0.99	1	1	1
2001	0	0	0.028	0.094	0.318	0.601	0.808	0.909	0.967	0.989	1	1	1
2002	0	0	0.026	0.088	0.255	0.592	0.812	0.923	0.966	0.989	1	1	1
2003	0	0	0.032	0.078	0.24	0.524	0.807	0.925	0.972	0.988	1	1	1
2004	0	0	0.031	0.101	0.218	0.505	0.768	0.923	0.972	0.99	1	1	1
2005	0	0	0.028	0.097	0.269	0.476	0.756	0.906	0.971	0.99	1	1	1
2006	0	0	0.024	0.087	0.261	0.541	0.736	0.901	0.965	0.99	1	1	1
2007	0	0	0.021	0.075	0.237	0.531	0.778	0.892	0.963	0.987	1	1	1
2008	0	0	0.022	0.062	0.209	0.502	0.773	0.911	0.96	0.986	1	1	1
2009	0	0	0.025	0.067	0.177	0.463	0.754	0.908	0.967	0.985	1	1	1
2010	0	0	0.032	0.075	0.19	0.415	0.727	0.9	0.966	0.988	1	1	1
2011	0	0	0.029	0.099	0.21	0.436	0.69	0.888	0.963	0.987	1	1	1
2012	0	0	0.042	0.09	0.26	0.472	0.724	0.878	0.96	0.988	1	1	1
2013	0	0	0.037	0.132	0.25	0.537	0.737	0.889	0.955	0.986	1	1	1
2014	0	0	0.042	0.115	0.336	0.522	0.778	0.895	0.96	0.984	1	1	1
2015	0	0	0.032	0.133	0.305	0.616	0.771	0.913	0.962	0.986	1	1	1
2016	0	0	0.039	0.099	0.339	0.581	0.822	0.909	0.968	0.986	1	1	1
2017	0	0	0.033	0.122	0.27	0.616	0.805	0.93	0.967	0.989	1	1	1
2018	0	0	0.029	0.103	0.316	0.548	0.823	0.923	0.975	0.988	1	1	1
2019	0	0	0.029	0.091	0.278	0.595	0.785	0.93	0.972	0.991	1	1	1

Table 4.8. Northeast Arctic haddock. Consumption of Haddock by NEA Cod (mln. spec).

Age	0	1	2	3	4	5	6	Biomass consumed
1984	1985.443	986.818	14.650	0.076	0.000	0.000	0.000	51.256
1985	1709.736	1205.489	5.160	0.000	0.000	0.000	0.000	47.136
1986	90.808	548.712	240.740	165.543	0.000	0.000	0.000	108.658
1987	0.000	740.664	0.000	0.000	0.000	0.000	0.000	4.074
1988	0.000	17.109	0.508	9.140	0.000	0.225	0.000	2.620
1989	22.009	230.386	0.000	0.000	0.000	0.000	0.000	10.287
1990	50.957	143.914	37.877	3.665	0.000	0.000	0.000	15.476
1991	0.000	457.565	14.211	0.000	0.000	0.000	0.000	20.196
1992	165.872	2109.799	150.798	1.080	0.000	0.000	0.000	106.028
1993	755.633	1361.690	165.151	36.588	3.369	2.853	0.000	70.247
1994	1229.416	1393.089	79.775	24.548	7.439	0.900	0.011	47.587
1995	177.291	2870.300	160.907	11.669	27.911	27.353	0.308	111.356
1996	320.005	1504.648	160.623	40.125	5.454	2.639	3.445	66.687
1997	0.000	873.388	34.396	25.375	1.726	0.783	0.529	39.832
1998	0.000	1468.486	28.174	1.972	2.906	0.505	0.000	31.231
1999	0.000	888.567	23.251	0.325	0.000	0.000	0.000	25.549
2000	678.164	1191.522	64.620	2.085	1.145	0.187	0.079	50.186
2001	987.869	561.347	54.284	5.307	0.092	0.000	0.000	49.659
2002	457.281	2475.722	244.670	40.056	2.323	0.378	0.173	129.074
2003	1163.408	3689.149	227.213	42.043	13.581	1.289	0.000	173.573
2004	5403.863	2892.015	313.860	41.909	10.678	2.668	0.000	200.787
2005	7559.656	6545.499	276.384	56.809	9.766	2.371	0.949	319.686
2006	13687.148	8413.087	374.936	5.572	4.519	1.182	0.479	365.080
2007	1309.075	10846.114	661.442	71.874	3.867	2.217	0.218	391.677
2008	1547.783	1069.449	947.435	239.346	45.851	5.881	3.357	311.971
2009	6550.921	2148.662	314.601	293.839	78.551	25.256	1.732	289.203
2010	2336.074	6584.182	202.641	75.218	77.167	70.642	13.248	306.342
2011	2789.661	3078.071	512.932	63.657	85.831	99.208	22.411	322.924
2012	265.254	8425.262	158.043	126.641	17.801	8.097	5.125	259.431

Age	0	1	2	3	4	5	6	Biomass consumed
2013	2420.488	1816.924	452.778	37.895	26.895	6.696	5.126	236.321
2014	1355.720	2219.149	160.834	31.876	2.062	0.713	0.000	99.212
2015	4863.851	2622.732	148.128	15.756	52.709	1.740	0.272	186.701
2016	7520.836	2614.541	269.091	24.871	2.872	9.091	2.099	219.651
2017	2902.326	6929.716	223.909	23.707	14.660	7.761	15.428	261.285
2018	1927.166	5986.443	545.631	64.405	7.347	0.627	0.017	247.300
1984-2018	2063.8	2768.9	207.7	45.2	14.5	8.0	2.1	148.0

Table 4.9. Northeast Arctic haddock. Survey indices for tuning assessment models

North-East Arctic haddock

104

RU-BTr-Q4

1991 2018

1 1 0.9 1.00

3 7

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

BS-NoRU-Q1(Aco)

1994 2019

1 1 0.083 0.21

4 8

1	626.6	121.4	8.6	0.7	0.3
1	121.5	395.4	47.6	2.8	0.1
1	22.1	68.7	143.7	5.7	0.9
1	22.2	15.5	56.1	62.8	4.7
1	58.8	24.2	7.7	14.1	20.7
1	21.6	22.1	6.2	1.6	3.9
1	75.5	14	12.6	1.6	0.5
1	40.2	41.4	2.2	1.6	0.2
1	201.8	18.5	11.7	1.6	0.3
1	184.6	136	12.3	6	0.3
1	101.8	107.8	57.7	7.6	1.2
1	115.7	57.4	56.7	12.7	0.4
1	123.8	47.4	19.3	13.6	3.2
1	46.1	80.6	28.9	10	5.1

1	303	90	74.1	7.4	12.8
1	630	266.6	38.9	14.6	1.3
1	631	604	167	12.1	2.9
1	84.2	313	292.2	54.9	1.7
1	48.8	88.1	310.6	172.5	30.1
1	146.8	35.4	53	223.8	102.7
1	38.2	107.9	22.4	33.8	84.5
1	171.5	25.5	39.4	8.3	21.1
1	11.8	56	11.8	16.6	6.9
1	62.8	4.4	32.2	5.8	7
1	60.3	60.7	5.7	12.8	2.3
1	142	29.7	21.2	4.5	3.4

Table 4.9. (Continuation)

BS-NoRu-Q1 (BTr)

1994 2019

1 1 0.083 0.167

4 9

1	4279	483	34	1.4	1.7	1.6
1	1630	3384	288	18.7	0.3	0.4
1	325	1610	2509	183	11.1	0
1	396	182	614	873	32.2	0.8
1	361	128	32	81.5	59.4	5.6
1	156	94	29	8.6	13	7.4
1	358	69	41	6.5	0.1	8.1
1	261	227	17	7.8	0.6	0.6
1	1868	119	84	8.6	1.9	0
1	1751	723	50	17.3	1.2	0.9
1	993	777	509	73.7	8.9	1.3
1	1401	509	617	102	2.5	0.8
1	1298	455	226	159	32	0.9
1	810	848	261	53.8	22.3	13.5
1	5813	529	540	70.5	106	1.6
1	7601	3723	258	123	8.5	0.9
1	4928	4546	1494	78	9.9	3.5
1	1257	4725	2936	663	14.5	11.1
1	291	761	2709	1564	245	26.4
1	1460	209	342	1938	686	60
1	303	1004	219	465	952	400
1	1767	441	356	136	183	277
1	329	1058	196	400	103	275
1	958	43.2	451	87.2	130	12
1	840	610	56	119	27.5	20.1
1	1797	459	158	37.8	27.9	6.9

FLT007: Eco-NoRu-Q3 (Btr)

2004 2018

1 1 0.65 0.75

3 8

1	123	70	69	31	3	2
1	325	90	30	32	15	-1
1	107	125	42	19	17	7
1	1283	88	90	19	6	7

1	1155	406	43	36	5	3
1	651	619	306	21	7	1
1	184	865	666	148	16	3
1	40	74	393	301	37	3
1	92	20	68	214	152	13
1	26	65	20	51	150	76
1	262	41	70	26	60	86
1	42	214	25	37	21	48
1	74	14	138	42	55	40
1	70	70	11	21	4	4
1	-1	-1	-1	-1	-1	-1

Table 4.10. Northeast Arctic haddock. SAM model configuration used

```
library(stockassessment)
setwd("run")
load("data.RData")
conf<-defcon(dat)
conf$keyLogFsta<-rbind(
c(0,1,2,3,4,5,5,6,6,6,6),
rep(-1,11),
rep(-1,11),
rep(-1,11),
rep(-1,11)
)
conf$corFlag<-2
conf$keyLogFpar<-rbind(
rep(-1,11),
c(0,0,1,1,1,-1,-1,-1,-1,-1,-1),
c(-1,2,2,3,3,3,-1,-1,-1,-1,-1),
c(-1,4,4,5,5,5,6,-1,-1,-1,-1),
c(7,7,8,8,8,9,-1,-1,-1,-1,-1)
)
conf$keyQpow<-rbind(
rep(-1,11),
c(0,0,1,1,1,-1,-1,-1,-1,-1,-1),
c(-1,2,2,3,3,3,-1,-1,-1,-1,-1),
c(-1,4,4,5,5,5,6,-1,-1,-1,-1),
c(7,7,8,8,8,9,-1,-1,-1,-1,-1)
)
conf$keyVarF[1,]<-
c(0,1,1,1,1,1,1,1,1,1,1)
conf$keyVarObs<-rbind(
c(0,1,1,1,1,1,1,2,2,2,2),
c(3,3,4,4,4,-1,-1,-1,-1,-1,-1),
c(-1,5,5,6,6,6,-1,-1,-1,-1,-1),
c(-1,7,7,8,8,8,9,-1,-1,-1,-1),
c(10,10,11,11,11,12,-1,-1,-1,-1,-1)
)
conf$fbarRange<-c(4,7)
par<-defpar(dat,conf)
fit<-sam.fit(dat,conf,par)

save(fit, file="model.RData")
```

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

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1950	67909	39825	115798	210469	174737	253508	0.732	0.582	0.922	382994	323807	452999
1951	643146	381940	1082989	126945	108067	149121	0.686	0.555	0.847	429160	320910	573924
1952	95519	56772	160709	102125	86200	120993	0.705	0.572	0.869	425872	320733	565475
1953	1069379	631697	1810315	119871	95326	150735	0.544	0.436	0.679	677426	487858	940656
1954	133121	78815	224847	169170	133774	213933	0.485	0.386	0.609	753641	556624	1020393
1955	54736	32141	93214	272359	208456	355853	0.408	0.322	0.518	735371	547988	986829
1956	227460	133694	386988	332172	248574	443885	0.436	0.345	0.552	631234	486606	818849
1957	58058	34401	97985	257612	197382	336221	0.408	0.323	0.516	435988	349935	543201
1958	65914	38761	112090	186839	150030	232678	0.493	0.393	0.62	313929	259687	379500
1959	380492	227537	636265	129867	106580	158244	0.45	0.358	0.566	332138	260728	423108
1960	328005	195623	549973	116575	98052	138598	0.56	0.452	0.694	421747	333683	533053
1961	151834	91294	252518	125149	104701	149591	0.661	0.537	0.813	403800	328041	497057
1962	309574	186447	514012	123602	102017	149755	0.739	0.599	0.913	378215	306643	466492
1963	309158	186325	512967	97043	81565	115458	0.722	0.579	0.899	360111	287584	450930
1964	318887	191099	532126	86600	73054	102658	0.656	0.526	0.818	376119	297734	475140
1965	124551	74452	208364	100233	82674	121522	0.564	0.451	0.706	366066	293202	457038
1966	303549	181433	507857	134158	108853	165345	0.541	0.431	0.68	420647	337792	523826
1967	311969	185687	524135	145559	118029	179510	0.457	0.361	0.578	441850	354840	550195
1968	16240	9580	27530	160493	131932	195237	0.482	0.38	0.611	405614	326491	503913
1969	20621	12290	34598	161338	131563	197852	0.409	0.32	0.523	302334	242104	377547
1970	196935	116554	332747	150069	120579	186771	0.394	0.308	0.504	274162	219948	341739
1971	94394	55361	160949	122811	98558	153032	0.338	0.263	0.434	246428	200820	302396
1972	1102790	663243	1833635	122580	101908	147445	0.62	0.493	0.779	600216	427168	843365
1973	317217	190923	527053	125530	103501	152247	0.511	0.405	0.645	668369	504594	885299
1974	71085	43019	117460	165607	131322	208841	0.561	0.446	0.705	508550	396735	651879
1975	60663	36808	99979	189702	147075	244684	0.512	0.408	0.642	372602	296619	468050
1976	65598	39642	108548	183385	143112	234992	0.727	0.589	0.898	282789	229767	348047
1977	125133	74676	209684	116319	91453	147947	0.745	0.601	0.922	201557	165404	245613
1978	214073	129010	355223	78699	61857	100128	0.616	0.49	0.774	197763	155935	250812
1979	151398	91008	251860	62078	49323	78131	0.571	0.449	0.725	202152	160714	254273
1980	18899	10989	32502	62398	50495	77106	0.454	0.353	0.585	205306	162856	258822
1981	9225	5454	15605	71542	57391	89183	0.406	0.314	0.524	161137	127444	203736
1982	16484	9804	27715	68072	53725	86251	0.361	0.279	0.467	119985	95854	150190
1983	9852	5806	16716	58935	46841	74153	0.366	0.284	0.471	88970	72452	109254
1984	14518	8589	24538	53015	42159	66667	0.301	0.233	0.389	72312	59051	88551
1985	329518	196308	553121	49865	40553	61317	0.402	0.317	0.51	181492	126050	261320
1986	458287	274143	766123	54254	44475	66183	0.556	0.445	0.696	353438	262172	476475
1987	83081	49261	140123	72012	56565	91678	0.66	0.524	0.831	332644	258590	427905
1988	38441	22566	65484	77166	60462	98484	0.534	0.413	0.69	248509	195262	316277
1989	31772	18787	53729	83359	63879	108780	0.301	0.228	0.396	191394	150457	243469
1990	39106	24100	63456	87990	68071	113738	0.228	0.175	0.297	157919	126972	196410
1991	103256	71851	148385	100726	80956	125325	0.243	0.191	0.309	184269	154818	219323
1992	312998	218071	449247	116241	96275	140347	0.281	0.224	0.354	293504	246161	349953
1993	848378	584630	1231113	136413	115911	160541	0.292	0.233	0.367	549336	448167	673341
1994	295569	207171	421687	165211	143769	189851	0.348	0.278	0.437	642376	542825	760185
1995	79138	55424	112997	208941	181012	241180	0.328	0.262	0.411	628688	534295	739758
1996	94320	66015	134760	250661	214823	292479	0.391	0.316	0.484	546579	470657	634748
1997	96732	67573	138473	220527	188549	257929	0.465	0.37	0.584	391511	340767	449811
1998	64801	45571	92147	160426	137489	187189	0.46	0.37	0.572	283427	248953	322676
1999	197387	138542	281225	115023	98676	134079	0.466	0.376	0.578	261306	226164	301908
2000	81630	57442	116002	93447	80046	109092	0.368	0.295	0.46	231993	201606	266961
2001	347092	242808	496166	93381	80977	107685	0.365	0.294	0.453	292473	248294	344514
2002	355408	250073	505110	107449	94003	122817	0.341	0.275	0.423	411701	351593	482086
2003	246548	174767	347813	139684	122955	158691	0.407	0.332	0.5	487157	422386	561860
2004	220076	162331	298364	159778	141020	181032	0.417	0.337	0.515	467885	412552	530640
2005	353226	256327	486755	174816	154248	198126	0.436	0.355	0.536	489670	430295	557238
2006	163602	120716	221724	172205	152288	194728	0.389	0.316	0.479	430986	381786	486526
2007	879343	619641	1247890	179156	158611	202362	0.355	0.287	0.439	587670	499664	691178
2008	1251215	887076	1764830	198050	174048	225362	0.291	0.231	0.367	875010	732017	1045936
2009	1030019	729075	1455185	211140	185777	239966	0.259	0.205	0.328	1116645	930653	1339807
2010	307787	227558	416303	311541	269914	359588	0.241	0.192	0.304	1292280	1092193	1529023
2011	110337	81686	149038	432296	369456	505825	0.232	0.184	0.292	1179414	1002645	1387349
2012	293014	212566	403908	565427	479604	666606	0.206	0.164	0.26	1096489	939681	1279465
2013	106180	77825	144866	604134	511426	713648	0.164	0.13	0.207	963051	830830	1116314
2014	332329	242707	455043	596585	502251	708638	0.168	0.133	0.212	953001	824712	1101248
2015	68172	48383	96056	555089	462004	666931	0.201	0.16	0.252	877696	756100	1018847
2016	177353	124838	251960	526338	433025	639760	0.255	0.204	0.32	786746	670439	923230
2017	147786	109072	200240	388448	312924	482200	0.383	0.306	0.479	606029	514318	714093
2018	336138	200367	563908	279971	216450	362133	0.378	0.294	0.487	547117	451504	662979
2019	336138	26903	4199783	214924	161452	286106	0.369	0.223	0.612	524486	304865	902318

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

Year	3	4	5	6	7	8	9	10	11	12	13
1950	0.092	0.385	0.674	0.841	1.029	0.982	0.81	0.81	0.81	0.81	0.81
1951	0.086	0.354	0.622	0.789	0.978	0.957	0.805	0.805	0.805	0.805	0.805
1952	0.089	0.364	0.635	0.809	1.012	0.998	0.845	0.845	0.845	0.845	0.845
1953	0.067	0.279	0.486	0.62	0.789	0.78	0.679	0.679	0.679	0.679	0.679
1954	0.056	0.237	0.422	0.555	0.727	0.727	0.635	0.635	0.635	0.635	0.635
1955	0.045	0.197	0.358	0.473	0.605	0.573	0.481	0.481	0.481	0.481	0.481
1956	0.051	0.213	0.387	0.511	0.636	0.594	0.505	0.505	0.505	0.505	0.505
1957	0.048	0.203	0.369	0.478	0.585	0.542	0.484	0.484	0.484	0.484	0.484
1958	0.059	0.242	0.446	0.579	0.705	0.67	0.635	0.635	0.635	0.635	0.635
1959	0.061	0.24	0.425	0.529	0.607	0.574	0.565	0.565	0.565	0.565	0.565
1960	0.087	0.324	0.554	0.657	0.707	0.658	0.645	0.645	0.645	0.645	0.645
1961	0.111	0.4	0.677	0.776	0.791	0.711	0.675	0.675	0.675	0.675	0.675
1962	0.131	0.462	0.78	0.872	0.842	0.726	0.667	0.667	0.667	0.667	0.667
1963	0.125	0.448	0.759	0.857	0.823	0.696	0.631	0.631	0.631	0.631	0.631
1964	0.106	0.387	0.668	0.784	0.786	0.689	0.638	0.638	0.638	0.638	0.638
1965	0.088	0.329	0.565	0.672	0.692	0.622	0.587	0.587	0.587	0.587	0.587
1966	0.09	0.329	0.55	0.638	0.648	0.576	0.527	0.527	0.527	0.527	0.527
1967	0.078	0.285	0.466	0.533	0.545	0.495	0.455	0.455	0.455	0.455	0.455
1968	0.087	0.308	0.494	0.556	0.57	0.523	0.477	0.477	0.477	0.477	0.477
1969	0.08	0.275	0.427	0.466	0.468	0.427	0.388	0.388	0.388	0.388	0.388
1970	0.084	0.277	0.414	0.443	0.441	0.406	0.372	0.372	0.372	0.372	0.372
1971	0.076	0.248	0.361	0.374	0.369	0.343	0.32	0.32	0.32	0.32	0.32
1972	0.169	0.48	0.69	0.679	0.63	0.567	0.518	0.518	0.518	0.518	0.518
1973	0.159	0.436	0.588	0.54	0.482	0.426	0.39	0.39	0.39	0.39	0.39
1974	0.175	0.468	0.627	0.593	0.554	0.514	0.485	0.485	0.485	0.485	0.485
1975	0.171	0.451	0.581	0.53	0.486	0.445	0.417	0.417	0.417	0.417	0.417
1976	0.253	0.635	0.823	0.752	0.699	0.655	0.621	0.621	0.621	0.621	0.621
1977	0.271	0.675	0.866	0.759	0.678	0.623	0.576	0.576	0.576	0.576	0.576
1978	0.198	0.528	0.717	0.646	0.572	0.53	0.481	0.481	0.481	0.481	0.481
1979	0.156	0.447	0.656	0.629	0.551	0.522	0.467	0.467	0.467	0.467	0.467
1980	0.105	0.327	0.509	0.519	0.462	0.454	0.401	0.401	0.401	0.401	0.401
1981	0.087	0.28	0.447	0.473	0.423	0.414	0.357	0.357	0.357	0.357	0.357
1982	0.077	0.247	0.394	0.423	0.381	0.376	0.32	0.32	0.32	0.32	0.32
1983	0.081	0.258	0.398	0.422	0.385	0.381	0.31	0.31	0.31	0.31	0.31
1984	0.064	0.212	0.325	0.345	0.321	0.309	0.237	0.237	0.237	0.237	0.237
1985	0.076	0.257	0.411	0.468	0.472	0.465	0.359	0.359	0.359	0.359	0.359
1986	0.095	0.326	0.552	0.657	0.689	0.68	0.515	0.515	0.515	0.515	0.515
1987	0.105	0.368	0.652	0.787	0.832	0.805	0.572	0.572	0.572	0.572	0.572
1988	0.08	0.291	0.528	0.648	0.667	0.647	0.442	0.442	0.442	0.442	0.442
1989	0.046	0.178	0.312	0.362	0.351	0.315	0.214	0.214	0.214	0.214	0.214
1990	0.032	0.129	0.23	0.274	0.279	0.263	0.199	0.199	0.199	0.199	0.199
1991	0.032	0.131	0.244	0.296	0.303	0.284	0.221	0.221	0.221	0.221	0.221
1992	0.032	0.135	0.273	0.349	0.368	0.347	0.278	0.278	0.278	0.278	0.278
1993	0.027	0.12	0.268	0.371	0.41	0.389	0.317	0.317	0.317	0.317	0.317
1994	0.028	0.126	0.302	0.445	0.52	0.495	0.406	0.406	0.406	0.406	0.406
1995	0.025	0.115	0.279	0.417	0.502	0.479	0.392	0.392	0.392	0.392	0.392
1996	0.03	0.134	0.328	0.494	0.608	0.586	0.48	0.48	0.48	0.48	0.48
1997	0.036	0.161	0.396	0.587	0.714	0.66	0.522	0.522	0.522	0.522	0.522
1998	0.039	0.17	0.404	0.577	0.687	0.634	0.5	0.5	0.5	0.5	0.5
1999	0.044	0.183	0.421	0.578	0.681	0.625	0.499	0.499	0.499	0.499	0.499
2000	0.035	0.151	0.339	0.454	0.529	0.485	0.393	0.393	0.393	0.393	0.393
2001	0.034	0.147	0.335	0.452	0.525	0.484	0.404	0.404	0.404	0.404	0.404
2002	0.032	0.138	0.312	0.425	0.488	0.443	0.368	0.368	0.368	0.368	0.368
2003	0.038	0.159	0.363	0.505	0.603	0.556	0.468	0.468	0.468	0.468	0.468
2004	0.04	0.163	0.368	0.517	0.618	0.571	0.476	0.476	0.476	0.476	0.476
2005	0.041	0.166	0.376	0.539	0.664	0.63	0.535	0.535	0.535	0.535	0.535
2006	0.037	0.149	0.332	0.477	0.598	0.58	0.49	0.49	0.49	0.49	0.49
2007	0.032	0.13	0.292	0.436	0.563	0.555	0.469	0.469	0.469	0.469	0.469
2008	0.024	0.099	0.225	0.355	0.485	0.49	0.418	0.418	0.418	0.418	0.418
2009	0.021	0.086	0.193	0.311	0.447	0.466	0.404	0.404	0.404	0.404	0.404
2010	0.02	0.081	0.178	0.287	0.419	0.456	0.41	0.41	0.41	0.41	0.41
2011	0.021	0.08	0.172	0.274	0.402	0.444	0.407	0.407	0.407	0.407	0.407
2012	0.021	0.078	0.158	0.241	0.347	0.387	0.362	0.362	0.362	0.362	0.362
2013	0.018	0.068	0.129	0.188	0.271	0.32	0.321	0.321	0.321	0.321	0.321
2014	0.02	0.074	0.137	0.191	0.27	0.33	0.351	0.351	0.351	0.351	0.351
2015	0.026	0.094	0.171	0.228	0.31	0.374	0.406	0.406	0.406	0.406	0.406
2016	0.035	0.121	0.221	0.291	0.389	0.458	0.499	0.499	0.499	0.499	0.499
2017	0.054	0.182	0.335	0.44	0.576	0.647	0.682	0.682	0.682	0.682	0.682
2018	0.052	0.177	0.332	0.433	0.57	0.638	0.681	0.681	0.681	0.681	0.681
2019	0.051	0.173	0.325	0.423	0.556	0.623	0.666	0.666	0.666	0.666	0.666

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

Year Age	3	4	5	6	7	8	9	10	11	12	13
1950	67909	107227	72214	37632	44464	16645	4833	3075	1279	1445	1974
1951	643146	44592	48826	27168	13050	12271	5241	2023	1191	445	1167
1952	95519	437279	28963	19384	9085	4348	3678	1711	831	449	580
1953	1069379	54828	210604	13581	6357	2728	1214	1064	574	317	424
1954	133121	795711	26845	93441	6658	2356	1194	549	390	212	323
1955	54736	83704	533568	14475	45820	2995	843	492	246	157	195
1956	227460	38487	57318	284653	7355	17249	1393	406	259	141	189
1957	58058	147937	26671	35665	113616	3283	6068	745	181	137	206
1958	65914	37856	88983	15421	19958	43305	1764	2501	386	103	220
1959	380492	47178	25259	40549	7470	7532	16128	822	887	164	151
1960	328005	263396	33531	15102	17791	3616	3910	6986	420	343	135
1961	151834	191838	144790	17118	6832	8095	1676	1546	2999	167	190
1962	309574	88372	89262	57661	6843	2726	3326	742	622	1259	132
1963	309158	186802	38226	27038	17709	2848	1133	1275	349	257	606
1964	318887	194545	79619	12310	7790	5865	1421	474	533	190	416
1965	124551	216527	111250	30262	3978	2658	2201	619	221	225	299
1966	303549	82231	141702	56993	11910	1538	1171	913	321	94	201
1967	311969	193075	43882	68767	24280	4669	692	568	445	164	140
1968	16240	233867	112617	22030	33937	12146	2175	364	300	231	158
1969	20621	10601	133867	52963	10717	15251	5625	1127	176	156	179
1970	196935	12184	6856	66679	24603	5939	7807	3006	644	96	200
1971	94394	124502	6742	4178	31865	12064	3271	4479	1671	380	162
1972	1102790	69667	72933	4450	3099	16630	6709	1949	2738	999	317
1973	317217	668499	39003	23649	1579	1631	7002	3011	918	1379	595
1974	71085	169222	296633	15188	10470	838	1189	3988	1677	545	1197
1975	60663	40102	87773	138331	6088	4691	376	638	1936	785	895
1976	65598	34018	17838	42303	72660	2821	2693	216	393	1038	929
1977	125133	34249	13652	6697	16925	29828	1102	1165	89	181	755
1978	214073	56760	10080	4365	3088	7469	14405	581	544	33	404
1979	151398	117247	23215	3163	2109	1492	4017	7010	350	265	207
1980	18899	97370	57120	8243	1040	1166	766	2203	3481	199	229
1981	9225	13938	59790	25715	3390	520	603	444	1239	1779	235
1982	16484	6058	10485	30590	10580	1622	271	348	295	731	1037
1983	9852	11472	4401	6767	13703	5448	983	146	211	196	898
1984	14518	5458	6710	2727	3911	8874	2578	593	78	126	602
1985	329518	9087	2853	3517	1973	2643	5470	1749	403	64	496
1986	458287	253882	5083	1663	1830	1020	1560	2902	1015	237	366
1987	83081	252430	134914	2454	727	730	474	771	1302	490	269
1988	38441	64725	140982	41541	1095	200	257	229	378	572	323
1989	31772	26653	46841	70146	11693	628	42	141	122	200	429
1990	39106	21939	17333	26767	33692	5167	529	48	95	78	341
1991	103256	26506	13412	13898	20041	20617	2937	380	42	66	232
1992	312998	86250	17156	10055	10829	12933	13892	1900	258	35	168
1993	848378	243098	60225	11731	6218	6628	8182	8668	1132	180	121
1994	295569	616291	145360	31069	4955	3150	4055	5207	5279	686	176
1995	79138	211435	422464	75076	15286	2056	1448	2244	2757	2884	459
1996	94320	62159	164824	226967	36884	7244	1252	800	1229	1537	1875
1997	96732	53743	38007	89386	97392	16527	2586	641	386	594	1687
1998	64801	77611	35300	21615	37549	40581	6012	1133	313	183	1149
1999	197387	49820	45086	19342	9800	15463	15235	2475	526	174	703
2000	81630	136241	28963	23861	7734	3667	6600	6743	1076	265	484
2001	347092	62846	82661	15888	10019	3145	2511	3795	3395	572	456
2002	355408	312871	45400	45788	8762	4798	1873	1482	2153	1786	528
2003	246548	263448	194193	33771	25178	4023	3567	1324	896	1275	1351
2004	220076	153886	156565	102791	17377	10935	2162	1903	759	466	1500
2005	353226	162996	90363	95789	47715	5985	5735	1330	903	423	1181
2006	163602	214317	96683	52932	46008	19500	3157	3023	688	443	791
2007	879343	128583	160919	58637	30213	19818	8314	1839	1612	378	624
2008	1251215	593613	105811	102296	25591	18922	7963	3862	1080	865	540
2009	1030019	848111	403505	64731	38895	10307	6655	3953	1894	691	869
2010	307787	790522	661967	233571	35646	15368	5386	3486	2096	1061	1029
2011	110337	202596	566178	390135	112441	13797	7453	2637	1802	1140	1317
2012	293014	71328	131023	345195	241502	54164	6785	3421	1336	971	1474
2013	106180	193760	53708	97185	238635	127259	23500	3667	1866	775	1490
2014	332329	73503	137563	51646	89110	142113	64786	11542	2050	1124	1356
2015	68172	290421	61717	88279	40914	65354	80299	31128	5740	1091	1283
2016	177353	39715	162841	49992	67352	33014	46098	41802	15027	2756	1139
2017	147786	152046	24757	87031	25083	34388	17925	21857	20183	6751	1664
2018	336138	115808	109135	23161	41136	13450	16480	7643	8864	8567	3406
2019	336138	231698	75011	57257	16735	18384	6254	6826	3166	3672	4960

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

Year	3	4	5	6	7	8	9	10	11	12	13
1950	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1951	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1952	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1953	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1954	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1955	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1956	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1957	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1958	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1959	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1960	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1961	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1962	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1963	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1964	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1965	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1966	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1967	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1968	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1969	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1970	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1971	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1972	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1973	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1974	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1975	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1976	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1977	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1978	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1979	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1980	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1981	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1982	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1983	0.353	0.261	0.239	0.236	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1984	0.22	0.228	0.225	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1985	0.211	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1986	0.63	0.273	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1987	0.2	0.21	0.388	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1988	0.381	0.2	0.222	0.363	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1989	0.204	0.2	0.2	0.243	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1990	0.337	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1991	0.2	0.22	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1992	0.212	0.21	0.216	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1993	0.259	0.254	0.296	0.279	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1994	0.281	0.219	0.25	0.219	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1995	0.346	0.322	0.308	0.229	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1996	0.711	0.304	0.234	0.265	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1997	0.485	0.243	0.206	0.231	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1998	0.242	0.284	0.233	0.204	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1999	0.212	0.225	0.24	0.252	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2000	0.216	0.228	0.212	0.273	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2001	0.215	0.2	0.202	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2002	0.323	0.227	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2003	0.404	0.257	0.223	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2004	0.415	0.268	0.2	0.215	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2005	0.413	0.289	0.2	0.204	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2006	0.222	0.218	0.223	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2007	0.311	0.202	0.245	0.26	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2008	0.389	0.305	0.267	0.352	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2009	0.441	0.273	0.309	0.245	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2010	0.37	0.278	0.317	0.319	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2011	0.551	0.502	0.374	0.255	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2012	0.618	0.329	0.201	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2013	0.513	0.345	0.244	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2014	0.292	0.209	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2015	0.372	0.444	0.211	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2016	0.315	0.2	0.265	0.289	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2017	0.353	0.291	0.224	0.39	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2018	0.429	0.275	0.231	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2019	0.429	0.275	0.231	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 4.15. Northeast Arctic haddock. Summary XSA (p-shrinkage not applied)
Wed May 22 14:47:48 2019

YEAR	RECR_a3	TOTBIO	TOTSPB	LANDINGS	YIELDSSB	SOPCOFAC	FBAR 4-7
1950	76656	234313	131580	132125	1.0041	1.5897	0.8652
1951	632805	338839	98204	120077	1.2227	1.2272	0.654
1952	71120	223913	55334	127660	2.3071	1.7404	0.7605
1953	1191820	477957	77602	123920	1.5969	1.4279	0.5462
1954	138033	500850	107937	156788	1.4526	1.474	0.4
1955	62457	456317	170331	202286	1.1876	1.536	0.5332
1956	195247	433516	222815	213924	0.9601	1.2623	0.4575
1957	60638	312422	181379	123583	0.6814	1.2455	0.4532
1958	80679	265315	153456	112672	0.7342	1.1252	0.5435
1959	379069	345838	127919	88211	0.6896	0.9405	0.3878
1960	279842	386132	111457	154651	1.3875	1.0411	0.51
1961	126095	376709	125565	193224	1.5388	0.9942	0.6642
1962	278911	330898	113156	187408	1.6562	1.0518	0.8368
1963	319522	296630	80006	146224	1.8277	1.1458	0.9038
1964	371407	284757	61393	99158	1.6151	1.3572	0.6855
1965	115788	334836	89622	118578	1.3231	1.1507	0.5188
1966	276029	361313	118841	161778	1.3613	1.1621	0.616
1967	339067	436932	144752	136397	0.9423	0.9984	0.4395
1968	21323	400431	163849	181726	1.1091	0.9976	0.5312
1969	19815	320703	174944	130820	0.7478	0.882	0.424
1970	193034	270439	148768	88257	0.5933	0.9762	0.3788
1971	116155	335710	166665	78905	0.4734	0.7638	0.2568
1972	1185095	591808	120823	266153	2.2028	1.0883	0.732
1973	322650	571776	109839	322226	2.9336	1.1656	0.5722
1974	65433	561646	188891	221157	1.1708	0.8946	0.4575
1975	57705	448529	232694	175758	0.7553	0.8957	0.4538
1976	65061	296885	201335	137264	0.6818	1.12	0.6013
1977	130645	225024	140560	110158	0.7837	1.09	0.7198
1978	203917	249630	129598	95422	0.7363	0.9219	0.5397
1979	164675	306596	128109	103623	0.8089	0.7684	0.5858
1980	31228	326123	130032	87889	0.6759	0.7568	0.4248
1981	13917	276226	142104	77153	0.5429	0.7174	0.4278
1982	16923	200375	121187	46955	0.3875	0.7224	0.3252
1983	9710	102857	70406	24600	0.3494	1.0373	0.2735
1984	12714	83954	64626	20945	0.3241	1.0547	0.2472
1985	281583	179889	61918	45052	0.7276	0.9761	0.3223
1986	525331	338672	61918	100563	1.6241	1.0484	0.447
1987	114301	321867	72702	154916	2.1308	0.992	0.627
1988	58068	247801	73117	95255	1.3028	0.9955	0.5325
1989	27154	205196	86342	58518	0.6777	0.9774	0.3923
1990	34682	175611	97951	27182	0.2775	1.0159	0.152
1991	98482	194419	111978	36216	0.3234	1.0374	0.2082
1992	193742	259714	124935	59922	0.4796	0.9797	0.294
1993	626895	419284	126490	82379	0.6513	1.0031	0.38
1994	325327	522832	143513	135186	0.942	1.0056	0.452
1995	108482	524967	163713	142448	0.8701	1.0247	0.3962
1996	102867	467558	202138	178128	0.8812	1.0175	0.4125
1997	114841	385083	206275	154359	0.7483	1.0519	0.4415
1998	71233	275741	152464	100630	0.66	1.0113	0.3872
1999	222065	270246	113796	83195	0.7311	1.021	0.3733
2000	118042	276387	106307	68944	0.6485	1.026	0.2362
2001	378944	388025	136432	89640	0.657	0.9903	0.2302
2002	362211	480755	158522	114798	0.7242	1.011	0.254
2003	270279	560283	199433	138926	0.6966	1.019	0.3485
2004	253945	565160	221817	158279	0.7136	1.0192	0.2878
2005	369805	632313	279242	158298	0.5669	1.0029	0.3385
2006	227707	608814	285805	153157	0.5359	0.9938	0.2735
2007	726300	716748	300838	161525	0.5369	0.9916	0.273
2008	1339523	1000952	314984	155604	0.494	0.9928	0.234
2009	1457159	1395840	379439	200061	0.5273	1.0019	0.1965
2010	601334	1626406	524641	249200	0.475	0.9994	0.1765
2011	256869	1679730	713064	309785	0.4344	0.9978	0.213
2012	429833	1636600	891007	315627	0.3542	0.9994	0.2152
2013	192610	1446766	930284	193744	0.2083	0.9967	0.1288
2014	390266	1336116	878576	177522	0.2021	0.9968	0.1045
2015	114789	1218838	830792	194756	0.2344	0.9953	0.138
2016	285074	1082192	738970	233183	0.3156	1.0006	0.18
2017	244619	873803	550062	227588	0.4137	0.994	0.2685
2018	485605	784760	406205	191276	0.4709	0.9943	0.2945

Table 4.16. Northeast Arctic haddock. Input data for recruitment prediction (RCT3)
NORTHEAST ARCTIC HADDOCK: recruits as 3 year-olds

yearclass	recruitment	NT1	NT2	NT3	NAK1	NAK2	NAK3	RT1	RT2	RT3	EC01	ECO2	ECO3
1990	866.3	NA	NA	NA	1890	868	563	NA	42.9	128.6	NA	NA	NA
1991	299.9	NA	NA	315.2	1135	626	348.7	16.7	28.2	35.7	NA	NA	NA
1992	80	NA	220.9	57.6	947	188	41.5	16.4	4.8	5.8	NA	NA	NA
1993	95.1	593.5	182.1	55.5	887.8	88.6	30	3.5	4.9	4.2	NA	NA	NA
1994	96.7	1393	245	80.9	1198	94.5	57.3	9.1	7.2	5.7	NA	NA	NA
1995	65.2	295.5	93.5	21.2	132.6	26.5	33.8	6.4	2.3	1.9	NA	NA	NA
1996	202	1069	196	57.1	508.9	151	83.7	6	4.6	11.5	NA	NA	NA
1997	82	239.2	79.8	24.1	211	30.1	36.4	1.8	2.9	6.1	NA	NA	NA
1998	352.1	1186	429.8	291.8	653.4	404.8	233.5	10.7	28.9	26.2	NA	NA	NA
1999	359.7	817	450	313.8	1063	266.1	255.2	11.7	20.7	26.1	NA	NA	NA
2000	250.9	1216	464.5	337.8	753	267.9	203.7	15.1	14.9	18.9	NA	NA	NA
2001	222.6	1652	481.3	174.9	1315	362.3	151	20.8	19.3	25.1	NA	NA	NA
2002	360.2	3254	707.3	315.7	2744	466.5	221.3	33.2	32.8	20.6	NA	NA	268
2003	165.6	705.1	369.6	78.8	529	144	56.3	19.8	11	13.6	NA	189	114
2004	900.9	4401	1297	459.1	2277	624.8	209.3	50	79.2	122.7	104	626	929
2005	1272.1	4879	1680	1579	2091	953.5	812.4	62	79.2	214.2	155	2270	1819
2006	1044.5	3654	2072	1237	2016	1754	883.7	53.4	83.9	232.7	283	988	1292
2007	311.5	831.1	329.1	96.1	778.4	209.1	128.1	6.5	12.7	15.8	114	322	144
2008	109.8	550	81.4	52.6	443.9	86	54.2	5.7	2.9	4.3	60	136	65
2009	291.3	1586	354.4	321.6	1559	288.3	191.6	10	19.7	21.7	169	274	114
2010	106.4	670.9	137.3	55.5	428.5	94.5	67.3	7.7	3.5	4.3	154	105	42
2011	334.3	1845	480.2	370.6	1583	407.2	324.5	14.7	30.6	28.3	213	591	223
2012	67.1	335.7	119.8	30.2	292.7	109	23.6	6.9	6	2.2	74	156	75
2013	178	1129	315.2	152.7	1704	224.4	68.5	33	10.2	10.2	163	265	145
2014	149.1	1072	509.2	127.5	1522	105.4	79.9	12	8.3	NA	183	320	84
2015	339.6	2203	734.6	312.6	1260	323.2	157.6	17.6	NA	24.2	343	538	189
2016	NA	4677	1598	1038	3264	760.5	490.6	NA	86.3	NA	496	936	NA
2017	NA	2690	1076	NA	2075	663.5	NA	33.8	NA	NA	931	NA	NA
2018	NA	1791	NA	NA	1473	NA	NA	NA	NA	NA	NA	NA	NA

Recr recruitment estimate from SAM 2019
RT1 Russian bottom trawl survey age 1
RT2 Russian bottom trawl survey age 2
RT3 Russian bottom trawl survey age 3
NT1 Norwegian bottom trawl survey age 1
NT2 Norwegian bottom trawl survey age 2
NT3 Norwegian bottom trawl survey age 3
NA1 Norwegian acoustic survey age 1
NA2 Norwegian acoustic survey age 2
NA3 Norwegian acoustic survey age 3
ECO1 Ecosystem survey age 1
ECO2 Ecosystem survey age 2
ECO3 Ecosystem survey age 3

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

Data for 12 surveys over 29 year classes : 1990 - 2018
Regression type = C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as 0.2
Minimum of 3 points used for regression
Forecast/Hindcast variance correction used.

yearclass:2012

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT1	1.1272	-2.45962	0.4163	0.8301	19	5.819	4.100	0.5324	0.043585
NT2	0.8998	0.26847	0.2911	0.9124	20	4.794	4.582	0.3545	0.098272
NT3	0.7652	1.60650	0.3461	0.8795	20	3.440	4.239	0.4374	0.064567
NAK1	1.3772	-3.82337	0.5795	0.7136	20	5.683	4.003	0.7378	0.022694
NAK2	0.9083	0.58152	0.3197	0.8912	20	4.700	4.851	0.3789	0.086050
NAK3	0.9788	0.66985	0.3991	0.8400	20	3.203	3.805	0.5317	0.043697
RT1	1.1795	2.38734	0.5549	0.7395	20	2.067	4.825	0.6541	0.028871
RT2	0.8146	3.30106	0.2551	0.9278	20	1.946	4.886	0.3019	0.135483
RT3	0.6799	3.51079	0.2023	0.9534	20	1.163	4.302	0.2558	0.188800
EC01	4.3907	-15.91572	1.9966	0.2140	8	4.317	3.041	2.7584	0.001623
ECO2	0.9957	-0.09227	0.3249	0.9062	9	5.056	4.942	0.4110	0.073128
ECO3	0.7067	1.97740	0.2025	0.9571	10	4.331	5.038	0.2504	0.197002
VPA Mean	NA	NA	NA	NA	22	NA	5.737	0.8724	0.016229

yearclass:2013

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT1	1.1108	-2.33608	0.3808	0.8702	20	7.030	5.473	0.4343	0.071862
NT2	0.9461	-0.03209	0.3086	0.9130	20	5.756	5.414	0.3523	0.109201
NT3	0.7700	1.57807	0.3323	0.8997	20	5.035	5.455	0.3791	0.094316
NAK1	1.3477	-3.61428	0.5258	0.7765	20	7.441	6.414	0.6130	0.036075
NAK2	1.0144	-0.07201	0.3774	0.8709	20	5.418	5.424	0.4307	0.073059
NAK3	0.9229	0.98310	0.3787	0.8701	20	4.241	4.897	0.4413	0.069612
RT1	1.3000	2.00089	0.6036	0.7311	20	3.526	6.585	0.7097	0.026911
RT2	0.9027	2.99200	0.3328	0.8966	20	2.416	5.173	0.3826	0.092580
RT3	0.6828	3.49866	0.1930	0.9627	20	2.416	5.148	0.2223	0.274327
EC01	3.6104	-11.97475	1.5452	0.3531	9	5.100	6.438	1.8853	0.003814
ECO2	1.1277	-0.94328	0.4213	0.8712	10	5.583	5.353	0.5025	0.053671
ECO3	0.8171	1.30861	0.3515	0.8993	11	4.984	5.380	0.4141	0.079064
VPA Mean	NA	NA	NA	NA	23	NA	5.630	0.9348	0.015510

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
NT1	1.1296	-2.4990	0.3666	0.8724	20	6.978	5.384	0.4185	0.106121
NT2	0.9556	-0.1040	0.3056	0.9097	20	6.235	5.854	0.3493	0.152336
NT3	0.7820	1.4912	0.3307	0.8952	20	4.856	5.288	0.3783	0.129831
NAK1	1.4400	-4.3626	0.6471	0.6846	20	7.328	6.190	0.7465	0.033351
NAK2	1.0406	-0.2472	0.3665	0.8712	20	4.667	4.609	0.4354	0.098042
NAK3	0.9080	1.0808	0.3688	0.8698	20	4.393	5.070	0.4253	0.102765
RT1	1.4026	1.5897	0.7603	0.6176	20	2.565	5.187	0.8706	0.024519
RT2	0.9060	2.9824	0.3223	0.8974	20	2.230	5.003	0.3731	0.133521
RT3	NA	NA	NA	NA	NA	NA	NA	NA	NA
EC01	3.8008	-13.0625	1.5794	0.3173	10	5.215	6.759	1.9172	0.005056
ECO2	1.1386	-1.0265	0.4036	0.8689	11	5.771	5.545	0.4737	0.082813
ECO3	0.8288	1.2296	0.3471	0.8937	12	4.443	4.912	0.4126	0.109166
VPA Mean	NA	NA	NA	NA	24	NA	5.592	0.9093	0.022478

yearclass:2015

```
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
      NT1 1.1605   -2.7559 0.3634  0.8685 20   7.698      6.178  0.4220    0.082016
      NT2 1.0082   -0.4852 0.4057  0.8438 20   6.601      6.170  0.4706    0.065947
      NT3 0.7969    1.3875 0.3305  0.8899 20   5.748      5.968  0.3800    0.101150
     NAK1 1.5603   -5.3117 0.7609  0.5989 20   7.140      5.829  0.8693    0.019325
     NAK2 1.0259   -0.1407 0.3577  0.8711 20   5.781      5.791  0.4087    0.087420
     NAK3 0.9070    1.0816 0.3533  0.8739 20   5.066      5.677  0.4029    0.089989
      RT1 1.4368    1.4699 0.7473  0.6125 20   2.923      5.670  0.8519    0.020124
      RT2     NA        NA     NA      NA NA      NA         NA      NA          NA
      RT3 0.6742    3.5332 0.1747  0.9684 19   3.227      5.709  0.2017    0.359071
     EC01 4.1765  -15.1186 1.7405  0.2578 11   5.841      9.275  2.4094    0.002516
     ECO2 1.1791   -1.3155 0.4314  0.8416 12   6.290      6.101  0.5093    0.056303
     ECO3 0.8291    1.2382 0.3351  0.8938 13   5.247      5.588  0.3869    0.097571
 VPA Mean     NA        NA     NA      NA 25      NA      5.531  0.8869    0.018569
yearclass:2016
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
      NT1 1.1497   -2.7132 0.3458  0.8714 20   8.451      7.003  0.4346    0.132074
      NT2 0.9987   -0.4570 0.4030  0.8355 20   7.377      6.910  0.4991    0.100169
      NT3 0.7932    1.3919 0.3148  0.8921 20   6.946      6.901  0.3916    0.162657
     NAK1 1.5633   -5.3519 0.7300  0.6015 20   8.091      7.297  0.9167    0.029687
     NAK2 1.0328   -0.1782 0.3401  0.8743 20   6.635      6.675  0.4122    0.146868
     NAK3 0.9069    1.0946 0.3388  0.8752 20   6.198      6.715  0.4123    0.146798
      RT1     NA        NA     NA      NA NA      NA         NA      NA          NA
      RT2 0.9127    2.9645 0.3195  0.8960 19   4.469      7.044  0.4114    0.147428
      RT3     NA        NA     NA      NA NA      NA         NA      NA          NA
     EC01 3.6146  -12.6493 1.7049  0.2424 12   6.209      9.792  2.4328    0.004215
     ECO2 1.1711   -1.2996 0.4139  0.8378 13   6.843      6.714  0.5098    0.096009
     ECO3     NA        NA     NA      NA NA      NA         NA      NA          NA
 VPA Mean     NA        NA     NA      NA 26      NA      5.533  0.8554    0.034095
yearclass:2017
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
      NT1 1.1490   -2.7151 0.3352  0.8783 19   7.898      6.359  0.4020    0.309083
      NT2 0.9993   -0.4641 0.4122  0.8288 19   6.982      6.513  0.5000    0.199791
      NT3     NA        NA     NA      NA NA      NA         NA      NA          NA
     NAK1 1.5570   -5.3259 0.7347  0.5992 19   7.638      6.567  0.8828    0.064103
     NAK2 1.0358   -0.1955 0.3400  0.8747 19   6.499      6.536  0.4146    0.290698
     NAK3     NA        NA     NA      NA NA      NA         NA      NA          NA
      RT1 1.4875    1.3353 0.7485  0.5937 19   3.550      6.615  0.9021    0.061384
      RT2     NA        NA     NA      NA NA      NA         NA      NA          NA
      RT3     NA        NA     NA      NA NA      NA         NA      NA          NA
     EC01 3.4367  -11.8035 1.6201  0.2590 12   6.837     11.694  2.8388    0.006199
     ECO2     NA        NA     NA      NA NA      NA         NA      NA          NA
     ECO3     NA        NA     NA      NA NA      NA         NA      NA          NA
 VPA Mean     NA        NA     NA      NA 26      NA      5.505  0.8525    0.068742
yearclass:2018
    index slope intercept     se rsquare  n indices prediction se.pred WAP.weights
      NT1 1.146    -2.701 0.3261  0.8834 18   7.491      5.884  0.3860      0.7132
      NT2    NA        NA     NA      NA NA      NA         NA      NA          NA
      NT3    NA        NA     NA      NA NA      NA         NA      NA          NA
     NAK1 1.543    -5.249 0.7401  0.5946 18   7.296      6.011  0.8773      0.1381
     NAK2    NA        NA     NA      NA NA      NA         NA      NA          NA
     NAK3    NA        NA     NA      NA NA      NA         NA      NA          NA
      RT1    NA        NA     NA      NA NA      NA         NA      NA          NA
      RT2    NA        NA     NA      NA NA      NA         NA      NA          NA
      RT3    NA        NA     NA      NA NA      NA         NA      NA          NA
     EC01    NA        NA     NA      NA NA      NA         NA      NA          NA
     ECO2    NA        NA     NA      NA NA      NA         NA      NA          NA
     ECO3    NA        NA     NA      NA NA      NA         NA      NA          NA
 VPA Mean    NA        NA     NA      NA 26      NA      5.471  0.8454      0.1487
```

```
                 WAP logWAP int.se
yearclass:2012 103.8  4.643 0.1111
yearclass:2013 212.8  5.361 0.1164
yearclass:2014 196.3  5.279 0.1363
yearclass:2015 338.9  5.826 0.1209
```

```
yearclass:2016 930.1  6.835 0.1580
yearclass:2017 629.3  6.445 0.2235
yearclass:2018 343.9  5.840 0.3260
```

Table 4.18. Northeast Arctic haddock. Prediction with management option table: Input data (based on SAM estimates

MFDP version 1a
Run: 2019
Time and date: 07:55 23.05.2019
Fbar age range: 4-7

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	930100	0.366	0.029	0	0	0.309	0.052	0.859
4	231698	0.255	0.091	0	0	0.554	0.178	1.085
5	75011	0.240	0.278	0	0	0.926	0.330	1.362
6	57257	0.293	0.595	0	0	1.397	0.433	1.652
7	16735	0.2	0.785	0	0	1.638	0.571	1.908
8	18384	0.200	0.930	0	0	2.294	0.648	2.130
9	6254	0.200	0.972	0	0	2.553	0.692	2.310
10	6826	0.200	0.991	0	0	3.089	0.692	2.544
11	3166	0.200	1.000	0	0	3.066	0.692	2.841
12	3672	0.200	1.000	0	0	3.066	0.692	3.013
13	4960	0.200	1.000	0	0	3.066	0.692	3.458

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	629300	0.366	0.028	0	0	0.298	0.052	0.859
4	.	0.255	0.092	0	0	0.558	0.178	1.085
5	.	0.24	0.25	0	0	0.86	0.330	1.362
6	.	0.293	0.556	0	0	1.287	0.433	1.652
7	.	0.200	0.812	0	0	1.801	0.571	1.908
8	.	0.200	0.915	0	0	2.024	0.648	2.130
9	.	0.200	0.975	0	0	2.699	0.692	2.310
10	.	0.200	0.990	0	0	2.947	0.692	2.544
11	.	0.200	1.000	0	0	3.469	0.692	2.841
12	.	0.200	1.000	0	0	3.469	0.692	3.013
13	.	0.200	1.000	0	0	3.469	0.692	3.458

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	343900	0.366	0.039	0	0	0.376	0.052	0.859
4	.	0.255	0.088	0	0	0.543	0.178	1.085
5	.	0.240	0.253	0	0	0.868	0.330	1.362
6	.	0.293	0.523	0	0	1.202	0.433	1.652
7	.	0.200	0.791	0	0	1.668	0.571	1.908
8	.	0.200	0.926	0	0	2.207	0.648	2.13
9	.	0.200	0.969	0	0	2.412	0.692	2.31
10	.	0.200	0.991	0	0	3.097	0.692	2.544
11	.	0.200	1	0	0	3.325	0.692	2.841
12	.	0.200	1	0	0	3.325	0.692	3.013
13	.	0.200	1	0	0	3.325	0.692	3.458

Table 4.19. Northeast Arctic haddock. Prediction with management option table for 2019-2021 (TAC constraint applied for intermediate year)

MFDP version 1a
Run: 2019
2019MFDP Index file 23.05.2019
Time and date: 07:55 23.05.2019
Fbar age range: 4-7

2019				
Biomass	SSB	FMult	FBar	Landings
708019	220245	0.9084	0.3434	172000

2020					2021	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
845706	216384	0	0	0	1097902	363570
.	216384	0.1	0.0378	28319	1075083	350302
.	216384	0.2	0.0756	55745	1053100	337660
.	216384	0.3	0.1134	82316	1031913	325611
.	216384	0.4	0.1512	108068	1011486	314122
.	216384	0.5	0.189	133038	991782	303165
.	216384	0.6	0.2268	157256	972768	292710
.	216384	0.7	0.2646	180756	954414	282731
.	216384	0.8	0.3024	203566	936688	273203
.	216384	0.9	0.3402	225716	919562	264102
.	216384	1	0.378	247231	903011	255407
.	216384	1.1	0.4158	268137	887007	247096
.	216384	1.2	0.4536	288459	871527	239149
.	216384	1.3	0.4914	308220	856549	231548
.	216384	1.4	0.5292	327442	842050	224275
.	216384	1.5	0.567	346145	828009	217314
.	216384	1.6	0.6048	364350	814408	210648
.	216384	1.7	0.6426	382076	801228	204262
.	216384	1.8	0.6804	399340	788451	198144
.	216384	1.9	0.7182	416160	776061	192278
.	216384	2	0.756	432552	764041	186654

Table 4.20. Northeast Arctic haddock. Prediction single option table for 2019-2021 based on HCR

MFDP version 1a
Run: HCR
Time and date: 08:33 23.05.2019
Fbar age range: 4-7

Year:	2019	F multiplier:	0.9084	Fbar:	0.3434				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan	SSB(Jan	SSNos(ST	SSB(ST
3	0.0472	35989	30914	930100	287401	26973	8335	26973	8335
4	0.1617	30639	33243	231698	128361	21085	11681	21085	11681
5	0.2998	17377	23667	75011	69460	20853	19310	20853	19310
6	0.3933	16295	26919	57257	79988	34068	47593	34068	47593
7	0.5187	6191	11813	16735	27412	13137	21518	13137	21518
8	0.5886	7486	15945	18384	42173	17097	39221	17097	39221
9	0.6286	2673	6174	6254	15966	6079	15519	6079	15519
10	0.6286	2917	7422	6826	21086	6765	20896	6765	20896
11	0.6286	1353	3844	3166	9707	3166	9707	3166	9707
12	0.6286	1569	4728	3672	11258	3672	11258	3672	11258
13	0.6286	2120	7330	4960	15207	4960	15207	4960	15207
Total		124609	172000	1354063	708019	157854	220245	157854	220245
Year:	2020	F multiplier:	0.8513	Fbar:	0.3218				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0443	22849	19628	629300	187531	17620	5251	17620	5251
4	0.1515	76604	83116	615266	343319	56604	31585	56604	31585
5	0.2809	33443	45550	152740	131357	38185	32839	38185	32839
6	0.3686	11789	19476	43722	56271	24310	31287	24310	31287
7	0.4861	10138	19344	28824	51912	23405	42153	23405	42153
8	0.5516	3163	6737	8156	16509	7463	15105	7463	15105
9	0.5891	3404	7863	8355	22550	8146	21986	8146	21986
10	0.5891	1113	2830	2731	8048	2704	7967	2704	7967
11	0.5891	1214	3450	2981	10340	2981	10340	2981	10340
12	0.5891	563	1697	1382	4796	1382	4796	1382	4796
13	0.5891	1536	5310	3769	13075	3769	13075	3769	13075
Total		165817	215000	1497227	845706	186569	216384	186569	216384
Year:	2021	F multiplier:	0.9259	Fbar:	0.35				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
3	0.0481	13558	11646	343900	129306	13412	5043	13412	5043
4	0.1648	56195	60972	417524	226716	36742	19951	36742	19951
5	0.3056	96496	131427	409744	355657	103665	89981	103665	89981
6	0.4009	26229	43330	90724	109050	47449	57033	47449	57033
7	0.5287	8471	16162	22562	37633	17847	29768	17847	29768
8	0.6	5995	12768	14514	32033	13440	29663	13440	29663
9	0.6407	1667	3851	3847	9278	3727	8990	3727	8990
10	0.6407	1645	4184	3795	11754	3761	11648	3761	11648
11	0.6407	538	1527	1241	4125	1241	4125	1241	4125
12	0.6407	587	1768	1354	4502	1354	4502	1354	4502
13	0.6407	1014	3507	2340	7781	2340	7781	2340	7781
Total		212393	291143	1311545	927837	244978	268486	244978	268486

Table 4.21. Northeast Arctic haddock. Yield-per-recruit. Input data and results.

MFYPR version 2a
Run: 2019
Time and date: 09:24 23.05.2019
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	4.3935	6.3615	2.1395	4.9413	2.1395	4.9413
0.1	0.0516	0.1155	0.2404	3.8392	4.8276	1.6172	3.4511	1.6172	3.4511
0.2	0.1031	0.188	0.3638	3.498	3.9323	1.3061	2.5959	1.3061	2.5959
0.3	0.1547	0.2392	0.4359	3.2626	3.3479	1.0987	2.0483	1.0987	2.0483
0.4	0.2063	0.2781	0.4824	3.0875	2.9373	0.9502	1.6718	0.9502	1.6718
0.5	0.2578	0.3091	0.5145	2.9506	2.6334	0.8382	1.3994	0.8382	1.3994
0.6	0.3094	0.3348	0.5382	2.8393	2.3994	0.7506	1.1947	0.7506	1.1947
0.7	0.3609	0.3567	0.5563	2.7463	2.2136	0.6801	1.0362	0.6801	1.0362
0.8	0.4125	0.3757	0.5707	2.6669	2.0623	0.622	0.9105	0.622	0.9105
0.9	0.4641	0.3924	0.5825	2.5978	1.9366	0.5733	0.8087	0.5733	0.8087
1	0.5156	0.4074	0.5923	2.5369	1.8304	0.5317	0.725	0.5317	0.725
1.1	0.5672	0.421	0.6007	2.4826	1.7393	0.4959	0.655	0.4959	0.655
1.2	0.6188	0.4333	0.6079	2.4337	1.6601	0.4647	0.5959	0.4647	0.5959
1.3	0.6703	0.4446	0.6143	2.3892	1.5907	0.4373	0.5454	0.4373	0.5454
1.4	0.7219	0.4551	0.6198	2.3486	1.5291	0.4129	0.5017	0.4129	0.5017
1.5	0.7735	0.4648	0.6248	2.3112	1.4742	0.3911	0.4637	0.3911	0.4637
1.6	0.825	0.4738	0.6292	2.2766	1.4247	0.3716	0.4304	0.3716	0.4304
1.7	0.8766	0.4823	0.6332	2.2445	1.3799	0.3539	0.401	0.3539	0.401
1.8	0.9281	0.4903	0.6368	2.2145	1.3391	0.3379	0.3749	0.3379	0.3749
1.9	0.9797	0.4978	0.6402	2.1864	1.3018	0.3233	0.3515	0.3233	0.3515
2	1.0313	0.5049	0.6432	2.16	1.2674	0.3099	0.3305	0.3099	0.3305
Reference point	F multi|	Absolute F							
Fbar(3-13)	1	0.5156							
FMax	>=1000000								
F0.1	0.4269	0.2201							
F35%SPR	0.3823	0.1971							

Table B1. HADDOCK. Abundance indices from bottom trawl surveys in the Barents Sea winter 1981-2018 (numbers in millions). 1981-1992 includes only main areas A, B, C and D.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	10+	Total	Biomass
1981	7	14	5	21	60	18	1	+	+							+	126	166
1982	9	2	3	4	4	10	6	+	+							+	36	50
1983	0	5	2	3	1	1	4	2	+							+	18	25
1984	1685	173	6	2	1	+	+	+	+							+	1867	101
1985	1530	776	215	5	+	+	+	+	+							+	2526	259
1986	556	266	452	189	+	+	+	+	+							+	1463	333
1987	85	17	49	171	50	+	+	+	0							+	372	157
1988	18	4	8	23	46	7	+	0	0							+	106	56
1989	52	5	6	11	20	21	2	0	0							0	117	49
1990	270	35	3	3	4	7	11	2	+							+	335	51
1991	1890	252	45	8	3	3	3	6	+							0	2210	166
1992	1135	868	134	23	2	+	+	1	2							+	2165	239
1993	947	626	563	130	13	+	+	+	+							3	2282	385
1994	593.50	220.90	315.20	427.90	48.30	3.39	0.14	0.17	0.16	0.14	0.45	0.04	0.00	0.00	0.00	0.63	1610.4	402.5
1995	#######	182.10	57.60	163.00	338.40	28.80	1.87	0.03	0.04	0.04	0.00	0.25	0.11	0.00	0.00	0.40	2165.1	435.7
1996	295.50	245.00	55.50	32.50	161.00	250.90	18.30	1.11	0.00	0.01	0.00	0.03	0.03	0.00	0.00	0.07	1059.9	453.3
1997*	#######	93.50	80.90	39.60	18.20	61.40	87.30	3.22	0.08	0.00	0.00	0.00	0.03	0.02	0.00	0.05	1452.8	284.5
1998*	239.20	196.00	21.20	36.10	12.80	3.24	8.15	5.94	0.56	0.03	0.02	0.00	0.00	0.00	0.05	0.10	523.3	85.2
1999	#######	79.80	57.10	15.60	9.36	2.87	0.86	1.30	0.74	0.01	0.00	0.02	0.00	0.00	0.00	0.03	1354.2	85.5
2000	817.00	429.80	24.10	35.80	6.91	4.05	0.65	0.01	0.81	0.24	0.03	0.03	0.01	0.00	0.00	0.31	1319.5	123.3
2001	#######	450.00	291.80	26.10	22.70	1.73	0.78	0.06	0.06	0.05	0.16	0.10	0.02	0.00	0.01	0.34	2009.1	226.6
2002	#######	464.50	313.80	186.80	11.90	8.43	0.86	0.19	0.00	0.10	0.15	0.04	0.04	0.00	0.00	0.33	2638.9	307
2003	#######	481.30	337.80	175.10	72.30	5.04	1.73	0.12	0.09	0.09	0.09	0.01	0.01	0.00	0.00	0.20	4328.1	408.3
2004	705.10	707.30	174.90	99.30	77.70	50.90	7.37	0.89	0.13	0.04	0.05	0.04	0.04	0.07	0.00	0.24	1824.2	307.5
2005	#######	369.60	315.70	140.10	50.90	61.70	10.20	0.25	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.01	5349.5	427.1
2006**	#######	#######	78.80	129.80	45.50	22.60	15.90	3.20	0.09	0.14	0.00	0.04	0.00	0.00	0.07	0.25	6470.4	449.1
2007*	#######	#######	459.10	81.00	84.80	26.10	5.38	2.23	1.35	0.77	0.07	0.00	0.00	0.00	0.03	0.87	5995	677.3
2008	831.10	#######	#######	581.30	52.90	54.00	7.05	10.60	0.16	0.04	0.08	0.05	0.00	0.00	0.00	0.17	5189.1	1099.2
2009	550.00	329.10	#######	760.10	372.30	25.80	12.30	0.85	0.09	0.34	0.00	0.01	0.00	0.00	0.00	0.35	3288.1	986.5
2010	#######	81.40	96.10	492.80	454.60	149.40	7.80	0.99	0.35	0.42	0.03	0.02	0.00	0.00	0.00	0.47	2870.5	760.6
2011	670.90	354.40	52.60	125.70	472.50	293.60	66.30	1.45	1.11	0.00	0.00	0.14	0.03	0.00	0.00	0.17	2038.6	834.4
2012**	#######	137.30	321.60	29.10	76.10	270.90	156.40	24.50	2.64	0.31	0.04	0.07	0.00	0.00	0.00	0.42	2863.7	747.2
2013	335.70	480.20	55.50	146.00	20.90	34.20	193.80	68.60	6.00	0.08	0.00	0.00	0.00	0.00	0.00	0.08	1340.9	602.3
2014	#######	119.80	370.60	30.30	100.40	21.90	46.50	95.20	40.00	1.52	0.46	0.00	0.00	0.02	0.00	2.00	1955.7	631.3
2015	#######	315.20	30.20	176.70	44.10	35.60	13.60	18.30	27.70	7.76	0.28	0.13	0.00	0.00	0.00	8.17	1741.2	373.2
2016	#######	509.20	152.70	32.90	105.80	19.60	40.00	10.30	27.50	24.70	4.04	0.92	0.00	0.14	0.06	29.86	3130.8	518.8
2017**	#######	734.60	127.50	95.80	4.32	45.10	8.72	13.00	1.20	8.02	5.94	3.18	0.72	0.00	0.00	17.86	5742.8	485.2
2018	2690.3	1608.3	321.2	84	61	5.57	11.9	2.75	2.01	1.33	3.95	3.46	0.82	0.13	0	9.69	4796.8	497.6
2019	1791	1076.2	1038.3	179.7	45.9	15.8	3.78	2.79	0.69	0.97	0.14	0.29	0.17	0.01	0.03	1.61	4155.8	567.4

Table B2 Northeast Arctic haddock. Results from the Russian trawl survey (RU-BTr-Q4) in the Barents Sea and adjacent waters in late autumn (numbers per hour trawling).

Year \Age	0	1	2	3	4	5	6	7	8	9	10+	Total
					Sub-area I							
1983	39.9	97.3	16.5	0.8	0.7	+	-	-	-	-	1.1	156.3
1984	9.7	100.2	110.6	2.8	0.4	0.2	+	-	-	-	0.7	224.6
1985	3.9	19.1	213.4	168.8	0.8	0.2	0.1	-	-	-	0.3	406.6
1986	0.2	2.3	16.6	58.1	27.6	0.1	+	+	+	-	-	105
1987	0.4	1.4	2.5	12.5	34.2	8.6	+	+	-	+	-	59.8
1988	1.9	0.4	1.1	2.8	6.2	11.6	1.1	+	+	+	-	25.2
1989	3.3	3	3.6	0.7	2.5	7.1	13.9	1.8	0.1	+	-	36
1990	71.7	22.2	18.6	13.2	7.5	13.2	13.3	10.3	0.6	0.1	-	170.7
1991	15.9	61.5	27.5	10.8	1.6	0.6	1	3.3	2.6	0.3	-	125.1
1992	19.6	44.2	180.6	52.1	8.4	0.7	1	1.6	1.3	0.2	-	309.7
1993	5.5	8.1	69.2	371.5	78.4	10.2	1.4	0.7	0.8	1.8	-	547.7
1994	13.5	6.7	8	65.9	146	15.9	1.7	0.1	0.2	0.7	-	258.8
1995	9.9	12.7	6.5	4	26.8	77.6	7.3	1	0.1	0.5	-	146.3
1996 (1	5	3.1	5.6	3.4	7.7	62.3	56.5	4.8	0.4	0.6	-	149.3
1997 (1	2.7	6.9	3.2	5.3	5.5	1.5	4.5	1.7	1.5	-	-	32.7
1998	10.5	2.9	17.2	6.7	7.8	0.6	0.9	2.1	0.7	+	-	49.4
1999	6.9	34.9	8.8	34	5.3	5.6	1.2	0.3	0.9	0.3	-	98.2
2000	18	25.4	37.5	9.3	13	3.2	1.1	0.2	0.1	0.4	-	108.3
2001	30.5	18.6	42.3	58.9	5.8	6.8	0.8	0.5	0.1	0.1	-	164.5
2002 (2	39.7	29.2	29.4	69.2	74.7	6.7	3.2	0.6	0.1	0.2	-	252.7
2003	28.1	38.9	35.4	28.1	43	28	3.5	0.8	0.1	0.1	-	206
2004	47.9	12	27.9	18.6	12.8	16.1	12.4	0.8	0.3	0.1	-	148.9
2005	62.7	109.6	20.7	34.4	12.4	6.5	7.1	2.5	0.1	0.1	-	256.1
2006 (3	48	168.7	157.9	15.2	25.5	7.3	3.1	2.7	0.8	0.2	-	429.4
2007	4.3	90.2	153.6	98.7	9.1	9	2.3	0.7	0.4	0.1	-	368.5
2008	5.9	14.6	284.4	283.4	153	17.2	11.8	1.5	0.3	0.3	-	772.5
2009	14.7	3.2	25.2	243.8	264.8	102.5	8.8	4.3	0.6	0.4	-	668.4
2010	6.6	25.6	4.7	46.2	223.3	204.5	60	2.4	1.2	0.3	-	574.8
2011	16.7	4.8	32.1	6.6	37.9	127.1	96.9	20.9	1.2	0.4	-	344.6
2012	7.6	32.3	6.2	29.6	7.3	23	92.9	63.4	8	0.8	-	271.1
2013	14.1	4.7	38.2	9.8	26	8.1	13.3	35.2	25.2	4.1	-	178.6
2014	9	10.6	2.7	29.3	6.5	24	8.4	19.3	40.2	14.7	-	164.5
2015	16.2	7.3	13.1	2.8	27	5.5	10.9	3.8	8.2	12	-	106.7
2016 (4	-	-	-	-	-	-	-	-	-	-	-	-
2017	43.5	134.8	37.2	11.3	15	1.3	3.7	0.7	0.9	1.8		250.1
2018 (4	-	-	-	-	-	-	-	-	-	-	-	-
					Division IIa							
1983	5.4	5.5	0.1	0.2	0.3	0.1	-	-	-	-	1	12.6
1984	4.9	14.4	5.6	0.1	0.1	0.1	-	-	-	-	0.2	25.4
1985	3.8	7	11.7	4.1	0.1	-	+	-	-	-	0.1	26.8
1986	0.4	0.3	3.5	10.4	2.9	0.1	+	+	-	-	-	17.6
1987	-	-	-	-	0.3	0.3	-	-	-	-	-	0.6
1988	1	0.1	-	+	0.2	0.5	0.2	-	-	-	-	2.1
1989	0.1	0.7	2.7	+	0.1	0.1	0.1	-	-	-	-	3.8
1990	6.1	0.9	0.9	0.1	0.1	0.1	0.1	0.1	-	-	-	8.4
1991	5.7	3.8	0.6	0.1	+	-	-	-	-	-	-	10.2
1992	1.2	2.3	5.6	2.3	3	0.3	0.3	0.4	0.4	-	-	15.8
1993	1.8	1.1	1.5	4.5	2.5	0.8	0.2	0.1	0.2	0.2	-	12.8
1994	1	0.6	0.5	3.1	15.9	4.4	1.5	+	0.1	0.1	-	27.2
1995	5	8.5	6.3	5.3	6.2	23.9	4.1	0.6	+	0.2	-	60.1
1996 (1	29.2	4.1	25	8.1	4.9	9.1	13.4	1.3	0.4	0.1	-	95.7
1997 (1	1.2	2.8	0.8	1.3	0.7	0.6	0.9	0.5	0.1	-	-	8.9
1998	23.2	7.8	15.5	1.1	2.4	3.2	0.5	2.8	0.8	0.1	-	57.3
1999	34.8	34.1	4.3	16.9	3.9	6.3	1.7	0.9	1.2	0.5	-	104.6
2000	27.9	23.9	13.5	1.8	9.3	2	0.9	0.2	0.2	0.4	-	80.1
2001	39	13.5	7.6	8.4	2.2	7.9	1.4	0.3	0.1	0.4	-	80.8
2002 (2	61.9	16.6	5.3	10.2	29.9	6	3.3	0.3	0.1	0.2	-	133.7
2003	20.6	30.8	9.8	8.3	10.4	16.1	2.4	2.1	0.2	+	-	100.7
2004	100.2	32.8	18.1	4.5	5.5	7.2	8.1	0.7	1.1	0.3	-	178.4
2005	61.6	23.9	4.6	10.9	2.1	2.7	5.3	2.9	0.5	0.2	-	114.6
2006 (3	33.3	36.9	15.2	1.9	8.2	3.4	2.5	1.8	1.8	0.3	-	105.5
2007	28.2	96	33.9	14.1	2.1	5.1	2.2	0.6	0.9	0.4	-	183.4
2008	13.6	23.8	64.3	26.8	9.6	1.8	2.6	0.4	0.3	0.3	-	143.6
2009	8.6	5.7	7.6	34.5	23.2	9.2	1.2	1.7	0.2	0.1	-	91.9
2010	19.9	31.2	9.6	7.4	29.3	22.3	10.8	1	1.1	0.2	-	132.8
2011	13.6	2.2	8.2	1.8	1.7	20	16.4	4.3	0.2	0.4	-	68.8
2012	14.1	24.6	1.9	9.1	3	5	13.4	11.5	1.5	0.3	-	84.6
2013	24.8	8.1	9.1	2.4	7.9	2.4	4.7	31.6	17.7	5.8	-	114.4
2014	34.8	11	1.3	7.8	0.6	3.9	0.7	2.6	5.7	2.6	-	71.2
2015	16.2	9.4	3.7	0.3	6.5	1.4	2.1	1.5	1.6	4.1	-	46.8
2016 (4	-	-	-	-	-	-	-	-	-	-	-	-
2017	1.8	2.4	1.1	0.8	1.6	0.2	0.9	0.2	0.3	0.3		9.3
2018 (4	-	-	-	-	-	-	-	-	-	-	-	-

Table B2. (Continuation)

Division IIb												
1983	22.1	9.9	0.2	0.1	+	+	-	-	-	-	0.1	32.4
1984	2.2	14.3	1.8	-	-	-	-	-	-	-	+	18.3
1985	1.4	10.2	61.4	5.1	+	+	+	-	-	-	+	78.1
1986	+	0.2	3.1	7.2	1.4	-	+	-	-	-	-	12
1987	-	-	0.1	0.7	1.4	0.5	+	-	-	-	-	2.8
1988	0.2	-	-	+	0.3	1.1	0.2	-	+	-	-	1.8
1989	0.7	0.1	0.2	+	0.1	0.3	0.6	0.1	+	-	-	2.1
1990	12.9	5.4	0.8	+	+	0.2	0.1	0.1	+	-	-	19.5
1991	20	22.9	6.2	0.4	0.1	0.1	0.1	+	+	-	-	49.8
1992	13.3	9.1	69.8	13.9	0.5	+	+	-	+	+	-	106.6
1993	0.7	0.9	1.9	24.7	1.9	0.2	+	+	+	+	-	30.4
1994	0.4	1.7	1.7	2.3	15.7	2.7	0.8	0.2	+	+	-	25.5
1995	0.1	0.4	0.4	0.8	0.6	1.6	0.4	+	+	+	-	4.3
1996 (1	4.3	0.6	0.5	0.3	0.2	0.4	0.5	0.3	-	-	-	7.1
1997 (1	0.4	1.1	0.1	0.1	0.1	0.1	0.1	0.1	+	+	-	2.1
1998	5.8	1.1	0.2	+	0.1	0.1	+	0.1	+	-	-	7.5
1999	8.6	20.1	1.8	1.2	0.5	0.3	0.1	-	0.2	0.1	-	32.9
2000	7.9	10	13.4	1.3	5.5	2.2	1.2	0.4	0.2	0.3	-	42.4
2001	2.7	13.1	15.9	11.4	0.8	4.7	1.2	0.4	0.1	0.6	-	51
2002 (2	9	4.2	7.7	5.1	2.6	0.7	0.8	0.1	0.1	0.1	-	30.4
2003	3.6	21.5	10.4	15.5	11.3	15.9	3.6	3	0.4	0.3	-	85.7
2004	34.9	5.6	6.4	1.3	2.6	1.8	2.9	0.1	0.2	0.1	-	56
2005	60.9	43.5	4.1	10.3	4.1	2.7	3.6	2.2	0.1	0.3	-	131.7
2006 (3	75.4	110.6	71.6	4.6	6.1	2.4	1.4	2	1.8	0.3	-	276.2
2007	3.3	67.3	396.4	78.7	5.5	26	7.3	2.9	2.6	0.8	-	590.9
2008	1.5	3.8	204.1	304.3	50.7	7.4	13.6	2.9	2	0.7	-	591.9
2009	2.6	1.1	3.5	93.6	81	22	2.4	2.1	0.3	0.5	-	209
2010	4.3	4.5	1.3	11.1	136.5	138.4	38.6	6.3	1.7	0.6	-	343.2
2011	10.8	1.2	4.3	1.7	12	100.8	60.5	11.5	0.5	0.3	-	203.7
2012	3.1	29.2	1.4	8	0.7	6.3	51.5	30.8	4.9	0.3	-	136.2
2013	64.2	7.1	19.9	1.8	8.1	1.1	8.2	42.8	22	3.3	-	178.3
2014	5.6	8.4	1.2	24.3	2	7.5	1.6	6.9	15.3	9.8	-	82.7
2015	21.8	8.3	7.6	2	12.2	2.2	3.7	1.4	4.7	10.3	-	74.3
2016 (4	-	-	-	-	-	-	-	-	-	-	-	-
2017	22.3	21.6	7	1.4	3	0.4	4.4	0.6	0.6	2.1		63.4
Total-Sub-area I and Divisions IIa and IIb												
1983	29.8	59.2	9.5	0.5	0.4	+	-	-	-	-	0.8	100.2
1984	6.4	58.6	58.4	1.5	0.2	0.1	+	-	-	-	0.3	125.5
1985	3	14.4	134.3	90	0.4	0.1	0.1	-	-	-	0.2	242.7
1986	0.2	1.4	10.7	36.3	16.4	0.1	+	+	+	-	+	65.1
1987	0.3	0.9	1.7	8.3	22.5	5.7	+	+	-	+	-	39.4
1988	1.3	0.3	0.7	1.7	4	7.6	0.8	+	+	+	-	16.4
1989	2.2	1.8	2.4	0.4	1.4	4.1	8.1	1.1	0.1	+	-	21.6
1990	44.8	14.3	10.6	7.3	4.2	7.3	7.4	5.7	0.3	0.1	-	102
1991	16.7	42.9	17.6	6.2	0.9	0.3	0.6	1.8	1.5	0.2	-	88.7
1992	16.4	28.2	128.6	34.6	5	0.4	0.6	0.9	0.8	0.1	-	215.6
1993	3.5	4.8	35.7	198.5	35.6	4.8	0.8	0.4	0.4	-	-	284.5
1994	9.1	4.9	5.8	44.2	101.4	11.6	1.5	0.1	0.1	0.5	-	179.2
1995	6.4	7.2	4.2	3.1	12.3	37	4	0.5	0.1	0.3	-	75.1
1996 (1	6	2.3	5.7	2.8	4.9	36.2	33.4	2.9	0.3	0.3	-	94.8
1997 (1	1.8	4.6	1.9	3.2	3.2	1	2.7	1	0.8	-	-	20.2
1998	10.7	2.9	11.5	3.8	4.6	0.8	0.5	1.5	0.5	+	-	36.8
1999	11.7	28.9	6.1	19.6	3.9	3.7	0.8	0.3	0.7	0.7	-	76.4
2000	15.1	20.7	26.2	6	10.9	2.6	1.1	0.2	0.1	0.4	-	83.3
2001	20.8	14.9	26.1	33.4	4	6.5	1.1	0.4	0.1	0.3	-	107.5
2002 (2	33.2	19.3	18.9	39.9	45	4.7	2.4	0.4	0.1	0.2	-	164
2003	19.8	32.8	25.1	22.1	29.9	23.1	3.4	1.6	0.2	0.1	-	158.3
2004	50	11	20.6	11.3	9.4	10.7	8.7	0.5	0.4	0.2	-	122.8
2005	62	79.2	13.6	24	8.6	4.8	5.7	2.4	0.1	0.2	-	200.7
2006 (3	53.4	79.2	122.7	11.3	11.9	5.7	2.6	2.4	1.1	0.2	-	290.5
2007	6.5	83.9	214.2	83.8	7.3	13.7	3.8	1.4	1.1	0.4	-	416
2008	5.7	12.7	232.7	255.7	105.1	12.4	11.1	1.7	0.7	0.4	-	638.7
2009	10	2.9	15.8	164.7	170.4	63.1	5.7	3.2	0.5	0.4	-	436.7
2010	7.7	19.7	4.3	29.9	169.7	158.9	46.6	3.4	1.4	0.3	-	441.9
2011	14.7	3.5	21.7	4.7	26.8	108.7	78.3	16.5	0.9	0.4	-	276.3
2012	6.9	30.6	4.3	20.9	4.9	16	72	48	6.4	0.6	-	210.5
2013	33	6	28.3	6.1	17.5	5	10.4	37.4	23.2	4	-	170.7
2014	12	10.2	2.2	25	4.6	17.5	5.6	14.2	29.8	11.8	-	133.2
2015	17.6	8.3	10.2	2.2	19.9	4	7.4	2.8	6.3	10.8	-	89.5
2016 (4	-	-	-	-	-	-	-	-	-	-	-	-
2017	33.8	86.3	24.2	7.1	9.9	0.9	3.8	0.6	0.8	1.9		169.2
2018 (4	-	-	-	-	-	-	-	-	-	-	-	-

(1 Adjusted data based on average 1985–1995 distribution.

(2 Adjusted based on 2001 distribution.

(3 Adjusted based on 2004-2006 distribution. + means value <0.1; - means 0 value

(4 Not conducted survey

Table B3 Northeast Arctic HADDOCK. Results from the Joint Barents Sea acoustic survey (BS-NoRu-Q1 (Aco)) in the Barents Sea in January-March. Stock numbers in millions.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	10+	Total
1981	7	14	5	21	60	18	1	0	0	0							126
1982	9	2	3	4	4	10	6	0	0	0							38
1983	0	5	2	3	1	1	4	2	0	0							18
1984	1685	173	6	2	1	0	0	0	0	0							1867
1985	1530	776	215	5	0	0	0	0	0	0							2526
1986	556	266	452	189	0	0	0	0	0	0							1463
1987	85	17	49	171	50	0	0	0	0	0							372
1988	18	4	8	23	46	7	0	0	0	0							106
1989	52	5	6	11	20	21	2	0	0	0							117
1990	270	35	3	3	4	7	11	2	0	0							335
1991	1890	252	45	8	3	3	3	6	0	0							2210
1992	1135	868	134	23	2	0	0	1	2	0							2165
1993	947	626	563	130	13	0	0	0	0	3							2282
1994	887.8	188.0	348.7	626.6	121.4	8.6	0.7	0.3	0.6	0.5	1.5	0.2	0.0	0.0	0.0	2	2184.8
1995	1198.2	88.6	41.5	121.5	395.4	47.6	2.8	0.1	0.1	0.0	0.0	0.5	0.1	0.0	0.0	1	1896.4
1996	132.6	94.5	30.0	22.1	68.7	143.7	5.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	498.2
1997*	508.9	26.5	57.3	22.2	15.5	56.1	62.8	4.7	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0	754.1
1998*	211.0	151.0	33.8	58.8	24.2	7.7	14.1	20.7	1.4	0.0	0.0	0.0	0.0	0.0	0.1	0	522.8
1999	653.4	30.1	83.7	21.6	22.1	6.2	1.6	3.9	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0	825.3
2000	1063.0	404.8	36.4	75.5	14.0	12.6	1.6	0.5	2.0	0.7	0.2	0.1	0.0	0.0	0.0	1	1611.5
2001	753.0	266.1	233.5	40.2	41.4	2.2	1.6	0.2	0.1	0.1	0.3	0.1	0.1	0.0	0.0	1	1338.8
2002	1315.2	267.9	255.2	201.8	18.5	11.7	1.6	0.3	0.0	0.1	0.3	0.1	0.1	0.0	0.0	1	2072.7
2003	2743.7	362.3	203.7	184.6	136.0	12.3	6.0	0.3	0.1	0.3	0.3	0.1	0.1	0.0	0.0	1	3649.8
2004	529.0	466.5	151.0	101.8	107.8	57.7	7.6	1.2	0.3	0.0	0.1	0.1	0.0	0.1	0.0	0	1423.2
2005	2276.5	144.0	221.3	115.7	57.4	56.7	12.7	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0	2885.0
2006**	2091.1	624.8	56.3	123.8	47.4	19.3	13.6	3.2	0.1	0.2	0.0	0.0	0.0	0.0	0.1	0	2979.9
2007*	2015.7	953.5	209.3	46.1	80.6	28.9	10.0	5.1	2.3	0.3	0.2	0.0	0.0	0.0	0.1	1	3352.0
2008	778.4	1753.5	812.4	303.0	90.0	74.1	7.4	12.8	1.6	0.1	0.2	0.2	0.0	0.0	0.0	0	3833.8
2009	443.9	209.1	883.7	630.0	266.6	38.9	14.6	1.3	0.3	0.7	0.7	0.0	0.1	0.0	0.0	1	2489.0
2010	1559.4	86.0	128.1	631.0	604.0	167.0	12.1	2.9	1.0	1.0	0.1	0.1	0.0	0.0	0.0	1	3192.6
2011	428.5	288.3	54.2	84.2	313.0	292.2	54.9	1.7	1.0	0.2	0.0	0.2	0.1	0.0	0.0	1	1518.4
2012**	1583.4	94.5	191.6	48.8	88.1	310.6	172.5	30.1	0.5	0.3	0.0	0.1	0.0	0.0	0.0	0	2520.8
2013	292.7	407.2	67.3	146.8	35.4	53.0	223.8	102.7	14.1	0.3	0.0	0.0	0.0	0.0	0.0	0	1343.2
2014	1703.7	109.0	324.5	38.2	107.9	22.4	33.8	84.5	35.3	1.5	0.5	0.0	0.0	0.0	0.0	2	2461.4
2015	1521.9	224.4	23.6	171.5	25.5	39.4	8.3	21.1	17.3	6.8	0.4	0.2	0.0	0.0	0.0	7	2060.5
2016	1260.3	105.4	68.5	11.8	56.0	11.8	16.6	6.9	15.5	11.9	2.4	0.5	0.0	0.0	0.0	15	1567.5
2017**	3263.8	323.2	79.9	62.8	4.4	32.2	5.8	7.0	1.5	6.4	5.5	2.0	0.4	0.0	0.0	14	3795.1
2018	2074.8	759.2	158.7	60.3	60.7	5.7	12.8	2.3	2.2	1.3	5.0	2.6	1.4	0.2	0.0	10.4	3147.1
2019	1472.7	663.5	490.6	142.0	29.7	21.2	4.5	3.4	1.0	1.5	0.4	0.5	0.3	0.2	0.1	3.0	2832.2

*** Indices raised to also represent the Russian EEZ.**

**** Indices raised to also represent uncovered parts of the Russian EEZ.**

Table B4. Northeast Arctic HADDOCK. Results from the Russian trawl-acoustic survey (RU-Aco-Q4) in the Barents Sea and adjacent waters in late autumn (new method). Index of number of fish at age (+ means value <1; - means 0 value).

Year	0	1	2	3	4	5	6	7	8	9	10+	Total
1995 (5	163	170	79	71	230	404	41	5	1	1	2	1168
1996 (1,3	992	245	291	91	63	206	187	17	1	+	+	2092
1997 (1,3	185	104	21	121	94	48	47	31	20	+	+	671
1998 (2	257	44	83	20	20	6	2	7	2	+	+	442
1999 (1	632	499	60	123	14	16	4	1	4	1	+	1355
2000 (1	524	395	287	54	57	14	6	1	1	1	1	1340
2001 (1	491	160	227	221	19	35	5	2	1	1	1	1163
2002 (1,4,5,6	1045	209	139	268	239	27	17	2	1	+	1	1947
2003	1168	473	217	116	134	94	14	6	1	+	+	2223
2004	8529	1141	342	116	54	55	44	3	4	1	1	10289
2005	17782	2903	123	205	62	33	38	16	1	1	+	21165
2006 (7	9396	1286	308	30	31	10	-	5	5	4	1	11075
2007	812	1473	2226	745	53	75	22	8	7	2	1	5423
2008	245	203	2134	1947	728	88	83	13	6	4	2	5455
2009	1650	204	243	1455	1258	485	46	30	4	2	1	5380
2010	1033	643	133	267	1032	923	274	19	9	1	1	4335
2011	1603	137	242	40	166	631	459	96	5	1	1	3383
2012	320	501	52	166	35	101	429	286	37	2	+	1931
2013	1843	373	625	105	145	40	74	261	167	29	1	3665
2014	551	238	37	240	30	98	32	77	162	58	6	1529
2015	1032	334	176	28	161	30	58	21	49	62	19	1972
2016 (8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2017	1573	1601	409	109	133	12	39	6	8	4	13	3907
2018 (8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

(1 October-December

(2 September-October

(3 November-January

(4 Adjusted based on average 1985-1995 distribution

(5 Adjusted based on 2001 distribution

(6 Adjusted data in 2004

(7 Not adjusted data to the whole area

(8 Not conducted

Table B5 Northeast Arctic HADDOCK. Results from the joint ecosystem survey (Eco-NoRu-Q3 (Btr)) in August-September in the Subareas 2 and 2. Indices of numbers (in millions) of fish at age (+ means value <0.5).

	Age													
Year	0	1	2	3	4	5	6	7	8	9	10	11	12+	Total
2004	104	189	268	123	70	69	31	3	2	0	+	0	+	861
2005	155	626	114	323	89	29	31	15	+	+	+	+	+	1383
2006	283	2270	929	107	125	42	19	17	7	1	+	+	+	3802
2007	114	988	1819	1283	88	94	19	6	7	2	1	+	+	4421
2008	60	322	1292	1155	406	43	36	5	3	2	+	0	0	3323
2009	169	136	144	651	618	306	21	7	1	1	+	0	0	2053
2010	154	274	65	184	865	666	148	16	3	0	+	+	+	2376
2011	213	105	114	40	74	393	301	37	3	+	+	0	+	1281
2012	74	591	42	93	20	68	214	152	13	+	+	0	2	1268
2013	163	156	223	26	65	20	51	150	76	7	+	0	+	938
2014	183	265	75	262	41	70	26	60	86	18	1	+	0	1087
2015	343	320	145	42	214	25	37	21	48	34	9	+	+	1238
2016	474	796	144	210	35	183	48	57	39	66	46	11	+	2111
2017	931	936	189	70	70	11	21	4	4	5	4	5	1	2252
2018(1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

(1 no coverage in main area of haddock, no index calculated

Table B6 Northeast Arctic HADDOCK. Length data (cm) from Joint Barents Sea surveys (BS-NoRu-Q1 (BTr)) in January-March (+ means value <1; - means 0 value)

Age/	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	16.8	25.2	34.9	44.7	52.5	58.0	62.4	65.1						
1984	16.6	27.5	32.7	-	56.6	62.4	61.8	66.2						
1985	15.7	23.9	35.6	41.9	58.5	61.9	63.9	67.6						
1986	15.1	22.4	31.5	43.0	54.6	-	-	-						
1987	15.4	22.4	29.2	37.3	46.5	-	-	-						
1988	13.5	24.0	28.7	34.7	41.5	47.9	54.6	-						
1989	16.0	23.2	31.1	36.5	41.7	46.4	52.9	57.6						
1990	15.7	24.7	32.7	43.4	46.1	50.1	52.4	55.7						
1991	16.8	24.0	35.7	44.4	52.4	54.8	55.6	55.9						
1992	15.1	23.9	33.9	45.5	53.1	59.2	60.6	60.5						
1993	14.5	21.4	31.8	42.4	50.6	56.1	59.4	64.2						
1994	14.5	20.1	29.4	38.0	47.6	54.3	61.7	65.2	70.7	64.4	64.6	72.0	-	-
1995	15.1	18.4	28.7	34.0	42.8	51.0	59.6	60.0	67.2	68.0	-	64.7	78.6	-
1996	15.3	20.9	28.0	37.0	41.3	47.2	53.8	58.7	-	76.0	-	74.0	75.0	-
1997*	15.8	19.4	27.0	33.5	40.5	46.9	47.6	53.3	62.0	-	-	-	75.6	78.0
1998*	14.1	19.6	28.9	34.2	41.6	46.5	50.3	52.8	58.2	72.1	65.0	-	-	-
1999	14.3	18.0	32.3	38.6	46.5	51.9	56.1	55.1	58.8	62.0	-	72.0	-	-
2000	15.5	21.7	29.9	42.0	47.1	51.1	52.7	59.3	59.4	62.0	63.3	+	+	-
2001	14.6	22.1	32.1	37.6	48.0	50.1	59.2	55.0	64.9	66.3	67.7	+	+	-
2002	15.0	20.9	29.2	39.8	45.6	51.5	58.0	58.6	-	62.0	64.4	67.7	70.1	-
2003	15.8	24.0	26.4	36.5	45.8	49.8	54.5	61.2	62.6	60.3	66.0	70.0	+	-
2004	14.1	22.1	30.1	35.7	42.7	49.9	49.6	58.8	63.3	73.6	75.7	+	+	+
2005	14.8	20.6	29.9	36.1	40.4	48.4	51.5	56.2	60.8	67.0	-	-	-	-
2006	14.4	22.1	30.7	37.9	43.3	47.3	50.7	56.6	60.5	69.9	-	+	-	-
2007*	15.2	23.5	28.2	31.2	43.5	43.9	50.0	58.0	58.1	+	62.0	-	-	-
2008	15.7	23.7	29.6	37.9	42.7	46.0	52.9	52.5	58.5	+	63.3	63.0	-	-
2009	14.2	22.6	29.7	35.5	41.8	48.1	48.9	56.4	65.0	62.3	-	62.0	-	-
2010	14.4	19.8	30.6	36.8	40.8	45.1	49.9	59.9	58.9	62.3	+	66.5	-	-
2011	13.6	23.3	28.5	39.5	42.9	46.1	48.2	62.7	+	-	-	63.3	+	-
2012	14.6	19.2	31.6	35.1	43.7	47.1	50.2	50.8	47.6	65.0	67.0	72.0	-	-
2013	14.5	22.8	30.0	40.9	42.8	48.6	52.3	52.8	55.6	67.3	-	-	-	-
2014	15.5	18.6	31.9	39.0	46.5	52.7	53.5	55.3	54.9	60.3	59.2	-	-	75.0
2015	14.5	20.4	26.1	39.8	45.3	52.6	53.4	57.6	56.9	60.2	59.6	67.4	-	-
2016	14.8	18.5	30.7	35.8	47.8	53.0	56.0	58.4	61.0	60.4	59.8	64.5	-	72.0
2017	15.8	20.6	30.4	39.7	49.4	52.7	55.8	60.4	59.8	63.0	62.1	63.9	69.0	-
2018	14.3	22.1	30.4	39.4	47.6	54.0	57.6	60.9	64.3	66.0	64.5	63.9	67.1	68.6
2019	14.8	21.5	29.7	37.0	46.0	52.5	52.9	60.4	64.5	65.8	67.4	68.1	69.5	75.0

***Limited area coverage, lengths are not adjusted to account for limited area coverage.**

+ indicates few samples, - means missing values

Table B7 Northeast Arctic HADDOCK. Length data (cm) from Russian surveys (RU-BTr-Q4) in November-December

Year	0	1	2	3	4	5	6	7	8	9	10
1982	14.5	21.3	33.4	37.0	-	-	-	-	-	-	
1983	18.1	26.2	30.9	44.9	53.3	62.0	65.5	67.6	68.0	73.1	
1984	-	24.0	35.8	42.7	53.7	63.1	68.1	68.1	71.0	75.2	
1985	-	21.1	31.7	43.4	53.6	62.2	64.2	-	73.1	74.1	
1986	18.1	21.0	28.7	37.0	46.6	58.8	63.1	68.1	-	73.1	
1987	-	21.7	27.6	33.3	40.9	49.4	-	-	-	-	
1988	-	19.9	29.9	35.1	40.4	46.6	52.0	-	-	-	
1989	-	20.5	25.1	40.2	45.0	48.5	52.2	58.8	63.5	-	
1990	-	20.5	29.8	37.3	48.7	50.8	54.7	58.8	63.3	68.1	
1991	-	23.2	31.7	40.3	52.7	56.7	58.8	60.3	63.2	69.1	
1992	-	22.0	32.2	41.6	52.6	59.7	61.9	65.7	68.3	70.3	
1993	18.1	20.8	28.0	38.6	48.8	55.0	61.2	64.1	63.2	65.0	
1994	15.5	20.8	28.9	36.2	44.6	53.6	60.0	66.2	67.7	67.0	
1995	14.9	21.8	28.6	36.6	42.0	48.3	56.6	62.5	66.1	66.8	
1996*	15.7	20.2	28.6	36.8	43.9	49.3	54.7	63.3	67.3	70.8	
1997*	13.7	23.3	29.5	36.6	44.6	50.0	54.7	58.7	69.1	68.1	
1998	14.4	19.3	33.1	39.2	45.9	47.9	53.5	56.1	62.0	74.1	
1999	13.5	22.6	28.0	41.9	46.6	49.2	53.1	56.3	59.8	63.5	
2000	14.2	22.3	31.7	37.0	48.6	52.5	54.8	60.8	62.0	60.5	
2001	14.8	21.9	30.7	40.3	45.1	53.0	57.3	60.7	62.2	62.5	
2002	14.7	23.5	29.4	38.2	46.4	50.8	56.2	56.0	64.6	66.9	
2003	13.8	22.7	29.4	37.5	43.9	50.5	55.2	61.1	63.3	63.5	
2004	14.3	22.5	30.0	37.9	43.6	48.4	53.7	58.4	63.5	69.1	
2005	14.9	23.5	30.0	36.9	44.8	49.9	54.7	59.2	65.9	66.6	
2006*	15.3	24.1	32.6	39.8	46.7	51.8	54.9	59.0	62.4	65.3	
2007	15.4	23.7	30.6	39.2	46.6	52.0	54.4	58.4	61.3	65.8	
2008	14.5	22.3	30.8	38.1	47.3	52.8	55.8	59.1	62.8	65.0	
2009	15.4	21.8	29.4	36.0	43.9	51.0	55.3	59.2	62.3	63.3	
2010	13.0	23.9	28.3	35.5	42.8	47.8	53.7	60.0	61.8	66.9	
2011	14.7	23.0	31.9	34.3	41.6	47.7	53.0	59.2	64.3	67.8	
2012	14.5	24.0	32.0	39.4	43.9	48.7	53.1	56.9	62.0	67.3	
2013	15.3	21.7	31.4	37.5	45.8	48.9	53.6	56.4	62.9	69.4	
2014	14.6	22.2	28.7	37.8	44.9	51.1	53.6	57.4	60.0	61.8	
2015	15.2	21.6	30.0	37.0	46.3	51.1	56.0	58.3	60.6	62.0	
2016	-	-	-	-	-	-	-	-	-	-	
2017	16.1	22.2	31.3	39.3	47.1	52.8	57.9	61.9	63.1	64.6	69.5
2018	-	-	-	-	-	-	-	-	-	-	

***Limited area coverage, lengths are not adjusted to account for limited area coverage.**

+ indicates few samples, - means missing values

Table B8 Northeast Arctic HADDOCK. Weight data (g) from Joint Barents Sea surveys (BS-NoRu-Q1 (BTr)) in January-March (revised data from 1994 onwards and historical data for 1983-1993) (+ means value <1; - means 0 value).

Age/ Yea	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	52	133	480	1043	1641	2081	2592	2847						
1984	36	196	289	964	1810	2506	2240	2905						
1985	35	138	432	731	1970	2517	-	3600						
1986	47	100	310	734	-	-	-	-						
1987	24	91	273	542	934	-	-	-						
1988	23	139	232	442	743	1193	1569	-						
1989	43	125	309	484	731	1012	1399	1833						
1990	34	148	346	854	986	1295	1526	1782						
1991	41	138	457	880	1539	1726	1808	1869						
1992	32	136	392	949	1467	2060	2274	2341						
1993	26	93	317	766	1318	1805	2166	2734						
1994	25	87	248	539	1056	1601	2201	2846	3439	2680	2712	3890	-	-
1995	30	71	221	380	775	1331	2005	2070	2685	2905	-	2502	3972	-
1996	32	93	218	472	668	1020	1537	1768	-	4630	-	4018	3626	-
1997*	35	85	188	329	619	1034	1064	1532	2474	-	-	-	3731	4130
1998*	24	89	232	416	815	1032	1298	1559	2006	3740	3040	-	-	-
1999	27	75	335	570	1022	1435	1791	1722	2011	2440	-	3525	-	-
2000	32	110	275	736	1061	1366	1521	2123	2239	2588	2741	+	+	-
2001	28	107	337	581	1145	1402	2147	1896	2903	3110	2965	+	+	-
2002	30	85	245	618	940	1375	1940	2048	-	2352	2670	3252	3497	-
2003	36	129	192	490	958	1209	1479	1933	2479	2533	3055	3470	+	-
2004	23	98	271	456	750	1162	1204	1958	2658	3926	4157	+	+	+
2005	29	98	261	474	666	1093	1372	1976	2120	2730	-	-	-	-
2006	25	109	302	561	810	1083	1358	1917	2102	3991	-	+	-	-
2007*	30	114	246	356	894	956	1388	2135	2508	+	2959	-	-	-
2008	32	113	245	553	832	1080	1573	1417	2120	+	2280	2840	-	-
2009	26	96	225	442	747	1147	1275	1726	2377	2563	-	2594	-	-
2010	27	87	270	466	658	949	1260	1897	2143	2512	+	3184	-	-
2011	21	117	220	520	727	939	1163	2285	+	-	-	+	2805	-
2012	28	73	305	432	816	1015	1285	1282	1219	2683	2980	3264	-	-
2013	24	113	272	644	783	1130	1350	1495	1836	3098	-	-	-	-
2014	32	68	357	611	1014	1424	1551	1677	1671	2141	2184	-	-	4800
2015	23	88	201	588	848	1423	1465	1921	1834	2078	2256	3133	-	-
2016	27	74	282	458	1057	1457	1752	2078	2280	2266	2404	2843	-	3555
2017	33	95	290	621	1220	1520	1785	2280	2309	2610	2594	2789	3369	-
2018	25	97	273	622	1039	1636	1935	2319	2699	2855	2652	2616	3005	3369
2019	25	90	242	507	965	1407	1558	2059	2712	2941	3001	3404	3412	3980

***Limited area coverage, weights are not adjusted to account for limited area coverage.**

+ indicates few samples, - means missing values

Table B9 Northeast Arctic HADDOCK. Weight (g) from Russian surveys (RU-BTr-Q4) in November-December (- means missing data).

Year /Age	0	1	2	3	4	5	6	7	8	9	10
1982	32	102	364	500	-	-	-	-	-	-	-
1983	57	170	271	916	1625	2346	2751	3153	3217	4290	5200
1984	-	124	434	722	1410	2296	3071	2942	3224	3747	5408
1985	-	94	302	788	1533	2275	2650	-	3400	4076	3943
1986	40	91	220	470	905	1759	2300	2500	-	3550	4100
1987	-	96	193	353	612	1101	-	-	-	-	-
1988	-	84	250	409	641	1036	1451	-	-	-	-
1989	-	94	160	718	926	1254	1548	2106	2781	-	7160
1990	-	97	264	530	1250	1474	1812	2188	2626	3080	5520
1991	-	122	342	702	1518	1915	2244	2324	2649	3249	3810
1992	-	103	310	726	1505	2101	2386	2977	3315	3773	4800
1993	55	84	197	543	1120	1568	2125	2474	2476	2803	3324
1994	34	91	217	435	850	1498	2167	2875	2880	2963	3742
1995	32	90	210	445	708	1123	1776	2398	2847	3032	3781
1996	37	80	210	468	854	1186	1643	2429	3038	2991	4413
1997	27	113	226	458	882	1191	1579	1963	3155	2815	3565
1998	38	72	340	593	972	1226	1593	1803	2389	3681	4494
1999	27	103	196	730	1003	1182	1522	1748	2148	2547	2807
2000	24	105	313	480	1197	1502	1713	2375	2445	2286	3065
2001	25	98	264	632	930	1534	1935	2383	2589	2631	3210
2002	26	127	302	586	1077	1470	2029	2127	1954	2933	3986
2003	21	103	229	498	797	1241	1649	2308	2617	3061	3390
2004	24	87	253	518	846	1130	1571	1959	2633	3366	3859
2005	27	115	259	511	933	1289	1670	2079	2833	2965	-
2006*	26	105	269	444	867	1307	1604	1922	2274	2520	-
2007	30	117	274	600	1012	1436	1647	2018	2314	2885	-
2008	25	94	267	545	1046	1445	1755	2126	2458	2735	3289
2009	28	91	241	448	841	1335	1666	2048	2438	2498	3132
2010	17	123	208	425	764	1071	1546	2116	2317	2827	-
2011	26	107	305	395	737	1102	1546	2177	2779	3055	4069
2012	25	120	300	599	852	1174	1519	1871	2467	3018	-
2013	29	86	280	488	924	1135	1504	1766	2065	2490	3216
2014	25	96	224	538	914	1340	1578	1913	2182	2407	2989
2015	28	89	256	524	1007	1369	1810	2031	2274	2446	2880
2016	-	-	-	-	-	-	-	-	-	-	
2017	33	97	291	603	1030	1477	1946	2384	2532	2671	2928
2018	-	-	-	-	-	-	-	-	-	-	-

***Limited area coverage, weights are not adjusted to account for limited area coverage**

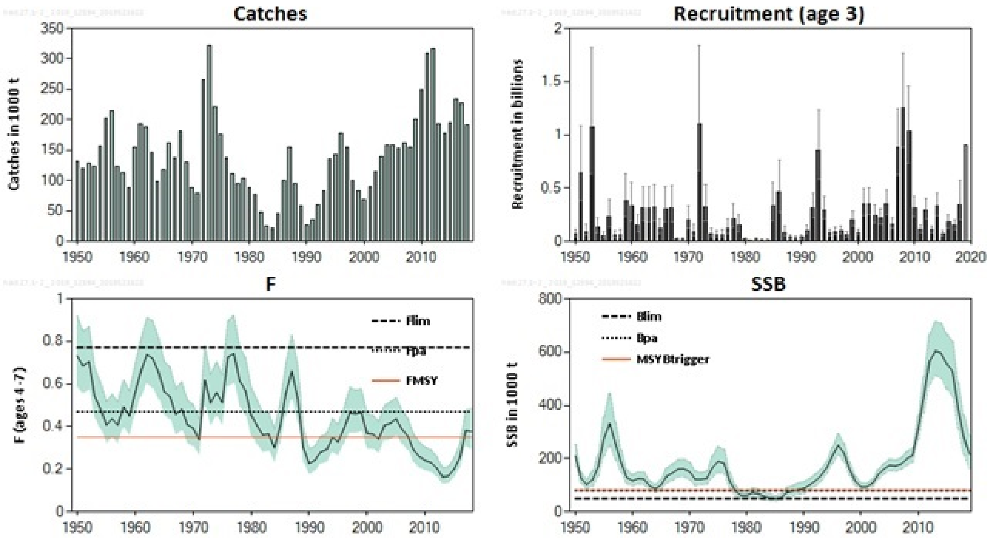
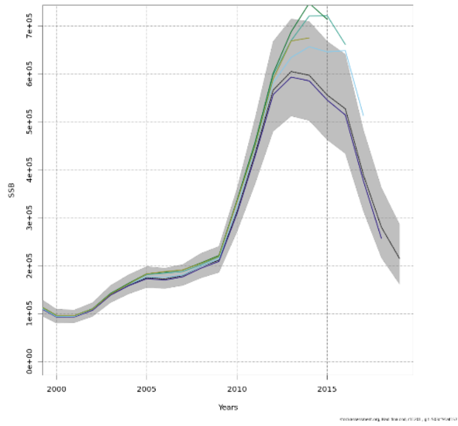
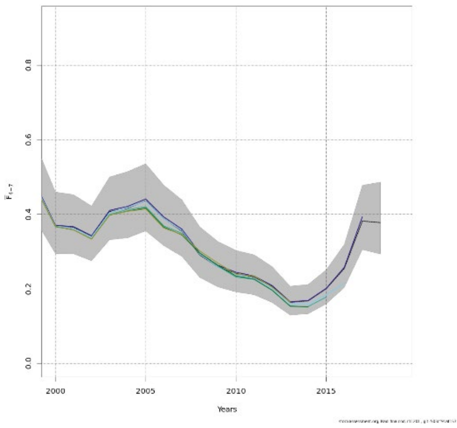


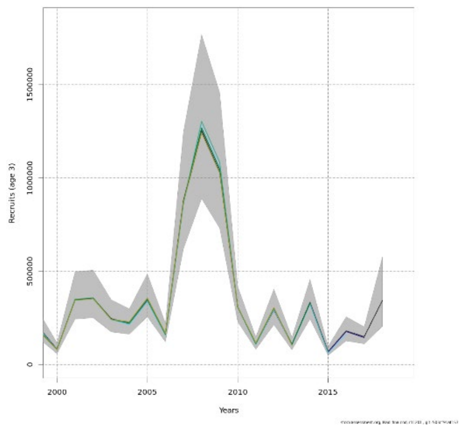
Figure 4.1 Landings, fishing mortality, recruitment (2018 prediction unshaded), and spawning-stock biomass of Northeast Arctic haddock 1950–2019. Fishing mortality and spawning-stock biomass are given with point wise 95% confidence intervals (shaded areas).



(a)



(b)



(c)

Figure 4.2. Northeast Arctic haddock. 5 year retrospective plots of SSB (a), fishing mortality (b), and recruitment (c) for years 2000–2018 (SAM with 95% confidence intervals).

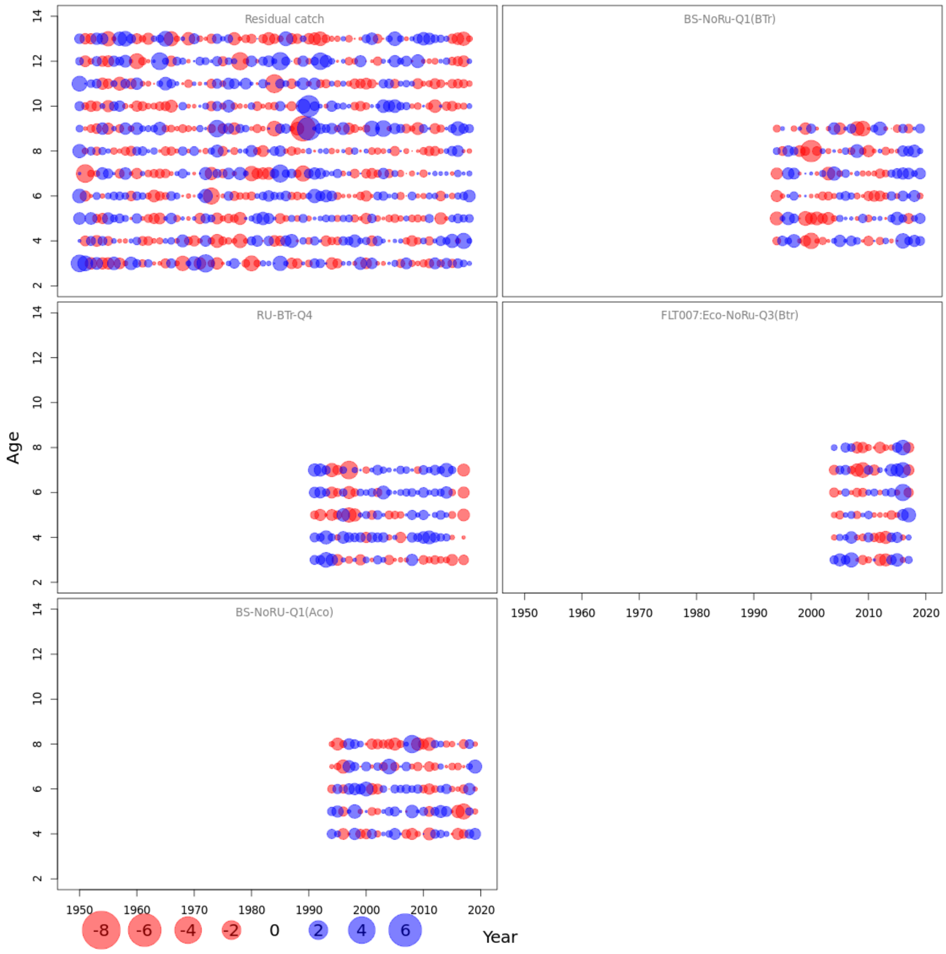


Figure 4.3. Northeast Arctic haddock; Normalized residuals for the final SAM run. Blue circles indicate positive residuals (observations larger than predicted) and white circles indicate negative residuals.

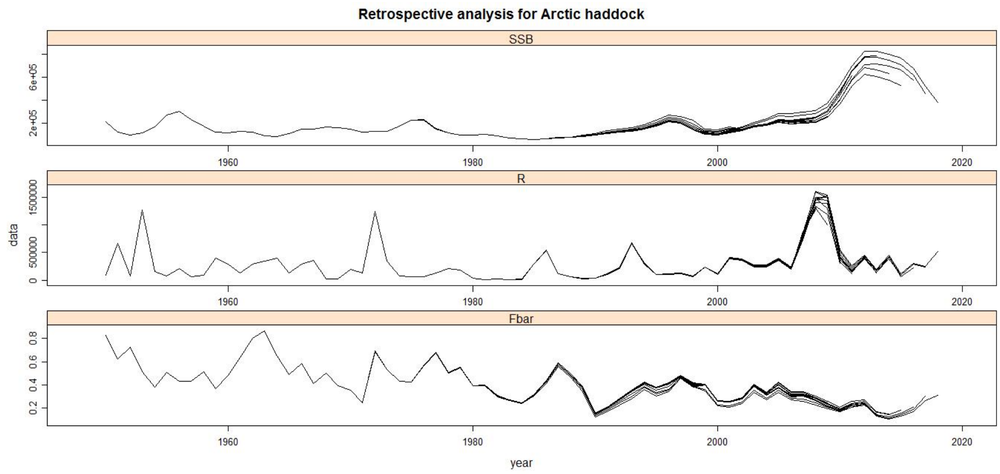


Figure 4.4. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1950–2017 (XSA without P shrinkage)

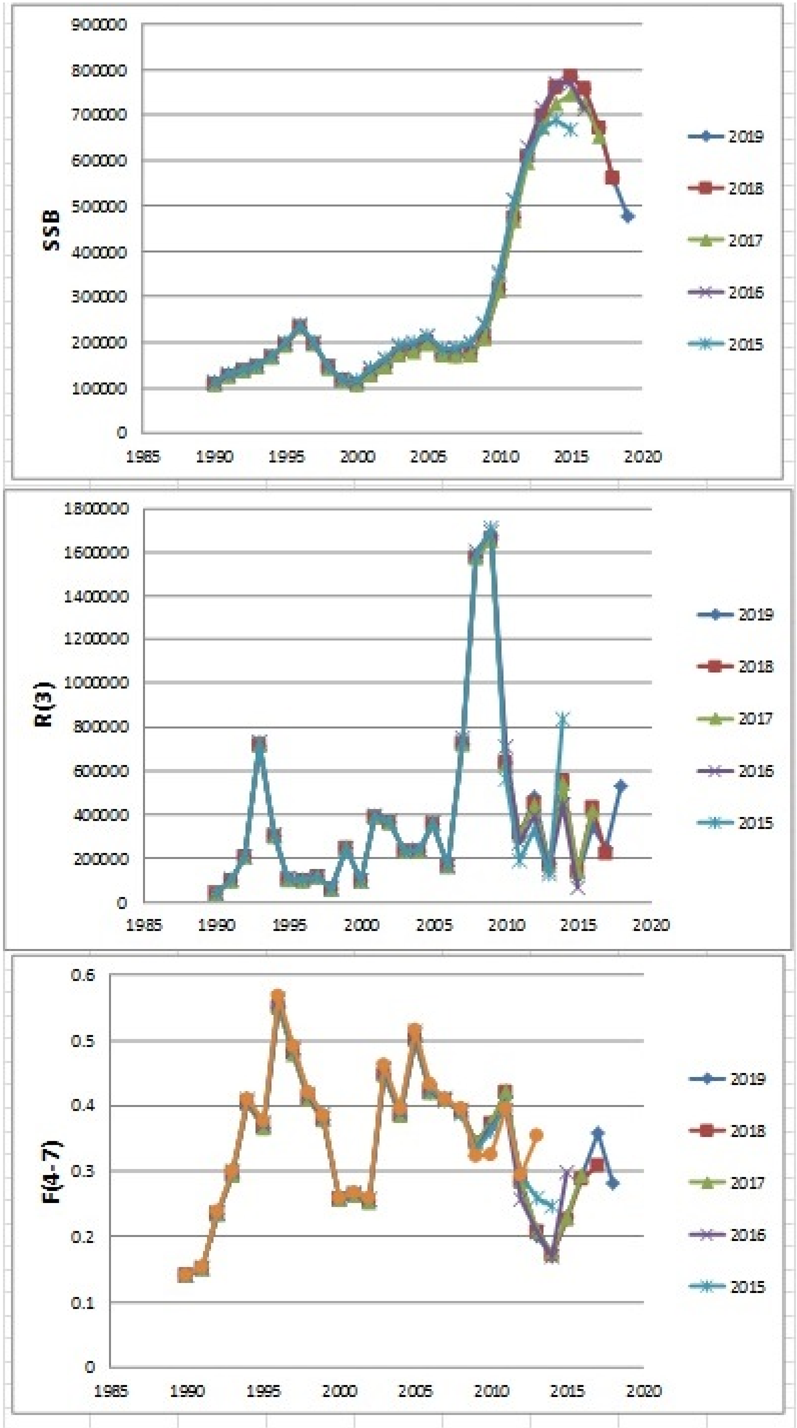


Figure 4.5. Northeast Arctic haddock. Retrospective plots of SSB, fishing mortality and recruitment for assessment years 1990–2018 from TSVPA model (see WD 10).

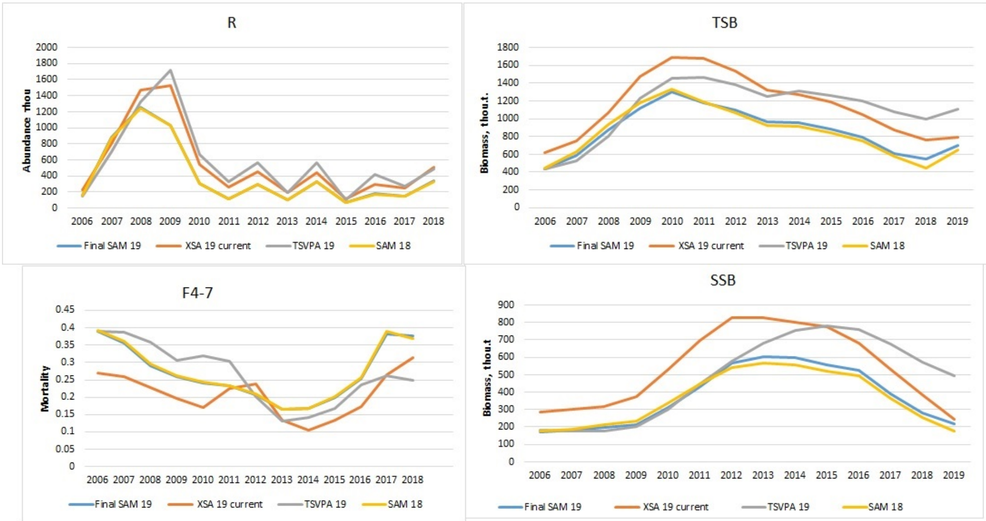


Figure 4.6. Results of assessment of NEA haddock - Recruits, biomass, spawning biomass and F by different models: medium SAM estimates from 2019 (final SAM 19), medium SAM estimates from 2018 (SAM 18) , XSA estimates from 2019 with current settings (XSA 19 current) and TISVPA estimates from 2019 with settings as mentioned at WD 10 (TISVPA 19).

5 Saithe in subareas 1 and 2 (Northeast Arctic)

An assessment based on the decisions of the Inter-Benchmark Protocol (IBP) on Northeast Arctic saithe from March/April 2014 (ICES CM 2014/ACOM: 53) is presented for this stock. The main decisions were to change model from XSA to the state–space assessment model SAM (Nielsen and Berg, 2014) and to leave out the CPUE time-series in its current form.

The last benchmark assessment was done at WKROUND February 2010 (ICES CM 2010/ACOM: 36).

The 2019 assessment (ICES CM 2015/ACOM: 05) showed that the SSB has been above B_{pa} since 1996, declined considerably from 2007 to 2011, then increased again and is currently (2018) 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 currently estimated to be below F_{pa}. The 2008, 2010, 2013 year classes are above average, while the 2007, 2009, 2011, and 2012 year classes were below average strength

ICES advised that catches in 2019 should be no more than 149 550 t, and The Norwegian Ministry of Trade, Industry and Fisheries set the final TAC at 149 550 t. ICES evaluated the management plan (harvest control rule, HCR) in 2007 and again in 2011 due to changes introduced at the 2010 benchmark and concluded that it is consistent with the precautionary approach. The HCR has not yet been evaluated for the new assessment model that the NEA saithe IBP decided to use.

More details and general information is given in (ICES CM 2010/ACOM: 36) and the Stock Annex (Quality Handbook).

5.1 The Fishery (Tables 5.1-5.2, Figure 5.1)

Currently the main fleets targeting saithe include 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 2018 landings increased to 181 282 t.

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 2018 and 2019

The advice from ICES for 2018 was as follows:

ICES advised that catches in 2018 should be no more than 172 500 t.

The advice from ICES for 2019 was as follows:

ICES advised that catches in 2018 should be no more than 149 550 t.

5.1.2 Management applicable in 2018 and 2019

Management of Saithe in subareas 1 and 2 is by TAC and technical measures. For 2018, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 172 500 t.

For 2019, The Norwegian Ministry of Trade, Industry and Fisheries set the TAC according to the advice from ICES, i.e. 149 550 t.

5.1.3 The fishery in 2018 and expected landings in 2019

Provisional figures show that the landings in 2018 were approximately 181 250 t, approximately 10 000 t higher than the TAC of 172 500 t.

Since the WG does not have any prognosis of total landings in 2019 available, the TAC of 149 550 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 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 5.2-5.3)

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 fitwith 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 impacts 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 impacts on model performance.

Though the echo abundance in 2019 (Staby *et al*., 2019) estimated using StoX decreased by 24% compared to 2018 (which in 2018 had decreased by 15% compared to the previous year), and was about 72% of the average for 2003–2017, the estimated biomass increased due to increased abundances of 5-, 6-, and 8-year old saithe, which were well above the average (2003–2017) for those age classes. The 4 year old saithe (2014 year class) was most abundant, followed by 5 year old fish (2013 year class), while the index for 3 year olds was well below the 2003-2017 average. The proportion of saithe in the southern part of the survey area (subareas C+D) increased from about 20% in 1997 to above 60% in 2008, decreased in later years to below 20% in 2017, and was approximately 21% in 2018.

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 in 2018 and 2018 landings data for all other countries were updated based on the official total catch (preliminary) reported to ICES or to Norwegian authorities.

Age composition data for 2018 were available for Norway and Germany. An ALK for Norwegian trawl was applied to Russian length data for subareas 2.a, and for 2.b and 1 combined. Landings from other countries were assumed to have the same age composition as the combined Norwegian trawl catches. The biological sampling of some vessel groups, periods and areas may have become critically low after the termination of the Norwegian port-sampling program in 2009. Sampling of age data from purse-seine catches had improved by 2016, but catches from some areas and particularly quarter 3 in 2017 were not sampled adequately.

Catch-at-age data were estimated by ECA for the 2019 assessment of NEA saithe. This is the third year that catch-at-age estimates from ECA are used as input in the SAM assessment. In previous years catch-at-age was estimated manually, as described in the NEA saithe stock annex.

In 2016, it was not possible due to time constraints to apply the manual method to 2017 to compare the 2016 data. A comparison of ECA and manual allocation data using 2015 catch data, showed that ECA produced somewhat lower estimates of number of younger fish, while it produced slightly higher estimates for older fish. However, a comparison of two respective SAM runs with 2016 ECA and manually allocated data showed that estimates of numbers by age for the intermediate year (2016) did not differ substantially. They also showed very similar trends in SSB and estimated fishing mortality (F_{bar}), though the SSB estimated with ECA data showed a slightly higher SSB estimate than the estimate based on manually allocated data.

5.3.2 Weight-at-age (Table 5.4)

Constant weights-at-age values are used for the period 1960–1979. 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 last year negligible differences in weight-at-age for the most important age groups in 2018 were estimated, with an increase in weight of 3 year old fish most notable.

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). Table 5.3.3 presents the maturity ogives used in the present assessment. It needs to be clarified why the above mentioned inconsistencies occurred, e.g. are spawning zones not a robust indicator for maturity.

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 does not show the trends in stock size abundance of NEA saithe in later years (Figure 5.3.2). In the most recent years there are 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, seems to track the stock changes better, both in abundance and distribution.

The trawl CPUE series does not show the trends in stock size abundance of NEA saithe in later years. In the most recent years there are 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). The acoustic survey, on the other hand, seems 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 show that the residual pattern get worse (strong year effects) when using both tuning series in SAM. It becomes obvious that SAM tries to fit something in between both contradicting data sources. Therefore, it had to be decided whether one data source is more reliable or whether both data sources should be taken into account 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 has 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:

- 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 2002–2018, 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). Therefore, no new exploratory runs were performed during the 2019 AFWG, just one SAM run with 2018 data included and model settings decided in the IBP:

- Catch data age 3–12+;
- 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 (Tables 5.8-5.11, Figures 5.4-5.7)

The state–space assessment model (SAM) was used for the final. SAM catchabilities and negative log likelihood values are given in Table 5.8. The predictive power (AIC) of the model was estimated to 1128.45, compared to 1111.73 for the 2018 run.

Figure 5.4 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 5.5 shows plots of the stock numbers from the SAM vs. tuning indices, a circle indicates last year's result.

5.5.1 SAM F, N, and SSB results (Tables 5.9-5.11, Figures 5.6-5.7)

The fishing mortality ($F_{4–7}$) in 2017 was 0.22, which is below the value of 0.26 from last year's assessment and below the F_{pa} of 0.35, while in 2018 fishing mortality ($F_{4–7}$) was 0.23. From 1997 to 2009 fishing mortality was below F_{pa}, but started to increase in 2005 and was above F_{pa} in 2010–2012.

Fishing mortality and stock size have in the last decade generally been considerably over- and underestimated respectively. Due to the changes made to the assessment following the benchmark assessment workshop in 2010 (ICES CM 2010/ACOM: 36) and later the NEA saithe IBP in 2014 (ICES CM 2014/ACOM: 53), the retrospective patterns have improved considerably, as is illustrated in Figure 5.7. Based on the 2019 assessment the SSB has in recent years been underestimated and F_{4-7} 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 2008, 2010, and 2013 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 (1960–2018) average from 1996 to 2010, reached a maximum in 2005, declined below the average level between 2011 and 2015, and has been above the long-term average since 2016. The SSB was above the long-term mean from 2000 to 2009, decreased below the average between 2010 to 2013, and has been above since 2014. SSB has been above B_{pa} (220 000 t) since 1996 (Figure 5.1).

5.5.2 Recruitment (Table 5.10, Figure 5.1)

Catches of age group 3 have varied considerably during the period 2004−2017 (Table 5.10). Until the 2005 WG, RCT3-runs were conducted to estimate the corresponding year classes, with 2 and 3 year olds from the acoustic survey as input together with XSA numbers. However, it was stated several times in the ACOM Technical Minutes that it would be more transparent to use the long-term geometric mean (GM) recruitment. GM values were therefore used in the 2005–2014 since the issue was not discussed at the IBP when SAM was adopted as assessment model. During the 2015 AFWG assessment, analyses were performed to investigate if the last year recruitment value from SAM could be used instead of the long-term GM (for method description refer to Stock Annex). Results from this analysis showed that the retrospective runs of SAM gave better estimates of recruitment than the geometric mean and consequently estimates of the recruiting year class (3 year olds in the last data year) from the SAM were accepted for the last year.

5.6 Reference points (Figure 5.1)

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.

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 stock number-at-age in 2019 was taken from the SAM for age 4 (2015 year class) and older. The GM age 3 recruitment of 159 million was used for the 2019 and subsequent year classes. The natural mortality of 0.2 is the same as used in the assessment. For exploitation pattern the average of 2016–2018 was used for all age groups. For weight-at-age in stock and catch the average of the last three years in the SAM was used. For maturity-at-age the average of the 2005–2007 annual determinations was applied.

5.7.2 Catch options for 2020 (short-term predictions; Tables 5.13-14)

The management option table (Table 5.13) shows that the expected catch of 149 550 t in 2019 will reduce the fishing mortality compared to 2018 from 0.26 to 0.22, which well below the F_{pa} of 0.35. A catch in 2020 corresponding to the $F_{status\ quo}$ level (3-year average 2016–2018) of 0.23 will be 156 484 t, while a catch in 2020 corresponding to the evaluated and implemented HCR of 171 982 t will result in F of 0.26 (Table 5.13).

For a catch in 2019 corresponding to the TAC, i.e. 149 550 t, the SSB is expected to decrease from about 555 377 t at the beginning of 2019 to 537 009 t at the beginning of 2020. At $F_{status\ quo}$ in 2020 SSB is estimated to decrease to 497 334 t at the beginning of 2021 and for a catch corresponding to the HCR it will decrease to about 483 172 t.

5.7.3 Comparison of the present and last year's assessment

The current assessment estimated the total stock in 2018 to be 27% higher and the SSB 29% higher, compared to the previous assessment. The F in 2017 is estimated to be the same as estimated in the previous assessment, and the realized F in 2018 is 32% lower compared to the predicted one based on the TAC.

	Total stock (3+) by 1 January 2018 (tonnes)	SSB by 1 January 2018 (tonnes)	$F_{4\text{-}7}$ in 2018	$F_{4\text{-}7}$ in 2017
WG 2018	714 440	383 022	0.34	0.22
WG 2019	909 053	494 841	0.23	0.22

5.8 Comments to the assessment and the forecast (Figure 5.5.4).

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 neighboring 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 somewhat more stable.

The biological sampling from the fishery may have become 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 Division 1 and age samples from purse-seine fishery south of Lofoten and in quarter two in ICES Division 1. This may affect the precision of the catch, weight and maturity-at-age data.

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.

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	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others [5]	Total all countries
1960	23	1 700		25 948		96 050					9 780	14	133 515
1961	61	3 625		19 757		77 875					4 595	18	105 951
1962	2	544		12 651		101 895			912		4 699	4	120 707
1963		1 110		8 108		135 297					4 112		148 627
1964		1 525		4 420		184 700			84		6 511	186	197 426
1965		1 618		11 387		165 531			137		6 741	181	185 600
1966		2 987	813	11 269		175 037			563		13 078	41	203 788
1967		9 472	304	11 822		150 860			441		8 379	48	181 326
1968			70	4 753		96 641					8 781		110 247
1969	20	193	6 744	4 355		115 140					13 585	23	140 060
1970	1 097		29 362	23 466		151 759			43 550		15 469		264 924
1971	215	14 536	16 840	12 204		128 499	6 017		39 397	13 097	10 361		241 272
1972	109	14 519	7 474	24 595		143 775	1 111		1 278	13 125	8 223		214 334
1973	7	11320	12 015	30 338		148 789	23		2 411	2 115	6 841		213 859
1974	46	7119	29 466	33 155		152 699	2521		28 931	7 075	3 104	5	264 121
1975	28	3156	28 517	41 260		122 598	3860	6430	13 389	11 397	2 763	55	233 453
1976	20	5609	10 266	49 056		131 675	3164	7233	9 013	21 661	4 724	65	242 486
1977	270	5658	7 164	19 985		139 705	1	783	989	1 327	6 935		182 817
1978	809	4345	6 484	19 190		121 069	35	203	381	121	2 827		155 464
1979	1117	2601	2 435	15 323		141 346			3	685	1 170		164 680
1980	532	1016		12 511		128 878			43	780	794		144 554
1981	236	218		8 431		166 139			121		395		175 540
1982	339	82		7 224		159 643			14		732		168 034
1983	539	418		4 933		149 556			206	33	1 251		156 936
1984	503	431	6	4 532		152 818			161		335		158 786
1985	490	657	11	1 873		103 899			51		202		107 183
1986	426	308		3 470		63 090			27		75		67 396
1987	712	576		4 909		85 710			426		57	1	92 391
1988	441	411		4 574		108 244			130		442		114 242

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others [5]	Total all countries
1989	388	460 [2]		606		119 625			506	506	726		122 817
1990	1207	340 [2]		1 143		92 397			52		709		95 848
1991	963	77 [2]	**Greenland**	2 003		103 283			504 [4]		492	5	107 327
1992	165	1980	734	3 451		119 763			964	6	541		127 604
1993	31	566	78	3 687	3	140 604		1	9 509	4 [2]	415	5	154 903
1994	67 [2]	557	15	1 863	4 [2]	141 589		1 [2]	1640 [2]	655 [2]	557	2	146 950
1995	172 [2]	358	53	935		165 001		5	1 148		688	18	168 378
1996	248 [2]	346	165	2 615		166 045		24	1 159	6	707	33	171 348
1997	193 [2]	560	363 [2]	2 915		136 927		12	1 774	41	799	45	143 629
1998	366	932	437 [2]	2 936		144 103		47	3 836	275	355	40	153 327
1999	181	638 [2]	655 [2]	2 473	146	141 941		17	3 929	24	339	32	150 375
2000	224 [2]	1438	651 [2]	2 573	33	125 932		46	4 452	117	454	8 [2]	135 928
2001	537	1279	701 [2]	2 690	57	124 928		75	4 951	119	514	2	135 853
2002	788	1048	1393	2 642	78	142 941		118	5 402	37	420	3	154 870
2003	2056	1022	929 [2]	2 763	80 [2]	150 400		147	3 894	18	265	18 [2]	161 592
2004	3071	255	891 [2]	2 161	319	147 975		127	9 192	87	544	14	164 636
2005	3152	447	817 [2]	2 048	395	162 338		354	8 362	25	630		178 568
2006	1795	899	786 [2]	2 779	255	195 462	89	339 [2]	9 823	21 [2]	532	42	212 822
2007	2048	966	810 [2]	3 019	219	178 644	99	412	12 168	53 [2]	558	12	199 008
2008	2314	1009	503 [2]	2 263	113	165 998	66	348	11 577	33	506	10	184 740
2009	1611 [2]	326 [2]	697	2 021	69	144 570	30	204 [2]	11 899	2 [2]	379	45 [2]	161 853
2010	1632	677 [2]	954	1 592	109 [2]	174 544	279	93	14 664	8	283	2 [2]	194 837
2011	112	367	445	1 371	65	143 314		46	10 007	2	972	15	156 716
2012	146	781	658	1 371	126	143 145		23 [2]	13 607	4	1 000	4 [2]	160 865
2013	80	1901	972	1326 [6]	290 [2]	111 962	2	17	14 796	5	433	22	131 806
2014	273	1 674	407	259	659	115 798	1	8	12 396	12	518	0	132 005
2015	576	514	393	424	249	114 830	1 154	10	13 181	34	400		131 765
2016	1 139	526	613	952	301	120 740	528	53	15 203	26	301	10	140 392
2017 [1]	638	680	407	1 148	560	126 946	504	86	14 551	88	439	23	146 070

Year	Faroe Islands	France	Germany Dem.Rep	Fed.Rep. Germany	Iceland	Norway	Poland	Portugal	Russia[3]	Spain	UK	Others [5]	Total all countries
2018	626	937	448	1642		162460	404	51	14171	60	464	17	181282

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 members

Table 5.2 Saithe in subareas 1 and 2 (Northeast Arctic). Catch 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 [2]
87	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 [3]
1995	21,8	103,5	26,9	16,1	168,4 [4]
1996	46,9	72,5	31,6	20,3	171,3
1997	44,4	55,9	24,4	19,0	143,6

1998		44,4	57,7	27,6	23,6	153,3
1999		39,2	57,9	29,7	23,6	150,4
2000		28,3	54,5	29,6	23,5	135,9
2001		28,1	58,1	28,2	21,5	135,9
2002		27,4	75,5	30,4	21,5	154,8
2003		43,3	73,8	25,2	19,3	161,6
2004		41,8	74,6	26,9	21,3	164,6
2005		42,1	91,8	25,6	19,1	178,6
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	21,4	27,3	146,1
2018	1	36	83,4	28,8	33,2	181.3

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) Northeast Arctic saithe

	Age groups								
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1960	13517	16828	17422	6514	6281	3088	1691	956	481	1481
1961	25237	12929	17707	5379	1886	1371	736	573	538	1202
1962	45932	13720	5449	10218	2991	1262	1156	556	611	1518
1963	51171	35199	7165	5659	4699	1337	1308	848	550	1612
1964	10925	72344	15966	3299	4214	3223	1518	1482	1282	3038
1965	42578	5737	30171	11635	3282	2421	3135	802	1136	2986
1966	25127	61199	14727	14475	5220	1542	1047	1083	530	2724
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

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1988	8144	35928	32901	4570	2333	1222	968	321	73	30
1989	12607	19400	33343	18578	1762	352	177	189	1	205
1990	23792	16930	9054	10238	7341	1076	160	112	150	118
1991	68682	13630	5752	4883	3877	2381	383	61	90	89
1992	44627	33294	5987	5412	4751	3176	1462	286	93	350
1993	22812	61931	31102	3747	1759	1378	1027	797	76	71
1994	7063	32671	49410	19058	2058	724	421	278	528	129
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

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

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

	Age groups									
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**
1960	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,55
1961	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,75
1962	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,52
1963	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,33
1964	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,35
1965	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,54
1966	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,43
1967	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,49
1968	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,36
1969	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,16
1970	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,03
1971	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,87
1972	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,14
1973	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,01
1974	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,69
1975	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,73
1976	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	7,86
1977	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,05
1978	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,00
1979	0,71	1,11	1,63	2,33	3,16	4,03	4,87	5,63	6,44	8,28
1980	0,79	1,27	2,03	2,55	3,29	4,34	5,15	5,75	6,11	7,22
1981	0,73	1,40	2,05	2,76	3,30	4,38	5,95	6,39	6,61	7,00

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
1982	0,77	1,12	2,02	2,61	3,27	3,91	4,69	5,63	7,18	7,69
1983	1,05	1,33	1,86	2,80	4,00	4,18	5,33	5,68	7,31	9,16
1984	0,71	1,26	2,02	2,70	3,88	4,47	5,36	6,06	6,28	7,88
1985	0,75	1,33	2,07	2,63	3,28	3,96	4,54	5,55	6,88	8,74
1986	0,59	1,22	1,97	2,30	2,87	3,72	4,30	4,69	5,84	7,21
1987	0,53	0,84	1,66	2,32	2,97	4,00	4,72	5,44	5,79	7,42
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

	Age groups									
Year	3	4	5	6	7	8	9	10	11	12+
2010	0,70	0,99	1,45	2,14	2,50	3,13	3,34	3,81	3,99	5,17
2011	0,70	0,82	1,42	2,07	2,68	3,25	3,62	3,97	4,52	5,84
2012	0,59	1,07	1,35	2,15	2,82	3,20	3,67	4,16	4,60	5,70
2013	0,57	1,01	1,50	1,83	2,74	3,33	3,91	4,61	4,50	6,13
2014	0,66	0,92	1,58	2,12	2,54	3,49	4,01	4,22	4,71	5,80
2015	0,61	0,85	1,24	1,91	2,45	3,02	3,97	4,74	4,51	6,05
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

Table 5.5. 3-year running average maturity ogive 1985–2006, values for 2007–2017 average of 2005–2007.

Year	3	4	5	6	7	8	9	10	11	12+
1985	0	0.02	0.5	0.92	0.99	1	1	1	1	1
1986	0	0.02	0.51	0.94	0.99	1	1	1	1	1
1987	0	0	0.35	0.98	1	1	1	1	1	1
1988	0	0	0.25	0.96	1	1	1	1	1	1
1989	0	0	0.15	0.92	1	1	1	1	1	1
1990	0	0	0.2	0.85	0.99	1	1	1	1	1
1991	0	0.02	0.25	0.84	0.98	1	1	1	1	1
1992	0	0.02	0.3	0.83	0.93	0.92	0.9	0.95	1	1
1993	0	0.02	0.26	0.88	0.92	0.89	0.87	0.89	1	0.99
1994	0	0.02	0.26	0.84	0.9	0.82	0.87	0.89	1	0.99
1995	0	0.02	0.22	0.8	0.92	0.9	0.97	0.94	1	0.99
1996	0	0.03	0.21	0.65	0.91	0.93	1	1	1	1.00
1997	0	0.03	0.14	0.45	0.83	0.94	0.93	0.97	1	1.00
1998	0	0.04	0.07	0.33	0.74	0.93	0.92	0.96	1	1.00
1999	0	0	0.08	0.32	0.74	0.92	0.92	0.96	0.99	0.98
2000	0	0	0.08	0.46	0.82	0.96	0.98	0.99	0.97	0.95
2001	0	0	0.11	0.64	0.93	0.97	0.98	0.99	0.97	0.94

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

Table 5.6 Northeast Arctic saithe. Tuning datasets applied in final SAM run

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
1	38	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	19.2
1	142.5	176.3	11.6	11.5	8
1	275.9	45.9	53.8	5.6	6.1

FLT14: Norway Ac Survey (Catch: Unknown) (Effort: Unknown)
2002 2018
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	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	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

Table 5.7 SAM parameter settings.

Model used: State-space assessment model SAM (https://www.stockassessment.org).

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

Visible stock on (https://www.stockassessment.org) "afwg_saithe_ 2019_001".

Model Options agreed upon at IBP saithe winter 2014.

$minAge
The minimium age class in the assessment
3
$maxAge
The maximum age class in the assessment
12

```
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no).
1
$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  4  5  5  5  5  5
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR(1)
 2
$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is not used, as that is covered
by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
  0  1  2  3  3 -1 -1 -1 -1 -1
  4  5  6  7  7 -1 -1 -1 -1 -1
$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (nomally only first row is used)
  0  0  0  0  0  0  0  0  0  0
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
  0  0  0  0  0  0  0  0  0  0
  1  1  1  1  1 -1 -1 -1 -1 -1
  2  2  2  2  2 -1 -1 -1 -1 -1
```

Table 5.7 SAM parameter settings continued

```
$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). |
Possible values are: "ID" "AR" "US"
 "ID" "ID" "ID"
$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#3-4 4-5 5-6 6-7 7-8 8-9 9-10 10-11 11-12
  NA  NA  NA  NA  NA  NA  NA  NA  NA
  NA  NA  NA  NA  -1  -1  -1  -1  -1
  NA  NA  NA  NA  -1  -1  -1  -1  -1
$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton–Holt).
 2
$noScaledYears
# Number of years where catch scaling is applied.
 0
$keyScaledYears
# A vector of the years where catch scaling is applied.
  $keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
$fbarRange
# lowest and higest age included in Fbar
 4 7
$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).
 -1 -1 -1
$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "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
```

Table 5.8. SAM catchabilities, negative log likelihood values, and number of parameters.

Index	Fleet number	Age	Catchability	Low	High
1	2	3	0.864	0.588	1.269
2	2	4	1.164	0.794	1.706
3	2	5	0.604	0.412	0.886
4	2	6	0.373	0.278	0.502
5	2	7	0.373	0.278	0.502
6	3	3	0.638	0.517	0.788
7	3	4	0.489	0.396	0.604
8	3	5	0.269	0.217	0.333
9	3	6	0.177	0.147	0.214
10	3	7	0.177	0.147	0.214

Model fitting.

Model	log(L)	#par	AIC
Current	-547.23	17	1128.45
base	-547.23	17	1128.45

Table 5.9 Estimated fishing mortalities.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	0.237	0.285	0.321	0.277	0.221	0.163	0.163	0.163	0.163	0.163
1961	0.223	0.260	0.273	0.226	0.174	0.127	0.127	0.127	0.127	0.127
1962	0.223	0.262	0.268	0.226	0.177	0.133	0.133	0.133	0.133	0.133
1963	0.225	0.273	0.282	0.239	0.194	0.154	0.154	0.154	0.154	0.154
1964	0.239	0.299	0.319	0.277	0.241	0.208	0.208	0.208	0.208	0.208
1965	0.235	0.292	0.326	0.288	0.254	0.231	0.231	0.231	0.231	0.231
1966	0.261	0.320	0.343	0.289	0.245	0.224	0.224	0.224	0.224	0.224
1967	0.261	0.309	0.318	0.264	0.225	0.217	0.217	0.217	0.217	0.217
1968	0.221	0.241	0.229	0.185	0.153	0.147	0.147	0.147	0.147	0.147
1969	0.230	0.240	0.221	0.175	0.143	0.132	0.132	0.132	0.132	0.132
1970	0.328	0.361	0.340	0.283	0.250	0.240	0.240	0.240	0.240	0.240

Year Age	3	4	5	6	7	8	9	10	11	12
1971	0.359	0.384	0.356	0.295	0.269	0.259	0.259	0.259	0.259	0.259
1972	0.380	0.390	0.350	0.283	0.259	0.245	0.245	0.245	0.245	0.245
1973	0.419	0.428	0.386	0.317	0.299	0.284	0.284	0.284	0.284	0.284
1974	0.542	0.561	0.513	0.429	0.416	0.395	0.395	0.395	0.395	0.395
1975	0.596	0.621	0.568	0.479	0.488	0.477	0.477	0.477	0.477	0.477
1976	0.649	0.683	0.611	0.499	0.496	0.470	0.470	0.470	0.470	0.470
1977	0.575	0.615	0.540	0.431	0.417	0.377	0.377	0.377	0.377	0.377
1978	0.574	0.653	0.596	0.488	0.475	0.430	0.430	0.430	0.430	0.430
1979	0.554	0.678	0.638	0.529	0.508	0.451	0.451	0.451	0.451	0.451
1980	0.494	0.638	0.619	0.519	0.481	0.420	0.420	0.420	0.420	0.420
1981	0.458	0.630	0.621	0.521	0.460	0.391	0.391	0.391	0.391	0.391
1982	0.422	0.622	0.622	0.527	0.450	0.374	0.374	0.374	0.374	0.374
1983	0.403	0.630	0.655	0.596	0.533	0.452	0.452	0.452	0.452	0.452
1984	0.444	0.716	0.733	0.725	0.685	0.591	0.591	0.591	0.591	0.591
1985	0.352	0.592	0.614	0.652	0.683	0.590	0.590	0.590	0.590	0.590
1986	0.243	0.451	0.499	0.574	0.650	0.591	0.591	0.591	0.591	0.591
1987	0.226	0.457	0.533	0.666	0.806	0.747	0.747	0.747	0.747	0.747
1988	0.215	0.457	0.538	0.660	0.766	0.652	0.652	0.652	0.652	0.652
1989	0.201	0.422	0.470	0.525	0.533	0.399	0.399	0.399	0.399	0.399
1990	0.223	0.478	0.525	0.595	0.602	0.451	0.451	0.451	0.451	0.451
1991	0.191	0.428	0.481	0.556	0.571	0.430	0.430	0.430	0.430	0.430
1992	0.172	0.430	0.543	0.692	0.754	0.601	0.601	0.601	0.601	0.601
1993	0.130	0.354	0.476	0.622	0.680	0.540	0.540	0.540	0.540	0.540
1994	0.100	0.296	0.418	0.567	0.627	0.503	0.503	0.503	0.503	0.503
1995	0.081	0.246	0.336	0.436	0.470	0.372	0.372	0.372	0.372	0.372
1996	0.072	0.224	0.312	0.419	0.485	0.415	0.415	0.415	0.415	0.415
1997	0.052	0.162	0.225	0.296	0.338	0.292	0.292	0.292	0.292	0.292
1998	0.046	0.153	0.220	0.296	0.346	0.322	0.322	0.322	0.322	0.322
1999	0.045	0.156	0.227	0.297	0.338	0.322	0.322	0.322	0.322	0.322

Year Age	3	4	5	6	7	8	9	10	11	12
2000	0.039	0.138	0.202	0.265	0.295	0.291	0.291	0.291	0.291	0.291
2001	0.030	0.114	0.174	0.234	0.262	0.272	0.272	0.272	0.272	0.272
2002	0.027	0.107	0.164	0.224	0.258	0.288	0.288	0.288	0.288	0.288
2003	0.025	0.102	0.155	0.212	0.259	0.322	0.322	0.322	0.322	0.322
2004	0.023	0.095	0.146	0.204	0.259	0.347	0.347	0.347	0.347	0.347
2005	0.032	0.126	0.178	0.237	0.287	0.377	0.377	0.377	0.377	0.377
2006	0.040	0.154	0.211	0.281	0.341	0.453	0.453	0.453	0.453	0.453
2007	0.047	0.172	0.227	0.294	0.352	0.462	0.462	0.462	0.462	0.462
2008	0.071	0.247	0.295	0.359	0.415	0.529	0.529	0.529	0.529	0.529
2009	0.081	0.274	0.317	0.366	0.411	0.516	0.516	0.516	0.516	0.516
2010	0.098	0.326	0.366	0.396	0.422	0.499	0.499	0.499	0.499	0.499
2011	0.097	0.311	0.361	0.396	0.424	0.479	0.479	0.479	0.479	0.479
2012	0.101	0.301	0.344	0.369	0.389	0.424	0.424	0.424	0.424	0.424
2013	0.085	0.249	0.286	0.303	0.319	0.337	0.337	0.337	0.337	0.337
2014	0.074	0.220	0.259	0.273	0.291	0.308	0.308	0.308	0.308	0.308
2015	0.069	0.209	0.249	0.257	0.272	0.285	0.285	0.285	0.285	0.285
2016	0.060	0.192	0.239	0.254	0.278	0.303	0.303	0.303	0.303	0.303
2017	0.054	0.172	0.215	0.233	0.258	0.285	0.285	0.285	0.285	0.285
2018	0.057	0.182	0.229	0.244	0.271	0.301	0.301	0.301	0.301	0.301

Table 5.10 Estimated stock numbers.

Year Age	3	4	5	6	7	8	9	10	11	12
1960	84953	103904	53236	28382	25891	14185	10448	7310	3636	12144
1961	113991	57040	68506	29916	17462	15984	8965	7019	5131	11311
1962	204021	67565	36783	44139	18586	12666	11383	6223	5183	12481
1963	272404	131433	38770	25370	28421	11911	9816	8233	4504	13308
1964	81247	190059	77135	22676	17496	18776	8048	7407	6112	13620
1965	254964	50569	111626	44903	14509	11523	12223	5047	5124	13712
1966	133647	180099	34520	62977	26265	9306	7491	7294	3201	12474

Year Age	3	4	5	6	7	8	9	10	11	12
1967	175109	83126	109699	20308	36792	16017	6271	5176	4570	10014
1968	143445	116785	47572	63747	13139	23976	10074	4086	3333	8339
1969	263307	88992	80107	31887	42237	10727	17842	7014	2683	6987
1970	222544	167148	58646	54433	22553	29671	9099	13972	5137	7225
1971	230101	143955	87218	35633	32767	14407	17683	6437	9200	7946
1972	152826	138329	85802	46674	23034	19654	9613	10453	4223	10163
1973	201514	80296	79128	52164	27951	15438	12729	6750	6432	8942
1974	99937	111129	41931	45832	32604	16864	10235	8242	4242	9093
1975	167491	44241	53047	20033	23716	17771	9325	5987	4754	7186
1976	218085	74991	19349	25717	10549	11398	8677	4711	3053	5795
1977	201382	89952	30941	8438	13285	5472	5706	4284	2325	4250
1978	135201	89894	38650	14992	4595	7285	3202	3105	2408	3964
1979	196410	59793	38777	17236	7663	2361	4007	1756	1560	3429
1980	118184	95062	23552	16879	8549	3656	1142	2063	959	2679
1981	228873	56954	43392	10036	8279	4402	1851	687	1072	1845
1982	128955	122451	24390	19481	4730	4374	2260	1041	396	1649
1983	101770	69009	52742	9989	9344	2582	2503	1256	607	1286
1984	92939	58374	31018	20223	4362	4549	1304	1334	711	1053
1985	102179	42054	23298	12987	6931	1935	2090	561	610	826
1986	181485	49360	17680	11001	6017	2399	948	956	270	635
1987	144147	132627	22860	8336	5449	2790	854	478	427	463
1988	81210	100494	75832	11190	3437	2032	1317	237	200	302
1989	77229	55200	54872	38727	4882	1196	827	613	58	285
1990	85530	47645	29824	26222	18793	2434	603	464	366	214
1991	224375	48153	22181	15160	11132	8507	1240	302	264	321
1992	284775	142387	22612	10936	7768	4972	4698	649	170	367
1993	214176	213634	75813	10177	4277	3100	1964	2310	283	237
1994	152907	164086	131822	37195	4354	1726	1484	773	1232	268
1995	279958	132487	112233	74894	15642	1855	806	775	316	815

Year Age	3	4	5	6	7	8	9	10	11	12
1996	159923	245472	88521	68711	40088	7977	1038	485	446	699
1997	163808	121588	178450	57936	40057	21346	4172	511	261	627
1998	104103	134629	84741	127215	33048	24098	12802	2556	333	620
1999	241993	79020	94981	54183	73867	18535	14982	7619	1480	574
2000	158151	193548	51618	55945	31677	40831	11359	9527	4366	1139
2001	215548	108271	140484	35692	33322	19275	24261	7227	6008	3208
2002	352556	180435	79997	94702	24173	20679	12720	15047	4487	5875
2003	148627	311662	127203	53078	57822	17188	12745	8594	9172	6465
2004	152693	121343	210503	88709	36362	36899	10916	7440	5439	9144
2005	421639	119362	80483	127711	58194	24177	22344	6823	3869	7650
2006	72565	338396	81185	49712	75583	35640	14884	12586	3879	6163
2007	109959	54438	217166	53402	30453	40781	20006	8258	6302	4501
2008	193144	75595	38677	117533	30774	16862	20293	10824	4189	5194
2009	141340	151572	46633	25587	64227	16064	8015	9425	5314	4318
2010	264731	97189	91272	29030	14589	33984	7925	3842	4260	4456
2011	112113	198663	51136	47722	15981	8347	16392	4005	1892	4073
2012	148149	92242	125070	31626	25474	9277	4512	8009	1976	2973
2013	206890	91996	64882	79060	18872	13852	5184	2526	4116	2624
2014	105605	171403	61425	43997	47400	11482	8080	3265	1510	3923
2015	161651	80013	123650	43117	29994	28380	6820	4766	2058	3457
2016	247419	120379	55033	77373	28965	19171	16748	4065	3123	4006
2017	164535	214344	84656	35149	46157	18031	11775	9535	2341	5056
2018	90346	134793	171393	63525	25309	28233	11257	7417	5654	4856
pred		69862	92020	111650	40735	15800	17116	6824	4496	6371

Table 5.11. Estimated recruitment, total-stock-biomass (TBS), spawning-stock-biomass (SSB), and average fishing mortality for ages 4 to 7 (F47).

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1960	84953	53213	135625	461689	339573	627718	0.276	0.197	0.386	686789	536357	879413
1961	113991	74988	173281	455025	337687	613137	0.233	0.171	0.319	660449	518551	841176
1962	204021	134901	308555	459946	344568	613958	0.233	0.172	0.315	722629	576484	905823
1963	272404	180374	411390	456518	345564	603096	0.247	0.184	0.331	833457	674314	1030159
1964	81247	53331	123774	479946	368704	624751	0.284	0.214	0.378	812097	655854	1005561
1965	254964	168970	384722	518913	402944	668257	0.290	0.218	0.385	853996	694371	1050316
1966	133647	88803	201136	479829	370205	621914	0.299	0.225	0.397	821621	668022	1010536
1967	175109	116074	264169	492147	382841	632661	0.279	0.209	0.372	797709	650261	978590
1968	143445	95235	216059	470746	365312	606608	0.202	0.151	0.270	758931	619329	930000
1969	263307	174102	398218	510616	404502	644568	0.195	0.146	0.259	867929	718894	1047862
1970	222544	147873	334922	565689	457145	700004	0.309	0.237	0.402	970841	816929	1153751
1971	230101	153659	344569	554013	452646	678081	0.326	0.252	0.422	954076	807610	1127106
1972	152826	102171	228594	537029	442242	652133	0.321	0.249	0.413	878250	746367	1033436
1973	201514	134688	301495	536980	447205	644777	0.358	0.280	0.457	846330	723541	989957
1974	99937	66532	150114	491972	411626	588002	0.480	0.380	0.606	733882	630319	854462
1975	167491	111838	250838	398071	334125	474256	0.539	0.428	0.678	613017	526276	714055

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1976	218085	145204	327547	281688	234905	337787	0.572	0.456	0.718	542783	459946	640538
1977	201382	134484	301557	209744	174292	252408	0.501	0.397	0.631	478057	401975	568541
1978	135201	90182	202694	189232	158315	226188	0.553	0.441	0.693	417890	353732	493684
1979	196410	131211	294009	170643	142701	204056	0.588	0.470	0.736	410752	343305	491450
1980	118184	78976	176858	150451	125725	180039	0.564	0.451	0.707	391872	327740	468552
1981	228873	151892	344868	154708	128584	186140	0.558	0.446	0.699	445454	366436	541512
1982	128955	85880	193635	135940	113036	163486	0.555	0.442	0.698	401117	331603	485202
1983	101770	67590	153232	162762	134204	197398	0.604	0.483	0.754	409572	341772	490824
1984	92939	61440	140588	146367	121055	176972	0.715	0.575	0.888	321894	270606	382901
1985	102179	67571	154512	110846	91985	133576	0.635	0.509	0.794	269367	224837	322715
1986	181485	119911	274676	83484	69196	100721	0.544	0.433	0.682	268332	218247	329911
1987	144147	96109	216195	72113	59887	86835	0.615	0.496	0.764	284971	232456	349350
1988	81210	53571	123108	88171	72705	106928	0.605	0.486	0.754	301544	248007	366637
1989	77229	50831	117336	103206	79899	133312	0.487	0.386	0.615	283608	234165	343491
1990	85530	55836	131015	119544	95302	149954	0.550	0.437	0.692	271200	226913	324130
1991	224375	147958	340259	114596	93844	139936	0.509	0.404	0.641	353979	287222	436252
1992	284775	188451	430334	94977	79749	113113	0.605	0.484	0.756	466078	374271	580405

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
1993	214176	143148	320446	97175	80832	116824	0.533	0.425	0.668	534776	432767	660829
1994	152907	104146	224499	147869	120016	182186	0.477	0.377	0.603	487145	403474	588168
1995	279958	189137	414389	196889	158045	245281	0.372	0.292	0.474	590750	491160	710532
1996	159923	108730	235220	246126	200675	301873	0.360	0.281	0.461	684019	572213	817671
1997	163808	111598	240444	245371	200710	299969	0.255	0.197	0.330	725368	605273	869292
1998	104103	71194	152225	294112	240778	359259	0.254	0.196	0.329	802304	669727	961126
1999	241993	165404	354045	310104	250776	383467	0.254	0.195	0.332	806750	679444	957908
2000	158151	108128	231316	370374	299911	457391	0.225	0.172	0.294	828281	701242	978334
2001	215548	148663	312527	376555	309143	458667	0.196	0.150	0.255	890268	757854	1045818
2002	352556	248584	500016	452970	377812	543079	0.188	0.145	0.244	1031417	883813	1203671
2003	148627	104512	211364	442949	372768	526343	0.182	0.140	0.236	1006522	860468	1177367
2004	152693	106208	219522	525691	446290	619219	0.176	0.135	0.229	1024250	874615	1199487
2005	421639	296491	599610	611511	516830	723537	0.207	0.160	0.269	1100766	943264	1284568
2006	72565	51298	102647	543695	462224	639526	0.247	0.191	0.319	945673	811022	1102681
2007	109959	78021	154973	552527	471214	647870	0.261	0.203	0.337	886965	757850	1038076
2008	193144	137329	271643	477066	400833	567796	0.329	0.257	0.421	735530	632395	855485
2009	141340	100766	198250	368792	309450	439514	0.342	0.269	0.435	679141	585406	787884

Year	R(age 3)	Low	High	SSB	Low	High	Fbar(4-7)	Low	High	TSB	Low	High
2010	264731	189270	370278	333601	280568	396658	0.377	0.297	0.480	699993	599725	817025
2011	112113	79199	158706	298212	249961	355777	0.373	0.292	0.477	590297	504186	691115
2012	148149	105266	208500	307997	258049	367614	0.351	0.274	0.449	600392	511828	704280
2013	206890	147166	290853	331872	273460	402762	0.289	0.224	0.373	617206	523281	727991
2014	105605	74941	148817	360463	294502	441199	0.261	0.201	0.339	654209	551999	775344
2015	161651	114736	227750	372942	300919	462203	0.247	0.189	0.323	641337	535873	767557
2016	247419	173046	353756	413202	326495	522936	0.241	0.181	0.320	812806	673015	981632
2017	164535	112238	241200	431671	334567	556957	0.220	0.161	0.298	905925	740380	1108484
2018	90346	55636	146710	494841	375262	652524	0.231	0.164	0.327	909053	717470	1151795

Table 5.12 Northeast Arctic saithe. Prediction input data

MFDP version 1a
Run: fsh
Time and date: 10:15 29.04.2019
F_{bar} age range: 4-7

2019

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	159107	0.2	0	0	0	0.880	0.0570	0.880
4	69862	0.2	0.05	0	0	1.123	0.1820	1.123
5	92020	0.2	0.42	0	0	1.566	0.2277	1.566
6	111650	0.2	0.87	0	0	2.071	0.2437	2.071
7	40735	0.2	0.97	0	0	2.500	0.2690	2.500
8	15800	0.2	0.98	0	0	3.096	0.2963	3.096
9	17116	0.2	0.98	0	0	3.536	0.2963	3.536
10	6824	0.2	0.97	0	0	4.062	0.2963	4.062
11	4496	0.2	0.97	0	0	4.550	0.2963	4.550
12	6371	0.2	0.994	0	0	5.844	0.2963	5.844

2020

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	159107	0.2	0	0	0	0.880	0.0570	0.880
4	.	0.2	0.05	0	0	1.123	0.1820	1.123
5	.	0.2	0.42	0	0	1.566	0.2277	1.566
6	.	0.2	0.87	0	0	2.071	0.2437	2.071
7	.	0.2	0.97	0	0	2.500	0.2690	2.500
8	.	0.2	0.98	0	0	3.096	0.2963	3.096
9	.	0.2	0.98	0	0	3.536	0.2963	3.536
10	.	0.2	0.97	0	0	4.062	0.2963	4.062
11	.	0.2	0.97	0	0	4.550	0.2963	4.550
12	.	0.2	0.994	0	0	5.844	0.2963	5.844

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
3	159107	0.2	0	0	0	0.880	0.0570	0.880
4	.	0.2	0.05	0	0	1.123	0.1820	1.123
5	.	0.2	0.42	0	0	1.566	0.2277	1.566
6	.	0.2	0.87	0	0	2.071	0.2437	2.071
7	.	0.2	0.97	0	0	2.500	0.2690	2.500
8	.	0.2	0.98	0	0	3.096	0.2963	3.096
9	.	0.2	0.98	0	0	3.536	0.2963	3.536
10	.	0.2	0.97	0	0	4.062	0.2963	4.062
11	.	0.2	0.97	0	0	4.550	0.2963	4.550
12	.	0.2	0.994	0	0	5.844	0.2963	5.844

Input units are thousands and kg - output in tonnes

Table 5.13 Northeast Arctic saithe. Short-term prediction

MFDP version 1a
Run: fsh
North-East Arctic saithe
Time and date: 10:15 29.04.2019
F_{bar} age range: 4-7

2019

Biomass	SSB	F_{Mult}	F_{Bar}	Landings
890462	555377	0.9368	0.216	149550

2020–2021

2020					2021	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
878824	537009	0	0	0	1035106	642238
.	537009	0.1	0.0231	17396	1015853	625976
.	537009	0.2	0.0461	34377	997071	610136
.	537009	0.3	0.0692	50953	978747	594707
.	537009	0.4	0.0922	67135	960868	579677

2020					2021	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
.	537009	0.5	0.1153	82932	943425	565038
.	537009	0.6	0.1384	98355	926405	550778
.	537009	0.7	0.1614	113412	909798	536887
.	537009	0.8	0.1845	128114	893594	523355
.	537009	0.9	0.2075	142468	877782	510174
.	537009	1	0.2306	156484	862351	497334
.	537009	1.1	0.2536	170171	847293	484825
.	537009	1.2	0.2767	183536	832598	472640
.	537009	1.3	0.2998	196588	818256	460769
.	537009	1.4	0.3228	209335	804259	449205
.	537009	1.5	0.3459	221784	790598	437939
.	537009	1.6	0.3689	233943	777264	426964
.	537009	1.7	0.392	245819	764249	416272
.	537009	1.8	0.4151	257419	751545	405855
.	537009	1.9	0.4381	268751	739144	395706
.	537009	2	0.4612	279820	727038	385818

Input units are thousands and kg - output in tonnes

Table 5.14 Northeast arctic saithe. Short-term projection output HCR landings

MFDP version 1a
Run: fmp
tst1MFDP Index file 29.04.2019
Time and date: 10:30 29.04.2019
F_{bar} age range: 4-7

2019							
Biomass	SSB	FMult	FBar	Landings		Fmp (0.32)	
890462	555377	0.9368	0.216	149550		landings	SSB
						207794	537009
2020						188110	450602
Biomass	SSB	FMult	FBar	Landings		172354	399973
878824	537009	1.1134	0.2567	171982	average	189419	
The TAC should not be changed by more than 15% compared with the previous year's TAC.							
						171982	

2021-2022

2021					2022	
Biomass	**SSB**	**F_{Mult}**	**F_{Bar}**	**Landings**	**Biomass**	**SSB**
845301	483172	0	0	0	1002927	605922
.	483172	0.1	0.0231	16697	984434	590514
.	483172	0.2	0.0461	32993	966395	575510
.	483172	0.3	0.0692	48899	948797	560898
.	483172	0.4	0.0922	64424	931630	546667
.	483172	0.5	0.1153	79578	914881	532809
.	483172	0.6	0.1384	94371	898541	519313
.	483172	0.7	0.1614	108812	882598	506168
.	483172	0.8	0.1845	122909	867043	493367
.	483172	0.9	0.2075	136673	851866	480899
.	483172	1	0.2306	150110	837056	468756
.	483172	1.1	0.2536	163231	822604	456929
.	483172	1.2	0.2767	176041	808502	445410
.	483172	1.3	0.2998	188551	794739	434190
.	483172	1.4	0.3228	200766	781309	423263
.	483172	1.5	0.3459	212695	768201	412619
.	483172	1.6	0.3689	224345	755408	402251

2021					2022	
Biomass	SSB	F_{Mult}	F_{Bar}	Landings	Biomass	SSB
.	483172	1.7	0.392	235723	742921	392153
.	483172	1.8	0.4151	246836	730734	382316
.	483172	1.9	0.4381	257690	718837	372734
.	483172	2	0.4612	268293	707225	363401

Input units are thousands and kg - output in tonnes

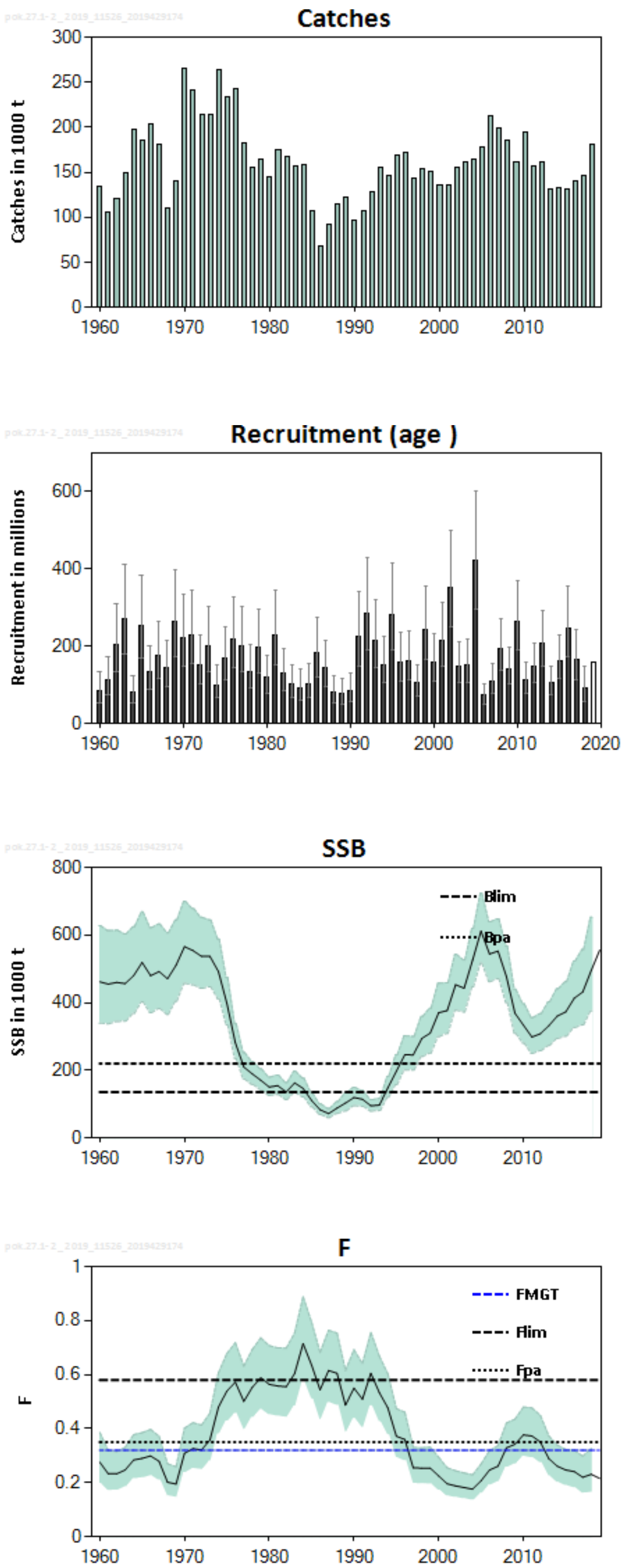


Figure 5.1. Northeast Arctic saithe (subareas 1 and 2).

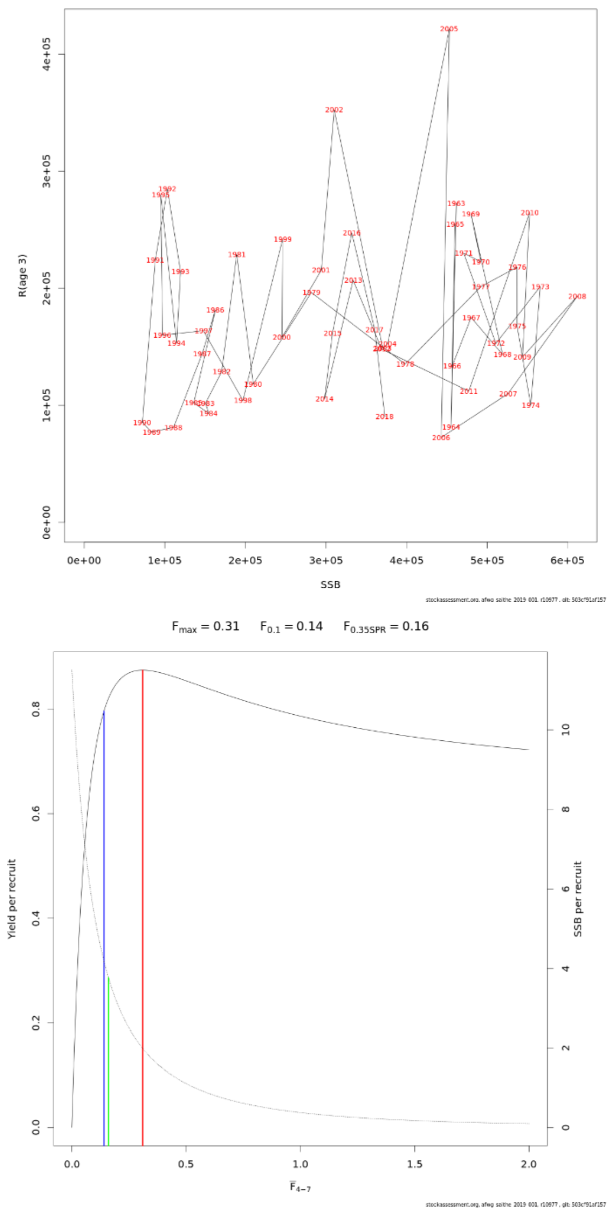


Figure 5.1. continued.

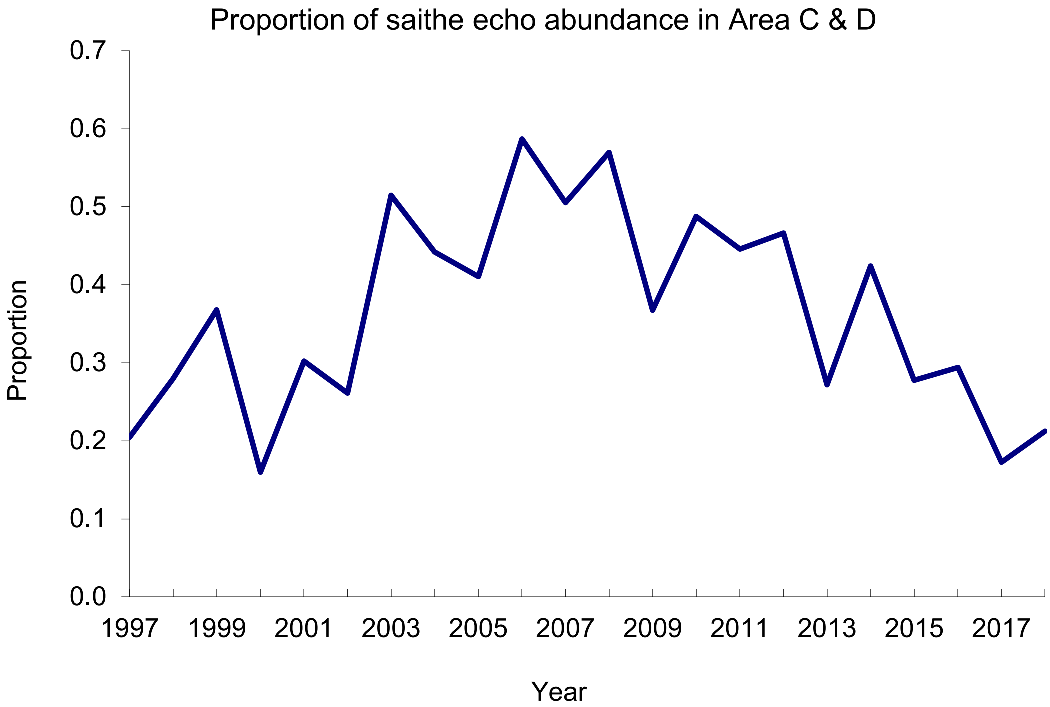


Figure 5.2. Northeast Arctic saithe. Proportion of saithe in the southern half of the survey area (subarea C+D).

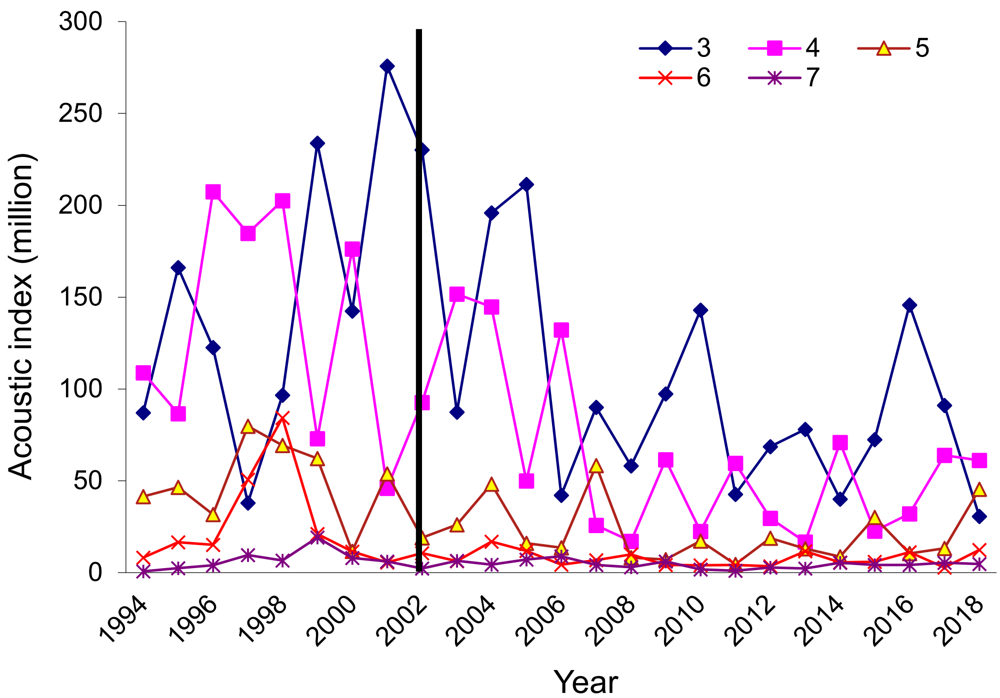


Figure 5.3. Northeast Arctic saithe, acoustic survey tuning indices, break in 2002 black line.

Figure 5.4. Northeast Arctic saithe. Final run normalized residuals. Blue circles indicate positive residuals (larger than predicted) and filled red circles indicate negative residuals.

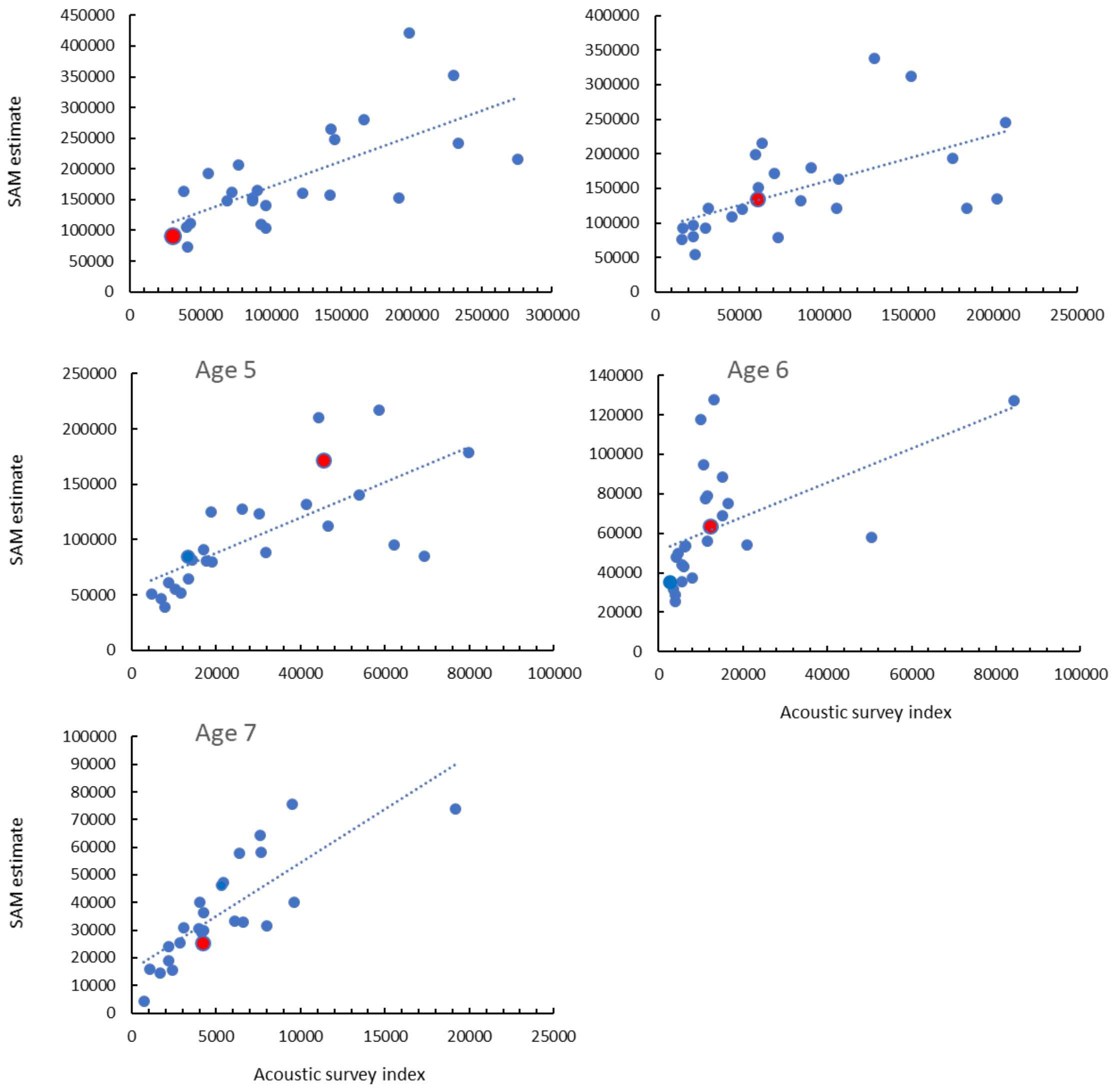
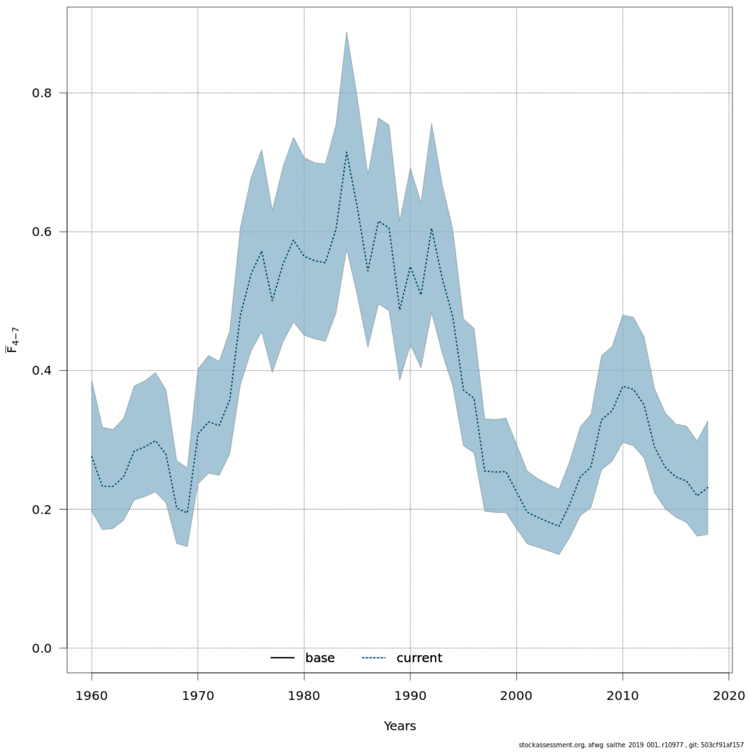


Figure 5.5. NEA saithe - Acoustic survey vs. SAM, red circles show last data year.



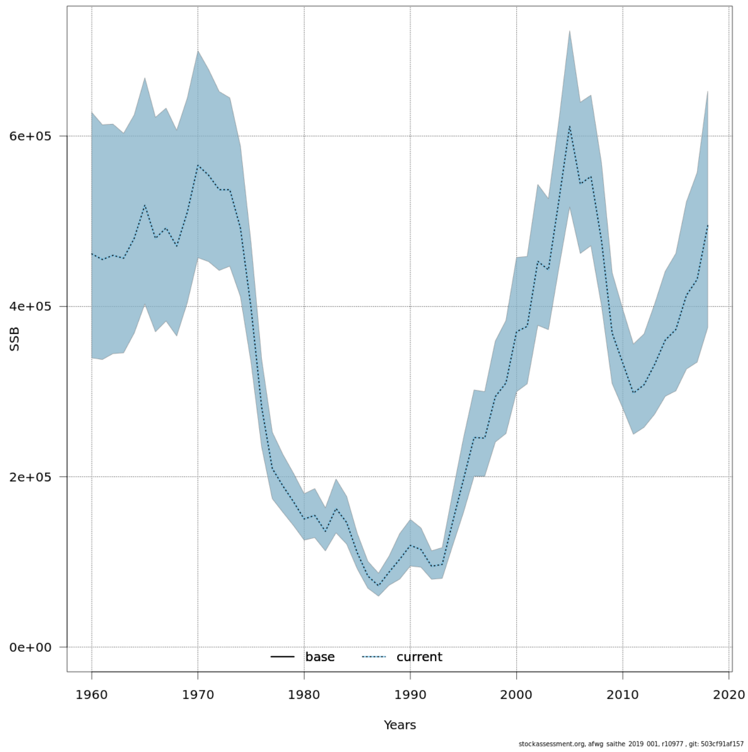


Figure 5.6. F_{4-7} and SSB. Estimates from the current run and point wise 95% confidence intervals are shown by black line and shaded area.

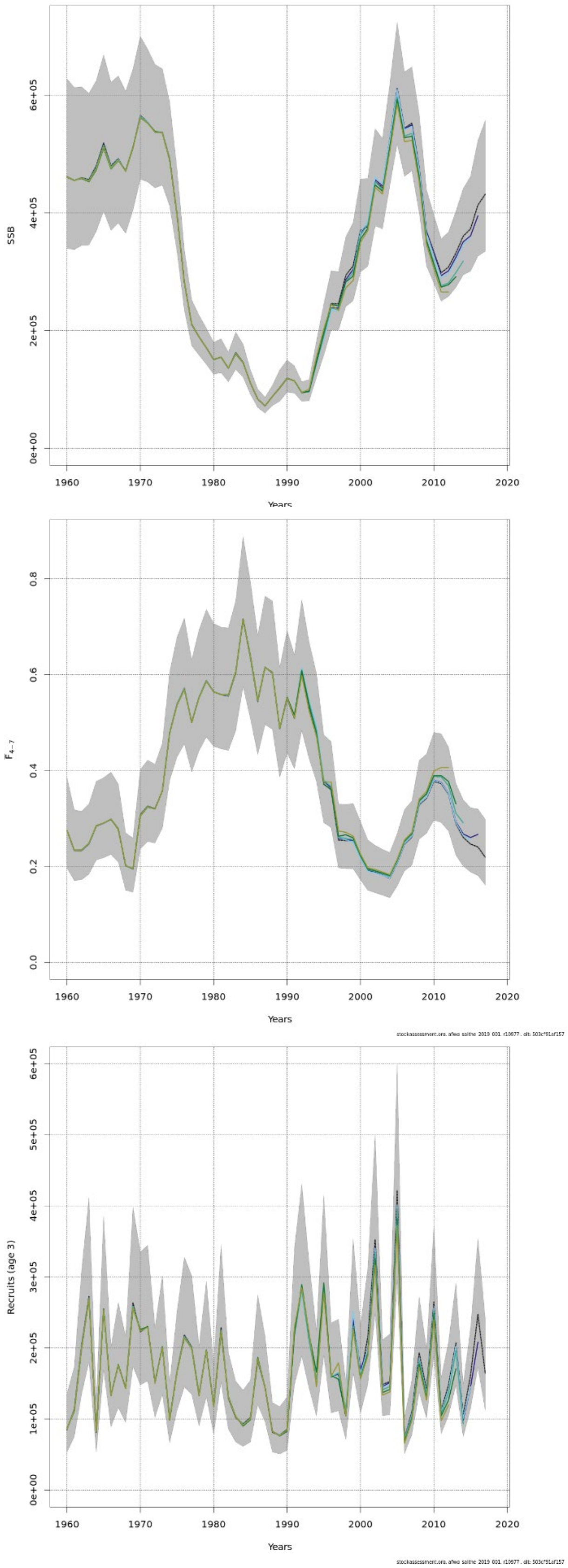


Figure 5.7. Saithe in subareas 1 and 2 (Northeast Arctic) RETROSPECTIVE SAM SSB, $F_{4\text{-}7}$, and recruits.

6 Beaked redfish *(Sebastes mentella)* in subareas 1 and 2

Following the recommendation from the benchmark assessment for redfish stocks in January 2018 (WKREDFISH, ICES 2018a) the analytical assessment is conducted using a statistical catch-at-age model (SCAA, for the period 1992–2018). Advice on beaked redfish in subareas 1 and 2 is to be provided every third year and should be provided in 2020. The present report therefore updates the assessment for this stock but does not provide advice.

6.1 Status of the Fisheries

6.1.1 Development of the fishery

A description of the historical development of the fishery in subareas 1 and 2 is found in the stock annex for this stock.

A pelagic fishery for *S. mentella* has developed in the Norwegian Sea outside EEZs since 2004 (Figure 6.1). This fishery, which is further described in the quality handbook for this stock, is managed by the Northeast Atlantic Fisheries Commission (NEAFC). A new directed demersal and pelagic fishery is permitted in the Norwegian Economic Zone since 2014. The spatial regulation for this new fishery is illustrated in Figures 6.2 and 6.23. In 2018, most of the catches of *S. mentella* from the Russian and Norwegian fisheries were taken in the Norwegian Exclusive Economic Zone or as bycatch in the Fisheries Protection Zone around Svalbard. Catches in international waters were mainly taken by EU nations.

Figure 6.2 shows the distribution of catch among national fishing fleets for 2017 and 2018 and the location of *S. mentella* catches in the Norwegian EEZ in 2018. The catch of *S. mentella* in the pelagic fishery reported to NEAFC and/or ICES amounted to 7 398 t in 2016, 6 852 in 2017 and 7 823 in 2018. The 44th Session of the Joint Norwegian-Russian Fisheries Commission decided to split the total TAC among countries as follows: Norway: 72%, Russia: 18%, Third countries: 10% (as bycatch in the fishery protection zone at Svalbard (Spitsbergen): 4.1%, and international waters of the Norwegian Sea (NEAFC-area): 5.9%). This split was reconducted at the 48th session of the commission in 2018.

6.1.2 Bycatch in other fisheries

During 2003–2013, all catches of *S. mentella*, except the pelagic fishery in the Norwegian Sea outside EEZ, were taken as bycatches in other fisheries. Some of the pelagic catches are taken as bycatches in the blue whiting and herring fisheries. From 2014 onwards most of the catch is taken as targeted catch and no longer as bycatch, following the opening of a targeted fishery in the Norwegian EEZ and Svalbard Fisheries Protection Zone. When fishing for other species it has since 2013 been allowed to have up to 20% redfish (both species together) in round weight as bycatch outside 12 nautical miles and only 10% bycatch inside 12 nautical miles in order to give a higher protection to *S. norvegicus*.

6.1.3 Landings prior to 2018 (Tables 6.1—6.5, 6.12, 6.13, Figure 6.1)

Nominal catches of *S. mentella* by country for subareas 1 and 2 combined are presented in Table 6.1, and for both redfish species (i.e. *S. mentella* and *S. norvegicus*) in Table 6.12. The nominal catches by country for Subarea 1 and divisions 2.a and 2.b are shown in Tables 6.2—6.4, while Table 6.5 shows the catches by country for the pelagic fishery in the Norwegian Sea. The sources of information used are catches reported to ICES, NEAFC, Norwegian authorities (foreign vessels fishing in the Norwegian 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 information and prior knowledge. All tables have been updated for the years 2016 and 2017 and new figures presented for 2018. Total international landings in 1952–2018 are also shown in Figure 6.1.

In 2014, ICES advised that the annual catch in 2015, 2016, and 2017 should be set at no more than 30 000 t and in 2017, ICES advised that the annual catch in 2018 should not exceed 32 658t. There was no advice provided for 2019–2020 because ICES conducted a benchmark assessment for this stock early in 2018. Following the benchmark (WKREDFISH, ICES 2018a) and the subsequent evaluation of a management plan for the stock (ICES 2018b) ICES advised an annual catch of no more than 53 757 t for 2019 and 55 860 t in 2020, corresponding to a fishing mortality of F = 0.06.

Because of the novelty of the situation regarding management regulations and fleet dynamics, the total landings of *S. mentella* in subareas 1 and 2 in 2014, demersal and pelagic catches, amounted to only 18 780 t. The total landings of the demersal and pelagic fishery increased to 25 856 t in 2015, to 35 646 t in 2016, 30 934 t in 2017 and 38 765 t in 2018. Of this, 7823 t were reported from the pelagic fishery in international waters of the Norwegian Sea. The total landings in 2016 to 2018 were respectively 5429 t, 1201 t and 6107 t above the TAC advised by ICES. Norway caught the major share of the demersal catches, but Russian demersal catches increased substantially, particularly in ICES Division 2.b.

The redfish population in Subarea 4 (North Sea) is believed to belong to the Northeast Arctic stock. Since this area is outside the traditional areas handled by this Working Group, the catches are not included in the assessment. The total redfish landings (golden and beaked redfish combined) from Subarea 4 have up to 2003 been 1000–3000 t per year. Since 2005 the annual landings from this area have varied between 114 and 333 t (Table 6.13).

6.1.4 Expected landings in 2019

ICES has advised on the basis of precautionary considerations that the annual catch should be set at no more than 32 658 t in 2018 and no more than 53 757 t in 2019. The 47th/48th sessions of the Joint Norwegian-Russian Fisheries Commission decided to follow these advices.

In 2019 Norwegian fishing vessels can catch and land up to 34 705 t of redfish in the Norwegian economic zone (NEZ) in a limited area north of 65°20’N (see map in Figure 6.24), in international waters and the fisheries zone around Jan Mayen. Of this quantity 100 t are allocated to cover bycatch in other fisheries and 34 t for research/surveillance and education purposes, while the remaining 34 571 t can be taken in a directed fishery. Only vessels with cod and saithe trawl permits can participate in the directed fishery for redfish. Each vessel which has the right to participate is assigned a maximum quota of 1000 t. This quota must also cover catches of redfish (both species) in other fisheries. It is prohibited to fish for redfish with bottom trawls in the period from 1 March until 20 May. Investigations were conducted in 2015–2016 to see if the protection of females during the main time of larvae release should be improved by extending the period of prohibited fishing until later in May and to see if the area south of Bear Island (marked in Figure 6.24) can be opened for directed fishing, either with or without sorting grid. The hitherto conclusion is that males dominated the catches (more than 70%) in the main fishing areas south and southwest of Bear Island during the investigations from late April until the directed fishery started on 10 May, and that the area south of Bear Island should stay closed during January-February due to smaller *S. mentella* inhabiting this area at the beginning of the year.

Since 2015, Russia has had access to the NEZ when fishing their quota share. In 2019 Russia may fish 9676 t (18%) and 2000 t transferred from Norway to Russia to cover bycatch of redfish in Russian fishery targeting other species. It is expected that 50% of this redfish bycatch will be *S. mentella*. The remaining 5376 t are divided between third countries in the NEZ and Svalbard Zone (2204 t) and the NEAFC areas (3172 t). Catch in the NEAFC areas in 2018 amounted to 7357 t while the catch in the NEZ and Svalbard zone amounted to 31 408 t. The total catch in 2018 exceeded the TAC advised by ICES by 6107 t. Assuming similar fishing patterns in 2019, the total catch should not exceed the TAC of 53 757 t set by ICES.

6.2 Data used in the Assessment

Analytical assessment was conducted for this stock following recommendation from the benchmark assessment working group (WKREDFISH, ICES 2018a). Input datasets were updated with the most recently available data. The analytical assessment, based primarily on a statistical catch-at-age model (SCAA) covers the period 1992—2018. The input data consists of the following tables:

- Total catch in tonnes (Table 6.1)
- Catch in tonnes in the pelagic fishery (Table 6.5)
- Total catch numbers-at-age 6—19+ (Table 6.6)
- Catch numbers-at-age 7—19+ in the pelagic fishery (Table 6.8)
- Weight-at-age 2—19+ in the population (Table 6.7)
- Maturity-at-age 2—19+ in the population (Table 6.19)
- Winter survey numbers-at-age 2—15 (Table 6.16b)
- Ecosystem survey numbers-at-age 2—15 (Table 6.18)
- Russian autumn survey numbers-at-age 0—11 (Table 6.14)

There was no direct observation of catch numbers-at-age for the pelagic fishery operating in 2012–2018. Instead, numbers-at-age were estimated based on catch-at-age from previous or following year, and weight-at-age and fleet selectivities (section 6.2.2 in AFWG report 2013). In 2013 and 2016, observations from the scientific survey in the Norwegian Sea were used to derive numbers-at-age in the pelagic fishery. This was considered appropriate given that the survey operates in the area of the fishery, with a commercial pelagic trawl and at the time of the start of the fishery.

6.2.1 Length- composition from the fishery (Figure 6.3)

Length distributions of the pelagic and demersal catches of *S. mentella* are shown in Figure 6.3. In 2018, data were available from the Spanish and Portuguese pelagic fleets and the Russian and Norwegian demersal fleets.

6.2.2 Catch-at-age (Tables 6.6 and 6.8, Figure 6.4)

Catch-at-age in the Norwegian fishery was estimated using ECA for 2014. For 2015, it was not possible to run ECA and the catch-at-age for the Norwegian Fishery was estimated using the older Biomass program in SAS. Not enough age readings were available to estimate catch-at-age in 2016. For the pelagic and demersal fisheries in 2016, 2017, and 2018 proportions-at-age in the catch were derived from proportions at-age in earlier years, weight-at-age and fleet selectivities (section 6.2.2 in AFWG report 2013). Updated age readings and estimations of catch-at-age for 2015 to 2019 are expected from Norway at the next assessment in 2020.

The procedure for estimating catch-at-age for recent years in which age data are not available is somehow problematic. This is because the last year of observation has a large impact on the estimated catch-at-age for several years. At the assessment working group in 2017 and at the benchmark assessment in January 2018, the last year of observations for the catch-at-age was 2014 and the values for the years 2015 and 2016 were extrapolated. The new data available for 2015 (demersal) and 2016 (pelagic) are substantially different from these earlier extrapolations.

Catch-at-age in the Russian demersal fishery were calculated using age reading. Ages of 884 individuals of *S. mentella* were estimated. The estimated Age-Length-Key was then used to estimate the age distribution of the Russian demersal catches depicted in Figure 6.4. Age-Length-Keys for *S. mentella* are uncertain because of the slow growth rate of individuals and therefore these data were not used in the assessment but may be considered in future. Given that age is difficult to derive from length it is important that age readings are available for the most recent years, at the time of the working group.

6.2.3 Weight-at-age (Table 6.7, Figures 6.5, 6.6)

In earlier assessment, weight-at-age in the stock was set equal to the weight-at-age in the catch. This turned out to be problematic because of important fluctuations in reported weight-at-age in the catch that cannot be explained biologically (i.e. these are noisy data). In 2015, it was advised to either use a fixed weight-at-age for the 19+ group, or use a modelled weight-at-age based on catch and survey records (Planque, 2015). The second option was chosen. Weight-at-age in the population was modelled for each year using mixed-effect models of a von Bertalanffy growth function (in weight). In 2018 an attempt was made to model weight-at-age for each cohort (rather than each year of observation). This showed that the growth function is nearly invariant between cohorts. As a result, it was decided to use a fixed (i.e. common to all years) weight-at-age as input to the Statistical Catch-at-age model. The observed and modelled weight-at-age are presented in Table 6.7 as well as Figures 6.5 and 6.6.

6.2.4 Maturity-at-age (Table 6.19, Figure 6.7)

The proportion maturity-at-age was estimated for individual years using a mixed-effect statistical model (Table 6.19, Figure 6.7). The modelled values of maturity-at-age for individual years are used in the analytical assessment models, except in 2011, 2014, 2015, and 2016 when the fixed effects only were considered. There were no age readings available for 2017 and 2018 and the fixed effect model was therefore used for these year.

6.2.5 Natural mortality

In previous years, natural mortality for *S. mentella* was set to 0.05 for all ages and all years. This was based on life-history correlates presented in Hoenig (1983). Thirty-nine alternative mortality estimates were explored during the benchmark workshop, based on the review work by Kenchington (2014) and several additional papers published recently (Then *et al.*, 2014; Hamel, 2014; Charnov *et al.*, 2013). Overall, the mode of these natural mortality estimates is 0.058 which departs only slightly from the original estimate of 0.050 (Figure 6.15). WKREDFISH_2018 decided to continue using 0.050 as the value of M in the assessment model.

Figure 6.16 shows cod's predation on juvenile (5–14 cm) redfish during 1984—2018. This time-series confirms the presence of redfish juveniles and may be used as an indicator of redfish abundance. A clear difference is seen between the abundance/consumption ratio in the 1980s and at present. A change in survey trawl catchability (smaller meshes) from 1993 onwards (Jakobsen *et al.*, 1997) and/or a change in the cod's prey preference may cause this difference. As long as the trawl survey time-series has not been corrected for the change in catchability, the abundance index of juvenile redfish less than 15 cm during the 1980s might have been considerably higher, if this change in catchability had been corrected for. The decrease in the abundance of young redfish in the surveys during the 1990s is consistent with the decline in the consumption of redfish by cod. It is important that the estimation of the consumption of redfish by cod is being continued.

6.2.6 Scientific surveys

The results from the following research vessel survey series were evaluated by the Working Group:

6.2.6.1 Surveys in the Barents Sea and Svalbard area (Tables 1.1, 1.3-1.4, 6.14-6.18, Figures 6.8–6.10)

Russian bottom-trawl survey in the Svalbard and Barents Sea areas in October-December for 1978–2015 in fishing depths of 100—900 m (Table 6.14, Figure 6.8). ICES acronym: RU-BTr-Q4

Russian-Norwegian Barents Sea 'Ecosystem survey' (bottom-trawl survey, August-September) from 1986—2016 in fishing depths of 100—500 m (Figures 6.8—6.9). Data disaggregated by age for the period 1992—2016 (Table 6.18). ICES acronym: since 2003 part of Eco-NoRu-Q3 (BTr)

Winter Barents Seabed-trawl survey (February) from 1986—2014 (jointly with Russia since 2000, except 2006 and 2007) in fishing depths of 100—500 m (Figures 6.8—6.9). Data disaggregated by age for the period 1992—2016 (Table 6.16b). ICES acronym: BS-NoRu-Q1 (BTr)

The Norwegian survey initially designed for redfish and Greenland halibut is now part of the ecosystem survey and covers the Norwegian Economic Zone (NEZ) and Svalbard incl. north and east of Spitsbergen during August 1996—2012 from less than 100 m to 800 m depth. This survey includes survey no. 2 above, and has been a joint survey with Russia since 2003, and since then called the Ecosystem survey. ICES acronym: Eco-NoRu-Q3 (Btr)

6.2.6.2 Pelagic survey in the Norwegian Sea (Figures 6.13 and 6.14)

The international deep pelagic ecosystem survey in the Norwegian Sea (WGIDEEPS, ICES 2016, no ICES-acronym) monitors deep pelagic ecosystems, with a particular focus on beaked redfish (*Sebastes mentella*). The latest survey was conducted in the open Norwegian Sea from 11 August until 1 September 2016, following similar surveys in 2008, 2009, and 2013. The spatial coverage of the surveys and the distribution of beaked redfish registered by acoustic is presented in Figure 6.13. The survey is scheduled every three year and previous cruises took place in 2008, 2009, 2013, and 2016. Estimated numbers-at-age from this survey were presented at the benchmark assessment in 2018 and used in the SCAA model. Data for 2016 was updated in 2019, using additional age readings. The details of the data preparation, using StoX, are available from WD7 of AFWG 2018 (Planque *et al.*, 2018). The data used as input to the analytical assessment consists of proportions-at-age from age 2 to 75 y (Figure 6.13).

6.2.6.3 Additional surveys (Figures 6.10—6.12)

The international 0-group survey in the Svalbard and Barents Sea areas in August-September 1980–2016, now part of the Ecosystem survey (Figures 6.10 and 6.11). ICES acronym: Eco-NoRu-Q3

A slope survey "Egga-sør survey" was carried out by IMR from 20 March to 14 April 2018, following similar surveys ran in 2009, 2012, 2014, and 2016. The spatial coverage of the surveys and the distribution of beaked redfish registered by acoustic is presented in Figure 6.12. Egga-Sør and Egga-Nor surveys operate on a biennial basis. The length and age distributions of beaked redfish from these surveys show consistent ageing in the population and gradual incoming of new cohorts after the recruitment failure period. These surveys are considered as candidates for data input to the analytical assessment of *S. mentella* (see also Planque, 2016).

6.3 Assessment

The group performed the analytical assessment using the statistical catch-at-age (SCAA) model reviewed at the benchmark in January 2018 (WKREDFISH, ICES 2018a). The model was configured as the benchmark baseline model which includes 53 parameters to be estimated and the model converged correctly.

6.3.1 Results of the Assessment (Tables 6.20—6.21, Figures 6.17—6.23)

6.3.1.1 Stock trends

The temporal patterns in recruitment-at-age 2 (Figures 6.17, 6.20) confirm the previously reported recruitment failure for the year-classes 1996 to 2003 and indicate a return to high levels of recruitment. The estimates of year-class strength for recent years (after the 2011 year class) are uncertain due to a lack of age data from the Winter and Summer ecosystem surveys. Modelled spawning-stock biomass (SSB) has increased from 1992 to 2007 (Table 6.21). In the late 2000s the total-stock biomass (TSB) consisted of a larger proportion of mature fish than in the 1990s. This is reversing as individuals from new successful year classes, but still immature, are growing. TSB has increased from 1.0 to approximately 1.3 million tonnes in the last 10 years (Table 6.21 and Figure 6.20). The decline in SSB in the same period can be attributed to the weak year classes (1996—2003) entering the mature stock. This trend has now levelled off and is expected to reverse in the coming years. SSB at the start of 2019 is estimated at 820 862 t.

6.3.1.2 Fishing mortality (Table 6.21, Figure 6.18)

The patterns of fleet selectivity-at-age indicate that most of the fish captured by the demersal fleet are of age 11 years and older, while the pelagic fleet mostly captures fish of age 14 and older (Figure 6.18). While model results at the benchmark workshop showed a gradual shift in the demersal selectivity towards older ages in recent years, this is no longer observed after the 2015 catch-at-age data were incorporated in the model. The demersal fleet selectivity appears shifted towards later ages only in 2014. In 2018 F19+ is estimated at 0.05 (Table 6.21), with 0.041 for the demersal and 0.009 for the pelagic fleets, respectively.

6.3.1.3 Survey selectivity patterns (Figure 6.19)

Winter and ecosystem surveys selectivity at age are very similar and show reduced selectivity for age 8 years and older, which is consistent with the known geographical distribution of different life stages of *S. mentella*. Conversely, the Russian survey shows a reduced selectivity for age 7 years and younger. This is believed to result from gear selectivity.

6.3.1.4 Residual patterns (Figure 6.23)

Residual patterns in catch and survey indices are presented in Figure 6.23a-e. There is generally no visible trend in the residuals for the Russian groundfish survey neither by age nor by year. Trends in residuals are visible in recent years for winter and ecosystem surveys. The reason for these will need to be investigated further. Alternative methods for the estimation of the survey selectivity patterns will be investigated in the forthcoming benchmark assessment and could resolve the issue. Residual patterns for the demersal fleet indicate a better fit of the model than the run at the AFWG2017. This is likely resulting from the implementation of a time varying selectivity-at-age for this fleet.

6.3.1.5 Retrospective patterns (Figure 6.21)

The historical retrospective patterns for the years 2007 to 2016 are presented in Figure 6.21. All model parameters were estimated in each individual run. The most recent model run (last year of data 2018) is consistent with previous runs. The SSB time-series is smoother, due to fixed weight-at-age for every year. The benchmark run stands out and this is due to the unavailability of recent catch-at-age data during the benchmark assessment (see section 6.2.2). The estimate of SSB in the early years is revised upward and this results from the use of new number-at-age indices from the WGIDEEPS survey.

6.3.1.6 Projections

F_{MSY} at age 19+ is approximated using $F_{0.1}$ and estimated at 0.084 (section 1.4 of the WKREBMSE report 2018b).

The estimated fishing mortality in 2018 is: $F_{19+} = 0.05$.

If the fishing mortality is maintained, this is expected to lead to a catch of 42 190 t in 2019, well below the advised TAC of 53 757 t. This would lead to an SSB of 852 268 t in early 2020, catches of 53 500 t in 2020 and SSB of 872 998 t in 2021.

Raising F_{19+} to F_{MSY} ($F_{19+} = 0.084$) in 2020—2022 would lead to average catches of 75 221 t during that period and a SSB of 842 290 t by 2023 (SSB at the start of 2019 is estimated at 820 862 t).

These projections assume that the selectivity patterns of the demersal and pelagic fleets are identical with those estimated for 2018. It is also assumed that the ratio of fishing mortality between these two fleets remains unchanged.

6.3.1.7 Additional considerations

Historical fluctuations in the recruitment-at-age 2 (Figures 6.17 and 6.20) are consistent with the 0-group survey index (Figure 6.11), although the 0-group survey index is not used as an input to the SCAA.

The population age structure derived from the model outputs for the old individuals (beyond 19+, Figure 6.22) is consistent with the age structure reported from the slopes surveys although these are not used (yet) as input to the model.

Recent recruitment levels estimated with SCAA are highly uncertain since they rely on only few years of observations and since readings from winter survey were not available for years 2012–2015 and no survey data were available for 2016. The use of the autoregressive model for recruitment (random effects in the SCAA) which was introduced in this assessment allows for a projection of the recruitment in recent years, despite the current lack of age data.

6.3.1.8 Assessment summary (Table 6.21, Figure 6.20)

The history of the stock as described by the SCAA model for the period 1992–2018 is summarized in Table 6.21 and Figure 6.20. The key elements are as follows:

- upward trend in Total-stock biomass from 1992 to 2006 followed by stabilization until 2011 and new upward trend until 2018,
- upward trend in spawning-stock biomass from 1992 to 2007 followed by stabilization (or slight decline) until 2017,
- recruitment failure for year classes 1996—2003 (2y old fish in 1998—2005),
- good (although uncertain) recruitment for year classes born after 2005. There is not data available for recruits (at age 2y) after 2014.

- fishing mortality for the 19+ is below natural mortality except in the first years of the assessment period (1992–1994) and the last year (2018) in which it is equal.

6.4 Comments to the assessment

Currently, the survey series used in the SCAA do not appropriately cover the geographical distribution of the adult population. Data from the pelagic survey in the Norwegian Sea has been reviewed in the last benchmark and is now included in the assessment model. Priority should be given to including additional data from the slope surveys that include older age groups, in the analytical assessment in future (WD 5 in 2015).

The SCAA model relies on the availability of reliable age data in surveys and in the catch. In recent years, these data have not been available at an appropriate level and the results of the analytical assessment are becoming less reliable.

6.5 Biological reference points

The proposed reference points estimated during the workshop on the management plan for *S. mentella* in (ICES 2018b) were:

Reference point	Value
B_{lim}	227 000 t
B_{pa}	315 000 t
F_{MSY19+}	0.084

Which are revised from those set during the benchmark in the same year (ICES 2018a) which were B_{pa} = 450 kt, B_{lim} = 324 kt and F_{MSY19+} = 0.08.

6.6 Management advice

The present report updates the assessment for this stock but does not provide advice.

The currently valid advice was released on 28 September 2018, containing the evaluation of HCRs as well as the standard advice sheet with catch scenarios for each of the HCRs evaluated to be precautionary. It recommends a TAC of 53 757 t for 2019 and 55 860 t for 2020 at a fishing mortality of F = 0.06.

6.7 Possible future development of the assessment

Many developments suggested in earlier years were presented and evaluated at the benchmark in January 2018. These include: integrating a stochastic process model i) for recruitment-at-age 2, ii) for the annual component of fishing mortalities, and iii) to account for annual changes in fleet selectivities-at-age. In addition, iv) a right trapezoid population matrix, v) coding of older ages into flexible predefined age-blocks, and vi) integrating of data from pelagic surveys in the Norwegian Sea were implemented. The purpose of these new features was to reduce the number of parameters to estimate (i, ii), include new data on the older age fraction of the population (iv, v, vi) and account for possible temporal changes in selectivity linked to changes in the national and international fisheries and their regulations (iii).

Future developments for the assessment of *S. mentella* may possibly include:

- Increase in the number of age readings from surveys and from the fishery, in particular for recent years;
- Use of standardized methods (StoX and ECA) for the determination of numbers-at-age in the surveys and in the catch. The use of StoX for survey indices will be evaluated at the beginning of AFWG 2020;
- A genetic-based method for rapidly identifying Sebastes species (*S. norvegicus*, *S. mentella*, *S. viviparus*);
- Direct use of length information (as in GADGET);
- Development of a joint model for *S. mentella* and *S. norvegicus* which can include uncertainty in species identification and reporting of catch of *Sebastes sp*.

Implementing the current model in a more generic framework (SAM or XSAM) would provide a set of diagnostic tools and the wider expertise shared by the groups developing these models.

Further studies of redfish mortality at young age, including a scientific publication, should be carried out. These studies should also take account of historic estimates of bycatch. Variable M by age and possibly time period could then be incorporated in the assessment.

Table 6.1. *Sebastes mentella* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1, divisions 2.a and 2.b combined.

Year		Estonia	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
1998		-	20	73	100	14	-	9	-	-	-	9 733	13	125	3 646	177	134	14 045
1999		-	73	26	202	50	-	3	-	-	-	7 884	6	65	2 731	29	140	11 209
2000		-	50	12	62	29	48	1	-	-	-	6 020	2	115	3 519	87	130	10 075
2001		-	74	16	198	17	3	4	-	-	-	13 937	5	179	3 775	90	120	18 418
2002		15	75	58	99	18	41	4	-	-	-	2 152	8	242	3 904	190	188	6 993
2003		-	64	22	32	8	5	5	-	-	-	1 210	7	44	952	47	124	2 520
2004	**Sweden** - 1	-	588	13	10	4	10	3	-	-	-	1 375	42	235	2 879	257	76	5 493
2005		5	1 147	46	33	39	4	4	-	-	7	1 760	-	140	5 023	163	95	8 465
2006	**Canada** - 433	396	3 808	215	2 483	63	2 513	4	341	845	-	4 710	2 496	1 804	11 413	710	1 027	33 261
2007		684	2 197	234	520	29	1 587	17	349	785	-	3 209	1 081	1 483	5 660	2 181	202	20 219
2008		-	1 849	187	16	25	9	9	267	117	13	2 220	8	713	7 117	463	83	13 096
2009	**EU** - 889	-	1 343	15	42	-	33	-	-	-	3	2 677	338	806	3 843	177	80	10 246
2010		-	979	175	21	12	2	-	243	457	-	2 065	-	293	6 414	1 184	79	11 924
2011		-	984	175	835	-	2	-	536	565	-	2 471	11	613	5 037	1 678	55	12 962

2012	-	259	-	517	-	36	-	447	449	-	2 114	318	1 038	4 101	1 780	-	11 059
2013	-	697	-	80	21	1	-	280	262	-	1 835	84	1 078	3 677	1 459	-	9 474
2014	-	743	215	446	15	-	-	215	167	3	13 503	103	505	1 704	1 162	-	18 780
2015	-	657	49	242	48	3	-	537	192	3	19 720	5	678	1 142	2 529	52	25 857
2016	-	502	134	493	74	24	0	1 243	1 065	-	19 083	208	1 066	8 419	3 213	122	35 646
2017	4	443	45	763	66	3	-	562	790	-	17 228	102	1060	6 593	2 838	436	30 934
2018 [1]	-	425	67	2 473	82	10	-	876	1 178	374	19 289	275	699	10 497	2 457	63	38 765

[1] **Provisional figures.**

Table 6.2. *Sebastes mentella* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1.

Year	Faroe Islands	Germany	Greenland	Iceland	Norway	Poland	Russia	Spain	UK	Total
1998	20	-	-	-	26	-	378	-	-	424
1999	69	-	-	-	69	-	489	-	-	627
2000	-	-	-	482	47	-	406	-	-	501
2001	-	-	-	32	8	-	296	-	-	307
2002	-	-	-	-	4	-	587	-	-	591
2003	-	-	-	-	6	-	292	-	-	298
2004	-	-	-	-	2	-	355	-	-	357
2005	-	-	-	-	3	-	327	-	-	330
2006	2	-	-	-	12	-	460	-	2	476
2007	-	-	-	8	11	-	210	-	20	249
2008	-	-	-	-	5	-	155	-	2	162
2009	-	-	-	8	3	-	80	-	-	91
2010	-	-	-	-	20	-	10	-	-	30
2011	-	-	-	-	48	-	13	-	-	61
2012	-	-	-	-	34	-	17	-	-	51
2013	-	-	-	-	61	-	27	-	-	88
2014	-	-	-	-	36	-	63	-	-	99
2015	-	-	18	-	76	1	125	-	-	220
2016	-	-	-	-	176	1	229	342	-	748
2017	-	-	12	-	165	3	196	-	-	376
2018[1]	-	19	26	3	195	-	376	-	-	619

[1] **Provisional figures.**

Table 6.3. *Sebastes mentella* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.a (including landings from the pelagic trawl fishery in the international waters).

Year		Faroe Islands	France	Ger-many	Green-land	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
1998		-	73	58	14	-	6	-	-	9186	118	-	2626	55	106	12 242
1999		-	16	160	50	-	3	-	-	7358	56	-	1340	14	120	9117
2000		50	11	35	29	-	-	-	-	5892	98	-	2167	18	103	8403
2001		63	12	161	17	-	4	-	-	13 636	105	-	2716	18	95	16 827
2002		37	54	59	18	41	4	-	-	1937	124	-	2615	8	157	5054
2003		58	18	17	8	5	5	-	-	1014	17	-	448	8	102	1700
2004	**Sweden** - 1	555	8	4	4	10	3	-	-	987	86	-	2081	7	18	3764
2005		1101	36	17	38	2	4	-	-	1083	71	-	3307	20	15	5694
2006	**Estonia** - 396 **Canada** – 433	3793	199	2475	52	2513	3	845	-	4010	1731	2467	10 110	589	958	30 574
2007	**Estonia** - 684	2157	226	519	29	1579	16	785	349	3043	1395	1079	5061	2159	120	19 201
2008	**Netherland** - 13	1821	179	9	24	9	9	117	267	1952	666	1	6442	430	62	12 001
2009	**EU** – 889	1316	7	23	-	25	-	-	-	2208	764	338	3305	137	62	9074
2010		961	175	13	12	2	-	457	243	1705	246	-	5903	1183	55	10 955
2011		932	175	697	-	2	-	561	536	1682	599	-	4326	1656	19	11 185
2012		259	-	469	-	32	-	449	447	1500	1038	311	3478	1770	-	9753

Year		Faroe Islands	France	Ger-many	Green-land	Iceland	Ireland	Lithuania	Latvia	Norway	Portugal	Poland	Russia	Spain	UK	Total
2013		675	-	24	21	1	-	262	280	921	1055	68	3293	1435	-	8035
2014	**Netherland** - 2	728	209	411	15	-	-	167	215	4367	505	100	1334	1159	-	9212
2015	**Netherland** - 3	657	49	236	25	3	-	192	537	11 214	678	3	480	2508	47	16 632
2016		495	107	493	61	-	24	1065	1243	9546	1052	183	3949	2862	71	21 151
2017		425	38	763	44	3	-	790	562	7405	1059	94	3922	2813	429	18 347
2018[1]	Netherland - 374	400	47	2440	51	7	-	1034	876	14 644	699	272	4721	2435	62	28 062

[1] **Provisional figures**

Table 6.4. *Sebastes mentella* in subareas 1 and 2. Nominal catch (t) by countries in Division 2.b.

Year		Netherland	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Poland	Portugal	Russia	Spain	Denmark	UK	Total
1998		-	-	-	42	-	3	521	13	7	642	122	-	29	1379
1999		-	4	10	42	-	-	457	6	9	902	15	-	20	1465
2000		-	-	1	27	-	1	82	2	17	946	69	-	27	1172
2001		-	11	4	37	-	-	293	5	74	763	72	**Estonia**	25	1284
2002		-	38	4	40	-	-	210	8	118	702	182	15	31	1348
2003		-	6	4	15	-	-	190	7	27	212	39	-	22	522
2004		-	33	5	6	-	-	386	42	149	443	250	-	58	1372
2005	**Iceland** - 2	7	46	10	17	1	-	673	-	69	1389	143	5	80	2442
2006		-	13	16	8	11	1	688	29	73	843	121	-	67	1870
2007		-	40	8	1	-	1	155	2	88	389	22	-	62	768
2008		-	28	8	7	1	-	263	6	47	520	33	-	19	932
2009	**Canada** - 3	3	27	8	19	-	-	466	1	42	458	41	-	17	1082
2010		-	18	-	8	-	-	339	-	47	501	1	-	24	938
2011	**Lithuania** - 4	-	52	-	139	-	-	741	11	14	698	23	-	36	1717
2012	**Iceland** - 4	-	-	-	48	-	-	581	7	-	606	10	-	-	1256
2013		-	22	-	56	-	-	854	16	23	357	23	-	-	1351

2014		1	15	6	34	-	-	9099	3	-	307	3	-	-	9468
2015		-	-	-	6	5	-	8429	1	-	536	21	-	5	9003
2016		-	7	27	-	14	-	9361	24	14	4241	9	-	50	13 747
2017		-	18	7	1	10	-	9658	5	1	2476	25	4	7	12 211
2018[1]	Lithuania - 144	-	25	20	14	6	-	4449	3	-	5400	22	-	1	10 083

[1] **Provisional figures.**

Table 6.5. ***Sebastes mentella*** **in subareas 1 and 2. Nominal catch (t) by countries of the pelagic fishery in international waters of the Norwegian Sea (see text for further details).**

Year		Estonia	Faroe Islands	France	Germany	Iceland	Latvia	Lithuania	Norway	Poland	Portugal	Russia	Spain	UK	Total
2002		-	-	-	9	-	-	-	-	-	-	-	-	-	9
2003		-	-	-	40	-	-	-	-	-	-	-	-	-	40
2004		-	500	-	2	-	-	-	-	-	-	1510	-	-	2012
2005		-	1083	-	20	-	-	-	-	-	-	3299	-	-	4402
2006	**Canada** - 433	396	3766	192	2475	2510	341	845	2862	2447	1697	9390	575	841	28 770
2007		684	1968	226	497	1579	349	785	1813	1079	1377	3645	2155	-	16 157
2008		-	1797	-	-	-	267	117	330	-	641	4901	390	-	8443
2009	**EU** - 889	-	1253	-	-	-	-	-	-	337	701	1975	135	-	5290
2010		-	912	-	-	-	243	457	450	-	244	5103	820	-	8229
2011		-	740	175	693	-	536	561	342	-	595	3621	1648	-	8911
2012		-	259	-	469	31	447	449	-	311	1038	2714	1768	-	7486
2013		8	675	-	-	-	280	262	1	68	1078	2720	1435	-	6527
2014		-	697	-	409	-	215	167	-	100	505	795	1146	-	4034
2015		-	606	-	231	-	537	192	-	-	678	-	2508	-	4752
2016		-	393	-	493	-	1243	1065	9	-	821	512	2862	-	7398
2017	**Netherland**	-	296	-	761	-	562	790	-	14	791	1014	2624	-	6852

2018[1]	374	400	-	2276	-	876	1010	-	116	372	-	2399	-	7823

[1] **Provisional figures.**

Table 6.6. *S. mentella* in subareas 1 and 2. Catch numbers-at-age 6 to 18 and 19+ (in thousands) and total landings (in tonnes). For the period 2012–2016 age data are missing from the pelagic fishery. For the period 2015–2018, age data are missing from all fisheries. The numbers-at-age have been estimated following the method outlined in section 6.2.2.

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tons Land.
1992	1873	2498	1898	1622	1780	1531	2108	2288	2258	2506	2137	1512	677	9258	33 946	15 590
1993	159	159	174	512	2094	3139	2631	2308	2987	1875	1514	1053	527	6022	25 154	12 814
1994	738	730	722	992	2561	2734	3060	1535	2253	2182	3336	1284	734	3257	26 118	12 721
1995	662	941	1279	719	740	1230	2013	4297	3300	2162	1454	757	794	2404	22 752	10 284
1996	223	634	1699	1554	1236	1078	1146	1413	1865	880	621	498	700	2247	15 794	8075
1997	125	533	1287	1247	1297	1244	876	1416	1784	1217	537	1177	342	3568	16 650	8598
1998	37	882	2904	4236	3995	2741	1877	1373	1277	1595	1117	784	786	6241	29 845	14 045
1999	9	83	441	1511	2250	3262	1867	1454	1447	1557	1418	1317	658	3919	21 193	11 209
2000	1	24	390	1235	2460	2149	1816	1205	1001	993	932	505	596	5705	19 012	10 075
2001	117	372	542	976	925	1712	2651	2660	1911	1773	1220	714	814	16 234	32 621	18 418
2002	2	40	252	572	709	532	1382	1893	1617	855	629	163	237	4082	12 965	6993
2003	6	37	103	93	132	220	384	391	434	466	513	199	231	1193	4402	2520
2004	11	24	108	148	427	624	931	580	1385	1047	937	927	549	2055	9753	5493
2005	5	44	128	347	540	567	432	1607	1332	3174	1041	1216	1024	4266	15 723	8465
2006	0	10	8	89	153	256	877	1980	2774	4580	5154	4823	4261	35 350	60 315	33 261
2007	0	1	3	22	33	86	235	631	2194	2825	3657	4359	3540	15 824	33 410	20 219

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	+gp	Total No.	Tons Land.
2008	0	0	1	10	44	128	186	492	541	1444	1423	923	1730	16 389	23 311	13 096
2009	0	1	16	22	42	48	1507	520	983	1136	1623	1292	2347	7389	16 926	10 246
2010	10	4	6	19	34	55	61	237	540	532	848	828	792	14 659	18 625	11 924
2011	4	4	4	25	55	114	234	186	177	482	415	445	394	17 315	19 854	12 962
2012	4	24	29	24	48	95	88	372	226	209	528	537	362	12844	15390	11056
2013	0	14	156	122	531	139	200	138	179	331	315	321	749	11390	14585	9474
2014	14	27	350	220	129	474	226	179	179	181	341	384	266	22670	25640	18780
2015	68	309	307	812	1603	1410	1608	1311	547	985	426	678	731	27968	38763	25857
2016	243	233	1022	1089	2607	4330	3039	2992	2133	911	1627	964	1017	34414	56621	35646
2017	4	232	263	1341	1608	4014	6288	3852	3296	2140	883	1542	941	25122	51526	30934
2018	0	6	397	523	3012	3679	8694	11948	6377	4981	3074	1236	2125	22472	68524	38765

Table 6.7. *S.mentella* in subareas 1 and 2. Observed mean weights-at-age (kg) from the Norwegian data (Catches and surveys combined). Weights-at-age used in the statistical catch-at-age model are identical for every year and given at the bottom line of the table. Modelled numbers and those for 2016 are updated using additional age data.

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.167	0.164	0.211	0.241	0.309	0.324	0.378	0.366	0.428	0.454	0.487	0.529	0.571	0.805
1993	0.141	0.181	0.217	0.254	0.306	0.357	0.349	0.400	0.450	0.436	0.460	0.499	0.462	0.846
1994	0.174	0.188	0.235	0.298	0.361	0.396	0.415	0.480	0.492	0.562	0.642	0.636	0.720	0.846
1995	0.158	0.185	0.226	0.261	0.324	0.360	0.432	0.468	0.496	0.519	0.566	0.573	0.621	0.758
1996	0.175	0.189	0.224	0.272	0.323	0.337	0.377	0.518	0.536	0.603	0.690	0.800	0.683	0.958
1997	0.152	0.191	0.228	0.280	0.324	0.367	0.435	0.492	0.521	0.615	0.601	0.611	0.671	0.911
1998	0.120	0.148	0.192	0.261	0.326	0.373	0.427	0.496	0.537	0.566	0.587	0.625	0.658	0.809
1999	0.133	0.170	0.226	0.286	0.343	0.382	0.441	0.483	0.537	0.565	0.620	0.644	0.672	0.757
2000	0.109	0.144	0.199	0.276	0.332	0.392	0.437	0.490	0.540	0.585	0.631	0.650	0.671	0.872
2001	0.115	0.137	0.183	0.262	0.310	0.356	0.400	0.434	0.484	0.534	0.581	0.615	0.624	0.819
2002	0.114	0.139	0.182	0.253	0.329	0.372	0.392	0.434	0.476	0.520	0.545	0.587	0.601	0.833
2003	0.109	0.124	0.196	0.245	0.312	0.371	0.422	0.434	0.477	0.516	0.551	0.591	0.623	0.817
2004	0.104	0.129	0.180	0.264	0.308	0.376	0.413	0.444	0.478	0.521	0.579	0.614	0.688	0.835
2005	0.104	0.136	0.196	0.263	0.322	0.370	0.408	0.451	0.478	0.523	0.550	0.551	0.640	0.797

Year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2006	0.107	0.143	0.200	0.266	0.314	0.374	0.419	0.462	0.489	0.527	0.570	0.602	0.590	0.796
2007	0.115	0.131	0.180	0.252	0.305	0.364	0.409	0.449	0.485	0.513	0.523	0.554	0.569	0.737
2008		0.158	0.177	0.242	0.304	0.402	0.465	0.486	0.511	0.546	0.600	0.596	0.635	0.803
2009	0.129	0.179	0.206	0.249	0.326	0.394	0.510	0.550	0.542	0.583	0.609	0.594	0.595	0.809
2010	0.129	0.128	0.175	0.263	0.375	0.447	0.501	0.541	0.582	0.602	0.593	0.608	0.592	0.706
2011	0.136	0.156	0.183	0.261	0.316	0.435	0.512	0.604	0.655	0.609	0.671	0.647	0.677	0.795
2012	0.135	0.178	0.225	0.246	0.249	0.356	0.474	0.582	0.530	0.626	0.654	0.730	0.699	0.833
2013	0.129	0.145	0.189	0.230	0.270	0.282	0.345	0.384	0.534	0.559	0.634	0.627	0.661	0.720
2014	0.129	0.149	0.193	0.168	0.192	0.239	0.333	0.277	0.364	0.516	0.713	0.780	0.797	0.875
2015	0.160	0.167	0.232	0.294	0.346	0.383	0.457	0.436	0.474	0.538	0.665	0.690	0.724	0.824
2016[1]				0.405	0.394	0.409	0.497	0.488	0.662	0.575	0.618	0.605	0.669	0.729
2017	No data available at the time of the working group													
2018	No data available at the time of the working group													
Modelled	**0.143**	**0.190**	**0.239**	**0.289**	**0.337**	**0.384**	**0.427**	**0.468**	**0.506**	**0.541**	**0.572**	**0.600**	**0.626**	**0.757**

[1] **preliminary figures**

Table 6.8 Pelagic *Sebastes mentella* in the Norwegian Sea (outside the EEZ). Catch numbers-at-age.

	Numbers 10^3							Age				
YEAR	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
2006	0	0	0	0	23	93	1083	323	1563	3628	2514	3756	29704
2007	0	0	9	18	25	154	444	1642	2302	3021	3394	3156	12684
2008	0	0	0	0	28	146	115	143	214	594	752	753	13258
2009	0	0	0	0	9	1314	294	471	889	999	869	1150	2981
2010	0	0	0	0	0	0	130	336	254	466	467	508	11510
2011	0	0	0	0	0	223	83	83	168	136	166	136	13182
2012[1]	0	0	0	22	29	19	294	146	132	217	288	126	8939
2013[2]	11	137	98	465	123	158	96	169	246	196	238	598	7968
2014[3]	0	10	125	88	406	103	125	70	113	151	112	130	4398
2015[3]	0	0	0	0	114	38	39	0	0	0	92	29	6073
2016[3]	0	0	121	241	213	228	115	71	84	188	350	180	8634
2017	0	0	0	175	344	299	312	152	90	102	215	381	7706
2018	0	0	0	0	307	594	502	507	236	133	143	288	8566

1 no age data in 2012, catch numbers-at-age are estimated from proportions at age in 2011 and in 2013.

2 no age data from the catches in 2013. Age readings from the research survey conducted in September 2013 are used to derive catch numbers-at-age.

3no age data in 2014 – 2018, catch numbers-at-age are estimated from previous year according to protocol described in section 6.2.2.

Table 6.9 Pelagic *Sebastes mentella* in the Norwegian Sea (outside the EEZ). Catch weights-at-age (kg).

Year/ Age	11	12	13	14	15	16	17	18	19+
2006	0,44	0,44	0,52	0,44	0,49	0,55	0,53	0,56	0,61
2007	0,39	0,43	0,41	0,48	0,50	0,52	0,55	0,57	0,64
2008	0,36	0,47	0,56	0,50	0,56	0,54	0,56	0,55	0,64
2009	0,38	0,44	0,45	0,48	0,54	0,59	0,64	0,58	0,69
2010[1]	-	-	0,62	0,56	0,54	0,59	0,59	0,56	0,61
2011[1]	-	0,48	0,54	0,54	0,64	0,59	0,54	0,59	0,59
2012	No data	-	-	-	-	-	-	-	-
2013[2]	0,31	-	-	-	0,56	0,62	0,60	0,62	0,68
2014	No data	-	-	-	-	-	-	-	-
2015	No data	-	-	-	-	-	-	-	-
2016	No data	-	-	-	-	-	-	-	-
2017	No data								
2018	No data								

1 preliminary figures

4 As observed in the research survey in the Norwegian Sea in September 2013

Table 6.10. ***S. mentella*** **in subareas 1 and 2. Total catch numbers-at-length, in thousands, for 2011–2018.**

	Length group																
Year	**18–20**	**20–22**	**22–24**	**24–26**	**26–28**	**28–30**	**30–32**	**32–34**	**34–36**	**36–38**	**38–40**	**40–42**	**42–44**	**44–46**	**46–48**	**48–50**	**50–52**
2011	0	12	0	0	1	8	249	2544	6481	6528	3620	829	95	18	1	0	0
2012	0	0	23	19	26	28	41	287	1898	5030	5385	1911	451	197	43	23	0
2013	0	0	4	32	154	137	90	69	1382	4214	4480	1633	497	197	0	0	0
2014	0	5	0	25	29	235	660	697	3358	7667	8544	3808	787	34	0	0	0
2015	Data not available at the time of the working group																
2016	Data not available at the time of the working group																
2017	Data not available at the time of the working group																
2018	Data not available at the time of the working group																

Table 6.11. ***S. mentella*** **in subareas 1 and 2. Catch numbers-at-length, in thousands, in the pelagic fishery for 2011–2018.**

	Length group																
Year	**18–20**	**20–22**	**22–24**	**24–26**	**26–28**	**28–30**	**30–32**	**32–34**	**34–36**	**36–38**	**38–40**	**40–42**	**42–44**	**44–46**	**46–48**	**48–50**	**50–52**
2011	0	0	0	0	1	8	244	2562	5887	4425	1537	287	13	0	1	0	0
2012	0	0	0	0	0	0	106	2014	5092	3681	952	48	0	0	0	0	0
2013	0	0	0	0	0	0	75	1352	4791	2967	730	87	6	0	0	0	0
2014	0	0	0	0	0	3	14	349	2408	2454	827	80	6	1	0	0	0
2015	Data not available at the time of the working group																
2016	Data not available at the time of the working group																
2017	Data not available at the time of the working group																
2018	Data not available at the time of the working group																

Table 6.12 REDFISH in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1, divisions 2.a and 2.b combined for both *Sebastes mentella* and *S. norvegicus*.

Year	Canada	Denmark	Estoia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Nethelands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
1984	-	-	-	-	2970	7457	-	-	-	-	18 650	-	1806	69689	25	716	-	101 313
1985	-	-	-	-	3326	6566	-	-	-	-	20 456	-	2056	59943	38	167	-	92 552
1986	-	-	-	29	2719	4884	-	-	-	-	23 255	-	1591	20694	-	129	14	53 315
1987	-	+	-	450[3]	1611	5829	-	-	-	-	18 051	-	1175	7215	25	230	9	34 595
1988	-	-	-	973	3349	2355	-	-	-	-	24 662	-	500	9139	26	468	2	41 494
1989	-	-	-	338	1849	4245	-	-	-	-	25 295	-	340	14344	5[2]	271	1	46 688
1990	-	37[3]	-	386	1821	6741	-	-	-	-	34 090	-	830	18918	-	333	-	63 156
1991	-	23	-	639	791	981	-	-	-	-	49 463	-	166	15354	1	336	13	67 768
1992	-	9	-	58	1301	530	614	-	-	-	23 451	-	977	4335	16	479	3	31 773
1993	8[3]	4	-	152	921	685	15	-	-	-	18 319	-	1040	7573	13	734	1	29 465
1994	-	28	-	26	771	1026	6	4	3	-	21 466	-	985	6220	34	259	13	30 841
1995	-	-	-	30	748	693	7	1	5	1	16 162	-	936	6985	67	252	13	25 900
1996	-	-	-	42[3]	746	618	37	-	2	-	21 675	-	522	1641	409	305	121	26 118
1997	-	-	-	7	1011	538	39[2]	-	11	-	18 839	1	535	4556	308	235	29	26 109
1998	-	-	-	98	567	231	47[3]	-	28	-	26 273	13	131	5278	228	211	94	33 200
1999	-	-	-	108	61[3]	430	97	14	10	-	24 634	6	68	4422	36	247	62	30 195
2000	-	-	-	67[3]	25	222	51	65	1	-	19 052	2	131	4631	87	-	203[6]	24 536
2001	-	-	**Est**	111[3]	46	436	34	3	5	-	23 071	5	186	4738	91	**-**	239[6]	28 965
2002	-	-	15	135[3]	89	141	49	44	4	-	10 713	8[3]	276	4736	193[2]	-	234[6]	16 636
2003	**Swe**	-	-	173[3]	30	154	44[3]	9	5[3]	89	8063	7	50	1431	47[2]	-	258[6]	10 360
2004	1	-	-	607	17[3]	78	24[3]	40	3	33	7608[12]	42	240	3601[2]	260[2]	-	145[6]	12 699
2005	**Can**	**Lith**	5	1194	56	105	75[3]	12[2]	4[3]	55[2]	7845[12]	-	196	5637	171[3]	-	147[6]	15 502
2006	433	845	396	3919	223	2518	107[3]	2544[3]	12[3]	21	11 015	2496[2]	1873	12126	719[2]	-	1066[6]	40 649
2007	**Latv**	785	684	2343	249	587	84[3]	1655[2]	7[3]	20	8993[2]	1081[2]	1708	6550	2186[2]	-	257[6]	27 591
2008	267	117	-	2123[3]	250	46	96[3]	36[3]	15[3]	15	7436[1]	8	785	7866	467[2]	**EU[7]**	168[6]	19 695
2009	-	-	-	1413	16	100	81	99	-	4	8128	338	836	4541	177	889	111	16 733
2010	243[3]	457[3]	-	1150	226	52	84[3]	24[3]	-	-	8059	1[3]	321	6979	1187	-	123	18 906

Year	Canada	Denmark	Estoia	Faroe Islands	France	Germany[4]	Greenland	Iceland	Ireland	Nethelands	Norway	Poland	Portugal	Russia[5]	Spain	UK (E&W)	UK (Scot.)	Total
2011	536	565	-	1008[2]	228	844	51	24	-	1	7152	59	638	5956	1684[2]	-	68	18 814
2012	447	449	-	346	182	588	58	59	12	5	6361	352	1055	4782	1780[2]	**Denm**	100	16 576
2013	280	262	-	780	353	81	66	9	1	-	5606	103	1114	4474	1459	1	493	15 082
2014	215	167	-	810	434	452	35	29	-	4	16 556	124	510	2510	1162	-	211	23 219
2015	537	192	-	733	102	266	259	38	-	3	22 208	22	678	1806	2531	1	109	29 485
2016[1]	1243	1065	-	685	164	497	161	79	-	-	22 322	234	1066	9283	32013	7	198	40 217
2017[1]	562	790	4	566	62	782	127	68	-	2	20 581	129	1150	7890	2882	-	596	36 192
2018[1]	876	1083	4	571	104	2252	159	77	-	374	23 565	311	766	12 331	2469	1	100	45 412

1 Provisional figures.

2 Working Group figure.

3 As reported to Norwegian authorities or NEAFC.

4 Includes former GDR prior to 1991.

5 USSR prior to 1991.

6 UK(E&W)+UK(Scot.)

7 EU not split on countries.

Table 6.13. REDFISH in Subarea 4 (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Belgium	Denmark	Faroe Islands	France	Germany	Ireland	Nether-lands	Norway	Portugal	Sweden	UK (Scot.)	Total
1998	2	27	12	570	370	4	21	1113	-	-	749	2868
1999	3	52	1	-	58	39	16	862	-	-	532	1563
2000	5	41	-	224	19	28	19	443	-	-	618	1397
2001	4	96	-	272	13	19	+	421	-	-	538	1363
2002	2	40	2	98	11	7	+	241	-	-	524	925
2003	1	71	2	26	2	-	-	474	-	-	463	1071
2004	+	42	3	26	1	-	-	287	-	-	214	578
2005	2	34	-	10	1	-	-	84	-	-	28	159
2006	1	49	1	12	3	-	-	155	33	-	79	333
2007[1]	+	27	-	8	1	-	-	107	-	+	78	221
2008[1]	+	3	-	8	1	-	-	77	-	1	54	144
2009	-	4	1	38	-	-	-	119	-	+	86	248
2010	-	5	-	3	-	-	-	62	-	-	150	220
2011	-	10	-	90	1	-	-	66	-	+	71	238
2012	-	10	-	19	-	-	-	71	-	+	87	187
2013	-	7	-	40	+	-	-	54	-	+	176	277
2014	-	-	-	32	1	-	-	160	-	-	933	286
2015	+	1	-	14	1	-	-	157	-	+	61	235
2016	-	3	-	11	+	-	-	180	-	+	22	216
2017	-	3	-	10	+	-	+	168	-	+	38	218
2018[1]		10		4	+			71		+	29	114

1 Provisional figures.

+ less than 0.5 tonne.

Table 6.14. *Sebastes mentella*. Average catch (numbers of specimens) per hour trawling of different ages of *Sebastes mentella* in the Russian groundfish survey in the Barents Sea and Svalbard areas (1976–1983 published in "Annales Biologiques"). The survey was not conducted in 2016 took place in 2017 with insufficient coverage and was terminated after that year.

Year class	0	1	2	3	4	5	6	7	8	9	10	11
1974	-	-	4.8	-	4.9	22.8	4.8	4.8	-	-	-	3
1975	-	7.4	-	1.7	6.4	2.4	3.5	5	-	-	4	-
1976	7	-	8.1	1.2	2.5	6.8	4.9	5	1	13	-	-
1977	-	0.2	0.2	0.2	0.9	5.1	3.7	1	19	2	-	-
1978	0.8	0.02	0.9	1	5	3.8	2	20	6	-	-	-
1979	-	1.9	1.4	3.6	2.3	9	11	16	1	-	-	0.1
1980	0.3	0.4	2	2.5	16	6	11	25	2	-	1.5	2
1981	-	2.2	3.9	20	6	12	47	18	6.3	1.6	0.5	1
1982	19.8	13.2	13	15	34	44	39	32.6	4.3	3.1	4.9	+
1983	12.5	3	5	6	31	34	32.3	13.3	4	4.2	0.6	1.1
1984	-	10	2	-	5	18.3	19	2.2	2.4	0.2	1.7	2.4
1985	107	7	-	1	5.2	16.2	1.7	1.7	0.6	2.8	3.8	0.3
1986	2	-	1	1.8	8.4	3.6	2.1	1.2	5.6	8.2	0.9	0.7
1987	-	3	37.9	1.3	8	4.1	2	10.6	9.6	1.4	2	1.3
1988	4	58.1	4.3	13.3	25.8	3.9	8.6	11.2	2.8	4.2	3	4.7
1989	8.7	9	17	23.4	4.6	5.4	4	6.6	6.6	4.1	7.7	5.3
1990	2.5	6.3	6.1	1	4.3	1.7	11.5	6.5	5.5	6.7	7.4	3.6
1991	0.3	1	0.5	1.5	1.2	11.3	3.9	3.3	4.6	5.8	2.7	1.9
1992	0.6	+	0.2	0.1	4.3	1.3	2	2.3	4.9	2.3	1	4.1
1993[1]	-	+	1.5	1.8	1	1.2	3	4.2	2.6	2	3.2	2.1
1994	0.3	3.5	1.7	1.7	0.9	3.6	5.2	4.3	3.1	3.3	1.8	1.2
1995	2.8	1	1.1	0.4	2.2	2.6	3.5	3.4	2.9	1.2	1	8.5
1996[2]	+	0.1	0.1	0.4	0.7	1.1	1	1.4	1	0.8	3.7	0.6
1997	-	-	+	0.4	0.5	0.3	0.9	0.6	1	1.1	0.5	0.4
1998	-	0.1	0.2	0.3	0.2	1.1	0.5	0.7	1	0.4	0.4	0.7
1999	0.1	-	0.1	+	0.1	0.3	0.5	0.8	0.5	0.2	0.4	0.6
2000	-	0.6	0.1	0.5	0.3	0.3	0.6	0.4	0.1	0.1	0.7	0.3

Year class	0	1	2	3	4	5	6	7	8	9	10	11
2001	-	0.1	0.4	-	0.1	0.2	0.2	0.3	0.2	0.8	0.1	1
2002[3]	0.1	0.5	0.1	-	-	0.1	0.5	0.4	1.5	0.5	1	1.1
2003	-	-	0.1	-	0.3	1.0	0.5	4.8	2.1	3.7	1.3	1.9
2004	-	0.2	0.3	0.5	1.5	0.9	4.4	3.7	7.5	4.1	3.1	3.3
2005	-	-	1.4	1.9	1.4	2.3	3.9	7.2	6.1	6.8	3.1	
2006[4]	0.1	1.8	1.2	1.1	0.8	2.1	4.1	3.0	6.1	5.9		
2007	2.5	0.4	0.1	1.2	1.7	2.4	3.6	4.3	7.4			
2008	0.1	0.1	1.6	1.8	4.1	2.9	5.8	5.5				
2009	1.6	1.9	1.1	4.4	4.8	2.9	4.8					
2010	7.5	0.7	1.2	1.5	1.9	1.6						
2011	0.1	0.3	0.6	1.6	1.6							
2012	0.2	0.7	0.5	0.3								
2013	0.1	0.1	0.4									
2014	3.6	1.0										
2015	6.6											

1 - Not complete area coverage of Division 2.b.

2 - Area surveyed restricted to Subarea 1 and Division 2.a only.

3 - Area surveyed restricted to Subarea 1 and Division 2.b only

4- Area surveyed restricted to Division 2.a and 2.b only.

Table 6.15a. *Sebastes mentella*[1] in Division 2.b. Abundance indices (on length) from the bottom-trawl survey in the Svalbard area (Division 2.b) in summer/fall 1986–2018 (numbers in millions).

	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[2]	6	101	192	17	10	5	2	4	+	338
1987[2]	20	14	140	19	6	2	1	2	+	208
1988[2]	33	23	82	77	7	3	2	2	+	228
1989	566	225	24	72	17	2	2	8	4	921
1990	184	820	59	65	111	23	15	7	3	1287
1991	1533	1426	563	55	138	38	30	7	1	3791
1992	149	446	268	43	22	15	4	7	4	958

	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
1993	9	320	272	89	16	13	3	1	+	722
1994	4	284	613	242	10	9	2	2	1	1165
1995	33	33	417	349	77	18	5	1	+	933
1996	56	69	139	310	97	8	4	1	1	685
1997	3	44	13	65	57	9	5	+	+	195
1998	+	37	35	28	132	73	45	2	+	353
1999	4	3	121	62	259	169	42	1	0	661
2000	+	10	31	59	126	143	21	1	0	391
2001	1	5	3	32	57	228	50	3	0	378
2002	1	4	6	21	62	266	47	4	+	410
2003	1	5	7	11	56	271	50	1	0	403
2004	0	2	7	6	14	78	53	2	0	163
2005	1	1	6	11	19	93	63	1	0	196
2006	82	6	5	7	49	211	101	3	0	463
2007	98	68	1	5	11	95	109	3	0	387
2008	119	45	20	3	9	25	79	4	0	303
2009	8	114	83	14	3	23	191	5	0	440
2010	96	19	46	39	2	20	88	7	0	317
2011	124	91	82	46	11	8	67	5	1	436
2012	27	73	68	78	48	8	91	9	0	401
2013	33	44	131	112	71	19	86	12	0	509
20143	3	12	56	49	39	23	58	17	+	257
2015	74	7	28	144	114	64	69	25	0	525
2016	215	30	41	201	146	150	152	51	+	984
2017	Not avaialable for AFWG 2018									
2018	Not avaialable for AFWG 2019									

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Old trawl equipment (bobbins gear and 80 m sweep length)

3 - Poor survey coverage in 2014

Table 6.15b. *Sebastes mentella*[1] in Division 2.b. Norwegian bottom-trawl survey indices (on age) in the Svalbard area (Division 2.b) in summer/fall 1992–2018 (numbers in millions).

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	283	419	484	131	58	45	14	8	5	2	7	2	1	3	1462
1993	2	527	117	202	142	8	23	6	13	1	7	1	1	+	1050
1994	7	280	290	202	235	42	94	1	1	3	4	1	1	+	1161
1995	4	50	365	237	132	61	19	17	11	+	1	3	0	0	900
1996	23	47	15	37	105	144	84	17	51	32	34	9	6	2	605
1997	8	43	6	6	40	20	30	25	7	3	1	2	2	1	194
1998	+	26	28	14	10	13	69	66	49	15	1	6	15	5	317
1999	3	16	114	27	36	53	117	78	67	41	45	11	19	13	640
2000	4	6	6	14	35	22	31	54	81	60	24	24	10	8	379
2001	2	4	3	1	9	16	22	30	34	57	57	50	54	6	344
2002	3	2	4	2	5	22	34	23	88	36	62	64	15	21	379
2003	0.3	3	4	3	5	4	29	31	50	59	45	70	38	23	365
2004	1	1	3	3	1	4	2	9	9	18	15	17	19	9	113
2005	1	1	2	3	3	6	9	15	14	16	14	21	22	25	152
2006	33	1	3	3	2	9	17	27	24	35	29	45	25	34	287
2007	23	45	0	0	3	2	5	5	8	5	5	9	29	19	158
2008	6	22	22	12	1	2	2	5	4	4	3	5	10	6	102
2009	14	43	55	41	34	19	7	1	2	2	9	10	26	7	270
2010	No age readings														
2011	112	45	57	43	34	35	22	7	2	0	1	0	0	2	360
2012	26	33	38	33	39	49	30	30	14	4	1	1	1	0	298
2013	31	2	29	50	49	65	55	79	21	5	14	11	1	1	509
2014[2]	+	3	2	4	23	29	17	29	15	19	12	13	6	2	290
2015	60	2	12	45	61	45	52	68	37	12	9	6	7	4	547
2016	No age readings available														
2017	No age readings available														
2018	No age readings available														

[1] - Includes some unidentified *Sebastes* specimens mostly less than 15 cm.

[2] - Poor survey coverage in 2014

Table 6.16a. *Sebastes mentella*[1]. Abundance indices (on length) from the bottom-trawl survey in the Barents Sea in the winter 1986–2019 (numbers in millions). The area coverage was extended from 1993 onwards. Numbers from 1994 onwards were recalculated while numbers for 1986–1993 are as in previous reports. NOTE: newly calculated values 2014–2018 differ from the ones reported in this table.

	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	81	152	205	88	169	130	88	24	13.8	950
1987	72	25	227	56	35	11	5	1	0.1	433
1988	587	25	133	182	40	50	48	4	0.1	1068
1989	623	55	28	177	58	9	8	2	0.3	961
1990	324	305	36	56	80	13	13	2	0.2	828
1991	395	449	86	39	96	35	24	3	0.2	1127
1992	139	367	227	35	55	34	8	2	0.5	867
1993	31	593	320	116	24	25	6	1	+	1117
1994	8	296	479	488	74	74	17	3	0	1440
1995	310	84	571	391	83	58	24	3	0	1523
1996	215	102	199	343	136	42	17	1	0	1054
1997[2]	65	118	22	242	258	70	39	4	0	819
1998[2]	1	88	62	101	203	40	13	2	0	511
1999	2	7	70	37	171	74	22	3	1	385
2000	9	13	40	78	142	95	25	7	2	410
2001	10	23	7	57	79	75	10	1	0	261
2002	17	8	19	37	96	117	24	1	0	318
2003	4	4	10	13	70	198	46	6	0	351
2004	2	3	7	19	33	86	32	2	1	183
2005	0	6	7	11	28	154	86	4	0	297
2006	100	2	10	15	23	104	83	3	1	339
2007	374	122	3	7	12	121	121	7	0	767
2008	858	359	27	5	12	104	165	5	0	1534
2009	95	325	136	5	9	67	163	6	0	806
2010	652	276	215	64	7	74	191	6	0	1485
2011	502	230	213	149	14	47	157	5	0	1316

	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
2012	129	280	86	125	47	14	154	18	0	855
2013	250	227	245	159	143	35	193	27	0	1280
2014	91	175	250	114	125	51	115	14	0	934
2015	175	111	216	302	290	215	171	18	0	1498
2016	615	105	149	332	213	163	124	14	1	1715
2017	604	202	70	199	287	309	232	11	0	1915
2018	190	253	83	110	191	270	217	23	1	1339
2019	53	305	277	93	160	257	213	20	0	1377

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1.

Table 6.16b. *Sebastes mentella*[1] in subareas 1 and 2. Preliminary Norwegian bottom-trawl indices (on age) from the annual Barents Sea survey in February 1992–2019 (numbers in millions). The area coverage was extended from 1993 onwards.

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1992	351	252	132	56	14	11	3	9	18	16	12	11	2	5	892
1993	38	473	192	242	62	45	19	22	13	11	10	4	2	3	1136
1994	7	85	332	189	370	228	73	42	3	30	8	14	25	7	1413
1995	308	45	146	264	364	211	69	23	7	17	23	9	11	10	1507
1996	173	119	109	114	128	122	106	64	24	19	12	7	8	4	1009
1997[2]	43	101	19	54	96	43	44	171	76	74	39	29	10	9	808
1998[2]	1	73	49	27	13	52	107	104	41	18	7	4	3	3	502
1999	1	+	32	43	30	24	30	81	79	28	2	1	6	+	357
2000	9	12	21	17	9	39	77	73	50	41	14	10	7	6	385
2001	1	17	8	1	7	22	39	30	34	23	24	17	9	3	236
2002	18	4	12	7	4	14	49	55	27	19	34	24	28	11	306
2003	0	2	2	4	6	6	14	39	24	34	39	65	46	20	301
2004	0	2	3	1	9	12	15	20	36	8	28	3	25	12	172
2005	0	4	3	3	6	6	11	15	23	14	21	40	35	49	229
2006	4	1	5	5	5	8	15	12	6	15	21	17	32	36	180
2007	428	82	13	1	2	2	5	7	8	8	21	20	31	35	144
2008	648	173	107	11	0	2	5	7	5	10	10	28	27	40	1073
2009	107	112	104	82	63	32	14	9	9	6	16	7	21	11	593
2010	150	239	172	161	103	71	27	13	4	7	13	12	21	33	1027
2011	391	211	106	125	109	67	47	14	5	4	1	3	2	10	1095
2012	No age readings														
2013	No age readings														
2014	No age readings														
2015	No age readings														
2016	No age readings														
2017	No age readings														
2018	No age readings														
2019	No age readings														

1 - Includes some unidentified Sebastes specimens mostly less than 15 cm.

2 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1

Table 6.17. Comparison of results on *Sebastes mentella* from the Norwegian Sea pelagic surveys in 2008, 2009 2013 and 2016.

	2008	2009	2013	2016
mean length (cm) All/M/F[1]	37.0 / 36.4 / 37.5	36.6 / 36.0 / 37.1	37.5 / 37.0 / 38.1	37.7 / 37.0 / 38.3
mean length (cm) S/DSL/D[2]	37.2 / 36.8 / 39.1	37.2 / 36.5 / 38.3	37.1 / 37.4 / 38.9	38.1 / 37.6 / 38.4
mean weight (g) All/M/F	619 / 585 / 648	625 / 609 / 666	659 / 625 / 706	656 / 619 / 694
Mean age (y) All/M/F	25 / 25 / 25	25 / 25 / 24	- / - / -	- / - / -
Sex ratio	45% (M) / 55% (F)	45% (M) / 55% (F)	59% (M) / 41% (F)	50% (M) / 50% (F)
Occurrence	96%	100%	95%	80%
Catch rates	3.80 t/NM^2	3.94 t/NM^2	3.47 t/NM^2	101 t/NM^2
mean s_A	33 m^2/NM^2	34 m^2/NM^2	19 m^2/NM^2	5.2 m^2/NM^2
Total Area	53 720 NM^2	69 520 NM^2	69 520 NM^2	67 150 NM^2
Abundance (Acoustics)[3]	395 000 t	532 000 t	297 000 t	136 000 t
Abundance (Trawl)[4]	406 000 t	548 000 t	482 000 t	116 000 t

[1] **M = males only F = females only**

[2] **S = shallower than DSL DSL = deep scattering layer D = deeper than DSL**

[3]**The abundance derived from hydroacoustics is calculated assuming a Length-dependent target strength equation of TS=20log(L)-68.0. In 2016 the TS equation used was TS=20log(L)-69.6 following recommendation from ICES-WKTAR (2010).**

[4]**Trawls: Gloria 2048 in 2008 and 2009 Gloria 2560 HO helix in 2013 and Gloria 1024 in 2016. Trawl catchability for redfish set to 0.5 for all trawls based on results from Bethke *et al.* (2010).**

Table 6.18. ***Sebastes mentella*** **in subareas 1 and 2. Abundance indices (on age) from the Ecosystem survey in August-September 1996–2018 covering the Norwegian Economic Zone (NEZ) and Svalbard incl. the area north and east of Spitsbergen (numbers in thousands and total biomass in thousand tonnes) and the continental slope down to 1500 m.**

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
1996	146198	112742	22353	53507	165531	181980	108738	43328	65310	40546	38254	19843	29446	10931	17414	1 056 120	171
1997	62682	130816	12492	23452	74342	55880	76607	82503	17640	14274	675	2238	1723	633	8765	564 723	73
1998	313	78767	85715	39849	25805	23413	84825	100332	54287	24329	11334	7457	15250	576	25212	577 464	105
1999	5359	23240	117170	47851	41608	76797	128677	73306	58018	64781	49890	13565	18458	12171	24672	755 562	155
2000	5964	23169	14336	19960	52666	68081	83857	77513	100442	72294	71148	36599	17183	20590	26501	690 304	178
2001	5026	6541	10957	1093	19766	25591	36594	51644	44407	61704	50083	86122	53952	15699	31877	501 057	162
2002	9112	6646	7379	3821	8635	28215	47456	63903	103368	49964	76133	71970	25241	36765	34957	573 565	181
2003	3954	7394	6142	3540	8030	9388	48564	59051	98554	69901	83192	73521	69970	37162	47323	625 687	213
2004	9068	10837	9008	7292	2510	7896	8193	15268	25544	29654	35249	21142	39581	25976	66792	314 010	111
2005	1310	4406	5241	5031	5722	8740	13452	20672	16207	19353	17430	32028	37564	34815	57103	279 072	103
2006	156578	5162	6695	5217	3768	10754	18771	29174	25278	38958	31869	46885	30895	44299	147951	602 255	184
2007	302988	224153	290	7686	11346	2031	7903	10770	12182	6578	6367	9998	41425	22090	211178	876 986	172
2008	86880	183796	121430	21430	4178	3009	3334	6991	5120	4441	3581	6008	10352	10172	99808	570 530	89
2009	98726	133218	196908	118322	131668	37586	18194	3679	8633	3494	9736	14091	25949	8384	251370	1 059 960	200
2010	No age reading																
2011	389536	285787	222753	60809	80266	67419	39695	12409	4144	1175	1174	2246	324	3379	93382	1 264 495	

Year/Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total N	Total B
2012	468 668	201 121	355 968	171 789	111 821	89 591	55 393	36 823	18 795	7 308	7 521	838	4 859	1 770	131 470	1 663 736	
2013	209 352	153 814	160 189	169 748	158 030	137 012	78 817	129 898	52 762	24 338	19 775	23 891	1 405	1 041	129 156	1 449 229	
2014[1]	2 440	23 091	38 542	69 219	49 720	86 768	74 944	69 021	48 043	45 568	42 281	17 440	16 739	3 584	162 911	783 055	
2015	450 847	32 390	53 292	84 098	84 938	101 485	67 651	94 248	69 453	17 908	17 962	8 112	8 073	4 771	141 040	1 269 508	
2016	No age reading																
2017	No age reading																
2018	No age reading																

[1] - Poor survey coverage in 2014

Table 6.19. Proportion of maturity-at-age 6–30 in *Sebastes mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data. The proportions were derived from samples with at least 5 individuals. a50 w1 and w2 are the annual coefficients for modelled maturity ogives using a double half sigmoid of the form 0.5 ((1+tanh(age- a50)/w1)) for age < a50 and 0.5 (1+tanh((age- a50)/w2) for age > a50. a50 equals the age at 50% maturity.

year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
1992	0.00	0.00	0.01	0.02	0.04	0.09	0.18	0.32	0.50	0.57	0.63	0.69	0.75	1.00
1993	0.01	0.02	0.03	0.07	0.15	0.28	0.45	0.55	0.61	0.67	0.73	0.78	0.82	1.00
1994	0.02	0.03	0.07	0.14	0.27	0.45	0.60	0.72	0.81	0.88	0.93	0.96	0.97	1.00
1995	0.03	0.06	0.12	0.23	0.39	0.57	0.71	0.82	0.90	0.94	0.97	0.98	0.99	1.00
1996	0.00	0.01	0.02	0.04	0.09	0.18	0.33	0.51	0.59	0.67	0.74	0.80	0.85	1.00
1997	0.02	0.04	0.08	0.15	0.29	0.47	0.55	0.61	0.66	0.71	0.76	0.80	0.83	1.00
1998	0.01	0.03	0.07	0.14	0.26	0.43	0.56	0.65	0.73	0.80	0.85	0.90	0.93	1.00
1999	0.02	0.05	0.10	0.19	0.34	0.51	0.58	0.64	0.70	0.75	0.79	0.83	0.87	1.00
2000	0.02	0.05	0.10	0.20	0.35	0.53	0.63	0.73	0.81	0.87	0.91	0.94	0.96	1.00
2001	0.01	0.02	0.04	0.09	0.18	0.33	0.50	0.57	0.63	0.69	0.74	0.79	0.83	1.00
2002	0.02	0.05	0.10	0.19	0.33	0.51	0.55	0.59	0.63	0.67	0.71	0.74	0.77	1.00
2003	0.02	0.05	0.11	0.21	0.37	0.52	0.58	0.63	0.68	0.73	0.78	0.81	0.85	1.00
2004	0.03	0.06	0.11	0.22	0.38	0.51	0.55	0.59	0.63	0.66	0.70	0.73	0.76	1.00
2005	0.02	0.04	0.09	0.17	0.31	0.49	0.55	0.61	0.66	0.71	0.75	0.79	0.83	1.00
2006	0.01	0.01	0.03	0.06	0.12	0.23	0.40	0.53	0.59	0.65	0.70	0.75	0.79	1.00

year/Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
2007	0.02	0.04	0.08	0.16	0.29	0.48	0.64	0.77	0.87	0.93	0.96	0.98	0.99	1.00
2008	0.01	0.03	0.07	0.13	0.25	0.42	0.56	0.65	0.73	0.80	0.85	0.89	0.92	1.00
2009	0.02	0.04	0.08	0.16	0.29	0.47	0.61	0.72	0.81	0.87	0.92	0.95	0.97	1.00
2010	0.02	0.04	0.07	0.15	0.28	0.46	0.55	0.60	0.66	0.71	0.75	0.80	0.83	1.00
2011[1]	0.01	0.03	0.06	0.12	0.24	0.40	0.53	0.60	0.67	0.73	0.78	0.82	0.86	1.00
2012	0.02	0.04	0.09	0.17	0.31	0.50	0.59	0.68	0.75	0.81	0.86	0.90	0.93	1.00
2013	0.00	0.01	0.02	0.03	0.07	0.14	0.27	0.44	0.63	0.78	0.89	0.94	0.97	1.00
2014[1]	0.01	0.03	0.06	0.12	0.24	0.40	0.53	0.60	0.67	0.73	0.78	0.82	0.86	1.00
2015[1]	0.01	0.03	0.06	0.12	0.24	0.40	0.53	0.60	0.67	0.73	0.78	0.82	0.86	1.00
2016[1]	0.01	0.03	0.06	0.12	0.24	0.40	0.53	0.60	0.67	0.73	0.78	0.82	0.86	1.00
2017[1]	0.01	0.03	0.06	0.12	0.24	0.40	0.53	0.60	0.67	0.73	0.78	0.82	0.86	1.00
2018	0.01	0.03	0.06	0.12	0.24	0.40	0.53	0.60	0.67	0.73	0.78	0.82	0.86	1.00

[1] **Model parameter estimates were unrealistic and replaced by average parameter values.**

Table 6.20a: *S. mentella* in subareas 1 and 2. Population matrix with numbers-at-age (in thousands) for each year and separable fishing mortality coefficients for the demersal and pelagic fleet by year (Fy) and selectivity at age for the pelagic fleet (Sa). Numbers are estimated from the statistical catch-at-age model.

sa (demersal)	**Varies over time**																	
sa (pelagic)	0.000	0.000	0.000	0.000	0.000	0.009	0.017	0.035	0.068	0.128	0.229	0.376	0.550	0.712	0.834	0.910	0.954	1.000

Fy (demer-sal)	**Fy (pe-lagic)**	**Year \ age**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19+**
0.051	0	1992	394 428	369 626	328 046	215 359	127 853	89 226	89 635	96 352	115 919	78 462	87 187	66 288	68 269	55 970	51 269	36 074	23 398	165 040
0.036	0	1993	264 183	375 271	351 674	312 114	202 350	119 866	83 451	83 617	89 639	107 542	72 589	80 442	61 001	62 673	57 537	47 059	33 110	172 948
0.032	0	1994	202 742	251 352	357 045	334 594	296 890	192 409	113 868	79 087	78 847	83 847	99 744	66 940	73 971	56 028	51 648	53 032	43 372	189 908
0.024	0	1995	182 269	192 895	239 144	339 704	318 095	281 965	182 343	107 475	74 193	73 473	77 726	92 178	61 768	68 209	63 389	47 994	49 278	216 763
0.016	0	1996	148 238	173 417	183 527	227 530	322 973	302 158	267 346	172 320	101 094	69 454	68 536	72 355	85 722	57 415	53 734	59 324	44 916	248 981
0.016	0	1997	116 177	141 039	164 994	174 613	216 421	307 050	286 880	253 094	162 434	94 934	65 086	64 171	67 726	80 229	75 139	50 324	55 560	275 245
0.022	0	1998	61 161	110 534	134 189	156 981	166 099	205 784	291 628	271 750	238 740	152 635	89 021	60 982	60 107	63 431	59 040	69 937	46 840	307 905
0.017	0	1999	47 176	58 190	105 166	127 671	149 342	157 961	195 399	275 501	254 636	222 624	142 128	82 866	56 761	55 947	52 341	55 235	65 430	331 884
0.013	0	2000	37 256	44 885	55 364	100 058	121 469	142 077	150 223	185 515	260 198	239 000	208 426	132 987	77 528	53 104	49 856	49 140	51 857	373 017
0.023	0	2001	28 975	35 446	42 705	52 675	95 198	115 568	135 156	142 728	175 236	244 537	224 409	195 682	124 854	72 787	67 660	46 341	45 675	394 907
0.008	0	2002	38 012	27 568	33 725	40 631	50 096	90 479	109 676	127 878	134 391	164 124	228 135	208 915	181 999	116 078	109 533	63 845	43 728	415 740
0.003	0	2003	39 022	36 166	26 229	32 087	38 657	47 659	86 055	104 198	121 158	126 988	154 920	215 286	197 138	171 737	162 921	103 909	60 566	435 874
0.006	0	2004	51 669	37 126	34 409	24 955	30 526	36 772	45 324	81 804	98 992	115 035	120 519	146 994	204 249	187 022	176 854	154 061	98 258	469 441
0.009	0	2005	97 950	49 160	35 323	32 738	23 740	29 034	34 959	43 050	77 592	93 765	108 863	114 001	139 017	193 150	182 076	166 713	145 227	535 145

Fy (demersal)	Fy (pelagic)	Year \ age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.011	0.032	2006	224 157	93 193	46 772	33 608	31 144	22 579	27 597	33 183	40 770	73 314	88 473	102 656	107 476	131 051	120 633	166 949	152 488	620 748
0.005	0.02	2007	401 392	213 270	88 666	44 500	31 974	29 629	21 471	26 223	31 480	38 557	69 017	82 844	95 570	99 461	92 818	112 287	155 150	717 395
0.005	0.011	2008	380 836	381 897	202 912	84 360	42 339	30 421	28 184	20 419	24 924	29 886	36 525	65 164	77 906	89 505	84 066	87 064	105 239	817 065
0.005	0.008	2009	348 342	362 340	363 349	193 057	80 263	40 282	28 940	26 808	19 414	23 670	28 313	34 512	61 438	73 302	69 015	79 074	81 844	866 443
0.005	0.01	2010	530 566	331 424	344 742	345 702	183 679	76 363	38 321	27 525	25 481	18 427	22 421	26 772	32 583	57 920	54 460	64 811	74 200	889 076
0.005	0.011	2011	472 171	504 798	315 327	327 998	328 909	174 753	72 642	36 445	26 163	24 193	17 464	21 204	25 266	30 689	28 822	51 076	60 732	901 784
0.005	0.009	2012	481 821	449 238	480 281	300 013	312 067	312 931	166 244	69 093	34 648	24 844	22 924	16 506	19 994	23 773	22 358	27 073	47 941	902 697
0.003	0.01	2013	167 415	458 420	427 420	456 955	285 440	296 905	297 693	158 121	65 689	32 911	23 560	21 690	15 582	18 836	17 743	21 032	25 449	892 834
0.014	0.012	2014	117 682	159 284	436 156	406 661	434 760	271 575	282 457	283 173	150 371	62 436	31 249	22 331	20 514	14 704	13 729	16 517	19 544	851 600
0.029	0.007	2015	176 106	111 966	151 547	414 972	386 901	413 625	258 333	268 627	269 192	142 825	59 209	29 553	21 035	19 234	17 710	12 620	15 169	799 324
0.04	0.009	2016	168 841	167 553	106 528	144 187	394 782	368 030	393 307	245 457	254 814	254 505	134 290	55 285	27 418	19 425	17 673	16 082	11 448	738 097
0.033	0.008	2017	161 891	160 641	159 415	101 355	137 162	375 460	349 804	373 343	232 348	239 923	237 666	124 229	50 738	25 028	22 905	16 155	14 690	684 136
0.041	0.009	2018	155 241	154 028	152 839	151 673	96 430	130 490	357 113	332 505	354 228	219 391	224 484	220 157	114 327	46 530	22 905	16 155	14 690	684 136

Table 6.20b. *S. mentella* in subareas 1 and 2. Fisheries selectivity at age for the demersal fleet by age (Sa). Numbers are estimated from the statistical catch-at-age model.

Year \age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1992	0.000	0.000	0.000	0.248	0.291	0.339	0.390	0.444	0.499	0.554	0.608	0.659	0.707	0.751	0.790	0.824	0.854	1.000
1993	0.000	0.000	0.000	0.006	0.016	0.043	0.109	0.248	0.472	0.708	0.868	0.947	0.980	0.992	0.997	0.999	1.000	1.000
1994	0.000	0.000	0.000	0.025	0.056	0.124	0.251	0.443	0.653	0.817	0.914	0.962	0.984	0.993	0.997	0.999	0.999	1.000
1995	0.000	0.000	0.000	0.030	0.068	0.146	0.285	0.483	0.686	0.836	0.922	0.965	0.985	0.993	0.997	0.999	0.999	1.000
1996	0.000	0.000	0.000	0.016	0.047	0.127	0.303	0.564	0.794	0.920	0.971	0.990	0.997	0.999	1.000	1.000	1.000	1.000
1997	0.000	0.000	0.000	0.013	0.039	0.111	0.279	0.545	0.788	0.920	0.973	0.991	0.997	0.999	1.000	1.000	1.000	1.000
1998	0.000	0.000	0.000	0.004	0.021	0.091	0.323	0.695	0.916	0.981	0.996	0.999	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.000	0.000	0.000	0.001	0.005	0.026	0.126	0.437	0.807	0.958	0.992	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.000	0.000	0.000	0.000	0.001	0.011	0.104	0.542	0.923	0.992	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.000	0.000	0.000	0.018	0.045	0.109	0.238	0.445	0.673	0.841	0.931	0.972	0.989	0.996	0.998	0.999	1.000	1.000
2002	0.000	0.000	0.000	0.002	0.009	0.042	0.176	0.508	0.834	0.960	0.992	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.000	0.000	0.000	0.030	0.069	0.150	0.297	0.502	0.707	0.852	0.932	0.970	0.987	0.995	0.998	0.999	1.000	1.000
2004	0.000	0.000	0.000	0.021	0.053	0.128	0.278	0.502	0.726	0.874	0.948	0.979	0.992	0.997	0.999	1.000	1.000	1.000
2005	0.000	0.000	0.000	0.013	0.037	0.103	0.252	0.500	0.747	0.897	0.963	0.987	0.996	0.999	0.999	1.000	1.000	1.000
2006	0.000	0.000	0.000	0.003	0.009	0.025	0.068	0.170	0.365	0.618	0.819	0.927	0.973	0.990	0.996	0.999	1.000	1.000
2007	0.000	0.000	0.000	0.001	0.003	0.009	0.024	0.065	0.163	0.352	0.604	0.810	0.923	0.971	0.989	0.996	0.999	1.000
2008	0.000	0.000	0.000	0.000	0.001	0.003	0.014	0.058	0.215	0.550	0.844	0.960	0.991	0.998	1.000	1.000	1.000	1.000

Year \age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2009	0.000	0.000	0.000	0.001	0.003	0.012	0.043	0.142	0.380	0.695	0.894	0.969	0.991	0.998	0.999	1.000	1.000	1.000
2010	0.000	0.000	0.000	0.002	0.006	0.018	0.049	0.127	0.293	0.541	0.770	0.905	0.964	0.987	0.995	0.998	0.999	1.000
2011	0.000	0.000	0.000	0.001	0.002	0.007	0.023	0.079	0.235	0.526	0.800	0.935	0.981	0.995	0.999	1.000	1.000	1.000
2012	0.000	0.000	0.000	0.001	0.004	0.010	0.030	0.080	0.200	0.418	0.673	0.855	0.944	0.980	0.993	0.998	0.999	1.000
2013	0.000	0.000	0.000	0.001	0.002	0.006	0.015	0.041	0.105	0.243	0.467	0.706	0.868	0.947	0.980	0.993	0.997	1.000
2014	0.000	0.000	0.000	0.002	0.003	0.007	0.015	0.032	0.065	0.129	0.239	0.400	0.586	0.751	0.865	0.931	0.967	1.000
2015	0.000	0.000	0.000	0.003	0.008	0.018	0.042	0.095	0.202	0.378	0.593	0.778	0.894	0.953	0.980	0.991	0.996	1.000
2016	0.000	0.000	0.000	0.004	0.010	0.023	0.054	0.120	0.245	0.437	0.651	0.817	0.914	0.962	0.984	0.993	0.997	1.000
2017	0.000	0.000	0.000	0.001	0.002	0.007	0.024	0.075	0.212	0.472	0.748	0.908	0.970	0.991	0.997	0.999	1.000	1.000

Table 6.21. Stock summary for *S. mentella* in subareas 1 and 2 as estimated by the statistical catch-at-age model. Stock biomass is for age 2 y+.

Year	Rec (age 2) in millions	Rec (age 6) in millions	Stock Biomass (tonnes)	SSB (tonnes)	F (12-18)	F(19+)
1992	394	128	496483	214407	0.037	0.051
1993	264	202	536630	270189	0.035	0.036
1994	203	297	588073	342415	0.031	0.032
1995	182	318	646281	395232	0.023	0.024
1996	148	323	705411	325177	0.016	0.016
1997	116	216	764253	402525	0.016	0.016
1998	61	166	818272	456936	0.022	0.022
1999	47	149	861767	516780	0.017	0.017
2000	37	121	899905	602594	0.013	0.013
2001	29	95	931845	568541	0.023	0.023
2002	38	50	945499	637100	0.008	0.008
2003	39	39	962078	704700	0.003	0.003
2004	52	31	975692	712073	0.006	0.006
2005	98	24	982342	763444	0.009	0.009
2006	224	31	985038	751913	0.031	0.042
2007	401	32	964605	881343	0.018	0.025
2008	381	42	958935	841711	0.012	0.016
2009	348	80	967245	863056	0.010	0.013
2010	531	184	986719	820136	0.011	0.015
2011	472	329	1011172	809331	0.012	0.016
2012	482	312	1042517	807249	0.011	0.014
2013	167	285	1091558	765724	0.009	0.013
2014	118	435	1147532	771905	0.017	0.026
2015	176	387	1200437	765510	0.030	0.036
2016	169	395	1234519	767049	0.042	0.049
2017	162	137	1254186	772982	0.037	0.042
2018	155	96	1276995	793980	0.045	0.050

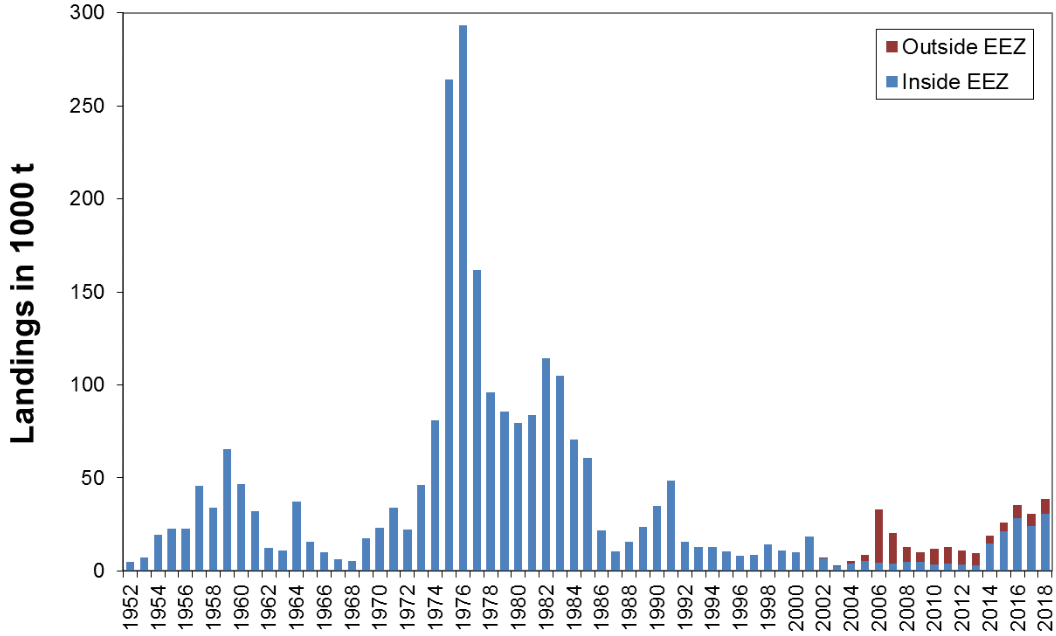


Figure 6.1. *Sebastes mentella* in subareas 1 and 2. Total international landings 1952–2018 (thousand tonnes).

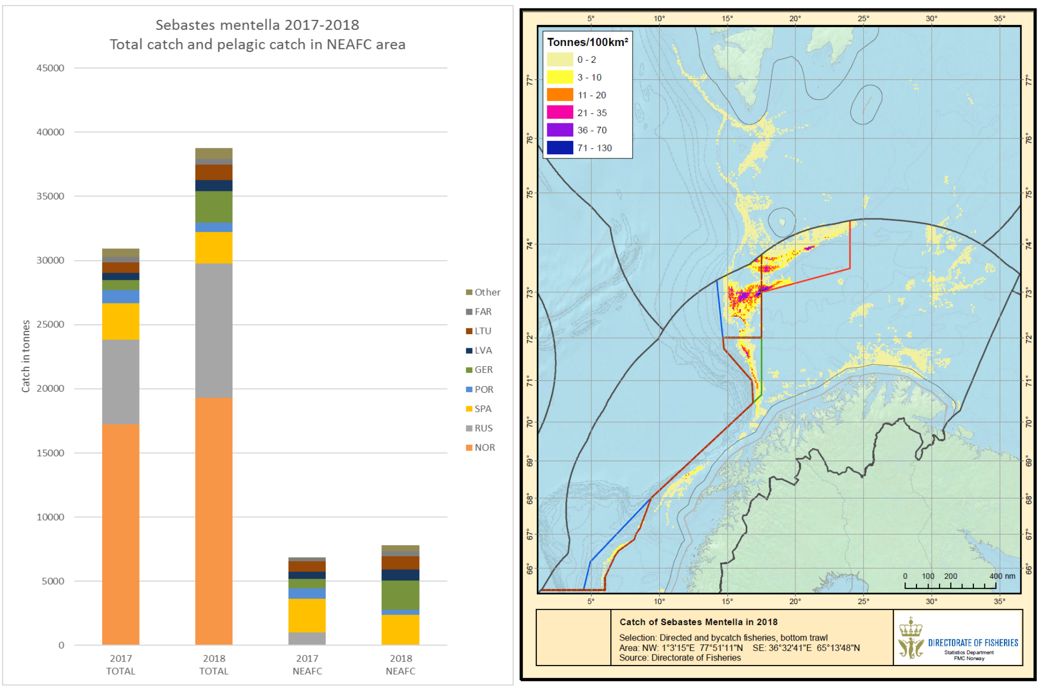


Figure 6.2. *Sebastes mentella* in subareas 1 and 2. Left panel: Catch in tonnes reported by national fleets for the Subarea 27.1 and 27.2 and in the NEACF regulatory area. Right panel: Geographical location of the directed Norwegian fishing within the Norwegian Exclusive Economic Zone and bycatches by Norwegian vessels in all areas. Directed fishing with bottom trawl is not permitted to the east of the red line. Directed fishing with pelagic trawl is not permitted to the east of the blue line. Directed fishing is not permitted in the Fishery Protection Zone around Svalbard.

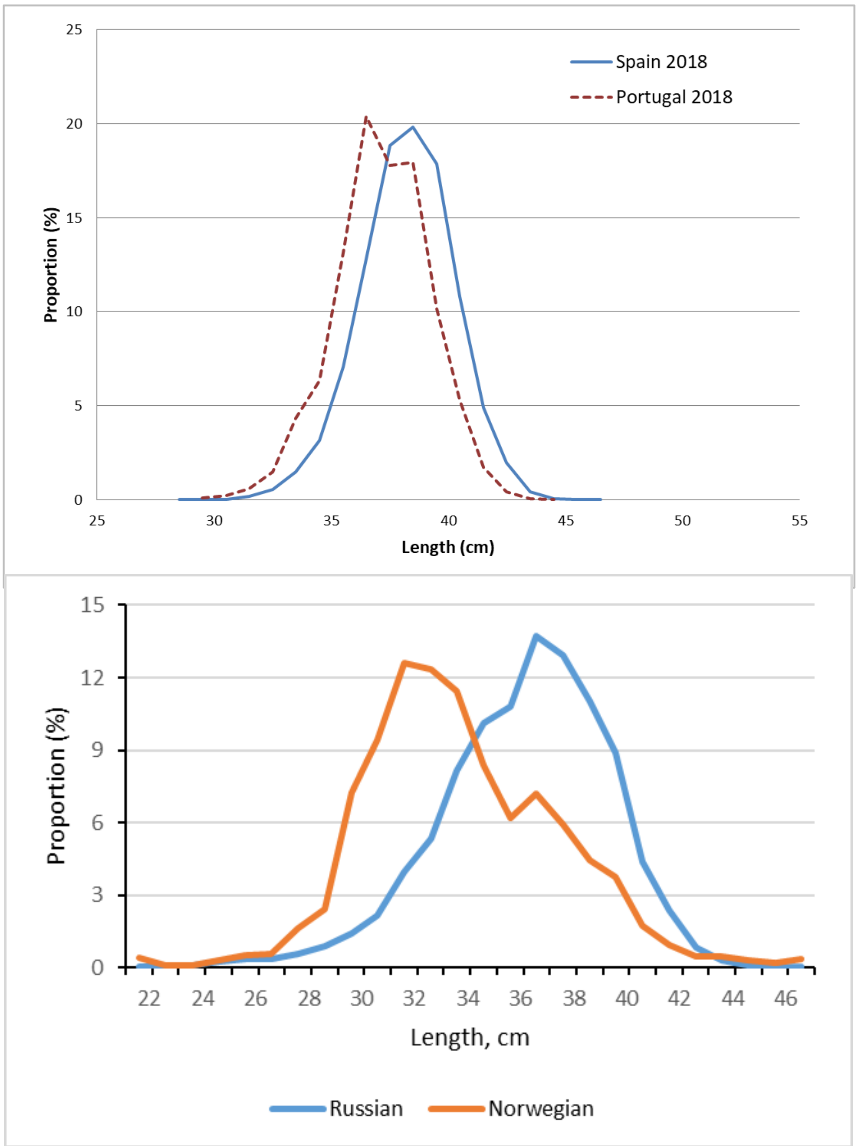


Figure 6.3. Upper panel: *Sebastes mentella* in Subarea 2. Length-distributions of the commercial pelagic catches by Spain and Portugal in 2018. Lower panel: *Sebastes mentella* in subareas 1 and 2. Length-distributions of the commercial demersal catches by Norway and Russia in 2018.

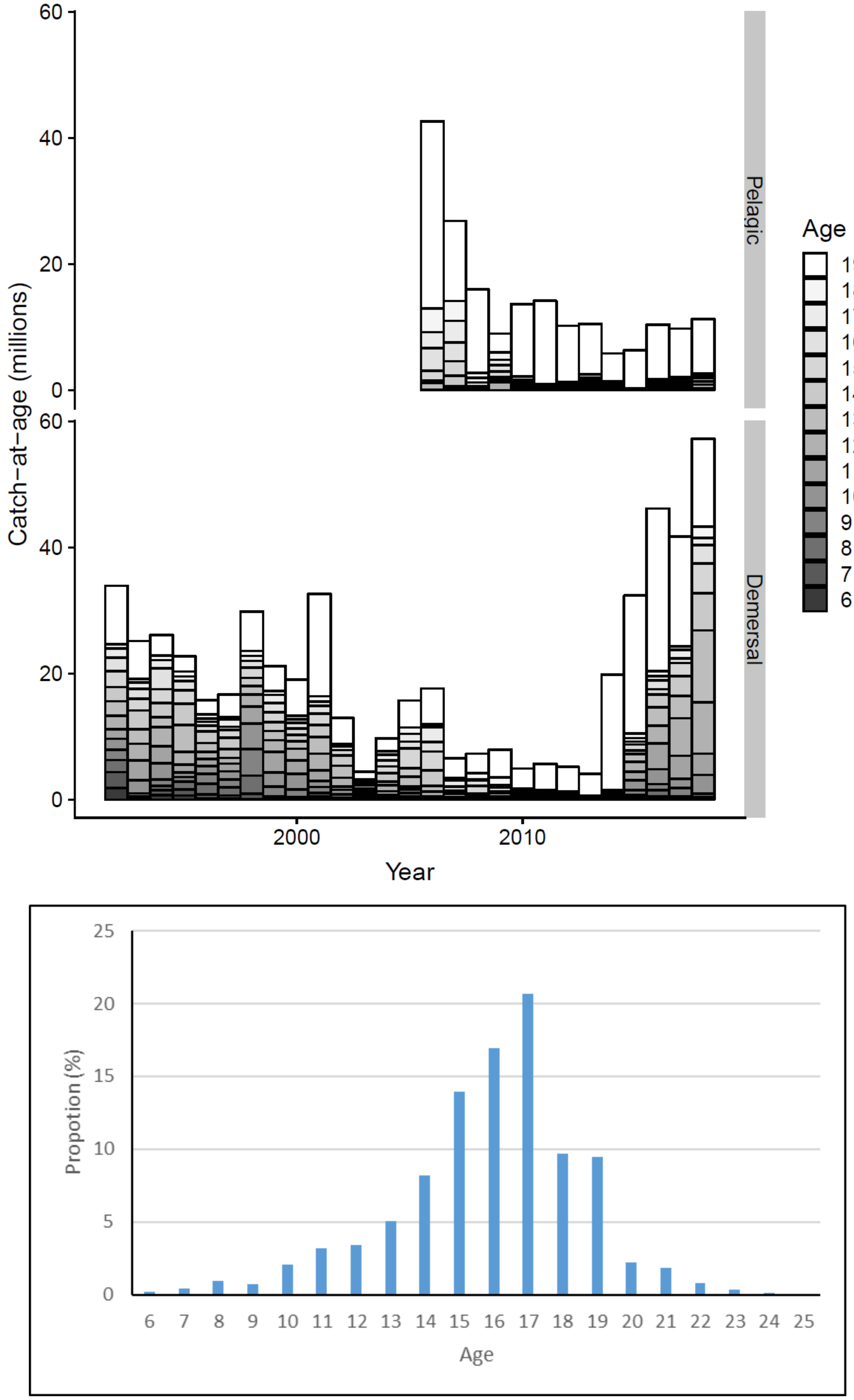


Figure 6.4. ***Sebastes mentella*** **in subareas 1 and 2. Upper panels: Catch numbers-at-age for the pelagic and demersal fleets 1992–2018. Lower panel: Age composition of the commercial demersal catches by Russia in 2018.**

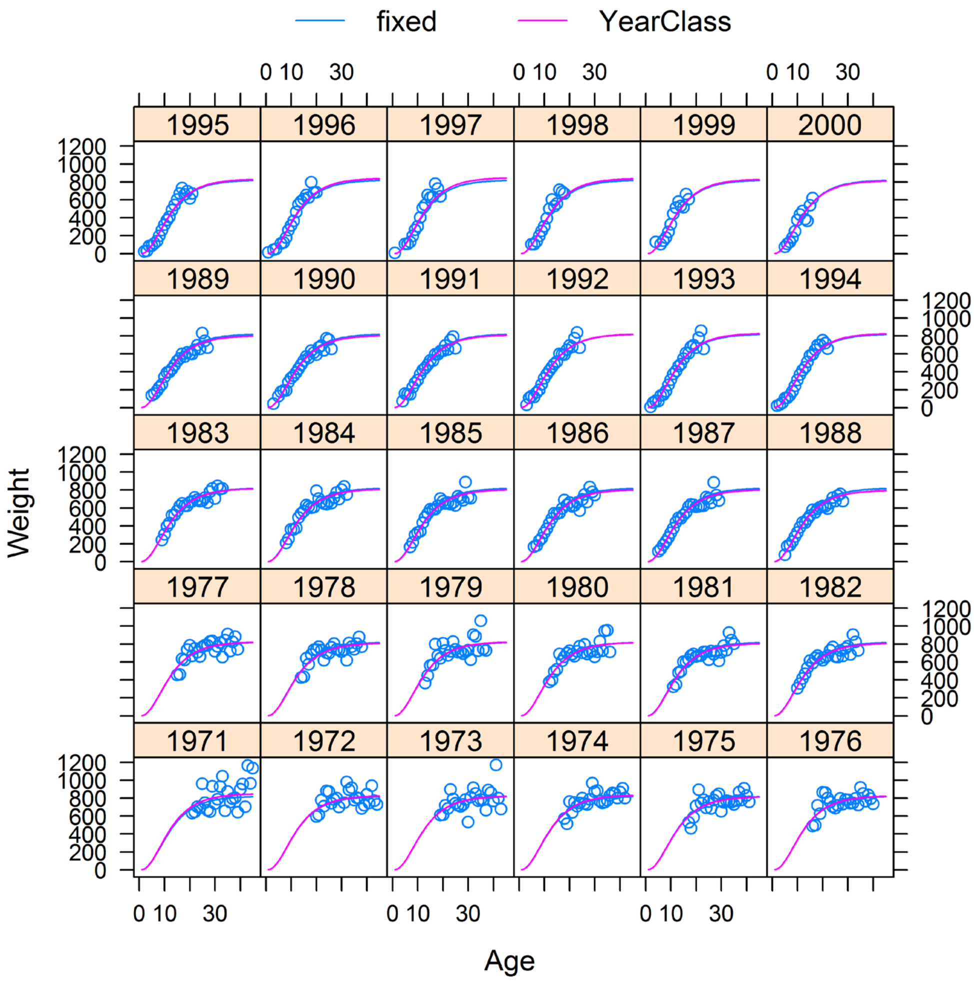


Figure 6.5. Weight-at-age of *S. mentella* per year class in subareas 1 and 2 derived from Norwegian commercial and survey data (Table 6.7). The weights were derived from samples with at least five individuals and are expressed in grammes. The blue and purple lines show the fitted mixed-effect models. Data for 2017 and 2018 were not available at the time of the meeting.

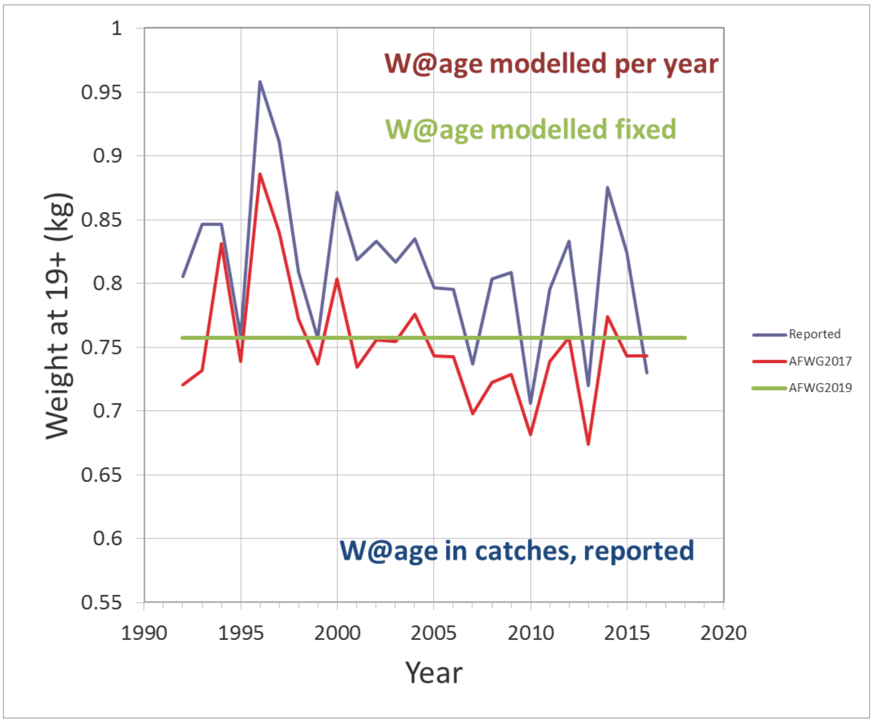


Figure 6.6. *S. mentella* in subareas 1 and 2. Weight-at-age 19+ as reported from catches (blue) or modelled from catches and survey observations (red) using a mixed effect model (Figure 6.5). The weights-at-age used in the assessment were based on the fixed effects model and are therefore the same for every year. These weights were updated in 2019 and differ only slight from those estimated in 2018.

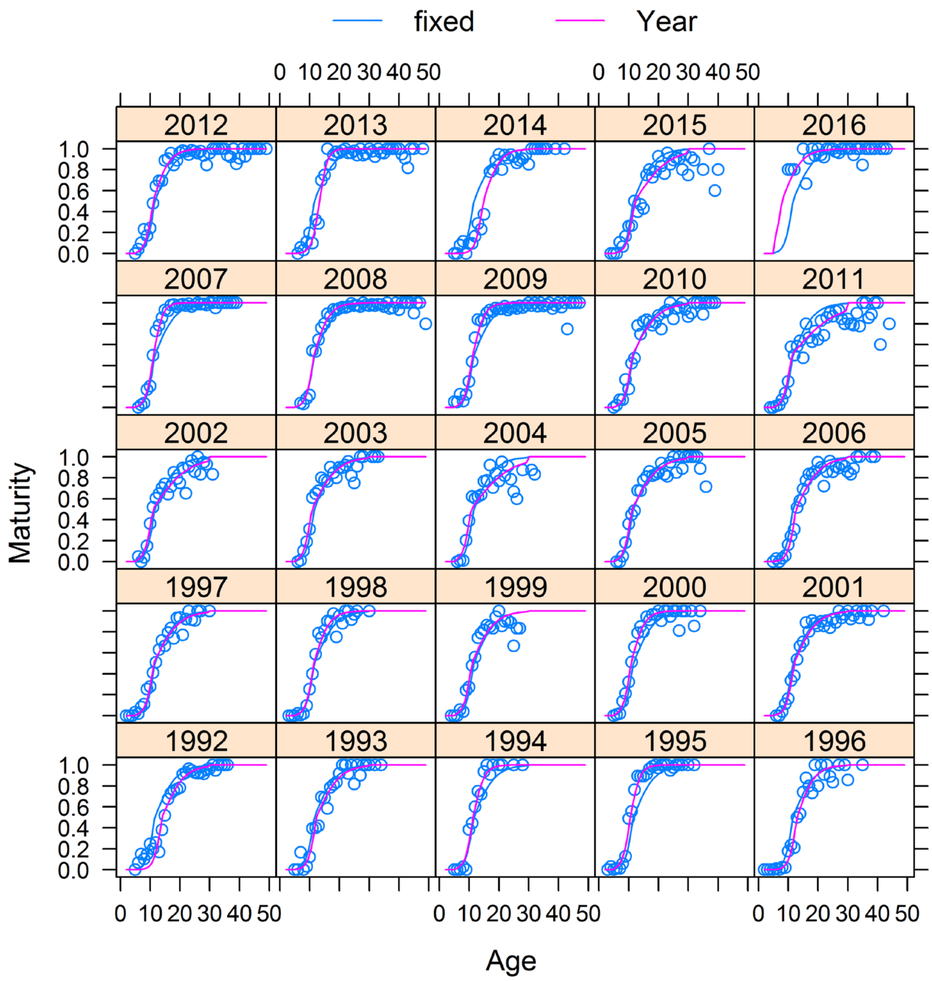


Figure 6.7. Proportion maturity-at-age of *S. mentella* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table D7). The proportions were derived from samples with at least five individuals. The blue and purple lines show the fitted mixed-effect models. For 2011, 2014, 2015, and 2016 the common model (fixed effects blue) was used for other years the annual models (random effects purple) were used. Data for 2017 and 2018 were not available at the time of the meeting and the fixed effect model was used.

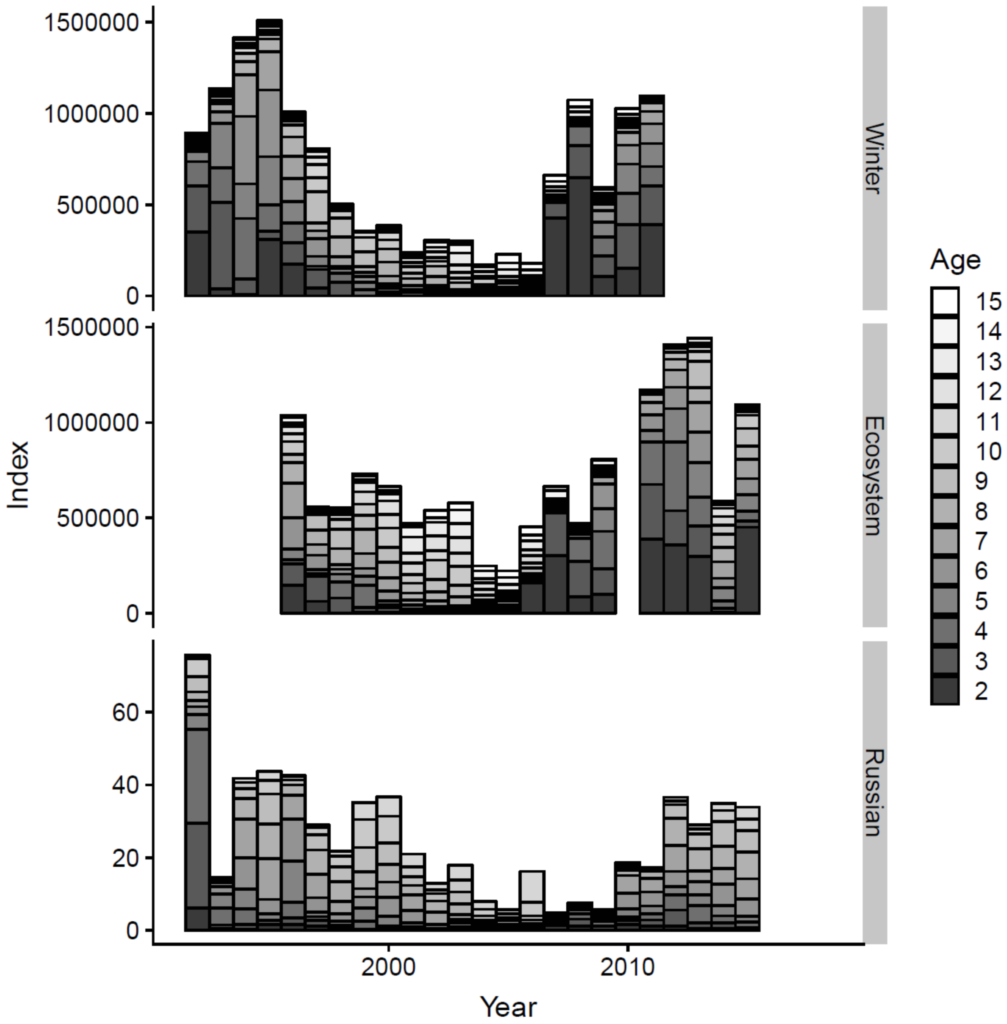
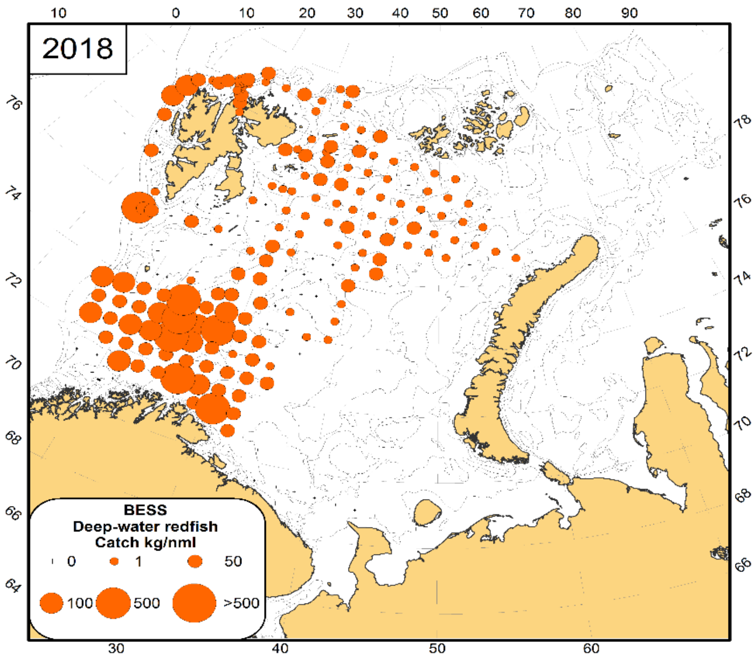


Figure 6.8. ***Sebastes mentella*** **in subareas 1 and 2. Age disaggregated abundance indices for bottom-trawl surveys 1992–2016 in the Barents Sea in winter (winter survey top) in summer (Ecosystem survey middle) and in autumn (Russian groundfish survey bottom).**



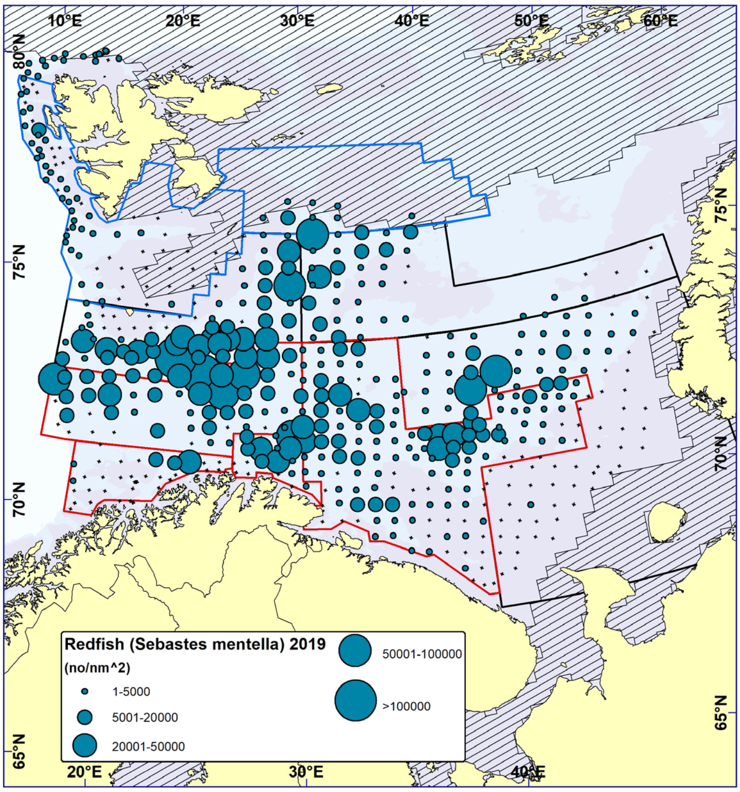
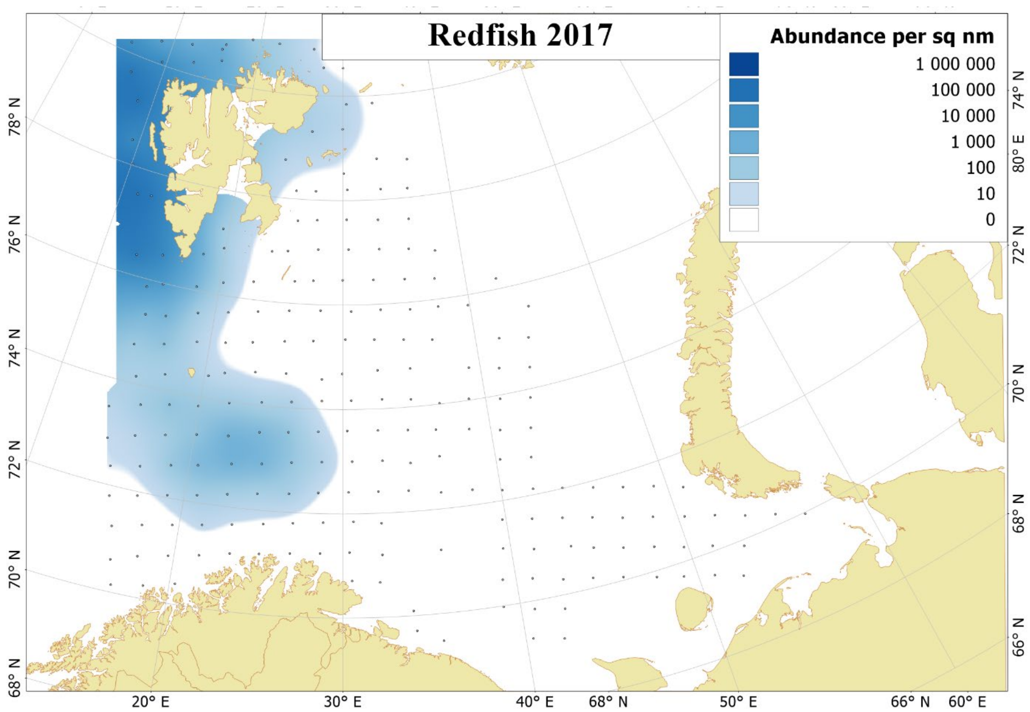


Figure 6.9. ***Sebastes mentella*** **in subareas 1 and 2. Abundance indices for individual trawl stations during the ecosystem survey in autumn 2018 (top) and winter survey 2019 (bottom).**



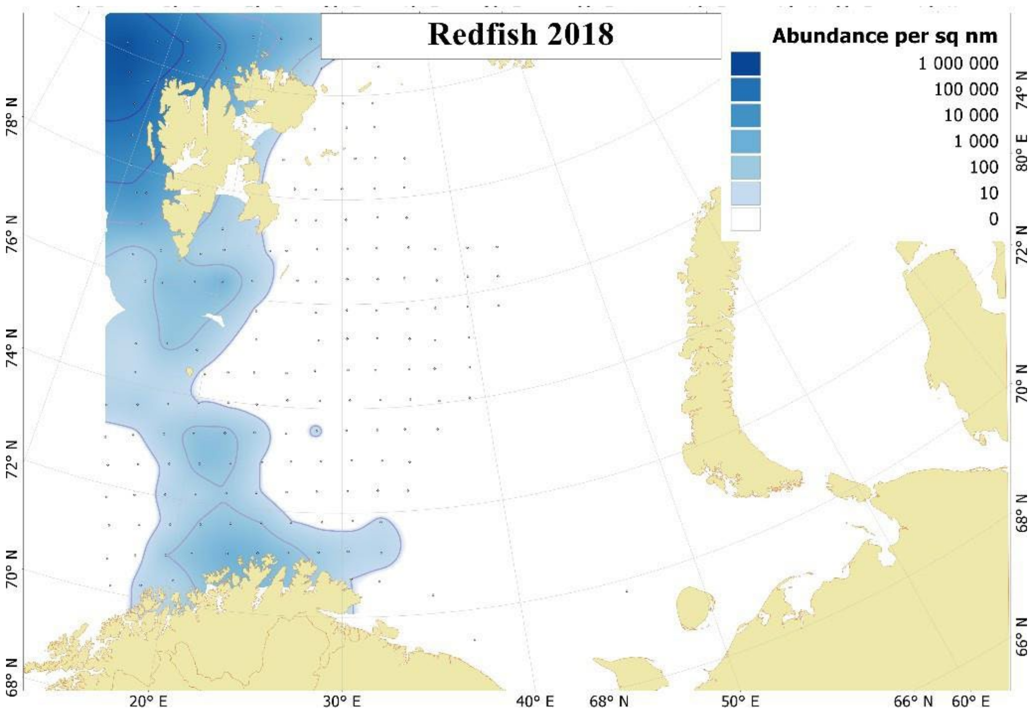


Figure 6.10. Map showing the specific pelagic 0-group trawl stations and the abundance of 0-group *Sebastes mentella* during the joint Norwegian-Russian Ecosystem survey in the Barents Sea and Svalbard in 2017 (upper panel) and 2018 (lower panel).

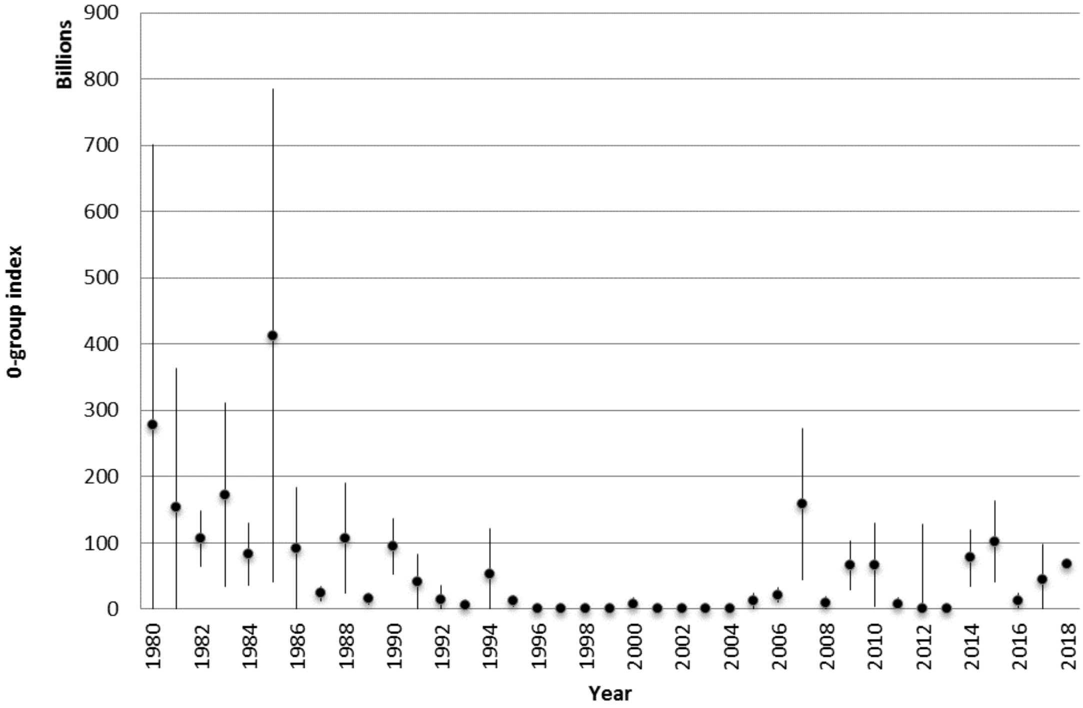


Figure 6.11. ***Sebastes mentella*** **in subareas 1 and 2. Abundance indices (in billions) with 95% confidence limits of 0-group redfish (believed to be mostly** ***S. mentella*****) in the international 0-group survey in the Barents Sea and Svalbard areas in August-September 1980–2018. For 2018 the method of estimation has changed and does not provide confidence limits. Numbers are given in Table 1.1.**

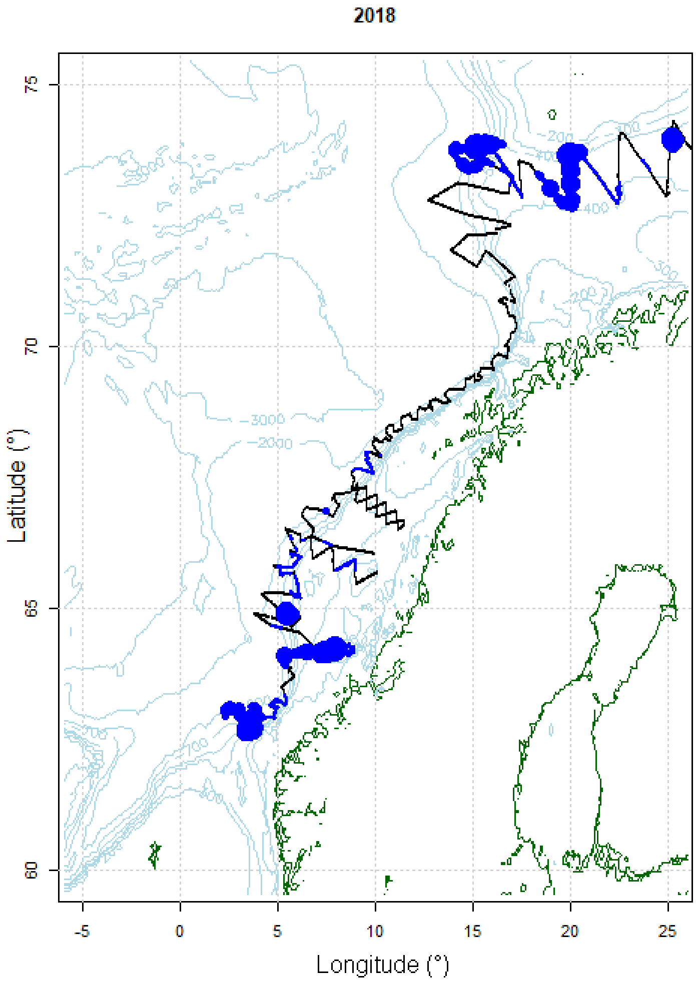


Figure 6.12. ***Sebastes mentella*** **in subareas 1 and 2. Horizontal distribution of** ***S. mentella*** **hydroacoustic backscattering (sA) during the Norwegian slope survey in spring 2018. The circles are proportional to the sA assigned to redfish along the vessel track.**

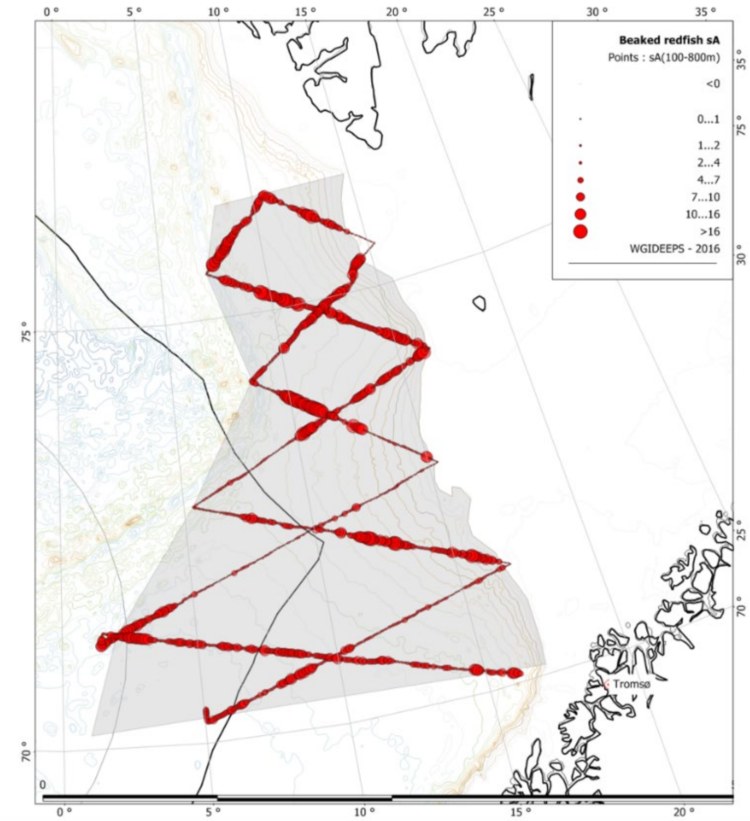


Figure 6.13. ***Sebastes mentella*** **in subareas 1 and 2. Horizontal distribution of** ***S.mentella*** **hydroacoustic backscattering (sA) during the Norwegian Deep Pelagic Ecosystem survey in summer 2016. The circles are proportional to the sA assigned to redfish along the vessel track.**

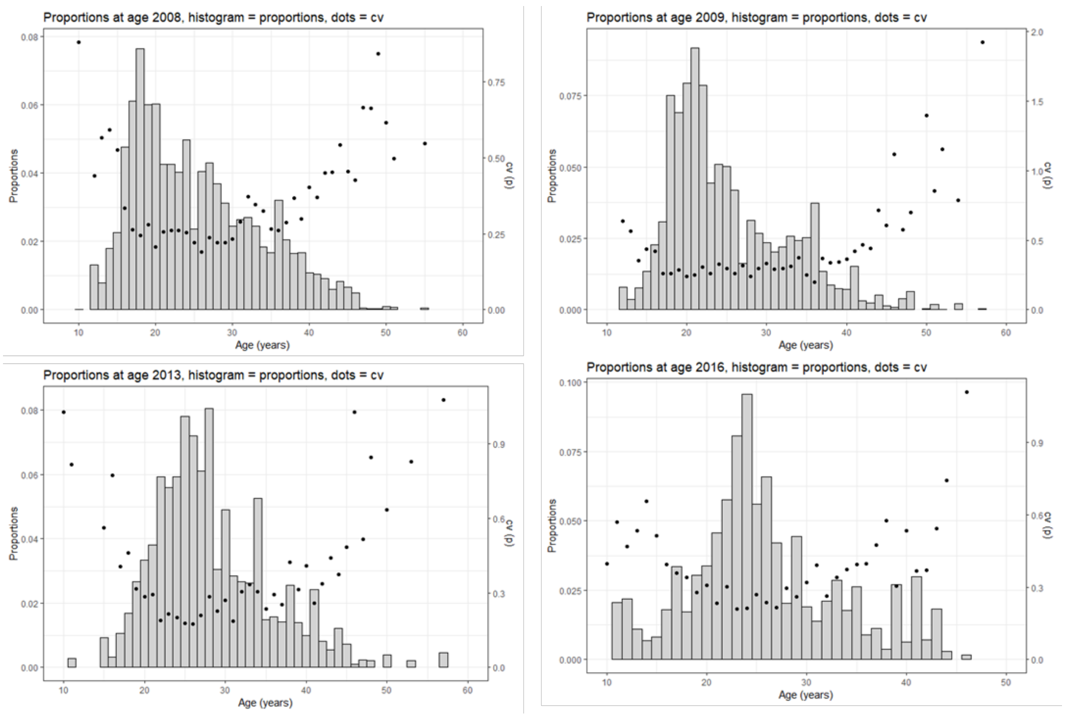


Figure 6.14. ***Sebastes mentella*** **in subareas 1 and 2. Proportions at age during the International Deep Pelagic Ecosystem Survey (WGIDEEPS) in the Norwegian Sea. Bars show proportions at age and dots shows the coefficient of variation for each age. Estimated with RStoX.**

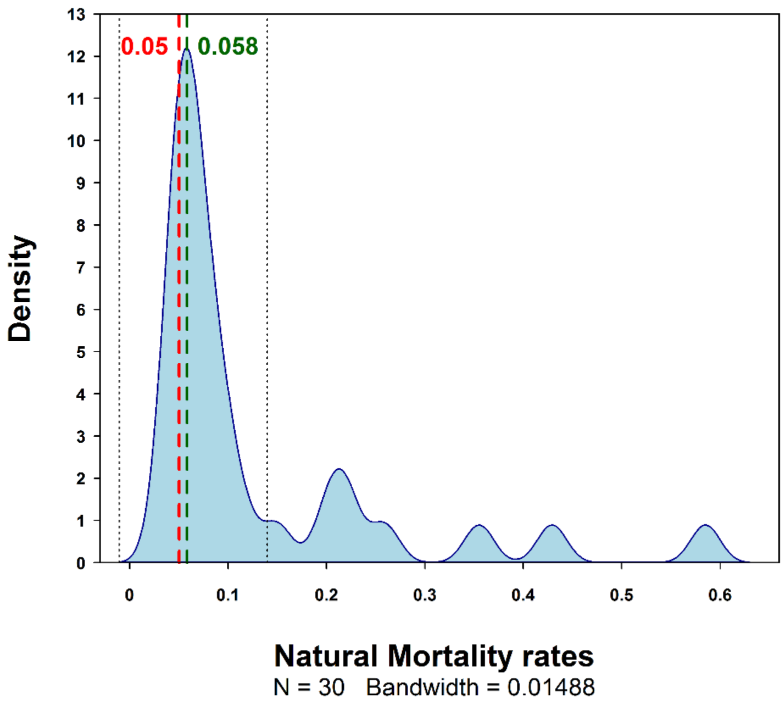


Figure 6.15. Density distribution of natural mortality rates calculated with 30 of the 39 compared methods. The excluded methods are those based on certain taxa or areas. The broken red line indicates the currently used value; the broken green line the most frequent one and the black dotted lines indicate the beginning and end of the distribution's peak.

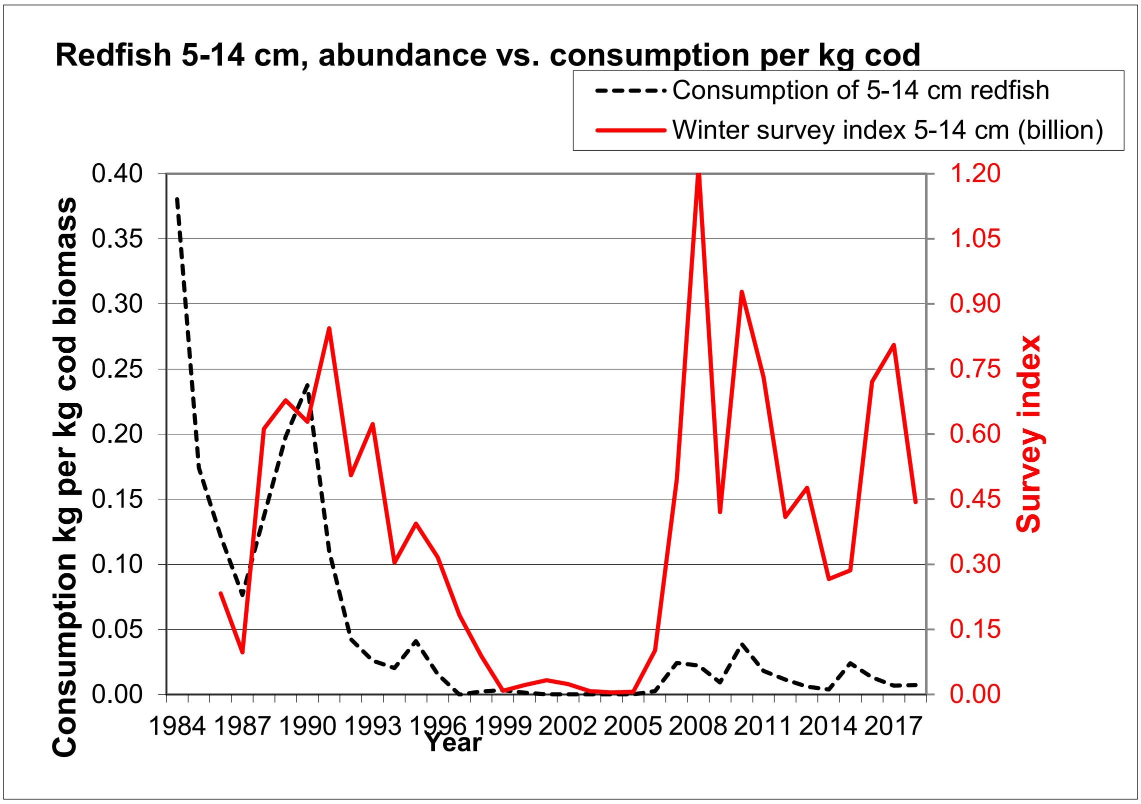
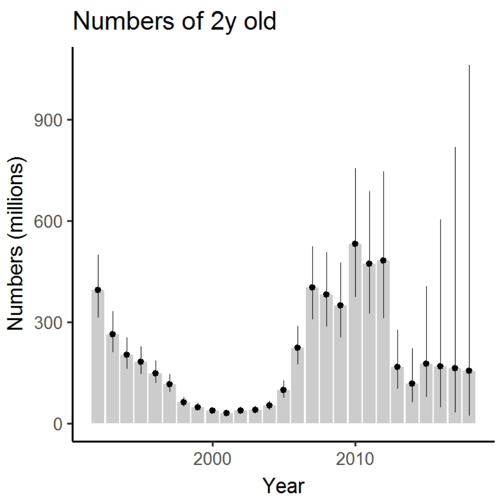
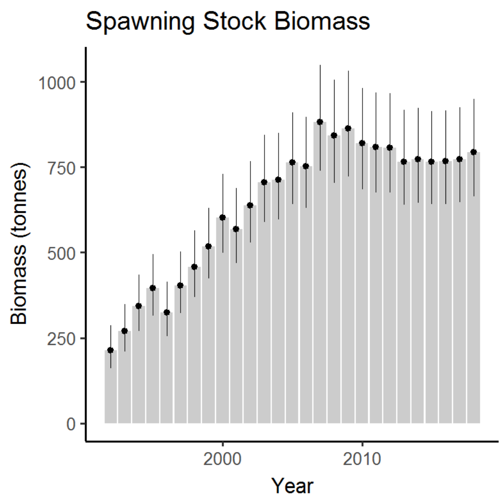


Figure 6.16. Abundance of *S. mentella* (5–14 cm) during the winter survey (February) in the Barents Sea compared with the consumption of redfish (mainly *S. mentella*) by cod (See Chapter 1 Table 1.3).

Recruitment-at-age 2	Spawning-stock biomass
	

Fishing mortality – year component

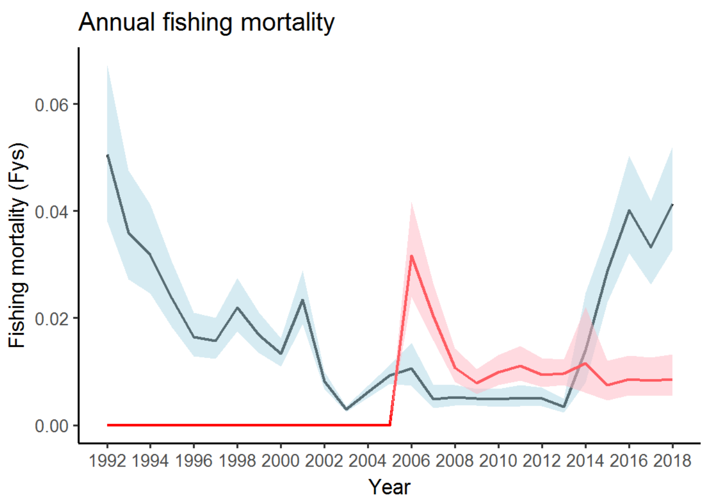


Figure 6.17. *Sebastes mentella* in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated recruitment-at-age 2 spawning-stock biomass from 1992 to 2018 and annual fishing mortality coefficients by year (Fy) from the demersal (blue) and pelagic (red) fleets. Error bars (top) and the colored envelope (bottom) indicate 95% confidence limits.

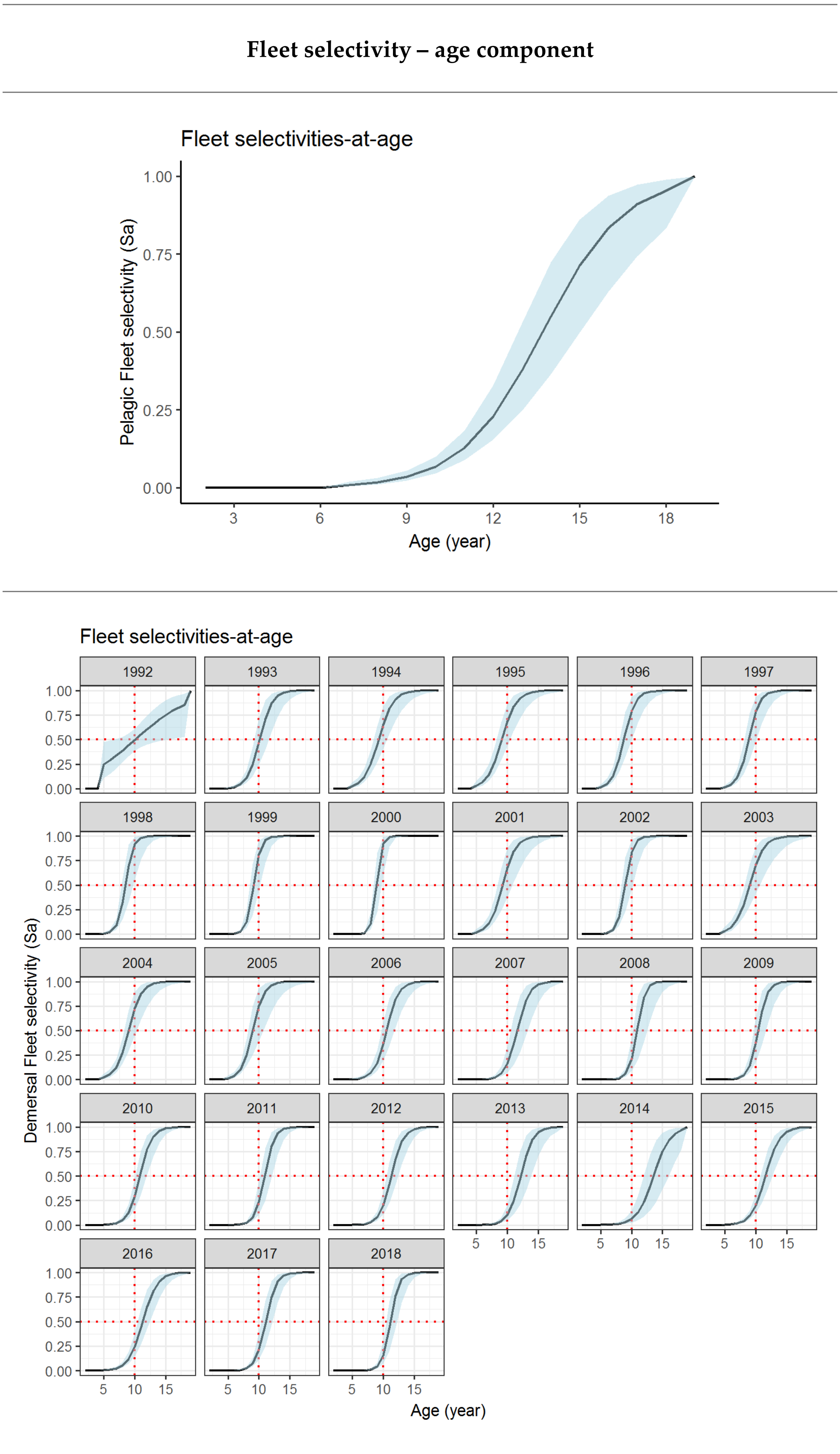


Figure 6.18. ***Sebastes mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the estimated annual fleet selectivity by age (Fa) from the pelagic (top panel) and demersal (lower panels) fleets. Colored envelopes indicate 95% confidence limits.**

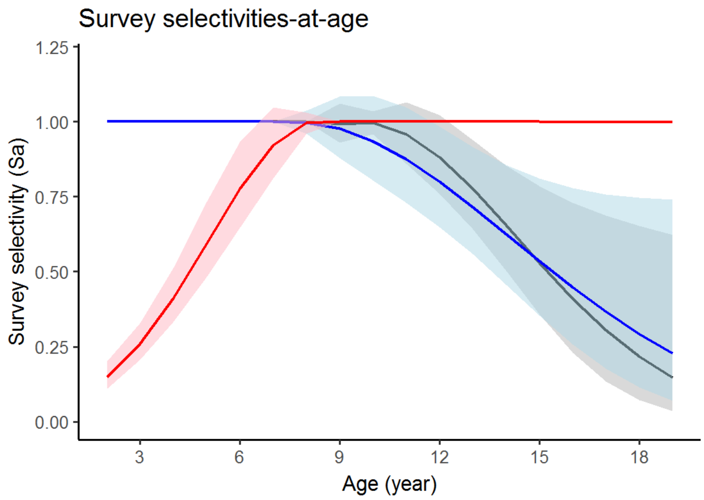


Figure 6.19. ***Sebastes mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age assessment run showing the selectivity-at-age for winter (blue) ecosystem (grey) and Russian groundfish (red) surveys.**

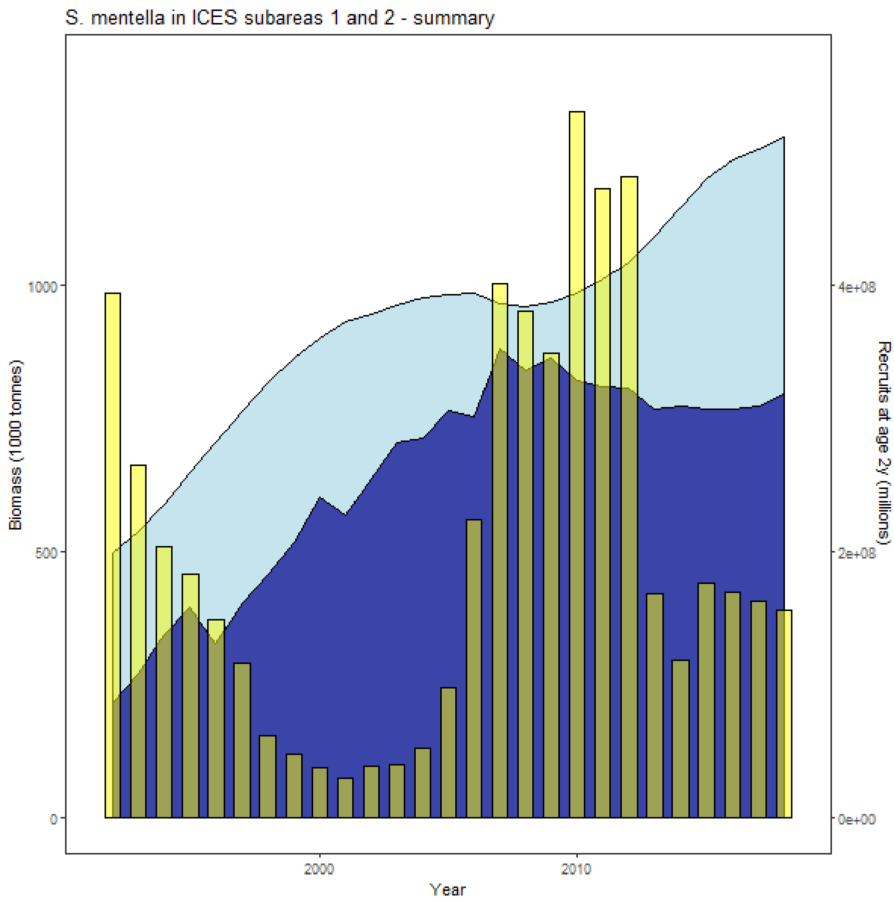


Figure 6.20. ***Sebastes mentella*** **in subareas 1 and 2. Results from the statistical catch-at-age model showing the evolution of total biomass (in tonnes light blue left axis) spawning-stock-biomass (in tonnes dark blue left axis) and recruitment-at-age 2 (in numbers yellow right axis) for the period 1992–2018 for** ***S. mentella*** **in subareas 1 and 2.**

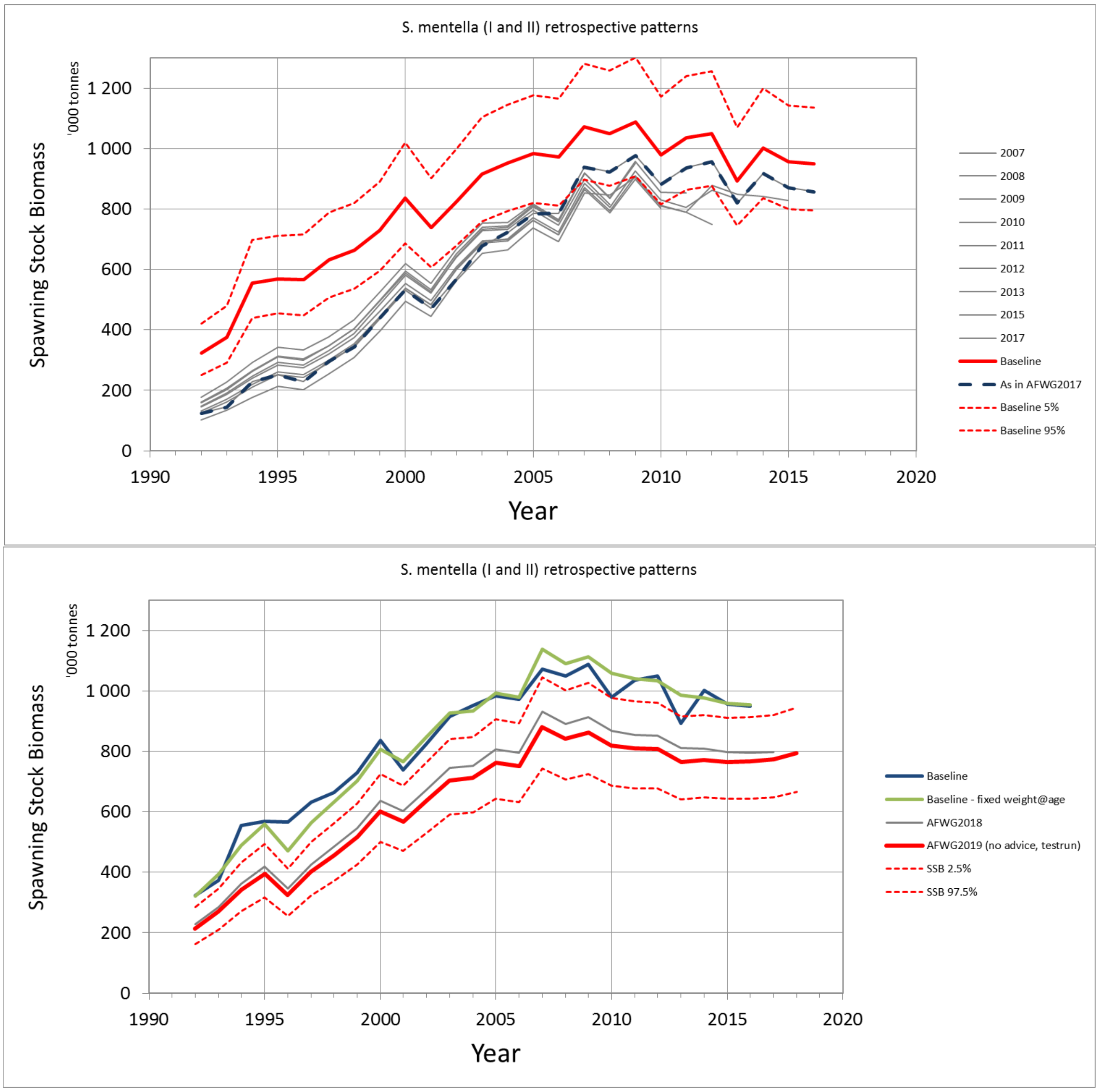


Figure 6.21. The upper panel shows the retrospective patterns of the spawning-stock biomass of *S. mentella* estimated by the SCAA model for runs up to years 2007–2017 and the baseline model of the 2018 benchmark. The lower panel presents the baseline the baseline model with fixed weights-at-age and the assessment models for 2018 and 2019. Confidence Intervals are shown for the latest assessment.

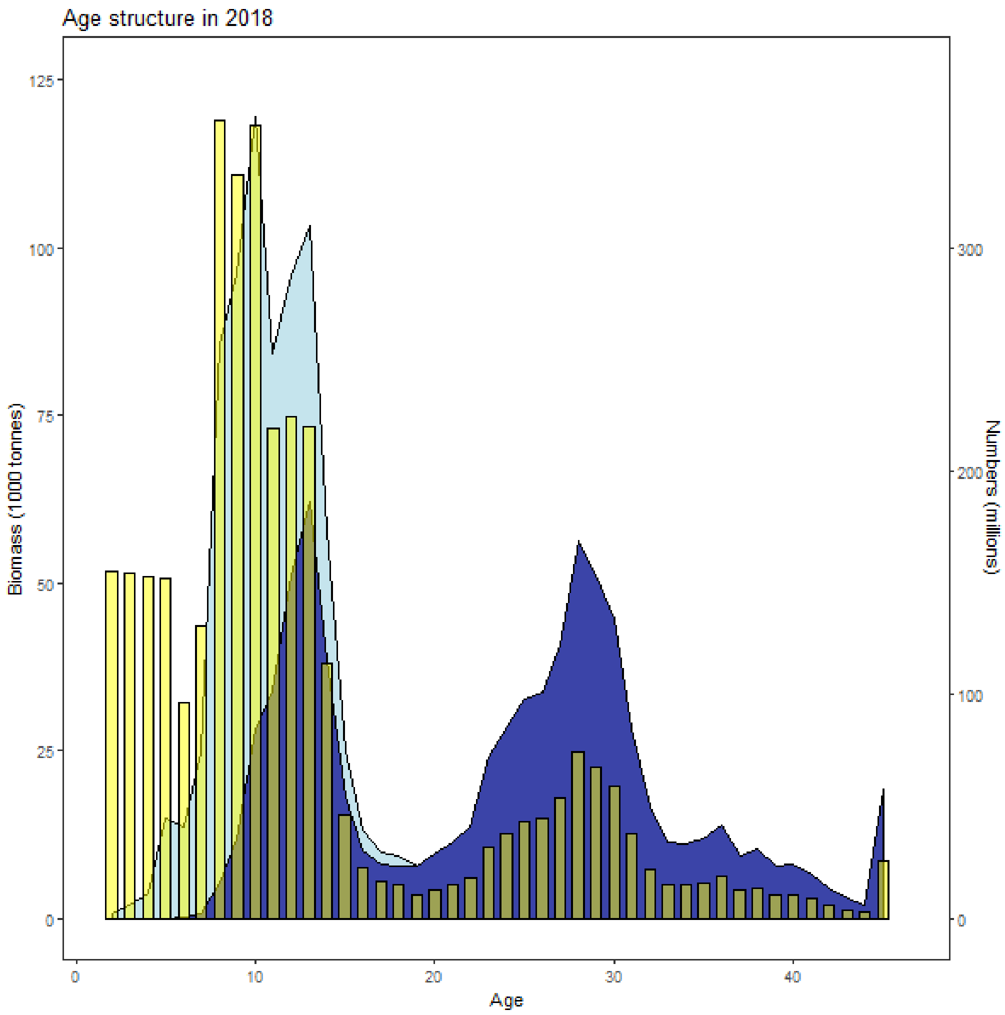


Figure 6.22. ***Sebastes mentella*** **in subareas 1 and 2. Modelled distribution of numbers (yellow bars right *y*-axis) biomass (light blue left *y*-axis) and spawning-stock-biomass (dark blue left *y*-axis) at age 2-44+ in 2018.**

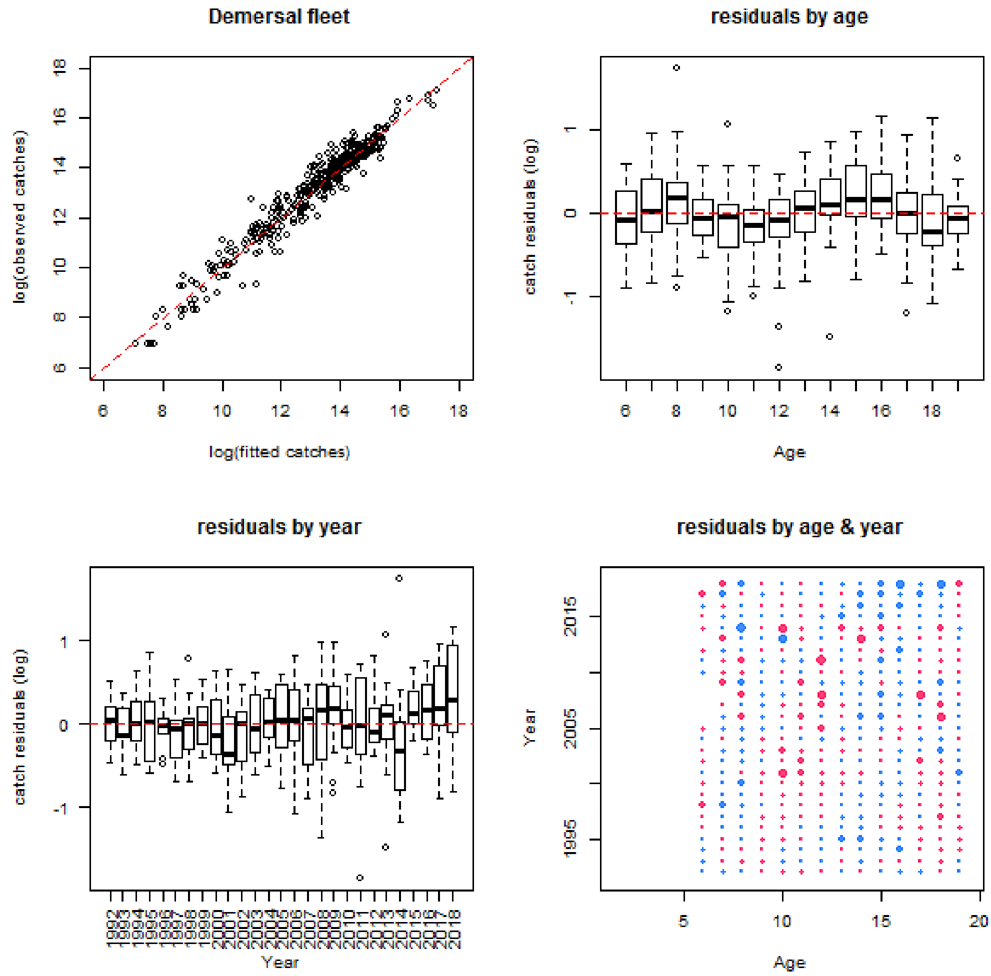


Figure 6.23a. Diagnostic plots for the demersal fleet catch-at-age data. Top-left: scatterplot of observed vs. fitted indices the dotted red line indicates 1:1 relationship. Top right: boxplot of residuals (observed-fitted) for each age. Bottom left: boxplot of residuals for each year. Bottom right: bubble plot of residuals for each age/year combination bubble size is proportional to mean residuals blue are positive and red are negative residuals.

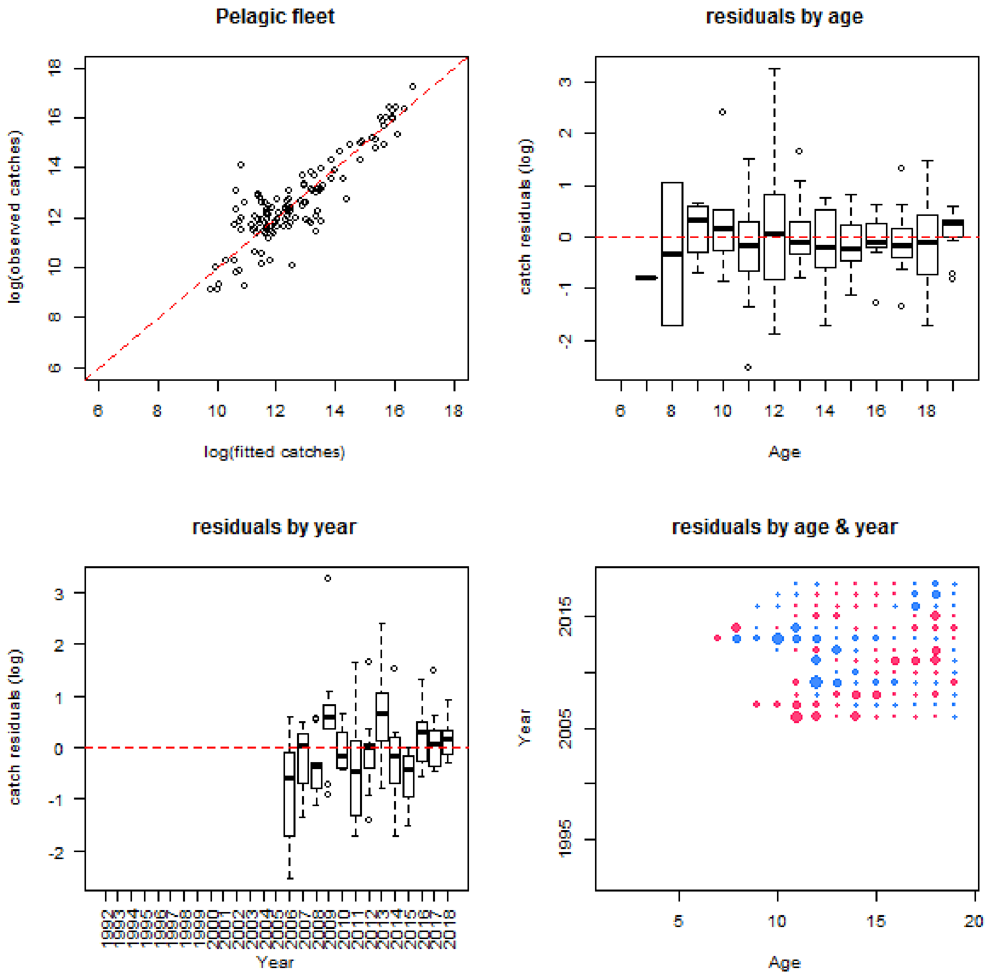


Figure 6.23b. Diagnostic plots for the pelagic fleet catch-at-age data. See legend from Figure 6.23a.

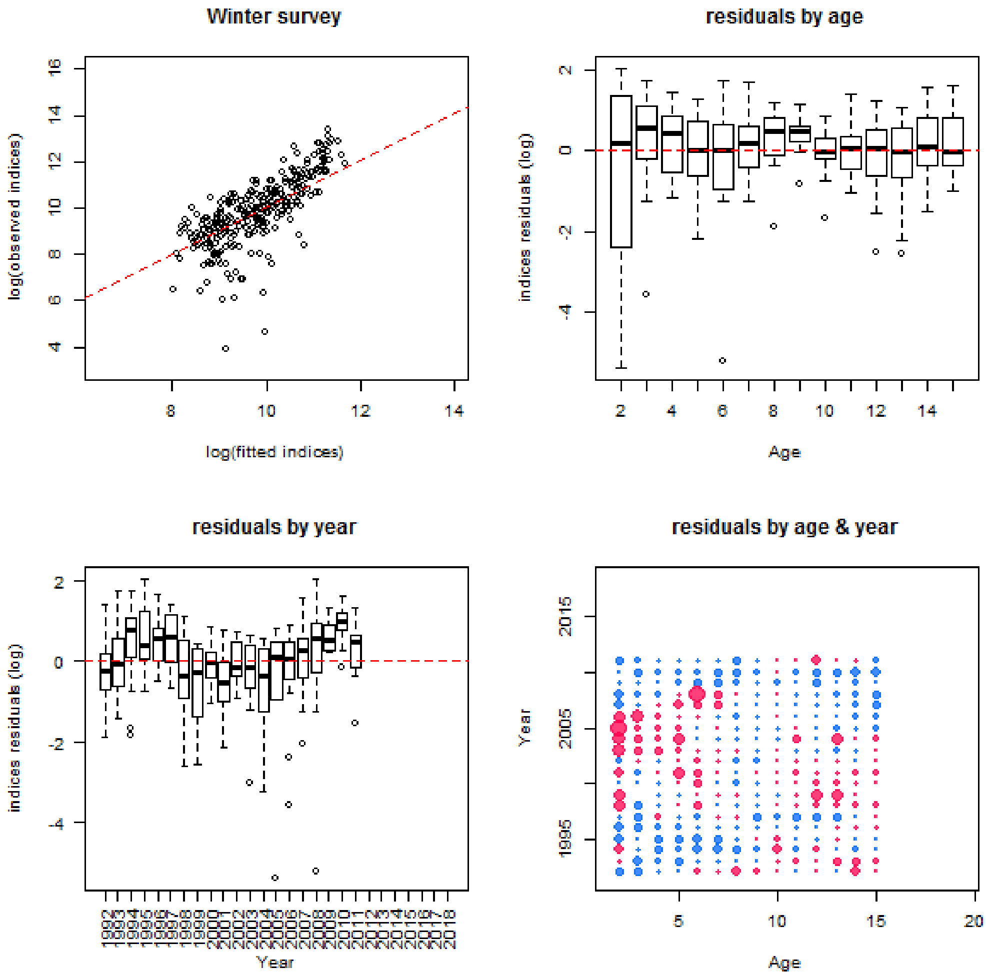


Figure 6.23c. Diagnostic plots for the Winter survey data. See legend from Figure 6.23a.

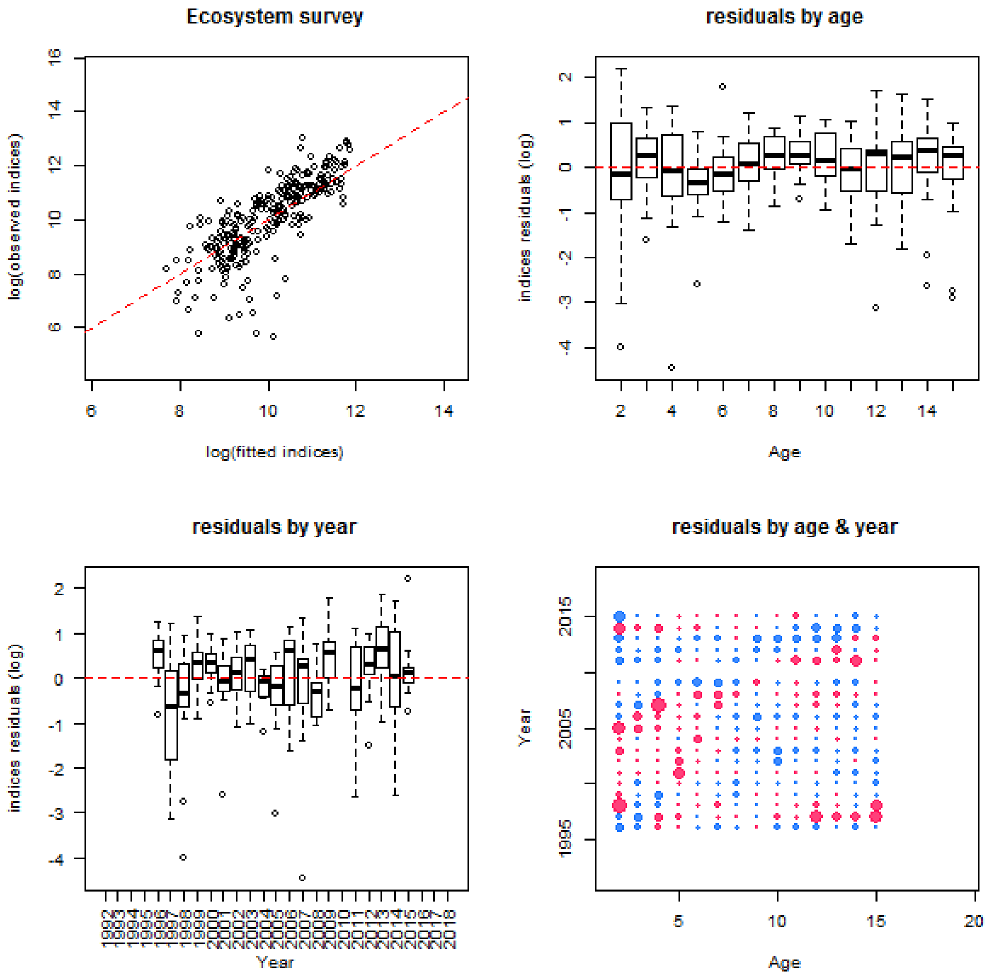


Figure 6.23d. Diagnostic plots for Ecosystem survey data. See legend from Figure 6.23a.

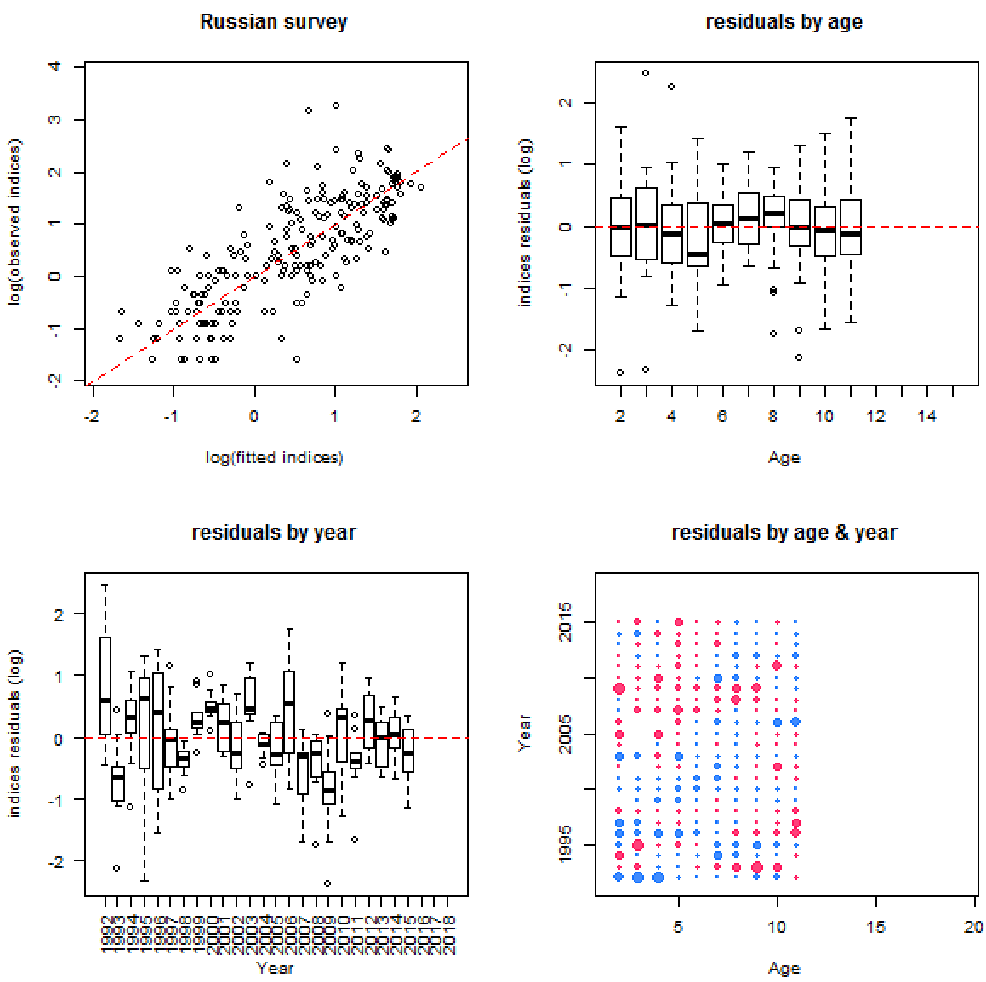


Figure 6.23e. Diagnostic plots for the Russian groundfish survey data. See legend from Figure 6.23a.

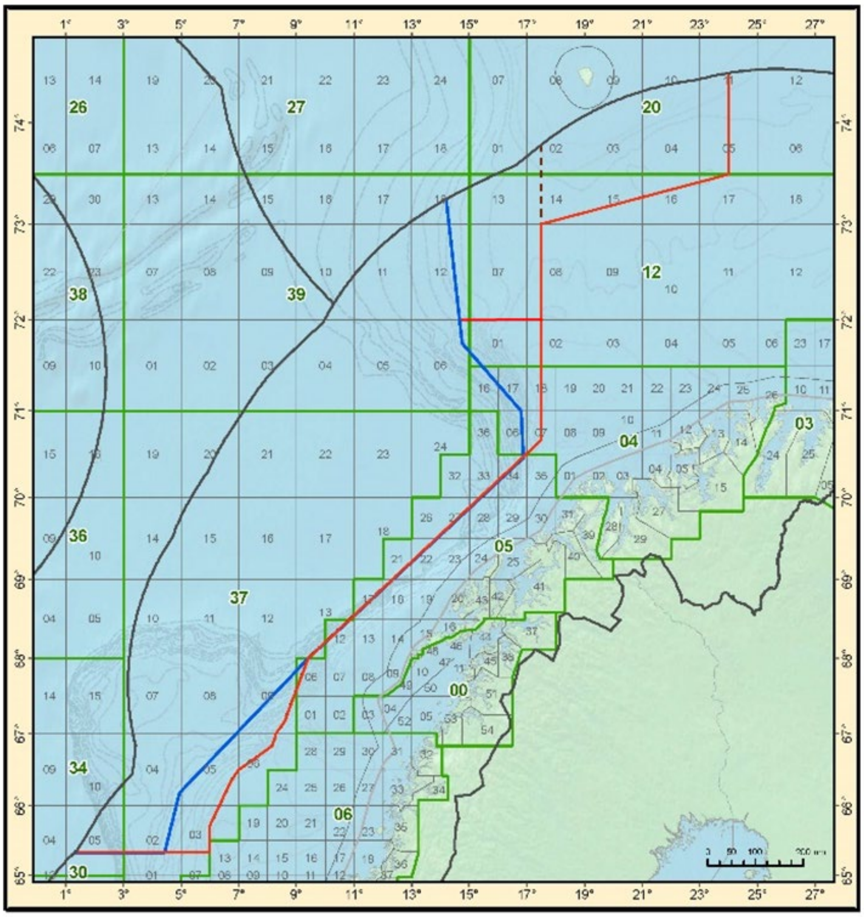


Figure 6.24. Delineation of the geographical limits for directed fishing in the Norwegian Economic Zone in 2014–2018. Directed pelagic trawling is only allowed west of the blue line. Directed demersal trawling is only allowed between the blue and the red line. The area east of the stippled line inside NEZ south of Bear Island is only open for directed demersal trawling after 10 May. The other areas for directed fishing are also open during 1 January-last February. Due to high bycatch ratios of golden redfish 72°N was suggested as southern limit for directed demersal fishing marked by the red line along that latitude to the Norwegian directorate of fisheries in November 2018.

7 Golden redfish (*Sebastes norvegicus*) in subareas 1 and 2

Multiyear advice

Following a three-year advice cycle, this stock was assessed in 2016 with advice nominally covering 2017–2019. Following the WKREDFISH 2018 benchmark, there is a new assessment and advice in 2018. The AFWG recommended that the stock follows a two-year assessment cycle, with the next assessment and advice being issued in 2020. The present report updates the catch tables but does not update the assessment or 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 the permanently closed areas were forbidden in the Norwegian Economic Zone north of 62°N and in the Svalbard area. When fishing for other species it was legal to have up to 15% redfish (both species together) in round weight as bycatch per haul and on board at any time. Until 14 April 2004 there were no regulations of the other gears/fleets fishing for *S. norvegicus*. After this date, a minimum legal catch size of 32 cm has been set for all fisheries, with the allowance to have up to 10% undersized (i.e. less than 32 cm) specimens of *S. norvegicus* (in numbers) per haul. In addition, a time-limited moratorium (up to 8 months) was enforced in the conventional fisheries (gillnet, longline, handline, Danish seine) except for handline vessels less than 11 metres. From 2016, when trawling outside 12 nm, vessels can have up to 20% by weight of redfish in each catch and upon landing. When trawling inside 12 nm, it is permitted to have up to 10% bycatch. Since 2015 it has been prohibited to fish for redfish with conventional gears north of 62°N. The ban does not, however, apply to vessels less than 15 metres fishing with handline during 1 June - 31 August. When fishing with conventional gears for other species, it is permitted to have up to 10% by weight of redfish. Vessels less than 21 metres can still have up to 30% by weight of redfish in the period 1 August to 31 December. Bycatch of redfish is calculated in live weight per week.

7.1.2 Landings prior to 2019 (Tables 7.1–7.4, D1 and D2, figures 7.1-7.2)

Nominal catches of *S. norvegicus* 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 6.12 and 6.13). The sources of information used are catches reported to ICES, NEAFC, Norwegian authorities (foreign vessels fishing in the Norwegian 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 information and prior knowledge. 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. Since then the landings have decreased further, and the total landings figures for *S. norvegicus* in 2003–2013 have been low but remarkably stable, between 5500–8000 t. In 2014 the landings decreased to 4436 t, followed by a further decrease in 2015 with landings of 3629 t, mainly due to stronger regulations. This has since reversed with 6647 tonnes in 2018 (provisional). The time-series of *S. norvegicus* landings is given in Figure 7.1. A map of *Sebastes norvegicus* catches from Norwegian vessels' logbooks in 2017 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 continued to decrease in 2015 and were then at the lowest level since World War II. Since 2015 only bycatches of *S. norvegicus* are allowed except for a limited amount caught by vessels less than 15 meters fishing with handline during 1 June to 31 August.

The reported Russian catches of *S. norvegicus* have been around 600–900 t since 2001, but increased in 2018 to 1834 tonnes. Twelve other countries together usually report catches of about or less than 300–600 t per year (Table 7.1).

The bycatch of redfish (*Sebastes* spp.) in the Norwegian Barents Sea shrimp fisheries during 1983–2017 were dominated by *S. mentella*, and hence influenced the *S. norvegicus* to a much lesser extent. However, these bycatches probably inflicted an 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 2019

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 and calculated in live weight per week. An observed increase of *S. norvegicus* in the trawl catches in 2016-2018 should lead to a careful monitoring of the trawl fishery in 2019 to see if this continues and hence be a sign of new recruitment to the trawl fishery. For the time being, however, the total landings in 2019 are expected to increase due to the raised quota for *S.mentella*, and thus an increase in bycatch of *S. norvegicus*.

7.2 Data Used in the Assessment (Table 0.1 and Figure E2)

An overview of the sampling levels (by season, area and gear) of the data used in the assessment is presented in Figure E2 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)

Age composition data for 2017 were only provided by Norway, accounting for 60% of the total landings. Norwegian data for 2009–2016 were also revised. Other countries were assumed to have the same relative age distribution and mean weight as Norway. The updated catch in numbers-at-age matrix is shown in Table 7.5. Catch at length data were also only available from Norway in 2017 (Figure 7.4). Norwegian data on age and length were revised for 2009–2016.

7.2.2 Catch weight-at-Age (Table 7.6)

Weight-at-age data for ages 7–24+ were available from the Norwegian landings in 2017, and revised for 2009–2016. 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 E4, Figure 7.9a-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, as reported in Table E4 and presented in Figure 7.9a. The maturity ogive modelled by Gadget is presented (Figure 7.9b). This analysis shows that 50% of the fish are mature at age 12.

7.2.4 Survey results (Tables E1a,b-E2a,b-E3, figures 7.5a,b–7.7)

The results from the following research vessel survey series were evaluated by the Working Group:

Winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS-NoRu-Q1 (BTr)) from 1986 to 2018 (joint with Russia some of the years since 2000) in fishing depths of 100—500 m. Length compositions for the years 1986—2017 are shown in Table E1a and Figure 7.5a. Age compositions for the years 1992—2016 are shown in Table E1b and Figure 7.5b. 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 2017 in fishing depths of 100—500 m (depths down to 800 m incl. in the swept-area). Since 2005 this is part of the Ecosystem survey (Eco-NoRu-Q3 (BTr)). Length compositions for the years 1985—2016 and age compositions for the years 1992—2008, 2012, 2013 and 2016 are shown in Table E2a and E2b, respectively. Data for 2017 were not available in time for AFWG 2018. This survey covers the northernmost part of the species' distribution. Insufficient number of age readings in 2009 and 2011, and no age samples collected in 2010 did not allow for updating the age composition in these years. This survey is not currently included in the model tuning.

Data on length and age from both these surveys have been combined and are shown in figures 7.6a,b.

Norwegian Coastal and Fjord survey in 1998—2016 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 7.7 and Table E3. The survey is an acoustic survey designed to obtain indices of abundance and estimates of length and weight-at-age of saithe and 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 2018). 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.

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 prerecruits (<25 cm) has steadily decreased since 1991 and has dropped to very low levels after 2000 (Figure 7.5a). An increase in the number of prerecruits is visible from 2008 onwards. Although this could originally partly result from taxonomic misidentification, the confirmation of increased numbers for individuals of size 15 cm and greater gives some confidence that at least some of the increasing numbers are *S. norvegicus*.

7.3 Assessment with the GADGET model

7.3.1 Description of the model

Since AFWG2005, the GADGET model has been used for this stock, first with experimental runs, and then as analytical assessments following its adoption by WKRED (2012) benchmark (ICES CM 2012/ACOM:48). The model was then approved again at WKREDFISH (2018). Although the stock has a three-year advice cycle, and advice was updated in 2016, we update the advice this year following the benchmark. A number of changes have been made to the model at the benchmark; 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 re-calculated; a number of minor errors in the model and data were fixed. Full details are in the WKREDFISH benchmark report (ICES 2018).

The GADGET model used for the assessment of *S. norvegicus* in subareas 1 and 2 is closely related to the GADGET model that currently is used by the ICES Northwestern WG on *S. norvegicus* (Björnsson and Sigurdsson, 2003). The functioning of a Gadget model, including parameter estimation and data used for tuning, is described in Bogstad *et al.* (2004) and in the stock annex for *S. norvegicus*. In brief, the model is a single species forward simulation age–length structured model, split into mature and immature components. There are three commercial fleets (a gillnet, a trawl and a combined longline and handline fleet). Prior to 2009 the trawl and longline fleets are combined into one, due to difficulties in obtaining data on a finer resolution. The gillfleet has different selectivity from 2009 compared to 2008 and earlier. There are two surveys used in the model, the winter survey and coastal survey. The winter survey tunes to total survey index, length distributions (only). Growth and fishing selectivity within each fleet and survey are assumed constant over time (with the exception of the gilfleet), and recruitment is estimated on annual basis (no SSB-recruit relationship).

The weighting scheme for combining the different datasets into a single likelihood score is a method where weights are selected so that the catch and survey data have approximately equal contribution to the overall likelihood score in the optimized model, and that each dataset within each group gives approximately equal contributions to each other. This ensures that both noise and bias (actually divergence from the consensus) are taken account of 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 2017. 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 2017

- Length disaggregated frequencies from the Barents Sea (Division 2.a) bottom-trawl survey (February) from 1990—2017 (Table E1a)
- Age–length data and aggregated survey indices from the same survey up to 2017 (Table E1b)
- Length disaggregated frequencies from the Barents Sea (Division 2.a) coastal survey (February) from 1998—2017 (Table E3, Figure 7.7)

7.3.3 Assessment results using the Gadget model

The general patterns in the stock dynamics of *S. norvegicus* are similar to those modelled for the past several years (Figure 7.12), and have not been altered by the benchmark, 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 numbers and biomass are now starting to improve. Some of the 2003 year class are now starting to mature, and the mature stock numbers are therefore stabilizing. The mature biomass is responding more slowly, 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 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 7.11)
- There has been somewhat better estimated recruitment in recent years, with a reasonably good recruitment in 2003. There may also be a second pulse of good recruitment in 2009, however this is still highly uncertain, and will need to be tracked for some years to reduce this uncertainty.
- The estimated fishing mortality (F_{15+}) declined between 1990 and 2005 and remained stable until around 2010, but has slowly increased since then (Table 7.7). The current mortality is estimated to F = 0.3 (Figure 7.10), well above a sustainable level for a redfish species, and above the F_{MSY} = 0.05 estimated at WKRED 2018. 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 151 000 tonnes in 1992–1993 just under 40 000 tonnes in 2015 (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.

7.1 State of the stock

Survey observations and 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, which produced similar trends. Indications are that the SSB is continuing to fall. This has led to an upwards trend resulting in a level of F which may place an increasing burden on an already poorly performing stock. Furthermore, in the absence of a substantial population of fish in the 10—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, and the rate of decline of SSB is reducing. However, the total level of this recruitment is still uncertain, and although the 2003 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 the SSB. 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.

Sebastes norvegicus is currently on the Norwegian Redlist as a threatened (EN) species according to the criteria given by the International Union for Conservation of Nature (IUCN).

Red-listing is understood to mean that a species (or stock) is at risk of extinction. ICES convened two workshops in 2009. The first Workshop WKPOOR1 (ICES CM 2009/ACOM:29) addressed methods for evaluating extinction risk and outlined approaches that could support advice on how to avoid potential extinction. The second Workshop WKPOOR2 (ICES CM 2009/ACOM:49) applied the results of the first workshop to four stocks selected as being of interest to Norway and ICES.

There are three general methods for evaluating extinction risk: (1) screening methods, such as the IUCN redlisting criteria; (2) simple population viability analysis (PVA) based on time-trends; and (3) age structured population viability analysis. None of the methods are considered reliable for accurately estimating the absolute probability of extinction, but they may be useful to evaluate the relative probability of extinction between species or between management options.

The fishery is largely concentrated on the mature individuals. With a currently estimated SSB of around 23 000 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 well above this level.

7.3.4 Biological reference points

Reference point calculations were conducted at WKRED benchmark (2018), based on a BLOSS with reasonable recruitment, and a forecast with constant recruitment to produce a F_{MSY} candidate. Note that the benchmark used preliminary data, and that the results presented here are slightly changed from those at WKRED (2018). We therefore follow the methodology presented at WKRED (2018), 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_2018 proposes $F_{0.1}$(15+), estimated to be 0.0525, as a candidate F_{MSY}.

Given the poor state of this stock, management should be based on the need to protect and recover the stock, not on F_{MSY}.

7.3.5 Management advice

AFWG considers that the stock is severely depleted. There are signs that recruitment in 2003 is now beginning to stabilize and, for the immature fish, improve the stock status. However, the stock remains in a poor state, and there are no indications that the mature stock is yet 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 2019. It is critical that the bycatch regulations do not allow the catch to increase, as this would impair prospects for recovery.

7.3.6 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. $F_{0.1}$) 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 (Section 7.6). The main focus should therefore be on reducing total F. The current priority is to stabilize the stock and prevent further decline, and allow the recruiting 2003 year class to grow and reproduce. Only then could a recovery strategy and eventually an MSY fishery be implemented. The recent upturn in immature biomass gives some hope that such recovery may be possible, given light fishing pressure.

Table 7.1 ***Sebastes 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	-	-	16 540	-	6	1 632	51	171	19 155
1999	-	35	35	228	47	14	7	-	-	16 750	-	3	1 691	7	169	18 986
2000	-	17	13	160	22	16	-	-	-	13 032	-	16	1 112	-	73	14 461
2001	-	37	30	238	17	-	1	-	-	9 134	-	7	963	1	119	10 547
2002	-	60	31	42	31	3	-	-	-	8 561	-	34	832	3	46	9 643
2003	-	109	8	122	36	4	-	-	89	6 853	-	6	479	-	134	7 840
2004	-	19	4	68	20	30	-	-	33	6 233	-	5	722	3	69	7 206
2005	-	47	10	72	36	8	-	-	48	6 085	-	56	614	8	52	7 037
2006	-	111	8	35	44	31	3	-	21	6 305	-	69	713	9	39	7 388
2007	-	146	15	67	84	68	13	-	20	5 784	-	225	890	5	55	7 372
2008	-	274	63	30	71	27	6	-	2	5 216	-	72	749	4	85	6 599
2009	-	70	1	58	81	66	-	-	1	5 451	-	30	698	-	31	6 487
2010	-	171	51	31	72	22	-	-	-	5 994	1	28	565	3	44	6 981
2011	-	24	53	9	51	22	-	-	1	4 681	48	25	919	6	13	5 852
2012	-	87	182	71	58	23	12	-	5	4 247	34	17	681	-	100	5 517
2013	-	83	353	1	45	8	1	-	-	3 771	19	36	797	-	493	5 609

Year	Denmark	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Lithuania	Netherlands	Norway	Poland	Portugal	Russia	Spain	UK	Total
2014	-	67	219	6	20	29	-	-	1	3 053	21	5	806	-	211	4 436
2015	1	76	53	24	211	35	-	-	-	2 488	17	-	664	2	57	3 629
2016	7	183	30	4	87	55	-	-	-	3 239	26	-	864	-	76	4 572
2017	-	123	17	19	61	65	-	-	2	3 353	27	90	1 297	44	160	5 258
2018[1]	1	146	37	52	77	67	-	5	-	4 276	36	67	1 834	12	37	6 647

[1] **Provisional figures.**

Table 7.2 *Sebastes norvegicus* in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1.

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	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	2159
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
2013	28	2	1	-	+	-	574	-	-	41	-	4	651
2014	59	10	6	17	4	-	403	2	-	27	-	17	542
2015	57	4	9	211	13	-	514	2	-	51	2	10	871
2016	161	7	4	74	-	51	782	4	-	136	-	60	1275
2017	81	5	-	8	4	-	844	2	2	211	2	23	1180
2018[1]	146	28	21	29	-	-	926	5	3	302	5	25	1 485

[1] **Provisional figures.**

+ Less than 1 t

Table 7.3 *Sebastes 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	-	14 326	-	6	1 078	51	137	16 260
1999	-	35	210	38		7	-	14 598	-	3	976	7	156	16 030
2000	17	13	159	22		-	-	11 038	-	16	658	-	61	11 984
2001	33	30	227	17		1	-	8 002	-	6	612	1	103	9 031
2002	45	30	37	31	3	-	-	7 761	-	18	192	2	32	8 151
2003	94	9	122	35	4	-	89	5 970	-	6	264		130	6 722
2004	12	4	68	20	30	-	33	4 872	-	5	396	3	58	5 500
2005	37	9	60	36	8	-	48	4 855	-	56	265	8	48	5 430
2006	60	8	35	44	31	3	21	4 404	-	59	293	9	39	5 006
2007	119	15	55	69	68	13	20	4 101	-	70	599	3	35	5 168
2008	229	56	28	71	27	6	2	4 456	-	68	450	4	70	5 467
2009	70	1	55	79	60	-	1	4 543	-	17	500	-	7	5 333
2010	113	51	31	72	22	-	-	5 414	1	26	287	2	38	6 056
2011	-	51	9	49	20	-	1	3 942	-	-	695	2	13	4 782

Year	Faroe Islands	France	Germany	Greenland	Iceland	Ireland	Netherland	Norway	Poland	Portugal	Russia	Spain	UK		Total
2012	49	182	33	57	13	2	2	3 599	-	1	427	-	33		4 398
2013	55	343	-	45	8	-	-	3 076	-	9	475	-	466	**Denmark** - 1	4 478
2014	8	209	-	3	25	-	1	2 465	-	2	559	-	178		3 449
2015	18	49	15	-	22	-	-	1 946	12	-	439	-	47		2 548
2016	22	23	-	13	4	-	-	2 417	8	-	545	-	15		3 047
2017	41	12	19	36	61	-	2	2 455	22	88	680	38	137		3 591
2018[1]	-	9	17	43	67	-	-	3 275	12	64	489	7	12	**Lithuania** - 5	4 000

[1] **Provisional figures.**

Table 7.4 *Sebastes 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	-				2281	-	-	288	-	-	529
2006	-	5	-	-	-				1211	-	10	284	-	-	1510
2007	-	12	-	-	-				649	-	155	242	-	-	1057
2008	-	-	-	-	-				126	-	1	250	-	-	377
2009	-	-	-	-	-				207	-	-	179	-	-	386
2010	-	-	-	-	-				83	-	22	257	-	-	342
2011	-	-	2	-	-	1	-	-	65	48	25	217	4	-	362
2012	-	21	-	35	-	1	8	3	102	34	16	227	-	49	496
2013	-	-	9	-	-	-	1	-	120	19	27	281	-	23	480
2014	-	-	-	-	-	-	-	-	185	19	3	221	-	16	444
2015	1	-	-	-	-	-	-	-	28	3	-	175	-	-	207
2016	7	-	-	-	-	-	-	-	40	14	-	183	-	-	244
2017	-	-	-	-	18	-	-	-	54	2	-	405	4	-	483
2018[1]	1	-	-	14	6	-	-	-	75	19	-	1043	-	-	1158

[1] Provisional figures.

Table 7.5. *Sebastes norvegicus* in subareas 1 and 2. Catch numbers-at-age (in thousands).

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
1992	5	22	78	114	394	549	783	1718	3102	2495	2104	1837	998	858	688	547	268	3110	19670	16185
1993	0	24	193	359	406	1036	1022	1523	2353	1410	1655	1678	745	716	534	528	576	3482	18240	16651
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

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp	Total Num.	Tonnes Land.
2007	15	21	31	68	138	306	448	495	523	637	892	616	510	396	225	322	170	630	6443	7306
2008	1	4	14	12	49	139	265	366	361	443	442	538	547	479	281	223	144	1032	5342	6557
2009	0	11	2	4	9	23	144	277	315	248	406	374	509	404	331	323	253	911	4544	6487
2010	1	0	10	7	4	20	75	261	291	529	359	311	531	502	385	295	247	776	4605	6982
2011	2	1	3	0	2	5	64	304	466	266	312	223	378	289	247	229	253	985	4028	5852
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[1]	40	34	108	56	188	411	484	651	286	139	109	92	88	116	127	116	148	996	4187	5340

[1] **Provisional figures.**

Table 7.6. *Sebastes norvegicus* in subareas 1 and 2. Catch weights at age (kg).

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
1992	0.18	0.29	0.48	0.42	0.50	0.59	0.58	0.65	0.65	0.71	0.82	0.84	0.94	1.02	1.03	1.15	1.27	1.27
1993	0.2	0.33	0.36	0.43	0.51	0.51	0.64	0.64	0.76	0.86	0.89	0.98	1	1.03	1.21	1.03	1.2	1.14
1994	0.25	0.37	0.38	0.49	0.51	0.64	0.74	0.76	0.86	0.95	1.03	1.07	1.11	1.16	1.15	1.13	1.02	1.36
1995	0.33	0.43	0.64	0.61	0.59	0.65	0.74	0.79	0.84	0.92	1.12	1.01	1.01	1.21	1.14	1.09	1.3	1.01
1996	0.22	0.49	0.56	0.65	0.71	0.81	0.84	0.88	0.96	1	1.02	1.01	1	1.03	1.04	1.14	1.09	1.16
1997	0.23	0.51	0.53	0.74	0.72	0.78	0.8	0.86	0.91	0.99	1.16	1.18	1.21	1.34	1.28	1.54	1.19	1.29
1998	0.37	0.21	0.47	0.62	0.67	0.77	0.77	0.85	1.05	0.96	1.25	1.28	1.3	1.23	1.87	1.46	1.73	1.29
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

Year/Age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	+gp
2008	0.41	0.55	0.55	0.57	0.52	0.58	0.65	0.81	0.9	1.07	1.14	1.36	1.51	1.81	1.99	2.01	2.26	1.93
2009	0.00	1.01	0.34	0.59	0.61	0.66	0.82	0.92	0.94	1.09	1.22	1.35	1.40	1.57	1.68	1.74	1.73	2.25
2010	0.15	0.00	0.10	0.32	0.52	0.73	0.77	0.89	0.98	1.09	1.25	1.40	1.48	1.64	1.77	1.99	1.82	1.86
2011	0.16	0.20	0.21	0.00	0.54	0.52	0.72	0.91	1.08	1.14	1.20	1.45	1.40	1.43	1.54	1.60	1.74	1.93
2012	0.19	0.25	0.33	0.72	0.61	0.88	0.70	0.86	0.95	1.02	1.13	1.18	1.33	1.48	1.31	1.55	1.50	2.59
2013	0.20	0.27	0.32	0.44	0.47	0.55	0.63	0.88	0.96	1.08	1.08	1.19	1.21	1.39	1.38	1.62	1.41	1.81
2014	0.20	0.26	0.39	0.41	0.56	0.61	0.71	0.87	0.95	1.07	1.14	1.28	1.46	1.35	1.51	1.62	1.69	1.84
2015	0.16	0.22	0.30	0.50	0.51	0.60	0.66	0.88	0.93	1.04	1.15	1.18	1.23	1.34	1.51	1.50	1.48	1.62
2016	0.17	0.21	0.34	0.62	0.53	0.66	0.68	0.86	0.94	1.03	1.11	1.32	1.43	1.29	1.42	1.43	1.48	2.67
2017[1]	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

[1] **Provisional figures.**

Table 7.7. *Sebastes 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
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
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
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
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
8	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
10	0.08	0.06	0.05	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02
11	0.11	0.09	0.08	0.08	0.05	0.04	0.05	0.04	0.05	0.05	0.04	0.03	0.03
12	0.15	0.11	0.10	0.11	0.12	0.07	0.07	0.07	0.08	0.08	0.07	0.05	0.05
13	0.19	0.15	0.13	0.14	0.15	0.13	0.11	0.10	0.12	0.12	0.10	0.08	0.07
14	0.24	0.18	0.16	0.16	0.18	0.15	0.17	0.14	0.15	0.16	0.13	0.10	0.10
15	0.30	0.22	0.19	0.19	0.20	0.17	0.20	0.20	0.19	0.20	0.17	0.13	0.12
16	0.36	0.26	0.22	0.22	0.23	0.19	0.22	0.22	0.25	0.25	0.20	0.16	0.15
17	0.43	0.31	0.25	0.25	0.26	0.22	0.24	0.24	0.28	0.30	0.24	0.18	0.17
18	0.46	0.35	0.29	0.28	0.29	0.24	0.26	0.26	0.29	0.32	0.28	0.20	0.18
19	0.50	0.37	0.32	0.30	0.31	0.25	0.28	0.27	0.31	0.34	0.29	0.22	0.20

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
20	0.53	0.39	0.33	0.32	0.33	0.27	0.30	0.29	0.33	0.35	0.30	0.22	0.21
21	0.56	0.41	0.34	0.33	0.35	0.28	0.31	0.30	0.34	0.37	0.30	0.23	0.21
22	0.58	0.42	0.35	0.34	0.36	0.29	0.32	0.31	0.35	0.37	0.31	0.23	0.21
23	0.60	0.43	0.36	0.34	0.36	0.29	0.32	0.31	0.35	0.38	0.31	0.23	0.21
24	0.61	0.44	0.36	0.34	0.36	0.29	0.32	0.31	0.35	0.37	0.30	0.22	0.20
25	0.61	0.44	0.35	0.34	0.35	0.28	0.32	0.31	0.34	0.36	0.29	0.22	0.20
26	0.61	0.43	0.34	0.33	0.34	0.28	0.31	0.30	0.33	0.35	0.28	0.21	0.19
27	0.60	0.41	0.32	0.31	0.33	0.26	0.30	0.29	0.32	0.33	0.25	0.19	0.18
28	0.58	0.39	0.30	0.30	0.31	0.25	0.29	0.28	0.31	0.32	0.24	0.18	0.17
29	0.56	0.37	0.29	0.28	0.29	0.23	0.27	0.26	0.29	0.30	0.23	0.17	0.15
30	0.52	0.33	0.26	0.26	0.27	0.21	0.25	0.23	0.25	0.28	0.19	0.15	0.14
This year													
15+	0.526	0.373	0.304	0.296	0.309	0.251	0.282	0.273	0.306	0.325	0.260	0.196	0.179

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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	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

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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	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	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	0.01	0.01	0.00	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	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.03
0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.06
0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.05	0.07	0.09
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.08	0.07	0.08	0.09	0.08	0.07	0.11	0.14
0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.11	0.10	0.11	0.12	0.12	0.10	0.15	0.19
0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.14	0.12	0.13	0.16	0.15	0.13	0.18	0.24
0.13	0.12	0.11	0.12	0.12	0.12	0.13	0.17	0.15	0.16	0.19	0.18	0.15	0.22	0.29
0.14	0.13	0.13	0.13	0.14	0.14	0.14	0.19	0.17	0.19	0.22	0.21	0.18	0.25	0.34
0.16	0.15	0.14	0.15	0.15	0.15	0.16	0.21	0.19	0.20	0.24	0.23	0.20	0.28	0.37
0.17	0.15	0.15	0.16	0.16	0.16	0.17	0.23	0.20	0.22	0.26	0.24	0.21	0.29	0.40
0.17	0.16	0.15	0.16	0.17	0.16	0.17	0.23	0.20	0.22	0.27	0.25	0.22	0.30	0.41
0.17	0.16	0.16	0.16	0.17	0.16	0.17	0.23	0.20	0.22	0.26	0.25	0.22	0.30	0.41
0.17	0.16	0.16	0.16	0.17	0.16	0.17	0.22	0.20	0.21	0.25	0.24	0.21	0.29	0.39

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0.17	0.15	0.15	0.16	0.17	0.16	0.16	0.22	0.19	0.20	0.24	0.22	0.20	0.27	0.37
0.16	0.15	0.14	0.15	0.16	0.15	0.15	0.20	0.18	0.19	0.22	0.20	0.18	0.25	0.33
0.15	0.14	0.14	0.15	0.15	0.14	0.15	0.19	0.17	0.18	0.21	0.18	0.16	0.23	0.30
0.14	0.14	0.13	0.14	0.15	0.13	0.13	0.18	0.15	0.16	0.19	0.17	0.15	0.21	0.26
0.13	0.13	0.13	0.14	0.14	0.12	0.12	0.16	0.14	0.15	0.17	0.15	0.14	0.19	0.23
0.12	0.12	0.12	0.13	0.14	0.12	0.11	0.14	0.13	0.14	0.16	0.14	0.12	0.17	0.21
0.11	0.11	0.12	0.13	0.13	0.11	0.10	0.13	0.11	0.13	0.15	0.13	0.12	0.16	0.19
0.09	0.09	0.10	0.11	0.11	0.09	0.08	0.10	0.09	0.10	0.12	0.10	0.09	0.12	0.13
0.144	0.136	0.132	0.142	0.146	0.136	0.138	0.184	0.162	0.176	0.207	0.189	0.166	0.232	0.305

Table 7.8. ***Sebastes 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	383	0.37	139.85	101	0.69	69.7	282	0.25	70.13		6.53
1987	376	0.36	136.94	102	0.68	68.9	274	0.25	68.09		3.52
1988	350	0.37	131.22	100	0.65	65.1	250	0.26	66.15		1.74
1989	325	0.39	127.41	99	0.63	62.4	226	0.29	64.99		1.44
1990	296	0.40	117.53	93	0.60	55.7	203	0.30	61.88	0.53	1.47
1991	277	0.42	115.95	94	0.60	55.8	183	0.33	60.14	0.37	1.42
1992	261	0.45	116.52	95	0.61	58.6	166	0.35	57.93	0.30	1.36
1993	245	0.47	115.76	96	0.64	61.4	149	0.37	54.35	0.30	1.29
1994	229	0.49	112.54	94	0.67	63.0	135	0.37	49.53	0.31	1.44
1995	216	0.51	110.92	93	0.71	65.8	123	0.37	45.08	0.25	1.31
1996	197	0.54	105.64	89	0.74	65.9	108	0.37	39.75	0.28	0.86
1997	180	0.56	99.78	84	0.77	64.9	96	0.36	34.87	0.27	0.89
1998	158	0.58	90.90	77	0.80	60.9	81	0.37	30.00	0.31	0.43
1999	137	0.59	80.89	68	0.81	55.2	68	0.38	25.72	0.32	0.35

		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)
2000	120	0.62	74.39	62	0.83	51.7	58	0.39	22.68	0.26	0.27
2001	108	0.66	71.05	58	0.87	50.6	50	0.41	20.46	0.20	0.30
2002	97	0.70	68.04	54	0.91	49.7	43	0.43	18.37	0.18	0.25
2003	87	0.76	66.03	51	0.97	49.6	36	0.46	16.43	0.14	0.13
2004	80	0.80	64.01	48	1.02	49.4	32	0.46	14.57	0.14	0.32
2005	73	0.85	61.68	45	1.08	49.0	28	0.46	12.73	0.13	0.22
2006	78	0.76	58.91	42	1.14	47.6	36	0.32	11.35	0.14	1.40
2007	72	0.77	55.64	39	1.18	45.6	34	0.30	10.07	0.15	0.38
2008	66	0.80	52.72	36	1.22	43.6	30	0.30	9.09	0.14	0.21
2009	61	0.82	49.78	33	1.26	41.4	28	0.30	8.38	0.14	0.24
2010	55	0.83	45.23	29	1.29	37.5	26	0.30	7.76	0.18	0.21
2011	60	0.71	42.46	27	1.31	34.7	33	0.24	7.78	0.16	1.14
2012	75	0.54	40.38	25	1.30	31.9	51	0.17	8.50	0.18	2.23
2013	69	0.55	37.86	23	1.23	28.9	45	0.20	8.96	0.21	0.06
2014	62	0.58	36.48	23	1.18	27.0	39	0.24	9.44	0.19	0.03

		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)
2015	58	0.62	35.87	23	1.13	26.0	35	0.28	9.84	0.17	0.05
2016	77	0.46	34.96	22	1.09	24.2	54	0.20	10.72	0.23	2.52
2017	110	0.31	34.45	22	1.00	22.0	88	0.14	12.41	0.30	4.11

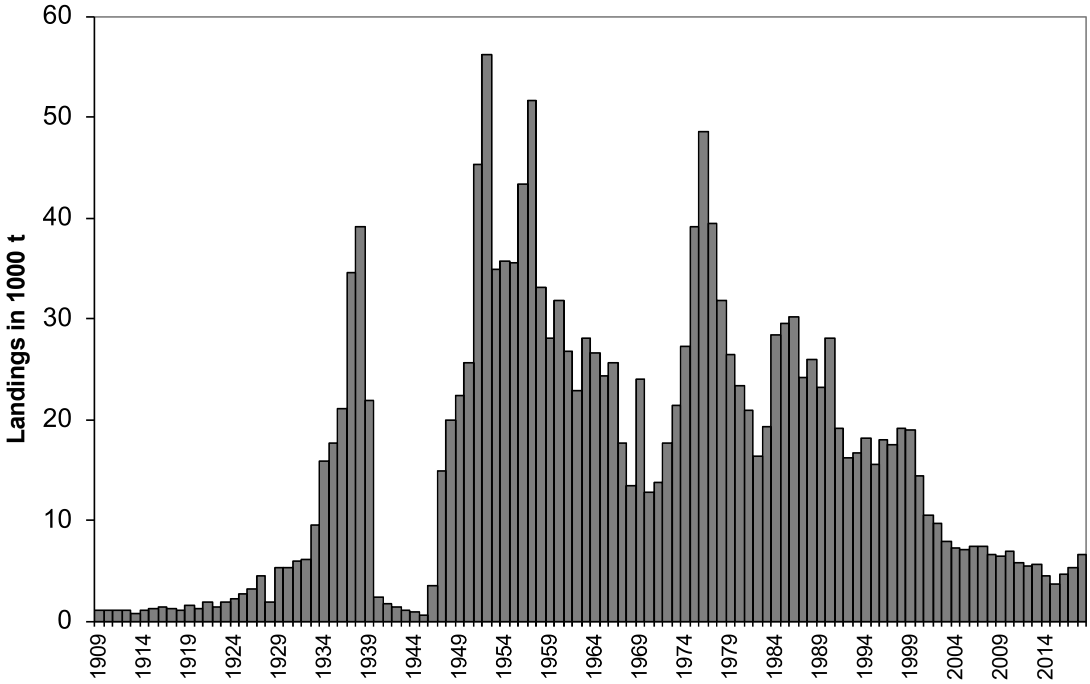


Figure 7.1. ***Sebastes norvegicus*** **in subareas 1 and 2. Total international landings 1908–2018 (in thousand tonnes).**

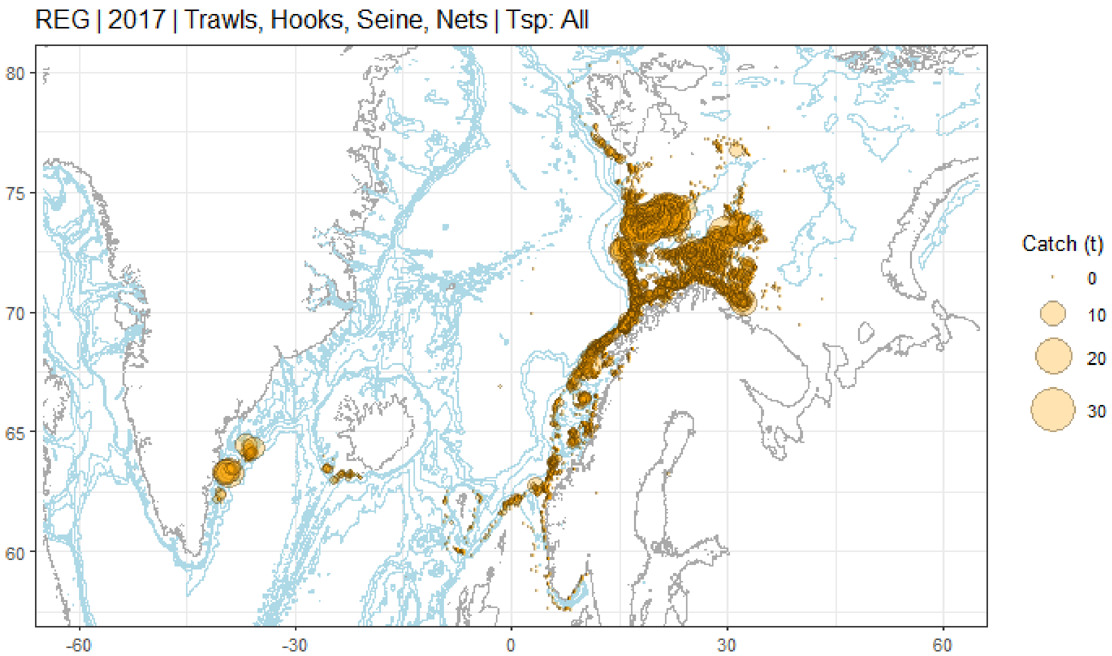
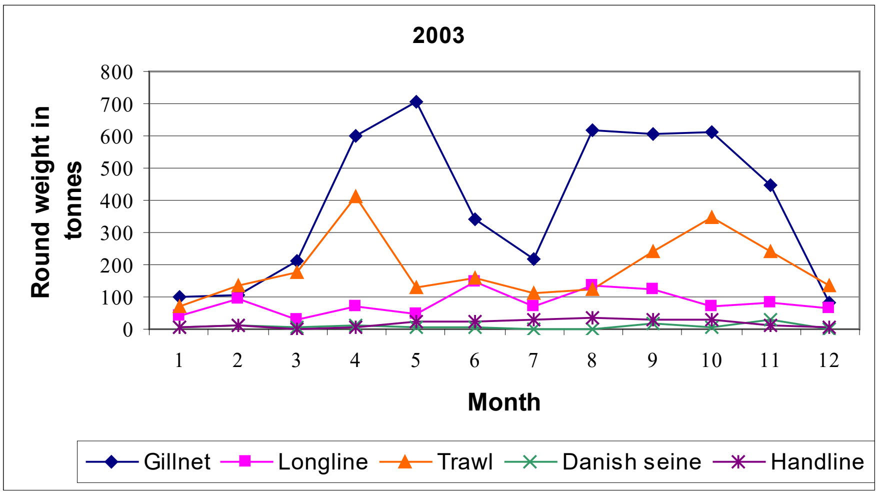
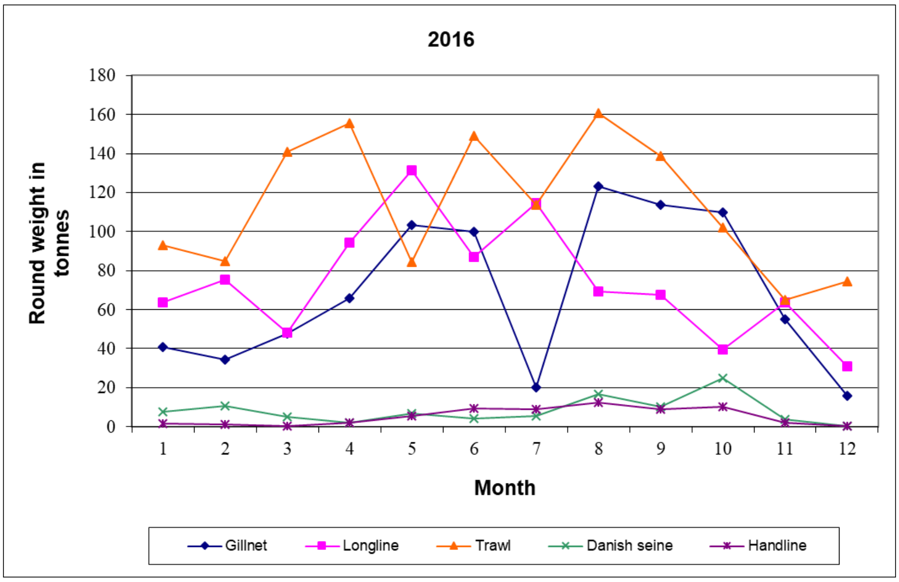


Figure 7.2. ***Sebastes norvegicus*** **in subareas 1 and 2. Catches (including bycatch) of** ***Sebastes norvegiucs*** **in 2017 from Norwegian logbooks.**





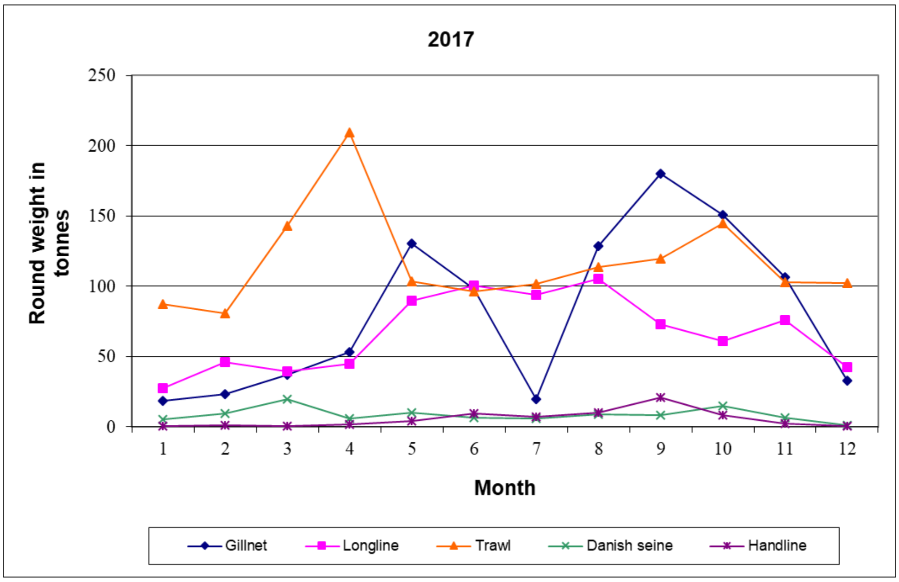


Figure 7.3a. Illustration of the seasonality in the different Norwegian *S. norvegicus* fisheries in 2003, 2016 and 2017, also illustrating how the current regulations are working.

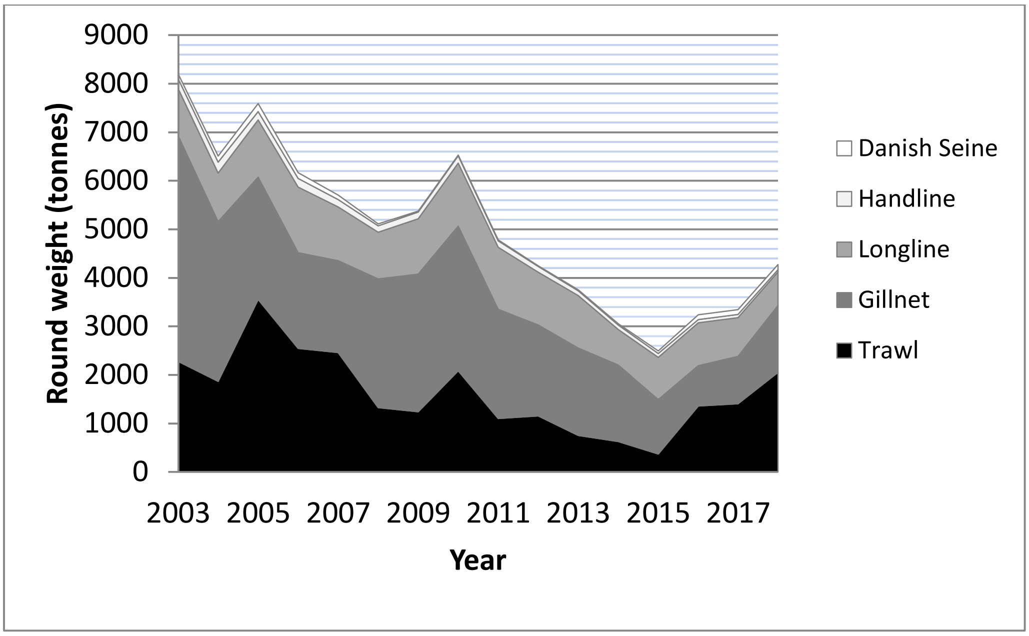


Figure 7.3b. Interannual changes in the Norwegian catches by fleet of *S. norvegicus* fisheries (2003–2018).

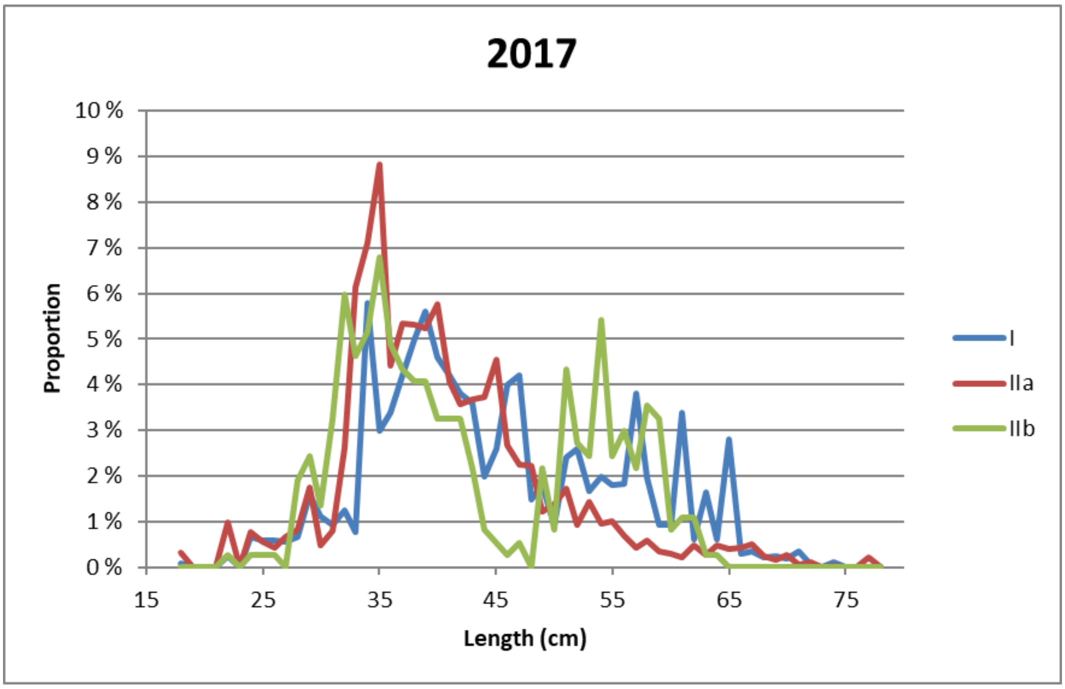
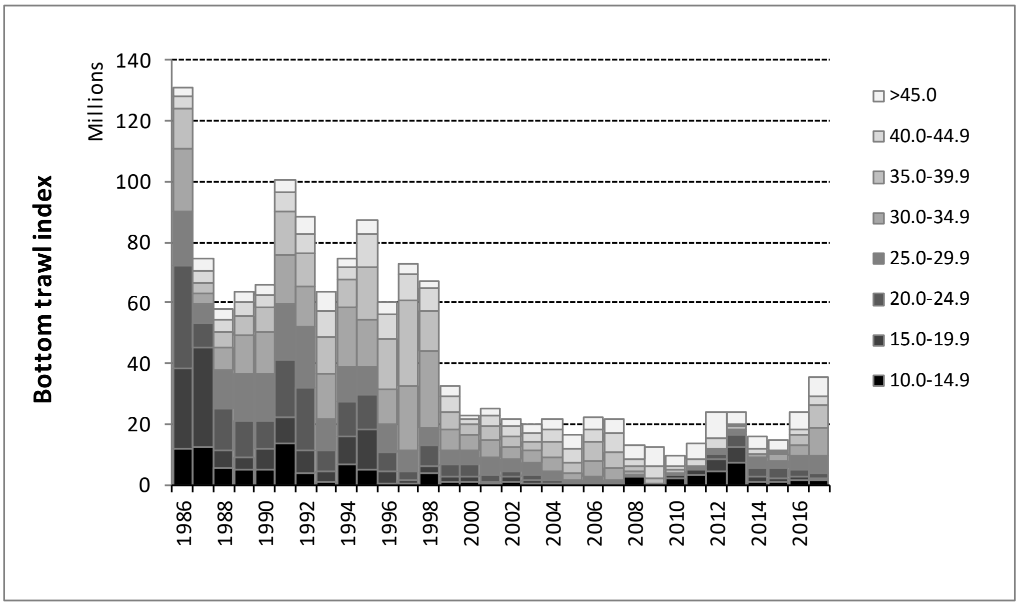


Figure 7.4. *Sebastes norvegicus*. Length frequency of *S. norvegicus* reported from Norwegian catches in Subarea 1, 2.a and 2.b in 2017, all gears combined.



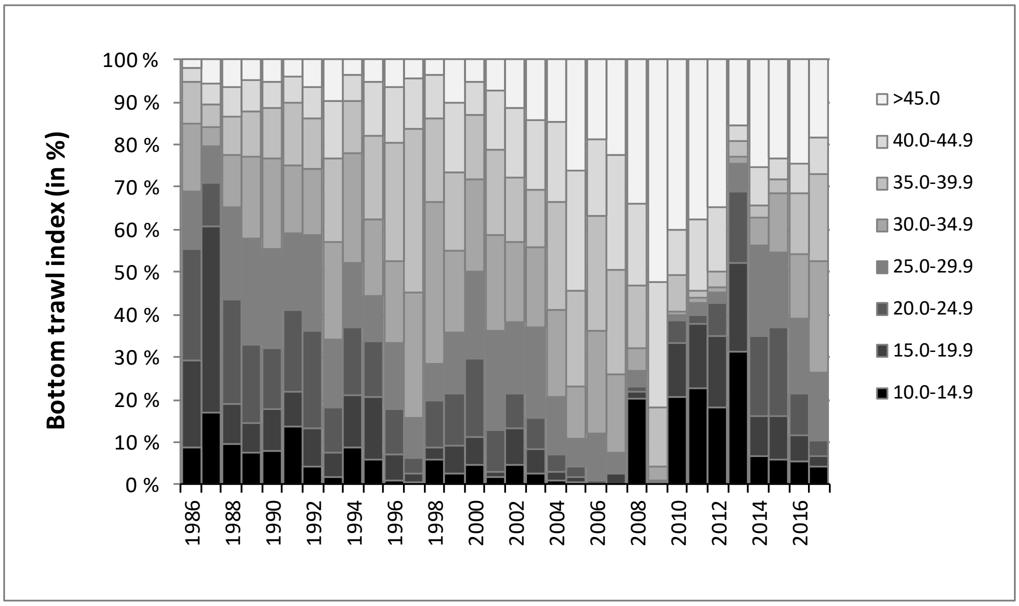
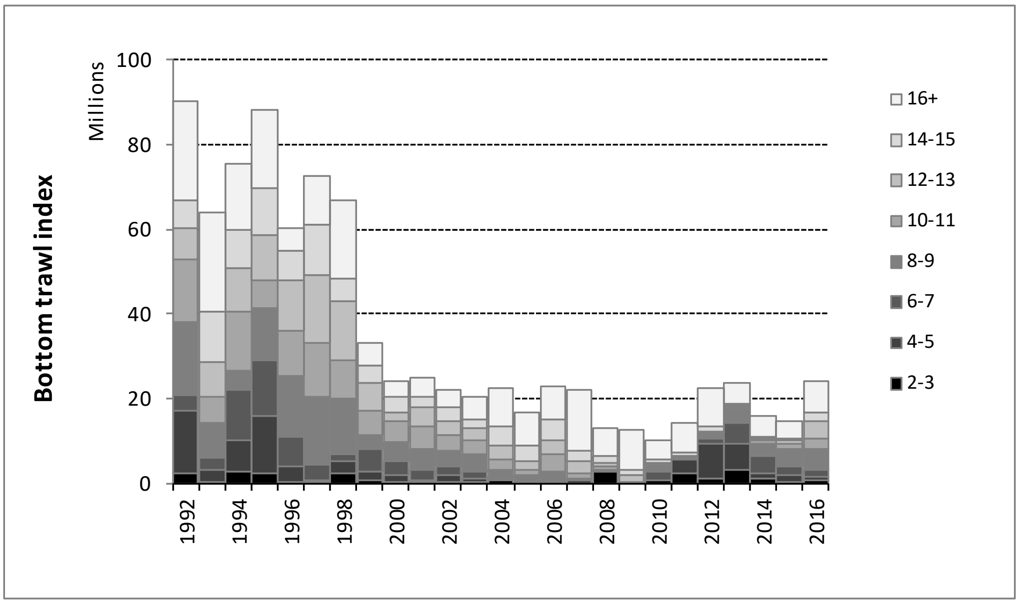


Figure 7.5a. *Sebastes norvegicus*. Abundance indices disaggregated by length for the winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS-NoRu-Q1 (BTr)) (joint with Russia some of the years since 2000), for 1986–2017 (ref. Table E1a). Top: absolute index values, bottom: relative frequencies.



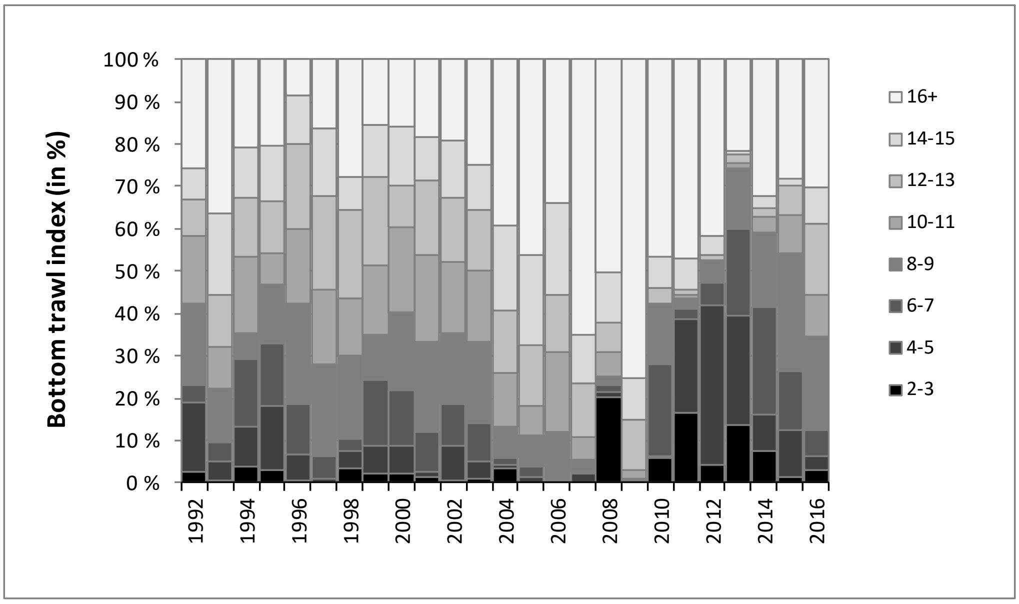


Figure 7.5b. *Sebastes norvegicus.* Abundance indices (by age) from the winter Norwegian Barents Sea (Division 2.a) bottom-trawl survey (BS-NoRu-Q1 (BTr)) (joint with Russia some of the years since 2000), for 1992-2016 (ref. Table E1b). Top: absolute index, bottom: relative frequencies. Horizontal line indicates the median age of the surveyed population.

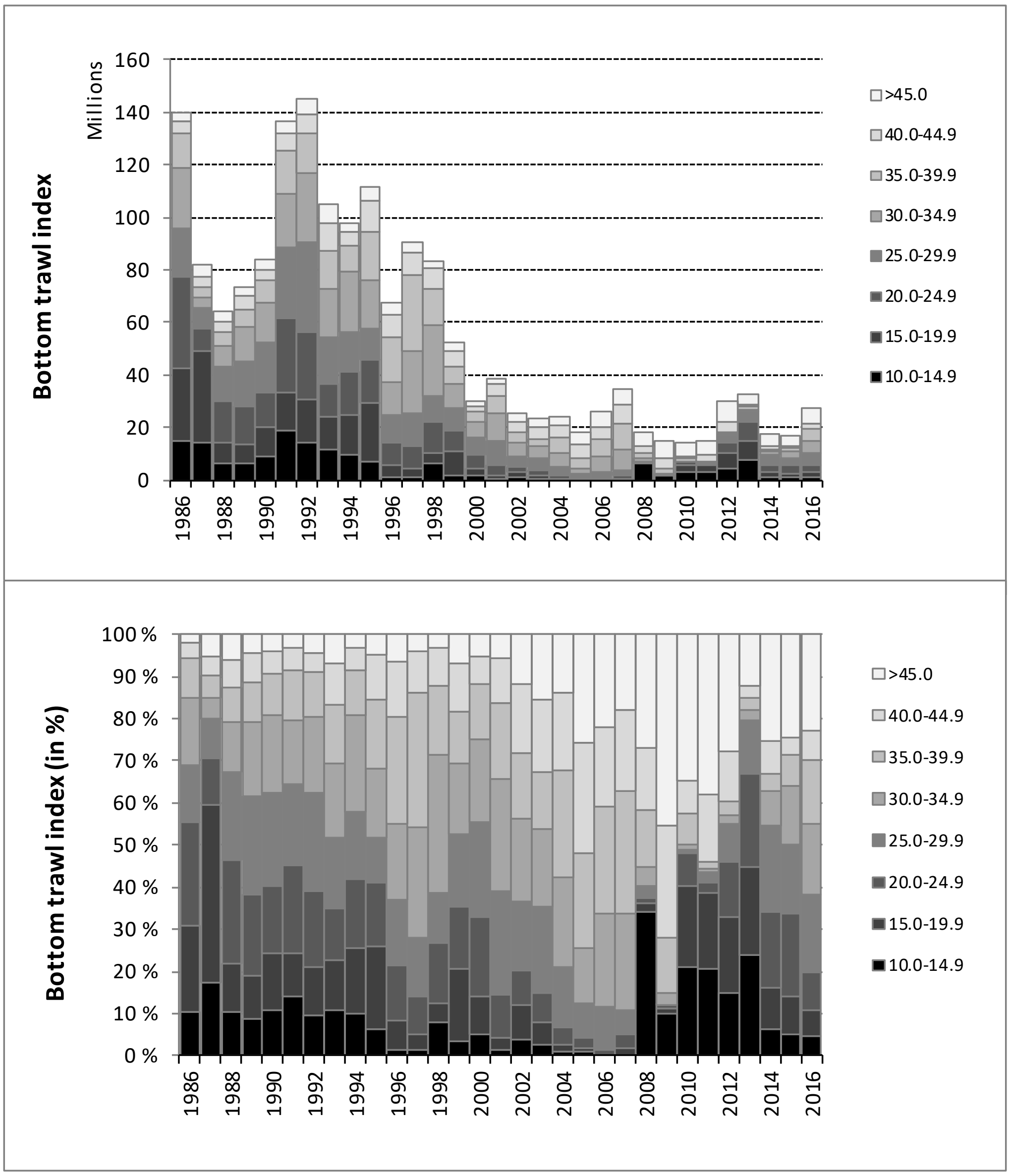
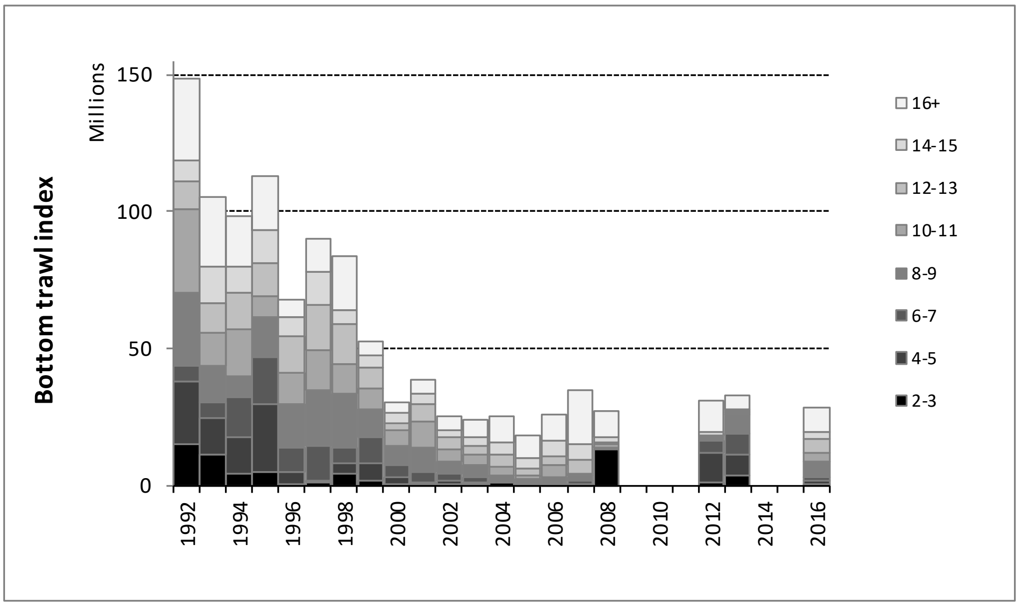


Figure 7.6a. ***Sebastes norvegicus.*** **Abundance indices disaggregated by length when combining the Norwegian bottom-trawl surveys 1986–2016 in the Barents Sea (winter) and at Svalbard (summer/fall). Top: absolute index values. Bottom: relative frequencies. Horizontal line indicates the median length in the surveyed population.**



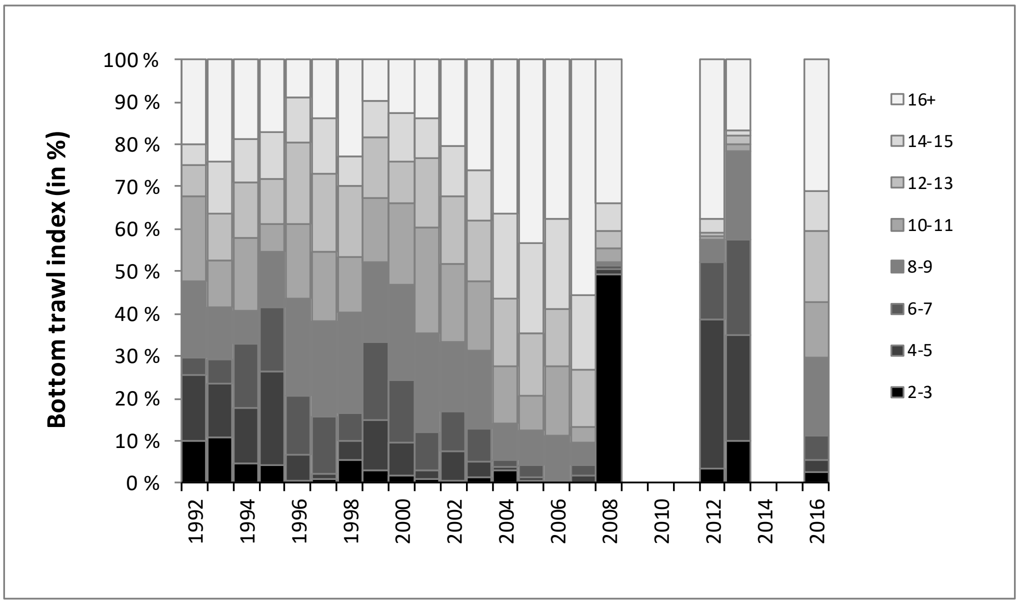


Figure 7.6b. *Sebastes norvegicus*. Abundance indices disaggregated by age. Combined Norwegian bottom-trawl surveys 1992–2016 in the Barents Sea (winter) and Svalbard survey (summer/fall). Top: absolute index values, bottom: relative frequencies. Horizontal line indicates median age of the surveyed population. In 2009–2011 and 2014–2015, there was insufficient number of age readings to derive numbers-at-age.

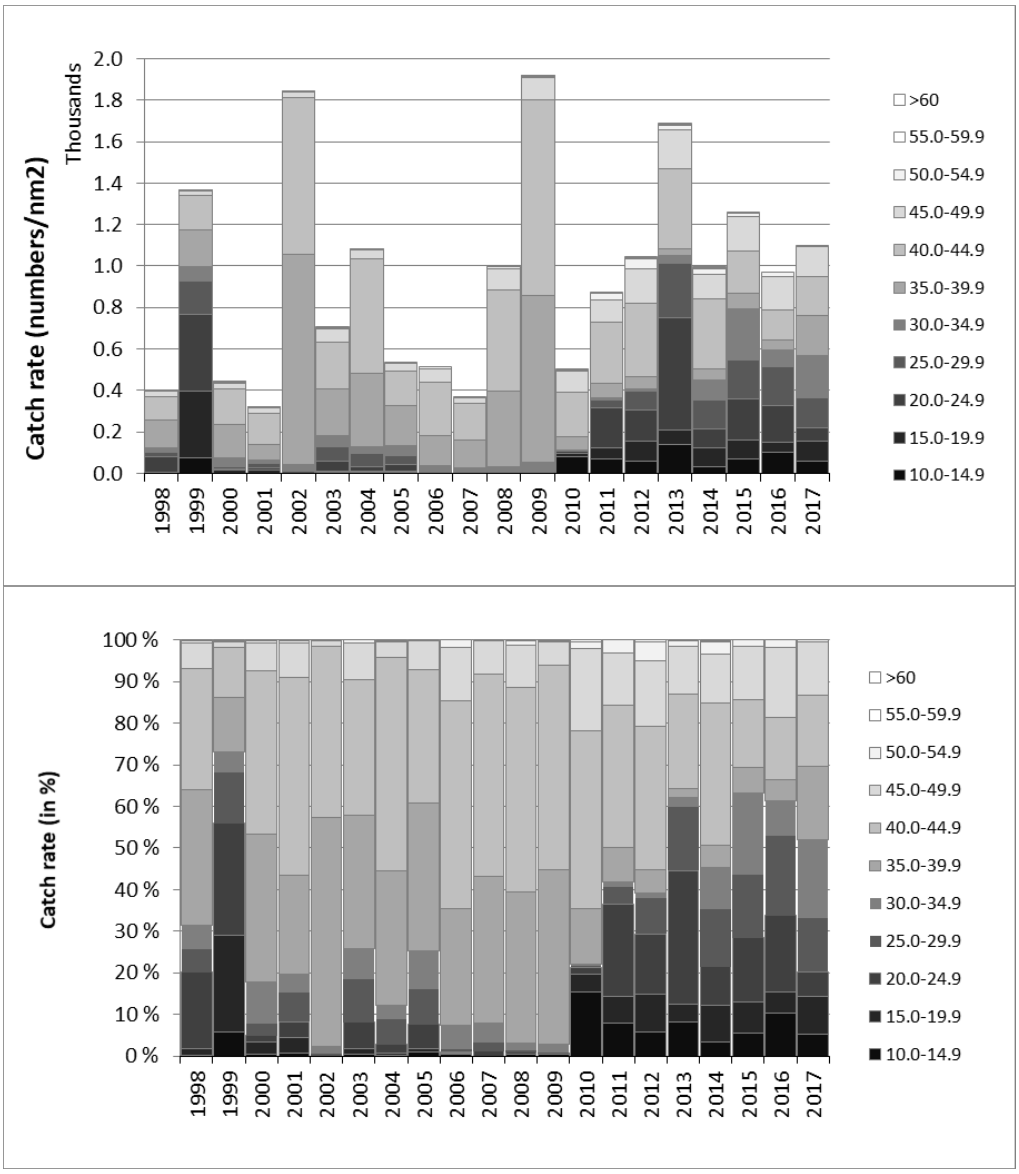


Figure 7.7. ***Sebastes norvegicus.*** **Catch rates (numbers/nm) disaggregated by length for the Barents Sea coastal survey 1998–2017. Top: absolute catch rates. Bottom: relative values.**

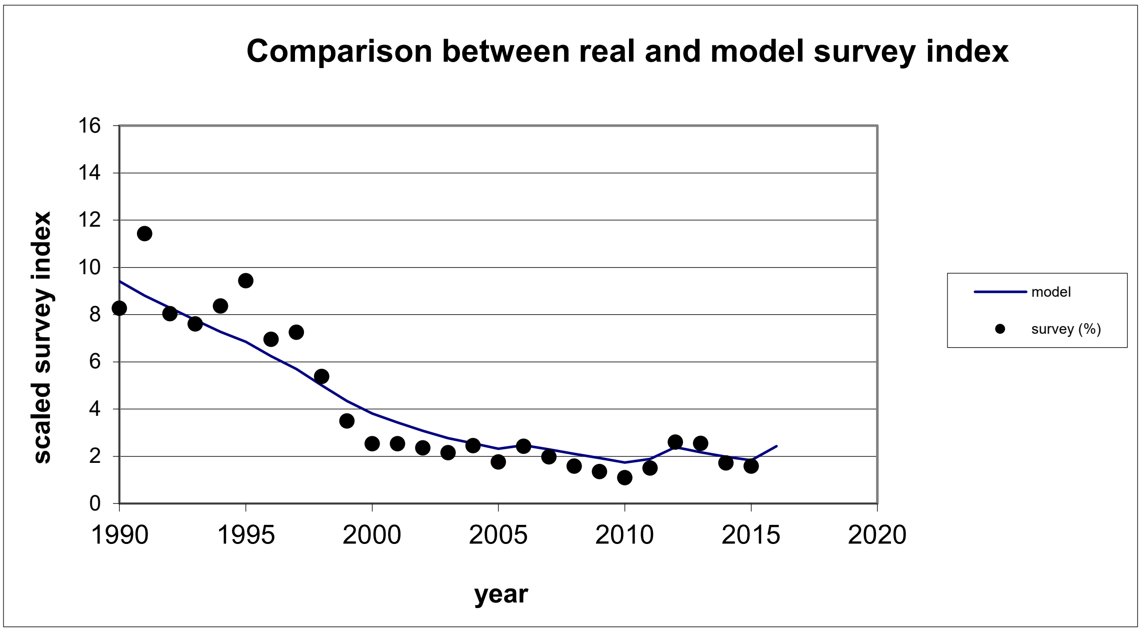


Figure 7.8. *Sebastes norvegicus* in subareas 1 and 2. Results from the Gadget assessment compared to the scientific survey. The Figure shows comparison of observed and modelled survey indices (total number scaled to sum=100 during the period) – the traditional Barents Sea February survey Dots: survey indices. Plain lines: survey indices estimated by the model.

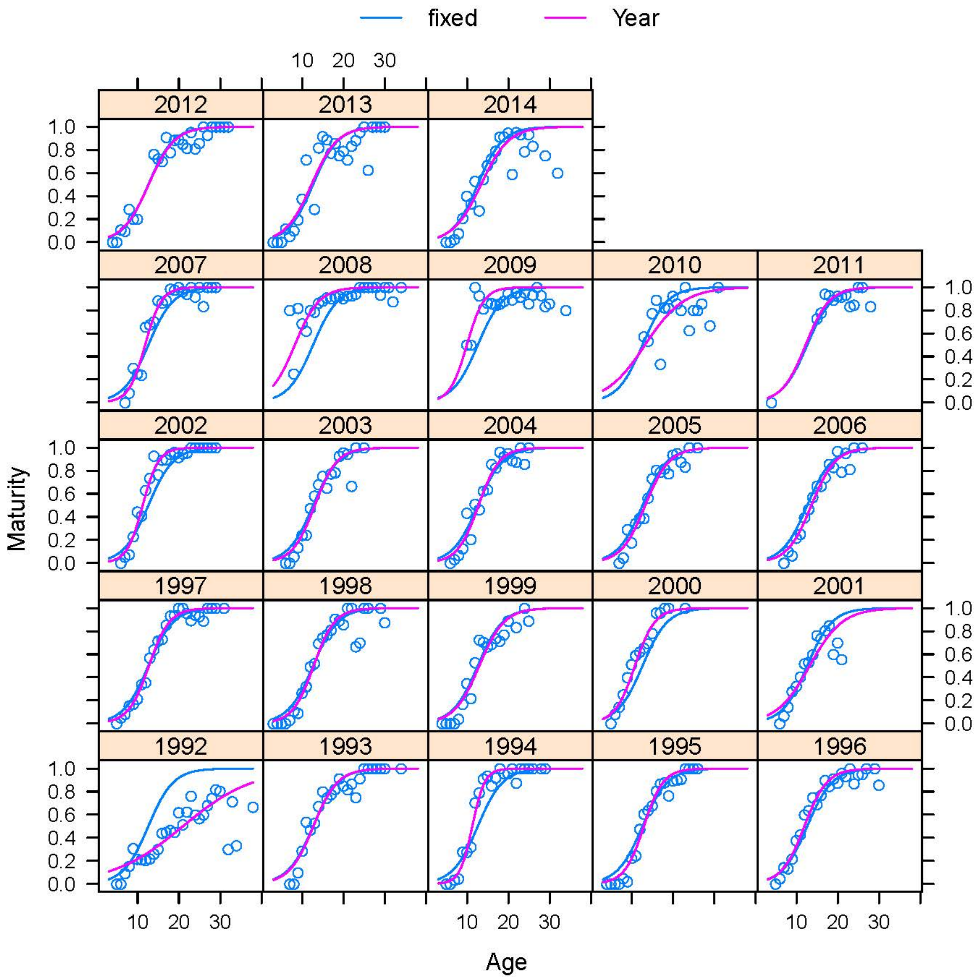


Figure 7.9a. Proportion maturity-at-age of *S. norvegicus* in subareas 1 and 2 derived from Norwegian commercial and survey data (Table E4). The proportions were derived from samples with at least five individuals. Note that due to time constraints this was not updated for the 2018 assessment and will be updated for the 2020 assessment.

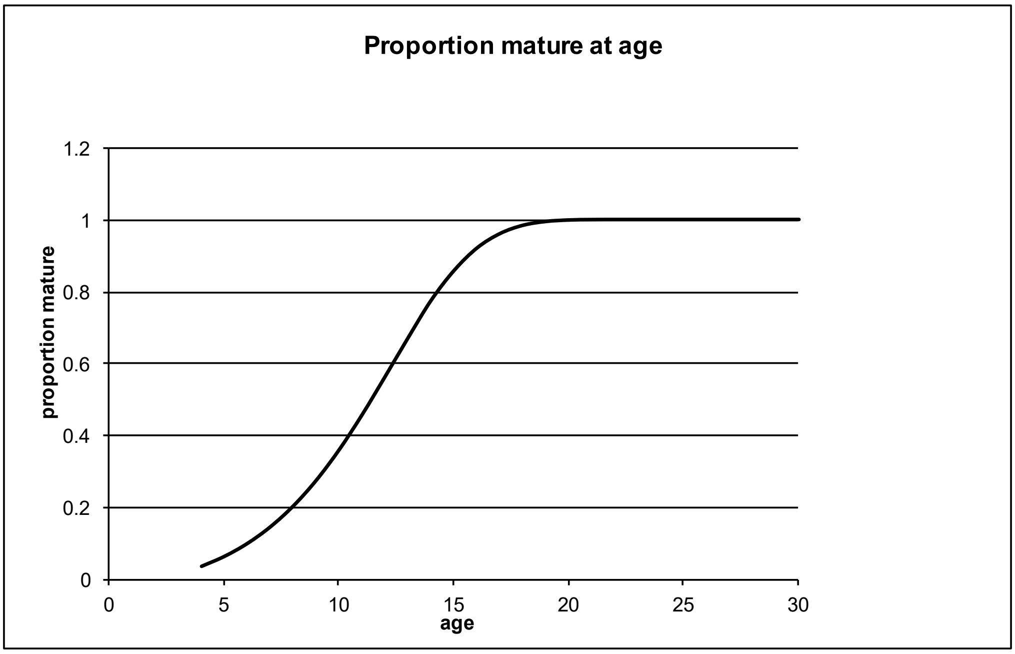
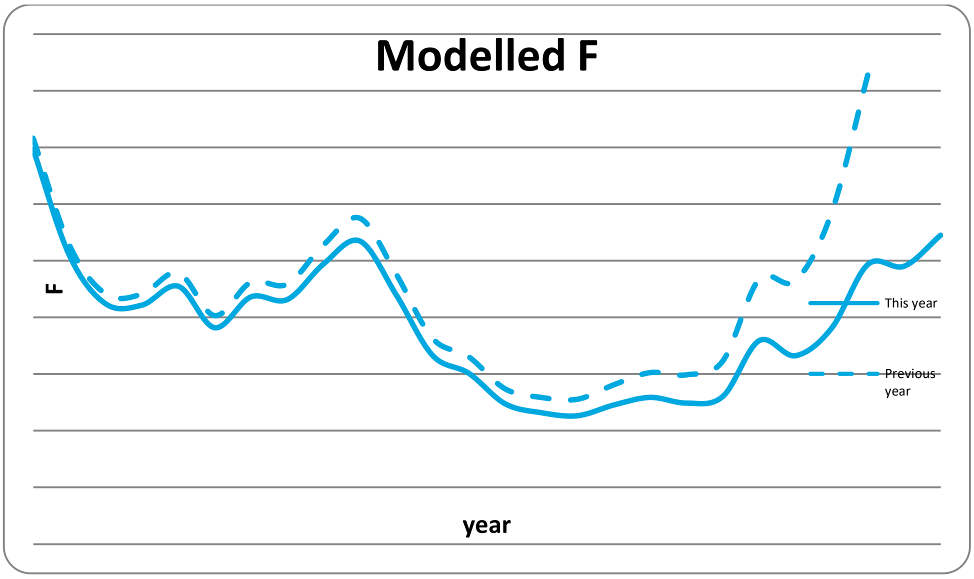


Figure 7.9b. *Sebastes norvegicus* in subareas 1 and 2. Estimates of maturity-at-age by Gadget. Input data have been proportions of *S. norvegicus* mature both at age and length as collected and classified from Norwegian commercial landings and surveys.



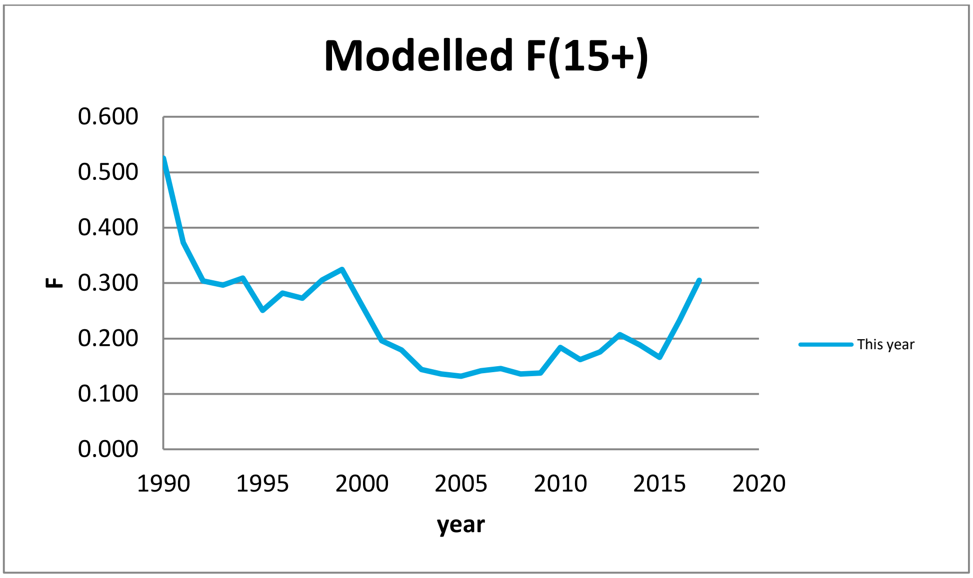


Figure 7.10. ***Sebastes norvegicus*** **in subareas 1 and 2. Unweighted average fishing mortality of ages 15+**

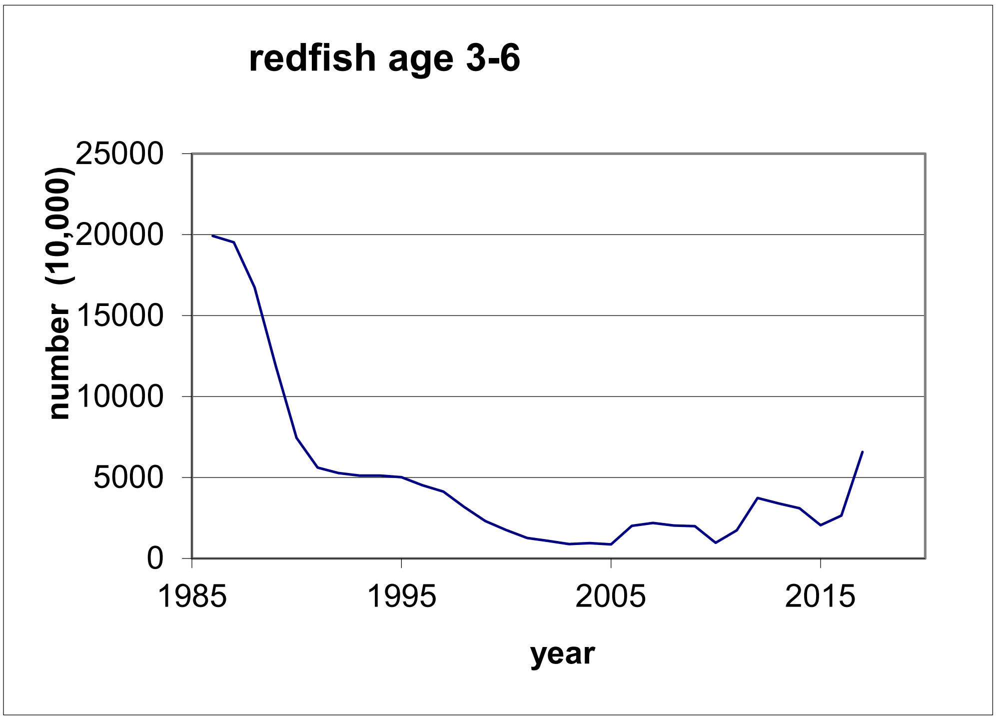


Figure 7.11. ***Sebastes norvegicus*** **in subareas 1 and 2. Estimates of abundance at age 3–6 by Gadget. Note that recent year (since 2015) have very little tuning data behind them.**

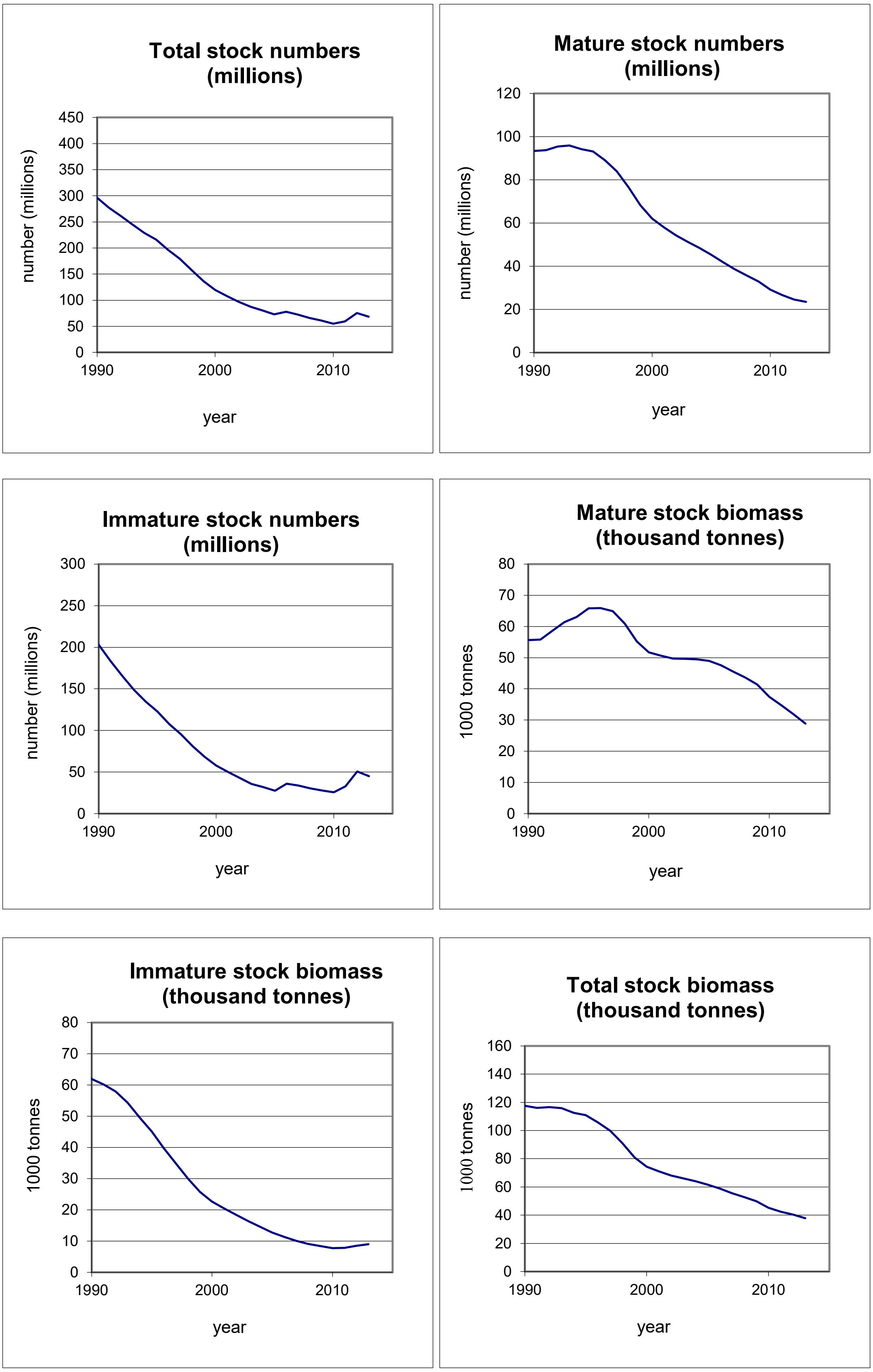
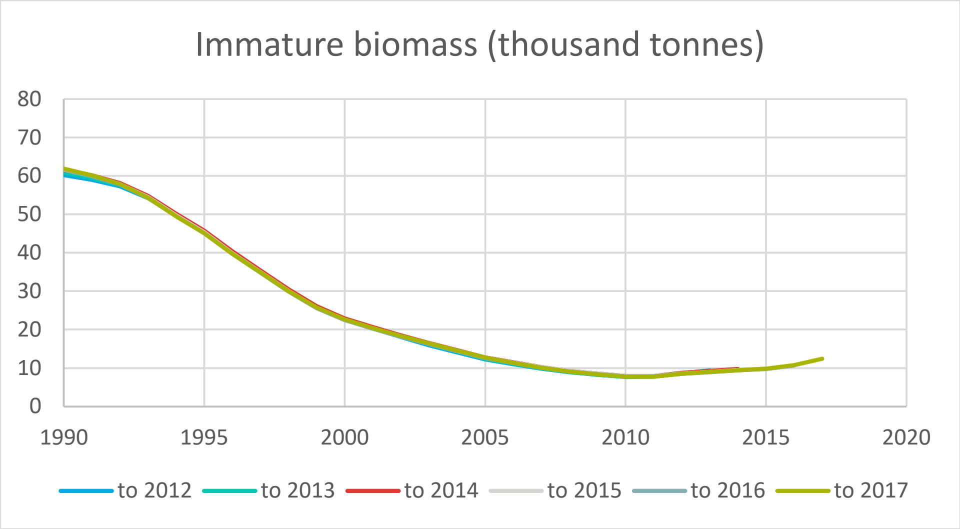
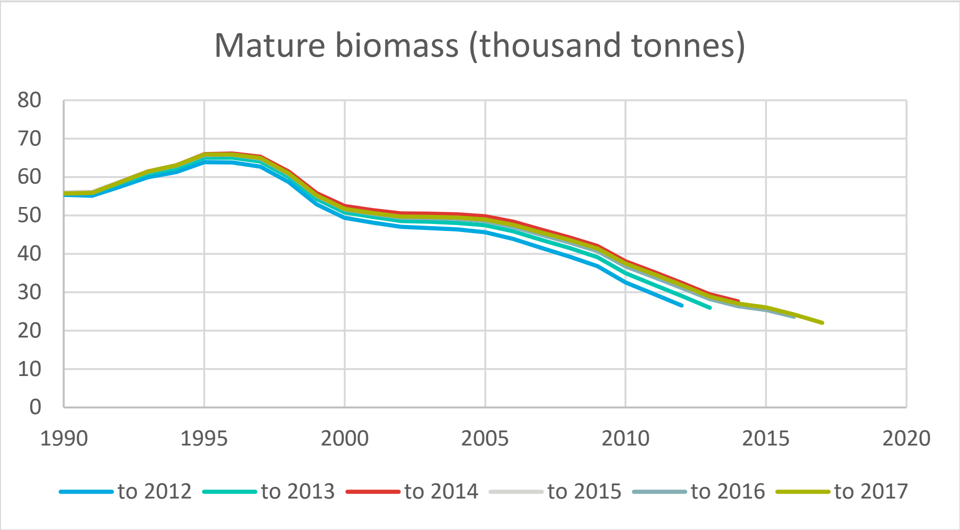
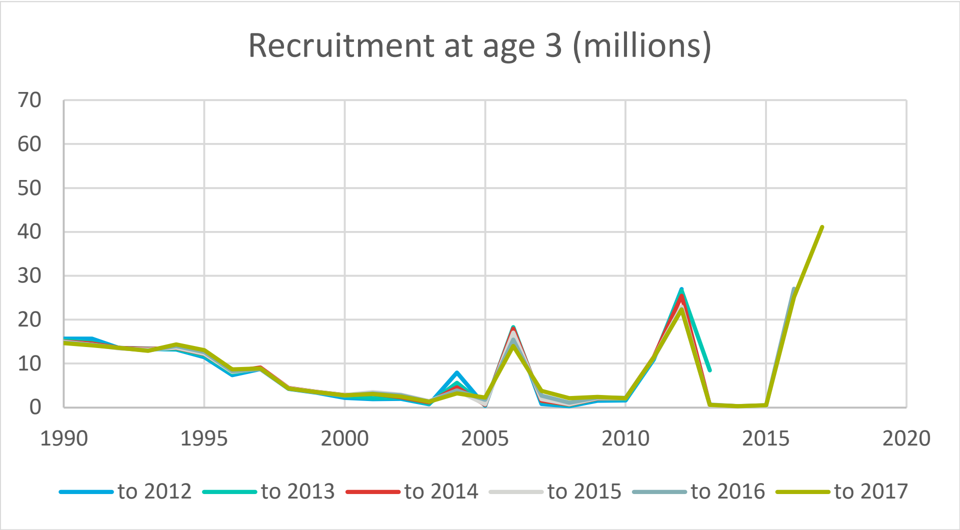


Figure 7.12. ***Sebastes norvegicus*** **in subareas 1 and 2. Stock numbers (in thousands) and biomass (in tonnes) for the total stock (3+) (upper panel), and the fishable and mature stock (middle panel), and the immature stock (lower panel), as estimated by Gadget using two surveys as input.**


Immature biomass (thousand tonnes)
80
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020
to 2012
to 2013
to 2014
to 2015
to 2016
to 2017


Mature biomass (thousand tonnes)
80
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020
to 2012
to 2013
to 2014
to 2015
to 2016
to 2017


Recruitment at age 3 (millions)
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
2020
to 2012
to 2013
to 2014
to 2015
to 2016
to 2017

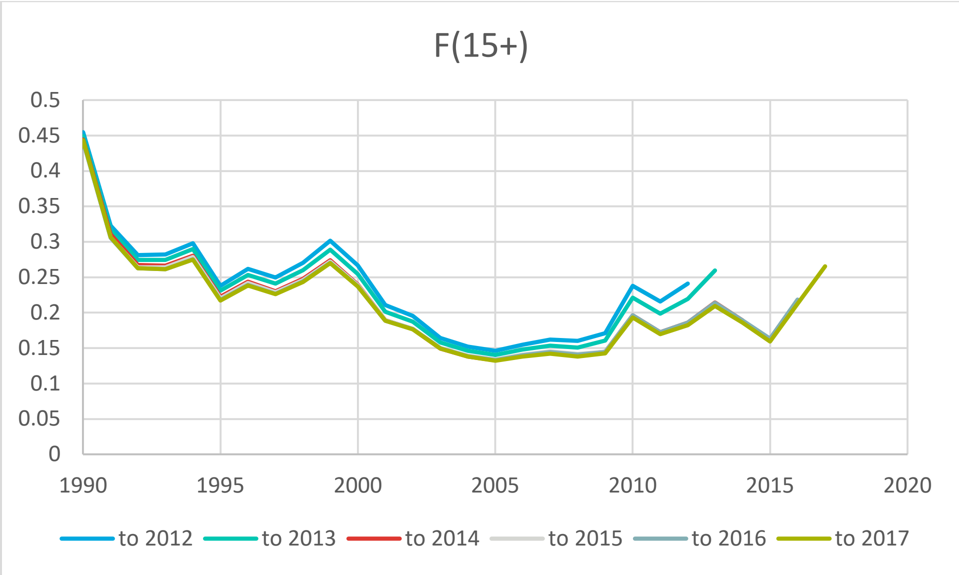


Figure 7.13. Gadget retrospective trends 2012 to 2017, immature biomass, mature biomass, recruitment-at-age 3, F(15+).

Table E1a. *Sebastes 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 2017. The area coverage was extended from 1993.

	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	6.5	9.3	11.7	11.5	19.4	9.1	4.4	2.8	75.4
1995	0.6	5.0	13.1	11.5	9.1	15.9	17.2	10.9	4.7	88.0
1996	+	0.7	3.5	6.4	9.4	11.7	16.6	7.9	3.9	60.1
1997[1]	-	0.5	1.3	2.7	6.9	21.4	28.2	8.5	3.3	72.7
1998[1]	0.1	3.9	2.0	7.4	5.8	25.3	13.2	7.0	2.3	67.0
1999	0.2	0.9	2.1	4.0	4.6	6.4	6.0	5.3	3.5	33.0
2000	0.5	1.1	1.5	4.2	4.7	5.0	3.5	1.8	1.2	24.0
2001	0.1	0.4	0.4	2.4	5.8	5.6	5.0	3.5	1.8	25.0
2002	0.1	1.0	1.9	1.7	3.7	4.1	3.3	3.6	2.5	22.0
2003	0.0	0.5	1.2	1.5	4.3	3.8	2.7	3.3	2.9	20.2
2004	0.7	0.2	0.4	1.0	2.9	4.4	5.5	4.0	3.2	22.3
2005	+	0.1	0.2	0.4	1.1	2.0	3.7	4.6	4.3	16.4
2006	0.0	0.0	0.0	0.2	2.5	5.4	6.1	4.1	4.2	22.5
2007	0.0	0.1	0.5	0.1	1.0	4.0	5.4	5.9	4.9	21.9
2008	1.8	2.6	0.2	0.2	0.4	0.7	1.9	2.5	4.4	14.8
2009	0.0	0.0	0.1	0.0	0.0	0.4	1.7	3.7	6.6	12.7
2010	0.4	2.0	1.2	0.6	0.1	0.1	0.8	1.1	3.9	10.3
2011	0.3	3.1	2.1	0.3	0.4	0.1	0.3	2.3	5.2	14.1
2012	0.8	4.4	4.0	1.9	0.6	0.3	0.9	3.6	8.3	24.8

	Length group (cm)									
Year	**5.0-9.9**	**10.0-14.9**	**15.0-19.9**	**20.0-24.9**	**25.0-29.9**	**30.0-34.9**	**35.0-39.9**	**40.0-44.9**	**>45.0**	**Total**
2013	0.0	7.4	4.9	4.0	1.6	0.4	0.9	0.8	3.7	23.8
2014	0.1	1.1	1.5	3.0	3.4	1.0	0.5	1.4	4.0	16.0
2015	0.1	0.9	1.5	3.1	2.6	2.0	0.5	0.7	3.4	14.8
2016	0.8	1.3	1.5	2.4	4.2	3.6	3.4	1.7	5.9	24.7
2017	0.4	1.4	1.0	1.4	5.7	9.3	7.3	3.1	6.5	36.1

1 - Adjusted indices to account for not covering the Russian EEZ in Subarea 1

Table E1b. *Sebastes 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 2016. The area coverage was extended from 1993 onwards.

Year/AGE	3	4	5	6	7	8	9	10	11	12	13	14	15	Total 1-15	16+
1992	2 295	4 261	10 760	2 043	1 474	13 178	4 230	6 302	8 251	3 751	3 865	3 064	3 568	67 042	23 300
1993	468	1 218	1 424	2 020	979	5 048	2 968	4 230	2 142	4 634	3 338	2 951	9 148	40 568	23 300
1994	2 951	4 485	2 573	3 801	8 338	3 254	1 297	7 231	6 443	248	10 192	6 341	2 612	59 766	15 600
1995	2 540	7 450	6 090	7 150	5 820	6 590	5 670	2 000	4 440	6 500	4 320	5 330	6 030	69 930	18 100
1996	310	1 300	2 340	3 520	3 660	8 720	5 650	3 960	6 590	5 730	6 230	4 070	2 950	55 030	5 100
1997	190	80	360	1 320	2 530	5 370	10 570	6 840	5 810	7 390	8 790	9 740	1 980	60 980	11 700
1998	2 380	1 930	850	660	1 140	7 090	6 124	4 962	4 091	5 190	8 790	2 730	2 560	48 487	18 500
1999	737	916	1 246	3 469	1 650	1 826	1 679	3 084	2 371	2 953	3 837	2 132	1 979	27 879	5 100
2000	490	720	900	1 310	1 800	2 440	2 020	2 710	2 090	940	1 440	2 940	430	20 230	3 800
2001	320	170	190	940	1 360	2 220	3 110	2 400	2 690	2 230	2 180	1 200	1 370	20 380	4 600
2002	130	910	902	1 590	544	1 546	2 153	1 822	1 900	2 220	1 073	1 294	1 730	17 814	4 200
2003	220	250	590	1 080	680	1 020	2 910	1 180	2 250	1 370	1 530	840	1 310	15 230	5 000
2004	780	100	100	90	240	540	1 130	1 260	1 590	1 740	1 490	2 570	1 890	13 520	8 800

Year/AGE	3	4	5	6	7	8	9	10	11	12	13	14	15	Total 1-15	16+
2005	39	85	107	110	321	524	669	497	697	820	1 517	1 905	1 653	8 944	7 652
2006	0	0	0	24	52	1 011	1 641	1 999	2 246	1 578	1 550	3 487	1 444	15 030	7 666
2007	58	202	248	50	51	185	422	582	592	1 747	1 030	1 127	1 359	7 652	14 248
2008	2 637	0	0	0	203	72	175	272	476	369	553	850	700	6 306	6 543
2009	0	0	0	0	85	0	14	77	192	358	1 146	532	737	3 141	9 539
2010	0	0	16	1 966	267	0	1 450	35	0	117	268	285	494	5 510	4 779
2011	1 832	1 621	1 529	163	148	0	343	0	122	0	204	107	903	7 459	6 624
2012	973	3 187	5 362	923	293	501	556	116	27	212	0	350	758	13 256	9 405
2013	1 432	929	5 194	2 183	2 757	2 346	1 031	250	0	378	117	250	0	18 684	5 112
2014	1 108	215	1 163	1 188	2 923	1 812	992	559	69	0	297	67	402	10 861	5 163
2015	143	526	1 106	954	1 111	1 955	2 126	300	1 043	487	537	143	51	10 554	4 173
2016	247	627	106	1 123	428	1 870	3 365	1 378	948	1 255	2 827	1 536	479	16 682	7 268
2017	Age data not available during AFWG 2018.														

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 E2a. *Sebastes 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 2016. 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]	-	1 307	795	1 728	2 273	1 417	311	142	194	8 325
1986[1]	200	2 961	1 768	547	643	1 520	639	467	196	8 941
1987[1]	100	1 343	1 964	1 185	1 367	652	352	29	44	7 060
1988[1]	500	1 001	1 953	1 609	684	358	158	68	95	6 450
1989	200	1 629	2 963	2 374	1 320	846	337	323	104	10 100
1990	1 700	3 886	4 478	4 047	2 972	1 509	365	140	122	19 185
1991	100	5 371	5 821	9 171	8 523	4 499	1 531	982	395	36 420
1992	1 700	10 228	8 858	5 330	13 960	12 720	4 547	494	346	58 172
1993	200	10 160	9 078	5 855	7 071	4 327	2 088	1 552	948	41 284
1994	100	3 340	5 883	4 185	3 922	3 315	1 021	845	423	22 985
1995	470	2 000	9 100	5 070	3 060	2 400	1 040	920	780	24 840
1996	80	130	1 260	2 480	1 030	480	550	990	400	7 400
1997	0	810	1 980	5 470	5 560	2 340	590	190	450	17 430

	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	2 698	1 741	4 620	4 053	1 761	535	545	241	16 403
1999	0	794	7 057	3 698	4 563	2 449	467	619	369	20 017
2000	40	360	1 240	1 390	2 010	760	400	160	390	6 750
2001	10	110	790	1 470	3 710	4 600	1 880	680	370	13 660
2002	0	0	64	415	459	880	620	565	519	3 522
2003	90	90	108	83	525	565	447	760	769	3 437
2004	0	0	10	50	650	740	670	430	190	2 740
2005	0	45	0	30	315	384	307	159	274	1 513
2006	0	0	70	64	167	376	473	735	1 514	3 398
2007	0	32	58	1 003	1 049	3 875	4 656	811	1 267	12 751
2008	7 009	3 573	175	21	42	142	475	162	529	12 130
2009	227	1 476	114	114	0	0	185	213	193	2 522
2010	666	917	1 506	522	0	117	172	0	985	4 885
2011	0	0	681	33	0	0	0	131	568	1 413
2012	0	85	1 512	2 138	2 145	327	32	0	133	6 372

	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
2013	48	437	1 971	3 239	2 564	412	152	33	392	9 248
2014	47	0	316	130	223	443	208	0	452	1819
2015	0	0	0	206	193	276	768	0	651	2094
2016	0	0	136	128	916	944	756	234	417	3531

1 - Old trawl equipment (bobbins gear and 80 m sweep length)

Table E2b. Sebastes *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 2016. Since 2005 this is part of the Ecosystem survey (Eco-NoRu-Q3 (BTr)). In 2009–2011 and 2014–2015, there was insufficient number of age readings to derive numbers-at-age.

	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	20155
1995	600	1600	6400	5100	1800	2200	1800	700	700	400	700	500	400	500	23400
1996	40	110	+	560	1050	940	930	400	1050	280	320	590	160	70	6500
1997	320	490	+	480	1500	6950	2720	1680	800	1310	550	30	+	120	16950
1998	210	1817	881	202	1555	2187	4551	1913	1010	797	49	264	73	187	15696
1999	0	760	2893	1339	3534	1037	3905	2603	762	1663	481	361	258	152	19748
2000	40	20	400	350	840	480	730	1670	620	340	510	100	80	70	6250
2001	0	40	50	450	330	790	1760	1970	3300	1200	1810	150	660	430	12940
2002	0	0	+	+	65	160	204	326	364	614	442	328	15	0	2518
2003	30	30	30	+	108	+	219	263	126	259	306	199	248	411	2229
2004	0	0	0	+	+	20	360	120	430	160	410	360	370	200	2430

	Age														
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
2005	0	45	0	0	0	30	48	228	138	187	194	93	105	109	1177
2006	0	0	23	23	23	21	22	21	84	0	84	279	194	376	1148
2007	0	33	19	19	19	764	764	525	0	0	21	1927	1927	1683	7702
2008	10583	44	88	44	11	11	0	42	88	13	13	118	63	174	11292
2009	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	0	28	121	2353	1836	1183	577	79	30	32	0	0	0	0	6239
2013	48	44	738	1298	1433	1097	2746	806	183	91	185	0	0	180	8849
2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	0	0	0	68	68	0	0	0	916	403	442	227	466	145	2734

Table E3. *Sebastes norvegicus* in Sub-area 1 and 2. Mean catch rates (numbers/nm) of *Sebastes norvegicus* from the Norwegian Coastal Surveys (NOcoast-Aco-Q4) (Division 2.a) in 1998-2017.

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	60-64	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
1998	0	0	692	6 632	73 075	22 255	22 430	130 161	116 216	23 519	2 547	880	0	89	139	778	NA	43 574
1999	0	7 587	77 067	317 802	369 258	165 769	67 222	178 802	163 919	20 445	3 642	1 520	0	103	138	2 144	NA	43 574
2000	0	0	1 856	13 048	6 459	13 065	42 990	156 418	171 407	29 117	3 036	331	191	99	144	756	503	43 574
2001	0	295	2 031	11 787	12 305	22 408	14 127	74 790	150 763	26 573	1 787	345	191	81	113	460	325	43 574
2002	0	0	0	0	2 321	7 588	34 283	1 011 273	754 947	26 769	3 195	513	0	109	172	3 289	332	43 574
2003	0	0	2 579	10 118	44 506	72 473	52 479	224 734	228 374	62 121	5 536	481	0	123	160	1 367	1 053	43 574
2004	0	937	3 139	5 591	21 042	66 182	34 613	351 154	552 183	41 851	2 666	1 345	0	104	130	1 290	950	43 574
2005	0	554	5 209	4 627	30 272	46 072	48 379	189 993	170 639	37 468	1 450	0	0	99	132	833	780	43 574
2006	0	0	2 884	496	1 738	3 065	29 933	144 743	256 394	65 959	9 272	0	0	112	112	771	680	43 574
2007	0	0	0	0	4 335	7 308	17 338	129 412	177 332	29 042	1 182	0	0	131	140	637	637	43 574
2008	0	3644	4 555	955	3 957	4 679	17 440	362 633	490 611	99 469	11 772	1 630	0	110	139	1 156	850	43 574
2009	0	0	6 976	2 285	2 984	4 530	39 275	800 208	945 004	106 479	6 244	663	1 122	114	136	2 947	598	43 574
2010	0	39 758	77 542	20 364	8 814	1 378	2 582	66 948	214 182	99 061	7 417	2 454	0	117	136	833	690	43 574
2011	0	3 654	67 407	55 725	193 640	35 323	10 043	72 244	296 697	107 318	27 832	286	0	113	104	998	571	43 574
2012	0	39 530	59 337	95 227	150 260	89 534	12 686	58 890	356 556	163 645	46 792	4 640	263	98	96	1 191	778	43 574
2013	0	5 176	137 751	72 253	540 679	260 689	38 079	34 628	384 207	190 595	21 534	3 528	2 091	93	95	2 231	1 105	43 574

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	60-64	# Hauls	Total.Dist-ance (nm)	# Fish Caught	# Fish Sampled	Area (nm^2)
2014	0	949	33 978	87 279	91 651	138 732	99 402	52 335	338 428	118 890	27 270	2 343	3 361	107	108	1 717	777	43 574
2015	399	32 520	69 615	93 690	193 721	189 891	246 181	77 869	202 366	163 442	17 169	565	0	97	103	1 886	984	43 574
2016	620	25 016	100 428	49 233	177 926	186 202	81 997	48 577	143 802	163 426	18 716	0	0	99	101	1 648	1 153	43 574
2017	0	24 275	56 939	100 863	64 461	140 908	205 950	194 298	187 502	141 478	4 160	0	0	108	144	3 054	1 888	43 574

Table E4. Proportion of maturity-at-age 5 – 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.

Year/Age	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1992	0.00	0.00	0.09	0.15	0.31	0.22	0.21	0.20	0.22	0.26	0.30	0.44	0.45	0.47
1993	-	-	0.00	0.00	0.10	0.29	0.54	0.47	0.53	0.67	0.80	0.75	0.78	0.82
1994	0.00	0.00	0.03	0.05	0.28	0.28	0.32	0.70	0.79	0.91	0.94	0.85	0.92	1.00
1995	0.00	0.00	0.00	0.05	0.02	0.22	0.25	0.48	0.61	0.64	0.68	0.80	0.87	0.88
1996	0.00	0.05	0.14	0.13	0.22	0.38	0.43	0.60	0.64	0.75	0.69	0.77	0.90	0.85
1997	0.00	0.05	0.08	0.15	0.17	0.21	0.34	0.35	0.57	0.64	0.72	0.73	0.85	0.93
1998	0.00	0.00	0.03	0.11	0.09	0.26	0.32	0.49	0.52	0.69	0.74	0.77	0.81	0.91
1999	0.00	0.00	0.00	0.04	0.17	0.35	0.22	0.53	0.73	0.71	0.67	0.69	0.74	0.71
2000	0.00	0.08	0.14	0.25	0.40	0.51	0.59	0.62	0.65	0.69	0.78	0.96	0.96	1.00
2001	-	0.00	0.06	0.14	0.28	0.32	0.40	0.52	0.53	0.60	0.76	0.74	0.81	0.85
2002	-	0.00	0.05	0.07	0.23	0.44	0.41	0.63	0.74	0.93	0.77	0.89	0.90	0.94
2003	-	0.00	0.00	0.05	0.13	0.24	0.24	0.47	0.58	0.68	0.75	0.65	0.77	0.78
2004	-	0.00	0.03	0.07	0.13	0.43	0.21	0.51	0.46	0.63	0.64	0.86	0.82	0.96
2005	-	-	0.00	0.05	0.29	0.18	0.34	0.39	0.39	0.56	0.73	0.81	0.79	0.82
2006	-	-	0.00	0.10	0.06	0.22	0.25	0.39	0.47	0.57	0.67	0.67	0.74	0.86
2007	-	-	0.00	0.08	0.30	0.25	0.24	0.66	0.68	0.70	0.88	0.86	0.89	0.99
2008	-	-	0.80	0.25	0.82	0.68	0.62	0.80	0.79	0.86	0.88	0.91	0.90	0.92
2009	-	-	-	-	-	0.50	0.50	1.00	0.93	0.81	0.86	0.86	0.84	0.86
2010	-	-	-	-	-	-	-	-	0.57	0.53	0.77	0.89	0.33	0.82
2011	-	-	-	-	-	-	-	-	-	-	0.73	0.78	0.94	0.93
2012	0.00	0.11	0.10	0.29	0.20	0.20	-	-	-	0.75	0.72	0.70	0.91	0.78
2013	0.00	0.12	0.05	0.10	0.19	0.38	0.71	-	0.29	0.82	0.92	0.89	0.77	0.86

Year/Age	19	20	21	22	23	24	25	26	27	28	29	30
1992	0.45	0.62	0.51	0.63	0.76	0.60	0.57	0.60	0.68	0.74	0.82	0.80
1993	0.91	0.85	0.82	0.87	0.75	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.96	0.96	1.00	0.88	1.00	1.00	1.00	1.00	-	1.00	1.00	-
1995	0.76	0.89	0.90	0.91	1.00	1.00	1.00	1.00	-	-	-	-
1996	0.91	0.88	0.96	0.93	1.00	0.87	0.95	0.95	1.00	-	1.00	0.86
1997	0.94	1.00	1.00	0.95	0.89	0.94	0.93	0.89	1.00	1.00	1.00	-
1998	0.89	0.86	1.00	1.00	0.67	0.70	1.00	1.00	-	-	1.00	0.88
1999	0.77	0.89	-	0.83	-	1.00	0.89	-	-	-	-	-
2000	1.00	-	-	-	1.00	-	-	-	-	-	-	-
2001	0.60	0.70	0.56	-	-	-	-	-	-	-	-	-
2002	0.96	0.92	0.95	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
2003	0.93	0.96	0.94	0.67	1.00	-	1.00	-	-	-	-	-
2004	0.92	0.95	0.89	0.88	1.00	0.86	1.00	-	-	-	-	-
2005	0.77	0.94	0.95	0.88	0.83	1.00	-	1.00	-	-	-	-
2006	0.83	0.97	0.79	0.95	0.81	1.00	-	1.00	-	-	-	-
2007	0.98	1.00	0.96	0.94	1.00	0.92	1.00	0.83	1.00	1.00	1.00	-
2008	0.92	0.90	0.93	0.93	0.94	1.00	1.00	1.00	1.00	1.00	0.93	1.00
2009	0.88	0.95	0.89	0.95	0.92	0.95	0.86	0.93	1.00	0.93	0.83	0.86
2010	0.82	0.92	0.86	0.80	1.00	0.63	0.80	0.80	0.86	-	0.67	-
2011	0.89	0.92	0.92	0.93	0.83	0.85	1.00	1.00	-	0.83	-	-
2012	0.88	0.89	0.85	0.81	0.95	0.81	0.86	1.00	0.93	1.00	1.00	1.00
2013	0.75	0.79	0.71	0.83	0.88	0.95	1.00	0.63	1.00	1.00	1.00	1.00

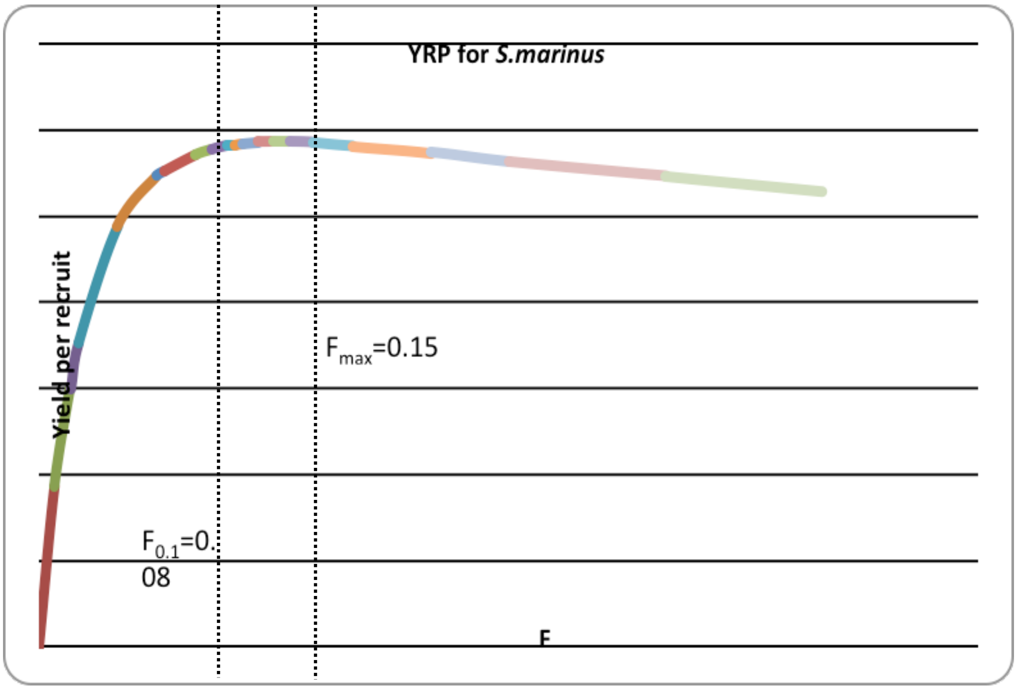


Figure E1. ***Sebastes norvegicus*** **in subareas 1 and 2. Yield-per-recruit for** ***S. norvegicus*****, computed from the base case GADGET model presented at the benchmark assessment in February 2012 (WKRED).**

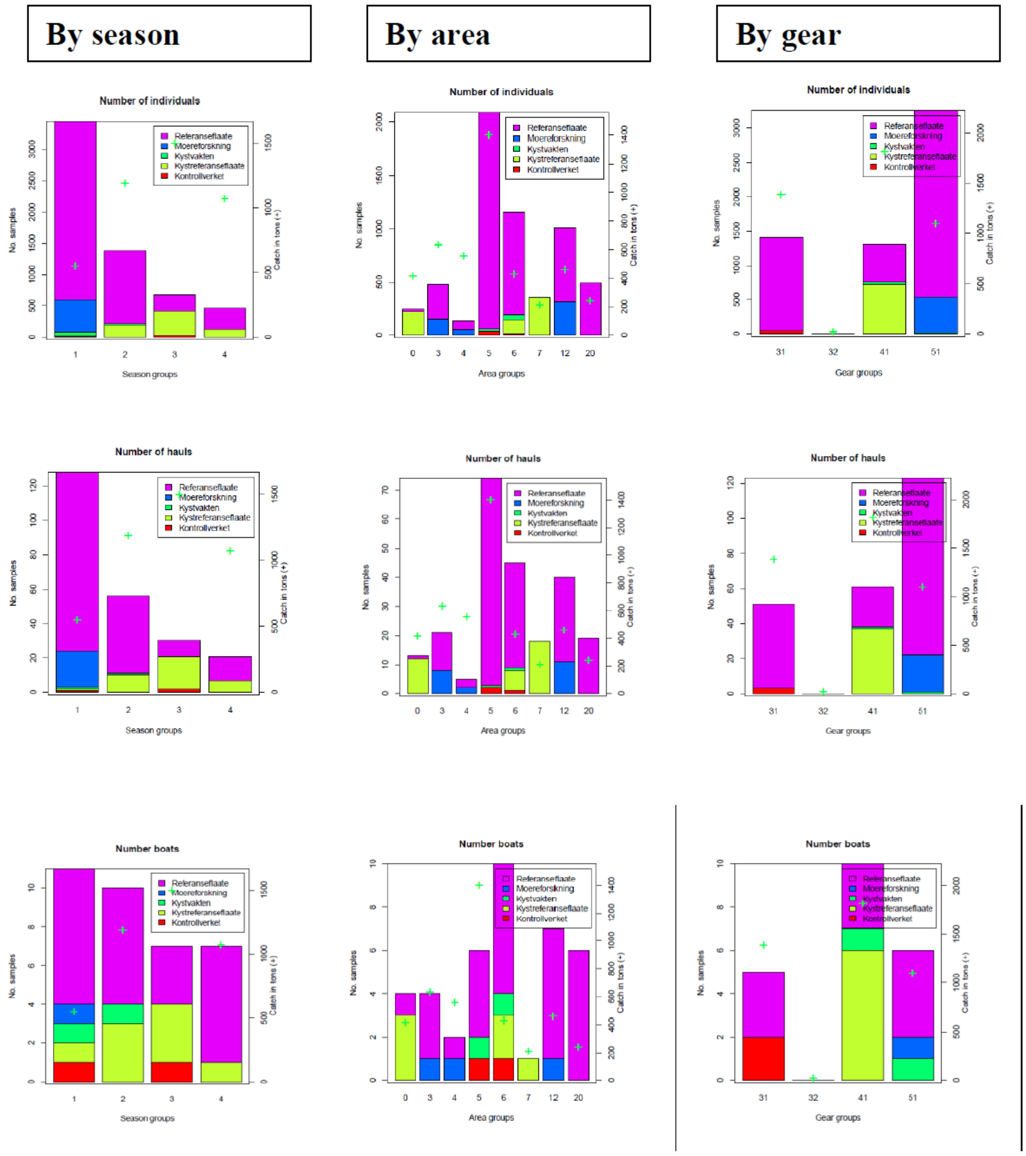


Figure E2. Overview of the Norwegian biological age samples (number individuals, number hauls/sets, number of boats) from the commercial fisheries for *S. norvegicus* in 2013 representing more than 80% of the catches and which the input data to the Gadget model are based upon. The colours denote which 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.

8 Greenland halibut in subareas 1 and 2 (ghl.27.1-2).

The stock is assessed by a GADGET length-based model since 2015. The stock has biennial advice and the last advice was given in 2017 for 2018 and 2019. A new stock assessment is run in 2019 to provide advice for 2020 and 2021. General information about this stock is in the Stock Annex, which was updated after the last benchmark.

8.1 Status of the fisheries

8.1.1 Landings prior to 2019 (Tables 8.1–8.8)

Nominal landings by country for subareas 1 and 2 combined are presented in Table 8.1. Tables 8.2—8.4 give the landings for Subarea 1 and divisions 2.a and 2.b separately, and landings separated by gear type are presented in Table 8.5. For most countries, the landings listed in the Tables are similar to those officially reported to ICES. Some of the values in the Tables vary slightly from the official statistics and represents those presented to the Working Group by the members. Catch per unit of effort is presented in Table 8.6 and total catch from 1935-till now in Table 8.7 and Figure 8.1.

The preliminary estimate of the total landings for 2018 is 28 544 t. This is 2164 t more than the landings in 2017 and about 5544 t more than the ICES advised maximum catch for 2018 (23 000 t). There was a large increased in both Norwegian and Russian catches, 1133 and 1358 tonnes, respectively, compared to 2017. Also, Faroese catches decreased substantially, by 508 t. Combined landings exceeded the quotas set by the Joint Russian-Norwegian Fisheries Commission for 2018 by 1544 t (total TAC 27 000 t). One explanation is the difficulties in bycatch regulation.

Some fishing for Greenland halibut has taken place in the northern part of Division 4.a during the past 20–30 years, varying between a few tonnes and up to 1670 t in 1995. From 2005 to 2011 this catch was mostly below 200 t, taken mostly by Norway, France, and UK. Preliminary numbers show 532 t in 2018, mainly due to contribution of the Norwegian trawl fleets (Table 8.8, figures 8.2 and 8.3). Although there is a continuous distribution of this species from the southern part of Division 2.a along the continental slope towards the Shetland area, stock structure is unclear in this area and these landings have therefore not been added to the total from subareas 1 and 2. Recent mark-recapture and genetic investigations indicate that the stock might have a more south and westward distribution than current ICES definition of stock boundaries (Albert and Vollen, 2015, Westgaard *et al.*, 2016).

8.1.2 ICES advice applicable to 2018 and 2019

The advice from ICES for 2018 and 2019 was as follows:

ICES advises that when the precautionary approach is applied, catches in each of the years 2018 and 2019 should be no more than 23 000 tonnes. This corresponds to a harvest rate of ≈0.039. All catches are assumed to be landed.

Additional considerations

The benchmark and data workshop process lead to an agreed analytic assessment in 2015.

A benchmark meeting (WKBUT; ICES 2013/ACOM:44) was held for the Northeast Arctic (NEA) Greenland halibut in 2013, but the benchmark process was prolonged due to problems with data.

A data workshop was conducted in November 2014 (DCWKNGHD ICES CM 2014/ACOM:65), followed by a benchmark by correspondence that ended in 2015. The assessment is reported in the benchmark by correspondence (IBPHALI; ICES CM 2015/ACOM:54) and in the stock annex.

8.1.3 Management

The 38th JRNFC's session in 2009 decided to cancel the ban against targeted Greenland halibut fishery and established the TAC at 15 000 t for the next three years (2010–2012). The 40th JRNFC Session in 2011 decided to increase the TAC for 2012 up to 18 000 t, and at the 42nd JRNFC Session in 2012, the TAC for 2013 was increased to 19 000 t. The 43rd and 44th session kept the same TAC for 2014 and 2015. For 2016 and 2017 TAC was set to 22 and 24 thousand tonnes, respectively. The TAC for 2018 was 27 thousand tonnes and is the same for 2019.

The TAC for Greenland halibut set by JNRFC applies to catches in ICES areas 1, 2.a and 2.b, except the Jan Mayen EEZ and the part of the EU EEZ which is north of 62°N.

In 2018 catches of 210 tonnes were taken in the Jan Mayen area (within ICES Area 2), where Greenland halibut fisheries are not regulated by TAC.

Norway has a quota for Greenland halibut in the EU EEZ which in recent years has been 1100 t and can be fished in ICES areas 2.a and 6. Thus this TAC is given partly within and partly outside the stock boundary. In 2017, 1000 t of this TAC was caught, assumingly mainly in ICES area 2.a. Catches in 2018 were 916 t. There is no ICES separate advice for the fishery in this area. However, this quota has previously not been reported in the advice sheet and when comparing TAC and the total catches in ICES areas 1 and 2 this should be kept in mind.

Further information on regulations is found in the stock annex.

8.1.4 Expected landings in 2018

Catches in 2018 exceeded the TAC and were 28 544 t. The total Greenland halibut landings in the Barents Sea and adjacent waters (ICES Subarea 1 and divisions 2.a and 2.b) in 2019 may thus be higher than the TAC of 27 000 t. Discards at present are not regarded as a problem.

8.2 Status of research

8.2.1 Survey results (Tables 8.9-8.13, Figures 8.4-8.11)

Survey indices from the Russian autumn survey (figures 8.4, 8.5, and 8.6), the Norwegian slope survey (figures 8.4, 8.5, 8.7, and 8.8), the Joint Ecosystem survey (Eco-juv and Eco-south indices) (figures 8.9 and 8.10) and the Joint Winter Survey are given (Figure 8.11). Length distributions from these surveys, along with the Spanish survey are presented in Tables 8.9-8.13.

The Russian bottom-trawl surveys in October-December (ICES acronym: *RU-BTr-Q4*) are important since they usually cover large parts of the total known distribution area of the Greenland halibut within 100–900 m depth. However, it has been considered imprudent to use the 2002, 2003 and 2013 data from this survey series. During the 2002 survey, no observations were available from the Exclusive Economic Zone of Norway (NEEZ). In 2003, observations on the main spawning grounds were conducted three weeks later than usual because access to NEEZ was obtained too late. 1 The number of trawl stations was also insufficient due to the same reason. Due to technical problems indices in 2013 were not obtained. Technical and practical changes were made in 2003. Length distributions by year for this survey are given in Table 8.9. The biomass indices for this survey increased steeply from 2005 to 2011, fell again until 2014, but have shown a steep increase since then (figures 8.4 and 8.5).

Total biomass indices from the Norwegian autumn slope survey (ICES acronym: *NO-GH-Btr-Q3*) showed an upward trend in biomass estimates between 1994 and 2003, then a downward trend until 2008 until it increased again in 2009 but levelled out again in 2011, 2013, and 2015 (figures 8.4, 8.5, and 8.7). The index for 2017 is the lowest since the start of the survey. The length distributions from this survey show mode that can be followed through the years with a marked change between 2006 and 2007 (Figure 8.12, Tables 8.10 and 8.11). This survey was conducted every year 1994—2009 but is now run biennially.

The Joint Ecosystem Survey covers a large part of the Barents Sea down to 500 m and concerning Greenland halibut it can be regarded to be in the areas where mainly juveniles and immature fish are found. Two indices for Greenland halibut are based on the Joint Ecosystem Survey in the Barents Sea and previous juvenile survey, one for juvenile areas (Figure 8.9) denoted Eco-juv index in the northernmost survey area, and another denoted Eco-south index for adults defined by the survey area south from 76.5°N and in addition west of Spitsbergen (Figure 8.10). The juvenile index indicates a highly variable recruitment success with years between good year classes. The 2015 and 2016 estimates are the lowest registered so far, followed by a large increase in 2017. The 2018 estimate, however, dropped down to the 2016 level. The Eco-south index for females showed an increasing trend towards 2012, followed by a decrease towards 2015. The index has since then shown an increasing trend. The male index shows a similar trend except the increase started a year later, in 2016. Length distributions by year for this survey are given in Table 8.12.

The Spanish bottom-trawl survey from 1997 to 2005 (Table 8.13, Figure 8.13), ICES acronym: *SP-Svalbard-Q4,* from 2008 the Spanish autumn survey is carried out on a new hired commercial trawler vessel and some changes have been done in the initial standard protocol. One of the most important changes is the increase of the bridle's length now being 300 m instead of 175 m before 2008. This new feature increased the swept-area in the trawl stations making the comparison of the biomass and abundance index before and after 2008 difficult. In Basterretxea *et al.* (WD13 2013) an attempt is made to standardize survey indices for Greenland halibut in earlier Spanish surveys (1997–2005) with recent surveys (2008–2012). The conclusion is that it is considered not possible to obtain a reliable standardization of the surveys. This means that the Spanish index from the survey in autumn is available for years 2008, 2010 and 2012–2014. The Spanish survey is now alternately run every other year in spring and autumn. No new information on the Spanish survey was presented to the meeting.

Polish bottom-trawl surveys on Greenland halibut were carried out in the Svalbard-Bear Island area (ICES 2.b) in October 2006, April 2007, April 2008, June 2009, and March 2011. The main objectives of the survey are to determine the biological structure, distribution, density and standing biomass of Greenland halibut in the survey area (Trella and Janusz, WD6 ICES AFWG 2012).

Polish survey index is shown in Figure 8.14, no new data were available to the meeting.

8.2.2 Commercial catch-per-unit-effort (Table 8.6)

The CPUE series for the stock has been a subject to the benchmark and following data workshops (see reports from WKBUT 2013, DCWKNGHD 2014 and IBPHALI 2015, and working documents by Bakanev (WD14 WKBUT 2013) and Nedreaas (WD 2 DCWKNGHD 2014)). An alternative CPUE series for the Russian fisheries for the years 2004–2015 was presented to the 2016 meeting (Mikhaylov, WD14 ICES AFWG 2016). It shows some discrepancy compared to previous CPUE series used for the Russian fisheries for the same years.

8.2.3 Age readings

Based on the scientific understanding that the species is more slow growing and vulnerable than the previous age readings suggest, the Norwegian age reading methods were changed in 2006. The new Norwegian age readings are not comparable with older data or the Russian age readings.

The report from Workshop on Age Reading of Greenland Halibut (WKARGH) 14—17 February 2011 (ICES CM 2011/ACOM:41) described and evaluated several age reading methods for Greenland Halibut.

The different methods can be classified into two groups: A) Those that produce age–length relationships that broadly compare with the traditional methods described by the joint NAFO-ICES workshop in 1996 (ICES CM 1997/G:1); and B) Several recently developed techniques that show much higher longevity and approximately half the growth rate from 40–50 cm onwards compared to the traditional method.

A second workshop on age reading of Greenland halibut (WKARGH 2) was conducted in August 2016 and worked on further validation on new age reading methods. The workshop recommended that two of the new methods can be used to provide age estimations for stock assessments. Further, recognizing some bias and low precision in methods, the WKARGH2 suggested that an ageing error matrix or growth curve with error be provided for use in future stock assessments (WKARGH2 report 2016, ICES CM 2016/SSGIEOM:16).

WKARGH2 recommends regular interlab calibration exercises to improve precision (i.e. exchange of digital images between readers for each method and between methods). AFWG suggests that Russian and Norwegian scientist and age readers meet to work out issues of disagreements on Greenland halibut aging.

8.3 Data used in the assessment

For the Gadget model, catch data have been split into four aggregated fleets. Longline/gillnet fleet includes landings from gillnet, longline, and handline. Trawl fleet includes landings from bottom trawl, purse-seine and Danish seine. Catch in tonnes and length distributions per quarter per fleet per sex were used from 1992–2018 for tuning the model. Fleets were split between Norwegian (with 3rd countries) and Russian catches, and selectivities were allowed to vary by sex (logistic for gill fleets, asymmetric dome-shaped for trawl fleets), to account for sexually dimorphism influencing vulnerability to fishing. For each fleet listed below, length distributions and reported catch in tonnes were available split by quarter and sex (although length distributions were not available for all quarters for some fleets).

- Russian, trawl and minor gears (split by sex)
- Russian, gillnet and longline (split by sex)
- Norwegian and 3rd countries, trawl and minor gears (split by sex)
- Norwegian and 3rd countries, gillnet and longline (split by sex)

In addition, the model has four surveys, all modelled with asymmetric dome-shaped selectivities (note that in a model context “selectivity” encompasses all aspects of vulnerability to the fishery, including gear effects, vessel effects, area effects etc.). In each case data are used as length distribution and biomass index. The biomass index was not available split by sex for all years, so a combined sex index is used. Four indices go into the current assessment:

- Norway slope – based on the Norwegian Greenland halibut slope survey *(NO-GH-Btr-Q3)* (yearly 1996–2009, biennially since then). Split by sex.

- EcoJuv - a juvenile index based on data from the northern/eastern areas of the Joint Ecosystem survey (Eco-NoRu-Q3 (Btr)) (2003–present) and the precursory Norwegian juvenile Greenland halibut survey north and east of Svalbard (1996—2002) (Hallfredsson and Vollen, WD 1 ICES IBPhali 2015). Split by sex.
- EcoSouth - an index for the Barents Sea south of 76.5°N, based on data from the Joint Ecosystem survey (Eco-NoRu-Q3 (Btr) (2003—present) (Hallfredsson and Vollen, ICES AFWG, WD 20, April 2015). Split by sex.
- Russian - Russian bottom-trawl survey in the Barents Sea (*RU-Btr-Q4*) (1992-2015 and 2017). Sex aggregated (can be split by sex in future work).

No age data or CPUE indices are used in the tuning.

Issues with 2019 assessment data

Landings data in 2019 assessment, compared to data in 2017 assessment:

- Revision of minor discrepancies between the datasets after 2005.
- Implemented revision of split between fleets in Russian data in 2014.
- Implemented revision of split between fleets, and total catch, for Russian data in 2013 and 2016
- Revision "other nations" catch in 2015 and 2016 (preliminary in 2017)

Most of these changes were minor and did not affect the assessment noteworthy. The changes in "other nations" catches were more substantial as it added 1334 t to the total catches in 2016, and in turn to the "Norwegian and 3rd countries" indices.

Survey data in 2019 assessment, compared to data in 2017 assessment:

- EcoJuv and EcoSouth indices (Both based on the Barents Sea Ecosystem Survey)
  - Challenges related to new database solution at IMR
  - Problems with sex-split of G. halibut, especially in 2016-2018

IMR has been moving data from the old SPD format to the new S2D database. During this process some data problems have submerged concerning Greenland halibut data in the Barents Sea Ecosystem survey, both adaption to new format and minor errors in the old data. This has been corrected as good as possible at the current stage (Working Documents 19 and 20). The difference does not affect the assessment in any major way.

The number of sexed length samples of Greenland halibut in the Barents Sea Ecosystem survey in autumn has been gradually decreasing year by year, especially in the area that defines the EcoSouth index (Figure 8.15), and consequently, the proportion sexed of the total catch. Additionally, experience shows that sex identification is uncertain for G. halibut below 20 cm in length, and a substantial part of the attempted sex identification is not successful. Regarding the index in the juvenile area (EcoJuv) expectation is that the ratio between males and females should be 50/50, and available data confirm this assumption (Figure 8.16). Thus, as a solution for the data input for EcoJuv index in the 2019 assessment, it was decided to use 50/50 male-female split for all years. For the EcoSouth index, a sex-split was constructed based on all available data from the survey in the EcoSouth area (Figure 8.17). This will smooth out the proportion of each sex by year in the index, but the trend in proportion females seems to be similar between new and old index (Figure 8.18)

The lack of biological samples also introduced difficulties in the split of biomass between sexes in the Ecosystem survey data. To solve this a length-weight relationship was established based on all available data on Greenland halibut in the IMR database (Figure 8.19).

The changes introduce some discrepancies between old and new calculations of the index (figures 8.9 and 8.10). This is reflected in the biomass estimate of the Gadget model (see section 8.5).

The sex identification issue in the Ecosystem survey needs to be addressed in future.

8.4 Methods used in the assessment

New assessment method with a length-based GADGET model was benchmarked in 2015 (IPHALI 2015) and accepted by ACOM the same year. The model is further described in the IPHALI report and in the stock annex.

8.4.1 Model settings

Model used: Gadget (see ICES, 2015).

Time period: 1992–2018, monthly time-steps

Model structure:

- 1 cm length classes (1—114+ cm) and 1-year age classes (1—30+)
- Two sexes, split into mature and immature
- Logistic maturity estimated for each sex
- Von Bertanlanffy growth estimated separately for males and females
- L-W relationship fixed based on data from the Norwegian slope (Females: a = 1.4E-6 and b = 3.47. Males: a = 5.7E-6 and b = 3.12)
- Natural mortality set to 0.1 for all fish
- Initial size of recruits fixed at 8.5 cm (necessary to fix this in the absence of age data)
- Recruitment modelled as annual numbers, no relationship with SSB
- Four aggregated fleets (as described above), each with sex-specific selectivity (logistic for gill fleets, asymmetric dome-shaped for trawl)
- Four surveys (as described above), all with asymmetric dome-shaped selectivity

Note that in order to avoid the problem of modelled fish not covered by any fleet (and therefore not tuned to any data) the gillfleets have been assumed to have logistic (flat topped) selectivity.

Estimated parameters:

L_{50} and slope for the maturation (male and female separately), two growth parameters per sex, two maturation parameters per sex, one annual recruitment parameter per year, two parameters for s.d. of length of recruits, parameters governing commercial selectivity (two per sex per gillfleet and three per sex per trawlfleet), one effort parameter per year for each fleet, three parameters per survey per sex governing selectivity, initial population numbers for male and female fish by age, initial population s.d. of lengths by sex and age

Data used for tuning are:

- Quarterly length distribution of the landings from commercial fishing fleets (by sex)
- Quarterly catch in tonnes for each fleet (by sex)
- Length disaggregated survey indices from the four surveys (by sex except for the Russian survey)
- Overall survey index (by biomass) for the four surveys (by sex except for the Russian survey)
- Estimated maturity ogives (maturity at length in the population) for 1992—2014 (by sex)

Note that no age data are used in tuning the model. Although age readings are available for some years there is not a full agreement on which age-reading methodology should be used, and these data are thus not suiTable for inclusion in an assessment model yet.

Concerning the recruitment, it should be noted that age 1 is the age for recruitment to the stock, NOT the age for recruitment to the fishery, which is the quantity normally used to describe recruitment. But since age 1 recruitment is the quantity estimated by the model and the age of recruitment to the fishery can't be defined due to lack of age data, we use age 1 as the recruitment age for this stock. Even if adequate age data were available, the strong sexual dimorphism in growth would make it very difficult to define an appropriate recruitment age.

8.5 Results of the Assessment

The assessment is conducted every two years and advice is to be given this year for catches in 2020 and 2021. Model results are shown in figures 8.20 and 8.21, and Table 8.14. The stock abundance and biomass are presented for fish larger than 45 cm, this corresponds to the minimum legal size and is slightly larger than L_{50} maturity for males. Both 45 cm+ abundance and biomass peaks ca in 2013-2014 and show a slow downward trend since then. There is a retrospective trend to reduce the stock estimate over time. However, the last 4 years of the retrospective for the 45cm+ biomass are very consistent (Figure 8.22). The modelled recruitment is spiky (Figure 8.21), and it is likely that this is exaggerated due to the lack of age data. However, although the real recruitment is likely more spread out, the modelled peaks show reasonably good agreement to the data from the juvenile survey. This stock is dominated by sporadic recruitment events, and the model does a reasonable job of capturing this. The model has been consistently estimating reasonably good recruitment in 2010, which should be entering the fishery in the coming years.

Biological reference points

The last observed year with good recruitment occurred in 1995 at 487 000 tonnes fishable (45+ cm) biomass. There is evidence (in the estimated initial population for the assessment model) that an earlier good recruitment event occurred in the 1980s from lower biomass, but the exact biomass level is unknown as this is before the model period. The precautionary reference point is therefore taken at 487 000 tonnes, with a note that this is likely to be on the high (precautionary) side. Using 45+ cm biomass (rather than total or female SSB) avoids uncertainty around maturation sizes and the different distributions of males and females, and relates directly to the fishable stock, but does not directly relate to the most vulnerable or critical female SSB.

Further work is planned on biological reference points.

8.5.1 NEA Greenland halibut surplus production models

Results of the assessment of the Barents Sea Greenland halibut stock based on a Bayesian surplus production model was provided by Bakanev in 2013, (WKBUT WD 14). Different sets of abundance indices were used for tuning the model. The analysis of model run results has shown that K is estimated within the range of 810 to 1139 kilotonnes, B_{MSY} of 405 to 570 kilotonnes and MSY of 23 to 47 kilotonnes. However, the model was sensitive to the choice of prior on K. Taking into consideration a high probability of the stock size being at the level which was quite a bit above B_{MSY}, the risk of the biomass being below this optimal one was very small in 2002–2012 (<1%). The risk analysis of the stock size in the prediction years (2013–2020) under the catch of 0 to 30 kilotonnes indicated that probability of the stock size being under the threshold levels (B_{MSY}, B_{lim}) was also minor (less than 1%). It was concluded that further work was needed on historical CPUE series. Based on scrutiny of the CPUE series it was recommended to examine runs with the surplus production model for the period 1964—1991 and 1964—2005, in addition to runs for the whole 1964—2013 period. Fisheries CPUE series were considered less reliable to reflect stock dynamics than survey indices in the period after regulations of the fishery were introduced in 1992. The Bayesian surplus model was not updated for presentation at the current meeting.

A production model was presented to the 2016 meeting (Mikhaylov, 2016, WD 14), although this model has not been reviewed at a benchmark, nor were biomass trends presented at this meeting. The model has been proposed as a possible method for estimation of long-term reference points. An update was presented to the meeting (Working Document21). In the current version, the MSY would be around 34 ktonnes, the BMSY around 500 ktonnes and F_{MSY} on the level 0.069. It should be noted that these values are not directly transferable to a different model with different biomass levels and in any case a long-term average. The WD concludes that, in general, the stock can withstand the current fishing load and the fishing regime is approaching optimum, indicating that the results of the exploratory surplus production model are in general alignment with the assessment and advice presented here.

F_{MSY} is not appropriate to this stock given the recent extended run of poor recruitment, and such values have not been evaluated for precautionarity. In a plenary, it was concluded that it would be useful for further development of the production model to conduct separate exploratory runs for CPUE split into before and after 1992 and run with CPUE only before 1992 and survey data. This production model was not updated for presentation at the current meeting.

At the 2018 meeting, AFWG results from SPiCT production model was presented (AFWG report 2018). In the run that is presented in this report, all available data up to 2016 were used. For run with default priors applied K = 995 421 t and deterministic reference points were B_{MSY} = 419 955 t, F = 0.07 and MSY = 29 742 t. Stochastic reference points for this run were in a similar range. Run with default priors deactivated gives similar MSY estimate but otherwise rather different estimates; K = 2 504 006, B_{MSY} = 609 410 t, F = 0.05 and MSY = 28 097 t. Further utilization of this approach demands closer scrutiny of model settings in relation to diagnostics. The SPiCT model can be a flexible tool to examine production model approach to G. halibut, however, concerns highlighted below still apply.

In principle, a production model could be used in conjunction with the GADGET assessment model in order to extend the simulations back in time and provide better estimates for B_{lim}. However, the inability of production models to follow variable recruitment, and especially runs of above or below average recruitment, limits their ability to give advice for this stock.

In the benchmark report (IBPHALI 2015) Table 3.3 gives CPUE series and survey estimates that can be helpful for this task (Table 8.15, Figure 8.23).

8.6 Comments to the assessment

The ongoing reduction in sex-split length samples in two survey indices, EcoJuv and EcoSouth required a change in methodology for computing the tuning indices used in the assessment. This increased the absolute biomass estimates about 10% but did not affect the trend in biomass through years (figures 8.20, 8.24 and 8.25). This change has also acted to reduce the retrospective pattern in recent years, likely as a result of the model no longer chasing noise in the data. We stress once again that the absolute biomass levels for this model are rather uncertain. Without age data in the model tuning there is little information on total mortality (Z) at age (number-at-age x in year y minus number-at-age x-1 in year y-1 gives information on Z). Without this, there is little information for the model to translate catch information into F, and hence inform biomass levels. Furthermore, the conflicting survey signals translate into an uncertainty range of several hundred thousand tonnes (IBPHALI 2015). All the exploratory work suggests that the overall trends are robust, but that care should be taken in interpreting the absolute abundance estimates (and hence absolute estimates of harvest rate).

Although there is little retrospective pattern over the last four years, the model exhibits a retrospective pattern in earlier years associated with the biomass peak around 2014 (Figure 8.22). The two coastal shelf surveys (the ecosystem survey and the Russian surveys) showed a more rapid rise than the other surveys, and then a more rapid reduction. The Russian survey had a very rapid rise and then a rapid decline. The model, therefore, had a series of downward revisions as the peak has been passed, where the model now estimates that it had previously been over-optimistic about the size of the peak. It should be noted (ICES IBPHALI REPORT 2015; ICES CM 2015\ACOM:54) that there is an issue with this stock where different surveys give different signals and choosing one survey over the others could affect the biomass level by several hundred thousand tonnes. Given this, a retrospective pattern is probably to be expected as the different surveys evolve. Note also that one of the surveys is run every two years (in odd-numbered years), this accounts for the grouping of lines in the retrospective pattern into pairs.

To facilitate calculation of spawning-stock biomass, maturity ogives from the Norwegian Slope survey were derived for years 1994–2015. These ogives give approximately identical length at 50% maturation (L_{50}) for males compared L_{50} based on Russian fisheries data (figures 8.27-8.30). L_{50} for females is higher in the Norwegian data due to new definition on when females are considered mature/immature in accordance to resent research (Kennedy *et al.*, 2009, 2011 and 2014, Nunez *et al*., 2015). GLM fitted ogives can be used in future assessment.

Future work

Further development of the assessment is needed and, in consistency with conclusions of the IBPHALI benchmark and report of the external benchmark reviewer.

AFWG suggest a new benchmark on the stock in 2022, and intersessional work will commence on a possible issues list. Such a benchmark, especially if it can extend the model back in time to a period of lower stock biomass, would allow a more accurate determination of precautionary biomass reference points. It would, therefore, be a precursor to a potential MSE to generate an HCR for this stock and move away from precautionary advice.

Table 8.1. GREENLAND HALIBUT in subareas 1 and 2. Nominal Catch (t) by countries (Subarea I, divisions 2.a, and 2.b combined) as officially reported to ICES.

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	138	2165	0	0	0	0	0	4376	0	0	15 181	0	0	23	0	21 883
1985	0	0	0	239	4000	0	0	0	0	0	5464	0	0	10 237	0	0	5	0	19 945
1986	0	0	42	13	2718	0	0	0	0	0	7890	0	0	12 200	0	0	10	2	22 875
1987	0	0	0	13	2024	0	0	0	0	0	7261	0	0	9733	0	0	61	20	19 112
1988	0	0	186	67	744	0	0	0	0	0	9076	0	0	9430	0	0	82	2	19 587
1989	0	0	67	31	600	0	0	0	0	0	10 622	0	0	8812	0	0	6	0	20 138
1990	0	0	163	49	954	0	0	0	0	0	17 243	0	0	4764	0	0	10	0	23 183
1991	11	2564	314	119	101	0	0	0	0	0	27 587	0	0	2490	132	0	0	2	33 320
1992	0	0	16	111	13	13	0	0	0	0	7667	0	31	718	23	0	10	0	8602
1993	2	0	61	80	22	8	56	0	0	30	10 380	0	43	1235	0	0	16	0	11 933
1994	4	0	18	55	296	3	15	5	0	4	8428	0	36	283	1	0	76	2	9226
1995	0	0	12	174	35	12	25	2	0	0	9368	0	84	794	1106	0	115	7	11 734
1996	0	0	2	219	81	123	70	0	0	0	11 623	0	79	1576	200	0	317	57	14 347
1997	0	0	27	253	56	0	62	2	0	0	7661	12	50	1038	157	0	67	25	9410
1998	0	0	57	67	34	0	23	2	0	0	8435	31	99	2659	259	0	182	45	11 893
1999	0	0	94	0	34	38	7	2	0	0	15 004	8	49	3823	319	0	94	45	19 517
2000	0	0	0	45	15	0	16	1	0	0	9083	3	37	4568	375	0	111	43	14 297
2001	0	0	0	122	58	0	9	1	0	0	10 896	2	35	4694	418	0	100	30	16 365
2002	0	219	0	7	42	22	4	6	0	0	7143	5	14	5584	178	0	41	28	13 293
2003	0	0	459	2	18	14	0	1	0	0	8216	5	19	4384	230	0	41	58	13 447
2004	0	0	0	0	9	0	9	0	0	0	13 939	1	50	4662	186	0	43	0	18 899
2005	0	170	0	32	8	0	0	0	0	0	13 011	0	23	4883	660	0	29	18	18 834
2006	0	0	204	46	8	0	8	0	0	196	11 119	201	26	6055	29	0	10	2	17 904
2007	0	0	203	41	8	198	15	0	0	0	8230	200	47	6484	8	0	11	8	15 453
2008	0	0	663	42	5	0	28	0	0	0	7393	201	46	5294	94	0	16	10	13 792

Year	Denmark	Estonia	Faroe Islands	France	Fed. Rep. Germany	Greenland	Iceland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
2009	0	0	422	16	19	16	15	2	0	0	8446	204	237	3335	210	0	9	60	12 990
2010	0	0	272	102	14	15	16	0	0	0	7700	3	11	6888	182	0	4	22	15 229
2011	0	0	538	46	80	4	7	0	0	234	8270	169	21	7053	144	0	36	4	16 606
2012	0	0	564	40	40	12	13	0	0	0	9331	22	1	10 041	190	0	21	14	20 288
2013	0	0	783	168	49	22	106	1	0	0	10 403	30	7	10 310	196	0	17	75	22 167
2014	0	0	887	269	33	20	86	0	0	0	11 232	19	0	10 061	206	0	28	184	23 025
2015	0	0	312	227	33	14	53	0	0	5	10 874	13	1	12 953	159	0	25	79	24 748
2016	0	359	483	229	9	17	79	0	0	0	12 932	8	19	10 576	198	0	20	19	24 948
2017	0	523	917	177	21	26	10	0	1	72	13 741	27	13	10 714	56	0	83	0	26 380
2018*	2	574	409	150	51	32	0	0	4	177	14 874	27	6	12 072	60	108	0	0	28 544

* **Provisional figures.**

Table 8.2. GREENLAND HALIBUT in subareas 1 and 2. Nominal catch (t) by countries in Subarea 1 as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Latvia	Lithuania	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
1984	0	0	0	0	0	0	0	0	0	593	0	0	81	0	0	17	0	691
1985	0	0	0	0	0	0	0	0	0	602	0	0	122	0	0	1	0	725
1986	0	0	1	0	0	0	0	0	0	557	0	0	615	0	0	5	1	1179
1987	0	0	2	0	0	0	0	0	0	984	0	0	259	0	0	10	0	1255
1988	0	9	4	0	0	0	0	0	0	978	0	0	420	0	0	7	0	1418
1989	0	0	0	0	0	0	0	0	0	2039	0	0	482	0	0	0	0	2521
1990	0	7	0	0	0	0	0	0	0	1304	0	0	321	0	0	0	0	1632
1991	164	0	0	0	0	0	0	0	0	2029	0	0	522	0	0	0	0	2715
1992	0	0	0	0	0	0	0	0	0	2349	0	0	467	0	0	0	0	2816
1993	0	32	0	0	0	0	0	56	0	1754	0	0	867	0	0	0	0	2709
1994	0	17	217	0	0	0	0	15	0	1165	0	0	175	0	0	0	0	1589
1995	0	12	0	0	0	0	0	25	0	1352	0	0	270	84	0	0	0	1743
1996	0	2	0	0	0	0	0	70	0	911	0	0	198	0	0	0	0	1181
1997	0	15	0	0	0	0	0	62	0	610	0	0	170	0	0	0	0	857
1998	0	47	0	0	0	0	0	23	0	859	0	0	491	0	0	2	0	1422
1999	0	91	0	0	0	0	13	7	0	1101	0	0	1203	0	0	0	0	2415
2000	0	0	0	0	0	0	0	16	0	1021	0	0	1169	0	0	0	0	2206
2001	0	0	0	0	0	0	0	9	0	925	0	0	951	0	0	2	0	1887
2002	0	0	3	0	0	0	0	0	0	834	0	0	1167	0	0	0	0	2004
2003	0	48	0	0	0	0	2	0	1	962	1	0	735	0	0	0.3	0	1749
2004	0	0	0	0	0	0	0	0.3	0	866	0	0	633	0	0	3	0	1503
2005	0	0	0	1	0	0	0	0	0	572	0	0	595	0	0	3	0	1171
2006	0	17	1	0	0	0	0	1	0	575	0	0	626	2	0	2	0	1224
2007	0	18	0	1	0	0	198	3	0	514	0	3	438	0	0	4	0	1179
2008	0	13	0	1	0	0	0	5	0	599	0	0	390	0	0	0	0	1008
2009	0	33	0	0	0	0	16	5	0	734	0	0	483	0	0	1	0	1272

Year	Estonia	Faroe Islands	Fed. Rep. Germany	France	Latvia	Lithuania	Greenland	Iceland	Ireland	Norway	Poland	Portugal	Russia[3]	Spain	GB	UK (England & Wales)	UK (Scot land)	Total
2010	0	15	0	0	0	0	0	16	0	659	0	0	708	2	0	0	0	1399
2011	0	63	0	0	0	0	0	6	0	867	0	0	782	0	0	0	0	1718
2012	0	8	5	0	0	0	0	7	0	921	0	0	1368	1	0	7	0	2318
2013	0	39	1	8	0	0	0	100	0	1055	4	0	1442	4	0	8	0	2661
2014	0	143	8	11	0	0	19	38	0	1271	7	0	1261	10	0	14	0	2782
2015	0	96	14	3	0	5	12	47	0	1424	5	0	1681	8	0	4	0	3299
2016	353	84	2	3	0	0	3	38	0	1265	7	0	1172	7	0	20	0	2954
2017	519	125	4	4	1	72	2	8	0	1389	9	1	1124	13	0	21	0	3293
2018*	574	111	9	6	0	169	2	0	0	1008	4	1	1083	2	97	0	0	3076

* **Provisional figures.**

Table 8.3. GREENLAND HALIBUT in subareas 1 and 2. Nominal catch (t) by countries in Division 2a as officially reported to ICES.

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Lithuania	Greenland	Ireland	Iceland	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
1984	0	0	265	138	0	0	0	0	3703	0	0	5459	0	0	1	0	9566
1985	0	0	254	239	0	0	0	0	4791	0	0	6894	0	0	2	0	12 180
1986	0	6	97	13	0	0	0	0	6389	0	0	5553	0	0	5	1	12 064
1987	0	0	75	13	0	0	0	0	5705	0	0	4739	0	0	44	10	10 586
1988	0	177	150	67	0	0	0	0	7859	0	0	4002	0	0	56	2	12 313
1989	0	67	104	31	0	0	0	0	8050	0	0	4964	0	0	6	0	13 222
1990	0	133	12	49	0	0	0	0	8233	0	0	1246	0	0	1	0	9674
1991	1400	314	21	119	0	0	0	0	11189	0	0	305	0	0	0	1	13 349
1992	0	16	1	108	0	13	0	0	3586	0	15	58	0	0	1	0	3798
1993	0	29	14	78	0	8	0	0	7977	0	17	210	0	0	2	0	8335
1994	0	0	33	47	0	3	4	0	6382	0	26	67	0	0	14	0	6576
1995	0	0	30	174	0	12	2	0	6354	0	60	227	0	0	83	2	6944
1996	0	0	34	219	0	123	0	0	9508	0	55	466	4	0	278	57	10 744
1997	0	0	23	253	0	0	0	0	5702	0	41	334	1	0	21	25	6400
1998	0	0	16	67	0	0	1	0	6661	0	80	530	5	0	74	41	7475
1999	0	0	20	0	0	25	2	0	13064	0	33	734	1	0	63	45	13 987
2000	0	0	10	43	0	0	0	0	7536	0	18	690	1	0	65	43	8406
2001	0	0	49	122	0	0	1	9	8740	0	13	726	5	0	56	30	9751
2002	0	0	9	7	0	22	0	4	5877	0	3	849	0	0	12	28	6811
2003	0	390	5	2	0	12	0	0	6713	0	10	1762	14	0	5	58	8971
2004	0	0	4	0	0	0	0	9	11704	0	24	810	4	0	1	0	12 556
2005	0	0	3	31	0	0	0	0	11216	0	11	1406	0	0	5	18	12 690
2006	0	175	0	38	0	0	0	7	8897	0	6	950	0	0	6	2	10 081
2007	0	162	2	37	0	0	0	12	6761	0	2	489	1	0	2	8	7475
2008	0	646	4	38	0	0	0	23	5566	1	1	1170	0	0	6	10	7465
2009	0	379	0	13	0	0	0	10	6456	0	9	1531	0	0	0	60	8459

Year	Estonia	Faroe Islands	Fed. Rep. Germ.	France	Lithuania	Greenland	Ireland	Iceland	Norway	Poland	Portugal	Russia[5]	Spain	GB	UK (Engl. & Wales)	UK (Scot-land)	Total
2010	0	255	0	102	0	15	0	0	6426	0	0	4757	0	0	0	22	11 577
2011	0	467	0	45	0	4	0	1	6637	0	0	3643	2	0	0	4	10 803
2012	0	553	0	37	0	12	0	6	7934	0	0	3878	0	0	0	14	12 434
2013	0	739	0	150	0	22	0	6	8215	0	2	4143	0	0	0	75	13 352
2014	0	741	0	255	0	1	0	48	8640	0	0	4800	0	0	0	184	14 669
2015	0	215	2	221	0	2	0	6	8166	0	1	3691	0	0	0	79	12 383
2016	6	380	6	216	0	14	0	41	10073	0	6	1797	7	0	0	19	12 566
2017	0	773	0	161	0	20	0	2	10122	0	7	1852	1	0	16	0	12 955
2018*	0	297	1	104	1	21	0	0	11255	2	5	1399	0	5	0	0	13 092

* **Provisional figures.**

Table 8.4. GREENLAND HALIBUT in subareas 1 and 2. Nominal catch (t) by countries in Division 2b as officially reported to ICES.

Year	Denmark	Estonia	Faroe Islands	France	Fed. rep. Germ.	Greenland	Ireland	Latvia	Lithuania	Norway	Poland	Portugal	Russia[4]	Spain	GB	UK (Engl. & Wales)	UK (Scot land)	Total
1984	0	0	0	0	1900	0	0	0	0	80	0	0	9641	0	0	5	0	11 626
1985	0	0	0	0	3746	0	0	0	0	71	0	0	3221	0	0	2	0	7040
1986	0	0	36	0	2620	0	0	0	0	944	0	0	6032	0	0	0	0	9632
1987	0	0	0	0	1947	0	0	0	0	572	0	0	4735	0	0	7	10	7271
1988	0	0	0	0	590	0	0	0	0	239	0	0	5008	0	0	19	0	5856
1989	0	0	0	0	496	0	0	0	0	533	0	0	3366	0	0	0	0	4395
1990	0	0	23	0	942	0	0	0	0	7706	0	0	3197	0	0	9	0	11 877
1991	11	1000	0	0	80	0	0	0	0	14 369	0	0	1663	132	0	0	1	17 256
1992	0	0	0	3	12	0	0	0	0	1732	0	16	193	23	0	9	0	1988
1993	2	0	0	2	8	0	0	0	30	649	0	26	158	0	0	14	0	889
1994	4	0	1	8	46	0	1	0	4	881	0	10	41	1	0	62	2	1061
1995	0	0	0	0	5	0	0	0	0	1662	0	24	297	1022	0	32	5	3047
1996	0	0	0	0	47	0	0	0	0	1204	0	24	912	196	0	39	0	2422
1997	0	0	12	0	33	0	2	0	0	1349	12	9	534	156	0	46	0	2153
1998	0	0	10	0	18	0	1	0	0	915	31	19	1638	254	0	106	4	2996
1999	0	0	3	0	14	0	0	0	0	839	8	16	1886	318	0	31	0	3115
2000	0	0	0	2	5	0	1	0	0	526	3	19	2709	374	0	46	0	3685
2001	0	0	0	0	9	0	0	0	0	1,231	2	22	3017	413	0	42	0	4736
2002	0	219	0	0	30	0	6	0	0	432	5	11	3568	178	0	29	0	4478
2003	0	0	21	0	13	0	0	0	0	541	4	9	1887	216	0	35	0	2726
2004	0	0	0	0	5	0	0	0	0	1369	1	26	3219	182	0	39	0	4840
2005	0	170	0	0	5	0	0	0	0	1223	0	12	2882	660	0	21	0	4973
2006	0	0	12	8	7	0	0	0	196	1647	201	20	4479	27	0	2	0	6600
2007	0	0	23	3	6	0	0	0	0	955	200	45	5557	7	0	5	0	6801
2008	0	0	4	3	1	0	0	0	0	1228	200	45	3734	94	0	10	0	5319
2009	0	0	10	3	19	0	2	0	0	1256	204	228	1321	210	0	8	0	3260

2010	0	0	2	0	14	0	0	0	0	615	3	11	1423	180	0	4	0	2252
2011	0	0	8	1	80	0	0	0	234	766	169	21	2628	142	0	36	0	4085
2012	0	0	2	3	35	0	0	0	0	476	22	1	4795	189	0	14	0	5537
2013	0	0	5	10	48	0	1	0	0	1133	26	5	4725	192	0	9	0	6154
2014	0	0	3	3	25	0	0	0	0	1321	12	0	4000	196	0	14	0	5574
2015	0	0	1	3	17	0	0	0	0	1284	8	0	7581	151	0	21	0	9066
2016	2	0	19	10	1	0	0	0	0	1594	1	13	7608	183	0	0	0	9431
2017	0	4	19	12	17	3	0	0	0	2230	17	5	7737	42	0	46	0	10 132
2018*	2	0	1	30	40	9	0	4	6	2611	21	0	9590	58	6	0	0	12 376

*** Provisional figures.**

Table 8.5. GREENLAND HALIBUT in subareas 1 and 2. Landings by gear (tonnes). Approximate figures, the total maty differs slightly from Table 8.1.

Year	Gillnet	Longline	Trawl	Danish seine	Other
1980	1189	336	11 759	-	-
1981	730	459	13 829	-	-
1982	748	679	15 362	-	-
1983	1648	1388	19 111	-	-
1984	1200	1453	19 230	-	-
1985	1668	750	17 527	-	-
1986	1677	497	20 701	-	-
1987	2239	588	16 285	-	-
1988	2815	838	15 934	-	-
1989	1342	197	18 599	-	-
1990	1372	1491	20 325	-	-
1991	1904	4552	26 864	-	-
1992	1679	1787	5787	-	-
1993	1497	2493	7889	-	-
1994	1403	2392	5353	-	-
1995	1500	4034	5494	-	-
1996	1480	4616	7977	-	-
1997	998	3378	5198	-	-
1998	1327	7395	6664	-	-
1999	2565	6804	10 177	-	-
2000	1707	5029	7700	-	-
2001	2041	6303	7968	-	-
2002	1737	5309	6115	-	-
2003	2046	5483	6049	-	-
2004	2290	7135	8778	599	-
2005	1842	7539	9420	447	-
2006	1503	6146	10 042	205	-
2007	997	4503	9618	119	-

Year	Gillnet	Longline	Trawl	Danish seine	Other
2008	901	3575	9285	9	8
2009	1409	4952	6583	34	18
2010	1449	5427	8165	170	10
2011	1583	5039	9351	239	15
2012	1929	5602	12 130	413	5
2013	2398	5805	13 791	176	0
2014	2647	6166	13 673	183	0
2015	2508	6287	15 445	489	18
2016	2646	7290	14 333	650	304
2017	2677	7221	15 774	679	29
2018*	3021	6542	17 367	842	20

Table 8.6. GREENLAND HALIBUT in subareas 1 and 2. Catch per unit of effort and total effort.

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1965	0.80	-	-	-	0.80	-	-	-	-
1966	0.77	-	-	-	0.77	-	-	-	-
1967	0.70	-	-	-	0.70	-	-	-	-
1968	0.65	-	-	-	0.65	-	-	-	-
1969	0.53	-	-	-	0.53	-	-	-	-
1970	0.53	-	-	-	0.53	-	169	0.50	-
1971	0.46	-	-	-	0.46	-	172	0.43	-
1972	0.37	-	-	-	0.37	-	116	0.33	-
1973	0.37	-	0.34	-	0.36	-	83	0.36	-
1974	0.40	-	0.36	-	0.38	-	100	0.36	-
1975	0.39	0.51	0.38	-	0.39	0.45	99	0.37	-
1976	0.40	0.56	0.33	-	0.37	0.45	100	0.34	-
1977	0.27	0.41	0.33	-	0.30	0.37	96	0.26	-

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total effort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
1978	0.21	0.32	0.21	-	0.21	0.27	123	0.17	-
1979	0.23	0.35	0.28	-	0.26	0.32	67	0.19	-
1980	0.24	0.33	0.32	-	0.28	0.33	47	0.25	-
1981	0.30	0.36	0.36	-	0.33	0.36	42	0.28	-
1982	0.26	0.45	0.41	-	0.34	0.43	39	0.37	-
1983	0.26	0.40	0.35	-	0.31	0.38	58	0.32	-
1984	0.27	0.41	0.32	-	0.30	0.37	59	0.30	-
1985	0.28	0.52	0.37	-	0.33	0.45	44	0.37	-
1986	0.23	0.42	0.37	-	0.30	0.40	57	0.32	-
1987	0.25	0.50	0.35	-	0.30	0.43	44	0.35	-
1988	0.20	0.30	0.31	-	0.26	0.31	63	0.26	4.26
1989	0.20	0.30	0.26	-	0.23	0.28	73	0.19	2.95
1990	-	0.20	0.27	-	-	0.24	95	0.16	1.66
1991	-	-	0.24	-	-	-	134	0.18	-
1992	-	-	0.46	0.72	-	-	20	0.29	-
1993	-	-	0.79	1.22	-	-	15	0.65	-
1994	-	-	0.77	1.27	-	-	11	0.70	-
1995	-	-	1.03	1.48	-	-	-	-	-
1996	-	-	1.45	1.82	-	-	-	-	-
1997	0.71	-	1.23	1.60	-	-	-	-	-
1998	0.71	-	0.98	1.35	-	-	-	-	-
1999	0.84	-	0.82	1.77	-	-	-	-	-
2000	0.94	-	1.38	1.92	-	-	-	-	-
2001	0.82 [11]	-	1.18	1.57	-	-	-	-	-
2002	0.85	-	1.07	1.82	-	-	-	-	-
2003	0.97 [12]	-	0.86	2.45	-	-	-	-	-
2004	0.63 [13]	-	1.16	1.79	-	-	-	-	-

Year	USSR catch/hour trawling (t)		Norway[10] catch/hour trawling (t)		Average CPUE		Total ef-fort (in '000 hrs trawling)[5]	CPUE 7+[6]	GDR[7] (catch/day tonnage (kg)
	RT[1]	PST[2]	A[8]	B[9]	A[3]	B[4]			
2005	0.61 [12]	-	1.30	2.29	-	-	-	-	-
2006	0.57 [12]	-	0.96	2.09	-	-	-	-	-
2007	0.64 [12]	-	-	-	-	-	-	-	-
2008	0.48 [12]	-	-	-	-	-	-	-	-
2009	0.77 [13]	-	-	-	-	-	-	-	-
2010		1.57 [12]	-	-	-	-	-	-	-
2011		2.32 [12]							
2012		2.06 [12]							
2013		2.25 [12]							
2014		2.52 [12]							

[1] Side trawlers, 800–1000 hp. From 1983 onwards, stern trawlers (SRTM), 1000 hp. From 1997 based on research fishing.

[2] Stern trawlers, up to 2000 HP.

[3] Arithmetic average of CPUE from USSR RT (or SRTM trawlers) and Norwegian trawlers.

[4] Arithmetic average of CPUE from USSR PST and Norwegian trawlers.

[5] For the years 1981–1990, based on average CPUE type B. For 1991–1993, based on the Norwegian CPUE, type A.

[6] Total catch (t) of seven years and older fish divided by total effort.

[7] For the years 1988–1989, frost-trawlers 995 BRT (FAO Code 095). For 1990, factory trawlers FVS IV, 1943 BRT (FAO Code 090).

[8] Norwegian trawlers, ISSCFV-code 07, 250–499.9 GRT.

[9] Norwegian factory trawlers, ISSCFV-code 09, 1000-1999.9 GRT

[10] From 1992 based on research fishing. 1992–1993: two weeks in May/June and October; 1994–1995: 10 days in May/June

[11] Based on fishery from April-October only, a period with relatively low CPUE. In previous years fishery was carried out throughout the whole year.

[12] Based on fishery from October-December only, a period with relatively high CPUE.

[13] Based on fishery from October-November only.

Table 8.7. GREENLAND HALIBUT in 1 and 2 catch history back to 1935.

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1935	1534	n/a	-	1534	1979	2843	10 311	4088	17 312
1936	830	n/a	-	830	1980	3157	7670	2457	13 284
1937	616	n/a	-	616	1981	4201	9276	1541	15 018
1938	329	n/a	-	329	1982	3206	12 394	1189	16 789
1939	459	n/a	-	459	1983	4883	15 152	2112	22 147
1940	846	n/a	-	846	1984	4376	15 181	2326	21 883
1941	1663	n/a	-	1663	1985	5464	10 237	4244	19 945
1942	955	n/a	-	955	1986	7890	12 200	2785	22 875
1943	824	n/a	-	824	1987	7261	9733	2118	19 112
1944	678	n/a	-	678	1988	9076	9430	1081	19 587
1945	1148	n/a	-	1148	1989	10 622	8812	704	20 138
1946	1337	25	-	1362	1990	17 243	4764	1176	23 183
1947	1409	28	-	1437	1991	27 587	2490	3243	33 320
1948	1877	110	-	1987	1992	7667	718	217	8602
1949	198	177	-	375	1993	10 380	1235	318	11 933
1950	1853	221	-	2074	1994	8428	283	515	9226
1951	2438	423	-	2861	1995	9368	794	1572	11 734
1952	2576	377	-	2953	1996	11 623	1576	1148	14 347
1953	2208	393	-	2601	1997	7661	1038	711	9410
1954	3674	416	-	4090	1998	8435	2659	799	11 893
1955	3010	290	-	3300	1999	15 004	3823	690	19 517
1956	3493	446	-	3939	2000	9083	4568	646	14 297
1957	4130	505	-	4635	2001	10 896	4694	775	16 365
1958	2931	1261	-	4192	2002	7143	5584	566	13 293
1959	4307	3632	-	7939	2003	8216	4384	847	13 447
1960	6662	4299	-	10 961	2004	13 939	4662	298	18 899
1961	7977	3836	-	11 813	2005	13 011	4883	940	18 834
1962	11 600	1760	-	13 360	2006	11 119	6055	730	17 904
1963	11 300	3240	-	14 540	2007	8230	6484	739	15 453

Year	Norway	Russia	Others	Total	Year	Norway	Russia	Others	Total
1964	14 200	26191	-	40 391	2008	7393	5294	1105	13 792
1965	18 000	16682	-	34 751	2009	8446	3335	1210	12 990
1966	16 434	9768	119	26321	2010	7700	6888	641	15 229
1967	17 528	5737	1002	24 267	2011	8270	7053	1283	16 606
1968	22 514	3397	257	26 168	2012	9331	10 041	916	20 288
1969	14 856	19 760	9173	43 789	2013	10 403	10 310	1454	22 167
1970	15 871	35 578	38 035	89 484	2014	11 232	10 061	1732	23 025
1971	9466	54 339	15 229	79 034	2015	10 874	12 953	921	24 748
1972	15 983	16 193	10 872	43 055	2016	12 932	10 576	1440	24 948
1973	13 989	8561	7349	29 938	2017	13 741	10 714	1925	26 380
1974	8791	16 958	11 972	37 763	2018*	14 874	12 072	1598	28 544
1975	4858	20 372	12 914	38 172					
1976	6005	16 580	13 469	36 074					
1977	4217	15 045	9613	28 827					
1978	4082	14 651	5884	24 617					

* **Provisional figures.**

Table 8.8. GREENLAND HALIBUT in ICES Division 4.a (North Sea). Nominal catch (t) by countries as officially reported to ICES. Not included in the assessment.

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Total
1973	0	0	0	4	0	0	9	8	0	28	0	49
1974	0	0	0	2	0	0	2	0	0	30	0	34
1975	0	0	0	1	0	0	4	0	0	12	0	17
1976	0	0	0	1	0	0	2	0	0	18	0	21
1977	0	0	0	2	0	0	2	0	0	8	0	12
1978	0	0	2	30	0	0	0	0	0	1	0	33
1979	0	0	2	16	0	0	2	0	0	1	0	21
1980	0	177	0	34	0	0	5	0	0	0	0	216
1981	0	0	0	0	0	0	7	0	0	0	0	7
1982	0	0	2	26	0	0	17	0	0	0	0	45
1983	0	0	1	64	0	0	89	0	0	0	0	154
1984	0	0	3	50	0	0	32	0	0	0	0	85
1985	0	1	2	49	0	0	12	0	0	0	0	64
1986	0	0	30	2	0	0	34	0	0	0	0	66
1987	0	28	16	1	0	0	35	0	0	0	0	80
1988	0	71	62	3	0	0	19	0	0	1	0	156
1989	0	21	14	1	0	0	197	0	0	5	0	238
1990	0	10	30	3	0	0	29	0	0	4	0	76
1991	0	48	291	1	0	0	216	0	0	2	0	558
1992	1	15	416	3	0	0	626	0	0	+	1	1062
1993	1	0	78	1	0	0	858	0	0	10	+	948
1994	+	103	84	4	0	0	724	0	0	6	0	921
1995	+	706	165	2	0	0	460	0	0	52	283	1668
1996	+	0	249	1	0	0	1 496	0	0	105	159	514
1997	+	0	316	3	0	0	873	0	0	1	162	1355
1998	+	0	71	10	0	10	804	0	0	35	435	1365
1999	+	0		1	0	18	2 157	0	0	43	358	420

Year	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Norway	Russia	GB	UK England & Wales	UK Scotland	Total
2000	+		41	10	0	19	498	0	0	67	192	827
2001	+		43	0	0	10	470	0	0	122	202	847
2002	+		8	+	0	2	200	0	0	10	246	466
2003	0	0	1	+	+	+	453	0	0	+	122	576
2004	0	0	0	0	0	0	413	0	0	90	0	503
2005	0	0	2	0	0	0	58	0	0	4	0	64
2006	0	0	3	0	0	0	90	0	0	0	7	100
2007	0	1	0	0	0	0	133	0	0	1	6	141
2008	0	0	0	0	0	0	14	0	0	0	22	36
2009	0	9	22	0	0	0	5	0	0	0	129	165
2010	+	1	38	0	0	0	10	0	0	0	49	98
2011	0	1	39	0	0	0	94	0	0	0	44	178
2012	0	0	14	0	0	0	788	0	0	0	43	845
2013	0	0	25	0	0	0	122	0	0	0	174	321
2014	0	2	27	0	0	0	723	0	0		104	856
2015	0	0	34	1	0	0	1151	0	0	0	127	1313
2016	0	0	31	0	0	0	983	0	0	0	120	1134
2017	0	0	20	0	0	0	753	0	0	0	73	846
2018	0	0	15	0	0	0	472	0	42	0	0	532

Table 8.9. Abundance indices of different length groups in 1984–2017 (in thousands), Russian autumn survey.

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
1984	4837	5078	11 690	21 171	15 167	10 886	7370	6549	3751	1786	1128	483	89 896
1985	4003	6748	16 858	24 897	23 244	15 702	8376	5704	3776	2054	1028	698	113 088
1986	3482	6062	13 765	18 945	15 997	10 369	4839	3022	2534	1325	440	205	80 985
1987	2010	4828	7228	10 490	8831	5513	2123	1784	1437	645	481	421	45 791
1988	3374	5111	9022	10 147	10 128	5828	2265	1862	1218	511	361	341	50 168
1989	2030	7055	13 962	17 252	16 790	10 028	3789	1916	1279	415	200	388	75 104
1990	2762	6056	12 802	13 061	9527	9829	4967	2094	589	312	115	119	62 233
1991	1036	5012	16 237	20 998	17 418	11 728	8012	4562	814	181	122	174	86 294
1992	184	2153	17 185	32 399	22 481	12 977	6229	3473	1869	502	182	106	99 740
1993	-	290	3593	14 782	21 080	16 013	6743	3341	2031	859	269	164	69 165
1994	49	17	1651	12 582	16 203	12 566	5391	3320	2019	819	188	106	54 911
1995	-	38	1245	13 193	20 571	12 445	5432	2717	1587	579	187	82	58 076
1996*	-	11	786	13 012	30 573	18 294	5730	1795	773	534	169	12	71 689
1997	140	152	1318	7744	18 504	17 221	6932	3079	1952	465	195	142	57 844
1998	2449	2238	2949	10 847	24 266	19 640	11 112	5946	2158	440	172	90	82 307
1999	1070	2815	4632	7886	17 734	18 489	10 158	4827	2043	529	196	74	70 453

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
2000	1274	1698	5184	14 996	24 170	20 721	12 805	5675	3100	1228	240	143	91 234
2001	1399	2887	7496	18 136	34 752	29 886	13 463	6759	3772	1511	593	369	121 024
2002**	662	2033	6395	13 329	19 810	13 135	7180	3406	1311	381	129	58	67 828
2003***	955	2396	7420	13 006	17 160	11 630	7978	5332	3541	985	485	238	71 126
2004	1431	2705	11 945	16 937	20 155	18 274	12 594	6948	4783	2087	813	536	99 209
2005	830	3970	10 726	17 850	17 547	15 164	9726	5859	3343	1150	453	545	87 163
2006****	293	1981	18 471	35 224	36 563	26 335	14 138	7248	4943	1669	668	488	148 021
2007	376	1431	6937	24 330	26 780	26 086	22 157	15 586	7480	3786	932	628	136 510
2008	463	4626	19 991	28 799	30 062	32 159	23 175	11 326	8368	4198	1872	1089	166 129
2009	152	4919	29 389	48 321	45 833	33 915	24 484	10 227	6568	3032	881	616	208 338
2010	146	5097	37 901	66 086	57 863	46 321	25 428	10 058	8612	3983	1587	1610	264 692
2011	456	1285	22 470	61 115	78 247	64 186	49 620	19 412	11 607	7226	3529	874	320 025
2012	213	798	12 051	49 062	56 704	52 393	36 362	13 622	7533	4213	1944	1611	236 506
2013*****													
2014	17	1697	10 296	34 074	45 287	35 861	22 621	8613	5505	2227	929	427	167 553
2015	318	2099	13 542	35 864	43 551	36 082	21 114	10 924	4472	1342	850	339	170 497

Year/Length (cm)	≤30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80	>80	Total
2016*****													
2017	158	2198	10 687	32 464	61 577	71 590	40 700	16 830	7449	3483	1206	1245	249 585

*** Only half of the standard area was investigated**

**** No observations in NEEZ**

***** Observations in the NEEZ on the main spawning grounds were conducted considerably later than usual**

****** Survey was conducted by one vessel with a reduced number of trawls at depths less than 500 m**

*******No indices for 2013 and 2016**

Table 8.10. Abundance indices of different length groups in 1994–2017 (in thousands), Norwegian autumn survey.

Year	<30	30.5	31.5	33	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	51
1994	0	0	0	0	1	15	23	80	197	335	645	1225	1611	2432	3431	3511	3830	3519	3940	3724	2896	3020
1995	0	0	1	3	6	15	29	86	141	242	472	931	1210	2294	3092	3840	4475	4540	4633	4321	3836	3856
1996	0	2	1	6	6	2	18	49	54	166	321	772	957	1787	2912	3769	4728	5199	5944	5644	5224	5132
1997	7	5	11	4	33	27	49	186	250	297	443	862	1009	1814	2888	3578	5451	5402	6132	5206	4125	5455
1998	7	2	6	15	17	22	51	103	174	219	372	504	727	1061	1491	2103	2941	3092	3609	3735	3851	4850
1999	10	4	18	15	20	40	61	75	110	174	202	377	476	862	1175	1655	2397	2543	3485	4214	3694	5274
2000	2	7	11	30	34	46	128	122	163	264	383	677	739	932	1183	1439	2038	2030	2268	2644	2846	3888
2001	21	20	35	37	77	147	274	270	440	462	724	986	1176	1373	1630	1720	2724	2655	3349	3128	3973	3999
2002	97	75	107	122	180	267	399	404	723	669	869	1026	1097	1360	1883	1870	2560	2185	3322	3450	3597	4032
2003	38	27	65	97	172	270	383	692	783	894	1214	1100	1481	1561	2082	1792	2468	2104	3193	3360	3506	3117
2004	27	15	47	125	191	402	636	639	951	1042	1092	1206	1337	1319	1398	1546	2013	1967	2638	2646	3337	3373
2005	66	104	285	317	517	765	861	1220	1492	1540	2053	2295	2293	2588	2262	2677	3041	2446	2854	2095	3056	2336
2006	12	50	80	158	258	456	849	1022	1429	1579	1603	1900	1823	1824	2015	1974	2529	2359	2350	2137	2338	2175
2007	157	96	161	359	766	1423	2508	3142	4411	5679	5346	5639	5502	5038	4600	3632	3667	3628	3278	2571	2882	2597
2008	378	384	723	1323	1763	1793	2441	2911	3249	3685	4229	4300	4257	3568	3911	3534	3020	3066	2769	2582	2639	2284
2009	31	36	93	349	505	934	1663	2660	3050	3680	4138	4885	5567	4148	5327	4639	3688	3752	3682	3410	3553	3215
2011	0	0	20	36	57	124	288	563	646	1414	1454	2228	2680	3174	3649	3750	3532	3031	3299	3991	3251	2454

2013	17	5	3	1	13	64	103	122	324	582	1022	1266	2138	2207	3553	3748	3476	4124	3717	3045	3718	3052
2015	3	24	24	36	131	318	439	721	757	1043	1253	1473	2602	2444	3776	4459	4602	4598	4371	3962	4156	3694
2017	6	20	45	54	63	144	184	328	593	365	928	955	1267	1457	1764	1983	2367	2465	2651	2569	2816	3011

Year	51.5	52.5	53.5	54.5	55.5	56.5	57.5	58.5	59.5	60.5	61.5	62.5	63.5	64.5	65.5	66.5	67.5	68.5
1994	2545	2729	2398	2092	1975	1547	1488	1103	920	788	565	702	576	523	577	370	367	386
1995	3165	3152	2963	2647	2272	1756	1586	1153	970	880	764	690	680	592	525	461	387	334
1996	4106	3638	3571	2752	2177	1568	1443	1017	867	782	512	449	538	404	391	356	281	248
1997	3644	3427	3018	2302	2111	1502	1131	1042	617	849	585	576	537	403	446	481	294	230
1998	4211	3824	3166	2988	2857	1974	1714	1515	981	1172	783	613	598	668	641	569	479	364
1999	4092	5196	4136	3909	4122	2631	2299	1787	1374	1388	895	1037	865	886	923	791	807	594
2000	3692	3681	3512	3016	3197	2388	2007	1545	1227	1327	915	1028	734	630	732	517	509	505
2001	3649	4512	4106	3005	3358	2552	2589	2147	1293	1350	1099	939	1187	684	787	612	751	603
2002	4241	3516	3966	3602	3855	2837	2511	2248	1672	1787	1239	1237	1139	808	882	604	679	474
2003	4400	3465	3808	3512	3907	3368	3035	2319	1896	1705	1612	1384	1542	1130	1350	972	994	675
2004	3535	4405	3614	3801	3249	2751	2252	1911	1493	1455	1372	1360	1284	1162	962	763	891	590
2005	2400	2734	2413	2084	2295	1882	1681	1492	1458	1168	1241	1057	1065	984	903	782	865	479
2006	2493	2125	2290	2025	2189	1790	1668	1542	1337	1159	1188	1009	925	1036	807	798	647	678
2007	2109	2249	2123	2142	1758	1609	1581	1070	1008	1044	625	938	672	558	537	526	394	469

2008	2288	2248	2229	1815	1751	1514	1150	1019	861	668	652	657	508	582	629	523	484	361
2009	2668	2944	2850	2441	2372	2233	1837	1698	1503	1135	845	962	647	858	715	607	653	609
2011	2905	2746	2602	2713	2387	1709	1704	1529	978	1179	577	649	554	440	466	315	440	550
2013	2498	2035	1905	1631	1710	1573	1424	1009	790	671	503	506	400	456	234	266	227	176
2015	3469	2384	2546	2084	2142	1734	1336	1108	1020	899	713	621	605	495	274	289	341	291
2017	2890	2547	2501	2091	1792	1786	1532	1274	1269	1029	765	579	481	446	294	299	247	245

Year	**69.5**	**70.5**	**71.5**	**72.5**	**73.5**	**74.5**	**75.5**	**76.5**	**77.5**	**78.5**	**79.5**	**>80**	**SUM**
1994	256	253	151	136	122	74	113	47	39	40	30	97	59 436
1995	339	244	181	179	97	100	137	56	53	53	34	101	66 568
1996	232	168	118	123	93	97	61	28	40	39	21	74	70 886
1997	171	207	216	119	109	111	104	61	32	35	40	185	69 818
1998	308	320	235	222	229	144	102	64	65	61	43	192	62 052
1999	478	406	385	319	182	205	223	125	109	145	51	328	69 570
2000	341	376	232	210	168	153	141	77	96	77	47	233	57 187
2001	490	375	279	170	207	178	157	85	133	69	49	306	68 944
2002	469	383	297	251	183	163	134	104	130	48	65	251	72 073
2003	563	632	464	249	244	170	242	201	128	125	114	356	76 964
2004	654	420	373	325	521	248	181	135	121	100	109	431	70 415

2005	523	508	400	262	196	159	156	162	109	82	61	426	69 195
2006	474	508	397	285	185	276	185	140	136	81	96	497	61 893
2007	289	254	261	101	140	130	75	52	80	59	47	278	92 269
2008	313	258	226	201	138	107	59	62	89	66	76	508	82 860
2009	574	541	271	386	219	171	191	112	121	89	100	407	95 773
2011	415	409	200	285	235	193	225	204	175	51	87	503	69 075
2013	162	173	124	114	109	112	66	72	79	34	43	260	57 674
2015	252	265	176	195	186	205	89	78	73	141	53	286	71 252
2017	178	185	88	98	77	51	61	50	35	40	46	184	49193

***Biennial surveys since 2009**

Table 8.11. Abundance indices of females of different length in 1996–2017 (in thousands), Norwegian autumn survey.

Year	<30	30.5	31.5	33	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	51
1994	0	0	0	0	1	15	23	80	196	335	643	1223	1611	2429	3426	3503	3824	3510	3934	3716	2886	3018
1995	0	0	1	3	6	15	29	86	141	242	472	930	1210	2291	3088	3837	4470	4537	4629	4317	3835	3855
1996	0	0	0	4	0	1	10	26	28	64	123	228	233	424	415	773	937	1020	1185	1151	1037	1374
1997	6	5	7	4	17	14	36	134	139	146	187	337	331	419	569	685	899	852	1169	1058	828	1226
1998	5	0	0	11	4	7	26	41	78	77	156	170	190	274	290	364	413	526	605	665	743	970
1999	2	0	1	0	7	14	19	12	41	68	93	137	117	227	285	300	336	313	496	574	533	1049
2000	1	5	6	14	16	16	44	44	65	121	155	201	229	245	268	278	374	311	303	411	410	517
2001	13	6	14	15	38	61	118	123	177	167	293	411	462	355	425	376	544	477	493	379	558	673
2002	51	48	58	60	77	109	178	182	290	275	326	319	306	407	500	378	515	331	483	461	501	575
2003	25	25	27	43	100	124	182	276	413	429	532	504	512	545	610	450	552	394	539	487	523	406
2004	15	3	13	61	83	160	305	278	436	358	434	404	440	384	381	454	413	362	382	309	427	472
2005	30	24	110	99	182	258	322	464	565	537	723	758	619	630	452	633	723	467	593	293	500	329
2006	4	19	48	81	148	187	327	442	595	674	713	686	648	568	649	482	619	501	503	512	468	452
2007	85	67	104	178	371	731	1321	1539	2259	2654	2515	2403	2454	2145	1580	1242	1132	988	851	727	640	554
2008	216	210	432	698	829	958	1190	1372	1529	1597	1720	1516	1625	1069	1180	928	889	948	834	677	773	615
2009	13	19	33	146	210	343	662	1001	1263	1470	1491	1814	1979	1441	1752	1533	1044	1195	1037	988	922	878
2011	0	0	8	22	24	31	103	175	195	469	311	538	642	722	623	645	686	664	528	665	751	298

Year	<30	30.5	31.5	33	33.5	34.5	35.5	36.5	37.5	38.5	39.5	40.5	41.5	42.5	43.5	44.5	45.5	46.5	47.5	48.5	49.5	51
2013	0	0	0	0	3	11	49	30	50	186	261	246	521	286	650	509	621	693	626	664	745	576
2015	0	7	7	19	67	149	183	304	380	358	391	377	491	387	549	490	682	904	632	689	761	766
2017	4	17	16	43	44	79	83	120	267	117	395	312	365	373	288	411	524	444	6277	453	439	579

***Biennial surveys since 2009**

Year	52	53	54	55	56	57	58	59	60	61	61.5	63	64	64.5	65.5	67	68	68.5	69.5	71	72	73	74
1994	####	####	2384	2088	1969	1545	1482	1098	917	785	560	700	571	522	573	368	364	385	254	253	151	136	122
1995	####	####	2958	2646	2271	1752	1586	1152	968	875	761	689	680	592	525	461	387	333	339	244	181	179	97
1996	####	886	895	771	527	547	639	548	508	602	410	401	481	383	387	344	281	230	232	167	118	123	93
1997	911	985	824	650	669	590	523	562	346	633	484	501	506	364	433	437	289	225	171	207	216	119	109
1998	995	####	999	1056	903	758	754	831	667	907	615	543	569	639	638	567	453	362	308	307	235	222	225
1999	830	####	928	1042	1287	1019	1002	955	845	1106	754	927	816	814	890	780	798	582	478	403	384	317	182
2000	590	591	593	663	756	816	704	649	670	839	699	829	620	588	665	487	491	495	328	376	230	210	167
2001	479	632	761	643	680	698	962	877	743	936	928	714	1062	594	772	577	746	598	488	370	279	170	207
2002	610	438	638	694	823	672	824	779	780	989	780	1024	813	705	827	598	656	443	458	383	295	251	183
2003	604	582	662	611	968	854	1111	964	1057	1126	1260	1165	1314	1085	1278	938	962	670	555	625	462	249	242
2004	461	638	570	693	760	937	876	839	966	998	1202	1186	1227	1116	932	749	885	585	639	420	373	325	461
2005	378	411	427	451	597	638	775	718	800	871	935	938	965	904	860	740	860	449	523	465	390	262	192
2006	490	458	461	392	537	523	545	678	805	796	893	865	820	927	775	768	637	633	468	499	376	285	178

Year	52	53	54	55	56	57	58	59	60	61	61.5	63	64	64.5	65.5	67	68	68.5	69.5	71	72	73	74
2007	476	499	471	491	469	533	607	549	566	776	494	790	587	534	517	515	394	469	278	254	261	101	133
2008	509	481	515	495	443	547	441	543	466	490	530	572	482	539	610	514	483	361	309	252	226	201	138
2009	640	665	738	639	733	724	698	783	814	605	653	765	534	776	701	525	616	587	561	526	263	378	219
2011	557	468	480	472	466	369	329	469	324	378	341	523	477	348	450	300	415	550	393	409	192	285	235
2013	518	381	477	308	375	529	526	304	296	334	324	377	329	390	218	260	227	174	159	173	120	114	109
2015	826	770	744	579	811	649	471	494	553	537	470	462	420	450	270	283	339	283	251	265	176	195	186
2017	530	438	516	448	392	555	578	498	563	530	473	330	378	371	271	286	243	245	178	185	88	98	77

***Biennial surveys since 2009**

Year	74.5	75.5	76.5	77.5	78.5	79.5	>80	SUM
1994	74	113	47	39	40	30	95	59 284
1995	100	137	56	53	53	34	99	66 505
1996	92	61	28	40	39	21	74	21 998
1997	111	104	61	29	35	40	185	22 385
1998	144	102	64	65	61	43	192	22 881
1999	205	223	125	109	140	47	328	26 047
2000	153	141	77	96	77	47	233	19 913
2001	178	157	85	131	69	49	306	24 071
2002	163	131	104	130	48	65	251	23 984
2003	170	242	201	128	125	114	356	30 383
2004	241	181	135	119	100	109	431	27 731
2005	149	156	152	109	82	61	426	27 000
2006	259	185	138	136	81	96	491	26 528
2007	124	75	52	80	59	47	275	40 026
2008	107	59	62	89	66	76	506	34 926
2009	171	191	104	121	80	100	385	38 542
2011	193	225	204	175	51	87	503	20 780
2013	112	66	72	79	34	43	260	16 424

Year	74.5	75.5	76.5	77.5	78.5	79.5	>80	SUM
2015	205	89	78	73	141	53	286	22 019
2017	51	61	50	35	40	46	184	14738

***Biennial surveys since 2009**

Table 8.12. Abundance indices (numbers in thousands) from bottom-trawl surveys in the Barents Sea standard area winter 1994-2019 (Mehl *et al*., WD4 AFWG 2019).

	Length group (cm)																Biomass
Year	≤14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	≥80	Total	(tonnes)
1994	0	0	21	76	148	1117	3139	4740	3615	1941	889	541	21	0	0	16 248	19 228
1995	298	0	0	0	90	129	2877	7182	5739	2027	1622	839	489	86	0	21 378	27 459
1996	4121	0	0	0	62	124	1214	4086	4634	1871	1112	638	337	74	12	18 285	20 256
1997[1]	0	68	0	0	55	163	949	4313	5629	2912	1609	643	300	65	21	16 728	24 214
1998[1]	68	220	945	578	481	487	1088	4016	6591	3076	1798	707	326	93	44	20 518	27 248
1999	43	84	241	436	566	269	784	1701	3097	1669	1094	491	89	75	0	10 640	14 681
2000	140	184	344	836	1722	3857	2253	1560	2144	1714	1191	615	249	76	0	16 883	17 246
2001	68	49	147	179	737	1525	3716	3271	2302	2010	1088	529	160	50	39	15 871	18 224
2002	271	0	70	34	382	1015	1916	3803	3250	2279	1138	976	242	159	114	15 648	21 198
2003	51	0	74	19	304	715	1842	3008	4765	2235	714	561	245	146	0	14 678	19 635
2004	106	104	15	0	319	1253	1229	1717	2277	1227	798	298	148	94	26	9615	11 872
2005	263	70	159	1139	2235	2621	4206	3782	3847	2037	917	585	336	118	0	22 314	22 293
2006[2]	0	72	94	414	1968	5149	4613	5743	4283	2132	891	449	258	34	18	26 118	25 579
2007[1]	0	18	146	1869	1418	3114	5710	5947	4287	2205	963	658	391	80	89	26 896	28 006
2008	0	0	0	243	1708	5974	4654	6136	5198	3403	827	638	174	82	50	29 088	30 153
2009	55	0	0	26	1044	4327	8133	4551	4084	2266	996	627	442	253	154	26 960	28 919

Year	≤14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	≥80	Total	Biomass (tonnes)
	Length group (cm)																
2010	0	0	0	99	678	3648	5729	6560	4897	2467	1064	552	229	128	41	26 092	25 979
2011	51	0	0	0	216	4396	5864	5498	5237	3698	699	936	327	252	97	27 271	31 552
2012[3]	77	0	0	0	51	1145	4524	5366	4517	2774	1147	195	73	0	48	19 917	22 656
2013	0	0	0	0	0	511	5368	4868	5374	3687	1944	939	348	131	154	23 504	31 748
2014	0	0	46	92	156	368	2271	5587	5903	3555	2251	1369	154	260	79	22 090	31 112
2015	367	0	61	0	284	1612	3187	6452	7249	6752	3350	1936	587	334	0	32 172	46 828
2016	205	0	124	511	950	1953	3486	4539	5479	5613	1999	1973	646	98	80	27 657	35 831
2017[4]	52	0	0	78	592	1328	1885	3850	4852	4550	1721	1455	317	190	23	20 827	29 756
2018	0	0	62	0	383	1333	2049	3445	4258	3573	1904	1366	736	196	20	19 325	28 688
2019	0	0	0	375	272	1671	3285	4034	5177	4265	3570	2526	1328	535	137	27 176	45 912

[1] **Indices raised to also represent the Russian EEZ**

[2] **Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005**

[3] **Indices not raised to also represent uncovered parts of the Russian EEZ.**

[4] **Indices raised to also represent uncovered parts of the Russian EEZ**

Table 8.13. GREENLAND HALIBUT catch in weight, numbers, and biomass (in tonnes) and abundance (in thousands) estimated from Spanish autumn and spring surveys 1997–2013. NB. Absolute biomass and abundance values must not be compared between spring and autumn surveys due to different gears. The trawl used during the spring surveys is considered less efficient on benthic species as Greenland halibut and skates, and better to catch species less associated with bottom. No update presented at AFWG 2019.

Autumn survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance ('000)
1997	195 056	211 533	344 014	379 444
1998	180 974	187 259	351 466	373 149
1999	198 781	172 687	436 956	377 792
2000	169 389	140 355	340 619	291 265
2001	152 681	129 289	283 511	249 219
2002	144 335	115 213	256 460	207 466
2003	151 952	132 117	283 644	256 327
2004	153 859	135 631	320 485	283 965
2005	144 573	134 566	317 320	313 459
2006*				
2007*				
2008	91 573	101 578	129 221**	144 561**
2009*				
2010	167 862	182 464	191 510**	216 731**
2011*				
2012	178 607	174 670	336 543**	339 697**
2013	172 762	168 619	264 101**	267 548**
2014	175 553	160 557	321 485**	307 679**
2016	176 015	142 413	247 644**	214 778**

***No survey in 2006, 2007, 2009, 2011, and 2015**

****New swept-area estimation method**

Spring survey

Year	Catch (Kg)	Catch (numbers)	Biomass™	Abundance (‘000)
2008	96 797	109 515	38 406	38 951
2009	200 299	222 018	58 273	65 464
2010*				
2011	136 610	160 566	98 142	117 666
2012*				
2013*				
2014*				
2015**	111 425	105 385	150 385	155 333

*No survey

**Different from the one used during the 2014 Spanish “autumn” survey

Table 8.14. Greenland halibut in subareas 1 and 2. The catch scenarios. Weights in tonnes.

Basis	Catches (2020)	Harvest rate (2020–2024)	Mean catch (2020–2024)	Biomass 45cm+ 1 January 2025	% 45cm+ Biomass change 2020–2024
ICES ADVICE BASIS					
FI_{2018} ^	25 310	0.037	23 930	573 000	-22%
Other options					
F=0	0	0	0	672 000	-9%
FI_{2018} × 0.5	12 770	0.019	12 500	620 000	-16%
FI_{2018} × 0.75	19 070	0.028	18 340	596 000	-19%
FI_{2018} × 1.5	37 630	0.053	37 630	532 000	-28%
FI_{2018} × 2	49 730	0.070	44 000	495 000	-33%
FI_{2018} × 3	73 290	0.099	60 870	432 000	-42%

Table 8.15. Dynamics of indices of the Barents Sea Greenland halibut stock in 1964–2015 (indices are taken divided by corresponding mean to put them in comparable scale; CPUE series divided by two: 1964–1991 and after 1996). In addition to the standardized CPUE three survey indices are shown; the Russian autumn survey (RUS), the Norwegian autumn survey (NOR) and the EcoSouth index (ECO).

Year	CPUE	NOR	RUS	ECO
1964	2.0052083			
1965	1.421875			
1966	1.2760417			
1967	1.4583333			
1968	1.6041667			
1969	1.6770833			
1970	1.3125			
1971	0.9114583			
1972	0.765625			
1973	0.9114583			
1974	0.984375			
1975	0.8020833			
1976	0.6197917			
1977	0.4739583			
1978	0.546875			
1979	0.65625			
1980	0.65625			
1981	1.0572917			
1982	1.09375			
1983	0.9479167			
1984	0.984375		0.8035484	
1985	1.203125		0.9074373	
1986	1.0208333		0.5915304	
1987	0.9114583		0.344176	
1988	0.8385417		0.3462961	
1989	0.765625		0.5378191	
1990	0.5833333		0.4261563	

Year	CPUE	NOR	RUS	ECO
1991	0.5104167		0.6918856	
1992			0.7081403	
1993			0.6077851	
1994		0.790111	0.489055	
1995		0.9115792	0.5060164	
1996	0.7611138	0.9286075	0.6134389	
1997	0.8910601	0.9342836	0.5342855	
1998	0.9189057	0.9388244	0.7236883	
1999	1.0766976	1.1828961	0.6466551	
2000	1.0395701	0.9149849	0.8615	
2001	1.345872	1.0761857	1.1420706	
2002	0.9189057	1.1079717	0.595064	
2003	0.9653151	1.2430626	0.6770443	
2004	0.5661944	1.1760848	0.9371198	0.2915311
2005	0.6126038	0.9876387	0.7858802	0.5696662
2006	0.5476307	0.9286075	1.3060312	0.7983047
2007	0.5476307	1.0023966	1.5074483	0.9095588
2008	0.5476307	0.9637992	1.691904	1.0099145
2009	1.0117245	1.2362513	1.8120476	1.2723833
2010	1.197362		2.2749537	1.3277832
2011	1.8842208	0.9649344	3.0622474	1.0623628
2012	1.3737176		2.250925	1.6202225
2013	1.2437714	0.711781	1.1387631	1.2692046
2014	1.5500733		1.4790874	1.0142284
2015		0.8854692	1.4576736	0.8548399

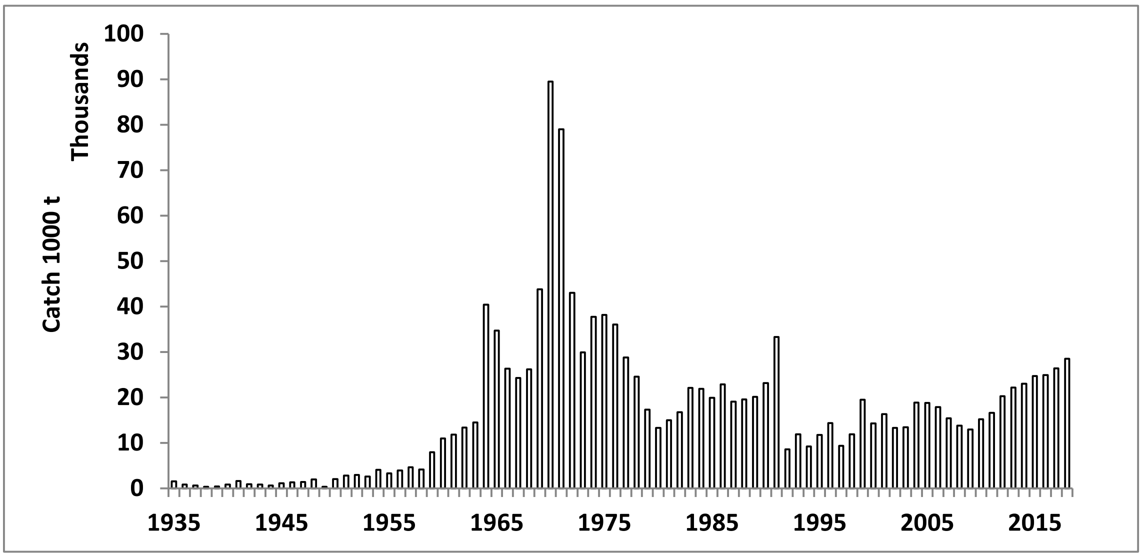


Figure 8.1. NEA Greenland halibut. Historical landings (Nedreaas and Smirnov 2003 and AFWG).

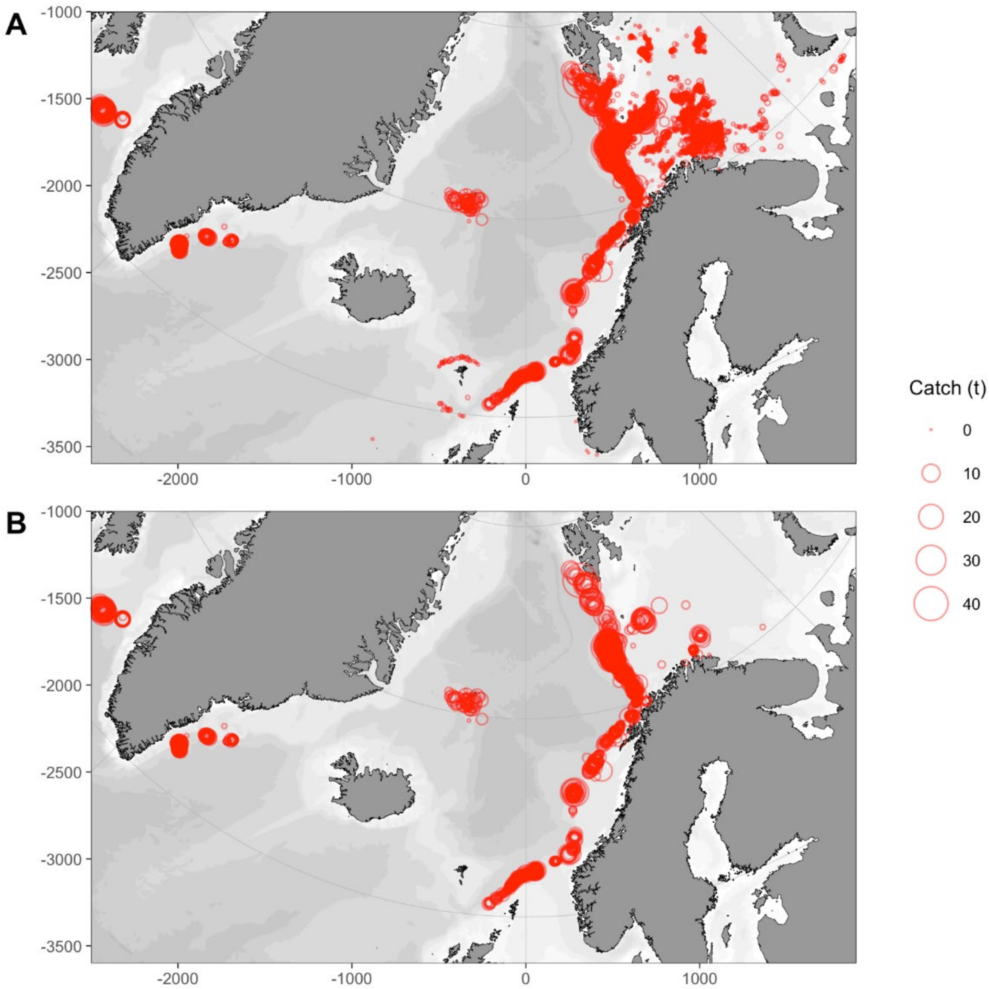


Figure 8.2. Spatial distribution of Greenland halibut catches in 2018 according to Norwegian electronic logbooks. Bubble area is proportional to the size of single catches expressed in metric tonnes. Upper panel (A) shows Greenland halibut catches in all registered fisheries (including bycatch), and lower panel (B) shows catches where Greenland halibut is the target species, i.e. species with the highest mass within a catch.

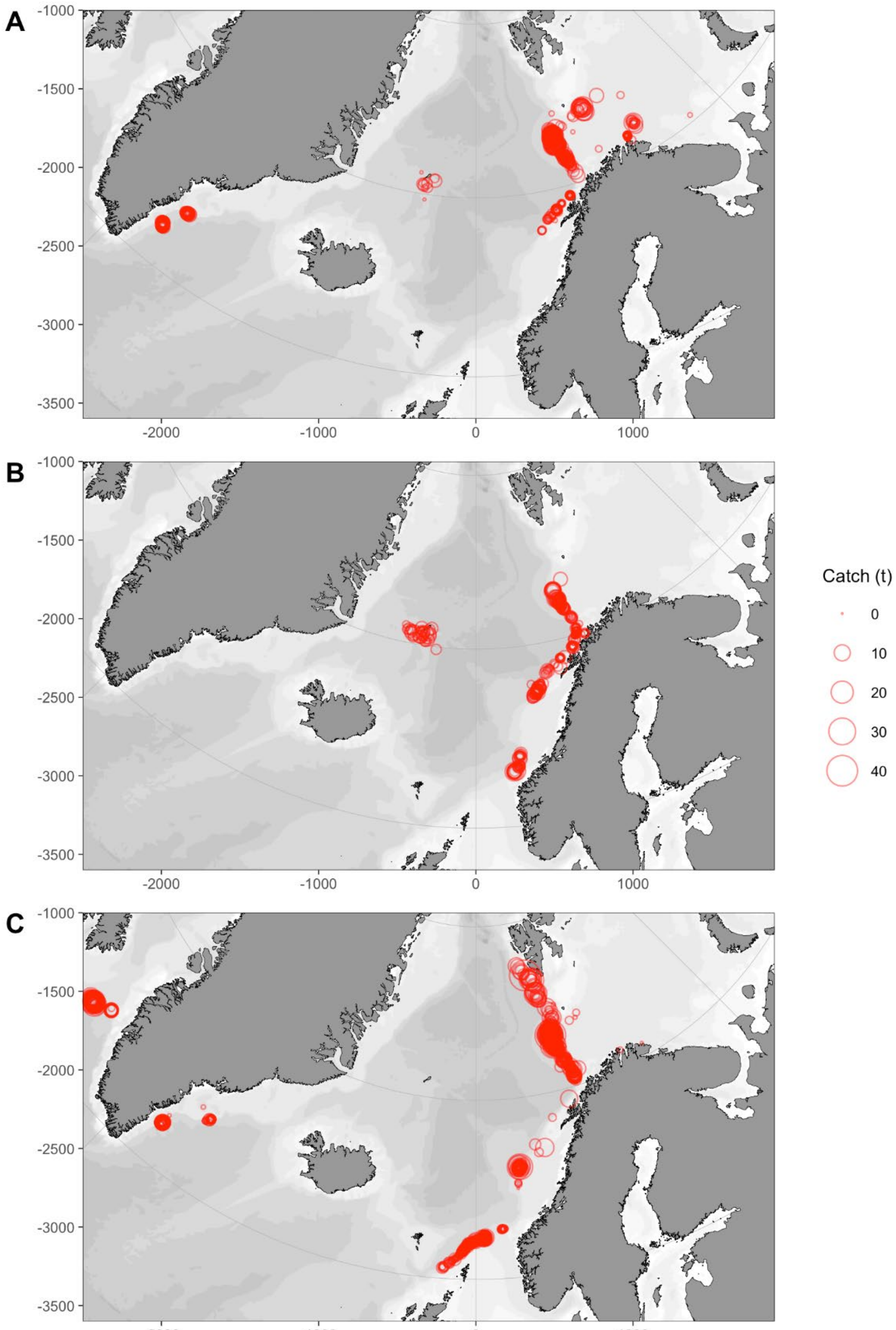


Figure 8.3. Spatial distribution of Greenland halibut as the target species in catches according to Norwegian electronic logbooks from 2018. Bubble area is proportional to the size of single catches expressed in metric tonnes. Uppermost (A), middle (B) and lowest (C) panel show longline, gillnet and trawl catches, respectively.

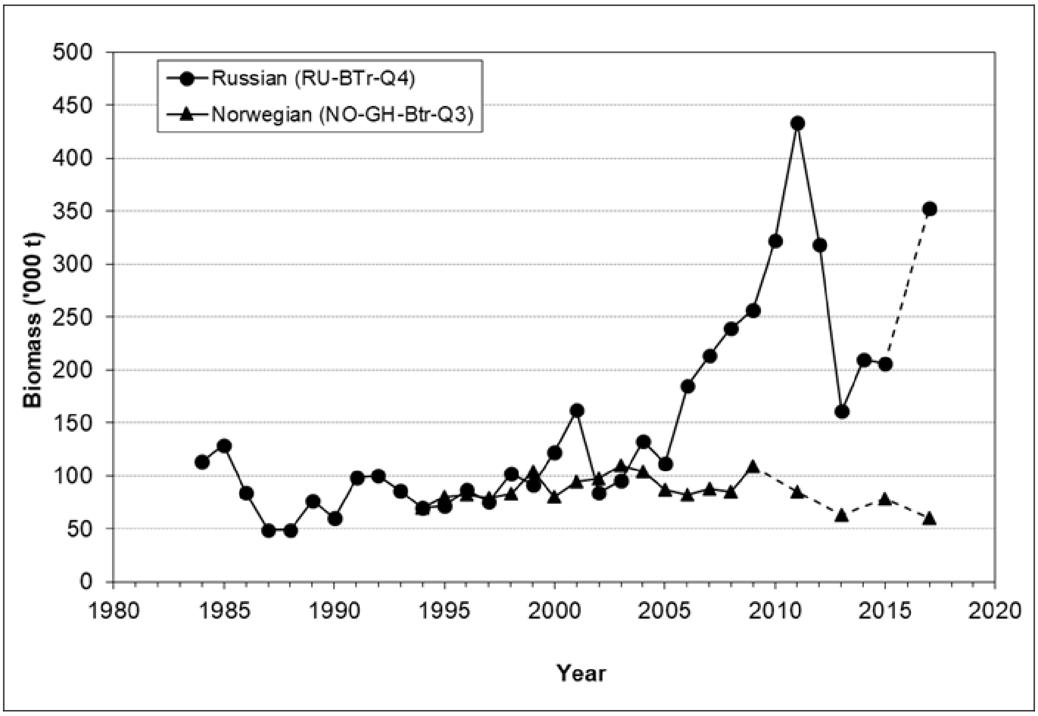


Figure 8.4. NEA Greenland halibut. Total biomass estimates from Russian autumn and the Norwegian slope survey. The Norwegian survey is run every other year since 2009. Uncertain estimate for 2013 from the Russian survey.

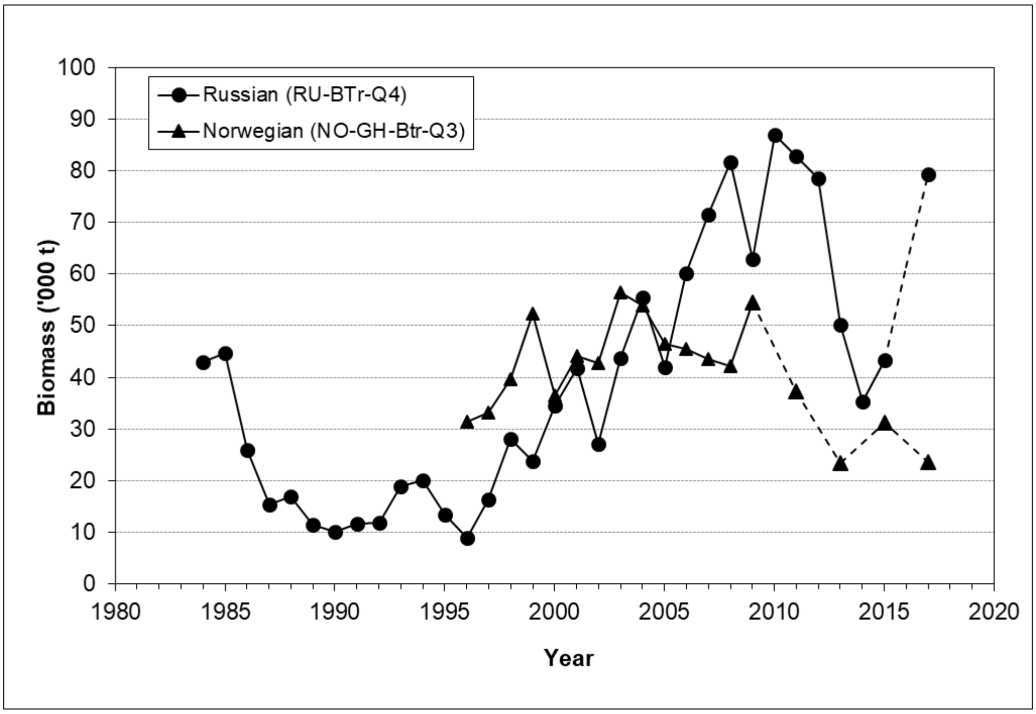


Figure 8.5. NEA Greenland halibut. Swept-area estimate of the mature female biomass based on the data from the Norwegian Greenland halibut survey along the continental slope in August (every other year since 2009) and Russian trawl survey in October-December (compared to previous reports, 2007–2008 recalculated using complete data for these years). Uncertain estimate for 2013 from the Russian survey.

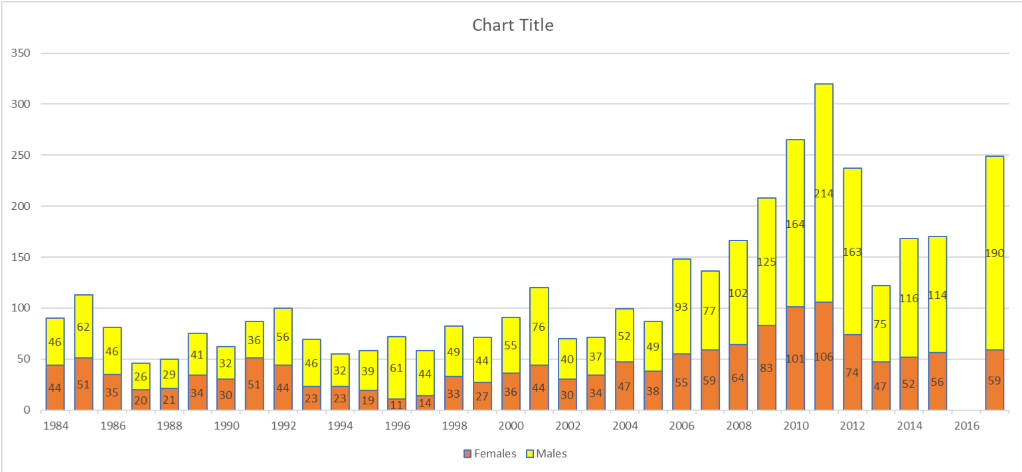


Figure 8.6. Russian autumn survey; Greenland halibut abundance by sex (Russkikh and Smirnov, WD16 AFWG 2016).

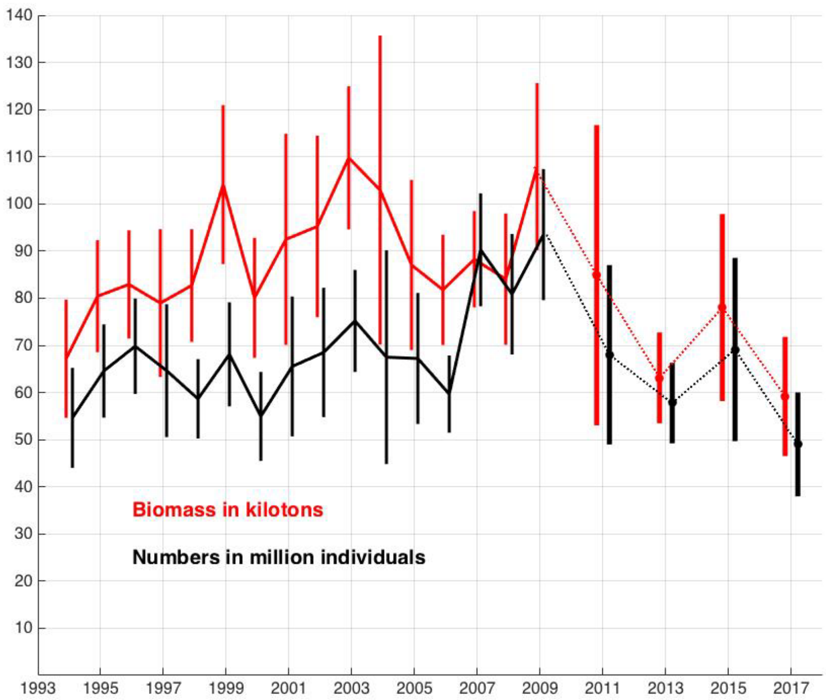


Figure 8.7. Estimated Greenland halibut total abundance in biomass and by number of individuals from the Norwegian slope surveys 1994–2017. The vertical bars show 95% confidence intervals.

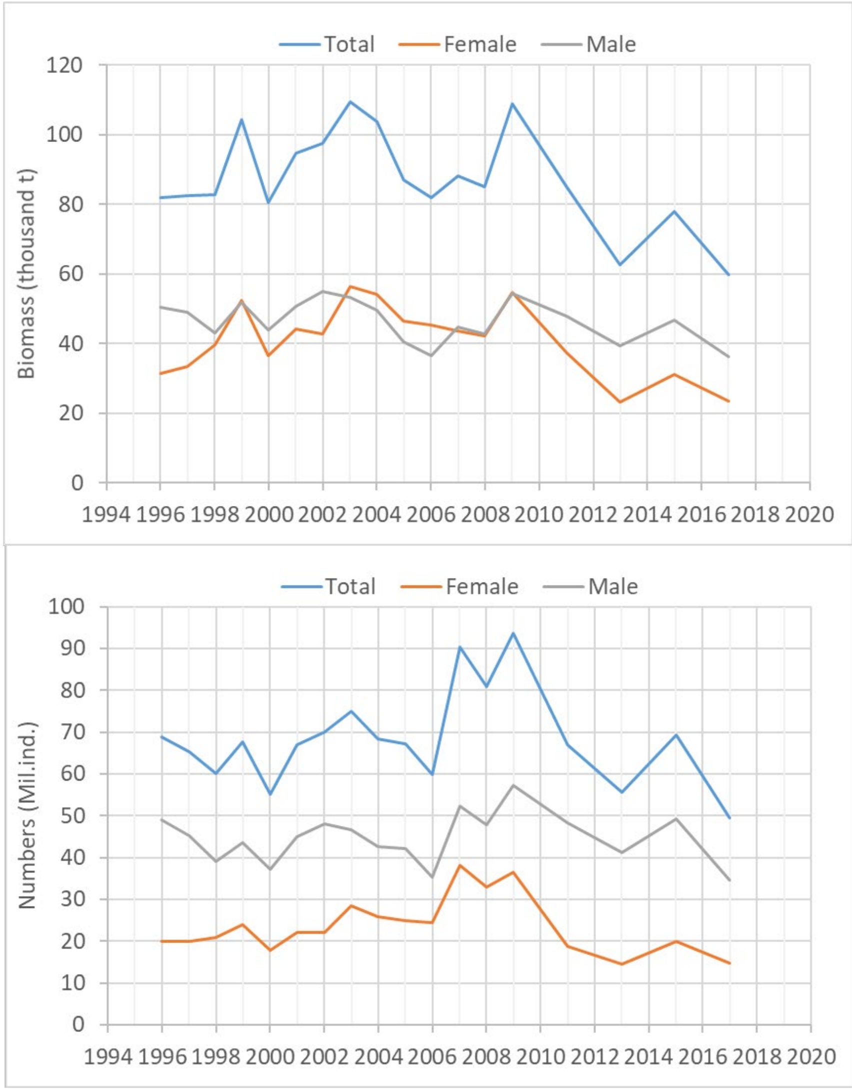


Figure 8.8. Norwegian autumn slope survey; Greenland halibut abundance and biomass estimates by sex.

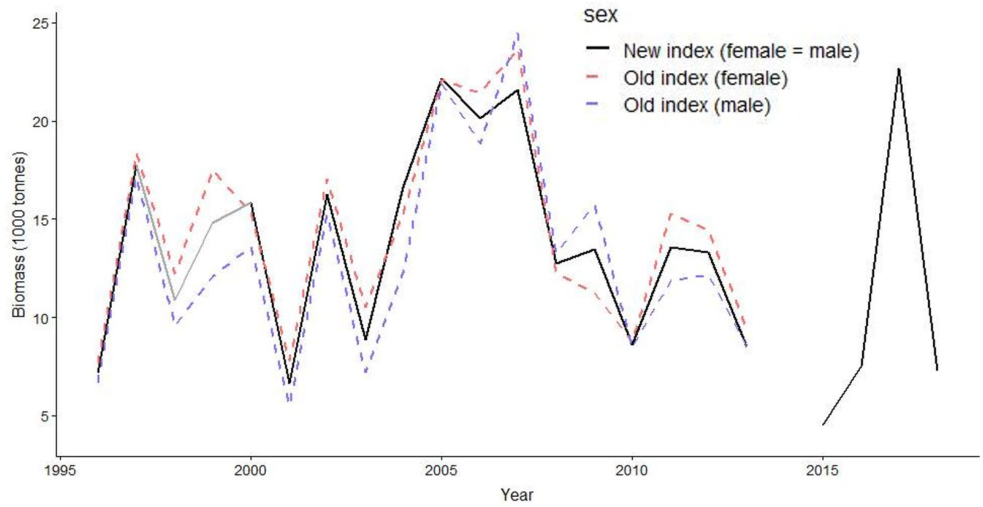


Figure 8.9. Juvenile biomass index (EcoJuv) in total and by sex for Greenland halibut based on the Barents Sea Ecosystem Survey 2003 – 2018 (2014 not included due to poor survey coverage in the juvenile area) and the juvenile survey 1996-2002 (for area see Hallfredsson and Vollen, WD20 AFWG 2015). Comparison of new and old biomass index (see chapter 8.3 about "Issus with 2019 assessment data")

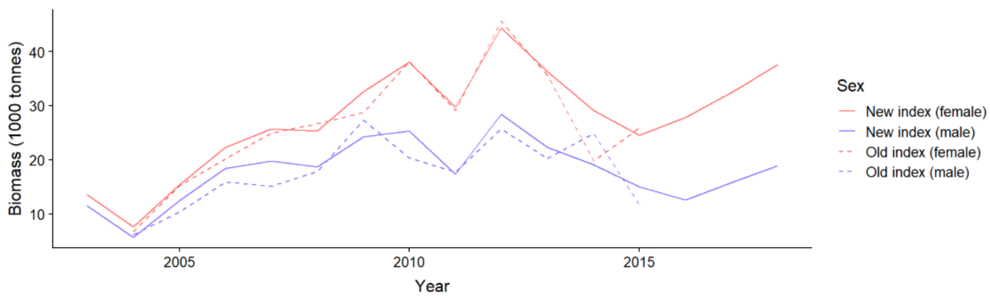


Figure 8.10. Eco-south biomass index by sex for Greenland halibut in the Barents Sea Ecosystem Survey 2004 – 2014, outside the juvenile area (for area see Hallfredsson and Vollen, WD20 AFWG 2015). Comparison of new and old biomass index (see chapter 8.3 about "Issus with 2019 assessment data")

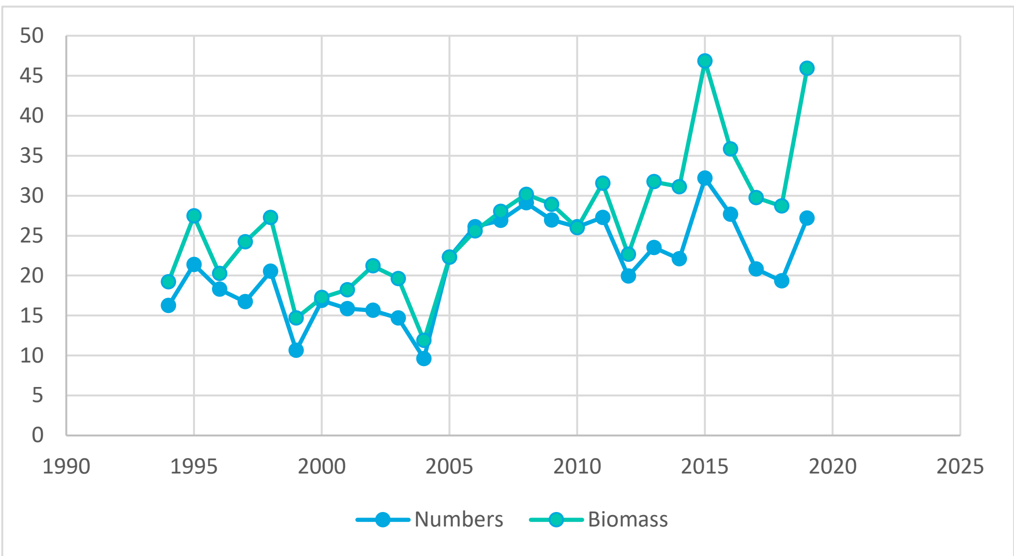


Figure 8.11. Joint winter survey in the Barents Sea; Greenland halibut abundance and biomass estimates.

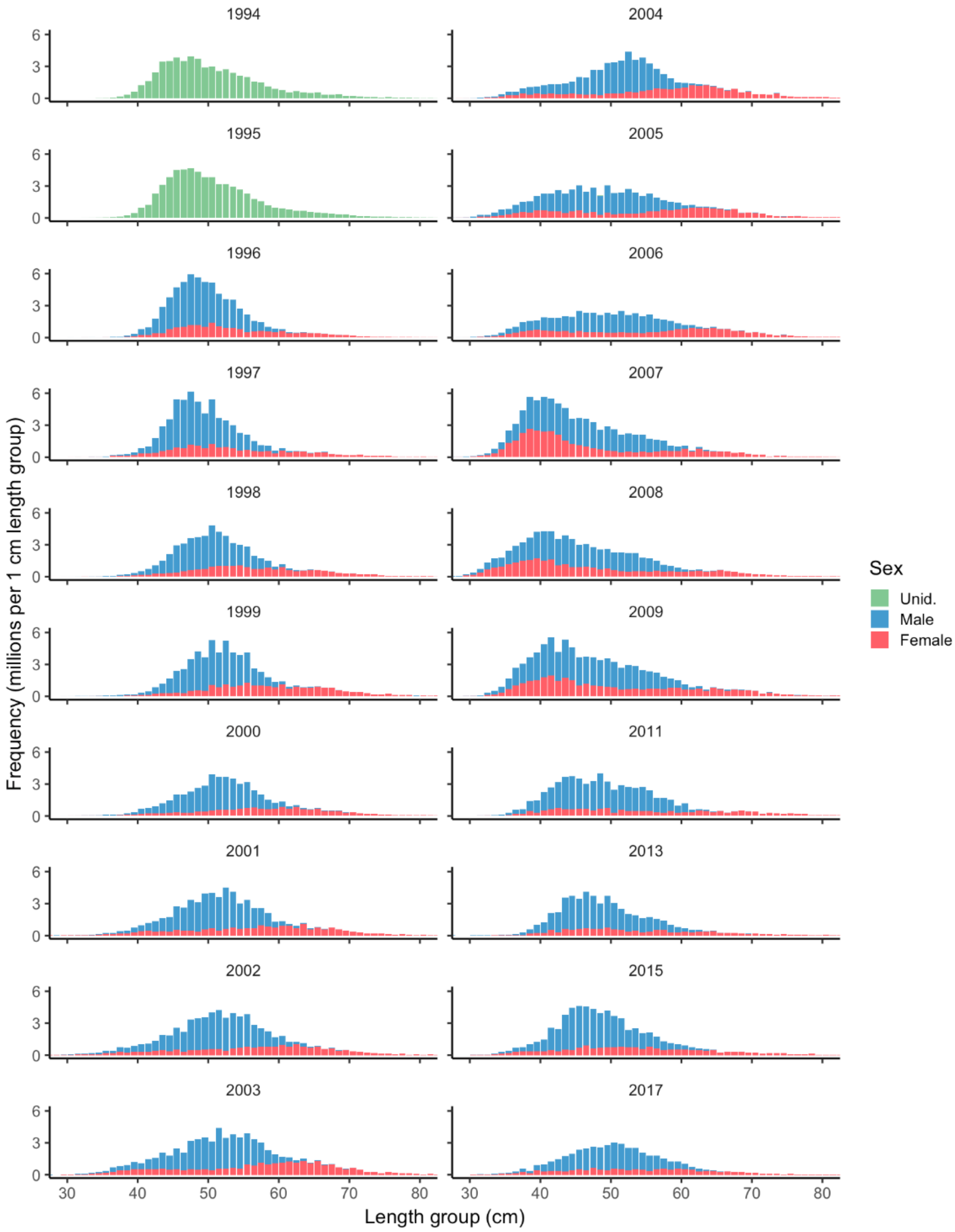
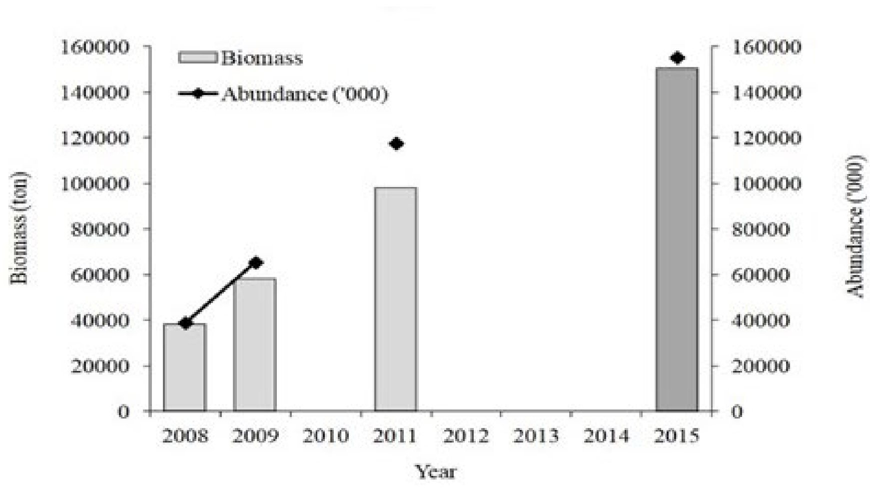


Figure 8.12. Length frequency distribution estimates for the entire area covered by the Norwegian Slope survey during autumns 1994-2017. Note biennial surveys after 2009.



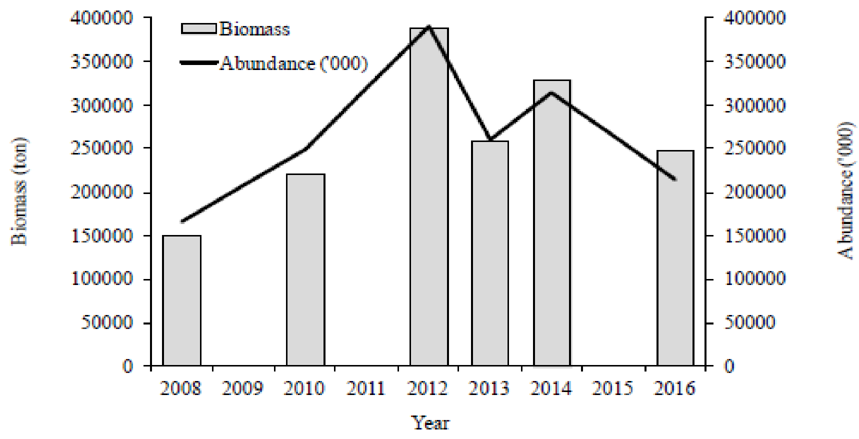


Figure 8.13. Abundance and biomass estimates from Spanish 2008, 2010, 2012, 2013, 2014, and 2016 autumn surveys (lower panel) (Muñoz *et al.,* WD7 AFWG 2017), and abundance and biomass estimates from Spanish 2008, 2009, 2011 and 2015 spring surveys (upper panel) (Muñoz *et al.,* WD10 AFWG 2016). No update presented to the 2019 AFWG.

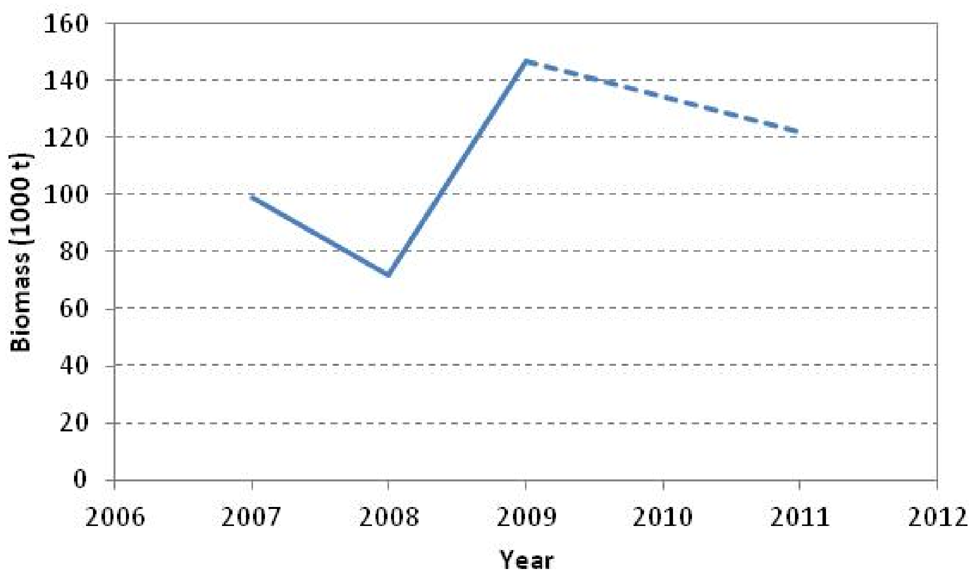


Figure 8.14. Biomass estimates from Polish 2007, 2008, 2009 and 2011 spring survey (based on: Janusz et al., WD8 AFWG 2008; Janusz and Trella, WD10 AFWG 2009; Trella and Janusz, WD6 AFWG 2012). No update presented to the 2019 AFWG

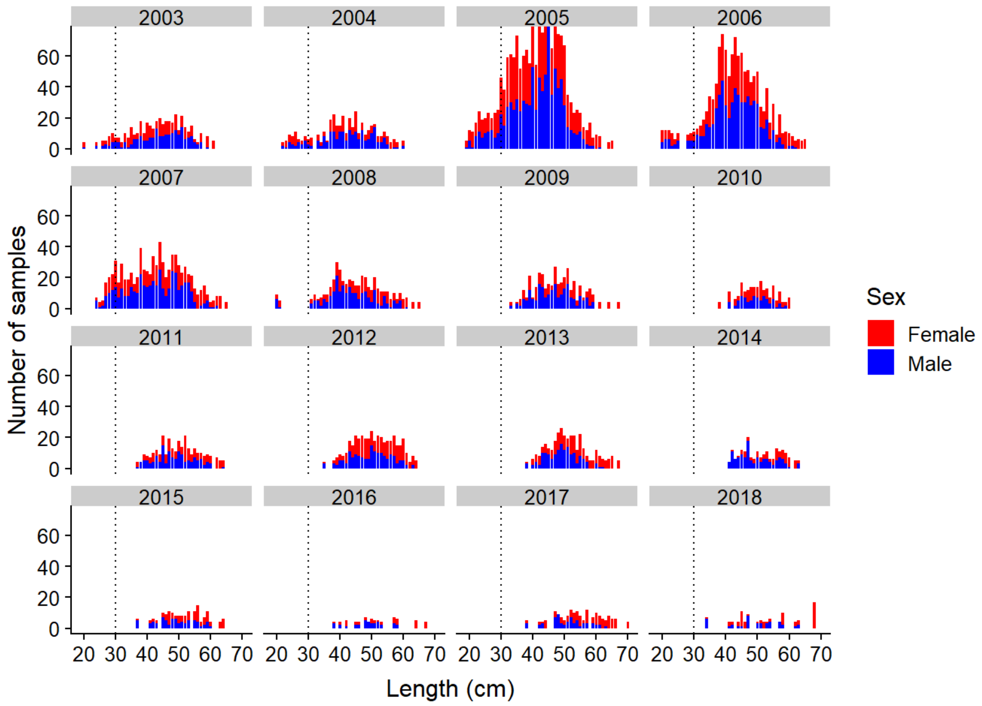


Figure 8.15. Total number of sexed length-samples by year by 1 cm length group and sex in the EcoSouth area.

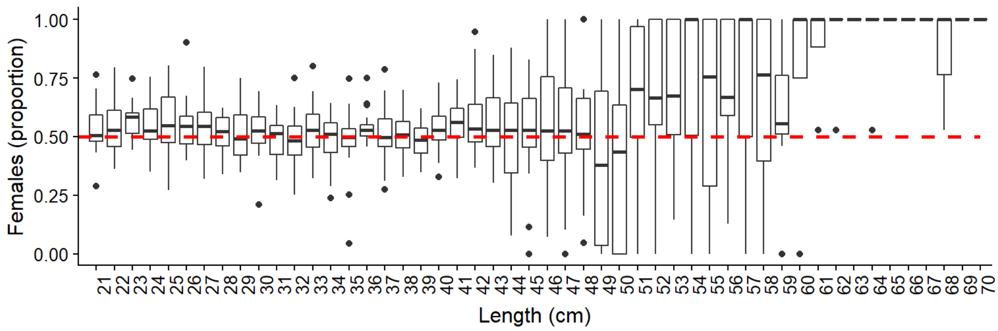


Figure 8.16. Yearly Proportion of female G. halibut by length based on survey data. Individuals <20 cm are removed because sex determination is not trusted. 99.6% of individuals are <50 cm.

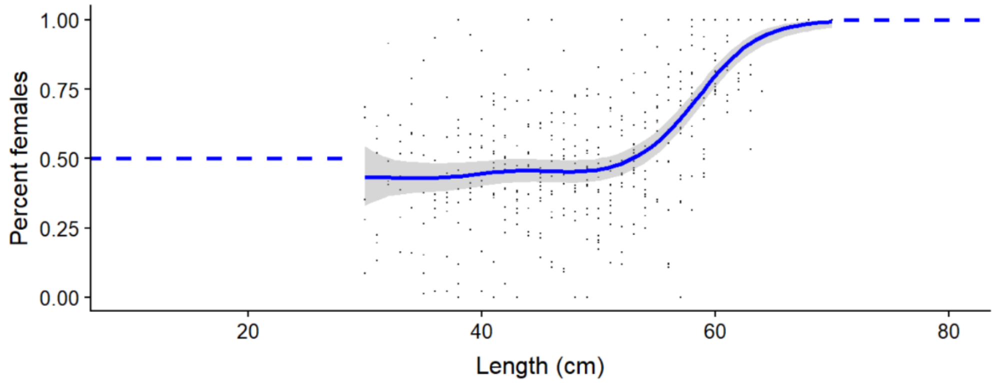


Figure 8.17. Key for splitting on sex in EcoSouth in the 2019 assessment. For 0-30 cm the percent females was set to 50%, and for 70-100 cm was set to 100%. For the interval 30-70 cm, a gam was fitted to all available data from the survey in the EcoSouth area.

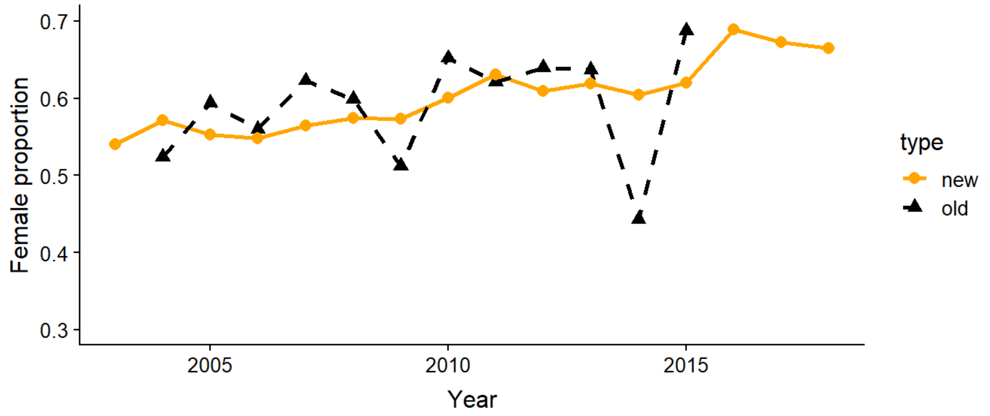


Figure 8.18. Proportion of females in EcoSouth biomass index, comparison of old and new index.

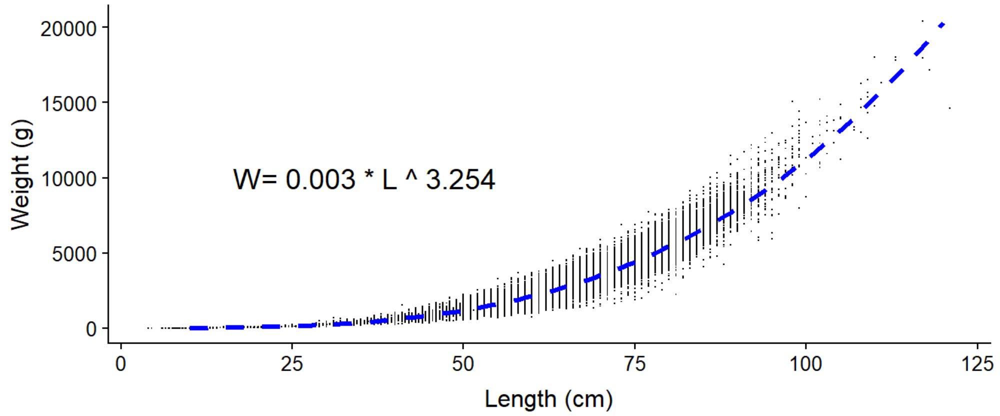


Figure 8.19. Length-weight relationship, linear model: log(W) = + b*log(L), R2 = 0.9814, p<0.001. All available data on G. halibut in IMR databases.

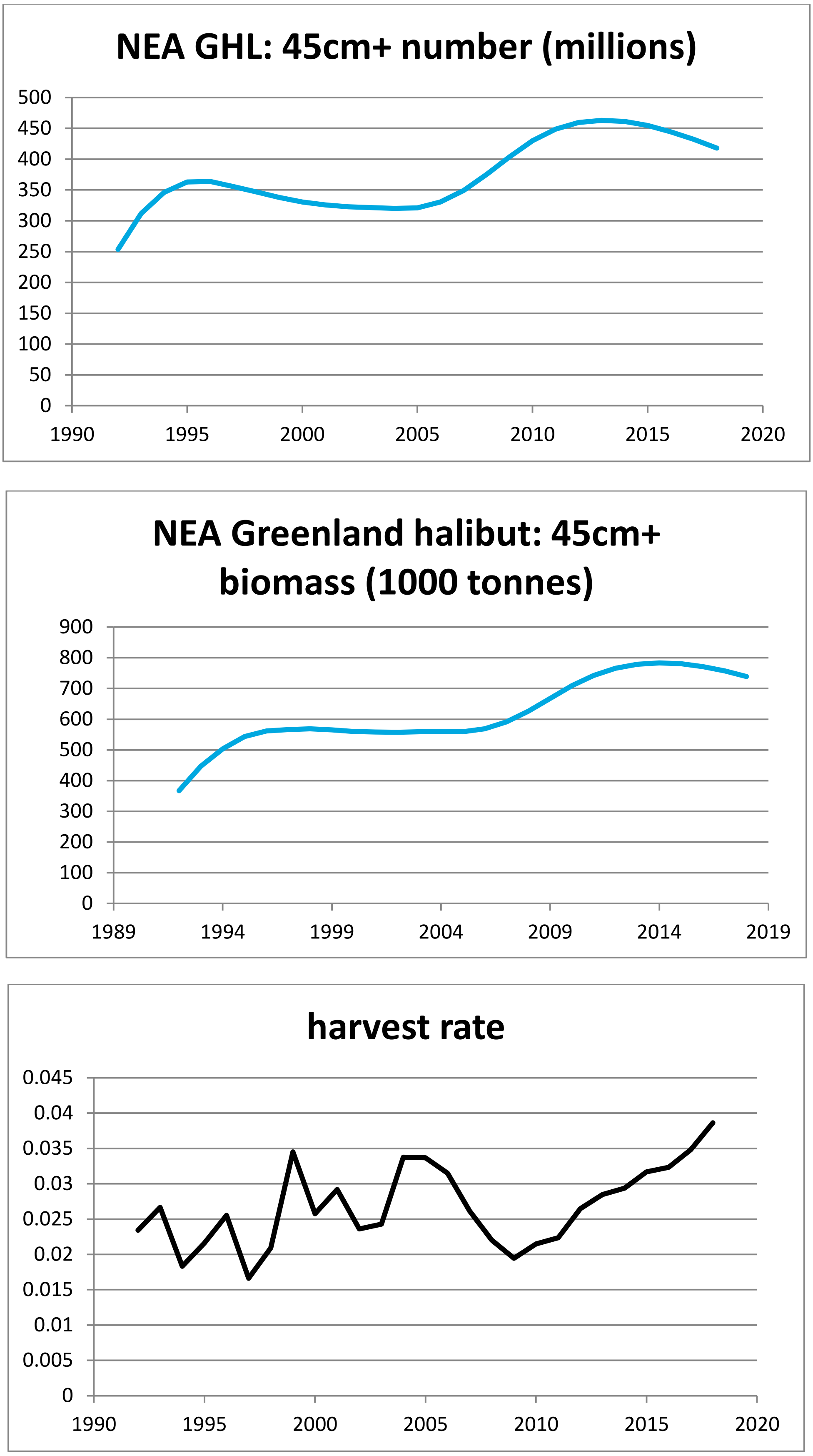


Figure 8.20. Numbers (upper) and biomass (middle) for 45+ cm Greenland halibut as estimated by the GADGET model, and estimated exploitation rates (below).

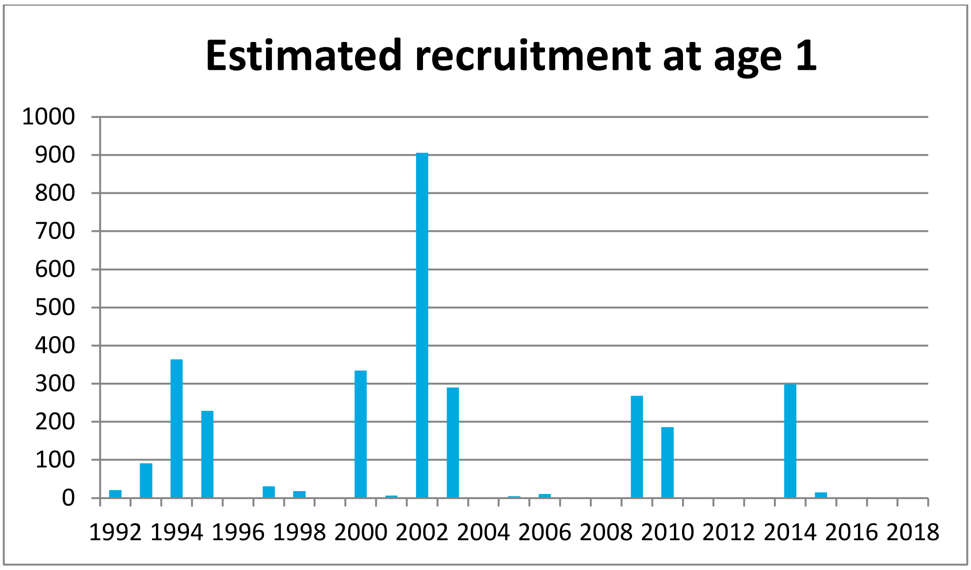


Figure 8.21. Gadget recruitment estimate (in millions) for the Greenland Halibut stock at 1st January. Note that the most recent year(s) of recruitment are tuned by very few data and should be considered tentative.

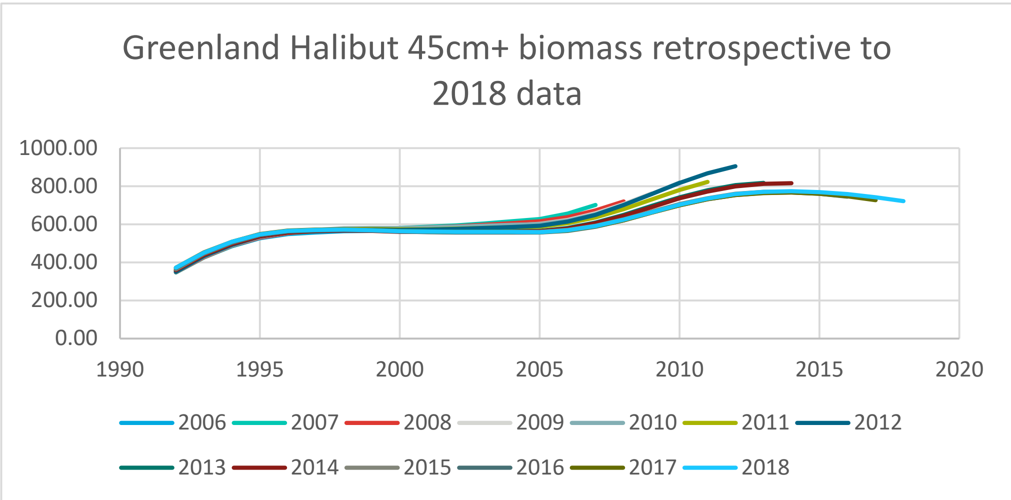


Figure 8.22. Retrospective patterns from the GADGET model run.

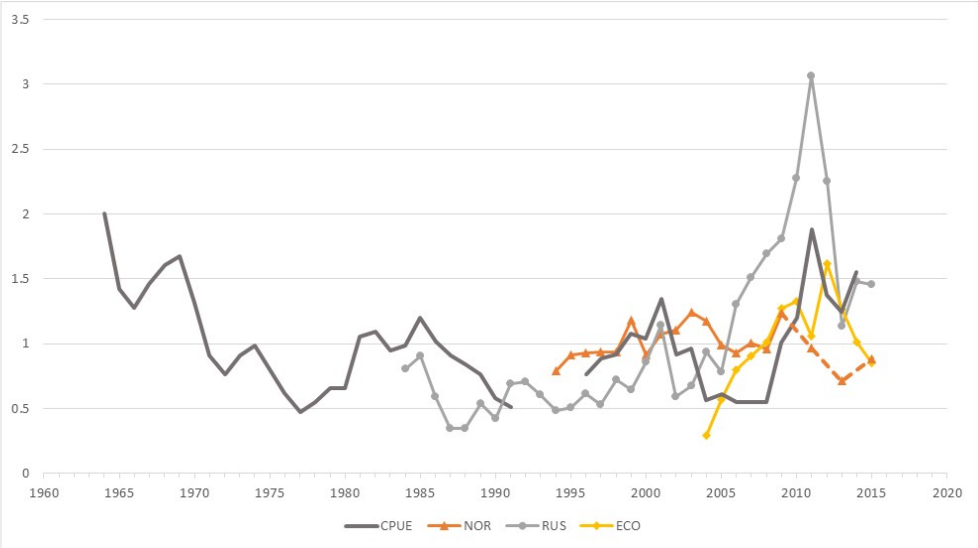


Figure 8.23. Dynamics of indices of the Barents Sea Greenland halibut stock in 1964–2015 (indices are taken divided by corresponding mean to put them in comparable scale; CPUE series divided by two: 1964–1991 and after 1996). In addition to the standardized CPUE three survey indices are shown; the Russian autumn survey (RUS), the Norwegian autumn survey (NOR) and the EcoSouth index (ECO).

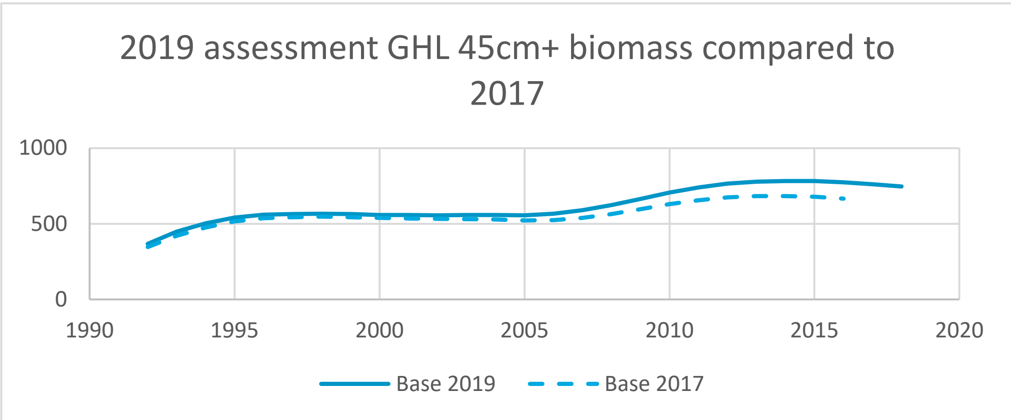


Figure 8.24. Change in Greenland halibut biomass since last assessment

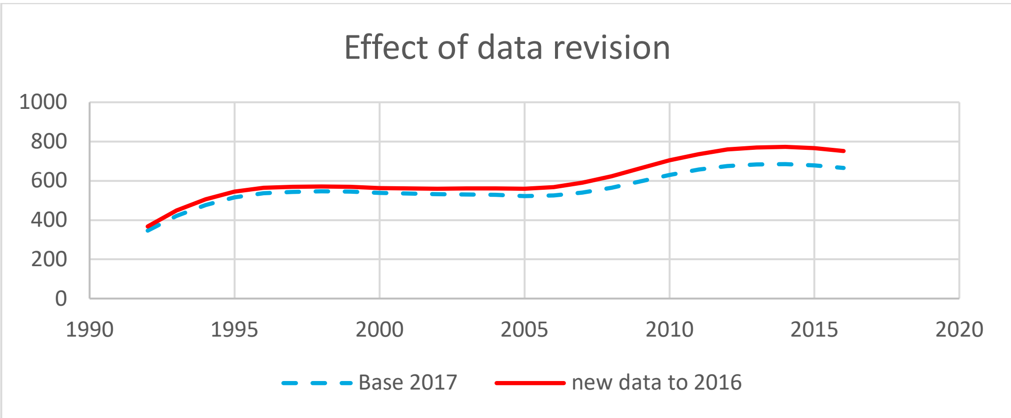


Figure 8.25. Effect of data revision on the estimated biomass of Greenland Halibut

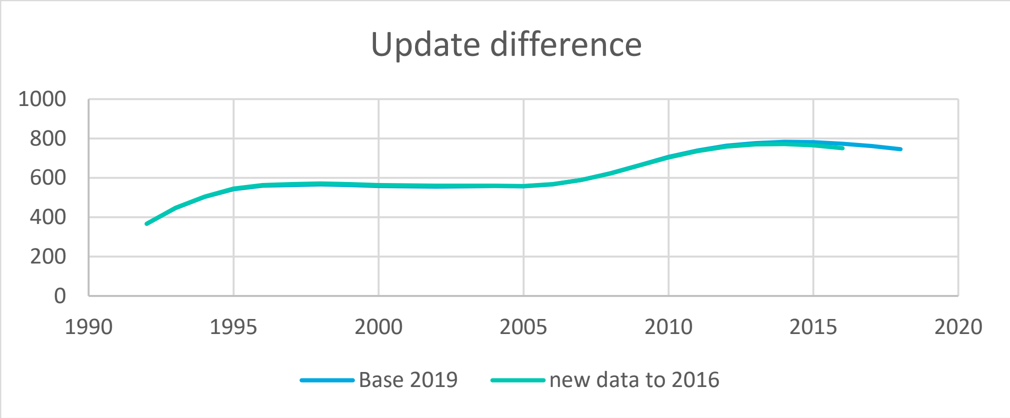


Figure 8.26. Effect of update year on estimated biomass of Greenland Halibut

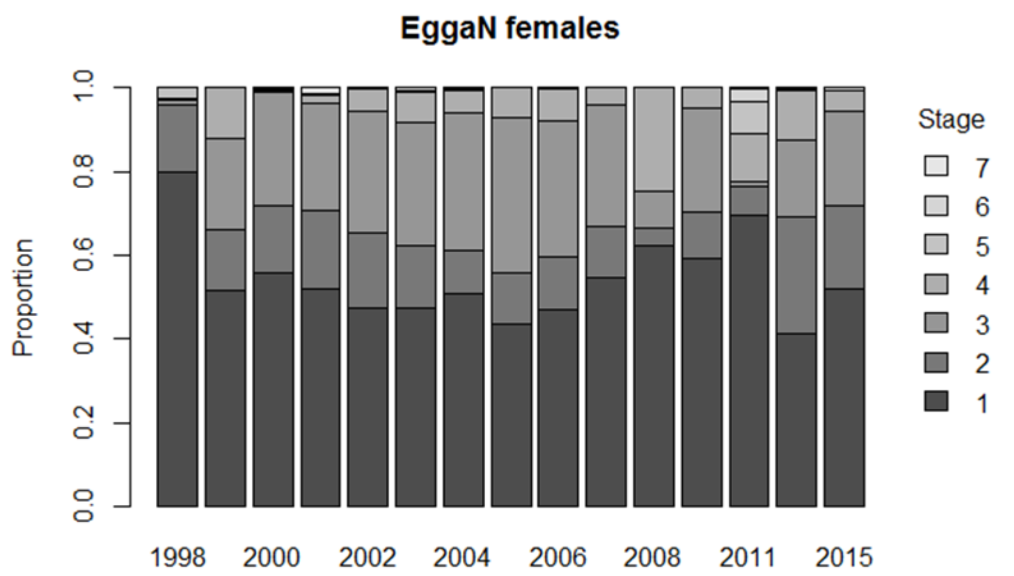


Figure 8.27. Proportion of numbers per maturity stage for Greenland halibut females in the Norwegian slope survey.

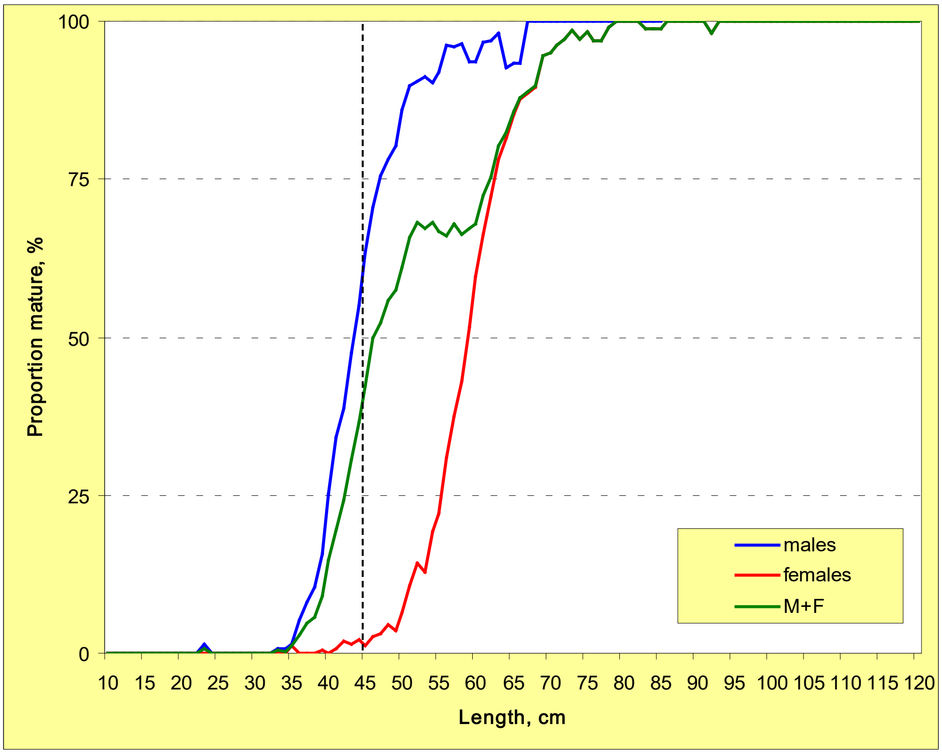


Figure 8.28. Greenland halibut maturity at length (Russian actual data, 2000–2009 combined). L_{50} for males ~43 cm, L_{50} for females ~57 cm (from Smirnov, 2011, WD21 ICES AFWG 2011)

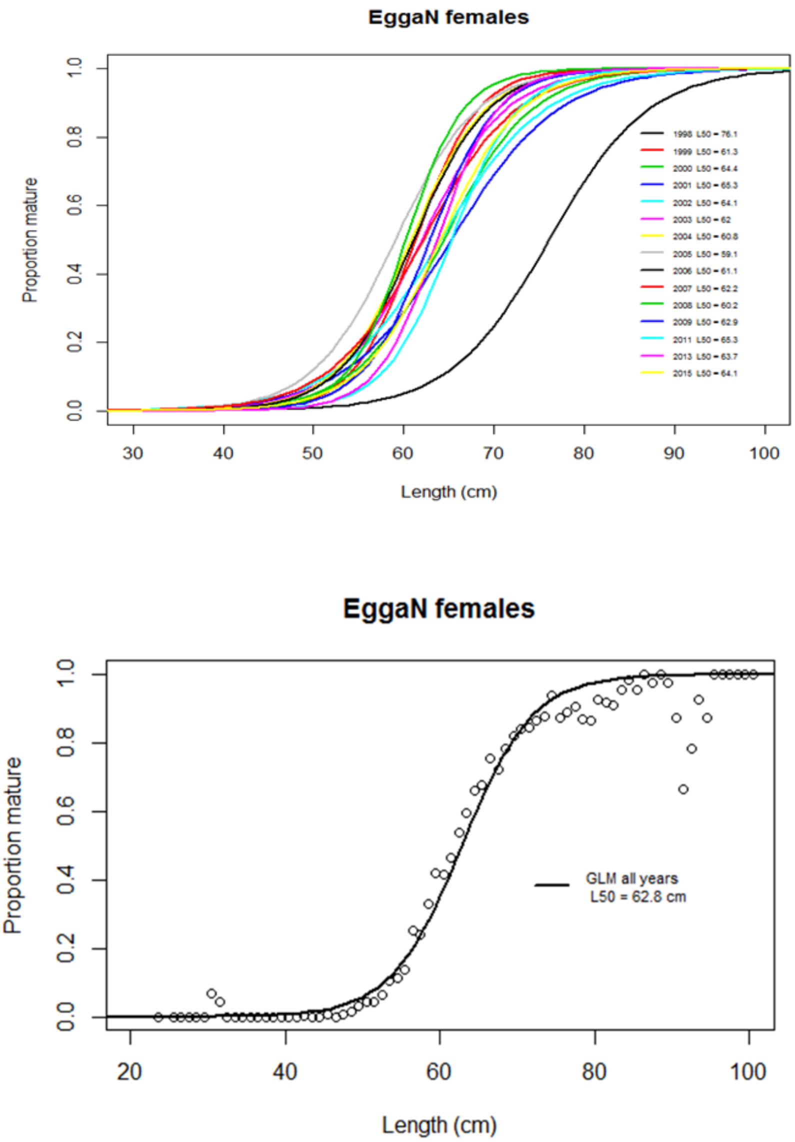


Figure 8.29. Maturity ogives for female Greenland halibut based on data from the Norwegian Slope survey, by year in upper panel and all years together (year 1998 omitted) in lower panel. Stage 1 and 2 on special maturity scale for females are taken as immatures; see Kennedy *et al.,* 2009, 2011, 2014, and Nunez *et al.,* 2015.

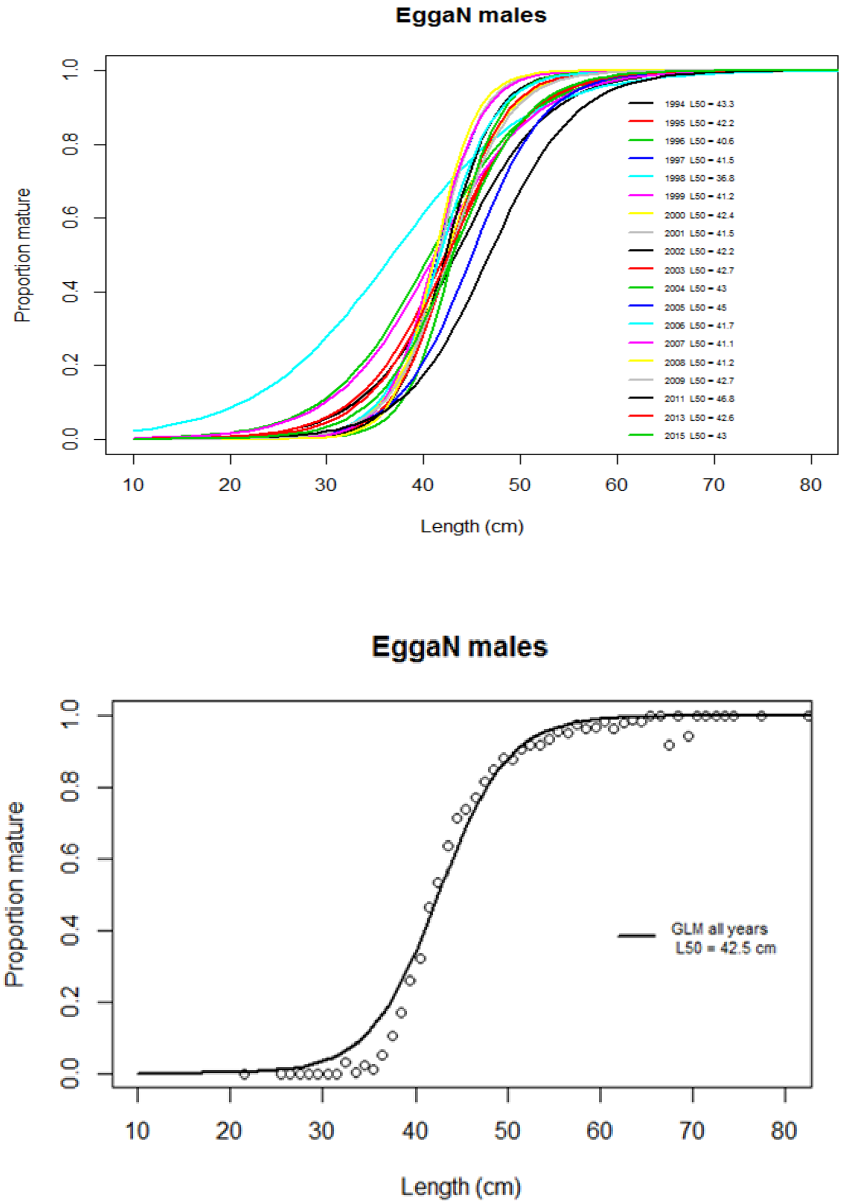


Figure 8.30. Maturity ogives for male Greenland halibut based on data from the Norwegian Slope survey, by year in upper panel and all years together (year 1998 and 2010 omitted) in lower panel.

9 Barents Sea Capelin

As decided by the Arctic Fisheries Working Group at its 2019 meeting, the assessment of Barents Sea capelin was left to the parties responsible for the autumn survey, i.e. IMR in Bergen and PINRO in Murmansk. In accordance with this, the assessment was made during a meeting in Murmansk, Russia on 3–4 October 2019. The assessment was an update assessment, without changes in the methodology.

Therefore, the information in this annex overrides section 9 of the initial AFWG 2019 report.

Participants:

Georg Skaret (Chair of meeting)	Norway
Stine Karlson	Norway
Bjarte Bogstad	Norway (by correspondence)
Dmitry Prozorkevich	Russia
Yuri Kovalev	Russia
Tatiana Prokhorova	Russia
Anatoly Chetyrkin	Russia

9.1 Regulation of the Barents Sea Capelin Fishery

Since 1979, the Barents Sea capelin fishery has been regulated by a bilateral fishery management agreement between Russia (former USSR) and Norway. A TAC has been set separately for the winter fishery and for the autumn fishery. From 1999, no autumn fishery has taken place, except for a small Russian experimental fishery in some years. A minimum landing size of 11 cm has been in force since 1979. AFWG strongly recommends capelin fishery only on mature fish during the period from January to April.

9.2 TAC and Catch Statistics (Table 9.1)

The Joint Russian-Norwegian Fishery Commission set a quota of 205 000 tonnes for 2018, while the TAC for 2019 was set to zero. Both the quotas were in accordance with the ICES advice. The international historical catch by country and season in the years 1965–2019 is given in Table 9.1. There were no landing in 2019, except very small catches during scientific research by Norway and Russia.

9.3 Sampling

The capelin sampling from the Barents Sea ecosystem survey used in the 2019 capelin assessment is summarized below:

Investigation	No. of trawl hauls	Length measurements	Aged individuals
Ecosystem survey in autumn 2019 (Norway)	105	9782	2734
Ecosystem survey in autumn 2019 (Russia)	142	8749	529

9.4 Stock assessment

9.4.1 Acoustic stock size estimates in 2019 (Table 9.2, Figure 9.1)

The geographical survey coverage of the Barents Sea capelin stock during the BESS in 2019 was considered to be complete (Figure 9.1). The northeastern part of the standard survey area was not covered, but based on the rest of the distribution data, no capelin was expected here. The catches in the survey were 5 t.

The stock estimate from the area covered by the 2019 survey was 0.41 million tonnes (Table 9.2). About 73% (0.30 million tonnes) of the estimated stock biomass consisted of maturing fish (>14.0 cm). The mean weight at age in the 2019 survey was similar to 2018 for all age groups (Figure 9.2).

As decided during the 2016 assessment meeting, the capelin abundance was estimated using the software StoX (Johnsen *et al.*, 2019), applying agreed settings.

A fixed sampling variance expressed as Coefficient of Variance (CV) of 0.2 per age group has been applied as input for CapTool in the capelin assessment and was also used this year (Tjelmeland 2002; Gjøsæter *et al.*, 2002). The survey design and estimation software now allows for estimation of a direct CV by age group, and for the 2019 survey this was estimated:

for age group 1 -0.13; for age group 2 - 0.33, and for age group 3 - 0.36.

These values are higher than previous years for age groups 2 and 3, and lower for age group 1. This can be due to the very patchy distribution of adult capelin this year. Relative sampling error based only on acoustic recordings (Nautical Area Scattering Coefficient (NASC; m^2nmi^{-2}) by nau-tical mile) was estimated to 25.37%, which was very similar to last year. These values are higher than in 2017. Detailed information about previous CV estimates can be found in AFWG WD5, 2018. Future implementation of direct survey CV in the assessment is discussed under future work (9.4.7).

9.4.2 Recruitment estimation in 2018 (Table 9.3)

The survey coverage of 0-group in 2019 was considered complete. Swept volume 0-index (Dingsør, 2005; Eriksen *et al.*, 2009) was calculated both: without correction and with correction for catching efficiency (Table 9.3). The capelin 0-group index for 2019 was above the long-term average. The mean length of 0-group capelin in the areas covered was the lowest since 1993, and well below the long-term average. Table 9.3 also shows the number of fish in the various year classes at age 0-2, and their "survey mortality" from age one to age two.

9.4.3 Forecast

Probabilistic projections of the maturing stock to the time of spawning at 1 April 2020 were made using the spreadsheet model CapTool (implemented in the @RISK add-on for EXCEL, 50 000 simulations were used). The settings were the same as last year. The projection was based on a maturation and predation model with parameters estimated by the model Bifrost and data on cod abundance and size at age in 2020 from the 2019 Arctic Fisheries Working Group.

The methodology is described in the 2009 WKSHORT report (ICES, 2009) and the WKARCT 2015 report (ICES, 2015). The natural mortality M for the months October to December is drawn among a set of M-values estimated for different years based on historical data. The same set of M-values was used in 2019 as in 2018 (ICES 2011, Annex 12).

With no catch, the estimated median spawning stock size on 1 April 2020 is 85 100 tonnes (Figure 9.3), and the probability for the spawning stock to be below B_{lim} (200 000 t) is 97.8%.

Estimates of stock in number by age group and total biomass for the historical period are shown in Table 9.4. Other data, which describe the stock development, are shown in Table 9.5. Summary plots are given in Figure 9.4.

9.4.4 Recruitment

The 1-group abundance in 2019 was 17.5 billion which is far below the long-term average and the lowest since 1995 (Figure 9.5). The most recent evaluation of the spawning stock and recruitment time-series was made by Gjøsæter *et al.* (2016).

Future recruitment conditions: High abundance of young herring (mainly age groups 1 and 2) has been suggested to be a necessary but not a single factor causing recruitment failure in the capelin stock (Hjermann *et al.*, 2010; Gjøsæter *et al.*, 2016). Based on survey data from the Barents Sea Ecosystem Survey in 2019, a significant proportion of the young herring is 3-year-olds, which are expected to leave the Barents Sea in the year to come, and the abundance of young herring in the Barents Sea in 2020 is expected to be below average.

9.4.5 Comments to the assessment

The survey estimate of abundance at age in 2019 is in correspondence with the 2018 estimate, but the "survey mortality" from age 1 to 2 is very high (Figure 9.6, Table 9.3). This is one of the highest values in the historical period.

Ecological considerations

The number of young herring in the Barents Sea can be an important factor that affects the capelin recruitment. It is not currently taken into account in the assessment model. The benchmark for capelin stocks in the Barents Sea (ICES, 2015) noted the need for further study of this effect as well as better monitoring of the young herring abundance.

The amount of other food than capelin for cod and other predators may also have changed in recent years. This may also indirectly have affected the predation pressure on capelin. A more detailed discussion of interactions between capelin and other species is given in the 2016–2019 WGIBAR reports (ICES 2016, 2017, 2018c, 2019).

9.4.6 Further work on survey and assessment methodology

Survey

Since the only source of information about the capelin stock abundance and composition comes from the BESS, it is crucial to the assessment that the survey results are reliable. While the survey results of 2016 and 2017 revealed inconsistencies related to monitoring issues (Skaret *et al.*, 2018), the results from 2017 and 2018 were consistent, and also from 2018 and 2019.

On 3–17 March 2019, IMR tested out acoustic monitoring and stock estimation of spawning capelin. The initiative and funding comes from the industry, and the idea in the long term is that monitoring closer to when fishery and spawning happens, can reduce uncertainty in stock advice. Monitoring during spawning has been attempted before, last time in 2007–2009, and has proven to be methodologically difficult due to unpredictable timing and location of the spawning migration. This time the survey was done using the fishing vessel 'Vendla' in collaboration with a scouting vessel, the fishing vessel 'Rødholmen'. A stratified design with zigzag transects with randomized starting points were used and the effort was allocated based on historical and recent information about capelin distribution. The fishery sonar was used actively during the whole survey to estimate size distribution of capelin schools, and migration speed and direction. The coverage of the capelin spawning migration was successful and the estimate was within the expected range from the autumn predictions (Table 9.6). The survey report (Peña *et al.*, 2019) is available here: https://www.hi.no/resources/Toktrapport-loddetokt-mars-2019.pdf.

Nevertheless, methodological issues due to timing and patchy distribution of capelin were still very apparent, and this must be looked further into before such monitoring can be potentially implemented in an advisory process. A similar survey will be carried out again in the winter of 2020 with increased effort.

With the aim of improving survey methodology, the Deep vision camera system was tested this year on board 'Johan Hjort' during BESS for the second time. It was mounted on a frame in the trawl opening and towed after the vessel to obtain image samples of fish. The results can help to validate the classification of acoustic data to species groups which was an issue in particular during the 2016 survey, and can potentially provide size distribution of capelin in different depths. The test was promising, but unfortunately, leakage into the camera housing limited the testing to only a few trawl hauls.

Assessment model

In the present capelin assessment model, the only species interaction in the Barents Sea taken explicitly into account is predation by cod on mature capelin. The model does not take into account possible changes in capelin stock dynamics (e.g. maturation), the current state of the environment and stock status of other fish species and mammals in the Barents Sea. The ICES Working Group of Integrated Assessment of the Barents Sea (WGIBAR) has addressed some of these issues.

Consumption of prespawning capelin by mature cod in winter-spring season and autumn season is still not included in the assessment model. It may have a significant impact on capelin SSB calculations.

Gjøsæter *et al*. (2015) calculated what the quota advice and spawning stock would have been in the period 1991–2013, given the present assessment model and knowledge of the cod stock. By exchanging that cod forecast with the actual amount of cod from the cod assessment model run later in time and rerunning the model, they showed that considerably smaller annual quotas would have been advised if the amount of cod had been known and the present assessment model had been used when the capelin quota was set. Following this work, a retrospective analysis of the capelin assessment as well as of the assessment performance should be included annually. This is a feature, which so far has been missing from the capelin assessment.

The further research should include improvement of the Bifrost model for calculation and inclusion interactions between capelin and other species for calculation new target reference point for capelin B_{target}.

A joint benchmark for IGJM capelin and BS capelin is planned for 2020. A few points, which are planned to be raised, are briefly discussed in the following:

Implementation of survey CV in the stock prediction. The StoX software allows for a rapid calculation of survey CV as part of the capelin biomass estimation process. Potentially this can be included in the stock prediction instead of the fixed CV of 0.2, which is used currently. A more detailed description of the CV estimation and discussion about its implementation is presented in WD5, 2018. The capelin stock projection as currently formulated implements uncertainty in a range of parameters, also related to the cod predation on capelin. A validation of the sensitivity of these uncertainties and their relative contribution to the output of the projection model is needed. At present and from a more practical point of view, the capelin projection model interface in use cannot efficiently run such evaluations and sensitivity tests, but potentially these can be available for the benchmark meeting.

Estimating the maturing part of the capelin stock. Currently a cut-off length of 14 cm is used and the proportion of the stock, which is above this length, is assumed to represent the maturing stock. There has been work investigating whether the cut-off is appropriate, and this will be presented at the benchmark.

Estimation of capelin mortality from cod predation during autumn. At present, the cod predation from 1 January to 1 April is explicitly modelled in the stock prediction model Bifrost. The cod predation during autumn is implemented as a monthly mortality rate based on a subset of historical estimates of capelin survey mortality. This implementation should be improved.

The parameterization for all processes in Bifrost and CapTool should be updated to include recent data.

9.5 Reference points

A B_{lim} (SSB_{lim}) management approach has been suggested for this stock (Gjøsæter *et al.,* 2002). In 2002, the JRNFC agreed to adopt a management strategy based on the rule that, with 95% probability, at least 200 000 tonnes of capelin should be allowed to spawn. Consequently, 200 000 tonnes was used as a B_{lim}. Alternative harvest control rules of 80, 85, and 90% probability of SSB > B_{lim} were suggested by JNRFC and evaluated by ICES (ICES, 2016). ICES considers these rules not to be precautionary. At its 2016 meeting, JNRFC decided not to change the adopted management strategy.

Table 9.1. Barents Sea CAPELIN. International catch ('000 t) as used by the Working Group.

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1965	217	7	0	224	0	0	0	224
1966	380	9	0	389	0	0	0	389
1967	403	6	0	409	0	0	0	409
1968	460	15	0	475	62	0	62	537
1969	436	1	0	437	243	0	243	680
1970	955	8	0	963	346	5	351	1314
1971	1300	14	0	1314	71	7	78	1392
1972	1208	24	0	1232	347	13	360	1591
1973	1078	34	0	1112	213	12	225	1337
1974	749	63	0	812	237	99	336	1148
1975	559	301	43	903	407	131	538	1441
1976	1252	228	0	1480	739	368	1107	2587
1977	1441	317	2	1760	722	504	1226	2986
1978	784	429	25	1238	360	318	678	1916
1979	539	342	5	886	570	326	896	1782
1980	539	253	9	801	459	388	847	1648
1981	784	429	28	1241	454	292	746	1986
1982	568	260	5	833	591	336	927	1760
1983	751	373	36	1160	758	439	1197	2357
1984	330	257	42	629	481	368	849	1477
1985	340	234	17	591	113	164	277	868
1986	72	51	0	123	0	0	0	123
1987-1990	0	0	0	0	0	0	0	0
1991	528	159	20	707	31	195	226	933
1992	620	247	24	891	73	159	232	1123
1993	402	170	14	586	0	0	0	586
1994-1996	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	1	1	1

Year	Winter-Spring				Summer-Autumn			Total
	Norway	Russia	Others	Total	Norway	Russia	Total	
1998	0	2	0	2	0	1	1	3
1999	50	33	0	83	0	22	22	105
2000	279	94	8	381	0	29	29	410
2001	376	180	8	564	0	14	14	578
2002	398	228	17	643	0	16	16	659
2003	180	93	9	282	0	0	0	282
2004	0	0	0	0	0	0	0	0
2005	1	0	0	1	0	0	0	1
2006	0	0	0	0	0	0	0	0
2007	2	2	0	4	0	0	0	4
2008	5	5	0	10	0	2	0	12
2009	233	73	0	306	0	1	1	307
2010	246	77	0	323	0	0	0	323
2011	273	87	0	360	0	0	0	360
2012	228	68	0	296	0	0	0	296
2013	116	60	0	177	0	0	0	177
2014	40	26	0	66	0	0	0	66
2015	71	44	0	115	0	0	0	115
2016-2017	0	0	0	0	0	0	0	0
2018	129	66	0	195	0	0	0	195
2019	5*	0	0	0	0	0	0	0

*** Research catch**

Table 9.2. Barents Sea CAPELIN. Stock size estimation table. Estimated stock size (10^9) by age and length, and biomass (10^3 tonnes) from the acoustic survey in August-September 2019. TSN: Total stock number. TSB: Total-stock biomass. MSN: Maturing stock number. MSB: Maturing stock biomass.

Length (cm)	Age/year class 1 2018	2 2017	3 2016	4 2015	Sum (10^9)	Biomass (10^3t)	Mean weight (g)
7-7.5	1.121	0	0	0	1.121	1.46	1.3
7.5-8	1.756	0	0	0	1.756	2.509	1.43
8-8.5	0.985	0	0	0	0.985	2.004	2.03
8.5-9	1.874	0.0088	0	0	1.883	4.649	2.47
9-9.5	1.387	0.042	0	0	1.429	4.137	2.9
9.5-10	1.452	0.006	0	0	1.459	5.141	3.52
10-10.5	1.522	0	0	0	1.522	6.405	4.21
10.5-11	1.598	0.016	0	0	1.615	7.914	4.9
11-11.5	0.875	0.015	0.053	0	1.077	6.054	5.62
11.5-12	1.112	0.122	0	0	1.234	7.785	6.31
12-12.5	0.95	0.271	0	0	1.221	9.28	7.6
12.5-13	0.512	0.4185	0.018	0	0.949	8.375	8.83
13-13.5	0.747	0.865	0.027	0	1.638	16.516	10.08
13.5-14	0.554	1.534	0.278	0	2.369	27.303	11.53
14-14.5	0.515	1.094	0.043	0	1.651	21.559	13.06
14.5-15	0.317	1.395	0.124	0.059	1.895	27.993	14.77
15-15.5	0.146	1.045	0.267	0.002	1.461	24.488	16.77
15.5-16	0.01	1.002	1.391	0.041	2.444	46.278	18.94
16-16.5	0.0194	0.736	1.195	0.116	2.066	43.827	21.21
16.5-17	0.003	0.388	1.537	0.343	2.271	52.693	23.21
17-17.5	0	0.049	0.801	0.244	1.095	28.896	26.39
17.5-18	0	0.101	0.665	0.179	0.945	28.35	29.99
18-18.5	0	0.014	0.551	0.149	0.714	23.057	32.31
18.5-19	0	0.003	0.06	0.015	0.008	2.752	35.08
19-19.5	0	0	0.024	0.008	0.032	1.213	37.9
19.5-20	0	0	0	0.006	0.006	0.244	38

Length (cm)	Age/year class				Sum (10^9)	Biomass (10^3t)	Mean weight (g)
	1 2018	2 2017	3 2016	4 2015			
20-20.5				0.006	0.006	0.264	41
20.5-21				0	0	0.002	44
TSN(10^9)	17.455	9.26	7.036	1.169	34.92		
TSB(10^3t)	86.015	134.535	160.425	30.171		411.147	
Mean length (cm)	10.03	14.26	16.22	16.83			
Mean weight (g)	4.93	14.53	22.8	25.71			11.77
MSN (10^9)	1.01	5.828	6.658	1.169	14 593	105.593	
MSB (10^3t)	14.51	100.915	156.141	30.055			301.615

Table 9.3. Barents Sea CAPELIN. Recruitment and natural mortality table. Larval abundance estimate in June, 0-group indices and acoustic estimate in August-September, total mortality from age 1+ to age 2+.

Year class	Larval abundance (10^{12})	0-group Index (10^9 ind.)		Acoustic estimate (10^9ind.)		Mortality survey(1—2)
		Without Keff	With Keff	1(Y+1)	2(Y+2)	%
1980	-	197.3	740	402.6	147.6	63
1981	9.7	123.9	477	528.3	200.2	62
1982	9.9	168.1	600	514.9	186.5	64
1983	9.9	100.0	340	154.8	48.3	69
1984	8.2	68.1	275	38.7	4.7	88
1985	8.6	21.3	64	6.0	1.7	72
1986	0.0	11.4	42	37.6	28.7	24
1987	0.3	1.2	4	21.0	17.7	16
1988	0.3	19.6	65	189.2	177.6	6
1989	7.3	251.5	862	700.4	580.2	17
1990	13.0	36.5	116	402.1	196.3	51
1991	3.0	57.4	169	351.3	53.4	85
1992	7.3	1.0	2	2.2	3.4	--
1993	3.3	0.3	1	19.8	8.1	59
1994	0.1	5.4	14	7.1	11.5	--
1995	0.0	0.9	3	81.9	39.1	52
1996	2.4	44.3	137	98.9	72.6	27
1997	6.9	54.8	189	179.0	101.5	43
1998	14.1	33.8	113	156.0	110.6	29
1999	36.5	85.3	288	449.2	218.7	51
2000	19.1	39.8	141	113.6	90.8	20
2001	10.7	33.6	90	59.7	9.6	84
2002	22.4	19.4	67	82.4	24.8	70
2003	11.9	94.9	341	51.2	13.0	75
2004	2.5	16.7	54	26.9	21.7	19
2005	8.8	41.8	148	60.1	54.7	9

Year class	Larval abundance (10¹²)	0-group Index (10^9 ind.)		Acoustic estimate (10^9ind.)		Mortality survey(1—2)
		Without Keff	With Keff	1(Y+1)	2(Y+2)	%
2006	17.1	166.4	516	221.7	231.4	--
2007	-	157.9	480	313.0	166.4	46
2008	-	288.8	995	124.0	127.6	--
2009	-	189.8	673	248.2	181.1	27
2010	-	91.7	319	209.6	156.4	25
2011	-	175.8	594	145.9	216.2	-
2012	-	310.5	989	324.5	106.6	67
2013	-	94.7	316	105.1	40.5	62
2014	-	49.0	164	39.5	8.1	79
2015	-	148.0	456	31.6	123.7	-
2016	-	274.0	779	86.4	59.6	31
2017	-	104.2	694	58.6	7.0	88
2018	-	-	-	17.5		
2019	-	156	538			
Average	9.0	95.8	338	175.3	104	

Table 9.4. Barents Sea CAPELIN. Stock size in numbers by age, total-stock biomass, biomass of the maturing component (MSB) on 1 October.

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
1973	528	375	40	17	0	961	5144	1350
1974	305	547	173	3	0	1029	5733	907
1975	190	348	296	86	0	921	7806	2916
1976	211	233	163	77	12	696	6417	3200
1977	360	175	99	40	7	681	4796	2676
1978	84	392	76	9	1	561	4247	1402
1979	12	333	114	5	0	464	4162	1227
1980	270	196	155	33	0	654	6715	3913
1981	403	195	48	14	0	660	3895	1551
1982	528	148	57	2	0	735	3779	1591
1983	515	200	38	0	0	754	4230	1329
1984	155	187	48	3	0	393	2964	1208
1985	39	48	21	1	0	109	860	285
1986	6	5	3	0	0	14	120	65
1987	38	2	0	0	0	39	101	17
1988	21	29	0	0	0	50	428	200
1989	189	18	3	0	0	209	864	175
1990	700	178	16	0	0	894	5831	2617
1991	402	580	33	1	0	1016	7287	2248
1992	351	196	129	1	0	678	5150	2228
1993	2	53	17	2	2	75	796	330
1994	20	3	4	0	0	28	200	94
1995	7	8	2	0	0	17	193	118
1996	82	12	2	0	0	96	503	248
1997	99	39	2	0	0	140	911	312
1998	179	73	11	1	0	263	2056	931
1999	156	101	27	1	0	285	2776	1718

Year	Stock in numbers (10^9)						Biomass (10^3 tonnes)	
	Age 1	Age 2	Age 3	Age 4	Age 5	Total	Total	MSB
2000	449	111	34	1	0	595	4273	2099
2001	114	219	31	1	0	364	3630	2019
2002	60	91	50	1	0	201	2210	1290
2003	82	10	11	1	0	104	533	280
2004	51	25	6	1	0	82	628	294
2005	27	13	2	0	0	42	324	174
2006	60	22	6	0	0	88	787	437
2007	222	55	4	0	0	280	1882	844
2008	313	231	25	2	0	571	4427	2468
2009	124	166	61	0	0	352	3756	2323
2010	248	128	61	1	0	438	3500	2051
2011	209	181	55	8	0	454	3707	2115
2012	146	156	88	2	0	392	3586	1997
2013	324	216	59	7	0	610	3956	1471
2014	105	107	39	2	0	253	1949	873
2015	40	40	13	1	0	94	842	375
2016	32	8	3	0	0	43	328	181
2017	86	124	17	0	0	227	2506	1723
2018	59	60	21	0	0	140	1597	1056
2019	17	9	7	1	0	35	411	302

Table 9.5. Barents Sea CAPELIN. Summary stock and data for prognoses table. Recruitment and total biomass (TSB) are survey estimates back-calculated to 1 August (before the autumn fishing season) for 1985 and earlier; for 1986 and later it is the survey estimate. Maturing biomass (MSB) is the survey estimate of fish above length of maturity (14.0 cm). SSB is the median value of the modelled stochastic spawning-stock biomass (after the winter/spring fishery). *-indicates a very small spawning stock.

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		SSB, assessment model, April 1 year+1 (10^3 t)	SSB, by winter acoustic survey (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^6 t) source: WGIBAR	Herring 0-group index (10^9 sp) corr. for catching efficiency	Capelin Landing (10^3 t)
	TSB	MSB						
1972	6600	2727			152	0.002		1591
1973	5144	1350	33		529	0.002		1337
1974	5733	907	*		305	0.048		1148
1975	7806	2916	*		190	0.074		1441
1976	6417	3200	253		211	0.039		2587
1977	4796	2676	22		360	0.046		2986
1978	4247	1402	*		84	0.052		1916
1979	4162	1227	*		12	0.039		1782
1980	6715	3913	*		270	0.066	0.08	1648
1981	3895	1551	316		403	0.047	0.04	1986
1982	3779	1591	106		528	0.009	2.52	1760
1983	4230	1329	100		515	0.012	195.45	2357
1984	2964	1208	109		155	1.467	27.35	1477
1985	860	285	*		39	2.638	20.08	868
1986	120	65	*		6	0.191	0.09	123
1987	101	17	34	4	38	0.287	0.05	0
1988	428	200	*	10	21	0.056	60.78	0
1989	864	175	84	378	189	0.156	17.96	0
1990	5831	2617	92	94	700	0.467	15.17	0
1991	7287	2248	643	1769	402	0.955	267.64	933
1992	5150	2228	302	1735	351	2.037	83.91	1123
1993	796	330	293	1498	2	3.649	291.47	586
1994	200	94	139	187	20	3.000	103.89	0
1995	193	118	60	29	7	0.821	11.02	0

Year	Estimated stock by autumn acoustic survey (10^3 t) 1 October		SSB, assessment model, April 1 year+1 (10^3 t)	SSB, by winter acoustic survey (10^3 t)	Recruitment Age 1, survey assessment 1 October 10^9 sp.	Young herring biomass age 1+2 (10^6 t) source: WGIBAR	Herring 0-group index (10^9 sp) corr. for catching efficiency	Capelin Landing (10^3 t)
	TSB	MSB						
1996	503	248	60		82	0.300	549.61	0
1997	909	312	85		99	0.349	463.24	1
1998	2056	932	94	414	179	0.620	476.07	3
1999	2775	1718	382		156	1.080	35.93	105
2000	4273	2098	599	700	449	2.136	469.63	410
2001	3630	2019	626		114	1.543	10.01	578
2002	2210	1291	496	1417	60	0.664	151.51	659
2003	533	280	427		82	1.695	177.68	282
2004	628	294	94	105	51	3.108	773.89	0
2005	324	174	122		27	2.105	125.93	1
2006	787	437	72		60	2.153	294.65	0
2007	2119	844	189		222	0.916	144	4
2008	4428	2468	330	469	313	0.865	201.05	12
2009	3765	2323	517	180	124	0.375	104.23	307
2010	3500	2051	504	452	248	0.579	117.09	323
2011	3707	2115	487	160	209	0.843	83.05	360
2012	3586	1997	504		146	0.394	177.19	296
2013	3956	1471	479		324	0.468	289.39	177
2014	1949	873	504		105	0.553	136.31	66
2015	842	375	82		40	0.698	82.75	115
2016	328	181	37		32	0.452	79.44	0
2017	2506	1723	462		124	0.703	153.76	0
2018	1597	1056	317		59		-	195
2019	411	302	85	295	17			0

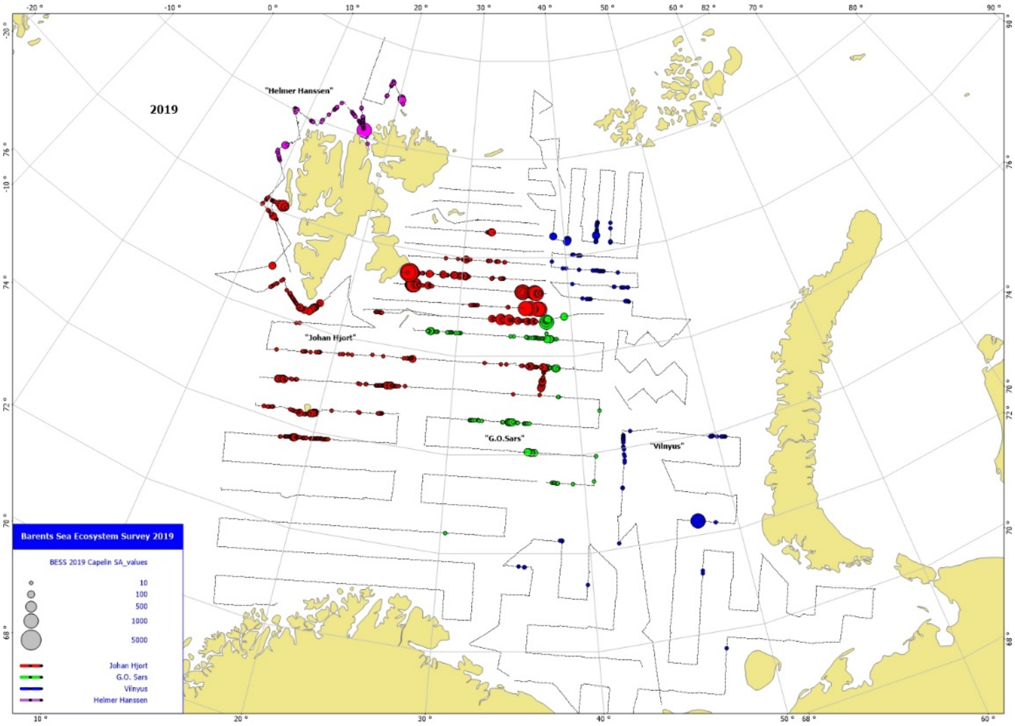


Figure 9.1. Geographical distribution of capelin in autumn 2019.

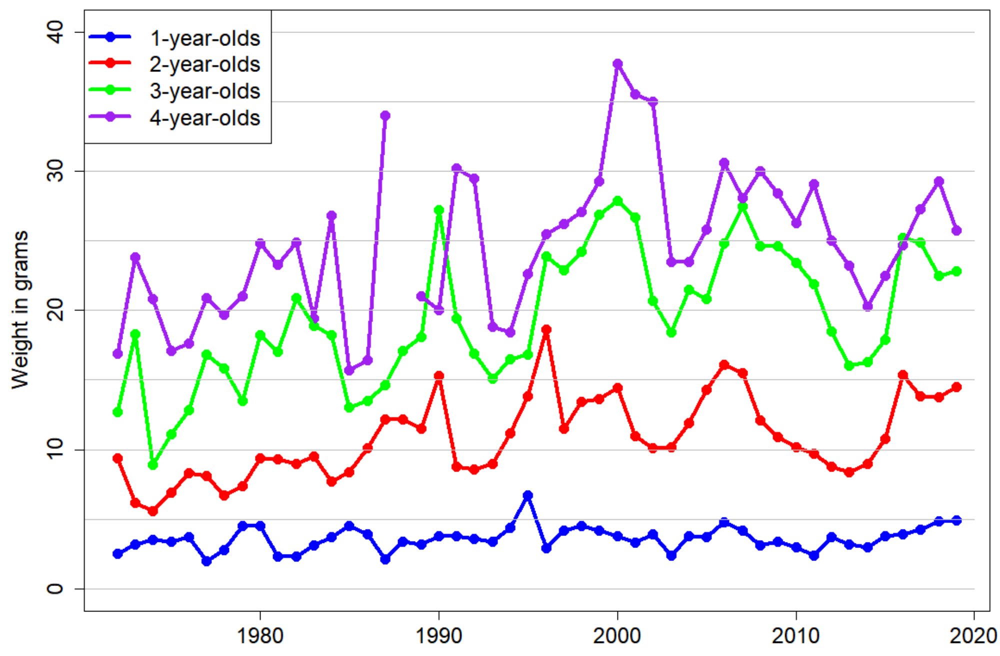


Figure 9.2. Weight-at-age (grammes) for capelin from the autumn survey.

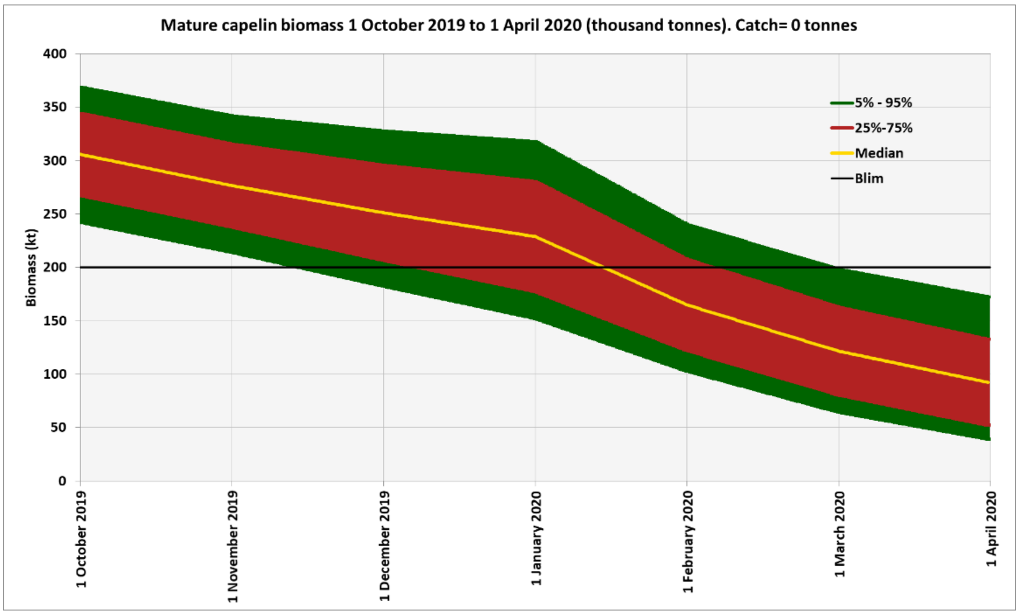


Figure 9.3. Probabilistic prognosis 1 October 2019–1 April 2020 for Barents Sea capelin maturing stock, with no catch (model CapTool, 50 000 simulations).

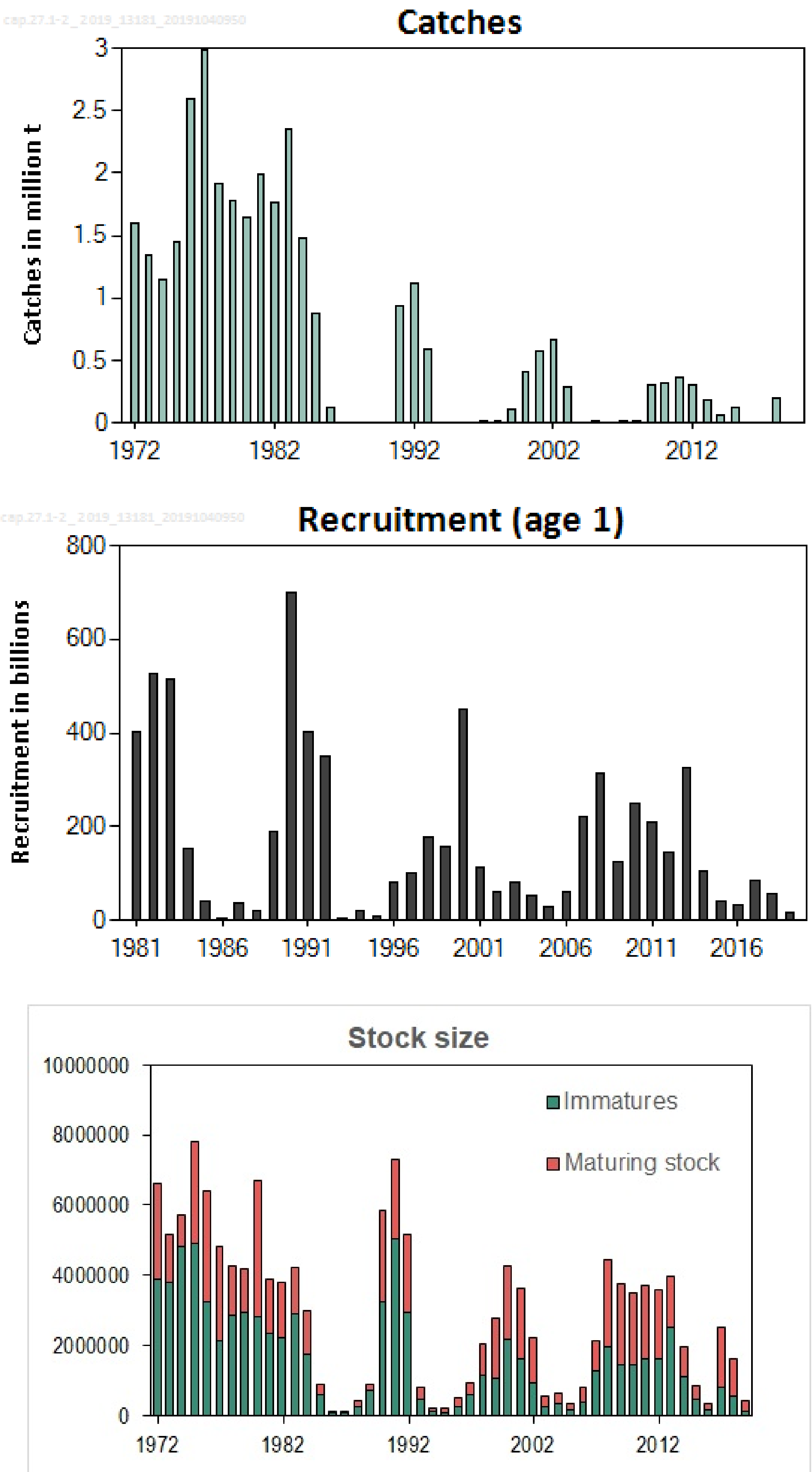


Figure 9.4. Capelin in subareas 1 and 2, excluding Division 2.a west of 5°W (Barents Sea capelin). Landing and summary of stock assessment (mature and immature stock biomass).

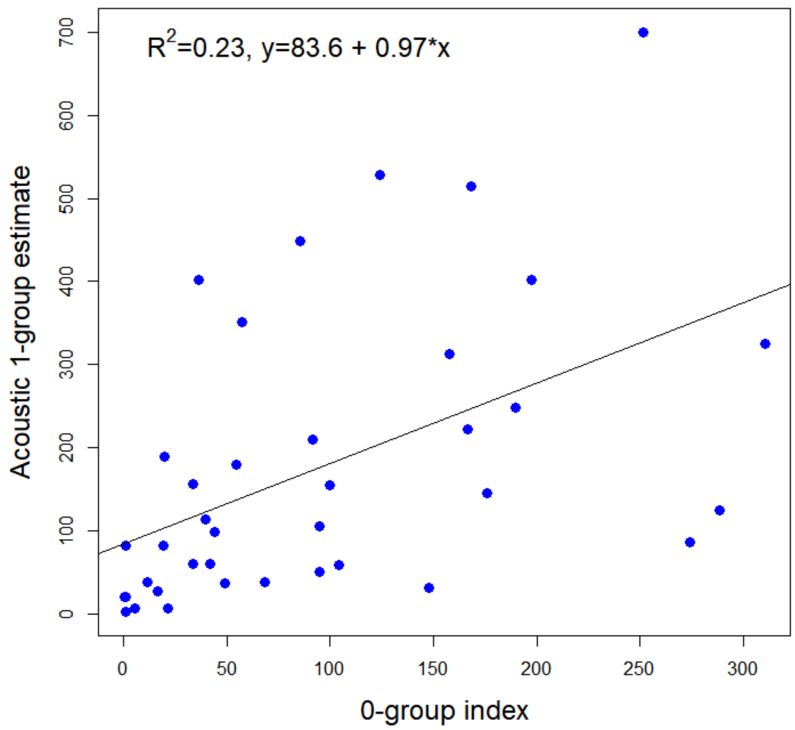


Figure 9.5. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 for cohorts 1980–2017. No 0-group estimate was made for the 2018 cohort.

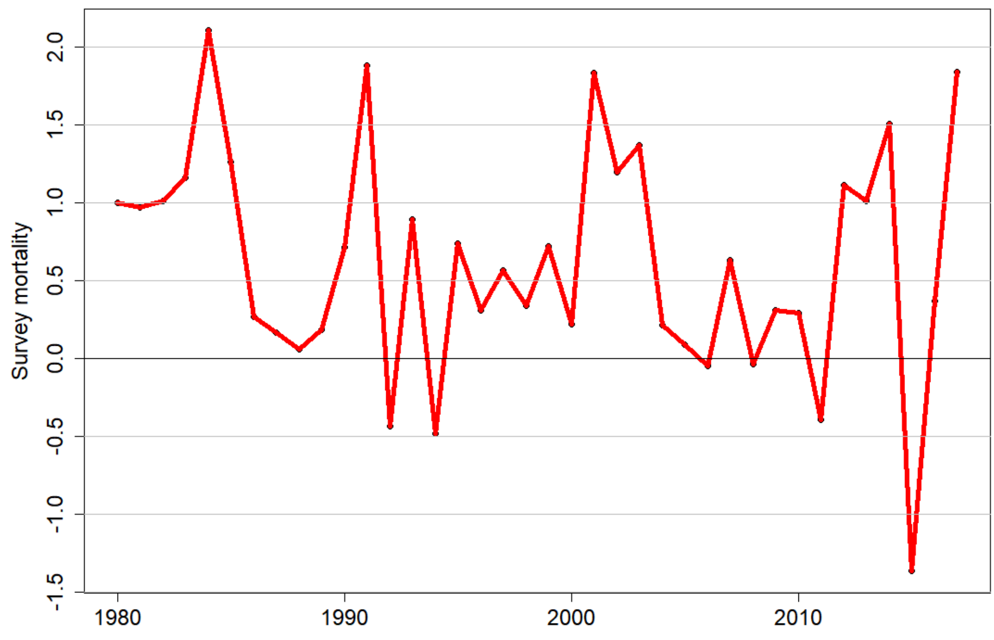


Figure 9.6. Capelin survey mortality from age 1–2.

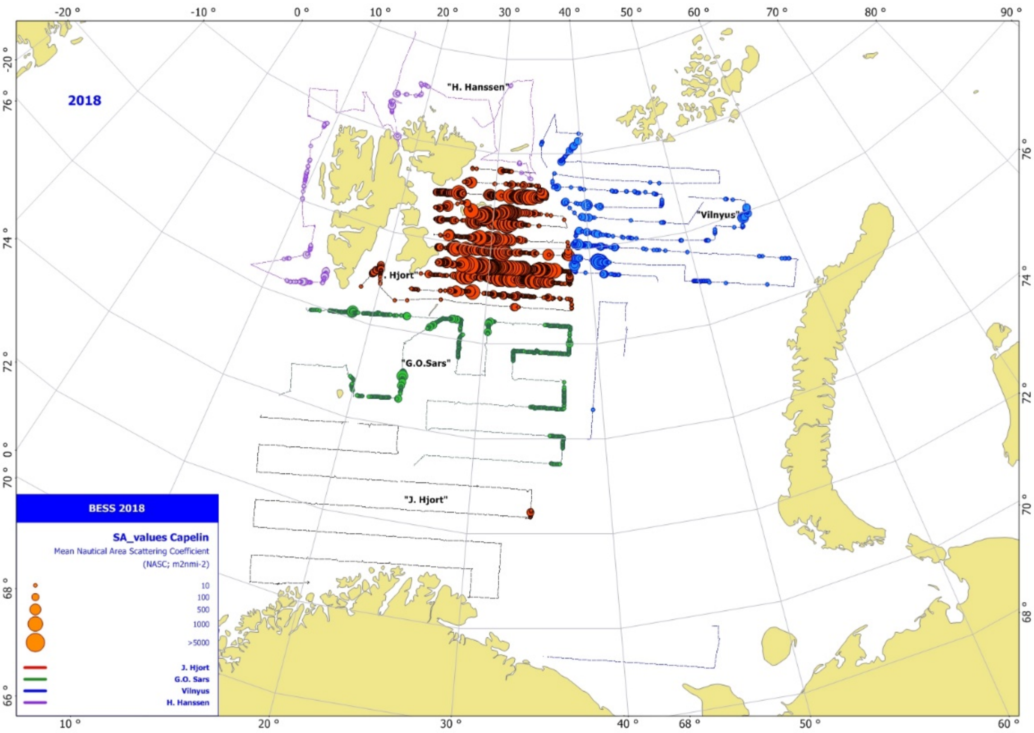


Figure 9.1. Estimated geographical distribution of capelin in autumn 2018. Circle sizes correspond to S*A* values per nautical mile.

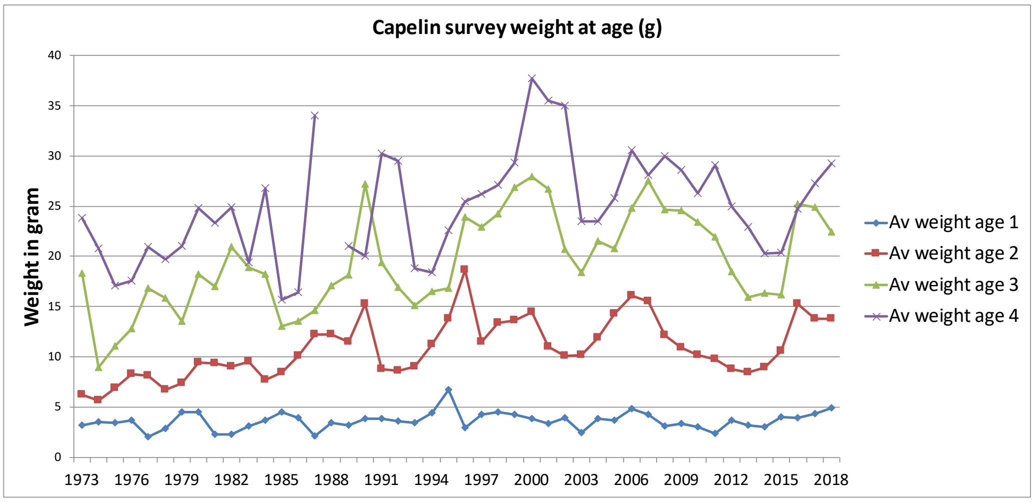


Figure 9.2 Weight-at-age (grammes) for capelin from the autumn survey.

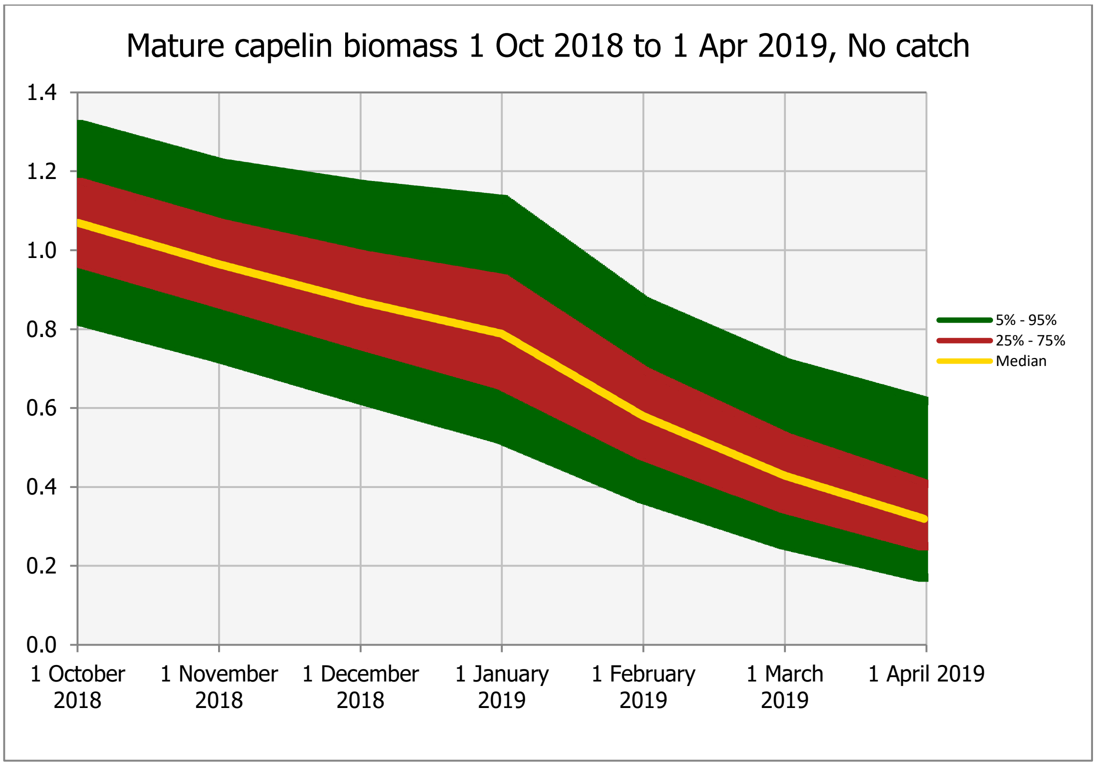


Figure 9.3. Probabilistic prognosis 1 October 2018–1 April 2019 for Barents Sea capelin maturing stock, with no catch (model CapTool, 20 000 simulations). Biomass in million tonnes.

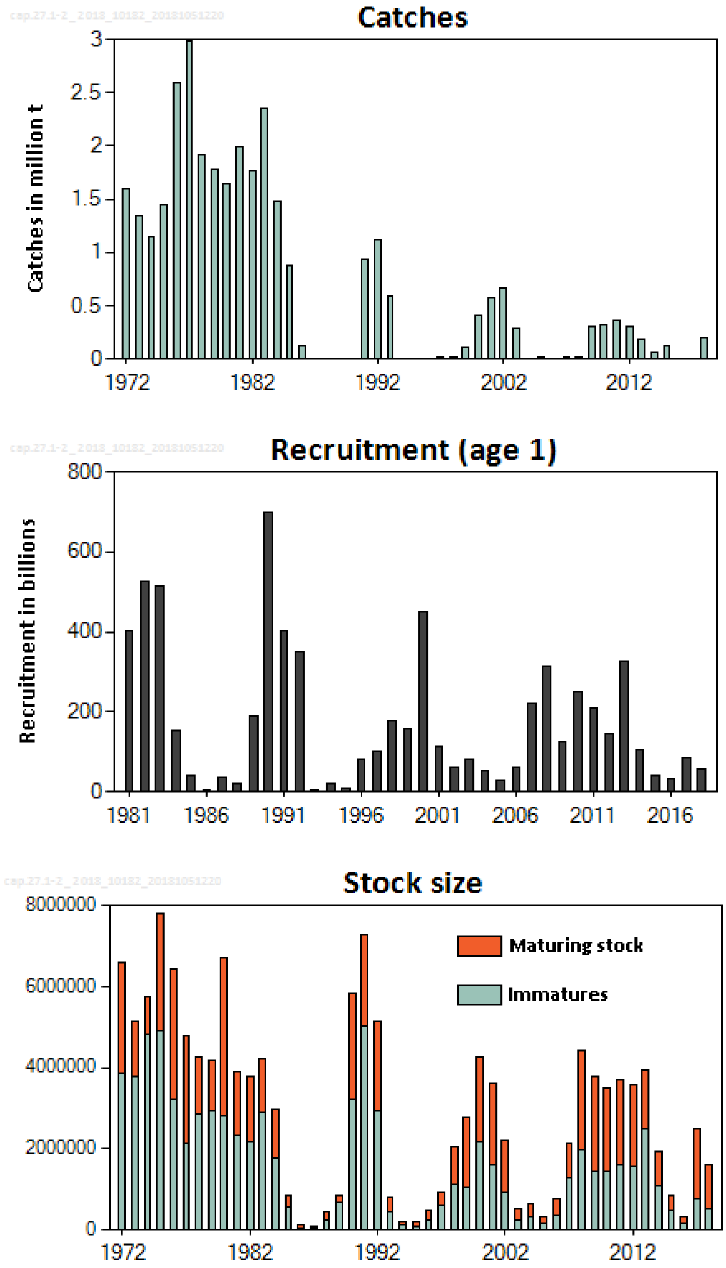


Figure 9.4. Capelin in subareas 1 and 2, excluding Division 2.a west of 5°W (Barents Sea capelin). Landing and summary of stock assessment (mature and immature stock biomass).

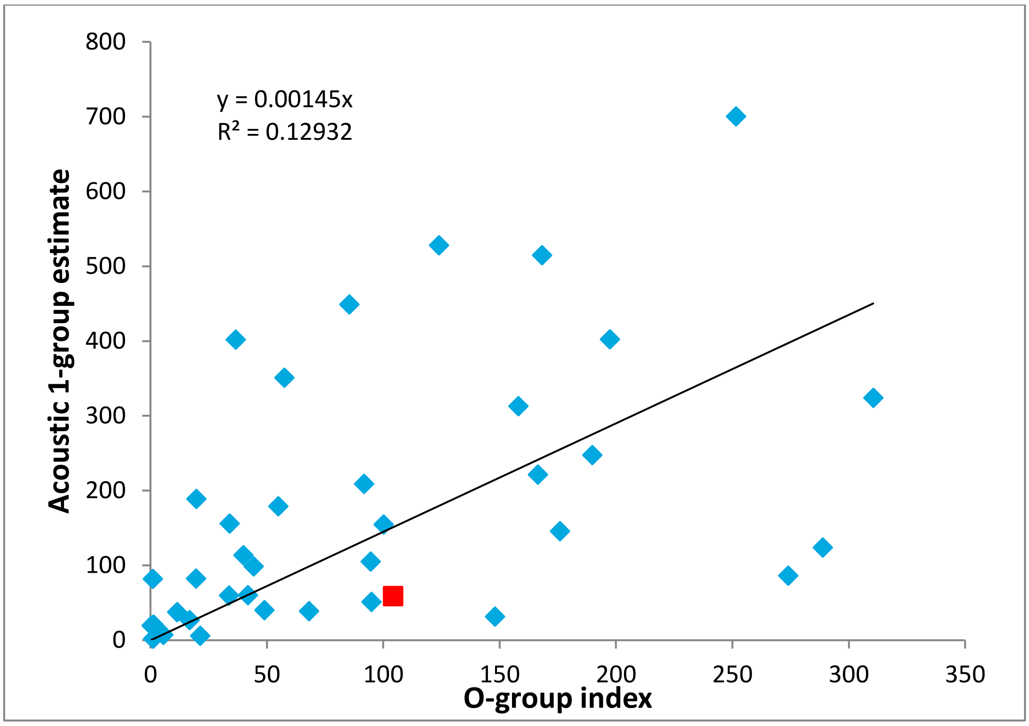


Figure 9.5. Regression of abundance of capelin at age 0 (0-group index without K_{eff}) and age 1 for cohorts 1980–2017. Red dot shows 2017 cohort.

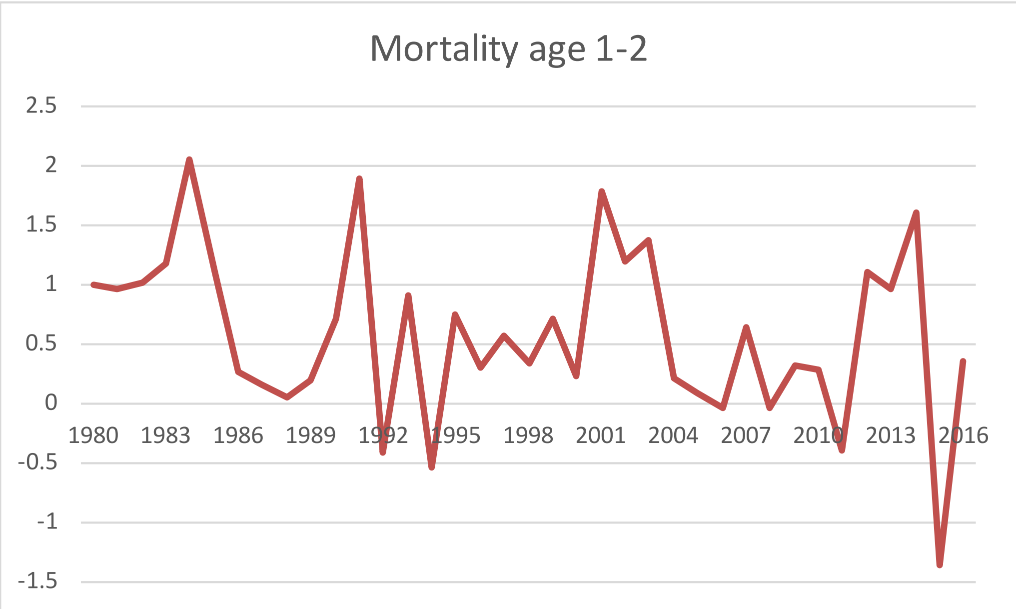


Figure 9.6. Capelin survey mortality from age 1–2. *x*-axis shows cohorts.

10 Anglerfish in ICES subareas 1 and 2

10.1 General

Our present knowledge of anglerfish (*Lophius spp*.) in ICES subareas 1 and 2 is based on two master 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). In February 2018, anglerfish in ICES subareas 1 and 2 was subject for a benchmark assessment (WKANGLER 2018). After this benchmark assessment, ICES suggests that this stock (or rather a stock component and a management unit) is considered as a Category 3 stock, for which survey or other indices are available that provide reliable indications of trends in stock metrics, such as total mortality, recruitment, and biomass.

Species composition

Two European anglerfish species of the genus *Lophius* are distributed in the Northeast Atlantic: white (or white-bellied) anglerfish (*L. piscatorius* L.) and black (or black-bellied) anglerfish (*L. budegassa* Spinola). *Lophius 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 recent years (2010-2017) this ratio has increased to about 1 out of 300 anglerfish being *L. budegassa* in Norwegian waters.

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 has therefore been treated and described separately by the 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 4 (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.b and 5.a (Hislop *et al.*, 2001). So, at previous WGs, assessments have been made for the whole Northern Shelf area combined, but exclusive ICES divisions 2.a, 5.b and 5.a. In fact, both microsatellite DNA analysis (O'Sullivan *et al.*, 2006) and particle tracking studies carried out as part of EC 98/096 also suggested that anglerfish from further south (Subarea 7) could also be part of the same stock. Hislop *et al.* (2001) simulated the dispersal of *Lophius* eggs and larvae using a particle tracking model. Their results also show the likelihood for *Lophius* at both Iceland (Solmundsson *et al.*, 2007), Faroe Islands (Ofstad, 2013) and Norwegian waters north of 62°N (i.e. Subareas 1 and 2) to be recruited from the area west of Scotland including Rockall. This is also supported by research survey data as a migration east-/northeastwards with size is seen in the IBTS- and other survey data (e.g. Dyb, 2003).

Recent results from the use of otolith shape analysis in stock identification of anglerfish (*L. piscatorius*) in the Northeast Atlantic (Cañás *et al.*, 2012) and previous references on *L. piscatorius* stock identification find no biological evidence to support the current separation of *Lophius* stocks in the Northeast Atlantic, but find substructures within the area.

Anglerfish were tagged during two IBTS surveys in the North Sea and five one-day trips using a small (15 m) Danish seiner off the Norwegian coast at around 62°40'N (Møre) (Thangstad *et al.*, 2006; Otte Bjelland, IMR, Norway, pers. comm.). A total of 872 individuals were tagged with conventional Floy dart type tags, 123 in the North Sea (25-78 cm) and 749 at Møre (30-102 cm). Some of this is further described in Thangstad *et al.* (2006). Figure 10.12 shows the tagging locations and the hitherto recaptures. There are migrations in all directions, i.e. recaptures from the southern North Sea, at the Shetland/Faroes and northwards to Lofoten. Most of the recaptures were done at Møre where most of the fish were tagged.

In 2000–2001 a total of 1768 trawl caught *L. piscatorius* was tagged using conventional dart tags and released on inshore fishing grounds at Shetland (Laurenson *et al.*, 2005). Anglerfish of 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 this publication, Dr Laurenson reported to www.fishupdate.com about a 104 cm anglerfish caught off the Norwegian coast near Ålesund in 2006. The fish had been tagged and released in the Scalloway Deeps on 13 September 2000 when it was 45 cm long, and had hence been at liberty for five years and nine months. This is of particular importance as it may indicate a wider mixing of stocks and validate the growth rate of anglerfish.

WKAngler (2018) considered that most recruitment in subareas 1 and 2 is from the more southerly stock unit, and this would require further R&D work in collaboration with ICES 3.a.46 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*. Align tagging methods, measurement protocols and outreach to industry. Recommend 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 time being.

Fishery

In autumn 1992 a direct gillnet fishery for anglerfish (*L. piscatorius*) started on the continental shelf in ICES Division 2.a off the northwestern coast of Norway. 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 10.2). 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. At 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 catches of anglerfish often culminate after a couple of years' fishing (Figure 10.2).

Norway is by far the largest exploiter of the anglerfish in subareas 1 and 2 accounting for 96–99% of the official landings (Table 10.1). The coastal gillnetting accounts for more than 90% of the landings (Table 10.2). 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, Norwegian waters. Catches of anglerfish in Division 2.a, EC waters, are taken as a part of the EC anglerfish quota for ICES areas 3, 4, and 6, or as part of the Norwegian 'Others' quota in EC 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 (streched mesh) gillnets;
- A minimum catch size of 60 cm in all gillnet fisheries, and a maximum permission of 5% anglerfish (in numbers) below 60 cm when fishing with gillnets;
- 72-hour maximum soak time in the gillnet fishery;
- A maximum of 500 gillnets (each net being maximum 27.5 m long) per vessel;
- A 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 of anglerfish in the trawl- and Danish seine fisheries, and maximum 10% bycatch 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 of anglerfish in gillnets targeting other species.

10.2 Data

Landings

The Norwegian statistical areas and locations used by the fishers for reporting their catches are shown in Figure 10.1. A very small fraction of the catches (3 tonnes in 2018) are taken in the Norwegian statistical area 03 which falls within ICES Subarea 1, and in Division 2.b (less than 1 tonne in 2018). The official landings for each country are shown in Table 10.1, and Norwegian landings by gear and fisheries in Table 10.2. Landings as reported to ICES for subareas 1 and 2 decreased rapidly from 2011 to 2015, to the lowest since 1997, but showed a small increase in 2016–2018 caused by an increase in the southern part of the area. Taken into account the expansion of the fishing area towards the margins of this species' distribution, and that we don't expect to discover more new fishing grounds, the rapid decline in catches per year gives reasons for concern. No information suggests that the official landing figures from Norway give a biased estimate of the actual landings, and no new regulations have been enforced that could explain the decrease.

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) 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 discarded anglerfish was higher south of 62°N (ICES 3 and 4) than north of 62°N (ICES 2). Average length of discarded anglerfish equals the length of the landed anglerfish. Work is ongoing to estimate discards based on data from the Reference fleet on a more regular basis, and WKAngler recommends a gillnet discard mortality study.

Biological

Length distributions are available from the directed gillnet fishery during the period 1992–2018, but data are lacking for 1997–2001 (Figure 10.3a,b). The length data indicate a drop in mean length of 15–20 cm occurring during the period without length samples (Figure 10.4). 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 (Figure 10.4). One third of the anglerfish measured during the 1990s were above 100 cm, this proportion was between 1and 6% for the early 2000s and between 12 and 17% in 2006–2010. This indicates recruitment into

Subarea 2 during 1997–2001 which has not been observed until 2017–2018 when a new drop in mean length is seen, again indicating some recruitment of smaller sized anglerfish to the area. For 2006–2011 and 2016, some length data from anglerfish caught as bycatch in other fisheries are presented in Figure 10.5a,b. This shows some promising recruitment of small anglerfish (40-50 cm) in 2016 not yet big enough for the large-mesh gillnets used in the directed anglerfish fishery. These recruits correspond to the promising year classes seen further south in the North Sea. Such recruitment is, however, not seen from the data collected in 2018.

Sex ratios in Subarea 2 show that females outnumber males above approximately 75 cm, and above 100 cm all fish were females (Thangstad *et al.,* 2006). This is very similar to 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 influx or migration of juveniles from ICES subareas 4 and 6. Estimation of GSI (gonad-somatic index) for females in Division 2.a, indicates developing ovaries 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 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 of 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 yield-per-recruit estimations (Figure 10.11). As a very simplified 'rule of thumb' one may divide the fish length by 10 to 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.

Figure 10.6 shows that a fishery using 300 mm mesh size will exploit 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 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.

Surveys

Anglerfish appears in demersal trawl surveys along the Norwegian shelf, but in very small numbers. There has been a change in the surveys, going from single species- to multispecies surveys, 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.

Commercial CPUE

Since late 2005, 10-13 gillnetters have been included in a self-sampling scheme established along the Norwegian coast within Division 2.a. Detailed information about effort and catch is provided through this scheme. Figure 10.7 shows standardized average CPUE (kg per 100 gillnet day) for all vessels in the Norwegian reference fleet fishing directly for anglerfish using large-meshed gillnets (360 mm), with and without precision measures. The figure shows that the catch rates have decreased by about 50% in recent years. The current catch rates, i.e. about 0.3 kg per gillnet soaking day, are, however, and for time being, at about the same level as the catch rates seen after the "Klondyke" fishing period during 1992–1994 in the southern area of Division 2.a (Figure 10.9).

Figure 10.8 shows that the effort in the large meshed gillnet fishery in the Coastal Reference fleet decreased by 50% from 2007–2011 to 2012–2016, but increased from 2016 to 2017–2018.

WKAngler (2018) suggests investigating a better standardization of the commercial CPUE index. There is evidence of spatio-temporal changes in distribution that should be accounted for in index standardization.

Yield-per-recruit estimations

Based on preliminary analyses and yield-per-recruit estimations done back in 2006 (Thangstad *et al.*, 2006), the fishing mortality in Norwegian waters at that time seemed to be too high to secure a high, sustainable and stable long-term yield, while the fishing pattern achieved when mostly using large meshed gillnets seems to be rather good concerning the net growth potential of the species. This is illustrated in Figure 10.10. Input data to the Y/R estimations are given in Table 10.3. The fishing mortality was estimated from catch curves (assuming M = 0.15) and also by combining equations from the fishery population dynamics (Thangstad *et al.,* 2006). These Y/R estimations must be considered very preliminary and approximate, and indicative rather than accurate, a.o. since the catch-at-age data available for anglerfish were too limited to follow a cohort through the fishery, i.e. the age distribution of catches is from one particular year (2002) to represent a single cohort's development.

Historical stock development

Anglerfish in subareas 1 and 2 have never been assessed quantitatively and besides the presented catch, CPUE and catch mean length series it is not possible to describe the historical stock development. Some very preliminary attempts to fit the Gadget model to the anglerfish data were done by Dyb (2003), but this need to be revisited and much more work is necessary before it can be properly evaluated. Former ICES-RG has recommended using the available catch data to perform a Depletion-Corrected Average Catch (DCAC) analysis and compare the results with possible trends in the other time-series (ICES CM 2012/ACOM:68).

At present, anglerfish in subareas 1 and 2 falls into ICES Category 3 – 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 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). This method was tested by WKAngler (2018) on anglerfish in subareas 3,4, and 6, and was considered not suitable or recommended to be used for either these subareas or subareas 1 and 2.

Work should hence be done to investigate the usefulness of the three first methods (LBI, MLZ and LBSPR) prior to next year's AFWG.

10.3 Management considerations and future investigations

The present abundance of anglerfish in subareas 1 and 2 seems to be dependent on influx or migration of juveniles from ICES subareas 4 and 6. It is therefore expected that an effective discard ban on anglerfish in these areas will have a positive impact on the abundance north of 62°N, as will also a reduced discarding in this area. Signs of smaller anglerfish recruiting to the bycatch in less selective gears may be a first indication of future improved recruitment to the directed fishery. This may have been a short lasting happening since such recruitment is not seen in 2018. Hence, monitoring of the fishery will be important in near future to protect the young specimens from recruitment- and growth overfishing. The AFWG has previously recommended that the anglerfish stock component in subareas 1 and 2 is annually monitored and a 20% reduction in fishing effort per year (also as an uncertainty cap) should be imposed until the decrease in CPUE is stopped. Despite that the decrease in CPUE may have stopped, the current increase in effort, which seem to have stopped in 2018, is not a vice long-term management strategy. Managers should halt any effort increase north of 62°N until new recruitment to the fishable biomass (by large meshed gillnets) has been documented.

The AFWG supports that ICES subareas 1, 2, 3, 4, and 6 should be investigated together to get a more complete understanding of migrations and distributions.

The ICES WKAngler (2018) recommends that anglerfish in ICES subareas 1 and 2 for time being continues as a separate management unit, and that improved information on stock identities is needed. To address stock structure, mixing rates, and growth estimates, WKAngler recommends a tagging program coordinated between all countries harvesting Lophius, and to align tagging methods, measurement protocols and outreach to industry. WKAngler recommends a shared site for Lophius tagging data and other applicable research projects concerning Lophius. This would also require further R&D work in collaboration with 3.a.46 looking at egg and larval dispersion and transportation as well as tagging and genetic studies.

WKAngler further recommends investigating a more formal assessment model for this stock component (ref. category 3 tools above), and to validate age-determination using tagging study data.

Table 10.1. Nominal catch (t) of Anglerfish in ICES subareas 1 and 2, 1999-2018, as officially reported to ICES

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Denmark	+	+	2	+	-	1	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Faroes	+	-	1	1	2	5	11	4	7	4	2	1	+	+	1	+	+	1	1	+
France	-	-	-	-	-	-	-	1	-	-	-	-	1	3	2	-	4	2	4	3
Germany	4	17	65	59	55	70	55	+	+	0	+	82	70	0	-	+	+	+	1	1
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-
Norway	1733	2952	3554	2000	2405	2907	2650	4257	4470	4007	4298	5391	5031	3758	2988	1655	933	1355	1473	1884
Portugal	-	-	-	-	-	-	-	-	-	2	6	1	+	-	-	-	-	-	-	-
UK	6	30	2	11	15	18	19	86	114	138	152	40	3	3	111	2	105	76	5	15
Others														1	1	-	-	+	-	+
Total	1743	2999	3624	2071	2477	3001	2735	4348	4591	4151	4458	5515	5112	3765	3103	1657	1043	1435	1484	1903

***Preliminary**

Table 10.2. Anglerfish in ICES subareas 1 and 2. Norwegian landings (tonnes) by fishery in 2006–2018. The coastal area is here defined as the area inside 12 nautical miles from the baseline.

Fleet NORWAY	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Coastal gillnetting	4039	3574	3934	4806	4557	3521	2758	1506	829	1231	1320	1727
Offshore gillnetting	204	240	171	391	319	115	158	95	52	62	87	68
Offshore dem trawling	65	34	36	48	19	11	8	7	3	5	6	10
Coastal Danish seine	63	75	68	40	26	16	19	11	12	17	23	28
Other gears	98	84	89	106	83	96	45	36	37	40	31	51
Total	4470	4007	4298	5391	5031	3759	2988	1655	934	1355	1468	1884

Table 10.3. Input data to the yield-per-recruit calculations based on (A) the exploitation pattern of the Norwegian gillnet (360 mm) fishery only, and (B) on the present exploitation pattern for the total fishery for anglerfish in the NEZ (incl. gillnet, trawl, Danish seine). In both cases the exploitation pattern has been scaled so that the average for the age group 7-10 becomes equal to 1.0 (F_{7-10} = 1.0). As a simplification, a knife-edged maturity-at-age 8 has been used. See Thangstad *et al.* (2006).

Age	Natural mortality	Maturation	Individual weight in stock and catch (kg)	Exploitation pattern (**A**)	Exploitation pattern (**B**)
1	0.15	0	0.53	0.0004	0.109
2	0.15	0	0.88	0.0040	0.180
3	0.15	0	1.70	0.035	0.239
4	0.15	0	3.16	0.106	0.250
5	0.15	0	3.97	0.171	0.350
6	0.15	0	5.75	0.266	0.408
7	0.15	0	7.44	0.564	0.677
8	0.15	1	9.37	0.829	0.832
9	0.15	1	11.08	1.188	1.182
10	0.15	1	13.12	1.420	1.310
11	0.15	1	17.24	1.539	1.462
12	0.15	1	21.12	1.121	1.439

Figure 10.1. Norwegian statistical areas and locations used by the fishers for reporting their catches. The 62°N and 67°N (stippled) latitudes are marked.

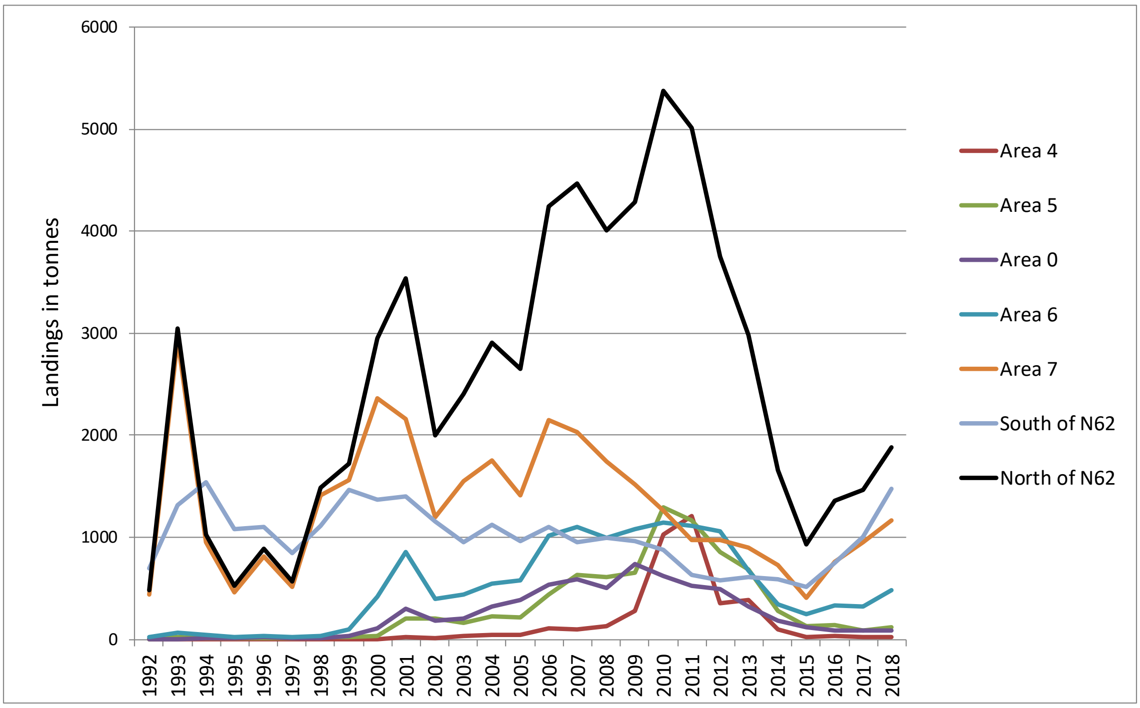


Figure 10.2. Norwegian official landings (in tonnes) of anglerfish (*Lophius piscatorius*) per statistical area (see Figure 10.1) within ICES areas 1 and 2 during 1992–2018. Norwegian landings from the area south of 62°N (ICES 4 and 3) are shown for comparison.

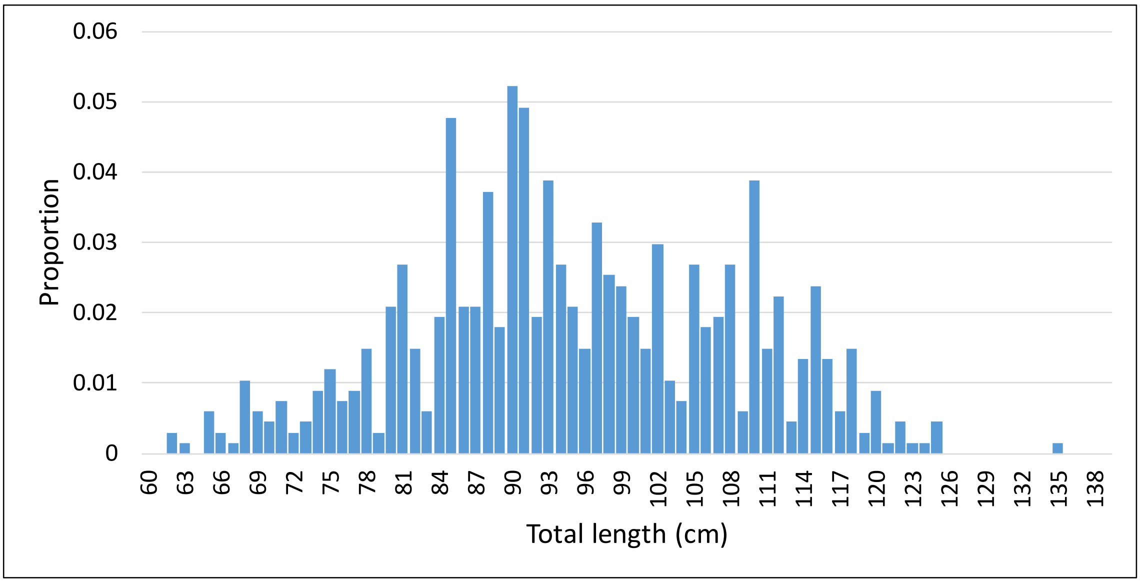


Figure 10.3a. Anglerfish (*Lophius piscatorius*) in 2.a. Total lengths in directed gillnetting, 2016. Based on 61 samples from 4 vessels (N = 671).

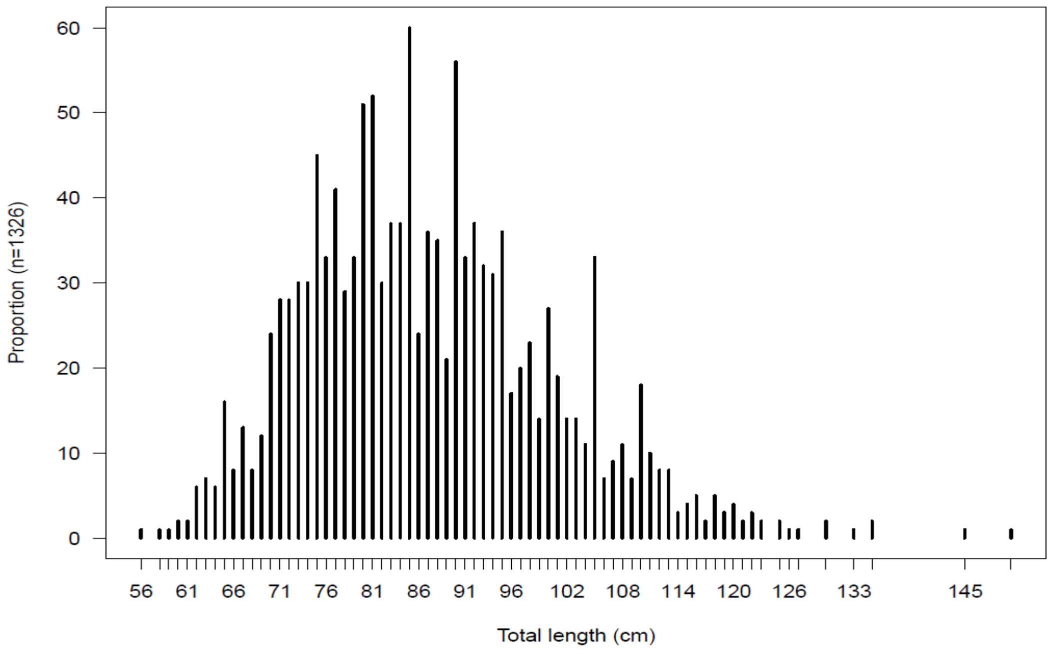


Figure 10.3a. Anglerfish (*Lophius piscatorius*) in 2.a. Total lengths in directed gillnetting, 2018 (N = 1326).

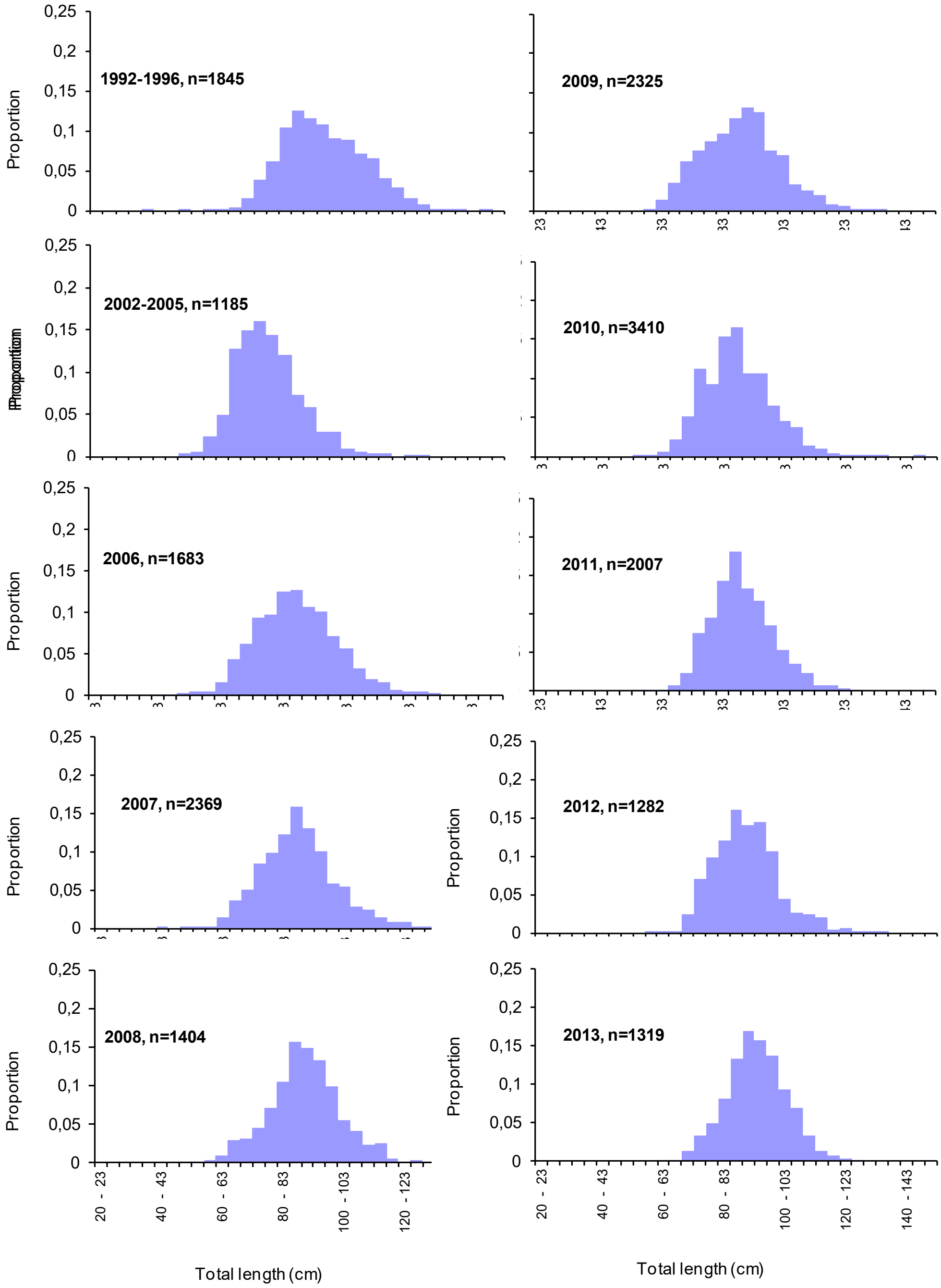


Figure 10.3b. Anglerfish (*Lophius piscatorius*) in 2.a. Length distributions for anglerfish caught in the directed coastal gillnetting in Division 2.a during 1992–2013. Note that data are lacking for 1997–2001.

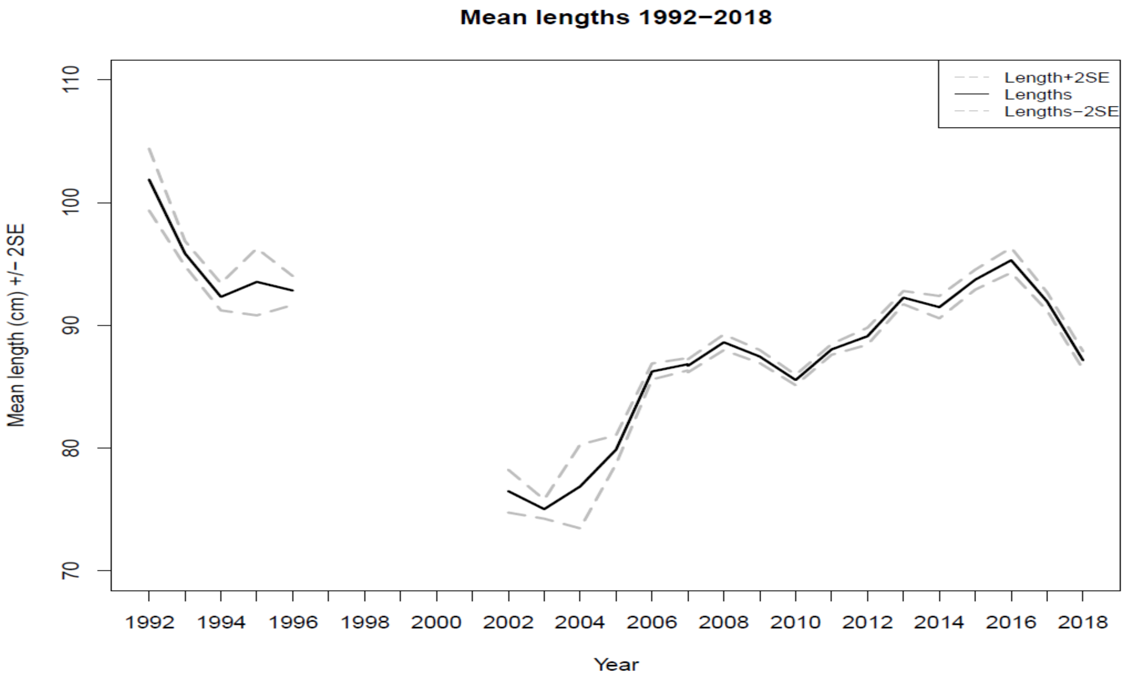


Figure 10.4. Anglerfish (*Lophius piscatorius* in subareas 1 and 2. Mean lengths for anglerfish caught in the directed coastal gillnetting in Division 2.a during 1992–2018, dotted lines represent ±2SE of the mean. Note that data are lacking for 1997–2001. This illustrates pulses of new recruitment entering Division 2.a from subareas 4/6 – last time during 2002–2003.

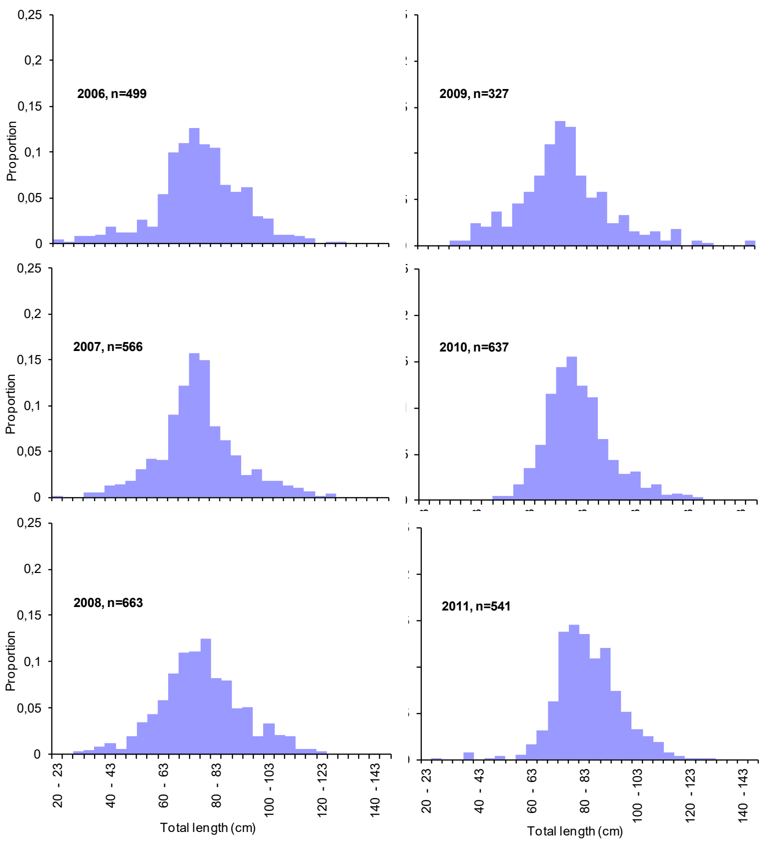


Figure 10.5a. Anglerfish (*Lophius piscatorius*) in subareas 1 and 2. Length distribution for anglerfish caught as bycatch by other gears (smaller meshed gillnets and longline) in Division 2.a in 2005-2011.

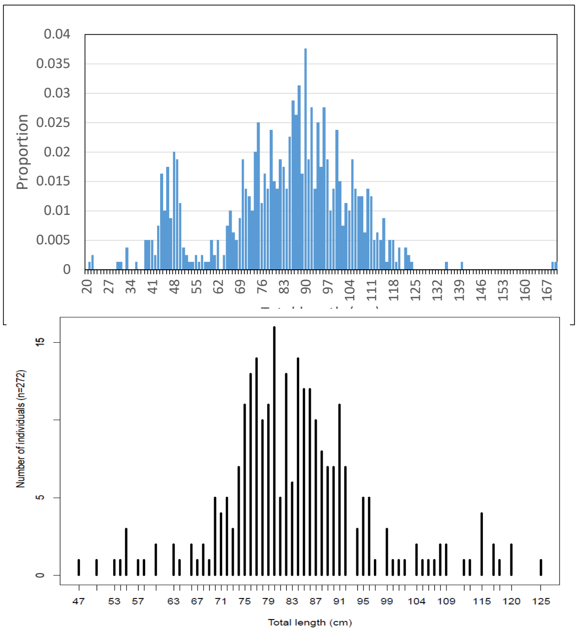


Figure 10.5b. Anglerfish (*Lophius piscatorius)* in 2.a. Total lengths, other smaller meshed gillnets and longline 2016 (N = 799, left) and 2018 (N = 272, right). Note the small (40–50 cm) anglerfish recruiting to these gears in 2016 but not in 2018.

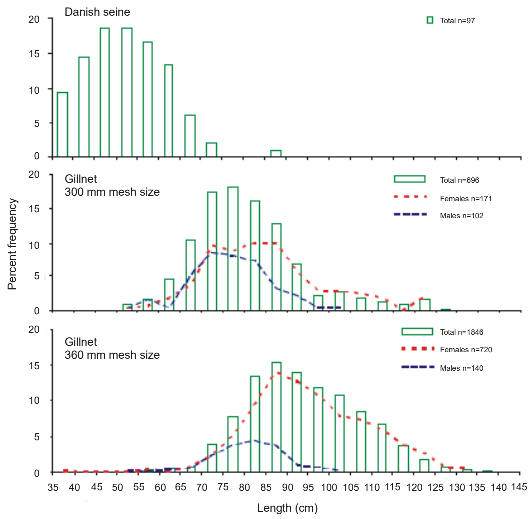


Figure 10.6. Length distributions of commercially landed catches of anglerfish from the Møre coast (ICES 2.a; Norw stat.area 07), 1992–1997, illustrating the fishing gears' different selectivity and the sex differences.

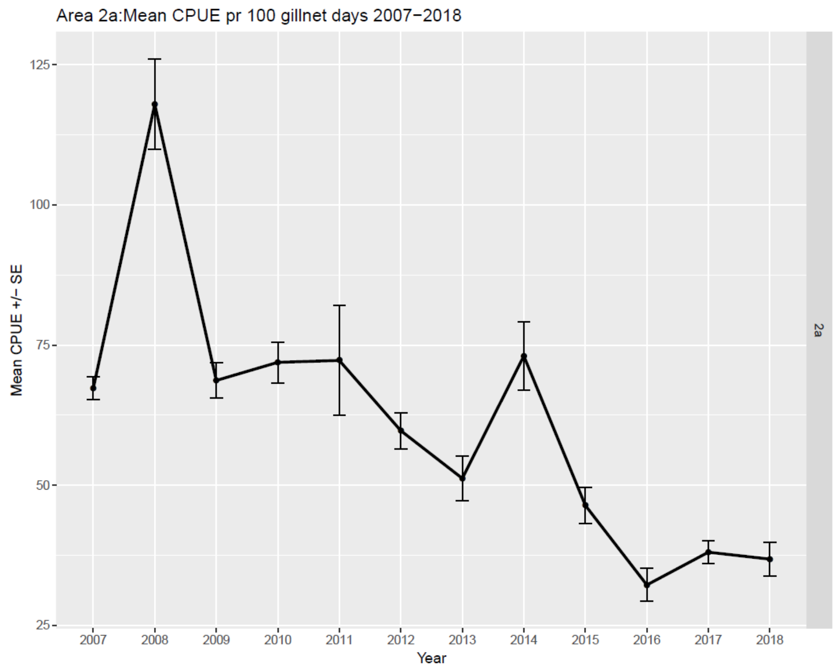


Figure 10.7. CPUE (kg per gillnet day) +/- SE of the mean of anglerfish for vessels in the Norwegian reference fleet in ICES Subarea 2.a targeting anglerfish with large meshed gillnets.

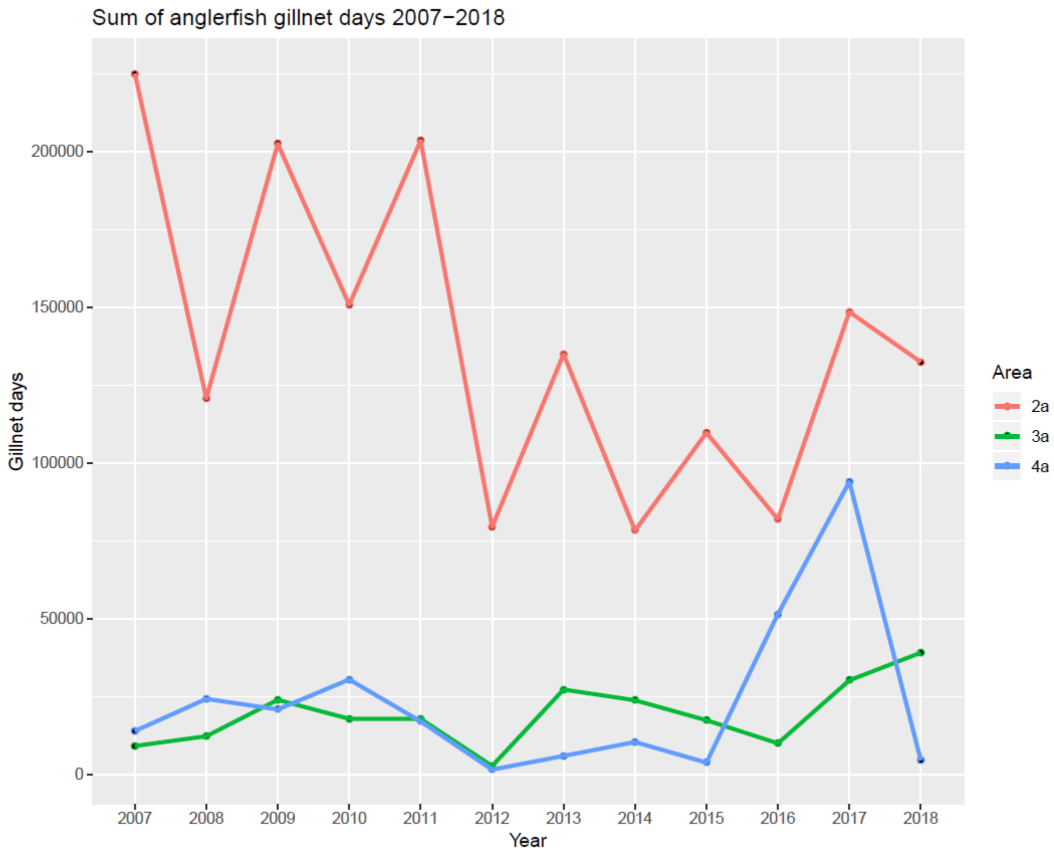


Figure 10.8. Fishing effort – sum of anglerfish gillnet days per year and ICES area for the entire Norwegian Coastal Reference fleet targeting anglerfish with large meshed gillnets.

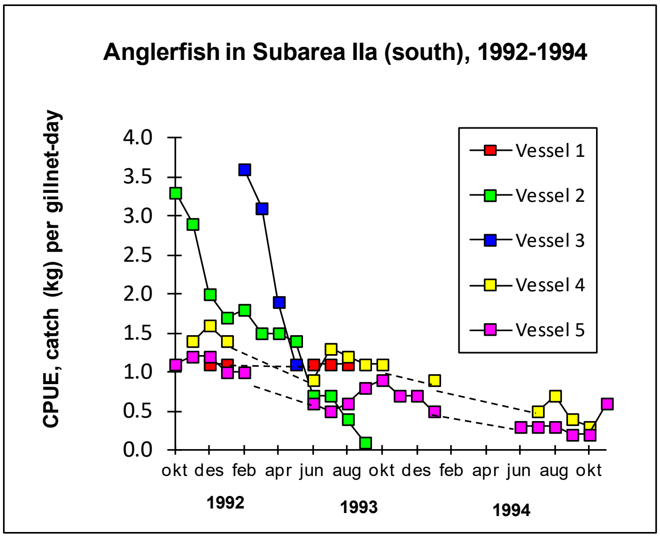


Figure 10.9. Catch per unit of effort for five boats in the gillnet fishery for anglerfish in Møre and Romsdal (the same area as vessel A in Figure 8 is fishing in) in the period October 1992 - October 1994. Boats 1 >25 m; Boats 2 ca. 20 m; Boat 3 ca. 10 m; Boat 4 and 5 ca. 16 m. Boats 1-4 were fishing with gillnet 360 mm nesh size, boat 5 with 300 mm mesh size.

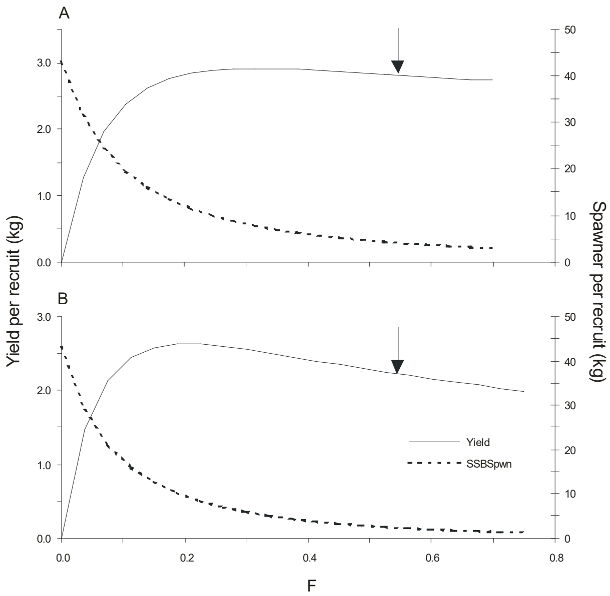


Figure 10.10. Yield- and spawning stock per 1-year old recruit as estimated in 2006 and (A) based on the exploitation pattern representative of the Norwegian gillnet (360 mm) fishery, and (B) based on the present exploitation pattern for the total fishery for anglerfish in the NEZ (incl. gillnet, trawl, Danish seine). M = 0.15, and the age range for the reference F includes ages 7-10. Input data are given in Table 10.3. See Thangstad *et al.* (2006) for information about the input data.

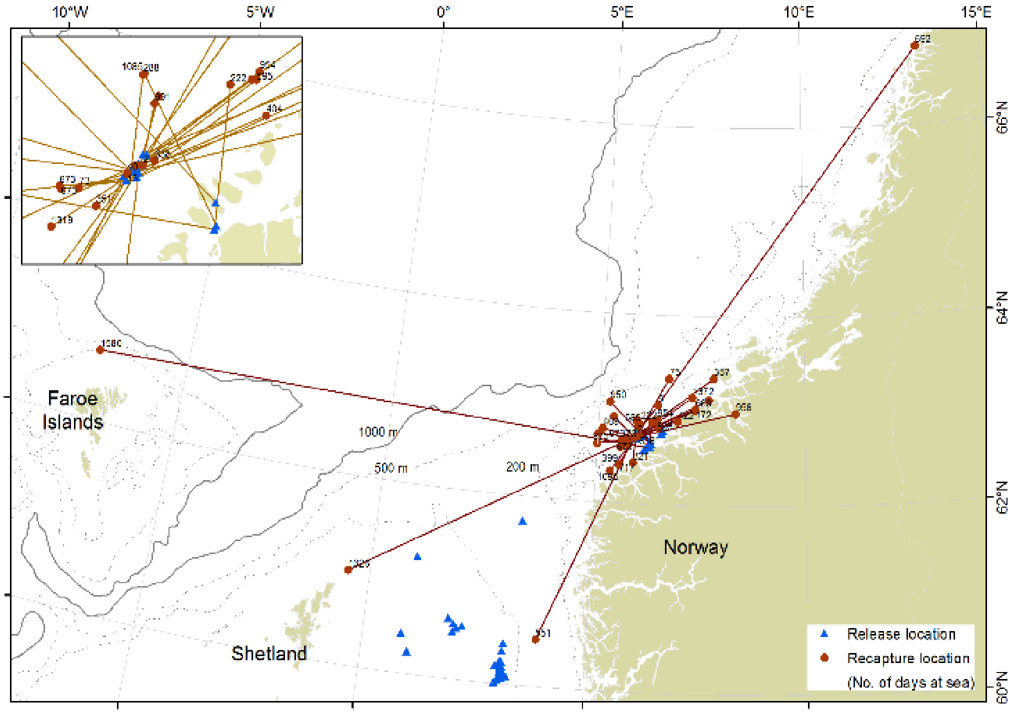


Figure 10.11. Anglerfish tagging locations 2003–2005 on the coast of western Norway in ICES 2.a and during the North Sea IBTS surveys, and recapture locations (to date) with number of days at sea.

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Annex 2: Draft ToRs for next meeting

AFWG – Arctic Fisheries Working Group

2018/X/ACOMXX The **Arctic Fisheries Working Group** (AFWG), chaired by Daniel Howell, Norway, will meet at XX (tbc), on 17-23 April 2020 (tbc) to:

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 the autumn;

For Barents Sea capelin oversee the process of providing intersessional assessment;

Conduct reviews as required of time any series computed using the STOX and ECA open source software for use in assessment in the Barents Sea.

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

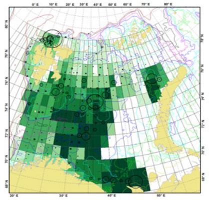
Material and data relevant for the meeting must be available to the group on the dates specified in the 2020 ICES data call.

AFWG will report by XX May 2020 and XX October 2020 for Barents Sea capelin for the attention of ACOM

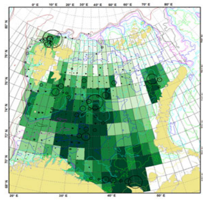
Annex 3: Working documents

Numbers of Northeast Arctic Cod Subareas 1 and II swept area estimation in August-September, ind.
*Additional estimation 0-group cod in pelagic layer in same time.

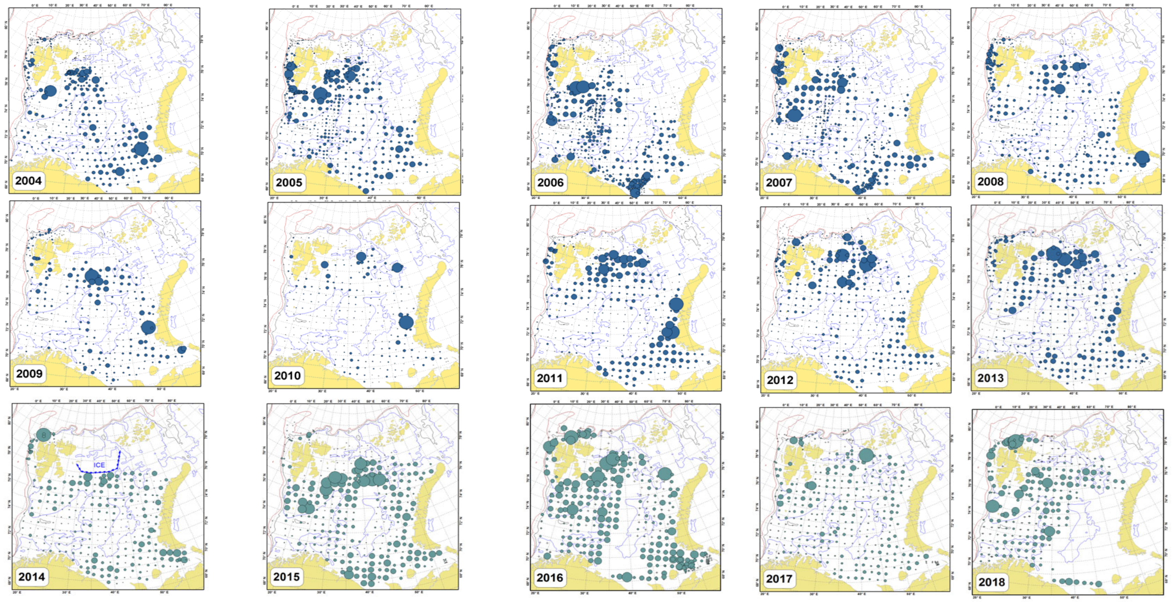
AGE\YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018 basic calcula	2018 (missing data in REEZ was interpolated manually)
*0+ (pelagic)	65,969,000,000	72,137,000,000	25,061,000,000	42,628,000,000	234,144,000,000	185,457,000,000	135,355,148,349	448,004,676,389	410,757,372,957	385,429,624,710	464,167,533,460	37,424,452,387	53,796,000,000	233,274,829,269	no data	
0+(bot)	543043827	180168866	276036279	101047588	483444472	903273844	652597518	2082961050	1412741073	2281839395	2445196115	350928401	1164833574	2316337064	1841190324	1841190324
1	330631130	440711170	479015340	333323541	130941903	569714897	310259067	509807608	1454272354	914192350	308152118	725315986	350788443	757497434	1620956461	2100290126
2	329740139	146597178	509664472	505358143	372611937	93519810	84155150	160004176	255852938	658991771	155120062	153988633	341343862	260628218	342220432	413806044
3	147720899	216599433	186104950	586191848	652619351	202337045	56811355	123647520	229092369	249105801	190015856	174410623	77182019	375003367	152180144	183609018
4	421528621	55799358	205590556	159152207	483428014	280639811	177043957	101526797	146406893	183591010	108592370	225163599	93716793	141494105	133597814	148870432
5	150214881	100855755	59854785	79074519	132268618	289625149	397182398	240166577	69962192	125688086	93909741	141294065	121593715	104917649	52046190	60034889
6	79761721	27998174	69754858	24568322	51067000	101693870	424932837	300389563	150768959	63154094	52808859	72569433	70088128	120876672	31228971	37643553
7	40210687	15645223	17640696	26919855	12815988	31883318	142729910	178433228	165155691	118220439	30410416	48559722	44438350	62575290	50975683	57078046
8	10088512	5652763	8089532	5967918	17453296	12662439	38534364	32276072	84513940	130196740	50180004	26240265	27216529	27955200	18510934	20191624
9	2210874	1172452	2557565	2164141	3283965	7276698	10549842	7693099	12698947	53847777	36338451	35256469	13801647	11207815	13123560	14441297
10	503390	464259	649658	932430	850157	2569231	6783647	1849795	4351948	9141091	12072868	26634386	13198391	6411862	4852779	5785155
11	128218	120001	248101	145584	228620	814921	1589247	1335895	1550456	3315461	3425765	7865353	5422231	4446171	2907406	3627643
12	65054	0	43801	205865	202136	283338	309677	593900	1429349	1521350	1024942	1696556	1650140	4486647	2909318	3477642
13	0	50079		0	108738	166792	204978	279561	428096	445255	837265	148578	491430	1779296	1955318	2041275
14	134857			34436	0	0	106583		142966	329399	266539	811245	447165	624015	598218	623661
15					0	0			75101	164247	204789	0	116769	279941	260291	239813
16					80306	54911					60807	95469	116769			
17													199830			
0+pel/bot (%)	1	0	1	0	0	0	0	0	0	0.59	0.53	1	2	1		



original



manual interpolation



Year/age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2004	6.9	30.1	121.4	505.0	831.4	1399.9	2381.5	3229.4	4511.5	6181.4	8381.2	19382.1	13480.0		14159.2		
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0			
2006	11.3	39.7	159.5	482.8	1042.2	1646.7	2529.1	3612.4	4951.7	6508.2	10663.2	9866.5	8356.1				
2007	9.9	50.8	162.8	452.1	975.2	1800.8	2554.5	3740.1	5184.4	6464.4	8036.7	10508.9	11182.6		15529.0		
2008	6.9	45.1	205.7	502.1	1100.7	1849.8	3113.5	4174.4	5511.0	7557.9	8694.2	10737.6	10962.2	14691.2			19021.0
2009	6.9	28.6	167.4	455.5	954.4	1551.5	2350.4	3802.7	5179.7	6415.0	7429.9	8213.5	12370.3	10218.3			13875.0
2010	7.0	32.1	141.2	486.8	960.8	1649.1	2504.1	3664.4	5204.7	6374.4	7482.9	8479.7	9139.1	13188.6	16412.2		
2011	5.0	32.6	139.9	469.8	1068.4	1712.5	2456.2	3415.9	4593.0	6717.4	8688.2	11631.6	10615.7	12905.3			
2012	6.2	32.4	144.8	461.4	870.3	1631.1	2346.7	3227.1	4289.6	6417.5	8079.6	10069.5	11277.4	13551.7	10822.8	17840.0	

Weight at length

Length/yea	2004	2005	2006	2007	2008	2009	2010	2011	2012
3.5	0.1	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8.5	6.0	5.7	6.1	5.3	5.8	5.6	5.6	4.7	5.7
13.5	19.0	18.9	19.2	20.5	18.9	19.6	18.8	21.6	20.9
18.5	48.3	46.9	44.0	47.5	46.6	40.3	42.2	40.9	47.8
23.5	97.4	99.2	102.6	101.3	110.0	103.1	100.7	102.3	100.5
28.5	180.5	184.3	184.4	176.6	192.9	179.5	175.8	176.9	183.2
33.5	308.3	309.7	292.9	297.0	315.1	306.3	307.8	298.7	307.4
38.5	459.6	477.7	476.6	447.7	475.0	461.0	466.8	456.6	467.5
43.5	684.5	689.6	696.1	666.2	669.2	667.0	680.9	671.6	680.2
48.5	944.3	985.6	951.7	901.3	991.6	930.5	979.6	957.5	951.0
53.5	1262.7	1365.7	1303.4	1229.9	1306.3	1246.4	1330.4	1320.6	1295.0
58.5	1661.7	1728.1	1680.1	1673.7	1700.4	1695.6	1738.1	1714.2	1687.5
63.5	2076.2	2181.7	2177.2	2170.9	2203.0	2155.3	2169.5	2147.9	2184.9
68.5	2585.1	2768.3	2708.8	2698.3	2743.5	2699.2	2740.0	2630.2	2638.1
73.5	3084.8	3326.9	3304.9	3332.5	3442.8	3313.3	3350.0	3269.9	3223.2
78.5	3829.3	4172.8	4086.1	4158.4	4232.4	4064.3	4078.0	3981.7	3908.5
83.5	4663.9	4941.0	4979.4	4894.0	5182.1	4926.2	5042.9	4719.7	4737.3
88.5	5659.2	5756.1	5972.8	5873.0	6080.8	5981.8	6018.6	5742.9	5753.2
93.5	6799.5	7140.3	7139.4	7100.7	7155.8	6937.8	6904.5	6835.9	6969.6
98.5	7502.3	8420.4	8356.1	7700.3	8502.4	8069.9	8166.8	8255.6	8388.8
103.5	9765.0	9987.5	9456.0	9158.2	9747.1	9785.6	9696.8	10143.5	9653.2
108.5	10880.0	10576.7	11029.4	11651.3	11506.2	10801.6	11540.0	11901.3	10822.8
113.5	13662.0		13703.3	11321.7	12705.0	13875.0	12643.3	12835.0	12791.3
118.5	13480.0	15762.2	14510.0	13076.3		15450.0		14519.0	14301.0
123.5	13940.0			15529.0	17475.0		20390.0	18093.3	17840.0
128.5	15970.0		26700.0						19270.0
133.5	23400.0				19021.0				

Converted to Norwegian length groups

Length/yea	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.5	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5	4.1	3.9	4.2	3.7	4.0	3.8	3.9	3.2	3.9
12.5	15.1	15.0	15.3	16.2	15.0	15.6	14.9	17.1	16.6
17.5	40.9	39.7	37.3	40.2	39.4	34.1	35.7	34.6	40.5
22.5	85.5	87.0	90.0	88.9	96.5	90.5	88.4	89.8	88.2
27.5	162.1	165.6	165.7	158.6	173.3	161.3	157.9	158.9	164.5
32.5	281.5	282.8	267.4	271.2	287.7	279.7	281.1	272.8	280.7
37.5	424.7	441.4	440.4	413.7	439.0	426.0	431.3	421.9	432.0
42.5	638.4	643.1	649.2	621.3	624.1	622.1	635.0	626.3	634.4
47.5	887.1	925.8	894.0	846.7	931.5	874.1	920.2	899.5	893.3
52.5	1193.2	1290.5	1231.7	1162.2	1234.4	1177.8	1257.2	1247.9	1223.7
57.5	1577.9	1641.0	1595.4	1589.4	1614.6	1610.1	1650.5	1627.7	1602.5
62.5	1979.7	2080.2	2076.0	2070.0	2100.6	2055.0	2068.6	2048.0	2083.3
67.5	2473.5	2648.8	2591.9	2581.8	2625.1	2582.7	2621.8	2516.7	2524.2
72.5	2960.6	3193.0	3171.9	3198.3	3304.2	3179.9	3215.2	3138.2	3093.4
77.5	3684.8	4015.4	3931.9	4001.5	4072.8	3910.9	3924.1	3831.5	3761.0
82.5	4498.4	4765.6	4802.6	4720.3	4998.2	4751.3	4863.8	4552.1	4569.2
87.5	5469.5	5563.2	5772.7	5676.1	5877.0	5781.3	5816.9	5550.4	5560.4
92.5	6583.7	6913.7	6912.7	6875.3	6928.6	6717.6	6685.3	6618.9	6748.4
97.5	7276.1	8166.5	8104.1	7468.1	8246.1	7826.6	7920.6	8006.7	8135.9
102.5	9484.7	9700.8	9184.6	8895.3	9467.3	9504.6	9418.5	9852.3	9376.1
107.5	10581.9	10286.9	10727.2	11332.1	11191.0	10505.7	11223.9	11575.2	10526.3
112.5	13304.1		13344.3	11025.0	12372.1	13511.5	12312.1	12498.7	12456.2
117.5	13141.6	15366.5	14145.7	12748.0		15062.2		14154.5	13942.0
122.5	13604.1			15154.8	17053.9		19898.7	17657.4	17410.1
127.5	15600.1		26081.5						18823.6
132.5	22878.1				18596.8				
35	353.1	362.1	353.9	342.5	363.3	352.8	**356.2**	**347.4**	**356.3**
45	762.8	784.5	771.6	734.0	777.8	748.1	**777.6**	**762.9**	**763.9**
55	1385.5	1465.8	1413.6	1375.8	1424.5	1394.0	**1453.8**	**1437.8**	**1413.1**

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5.9	607016	0.061	0.1	607016															
6	10.9	1584866291	9760.134	6.2	1584866291															
11	15.9	1296850576	24585.364	19	255717017	1041133559														
16	20.9	578922973	26472.569	45.7		540647075	38275898													
21	25.9	166140832	17241.635	103.8		36550983	126267033	3322817												
26	30.9	144366389	27659.288	191.6		2624844	129929750	11811795												
31	35.9	75805153	22976.036	303.1			39418680	33354267	2021471	1010735										
36	40.9	58813695	27365.287	465.3			5639669	48340024	4834002											
41	45.9	83167502	57119.063	686.8			1890170	41583751	38748495	945086										
46	50.9	66336318	62467.232	941.7			799233	11189258	46355499	7992328										
51	55.9	45320473	58353.408	1287.6				1320014	30800321	12320128	440005	440005								
56	60.9	29405121	49124.195	1670.6				753978	6785797	15833527	5654831	376989								
61	65.9	23834858	52690.834	2210.7				277150	2771495	8314485	9145934	3048645	277150							
66	70.9	26342475	72357.555	2746.8				227090	681271	3406354	9991973	11581605	454181							
71	75.9	25183610	84274.474	3346.4					412846	1857807	3096346	16720266	2477077	619269						
76	80.9	17912436	72148.604	4027.9						179124	1791244	11284835	4119860	358249	179124					
81	85.9	16235574	80187.687	4939					186616	186616	933079	5785090	6344937	2799237						
86	90.9	9480280	56554.962	5965.5							175561	1228925	3335654	3335654	1053364	351122				
91	95.9	6621222	47319.154	7146.6								509325	1018649	3395498	1188424	339550	169775			
96	100.9	4229985	35338.265	8354.2									483427	1933708	1329424	120857	362570			
101	105.9	4245271	41572.678	9792.7										471697	471697	1572322	943393	628929		157232
106	110.9	2733229	30645.179	11212.1										210248	630745	420497	840994	630745		
111	115.9	1382699	18933.101	13692.9													592585	592585	197528	
116	120.9	412234	6701.887	16257.5												103058		103058	103058	103058
126	130.9	297631	5044.844	16950															297631	
		4269513843	986893.498		1841190324	1620956461	342220432	152180144	133597814	52046190	31228971	50975683	18510934	13123560	4852779	2907406	2909318	1955318	598218	260291
		4269513843																		

Length		Numbers, ind	Tones	ean weight, g	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	5.9	4059006.51	0.405900651	0.1	4059006.51															
6	10.9	2310125967	13007.5847	5.630682	2281249392	28876574.59														
11	15.9	287423416.3	5687.667351	19.788462	31028665.56	256394750.7														
16	20.9	457427549.5	19810.86788	43.309302		443352856	14074693.48													
21	25.9	107000617.9	10923.75203	102.090551		27672573.62	77483205.92	1844838.31												
26	30.9	148884187.8	27855.33228	187.09396		1200679.51	105659746.3	42023762.02												
31	35.9	161981987.1	49513.42502	305.672414			47715623.55	113010688.9	1255674.65											
36	40.9	164938827.2	78665.21053	476.935673			11410862.27	130706240.4	21784373.12	1037351.41										
41	45.9	108733119	72505.94231	666.824818			3536036.91	63648654.65	38896400.61	2652026.87										
46	50.9	80041374.83	75981.94308	949.283333			748049.88	20945406.26	43386913.08	14961004.81										
51	55.9	69495527.56	90187.17743	1297.740741				1158259.02	23744305.48	35906022.8	8107811.78	579129.16								
56	60.9	62734509.27	105735.9026	1685.450382				1665517.78	6662071.76	27758632.66	26648287.06									
61	65.9	61482084.93	132808.8835	2160.123288					3310573.57	15606990.55	40199824.53	2364695.67								
66	70.9	53574470.69	142025.5472	2650.993007					2453792.73	3680688.82	30672406.67	16358616.93	408965.54							
71	75.9	39073102.71	129087.1288	3303.733766						1953655.14	10605556.39	22885674.61	3349123.26	279093.7						
76	80.9	28374824.62	110076.4255	3879.369369						540472.88	3513073.42	14322530.39	8107092.87	1351182.19	540472.88					
81	85.9	18060717.46	87377.75107	4838						622783.39	622783.39	3736700.13	9964533.81	2906322.35	207594.4					
86	90.9	13861346.32	82680.04302	5964.791667						198019.17	396038.49	1782173.12	4752461.56	3366326.92	2178211.6	990096.15	198019.17			
91	95.9	7913665.5	57103.26656	7215.779661								545770.06	818655.08	2455965.17	2455965.17	1364425.06	272885.03			
96	100.9	4435599.37	37797.11516	8521.309524							110889.98		443559.94	665339.91	554449.92	887119.87	1663349.76	110889.98		
101	105.9	3435032.49	33904.3074	9870.15625									110807.48	110807.48	110807.48	886460.01	1440497.5	443230.01	221615	110807.48
106	110.9	1626683.04	19704.69658	12113.42105											85614.9	256844.7	599304.27	342459.59	256844.7	85614.9
111	115.9	835181.31	11255.82203	13477.1											83518.13		167036.26	501108.79		83518.13
116	120.9	436666.42	6474.307454	14826.66667										72777.74	72777.74		145555.47		145555.47	
121	125.9	244900.23	4239.222981	17310											122450.12	61225.06		61225.06		
126	130.9	320382.91	6104.89635	19055														320382.91		
141	145.9	7673.37	243.7791282	31769.5																
		4196528421	1410758.404		2316337064	757497434.5	260628218.3	375003367.3	141494105	104917648.5	120876671.7	62575290.07	27955199.54	11207815.46	6411862.34	4446170.85	4486647.46	1779296.34	624015.17	279940.51
		4196520747																		

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
6	10.9	1138330550	7130	6.3	1125957386	12373164																
11	15.9	178620321	3542	19.8	38876188	139744133																
16	20.9	200548663	9263	46.2		174109771	26438892															
21	25.9	187320767	18622	99.4		23752489	163028448	539828														
26	30.9	130635209	23074	176.6		808887	123355229	6471093														
31	35.9	48048747	14422	300.2			24701117	22332516	1015114													
36	40.9	41227093	19618	475.8			3365477	30289293	7572323													
41	45.9	47743516	32518	681.1			454700	11822204	32738411	2728201												
46	50.9	50634676	47606	940.2				2893410	28934100	18807165												
51	55.9	63230026	80602	1274.8				1317292	17563896	39957863	4390974											
56	60.9	56485202	93852	1661.5				1516381	4928239	36772245	12889241	379095										
61	65.9	44836638	94765	2113.6					313543	15050060	25396977	4076058										
66	70.9	34855112	90910	2608.2					490917	4909171	17427556	10554717	1227293		245458							
71	75.9	28549226	90532	3171.1						2877054	7081979	15934452	2655742									
76	80.9	19870818	77630	3906.7					160249	320497	2243480	7852178	7691930	801243	160249	480746		160249				
81	85.9	18174552	87658	4823.1						171458	514374	3943535	10116024	2743329	514374	171458						
86	90.9	12201584	70469	5775.4							143548	1435481	3445153	4449990	2440317	287096						
91	95.9	9218113	65119	7064.3								141817	1418171	2269074	4538148	850903						
96	100.9	8376533	67429	8049.8									299162	2692457	3589943	1495809	299162					
101	105.9	4477663	42292	9445.1								121018	363054	605090	1089161	1573233	605090	121018				
106	110.9	1021980	11602	11352.3										240466	180349	300582	180349		120233			
111	115.9	438016	6007	13714.3											125147	62574	250295					
116	120.9	1050816	15658	14901.0											315245		315245	210163	210163			
121	125.9	350308	6715	19170.0															116769	116769	116769	
126	130.9	399661	8793	22000.0												199830						199830
146	150.9	129668	4669	36004.9																		
		2326775456	1090498		1164833574	350788443	341343862	77182019	93716793	121593715	70088128	44438350	27216529	13801647	13198391	5422231	1650140	491430	447165	116769	116769	199830
		2326645786																				

Length		Numbers, ind	Tones	ean weight, g	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	5.9	5354310	0.535	0.1	5354310																
6.0	10.9	340910014	1921.493	5.6	328513285	12396729															
11.0	15.9	549100023	10621.075	19.3	15424159	530591031	3084833														
16.0	20.9	207853977	9582.381	46.1	1636646	171847776	34369555														
21.0	25.9	66687661	6915.028	103.7		9879654	53514790	3293218													
26.0	30.9	57676488	10197.203	176.8		600797	39652586	16822309	600797												
31.0	35.9	76724375	22943.170	299.0			17877524	55122366	3724484												
36.0	40.9	94495153	44069.138	466.4			3073014	61460262	29193625	768253											
41.0	45.9	117280554	78185.000	666.6			820144	25424456	87755379	3280575											
46.0	50.9	98963602	89282.448	902.2			1596187	7980936	63847485	25538994											
51.0	55.9	83987979	104126.196	1239.8				4307076	30867377	48095680	717846										
56.0	60.9	63914672	104059.897	1628.1					6982275	42967847	13427452	537098									
61.0	65.9	49616472	101240.442	2040.5					1587727	15083408	28976020	3969318									
66.0	70.9	35662514	92124.893	2583.2					604449	4533370	20551279	9671190	302225								
71.0	75.9	28722215	90929.516	3165.8						455908	5470898	18236327	3875219	455908		227954					
76.0	80.9	24845462	96122.849	3868.8						403991	2423948	11311755	6665855	3433926	403991	201996					
81.0	85.9	25071781	119610.159	4770.7						166038	830191	3984919	7803799	9796259	2158498	166038	166038				
86.0	90.9	23192847	132143.738	5697.6							171799	687195	5325765	10136133	6012960	858994					
91.0	95.9	20401910	137828.182	6755.7								161920	1619199	8257916	9067516	1295359					
96.0	100.9	11977913	96648.419	8068.9									544451	2722253	6397294	2313915					
101.0	105.9	4461319	41589.347	9322.2									103752	311255	1971280	1660026	415006				
106.0	110.9	1708643	18966.683	11100.4										74289	520022	668600	222867	148578	74289		
111.0	115.9	1131063	14135.199	12497.3											102824	308472	514119		205648		
116.0	120.9	342653	5212.783	15213.0										68531		68531	137061		68531		
121.0	125.9	362196	6131.078	16927.5													241464		120732		
126.0	130.9	381876	7009.334	18355.0												95469			190938		95469
136.0	140.9	151108	2638.340	17460.0															151108		
		1990978780	1444234.528		350928401	725315986	153988633	174410623	225163599	141294065	72569433	48559722	26240265	35256469	26634386	7865353	1696556	148578	811245	0	95469
		1990978783																			

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	5.9	38171074	38.171	1.0	38171074																
6.0	10.9	2382957560	9035.382	3.8	2382957560																
11.0	15.9	256246049	4778.764	18.6	22477724	233768325															
16.0	20.9	92468683	4254.554	46.0	994287	69600084	21874312														
21.0	25.9	70860967	7012.874	99.0	595470	2977352	63715323	3572822													
26.0	30.9	77071221	14036.897	182.1		1806357	48771632	26493232													
31.0	35.9	83710121	24125.124	288.2			18602249	63114773	1993098												
36.0	40.9	70087735	31655.126	451.7			2156546	62000688	5930500												
41.0	45.9	61863962	40902.953	661.2				28032108	30931981	2899873											
46.0	50.9	51764216	47524.625	918.1				6089908	38569416	7104892											
51.0	55.9	53107626	66002.377	1242.8					23234586	29319835	553205										
56.0	60.9	47471133	76638.315	1614.4				382832	7273803	33306359	6508139										
61.0	65.9	36573727	76534.643	2092.6				329493	658986	14168201	20099075	988479	329493								
66.0	70.9	29130556	73574.966	2525.7						5612309	17638685	3474287	2138023	267253							
71.0	75.9	27422951	86278.779	3146.2						1246498	4736691	12464977	7229687	997198	498599	249300					
76.0	80.9	30716442	115762.290	3768.7						251774	3273064	8056772	13595802	4783708	503548			251774			
81.0	85.9	29899137	138399.291	4628.9								3686195	16178300	8601121	1228732					204789	
86.0	90.9	22803657	126122.881	5530.8								1341392	7473467	9772996	3257665	766510		191627			
91.0	95.9	14784030	96574.162	6532.3								152413	2743428	7773047	3200666	609651	152413	152413			
96.0	100.9	6393444	50360.920	7877.0								245902	491803	3196722	1598361	614754	245902				
101.0	105.9	2920890	26877.053	9201.7										865449	1081811	757268	108181	108181			
106.0	110.9	566696	6237.701	11007.1										80957	242870	161913	80957				
111.0	115.9	1066156	13083.737	12271.9											399809	133270	133270	133270	266539		
116.0	120.9	266201	3646.952	13700.0												133100	133100				
121.0	125.9	182421	2775.838	15216.7											60807		60807				60807
131.0	135.9	110313	2554.855	23160.0													110313				
		3488616968	1144789.226		2445196115	308152118	155120062	190015856	108592370	93909741	52808859	30410416	50180004	36338451	12072868	3425765	1024942	837265	266539	204789	60807
		3488616967																			

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.0	5.9	84468097	42.234	0.5	84468097															
6.0	10.9	2127420914	8629.930	4.1	2104296763	23124151														
11.0	15.9	702105736	13412.041	19.1	93074535	607007838	2023356													
16.0	20.9	382825005	16554.626	43.2		269124937	113700068													
21.0	25.9	313136268	30466.247	97.3		14342120	296403797	2390354												
26.0	30.9	226642488	39201.497	173.0		593305	199350460	26698723												
31.0	35.9	121692779	35150.274	288.8			43706562	76700731	1285487											
36.0	40.9	119322845	54822.052	459.4			2687451	95673272	20424631		537490									
41.0	45.9	99126764	67038.317	676.3			1120077	39202675	57123898	1680114										
46.0	50.9	86876969	82972.019	955.1				6246056	63028390	17602523										
51.0	55.9	77911367	100857.182	1294.5				1833209	32539453	40788892	2749813									
56.0	60.9	65680470	109491.168	1667.0					5017258	44699209	14595660	1368343								
61.0	65.9	52453162	114718.586	2187.1					2112208	17601732	21122079	10913074	704069							
66.0	70.9	60611288	166720.368	2750.6				360781	721563	2525471	14070478	36078148	6494067	360781						
71.0	75.9	73073603	243647.383	3334.3					1034060		8961857	39294296	21025895	2412808	344687					
76.0	80.9	76623550	310546.126	4052.9					304061	608124	608124	23108690	43784886	7905604	304061					
81.0	85.9	57216915	279411.559	4883.4							508595	6357435	37127421	12969168	254297					
86.0	90.9	32945848	194899.989	5915.8						182021		546064	16563934	14379679	910106	364042				
91.0	95.9	16869726	118380.371	7017.3								351453	3397375	10074975	2343017	468604	234302			
96.0	100.9	8682833	73222.547	8433.0								109909	1099093	4396371	2418004	659456				
101.0	105.9	3069919	29586.581	9637.6								93028		930279	930279	744223	186056	186056		
106.0	110.9	2452799	27682.555	11286.1										262800	1051200	613200	350400		87600	87600
111.0	115.9	1475467	18858.723	12781.5										155312	388281	465937	388281	77656		
116.0	120.9	361538	5403.181	14945.0											120513		180769		60256	
121.0	125.9	383234	7151.910	18662.0											76647		76647	76647	76647	76647
126.0	130.9	314689	6055.139	19241.7													104896	104896	104896	
		4793744272	2154922.601		2281839395	914192350	658991771	249105801	183591010	125688086	63154094	118220439	130196740	53847777	9141091	3315461	1521350	445255	329399	164247
		4793744268																		

	Length	Numbers, ind	Tones	Mean weight, g	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.0	5.9	36420319	3.642	0.1	36420319															
6.0	10.9	1352767145	7710.773	5.7	1317168009	35599136														
11.0	15.9	946443932	19753.707	20.9	59152746	887291187														
16.0	20.9	508927025	24321.779	47.8		475297484	33629542													
21.0	25.9	179131877	18004.099	100.5		55182805	122251138	1697932												
26.0	30.9	92428564	16929.054	183.2		901742	71237625	20289197												
31.0	35.9	84705050	26039.950	307.4			23449421	60777069	478560											
36.0	40.9	114813199	53671.871	467.5			3299230	98976897	12537073											
41.0	45.9	99961137	67998.234	680.2			1985983	36409685	60903474	661995										
46.0	50.9	60941140	57952.374	951.0				8390447	47251464	4416025	883205									
51.0	55.9	50244789	65067.819	1295.0				1647370	19768441	23886867	4942111									
56.0	60.9	58297259	98378.931	1687.5				419404	5032857	25164285	26422499	1258214								
61.0	65.9	85264725	186297.768	2184.9					435024	13050723	55248061	13920772	2610144							
66.0	70.9	100263875	264502.367	2638.1				484367		2421833	43108622	48921021	5328032							
71.0	75.9	87232590	281169.382	3223.2						360465	17662797	54430252	14779075							
76.0	80.9	63267045	247277.815	3908.5							1830039	34770732	25620539	1045737						
81.0	85.9	31626296	149824.635	4737.3							395329	9092560	19766435	1976643	395329					
86.0	90.9	18511936	106502.760	5753.2							276297	2210381	12157092	3315571	414446	138149				
91.0	95.9	8755780	61024.710	6969.6								389146	3307739	3794171	1070151		194573			
96.0	100.9	4556510	38223.651	8388.8								91130	729042	1913734	1093562	364521	273391	91130		
101.0	105.9	1821875	17586.927	9653.2									72875	510125	801625	437250				
106.0	110.9	1286693	13925.598	10822.8								71483	142966	142966	428898	214449	142966		142966	
111.0	115.9	1109526	14192.316	12791.3											147937	295874	517779	147937		
116.0	120.9	501069	7165.782	14301.0												100214	300641	100214		
121.0	125.9	75101	1339.806	17840.0																75101
126.0	130.9	88816	1711.479	19270.0														88816		
		3989443273	1846577.232		1412741073	1454272354	255852938	229092369	146406893	69962192	150768959	165155691	84513940	12698947	4351948	1550456	1429349	428096	142966	75101
		3989443274		Weight at age	6.2	32.4	144.8	461.4	870.3	1631.1	2346.7	3227.1	4289.6	6417.5	8079.6	10069.5	11277.4	13551.7	10822.8	17840.0

Length		Numbers, ind	Tones	Mean weight, g	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1.0	5.9	140226735	14.023	0.1	140226735													
6.0	10.9	1873632015	8833.976	4.7	1873632015													
11.0	15.9	351793531	7596.034	21.6	69102300	282691231												
16.0	20.9	223045823	9117.295	40.9		207208249	15837574											
21.0	25.9	98585591	10084.971	102.3		19448858	78466083	670650										
26.0	30.9	61082894	10806.528	176.9		459270	50060417	10563207										
31.0	35.9	55913827	16703.552	298.7			14511985	41401842										
36.0	40.9	40612218	18543.315	456.6			1128117	36851828	2256235	376039								
41.0	45.9	49409706	33181.582	671.6				23369455	25372552		667699							
46.0	50.9	58276105	55798.623	957.5				8218425	33620830	15689721	747129							
51.0	55.9	101169766	133606.679	1320.6				2572113	30865353	64302817	3429484							
56.0	60.9	134903617	231245.554	1714.2					6385970	88605334	38315820	798246	798246					
61.0	65.9	177517030	381284.391	2147.9					3025858	59508549	105905047	9077575						
66.0	70.9	154970176	407608.496	2630.2						10862396	99209880	43449582	1448319					
71.0	75.9	110303749	360677.428	3269.9						510666	42895902	63833188	3063993					
76.0	80.9	58167369	231605.045	3981.7						311055	8087442	39815098	9642719	311055				
81.0	85.9	29481423	139142.834	4719.7							1030819	16493104	9689699	2061638	206164			
86.0	90.9	10472275	60141.159	5742.9								4387034	4670069	1273655	141517			
91.0	95.9	5518761	37725.848	6835.9							100341	501706	2006822	2207504	401364	200682	100341	
96.0	100.9	2253187	18601.335	8255.6								77696	776961	776961	310784	233088	77696	
101.0	105.9	1396131	14161.606	10143.5									93075	558452	372302	186151	186151	
106.0	110.9	1034031	12306.267	11901.3									86169	258508	172339	172339	172339	172339
111.0	115.9	490651	6297.504	12835.0										245325	245325			
116.0	120.9	536110	7783.788	14519.0												428888		107222
121.0	125.9	172119	3114.213	18093.3												114746	57373	
		3740964842	2215982.047		2082961050	509807608	160004176	123647520	101526797	240166577	300389563	178433228	32276072	7693099	1849795	1335895	593900	279561
		3740964840		Weight at age	5.0	32.6	139.9	469.8	1068.4	1712.5	2456.2	3415.9	4593.0	6717.4	8688.2	11631.6	10615.7	12905.3

Length		Numbers, ind	Tones	Mean weight, g	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.0	5.9	4867366	0.487	0.1	4867366														
6.0	10.9	575677028	3226.821	5.6	575677028														
11.0	15.9	247382389	4646.745	18.8	72053124	175329265													
16.0	20.9	126761988	5344.548	42.2		119112558	7649431												
21.0	25.9	55799753	5617.291	100.7		15081014	40216038	502701											
26.0	30.9	32394131	5694.410	175.8		736230	29081095	2576806											
31.0	35.9	19793477	6093.033	307.8			6090301	13195651	507525										
36.0	40.9	39512730	18443.424	466.8			1118285	26838835	11555610										
41.0	45.9	62669424	42668.788	680.9				11959813	48317648	2391963									
46.0	50.9	106277865	104107.978	979.6				1136662	72746346	32394857									
51.0	55.9	165503815	220188.923	1330.4					39720916	118500731	7282168								
56.0	60.9	222891648	387410.052	1738.1					3595026	168966250	49611368	719006							
61.0	65.9	221126378	479734.275	2169.5				600887	600887	61891349	153827045	4206208							
66.0	70.9	188451082	516358.863	2740.0						12563406	150277658	25610020							
71.0	75.9	111352645	373036.573	3350.0						473841	54017879	53544037	3316887						
76.0	80.9	57043250	232620.614	4078.0							8802971	38028834	8450852	1760594					
81.0	85.9	31394691	158318.874	5042.9							909991	17517327	11602386	909991	454995				
86.0	90.9	17523241	105465.661	6018.6							203759	2445103	10595448	3056379	1222552				
91.0	95.9	10306109	71158.606	6904.5								448092	4032825	2539186	2837914	448092			
96.0	100.9	3838199	31345.914	8166.8								112888	338665	1693323	790217	790217	112888		
101.0	105.9	2263076	21944.653	9696.8								98395	98395	590368	1082341	98395	196789	98395	
106.0	110.9	692349	7989.711	11540.0									98907		395628	197814			
111.0	115.9	164189	2075.895	12643.3												54730		54730	54730
121.0	125.9	103708	2114.599	20390.0														51854	51854
total		2303790531	2805606.739		652597518	310259067	84155150	56811355	177043957	397182398	424932837	142729910	38534364	10549842	6783647	1589247	309677	204978	106583
		2303790532		Weight at age	7.0	32.1	141.2	486.8	960.8	1649.1	2504.1	3664.4	5204.7	6374.4	7482.9	8479.7	9139.1	13188.6	16412.2

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	5.9	965982	0.097	0.1	965982																
6.0	10.9	821963231	4597.192	5.6	821963231																
11.0	15.9	427795806	8383.546	19.6	79298733	348497073															
16.0	20.9	221730366	8940.754	40.3	1045898	214409080	6275388														
21.0	25.9	39348777	4057.758	103.1		5621254	33727523														
26.0	30.9	50666242	9095.065	179.5		1187490	38791342	10291580	395830												
31.0	35.9	76366894	23389.860	306.3			11785015	61282076	3299804												
36.0	40.9	117131580	54000.587	461.0			2940541	89196434	24014424	980180											
41.0	45.9	109764524	73216.235	667.0				33918652	65010748	10835125											
46.0	50.9	155728885	144898.800	930.5				6096149	103080330	44889821	1662586										
51.0	55.9	149600725	186461.354	1246.4				1104064	65691831	75628411	7176419										
56.0	60.9	127705836	216539.534	1695.6				448090	15235083	91858584	20164080										
61.0	65.9	87673011	188957.600	2155.3					3424727	51370905	29795125	2739782	342473								
66.0	70.9	45294053	122257.321	2699.2					487033	12419337	26786805	5600877									
71.0	75.9	22502781	74559.573	3313.3						1387158	11559648	7244046	1695415	462386	154129						
76.0	80.9	17126963	69608.323	4064.3						255626	3578768	9330360	2684076	1150318	127813						
81.0	85.9	8331435	41041.923	4926.2							784135	4018692	2744473	784135							
86.0	90.9	7824789	46806.024	5981.8							186304	2328806	2701415	1863045	465761	279457					
91.0	95.9	3879434	26914.890	6937.8								387943	1629362	1086241	698298	77589					
96.0	100.9	2483317	20040.143	8069.9								232811	698433	776037	543226	232811					
101.0	105.9	1723594	16866.326	9785.6									95755	957552	383021	95755	95755	95755			
106.0	110.9	568290	6138.460	10801.6									71036	142073	142073	71036	71036	71036			
111.0	115.9	164732	2285.656	13875.0										54911	54911						54911
116.0	120.9	174819	2700.957	15450.0												58273	116546				
total		2496516067	1351757.977		903273844	569714897	93519810	202337045	280639811	289625149	101693870	31883318	12662439	7276698	2569231	814921	283338	166792	0	0	54911
		2496516072		Weight at age	6.9	28.6	167.4	455.5	954.4	1551.5	2350.4	3802.7	5179.7	6415.0	7429.9	8213.5	12370.3	10218.3			13875.0

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.0	5.9	6349225	0.635	0.1	6349225																
6.0	10.9	446864561	2591.814	5.8	438739750	8124811															
11.0	15.9	55005060	1040.411	18.9	35651428	19353632															
16.0	20.9	99149196	4619.451	46.6	2704069	92839702	3605426														
21.0	25.9	102968736	11324.354	110.0		10623758	91527765		817212												
26.0	30.9	215003944	41465.408	192.9			188915600	26088344													
31.0	35.9	249645076	78658.281	315.1			76899598	168287528	4457947												
36.0	40.9	306246125	145478.014	475.0			10560212	272218778	23467135												
41.0	45.9	239424301	160214.945	669.2			1103337	142330576	94887049	1103337											
46.0	50.9	194787276	193141.405	991.6				38792381	149391935	6602959											
51.0	55.9	182175014	237972.618	1306.3				4358253	141207428	36609333											
56.0	60.9	99458751	169115.011	1700.4				543490	59783949	37500840	1630471										
61.0	65.9	47820905	105350.720	2203.0					7600674	30719389	9184147	316695									
66.0	70.9	32664318	89614.047	2743.5					1814684	15035956	14258234	1296203	259241								
71.0	75.9	26971708	92858.340	3442.8						3801382	18644872	3077309	1267127	181018							
76.0	80.9	15094243	63885.615	4232.4						895421	6267948	4477106	3197933	255835							
81.0	85.9	9995417	51797.667	5182.1							619185	2919016	6103396	176910	176910						
86.0	90.9	4949072	30094.372	6080.8							334397	601914	3343968	601914		66879					
91.0	95.9	3512983	25138.073	7155.8							127745	127745	2299407	830341	127745						
96.0	100.9	1007049	8562.352	8502.4									530026	318015	106005	53003					
101.0	105.9	1125281	10968.235	9747.1									312578	437609	312578		62516				
106.0	110.9	698103	8032.512	11506.2									139621	418862			139621				
111.0	115.9	317298	4031.273	12705.0										63460	126919	63460		63460			
121.0	125.9	90557	1582.475	17475.0												45278		45278			
131.0	135.9	80306	1527.497	19021.0																	80306
total		2341404503	1539065.526		483444472	130941903	372611937	652619351	483428014	132268618	51067000	12815988	17453296	3283965	850157	228620	202136	108738	0	0	80306
		2341404501		Weight at age	6.9	45.1	205.7	502.1	1100.7	1849.8	3113.5	4174.4	5511.0	7557.9	8694.2	10737.6	10962.2	14691.2			19021.0

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.0	5.9	4207032	0.421	0.1	4207032														
6.0	10.9	70361776	375.835	5.3	68645635	1716141													
11.0	15.9	62267183	1273.779	20.5	25944660	36322523													
16.0	20.9	281282552	13350.051	47.5	2250260	256529688	22502604												
21.0	25.9	218481656	22121.413	101.3		37870153	176241870	4369633											
26.0	30.9	300027428	52975.313	176.6		885036	236304789	61952568	885036										
31.0	35.9	212546238	63131.819	297.0			65398843	145103682	2043713										
36.0	40.9	239188924	107083.969	447.7			4910037	220250210	14028677										
41.0	45.9	161129797	107345.761	666.2				121755975	38162321	1211503									
46.0	50.9	81070856	73072.840	901.3				28834479	47639575	4596801									
51.0	55.9	53972882	66380.757	1229.9				3925300	35654813	14065660	327109								
56.0	60.9	51876788	86827.569	1673.7					18426182	28631451	4252196	283480		283480					
61.0	65.9	31566936	68529.872	2170.9					2162119	22269824	6270145	864848							
66.0	70.9	19919628	53748.249	2698.3					149772	6440181	8237440	5092236							
71.0	75.9	14617800	48713.591	3332.5						1484620	4225458	8222513	685209						
76.0	80.9	10579012	43992.079	4158.4						374478	1123435	7676805	1310674	93620					
81.0	85.9	5434131	26594.569	4894.0							132540	3247224	1656747	265080	132540				
86.0	90.9	3134735	18410.178	5873.0								1290773	1475170	307327	61465				
91.0	95.9	1045958	7426.996	7100.7								116218	522979	348653	58109				
96.0	100.9	1257585	9683.720	7700.3								125759	125759	503034	440155	62879			
101.0	105.9	574140	5258.106	9158.2									191380	255174	63793		63793		
106.0	110.9	100283	1168.425	11651.3										50142		25071	25071		
111.0	115.9	178101	2016.406	11321.7											118734		59367		
116.0	120.9	230534	3014.523	13076.3										57634	57634	57634	57634		
121.0	125.9	34436	534.756	15529.0															34436
total		1825086392	883030.995		101047588	333323541	505358143	586191848	159152207	79074519	24568322	26919855	5967918	2164141	932430	145584	205865	0	34436
		1825086394		Weight at age	9.9	50.8	162.8	452.1	975.2	1800.8	2554.5	3740.1	5184.4	6464.4	8036.7	10508.9	11182.6		15529.0

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12
1.0	5.9	1224409	0.122	0.1	1224409												
6.0	10.9	178154320	1092.908	6.1	178154320												
11.0	15.9	227171648	4370.699	19.2	90037543	137134106											
16.0	20.9	378995436	16682.226	44.0	6620008	319415367	52960060										
21.0	25.9	204888709	21020.240	102.6		22465867	181524207	898634									
26.0	30.9	209828125	38697.552	184.4			196093920	13734206									
31.0	35.9	127775616	37422.778	292.9			74385804	52789926	599886								
36.0	40.9	84814328	40418.710	476.6			3996487	71048653	9769190								
41.0	45.9	71103440	49494.612	696.1			703994	33087739	36255714	703994	351998						
46.0	50.9	102983468	98008.539	951.7				11953438	85972806	5057224							
51.0	55.9	79728104	103921.001	1303.4				2291037	56817729	18328300	2291037						
56.0	60.9	42787180	71886.053	1680.1				301318	14463272	20489636	7231636	301318					
61.0	65.9	39288789	85540.779	2177.2					1598962	12563276	23527589	1370539	228423				
66.0	70.9	29187510	79064.400	2708.8						2445881	22175986	4076468	489176				
71.0	75.9	16846737	55677.609	3304.9						215984	11123166	4211684	1079919	215984			
76.0	80.9	8947226	36559.203	4086.1					69900		2656208	4473613	1537804	139800	69900		
81.0	85.9	5554031	27655.593	4979.4						50491	353438	2524560	2070139	504912	50491		
86.0	90.9	2499524	14929.271	5972.8					43095			430952	1379048	517143	43095	86191	
91.0	95.9	1786747	12756.250	7139.4								207761	914150	623284	41552		
96.0	100.9	832212	6954.004	8356.1							43801	43801	350405	262804	87601		43801
101.0	105.9	202338	1913.308	9456.0									40468	80935	40468	40468	
106.0	110.9	340326	3753.582	11029.4										212704	85081	42541	
111.0	115.9	236706	3243.656	13703.3											157804	78902	
116.0	120.9	28384	411.850	14510.0											28384		
126.0	130.9	45281	1209.003	26700.0											45281		
total		1815250595	812683.947		276036279	479015340	509664472	186104950	205590556	59854785	69754858	17640696	8089532	2557565	649658	248101	43801
		1815250593		Weight at age	11.3	39.7	159.5	482.8	1042.2	1646.7	2529.1	3612.4	4951.7	6508.2	10663.2	9866.5	8356.1

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13
1.0	5.9	677969	0.678	1.0	677969													
6.0	10.9	148884199	853.361	5.7	148884199													
11.0	15.9	297385684	5608.596	18.9	29574266	267811419												
16.0	20.9	184805484	8670.165	46.9	1032432	164156827	19616224											
21.0	25.9	62120778	6160.955	99.2		8742924	52457546	920308										
26.0	30.9	77282961	14245.353	184.3			55761124	21521837										
31.0	35.9	99603687	30847.160	309.7			18294555	80292768	1016364									
36.0	40.9	87465502	41782.785	477.7			467730	79981823	6548219	467730								
41.0	45.9	41371438	28530.442	689.6				25252696	13163639	2955103								
46.0	50.9	42946042	42326.062	985.6				7782169	20175993	14699652	288229							
51.0	55.9	49456910	67542.595	1365.7				847833	12152270	35043753	1130444	282611						
56.0	60.9	42488061	73425.562	1728.1					2296652	32535903	7464119		191387					
61.0	65.9	23190302	50594.403	2181.7					366163	13181856	7933524	1464651	122054	122054				
66.0	70.9	12329000	34130.515	2768.3					80058	1521110	7365377	3042221	240175			80058		
71.0	75.9	9267455	30832.149	3326.9						298950	3213714	4708465	1046326					
76.0	80.9	6225582	25978.155	4172.8						119723	478891	4010711	1496534	119723				
81.0	85.9	3055623	15097.873	4941.0							123877	1569104	1114889	247753				
86.0	90.9	1342953	7730.196	5756.1						31975		479626	703451	127900				
91.0	95.9	981648	7009.305	7140.3								37756	377557	339801	226534			
96.0	100.9	651030	5481.904	8420.4								50079	300475	100158	150238			50079
101.0	105.9	159768	1595.688	9987.5									59913	19971	39942	39942		
106.0	110.9	142636	1508.617	10576.7										95091	47545			
116.0	120.9	23736	374.139	15762.2														
		1191858448	500326.658		180168866	440711170	146597178	216599433	55799358	100855755	27998174	15645223	5652763	1172452	464259	120001	0	50079
		1191834711																

Length		Numbers, ind	Tones	Mean weight, gr	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.0	5.9	480712	0.048	0.1	480712														
6.0	10.9	504475731	3040.980	6.0	504475731														
11.0	15.9	266611684	5070.912	19.0	38087383	228524302													
16.0	20.9	149868848	7243.260	48.3		88608590	61260259												
21.0	25.9	188011181	18311.330	97.4		13498238	173548782	964161											
26.0	30.9	79848525	14411.686	180.5			73194482	6142195	511850										
31.0	35.9	57394479	17693.353	308.3			20068000	33312880	4013600										
36.0	40.9	115134644	52916.049	459.6			1668618	60070249	53395777										
41.0	45.9	203343674	139198.675	684.5				34994027	161729155	6620492									
46.0	50.9	188267508	177789.479	944.3				12237388	139317956	35770826	941338								
51.0	55.9	108715988	137270.272	1262.7					55249109	49308344	4158535								
56.0	60.9	54159536	89996.363	1661.7					6334448	35156190	11402008	1266890							
61.0	65.9	44441031	92269.299	2076.2					976726	18557793	20999608	3662722	244182						
66.0	70.9	38058737	98386.133	2585.1						4092337	24554024	8798526	613851						
71.0	75.9	27646997	85284.964	3084.8						708897	14000723	11519582	1417795						
76.0	80.9	17044216	65267.367	3829.3							3334738	11115793	2346667	247018					
81.0	85.9	6420290	29943.800	4663.9							323712	2751553	2697601	647424					
86.0	90.9	3036864	17186.170	5659.2								860445	1720890	303686	151843				
91.0	95.9	1646236	11193.652	6799.5							47035	235177	752565	517388	94071				
96.0	100.9	511895	3840.389	7502.3									204758	255947	51189				
101.0	105.9	298411	2913.983	9765.0									37301	186507	74603				
106.0	110.9	64779	704.791	10880.0											64779				
111.0	115.9	264516	3613.822	13662.0									52903	52903		52903			105807
116.0	120.9	130108	1753.853	13480.0											65054		65054		
121.0	125.9	1851	25.808	13940.0											1851				
126.0	130.9	29050	463.936	15970.0															29050
131.0	135.9	75314	1762.356	23400.0												75314			
total		2055982808	1077552.734		543043827	330631130	329740139	147720899	421528621	150214881	79761721	40210687	10088512	2210874	503390	128218	65054	0	134857
		2055982809		Weight at age	6.9	30.1	121.4	505.0	831.4	1399.9	2381.5	3229.4	4511.5	6181.4	8381.2	19382.1	13480.0		14159.2

Year/Age	0	1	2	3	4	5	6	7	8	9
2004	6	11	21	36	41	51	66	71	81	91
2005	6	11	21	36	46	51	56	61	71	81
2006	6	16	26	36	46	56	61	76	81	91
2007	6	16	26	36	46	56	66	71	81	96
2008	6	16	26	36	46	56	71	76	81	91
2009	6	11	26	36	46	56	61	76	81	86
2010	6	11	21	36	46	56	61	71	81	86

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The effect of age-specific setting of variance parameters for the observations in North-East Arctic cod stock assessment by means of SAM

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In North-East Arctic cod stock assessment by means of SAM the fleet-specific variance parameters for the observations are used, but within the same fleet these parameters are age-independent (see table 1, representing the corresponding block in the model configuration file).

The first row in the table corresponds to catch-at-age, further rows correspond to “fleet 15”, “fleet 16”, “fleet 18” and “fleet 007”. The meaning of the same values in each of the rows is that the same values of variance are used for all age groups for a given fleet.

Table 1.
 # Coupling of the variance parameters for the observations.

0	0	0	0	0	0	0	0	0	0	0	0	0
-1	1	1	1	1	1	1	1	1	1	-1	-1	-1
-1	2	2	2	2	2	2	2	2	2	-1	-1	-1
3	3	3	3	3	3	3	3	3	3	-1	-1	-1
4	4	4	4	4	4	4	4	4	4	-1	-1	-1

Probably, more detailed specification of variances could be more appropriate if to look at Table 2, where standard deviations (STD) for the model residuals are given:

Table 2. Standard deviations of residuals by fleets and age groups

Age / Fleet	3	4	5	6	7	8	9	10	11	12	13	14	15
Catch	1.01	0.73	0.67	0.62	0.69	0.55	0.50	0.83	0.77	1.16	1.31	1.71	2.30
Fleet 15		0.39	1.09	0.97	0.95	1.05	1.02	0.90	1.42	1.14			
Fleet 16		0.83	0.82	0.90	0.87	0.91	0.97	0.71	1.30	1.10			
Fleet 18	0.61	0.99	1.03	0.97	0.68	0.71	1.40	0.96	1.37	1.40			
Fleet007	0.92	0.79	0.93	0.96	1.04	1.07	0.55	0.63	1.01	1.60			

As it can be seen from Table 2, in catch-at-age residuals the STD values are much higher for age groups 14 and 15;
for fleet 15 the STD value for age 4 is much lower than the others for this fleet. and for age 11 – apparently higher;
for fleet 16 – age 11 gives higher STD with respect to other ages of this fleet;
for fleet 18 higher STD are observed for age group 9. 11 and 12;
for fleet 007 apparent relatively higher STD is seen for age group 12.

The attention to more detailed specification of variances came from an expectation that if to use “age-average” variance for an age group with much more variable residuals with respect to others for a given fleet data, the model may have not enough “flexibility” to be tuned at the data for this age group. Vice versa, for an age group with much lower STD the “age-average” variance could give too much space to the model-derived abundance estimate to deviate from the corresponding survey data.

In accordance to the above mentioned the corresponding block in the model configuration file was modified as follows (see Table 3):

Table 3.
 # Coupling of the variance parameters for the observations.

0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**5**
-1	**6**	**1**	**1**	**1**	**1**	**1**	**1**	**7**	**1**	**-1**	**-1**	**-1**
-1	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**8**	**2**	**-1**	**-1**	**-1**
3	**3**	**3**	**3**	**3**	**3**	**9**	**3**	**9**	**9**	**-1**	**-1**	**-1**
4	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**10**	**-1**	**-1**	**-1**

As it can be seen, different from others (but equal to each other) variances now are used for ages 14 and 15 for catch-at-age; specific variances for ages 4 and 11 for fleet 15; specific variance for age 11 for fleet 16; specific (but equal to each other) variances for ages 9, 11 and 12 for fleet 18; and specific variance for age 10 for fleet 007.

Naturally, more detailed specification can be imagined, but the idea was not to introduce too many new free parameters into the model.

The results of retrospective diagnostics of the model with new settings are presented in the Figure 1. For comparison the same for the model with traditional settings is presented in Figure 2.

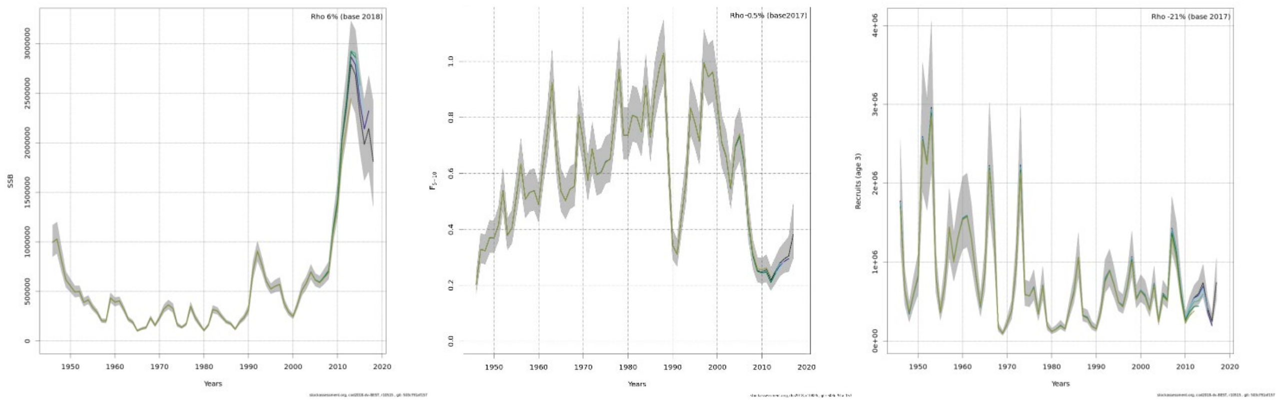


Figure 1.Retrospective diagnostics for the new settings of the model.

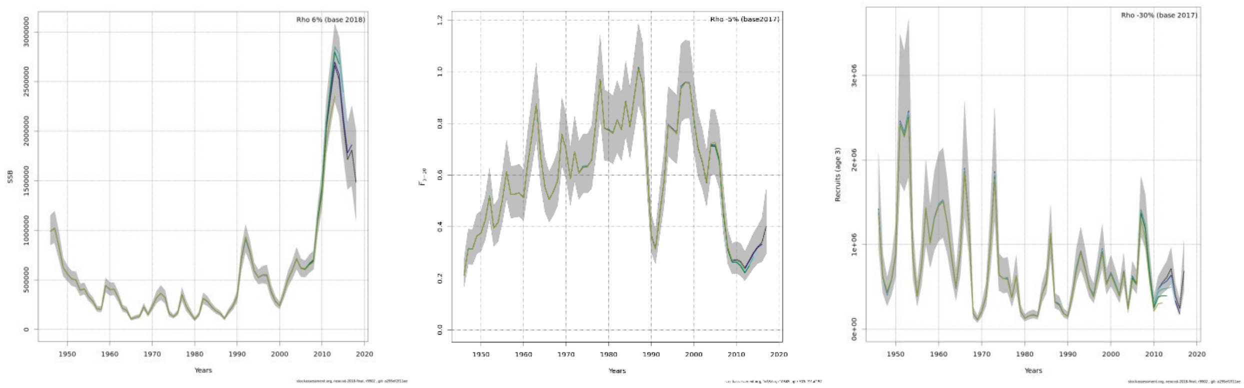


Figure 2.Retrospective diagnostics for traditional settings of the model.

Measures of retrospective bias for SSB, recruits and F are compared in Table 4. For recruits and F the new settings resulted in lower historical bias, while for SSB it was the same.

Table 4

	Rho(SSB)	Rho(R_3)	Rho($F_{5\text{-}10}$)
SAM (AFWG 2018)	6%	-30%	-5%
SAM-new settings	6%	-21%	-0.5%

Despite of higher number of parameters the value of Akaike's Information Criterion became better (see Table 5).

Table 5

	AIC
SAM (AFWG 2018)	2816.67
SAM-new settings	2544.75

Comparison of the results of SAM (AFWG-2018) and SAM with new settings (marked in the Figure 3 as SAM-2) shows that SSB for final years became somewhat higher, as well as recruitment; F became somewhat lower.

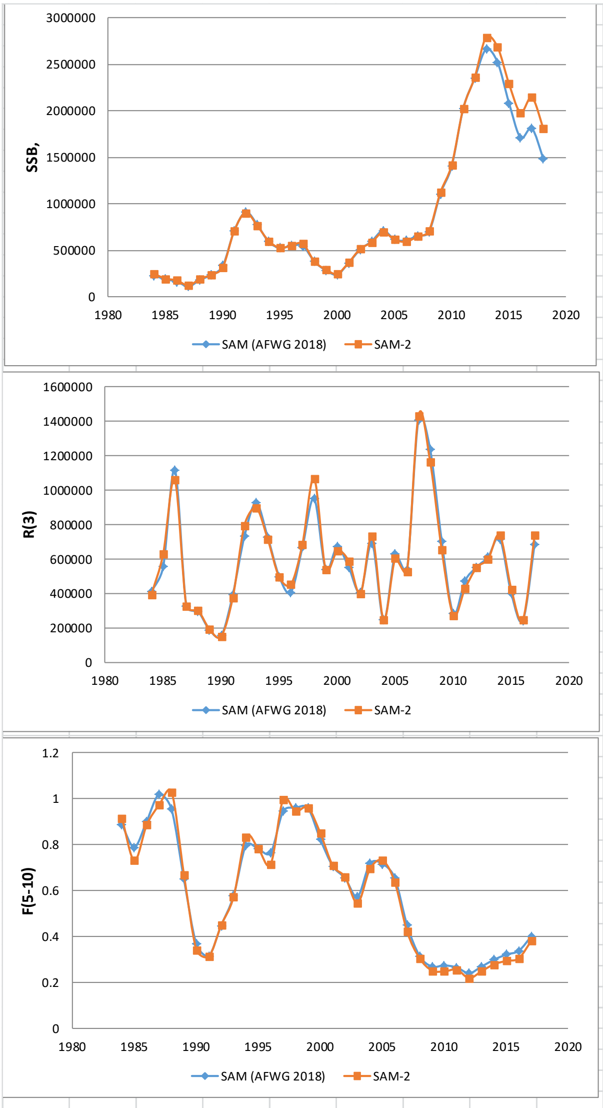


Figure 3. Comparison of the results of SAM(AFWG-2018) and SAM with new settings

Working Document to AFWG Lisbon 23rd to 30th of April 2019

Cod and haddock abundance indices by age from the ecosystem survey: comparing current indices from BIOFOX and new indices from StoX.

Edda Johannesen, Geir Odd Johansen and Dmitry Prozorkevich

Background

Bottom trawl indices from the Joint Norwegian Russian Barents Sea ecosystem survey (2004-) in the Barents Sea has been used in the assessment of Northeast Arctic cod (since 2015) and haddock (since 2011) in the Arctic fisheries working group (AFWG). The indices used in assessment are calculated at PINRO using the BIOFOX software and presented as a working document to AFWG each year. A working document from 2014 provides results for cod from various settings using BIOFOX (Prozorkevich and Gjøsæter 2014). Since 2015 a new open access survey software StoX (StoX 2015) has been developed at IMR. This software is used to calculate abundance indices from the joint IMR PINRO winter survey (Mehl et al 2016).

StoX gives uncertainty estimates based on bootstrap (not provided in this WD) and since it is open access it can be run by anybody who has access to data in the right format. However, it is not very well documented and therefore not necessarily easy to run. BIOFOX is easy to run and is flexible but not freely available. The BIOFOX software has many options for choosing trawl hauls and age-length keys. BIOFOX does not include uncertainty estimates.

Here we document the input data from the ecosystem survey and methods used by BIOFOX and StoX related to strata system, age length keys and swept area estimation. Then we compare the abundance indices from BIOFOX and StoX for cod and haddock run on the ecosystem survey data 2004-2018 for ages 1-10+

Methods

Survey design of the ecosystem survey

The Barents Sea ecosystem survey (BESS) covers the whole Barents Sea: an area of around 1.6 mill km^2 and is conducted in August-September when the Barents Sea shelf (in most years) is ice free. The survey was initiated by combining and extending several previous Barents Sea surveys. When initiated, there was no agreement on strata system. Since the ecosystem surveys are monitoring many aspects of the ecosystem, it was decided that the ecosystem trawl stations should be set out in a regular grid. This was taken from a 0-group survey that historically was the main predecessor of the BESS. In addition, in all years (except 2010, 2015-2016, Appendix figure) a denser and irregular station grid was applied along the shelf break west and north of Svalbard, due to the very steep depth gradient in this area.

The distance between the stations of about 35nm was a compromise to allow coverage of the whole shelf area within the allotted survey time. However, some notable deviations to the regular grid has occurred), mostly in the earliest years of the time series (Figure 1, Appendix Figure). On average 407 stations per year were taken (Table 1). In addition, some stations were set out at dense acoustic registrations close to the bottom or for other purposes, mostly on Russian vessels (Table 1 and Figure 1).

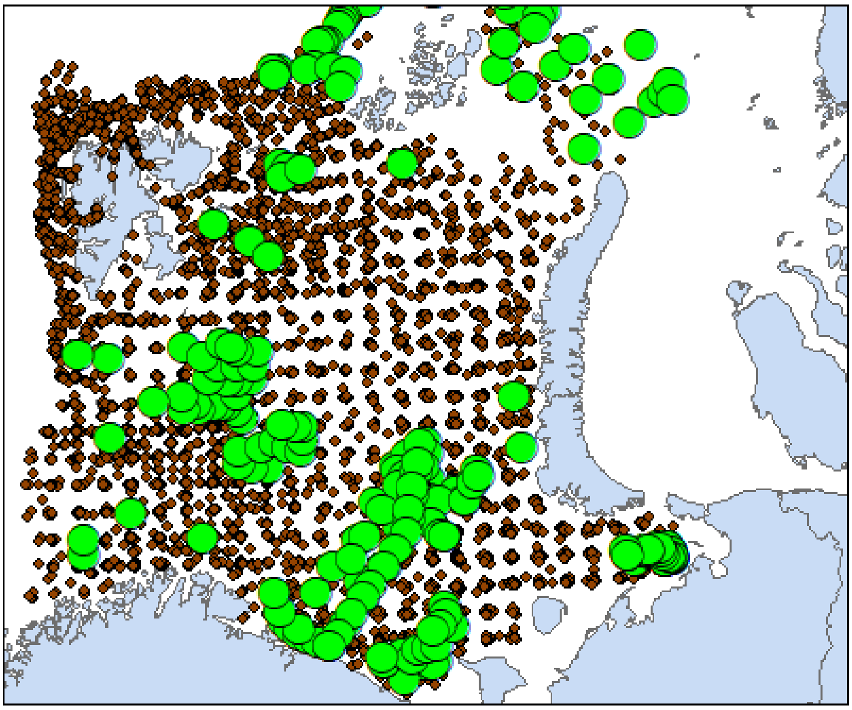


Figure 1. All bottom trawl stations 2004-2018. Brown dots are stations set of at predefined stations, green stations (extra stations) are bottom trawls set out at dense acoustic registrations close to the bottom or for other purposes. See also table 1 and text.

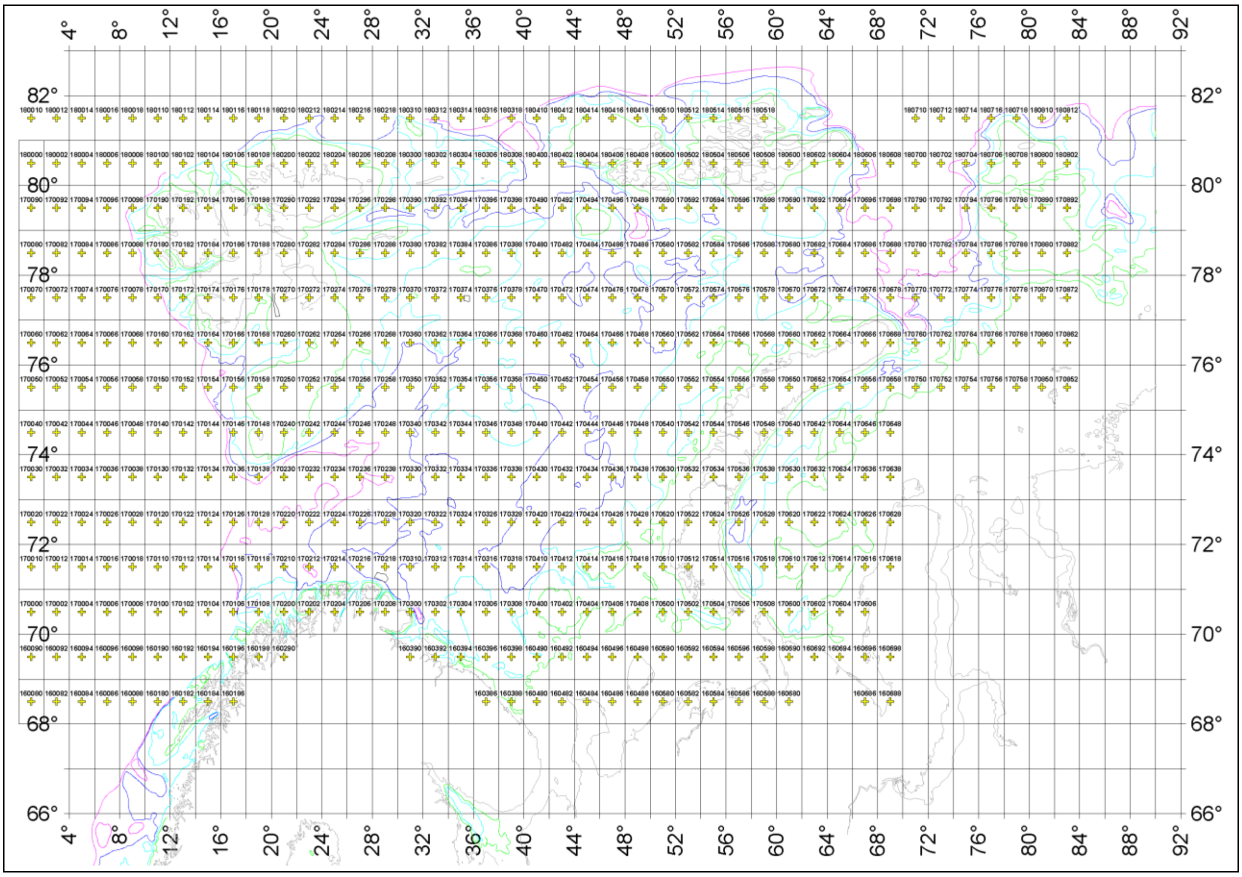
Table 1. Number of predefined and extra stations. Only 13 of the extra stations were set out by Norwegian vessels.

Year	Predefined	Extra
2004	600	2
2005	625	1
2006	638	0
2007	498	89
2008	387	21
2009	357	14
2010	321	6
2011	379	9
2012	428	13
2013	416	69
2014	294	8
2015	326	8
2016	294	10
2017	327	16
2018	224	1
Total	**6114**	267

The application of a strata system

BIOFOX

The BIOFOX method uses the same high resolution strata system (WMO squares; https://en.wikipedia.org/wiki/World_Meteorological_Organization_squares) that has been used for capelin abundance estimation.



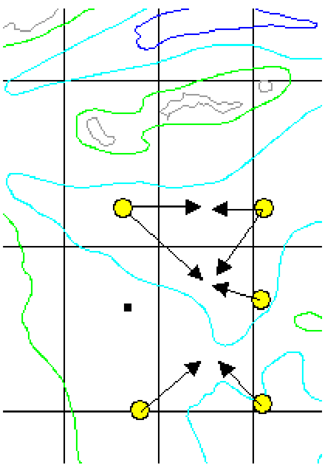


Figure 2

Top: The strata system used in the BIOFOX method. Each stratum is 1° latitude x 2° longitude. Each stratum is depth stratified using the following depth categories: <100, 100-200, 200-300, 300-400 and 400-800 m.

Bottom: Interpolation method used in BIOFOX. For strata-depth categories lacking stations, abundance is interpolated using the average abundance by length from the stations in the same depth interval in neighbouring strata.)

The BIOFOX strata system covers the whole Barents Sea and include the whole survey area, and was constructed based on standard 1° latitude x 2° longitude WMO squares. In addition, for the purpose of demersal fish abundance indices, it also included depth stratification by the ranges: <100, 100-

200, 200-300, 300-400 and 400-800 m, based on bathymetry data from GEBCO (https://www.gebco.net/). (Figure 2). This was done to enable possible future use of acoustic data in the calculations for stratum-depth categories lacking stations, abundance is interpolated using the average abundance by length from the station in the same depth interval from neighbouring strata (Figure 2). The interpolation radius is always within the range of one WMO square. At the edges, abundance is extrapolated to one neighbouring WMO square.

BIOFOX interpolates using neighbouring stations (Figure 2). In some years when the “holes” were small (2014, 2015), it is possible to use interpolation to fill the holes. In the case of “large holes” (as in 2018) it is impossible to fill the holes in a meaningful way (Figure 3).

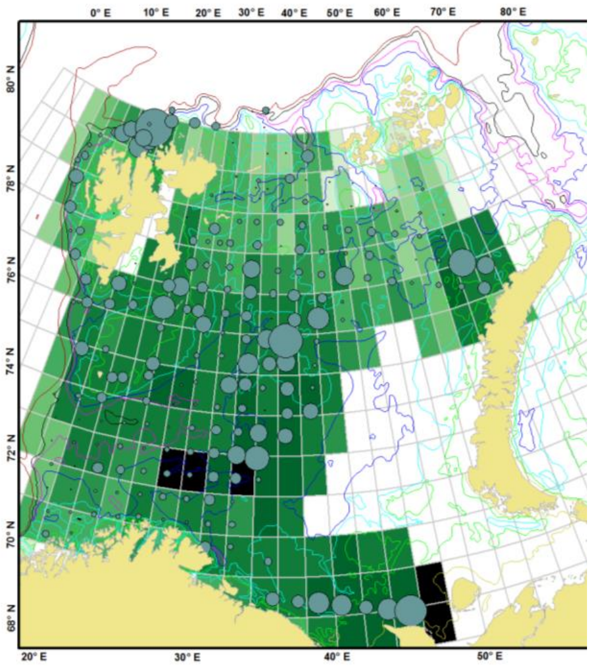


Figure 3. Biofox BESS 2018 cod index calculation. Actual cod catches (bubbles) and WMO strata filling.

StoX

StoX requires a strata system to calculate abundance indices. Within each stratum the average swept area abundance is calculated and then the total abundance in that stratum is calculated by multiplying the average with the area of that stratum. Total abundance is calculated by summing the abundances of all the strata.

Since there were no predefined strata system in BESS originally, but a regular grid with some notable deviations, we have developed a post-stratification of the survey. This is primarily based on the geographical distribution patterns of cod and haddock, observed at BESS and aggregated over the period 2009-2018. The 250 m depth contour were used as guideline for the borders between strata, as a preliminary analysis show that this depth seperate quite well between low density areas for demersal fish (deeper) and high density areas (shallower). Some practical considerations were also taken when defining the strata system. The size of the strata was defined so that each stratum ideally contained at least 20 trawl hauls (although this was difficult to satisfy some years). The strata system was in some areas separated geographically to homogenise the density and age structure of fish within strata. In addition, the southernmost strata were divided by the RUS-NOR border, since the survey effort varied between RUS and NOR vessels in this area some years. The 500 m depth contour was used as a limit for the strata system towards the Norwegian Sea in the west and the Polar Ocean in the north. The result is a basic strata system for demersal fish in the BESS, used as a starting point when generating the yearly strata systems used for estimation (Figure 4). We also modified the strata system some years to account for irregular sampling, ice coverage, and limited survey coverage due to other reasons (Appendix figures).

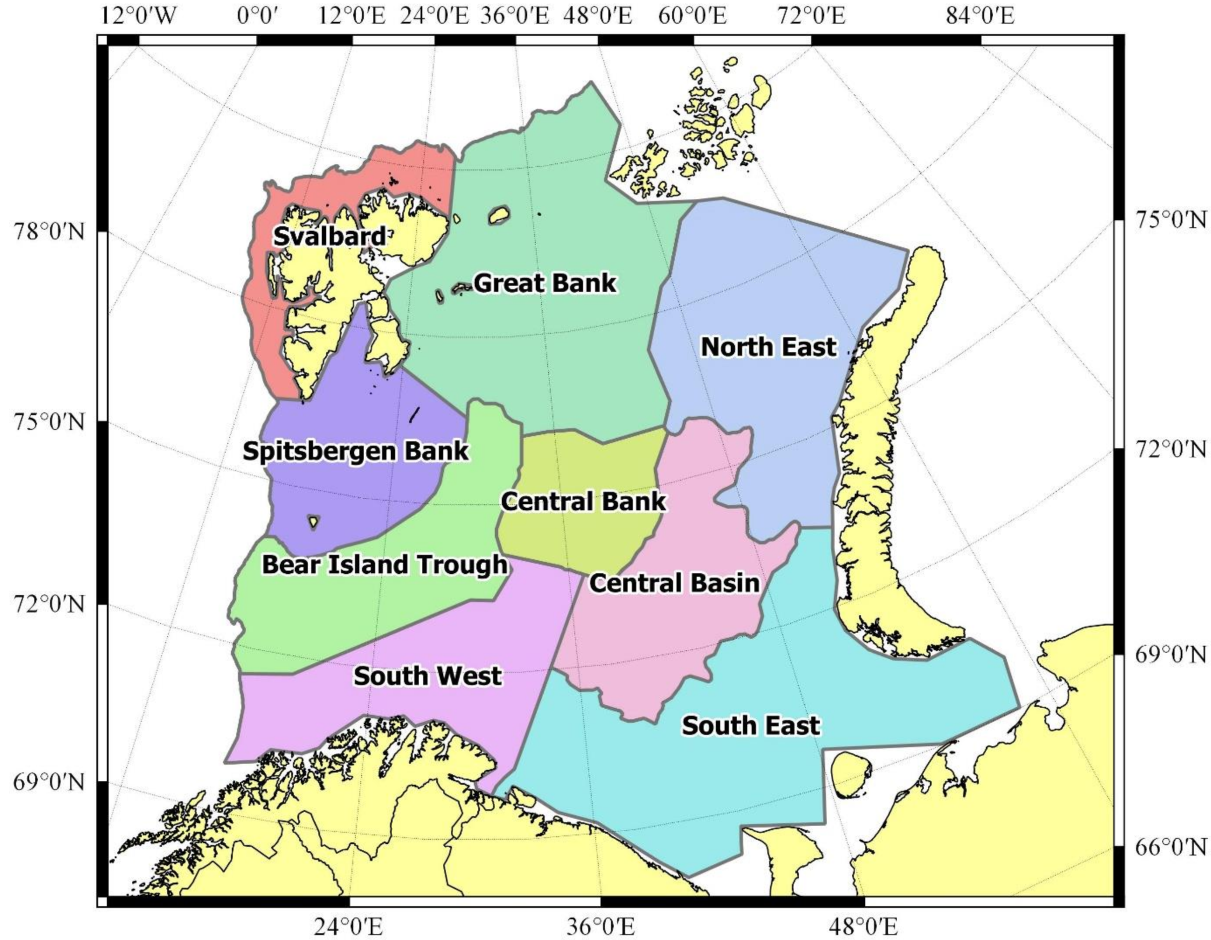


Figure 4. The basic strata system used in StoX. The names are given based on a combination of geographic area and well-known bathymetric features within each stratum. The strata system was modified each year to account for coverage issues and denser stations in some areas (Appendix Figure).

Age-length key and swept area estimation

Both Russian and Norwegian vessels used a standard research bottom trawl (Campelen 1800 shrimp trawl) with 80 mm (stretched) mesh size in the front and rockhopper ground gear. Details on rigging is given in Appendix Table. The small mesh size allows capture of small specimens. At least 100 cod and haddock from the trawl catches are measured to the nearest cm. Otoliths are sampled from one fish in each 5 cm length group from each station. Subsampling of catches occur particularly for large catches with smaller fish. Then the total number of fish by length group is calculated from the weight of the total catch relative to the weight of the subsample.

Stations included

The StoX method includes only the trawl hauls set out on predefined stations. The BIOFOX method includes the trawl hauls set out at predefined stations, as well as additional extra trawl hauls with the goal to fill in as many strata as possible by actual catch data. (Table 1, Figure 1).

Sweep width

Swept areas by length group and station is calculated using Dickson corrected length depended sweep width (see e.g. Mehl et al 2016), both in StoX and BIOFOX.

Age length keys

In StoX all cod in a 5 cm length group in a station is assigned to the same age as the individual in that station that was aged based on otoliths (see above). If age readings for some reason are lacking for that 5 cm length group in that station, age is selected at random from fish of the same length group within the same stratum. If data are missing at the stratum level, then an age is selected at random from fish from the whole survey area.

The BIOFOX method uses one age length key for the whole area per year.

Total abundance by age

Both BIOFOX and StoX use average swept area densities by strata. StoX first calculates density by age and stratum, then the age and stratum specific density is multiplied with the stratum area and then the stratum estimates are summed.

Total estimates for BIOFOX is obtained by multiplying the density with the stratum area and summing the strata. The BIOFOX software has many options for choosing trawl hauls and age-length keys, but for the final calculation options were chosen that gave the best internal consistency of the stock indexes ().

Age groups 1 – 10 + used for both cod and haddock as these are the ones reported by ICES AFWG.

Results

We compared the methods by comparing internal consistency and by comparing the percentage difference in the age and year specific estimates from StoX and BIOFOX (*StoX/BIOFOX).*

Northeast arctic cod

The estimates tended to be lower using the StoX method compared to the BIOFOX (Table 2, Figure 5, Figure 6). This varied by year, 2007 gave much lower StoX estimates than BIOFOX estimates, for all ages except 1-year olds. We do not know the reason for the discrepancy, but this year there was a high number of extra stations (Table 1): this might be relevant. The difference was also large in 2014, but this year there was ice hindrance in the northern Barents Sea during the survey and for that reason the indices from this survey was not used in the assessment of cod that year.

The largest difference by age across years was for 2-5 year olds (Figure 6).

Consistency was similar for the BIOFOX and StoX (Figure 7). Consistency was lowest from age 4 to 5 for both methods, but the problem was largest for BIOFOX (R^2<0.3) than for StoX (R^2<0.5). The problem was related to two years in particular: 2004 and 2009. In 2004 the estimates for 4-year olds was high, but the estimates for 5-year olds were comparably low. In 2009 the estimates for 4-year olds were low, but the estimates for 5-year olds in 2010 were comparably higher.

Table 2. Table of the swept area index estimates for Northeast arctic cod based on the BESS from StoX divided by those from BIOFOX (i.e. StoX/BIOFOX), by survey year and ages 1-10+. Green shading denotes proportions smaller than 0.80 (i.e. higher estimates from BIOFOX), and red shading denotes proportions larger than 1.20 (i.e. higher estimates from StoX).

Year	1	2	3	4	5	6	7	8	9	10+	Average	St_dev
2004	1.237	0.883	0.624	0.680	1.041	0.944	1.004	1.029	0.887	1.129	0.946	0.188
2005	0.806	0.834	0.823	0.625	0.965	1.115	1.165	1.235	1.512	1.666	1.075	0.331
2006	0.944	0.840	0.754	0.595	0.610	0.676	0.943	1.013	1.272	0.821	0.847	0.207
2007	0.909	0.592	0.509	0.475	0.583	0.392	0.598	0.538	0.597	0.485	0.568	0.138
2008	0.837	0.711	0.524	0.718	0.670	0.913	0.799	0.880	1.041	1.068	0.816	0.168
2009	0.944	0.769	1.057	0.845	1.219	1.272	0.838	0.867	1.106	0.999	0.992	0.170
2010	1.140	1.044	1.064	1.012	1.138	1.115	1.370	0.992	0.801	0.879	1.055	0.156
2011	0.734	0.942	0.914	0.962	0.917	1.060	1.199	0.938	1.014	1.020	0.970	0.119
2012	0.892	0.954	0.741	0.894	1.097	1.202	1.018	1.166	1.025	0.958	0.995	0.138
2013	0.741	1.006	1.015	0.808	0.863	0.802	1.026	1.004	1.052	0.904	0.922	0.113
2014	0.858	0.748	0.920	0.881	0.877	0.792	0.555	0.644	0.543	0.647	0.747	0.141
2015	0.821	1.137	1.058	0.976	1.050	0.855	1.259	1.273	1.017	0.951	1.040	0.152
2016	1.129	1.129	1.048	1.071	1.064	1.037	0.953	0.940	0.919	0.836	1.013	0.097
2017	0.964	0.766	0.937	0.667	0.648	1.161	1.165	0.964	1.063	0.933	0.927	0.184
Average	0.925	0.882	0.856	0.801	0.910	0.953	0.992	0.963	0.989	0.950		
St_dev	0.151	0.161	0.198	0.178	0.210	0.237	0.237	0.200	0.246	0.265		

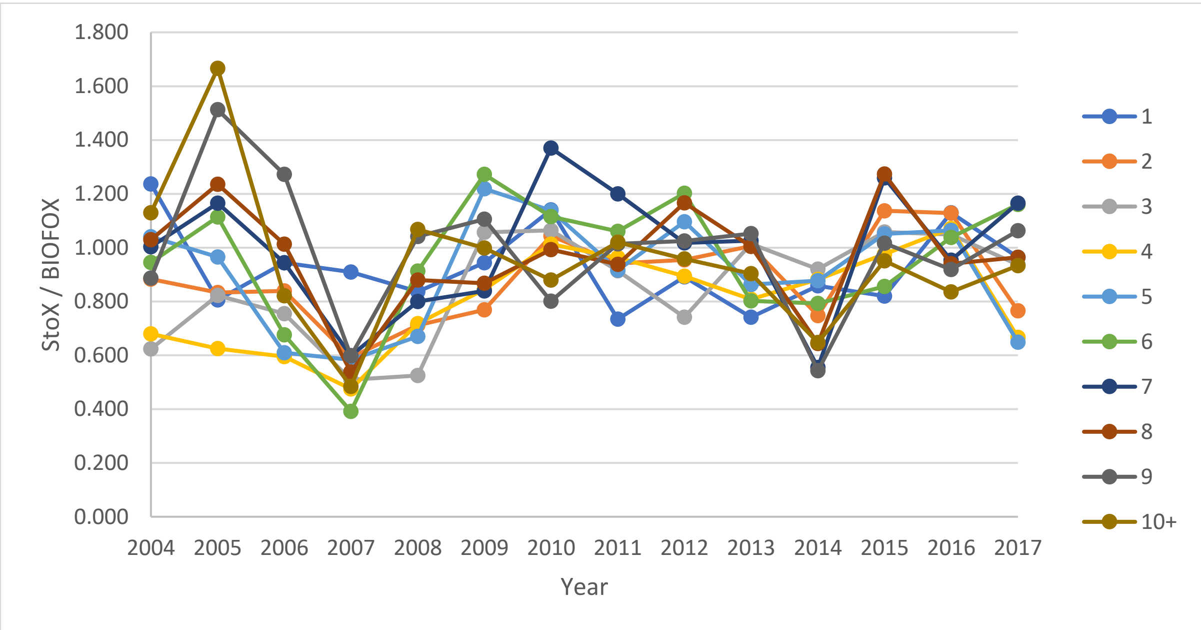
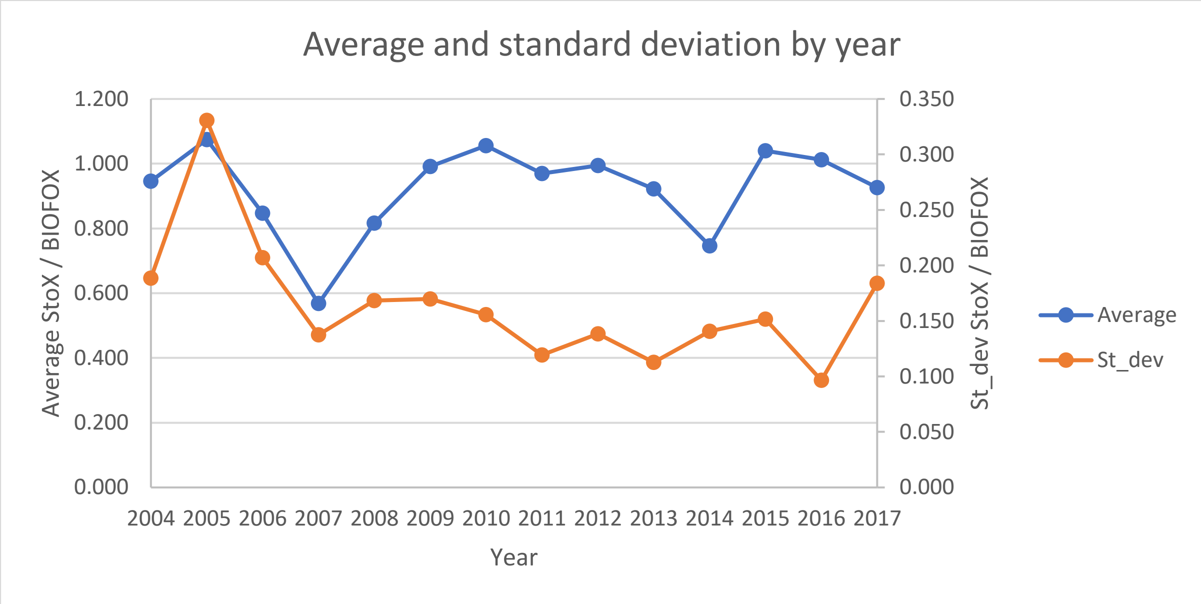


Fig 5 Swept area index estimates for Northeast arctic cod based on the BESS from StoX divided by those from BIOFOX (i.e. Stox/BIOFOX), by survey year and ages 1-10+.



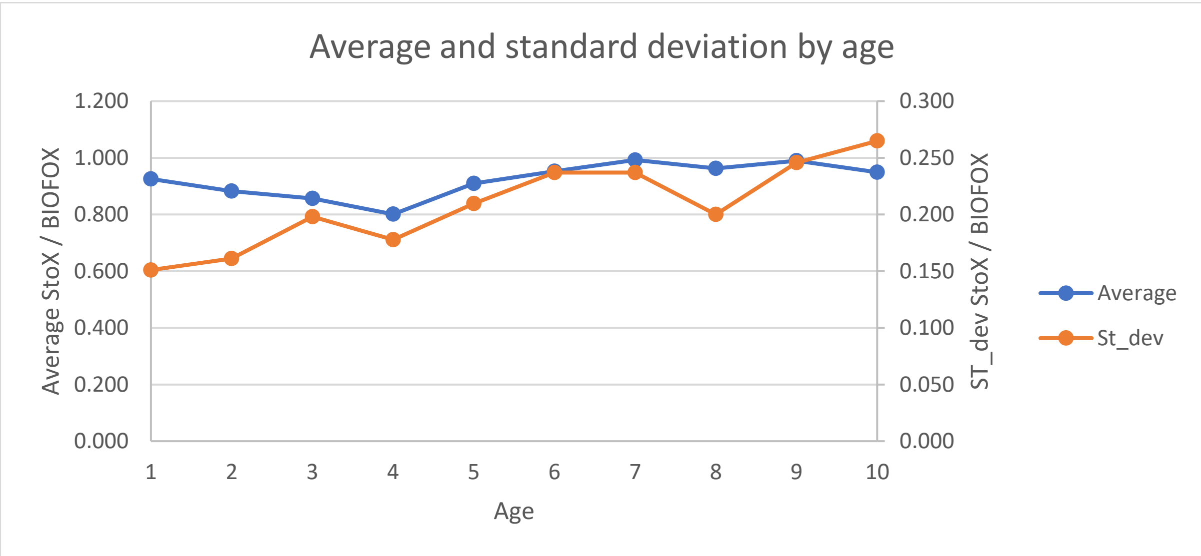


Fig 6. Average and standard deviation of proportions given in figure above by year (top) and age (bottom).

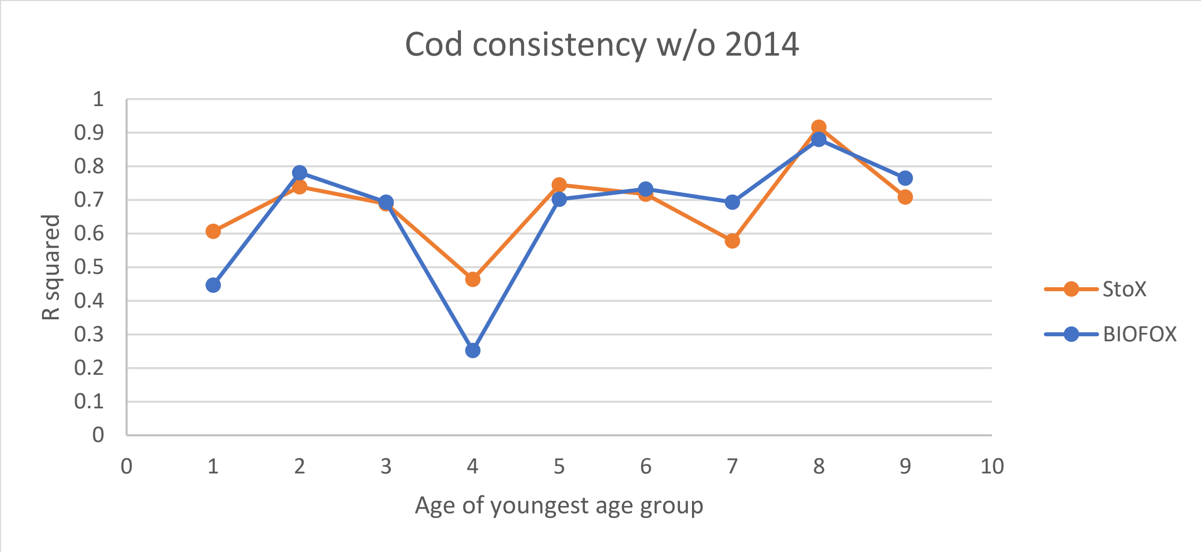


*Fig 7. Consistency between swept area indices for NEA cod from BESS of the year classes as age group a in survey year y and age group a+1 in survey year y+1. Consistency is given as R^2 (coefficient of determination) in linear regression of a+1 as a function of a for the year classes. Age of youngest age group denotes a. Indices for 2014 are not incl*uded and were excluded from the assessment due to po or survey coverage sue to ice coverage of large areas in the northern Barents Sea.

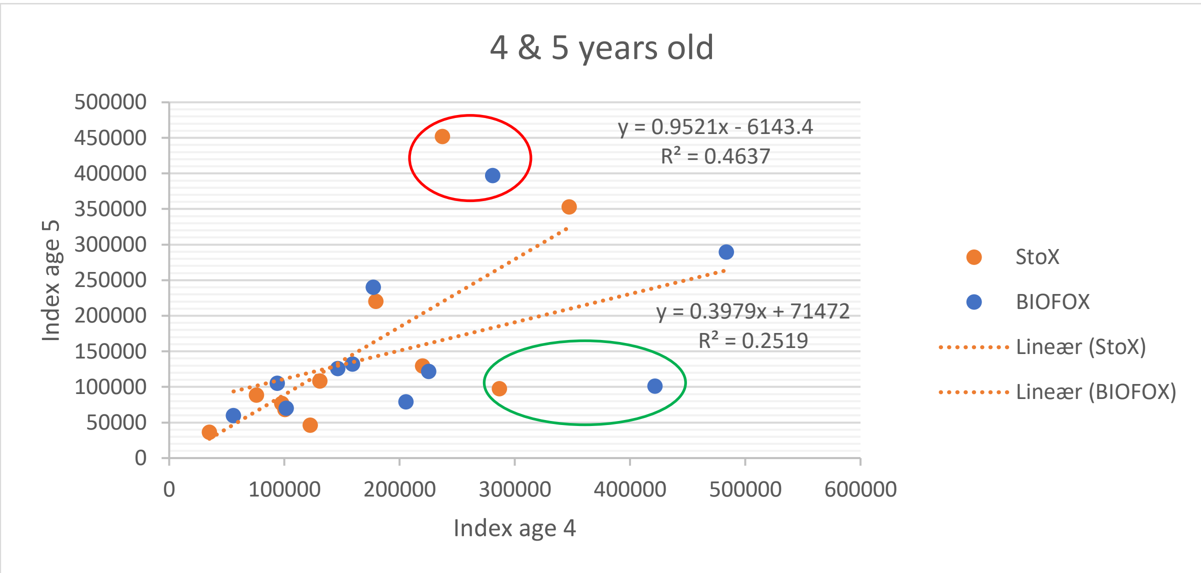


Fig 8. Consistency of 4-5 years old. The low consistency is due to extreme indices in 2009 (red circle) and 2004 (green circle).

Northeast arctic Haddock

Most years, StoX tended to give lower estimates than BIOFOX (Table 3). A notable exception was estimates from 2015 and 2017, were the numbers were much higher from StoX (Table 3, Figure 9, Figure 10). The reason for this is not known. Overall, StoX estimates were higher for the youngest (1-4) and oldest (9 to 10+) haddock, and BIOFOX estimates were higher for 5-8 year olds (Table 3, Figure 10).

Consistency was similar for the methods, except for a much lower consistency for StoX from 1 to 2 year olds and 7 to 8 and 8 to 9 year olds (Figure 11)

Table 3. Table of the swept area index estimates for Northeast arctic haddoc based on the BESS from StoX divided by those from BIOFOX (i.e. Stox/BIOFOX), by survey year and ages 1-10+. Green shading denotes proportions smaller than 0.80 (i.e. higher estimates from BIOFOX), and red shading denotes proportions larger than 1.20 (i.e. higher estimates from StoX).

Year	1	2	3	4	5	6	7	8	9	10+	Average	St_dev
2004	0.802	0.886	1.009	0.751	0.695	0.797	0.678	0.934	1.000	2.088	0.964	0.412
2005	0.337	0.275	0.305	0.525	0.168	0.330	0.266	0.246	0.221	0.328	0.300	0.095
2006	0.964	0.974	0.740	0.791	1.033	0.526	0.679	0.588	0.704	2.555	0.956	0.587
2007	0.886	0.539	0.400	0.519	0.400	0.412	0.240	0.404	3.814	0.550	0.816	1.067
2008	1.054	0.944	0.845	1.291	0.567	0.903	0.813	0.969	0.590	0.778	0.875	0.213
2009	1.253	0.716	0.885	0.948	0.486	0.258	0.284	0.207	1.180	2.940	0.916	0.806
2010	1.304	1.304	0.922	0.716	0.753	0.680	0.321	0.490	1.000	0.139	0.763	0.385
2011	0.770	1.186	0.568	1.691	0.552	0.747	0.582	0.414	0.434	0.667	0.761	0.394
2012	1.001	0.928	0.893	0.729	1.216	0.666	0.506	1.590	0.082	0.551	0.816	0.415
2013	1.113	1.048	0.775	0.916	1.270	0.731	0.838	0.759	0.725	1.471	0.965	0.255
2014	1.219	0.895	1.093	0.365	0.851	1.183	0.469	0.394	0.361	0.972	0.780	0.350
2015	2.494	2.635	1.775	2.047	1.804	2.860	2.253	2.254	2.343	2.543	2.301	0.352
2016	1.217	0.826	1.757	1.482	0.754	0.485	0.643	0.652	0.530	0.793	0.914	0.428
2017	2.536	3.320	2.411	2.814	2.684	2.728	4.223	1.610	2.445	2.338	2.711	0.684
Average	1.211	1.177	1.027	1.113	0.945	0.950	0.914	0.822	1.102	1.337		
St_dev	0.607	0.815	0.579	0.687	0.650	0.817	1.076	0.603	1.053	0.960		

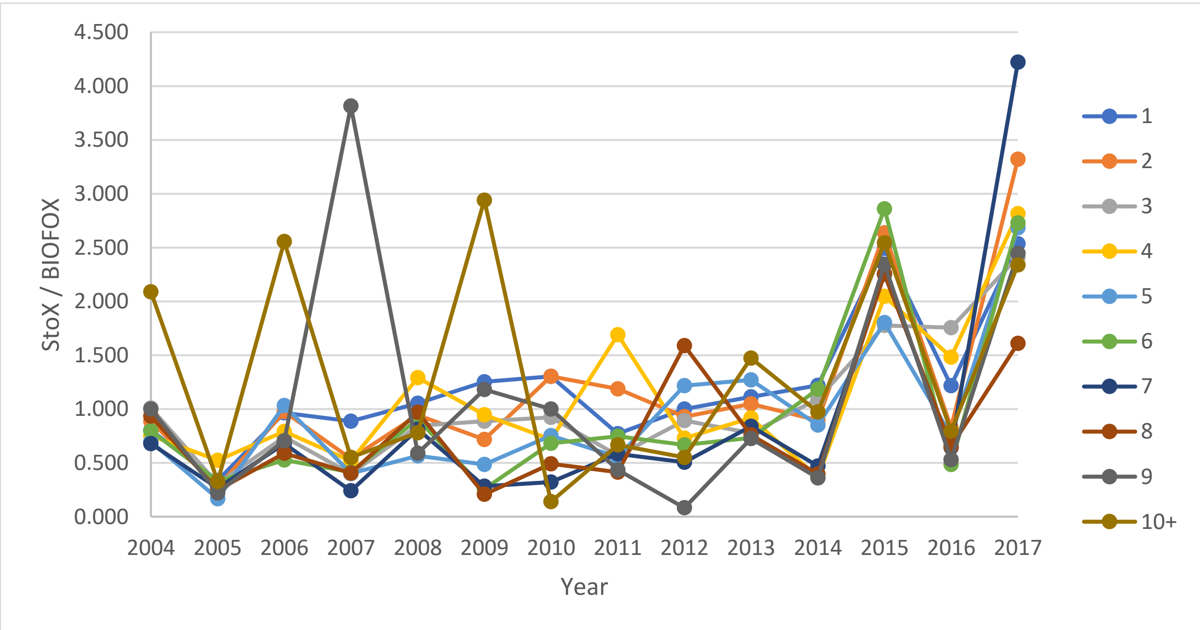
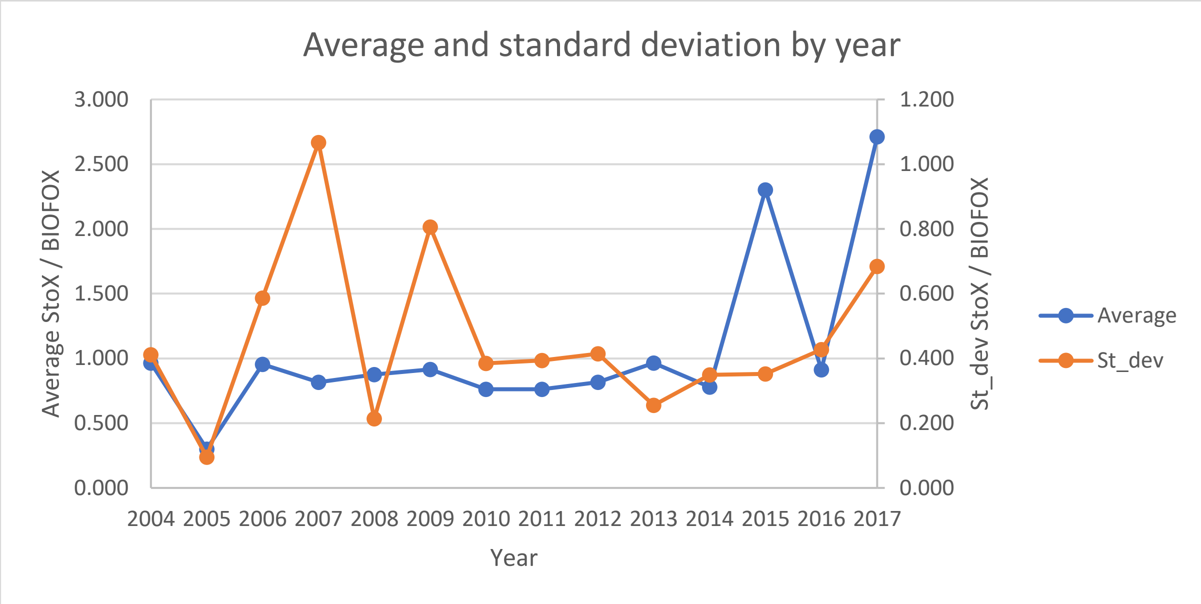


Fig 9. Swept area index estimates for Northeast arctic haddock based on the BESS from StoX divided by those from BIOFOX (i.e. Stox/BIOFOX), by survey year and ages 1-10+.



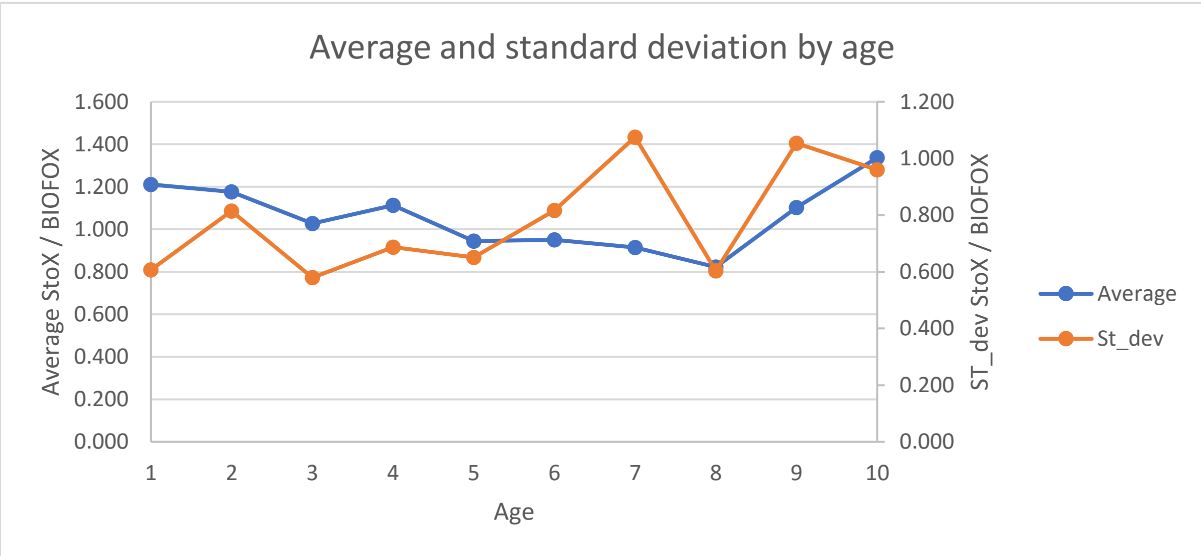


Fig 10. Average and standard deviation of proportions given in figure above by survey year(upper) and age (lower).

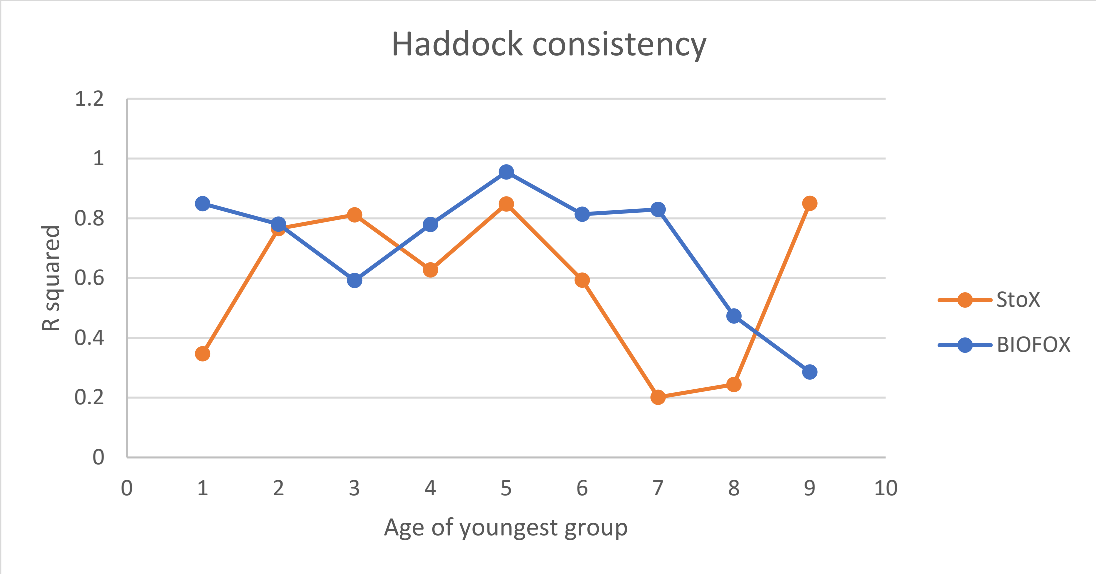


Fig 11. Consistency between swept area indices for NEA haddock from BESS of the year classes as age group a in survey year y and age group a+1 in survey year y+1. Consistency is given as R^2 (coefficient of determination) in linear regression of a+1 as a function of a for the year classes. Age of youngest age group denotes a.

Summary

1. There were greater differences between the StoX and BIOFOX abundance indices for haddock compared to cod.
2. Overall, consistency tended to be poorer for haddock than for cod, this was especially true using the StoX method.
3. The largest yearly differences between the methods when calculating indices for cod (2007 and 2014) could be explained by a high proportion of extra trawl stations included in BIOFOX (2007) and restricted survey coverage to the north (2014).
4. We cannot at the moment explain the largest largest differences for haddock (2015 and 2017 when StoX indices much higher than BIOFOX indices). The same applies to the low consistency for haddock using StoX for ages 7 to 8 and 8 to 9.

Given that the Russian winter survey is discontinued, there are now only two surveys available for assessment for haddock (three for cod which also has the Lofoton survey). Lately, a lot of haddock is found the Russian zone. It is vital that sufficient and consistent survey coverage is obtained every year, especially for haddock in the eastern Barents Sea, both at the winter survey and ecosystem survey.

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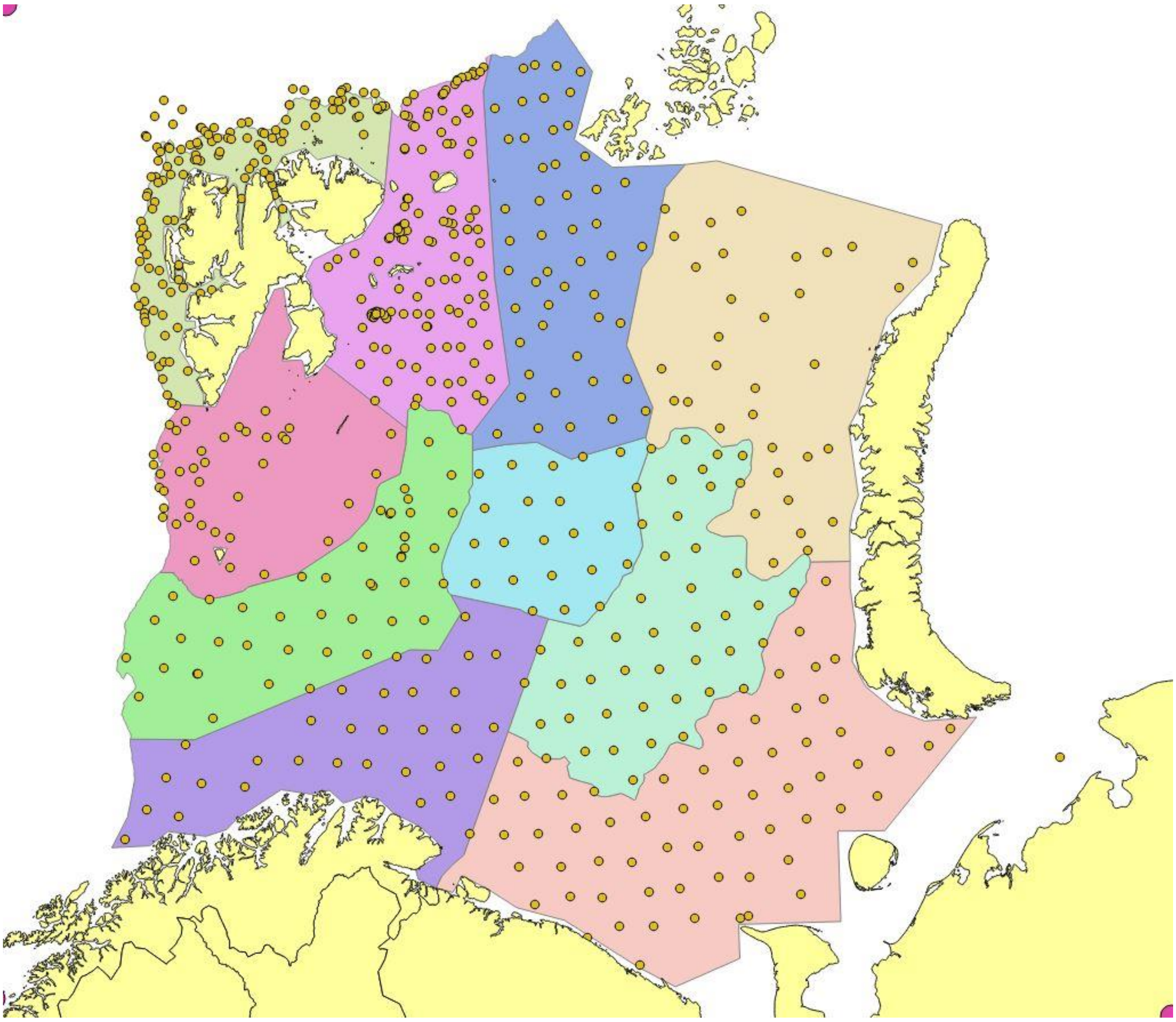
Prozorkevich D and Gjøsæter H. 2014. WD_02 cod_BESS_assessment.

StoX (2015) StoX: An open source approach to acoustic and swept area survey calculations. Institute of Marine Research, Bergen, Norway. URL: http://www.imr.no/stox

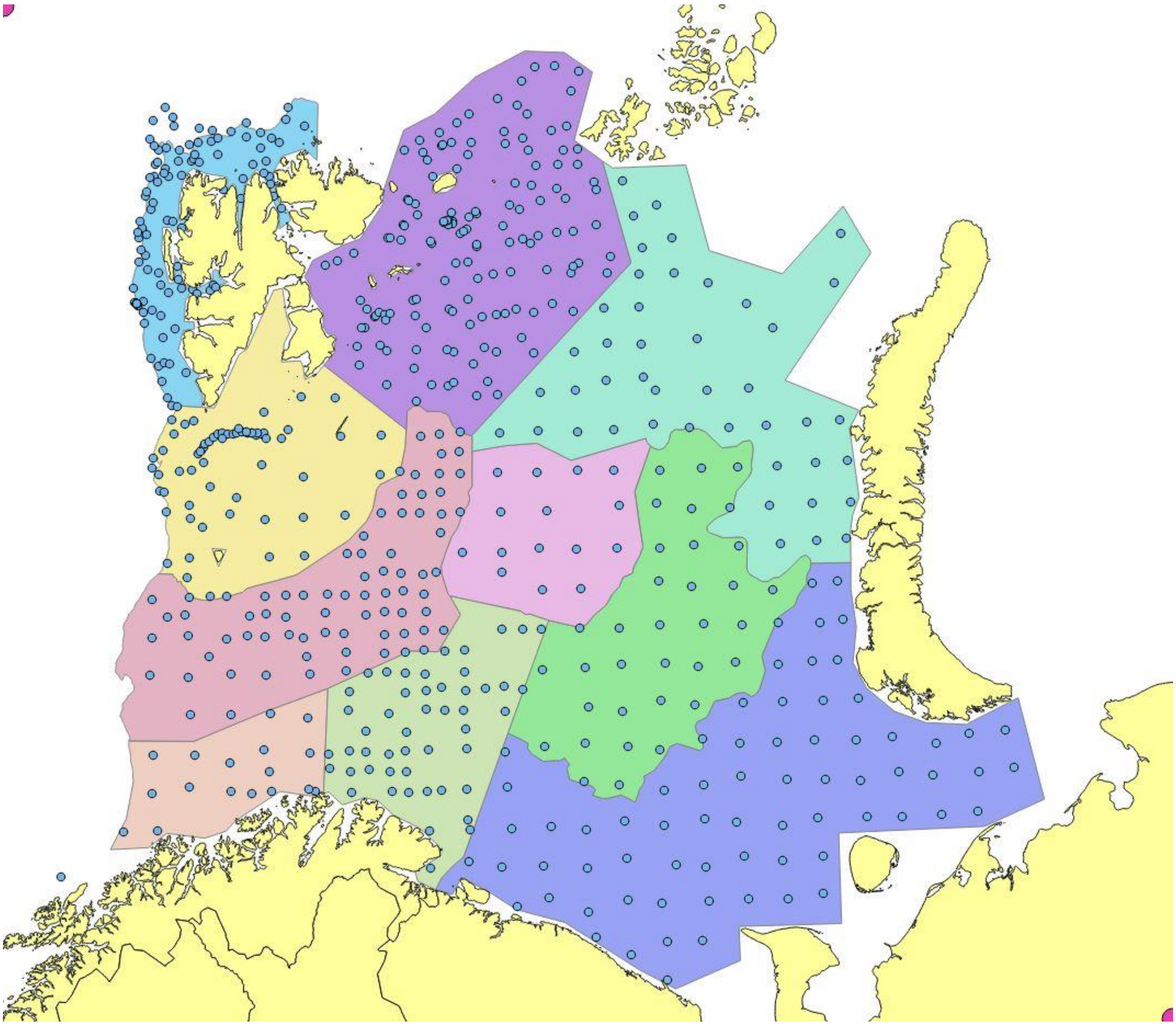
Appendix Table. Taken from appendix 6 to the Protocol from the March meeting 2019. Present overview of rigging and trawling procedure for the Campelen 1800 trawl used by IMR and PINRO

Parameters	Russian vessels	Norwegian vessels	Comments	Significant differences between PINRO and IMR	Significant differences from 2014
Trawl doors	Sparrow(1650 kg)	Thyborøn 7a(1800 kg)-all vessels		*	*IMR *PINRO
Distance between doors	47-55 m	50±2 m	PINRO and IMR use constraining rope		*PINRO
Warp/depth ratio	2.0- 4.5. Depends on depth.Depends on trawl master/cruise leader		2.5-4.5. Depends on depth. Norwegian vessels use information from roll sensors-trawl doors	*	
Bridle length	40m	40m			
Rigging of ground gear	Using 20 -25 cm rope between fishing line and groundgear	Rockhopper's -diameter 35 cm	PINRO rigging, reason to expect that center fishing line behind and close to seabed- resulting in higher catch rates of benthos etc. compared to Norwegian rigging	PINRO has not used tickler chain from 2015	*PINRO
Floats on headline	Total buoyancy 236 kg	Total buoyancy 261 kg±2 kg			
Floats on fishing line and extension			Norwegian vessels, Tromsø rigging(used on some few stations in the Svalbard area, soft bottom): Floats on fishing line(bouncy 130kg±2 kg) and on the extension(bouncy 52 kg±2 kg)	*	*IMR
Monitoring gear perfomance	Acoustic trawl sensors: door spread, roll and pitch of doors, speed, vertical opening	Acoustic trawl sensors: door spread, roll and pitch of doors, speed, vertical opening			*PINRO
Trawl design	Equal	Equal			
Trawl opening	Approx. 4 m	3.8-4.2 m			
Trawling procedure	Trawling duration 15 min after bottom contact	Trawling duration 15 min after bottom contact			
Speed	3 kn(speed over ground, GPS)	3 kn(through water)		*	

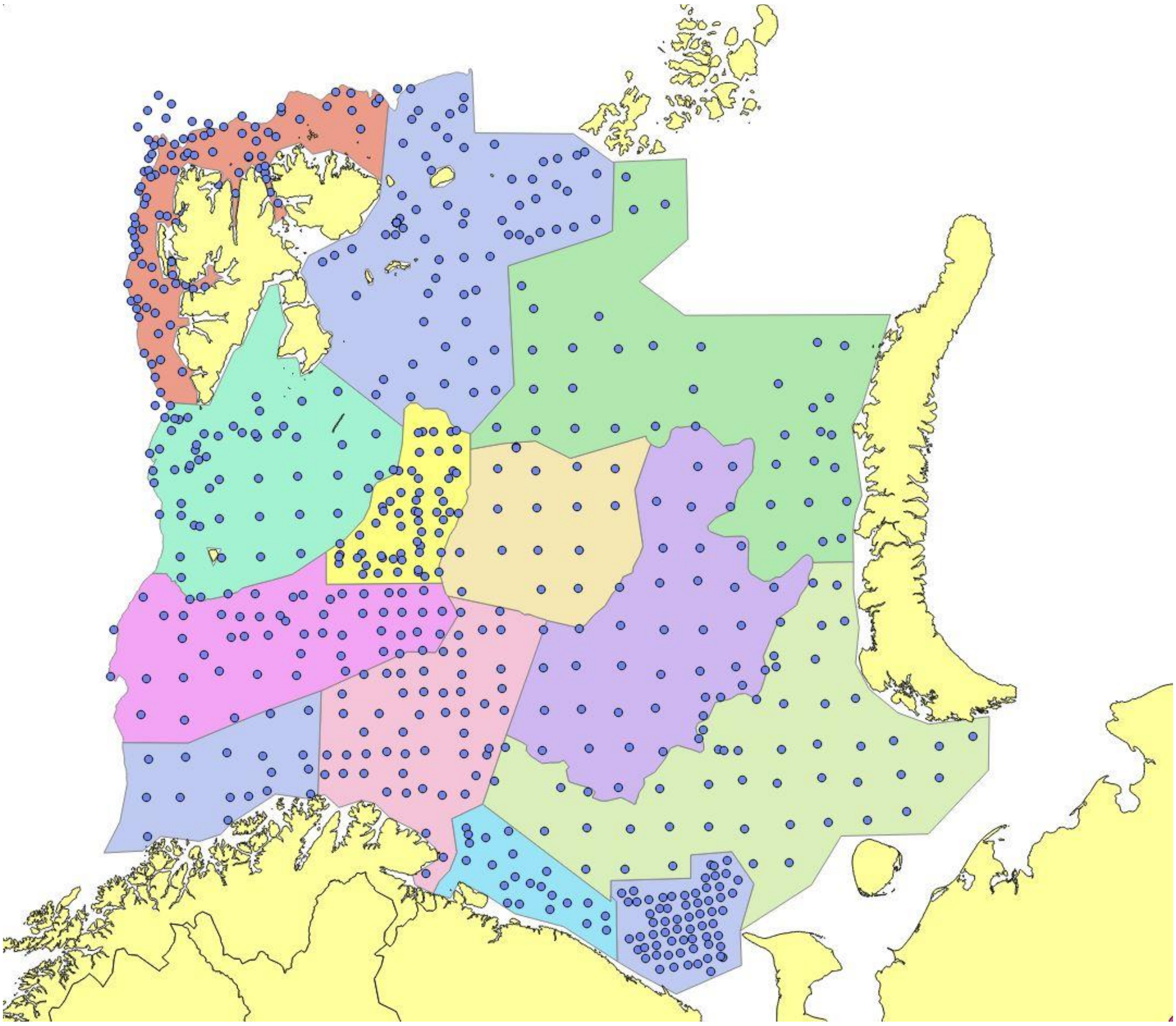
Appendix Figure. Strata systems (modified from figure 4) used in StoX and stations set out at predefined positions all years 2004-2018.



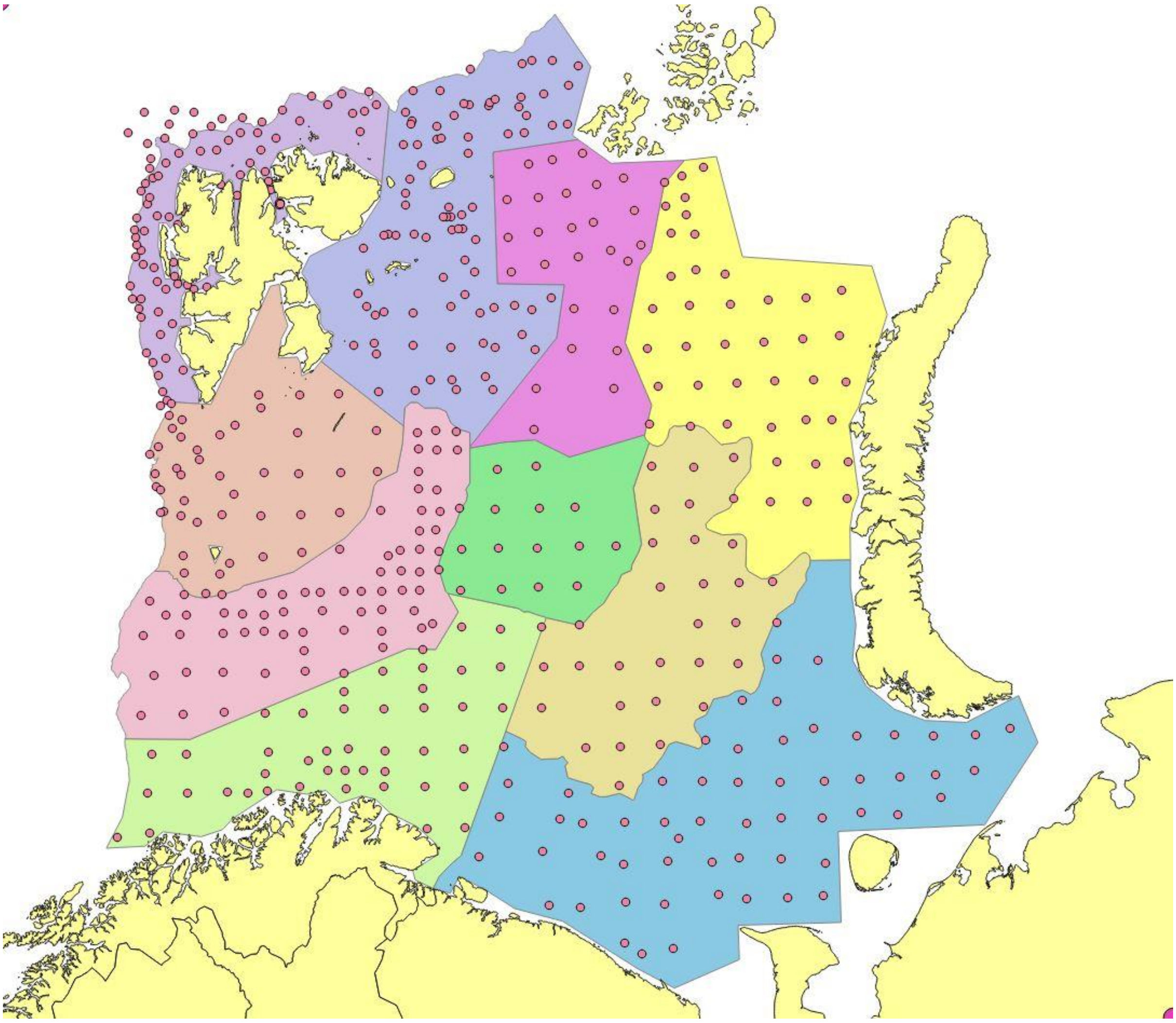
2004. Stations grid set out according to 0-group survey design with Mercator projection. Approximately 35 nautical mile grid station distance. Denser grid was due to Greenland halibut juvenile investigation in Storfjordrenna, and west and east of Svalbard, and due to this the “Great Bank” stratum is split to account for the denser sampling in the western part of this stratum. The “South East” stratum is reduced due to limited sampling coverage.



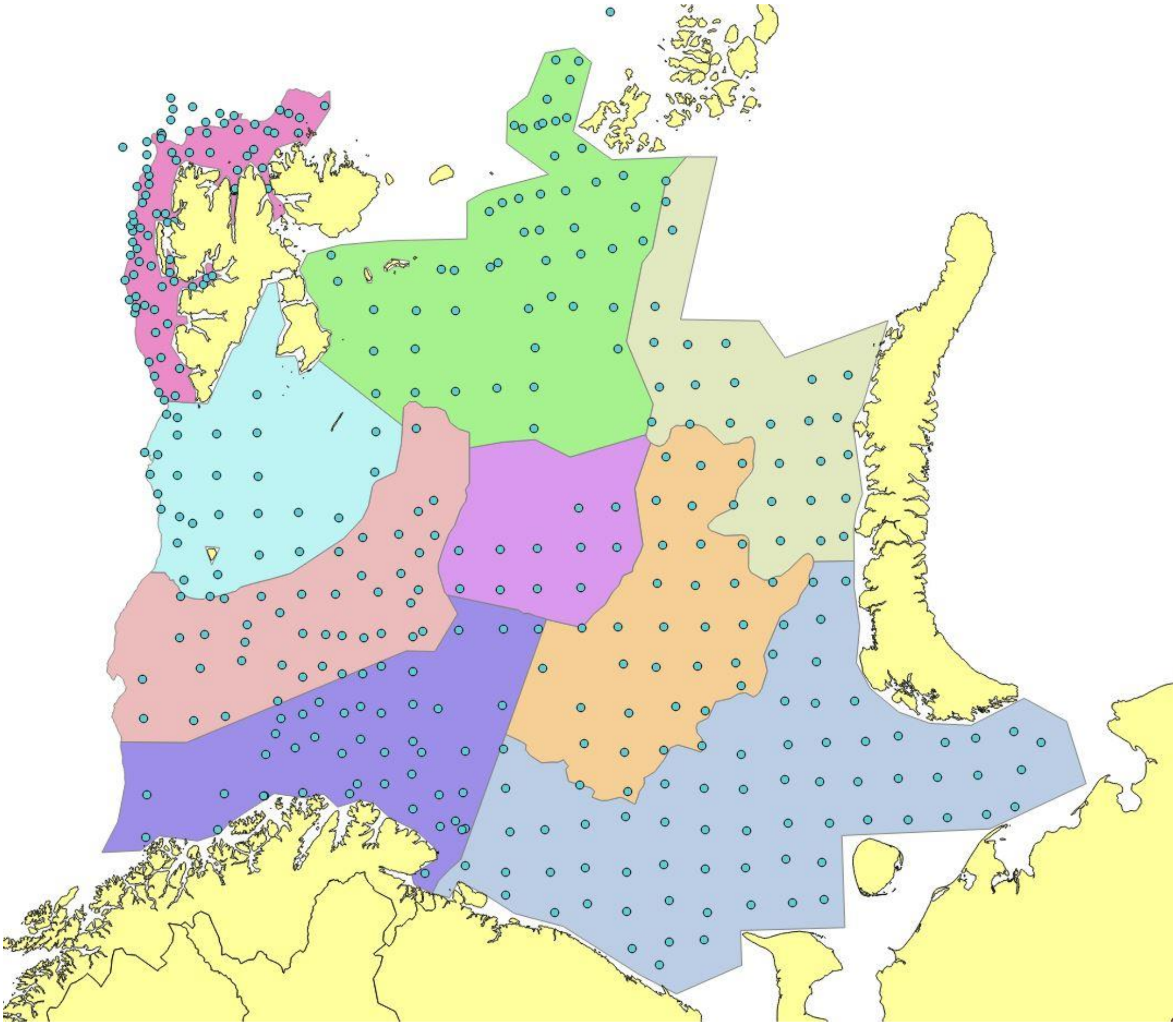
2005. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Denser grid was due to Greenland halibut juvenile investigation in Storfjordrenna, and west and east of Svalbard, and shrimp investigations in the Bear Island trough. Due to this, the “Great Bank” stratum is split to account for the denser sampling in the western part of this stratum, and the eastern part of this stratum is added to the “North East” stratum to obtain sufficient sample size. The “South West” stratum was split in two for the same reasons. Northern and eastern edges was reduced due to limited sampling coverage.



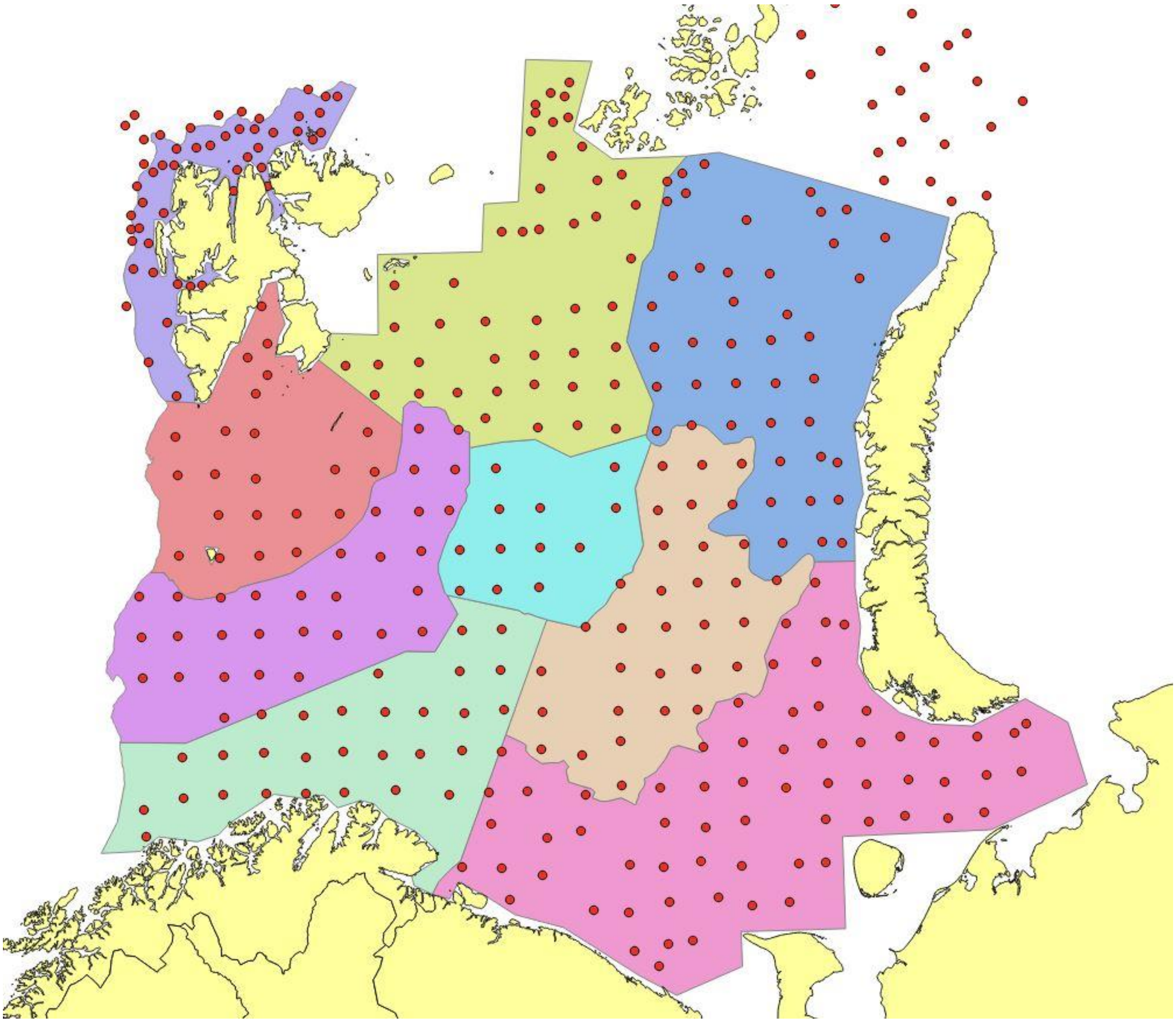
2006. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Denser grid was due to Greenland halibut juvenile investigation in Storfjordrenna, and west and east of Svalbard and shrimp investigations in the Bear Island trough. The “Great Bank”, “Bear Island Through”, “South East” (flatfish investigations) and “South West strata were modified to account for denser sampling. Northern and eastern edges was reduced due to limited sampling coverage.



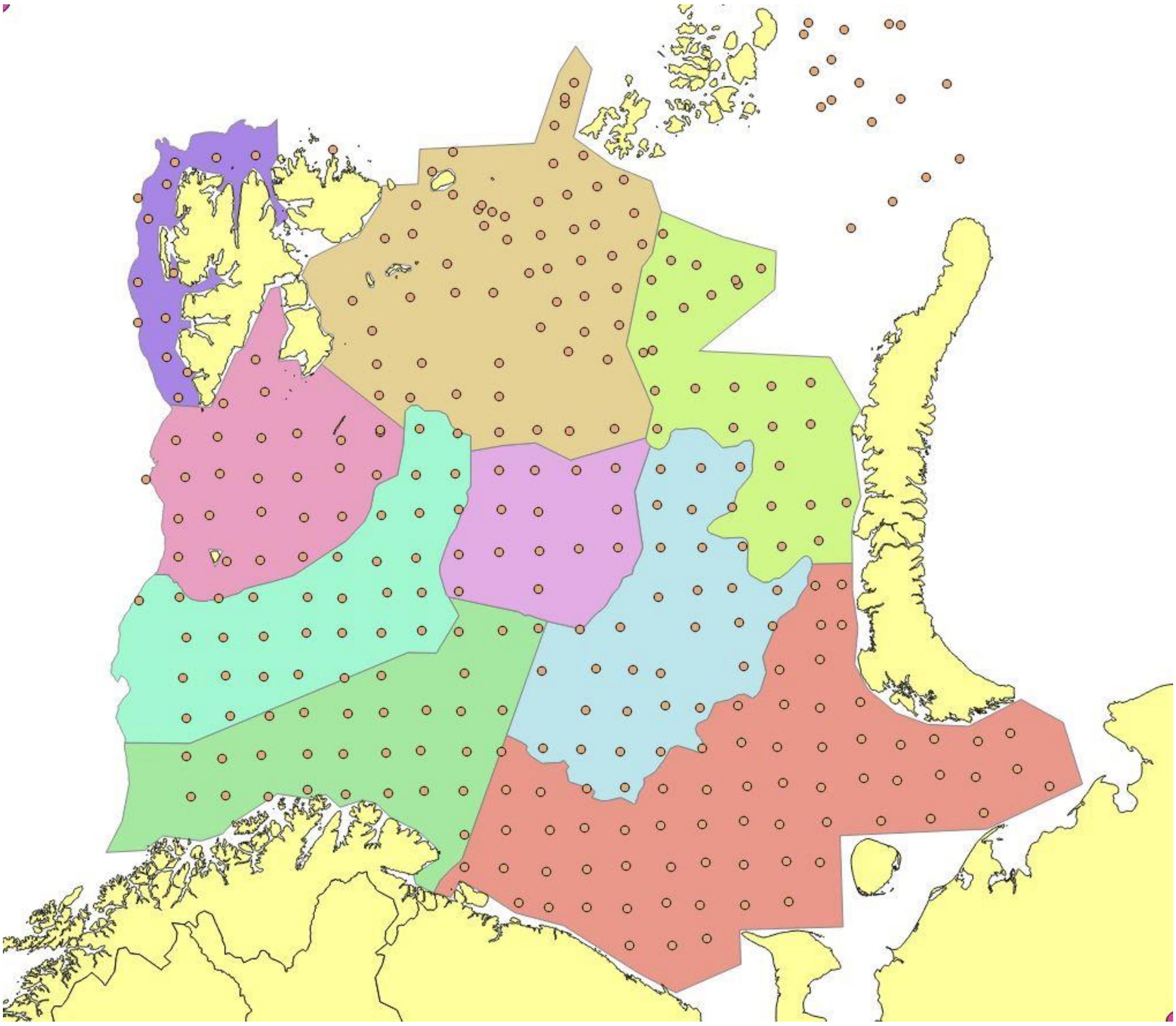
2007. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Denser grid was due to Greenland halibut juvenile investigation in Storfjordrenna, and west and east of Svalbard, and shrimp investigations in the Bear Island trough. The “Great Bank” strata was spli to account for denser sampling. North-eastern and eastern edges was reduced due to limited sampling coverage.



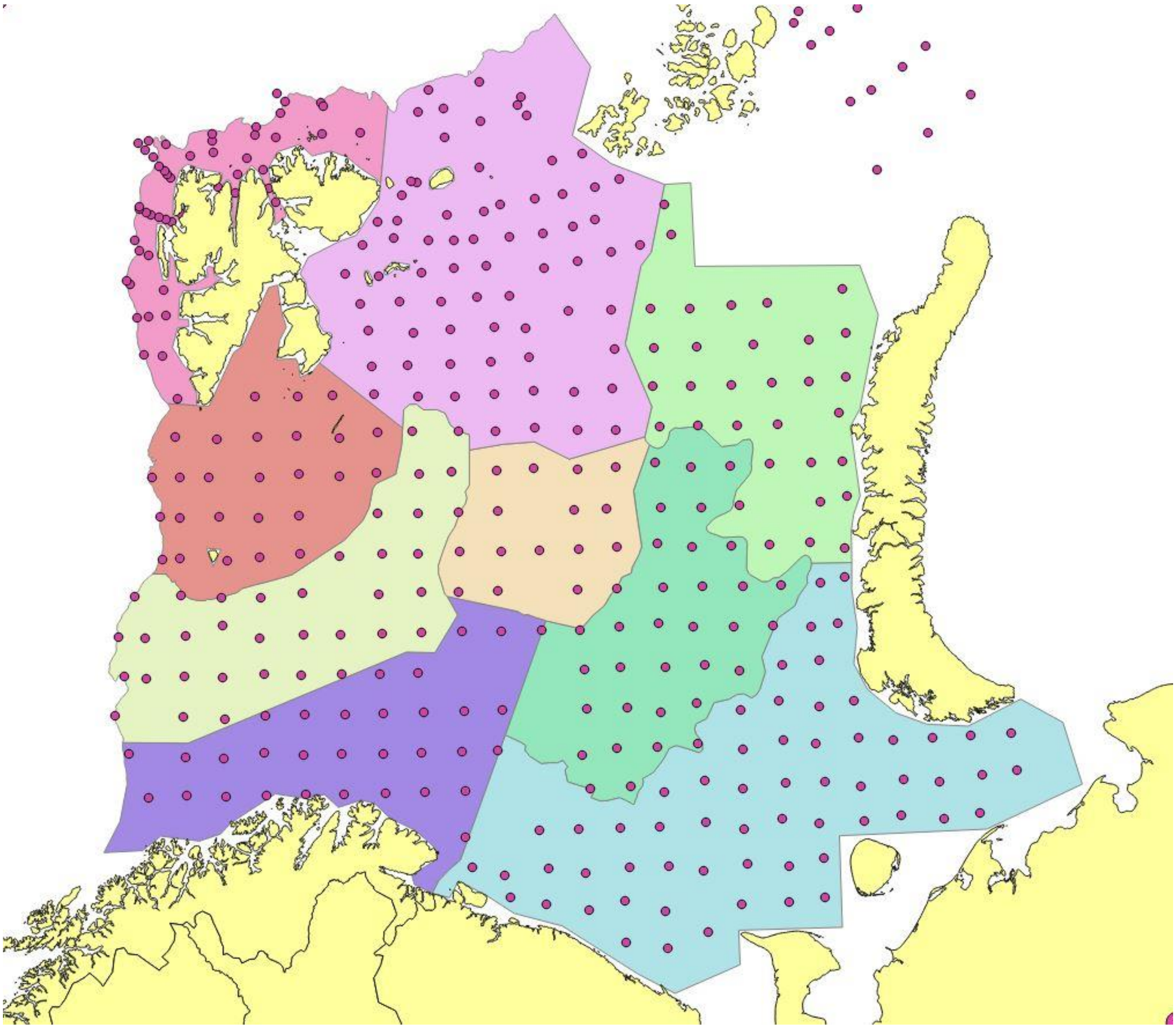
2008. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Denser grid was due to Greenland halibut juvenile investigation in Storfjordrenna, and west and east of Svalbard and shrimp investigations in the Bear Island trough. The sampling effort was regarded as fairly regular compared to earlier years, so the only modification was reduction of the northern edges due to limited survey coverage. This year suffered a strong reduction in Norwegian survey time due to budget cuts.



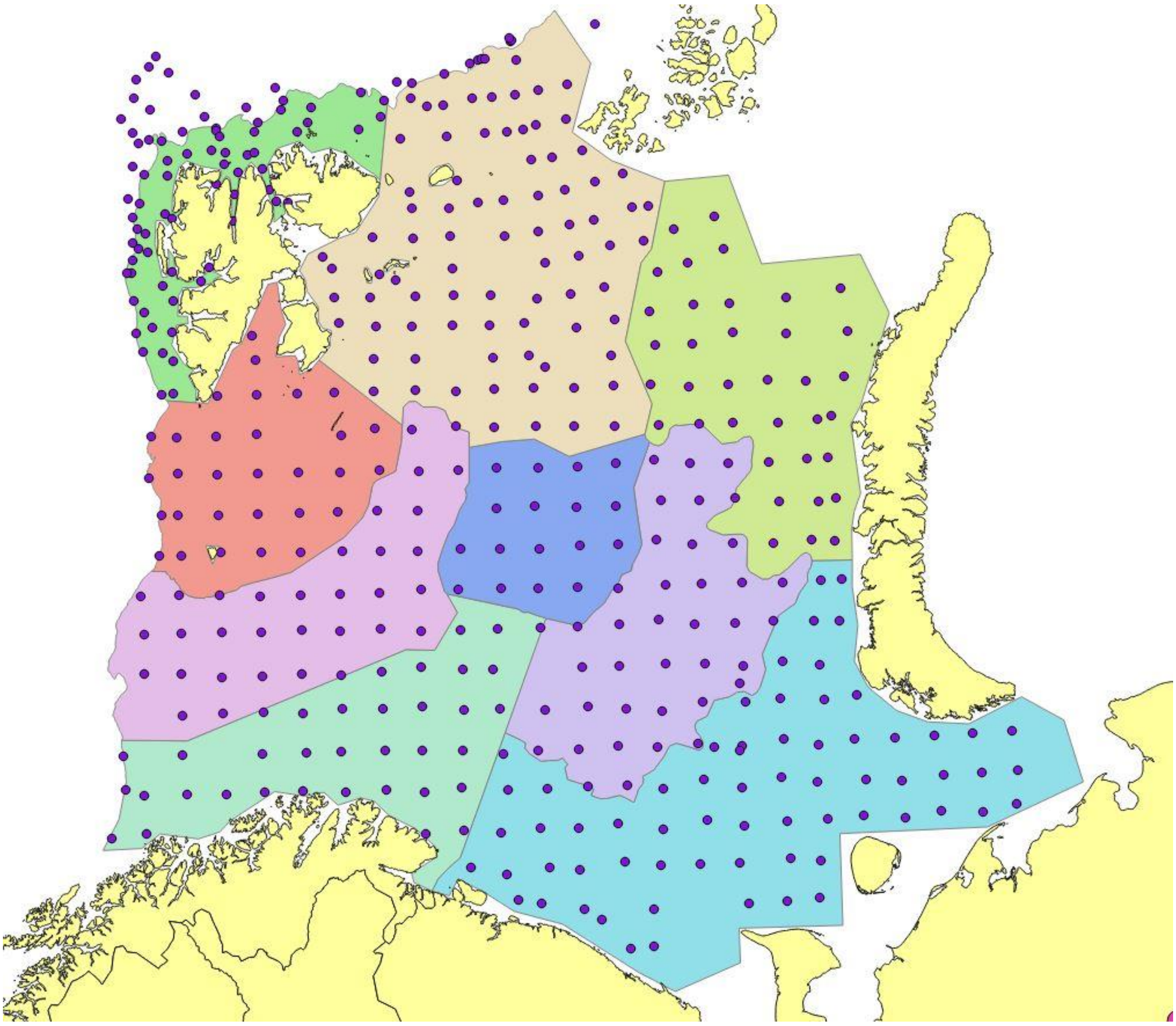
2009. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Denser grid west of Svalbard due to steep depth gradients. Reduction of the northern edges due to limited survey coverage. Russian investigations in Kara Sea (North east) not included in StoX calculations.



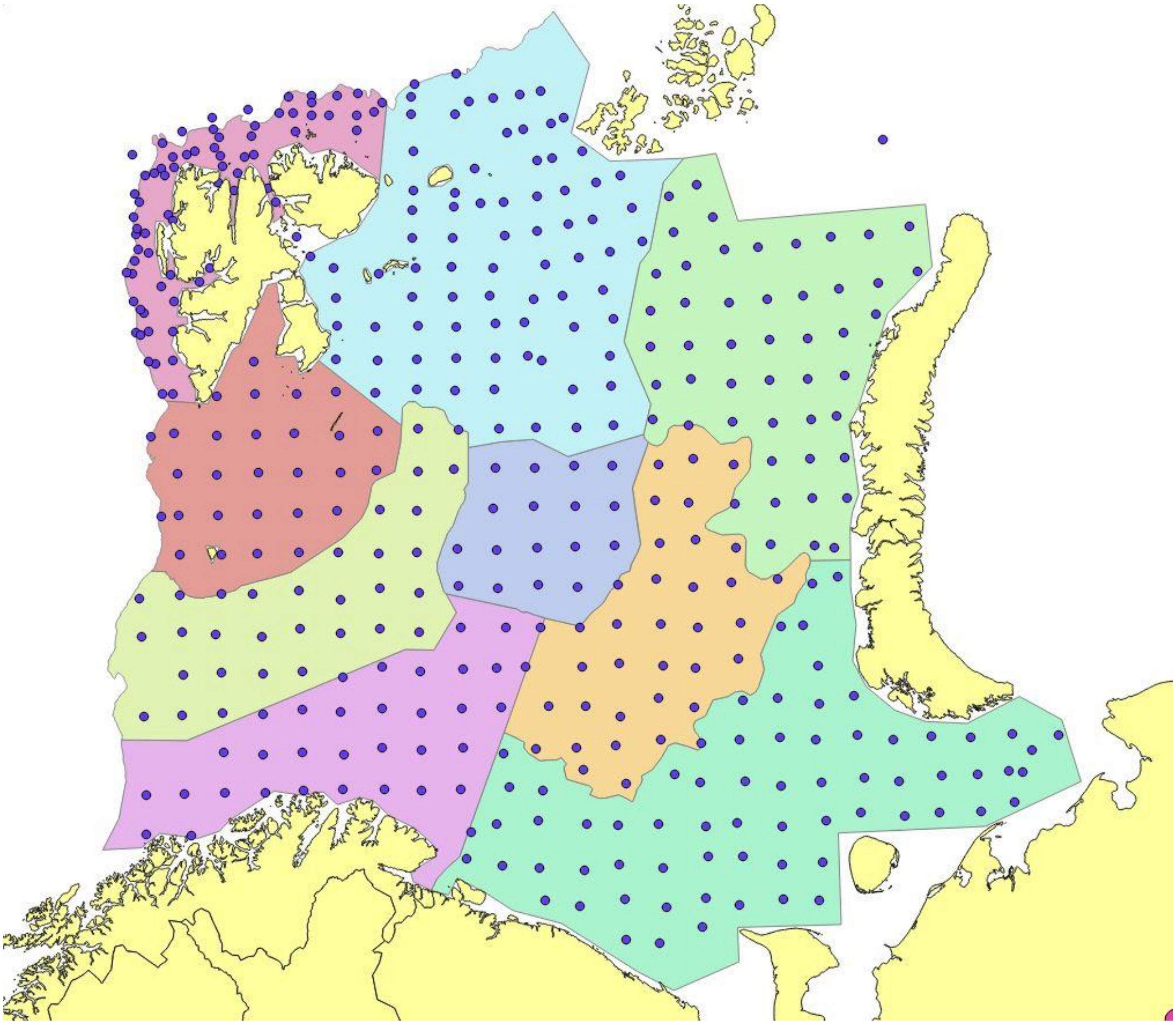
2010. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Reduction of the northern edges due to limited survey coverage. Russian investigations in Kara Sea (North east) not included in StoX calculations.



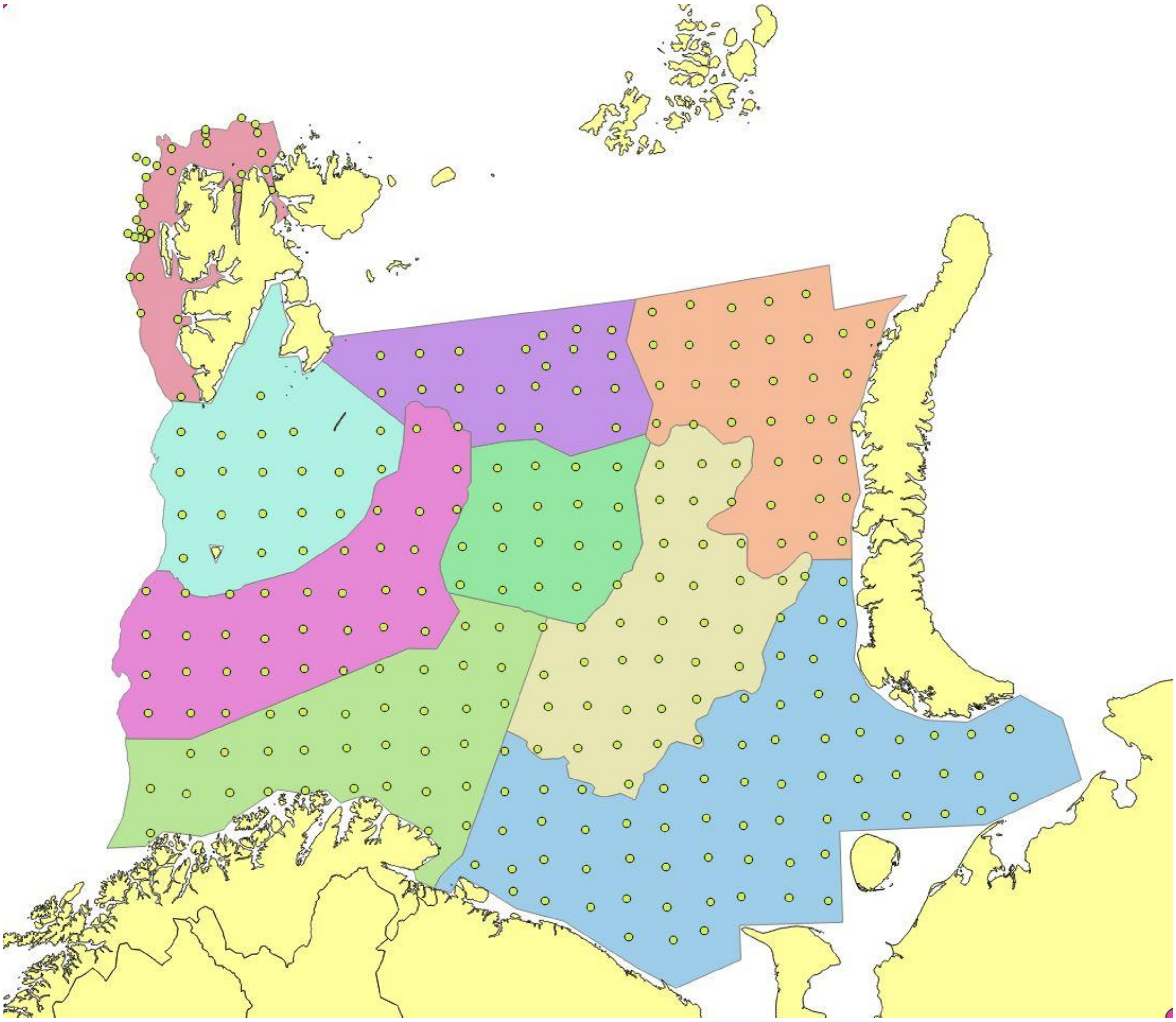
2011. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance. Denser grid west of Svalbard due to steep depth gradients. Reduction of the northern edges due to limited survey coverage. Russian investigations in Kara Sea (North east) not included in StoX calculations.



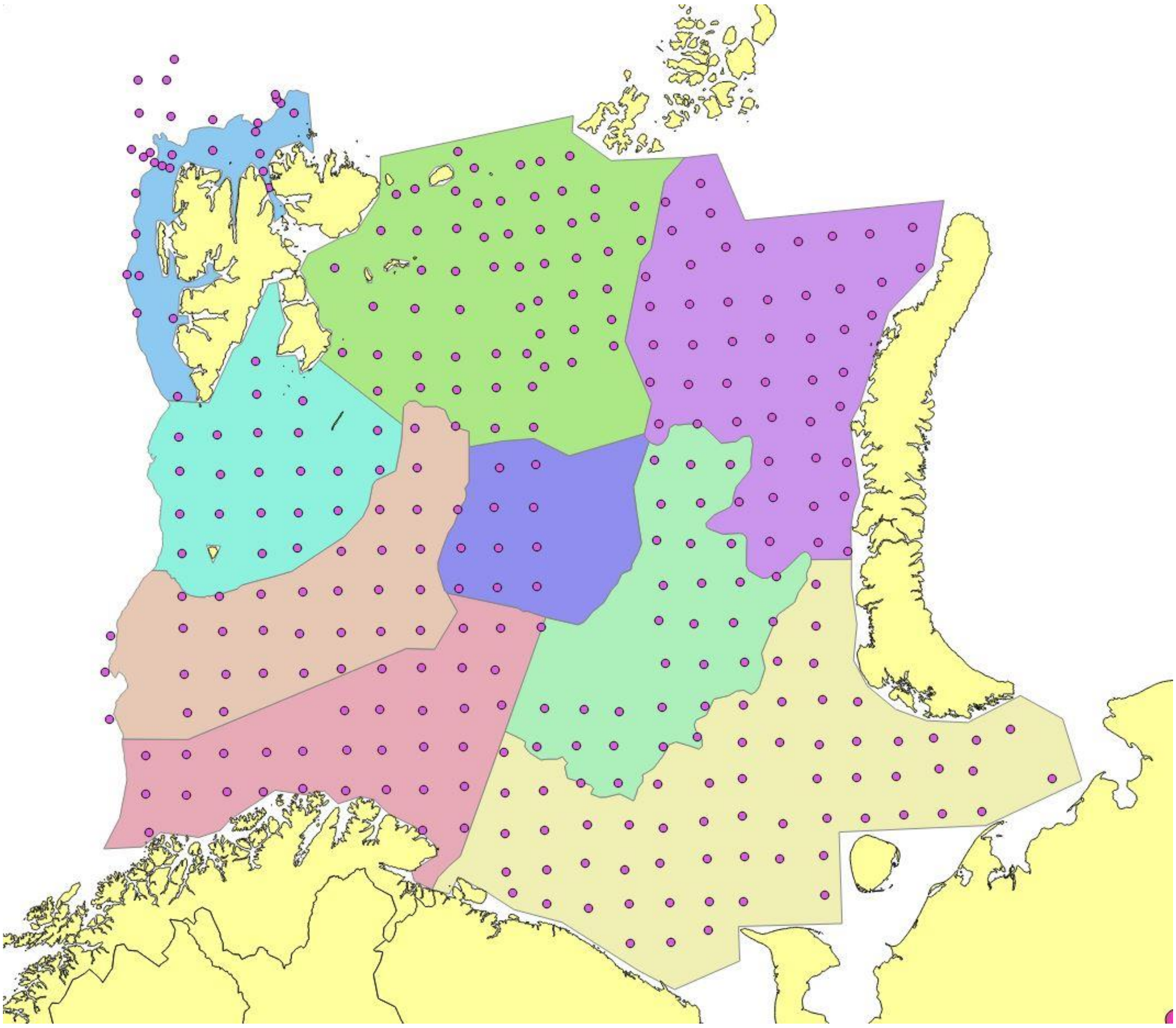
2012. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance, except around Svalbard. Denser grid west of Svalbard due to steep depth gradients. Reduction of the north-eastern edges due to limited survey coverage. Russian investigations in Kara Sea (North east) not included in StoX calculations.



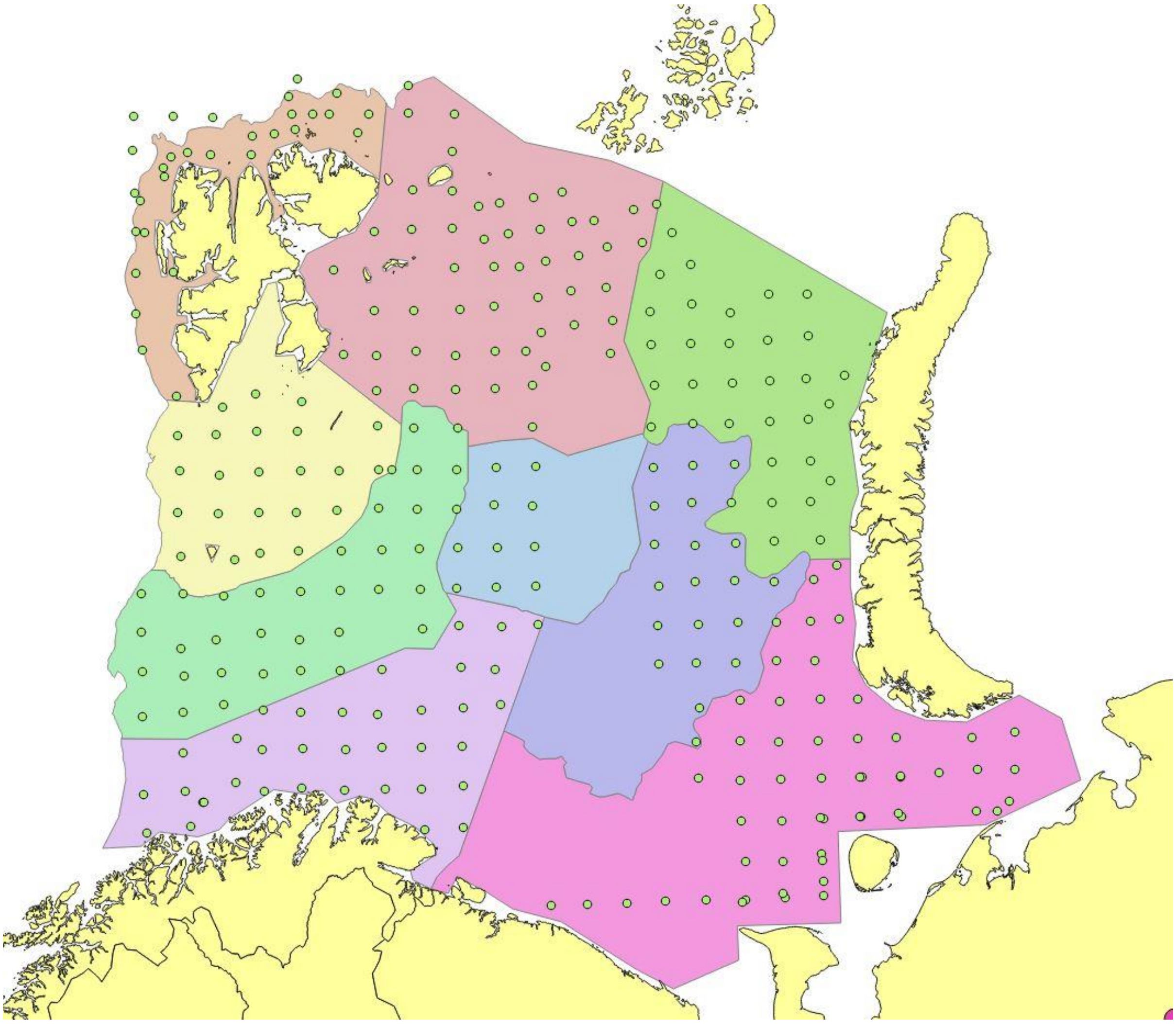
2013. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance, except around Svalbard. Denser grid west of Svalbard due to steep depth gradients. Reduction of the north-eastern edges due to limited survey coverage.



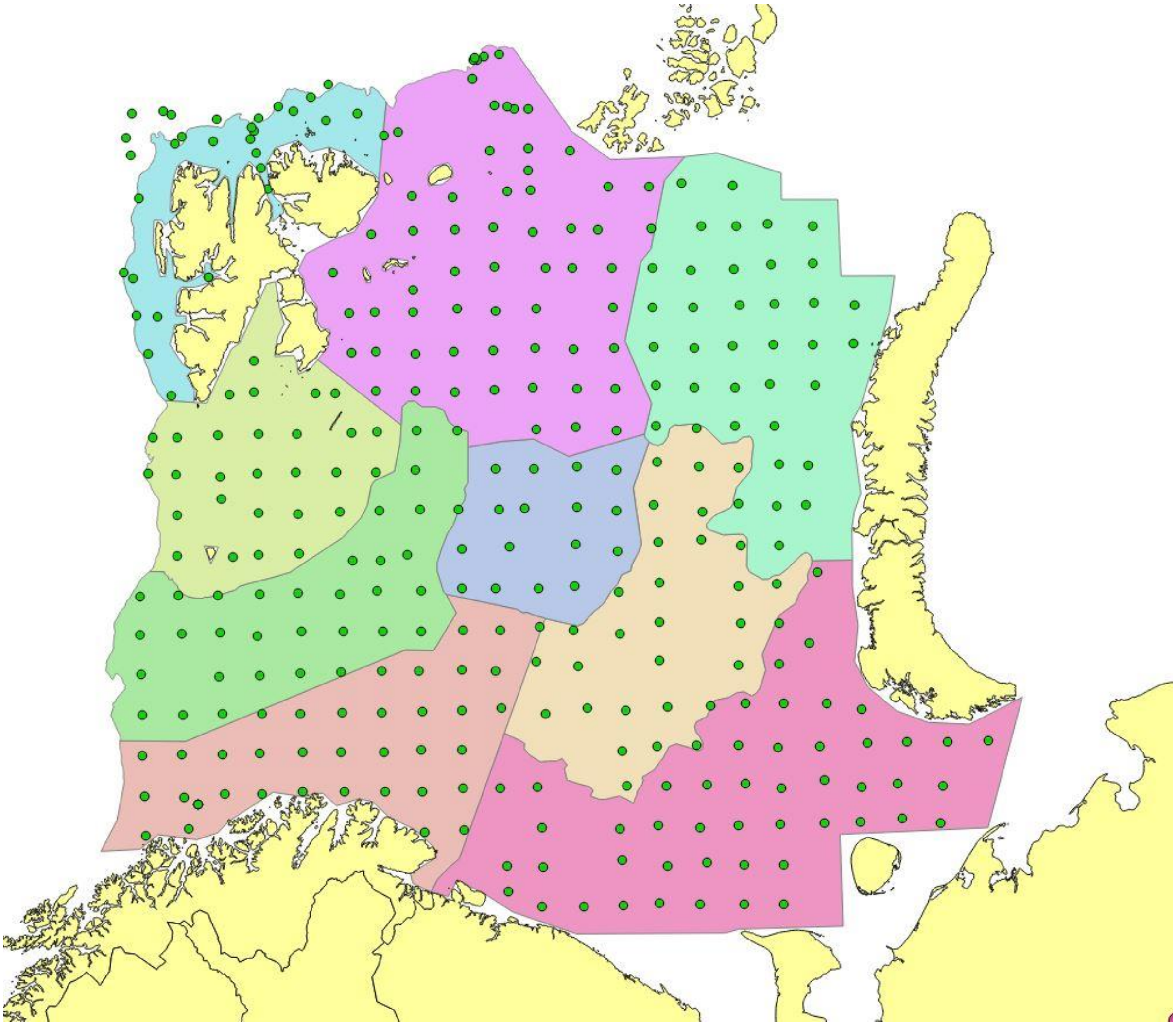
2014. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance, except around Svalbard. Denser grid west of Svalbard due to steep depth gradients. Reduction of the northern edges due to limited survey coverage. NB! Ice restrictions in the north – this year the survey indices were not used in the cod assessment.



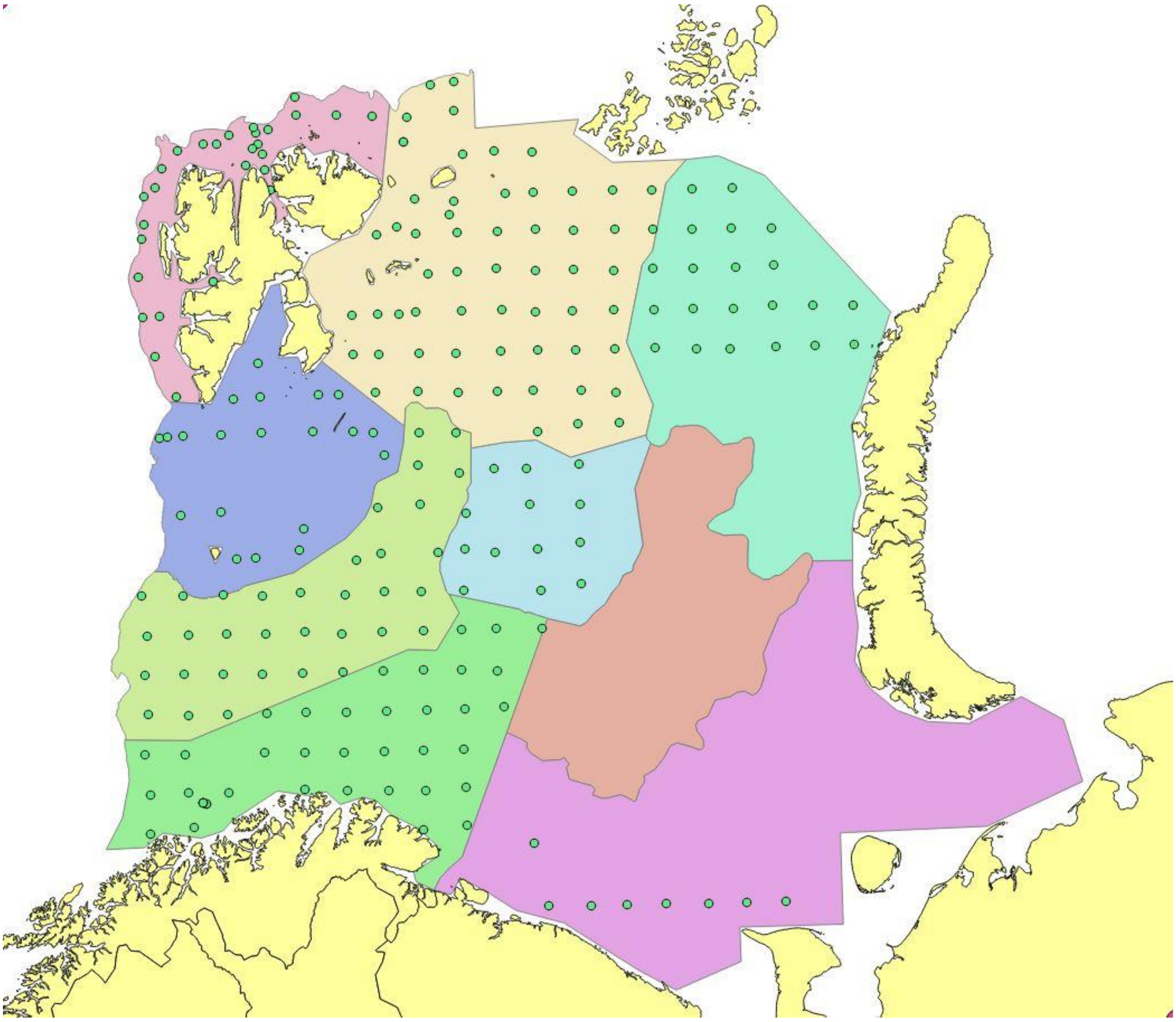
2015 Stations set out in a modified UTM with approximately 35 nautical mile grid station distance, except around Svalbard. Denser grid west of Svalbard due to steep depth gradients. No coverage in the loop hole due to unclear jurisdictions. Reduction of the northern edges due to limited survey coverage.



2016. Stations set out in a modified UTM with approximately 35 nautical mile grid station distance, except around Svalbard. Denser grid west of Svalbard due to steep depth gradients. No coverage in loop hole due to unclear jurisdictions. Russian military exercise limited survey access to the south eastern BS. Reduction of the north-eastern edges due to limited survey coverage.



2017. Stations set out with approximately 35 nautical mile grid station distance, according to Albers equal-area projection (also called: Albers Equal-Area Conic Projection) with the following parameter settings: Centre latitude: 75 N, Centre longitude: 30 E, 1st standard Latitude: 70 N, 2nd standard latitude: 80 N. Modified grid in the western part to avoid deeper stations than 500 m, and around Svalbard due to restrictions in natural reserves. Some additional stations in “Spitsbergen Bank”, “Svalbard” and “Great Bank” strata to cover Greenland halibut. Slight reduction of the north-eastern and south-eastern edges due to limited survey coverage.



2018. Stations set out with approximately 35 nautical mile grid station distance, according to Albers equal-area projection (also called: Albers Equal-Area Conic Projection) with the following parameter settings: Centre latitude: 75 N, Centre longitude: 30 E, 1st standard Latitude: 70 N, 2nd standard latitude: 80 N. Modified grid in the western part to avoid deeper stations than 500 m, and around Svalbard due to restrictions in natural reserves. Some additional stations in “Spitsbergen Bank”, “Svalbard” and “Great Bank” strata to cover Greenland halibut. Slight reduction of the north-eastern edges due to limited survey coverage. Lack of coverage in east was due technical problems with the Russian vessel. No attempt was done to calculate survey indices in 2018, due to this severe coverage problem.

Fish investigations in the Barents Sea winter 2019

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CONTENTS

Preface

Annual catch quotas and other regulations of the Barents Sea fisheries are set through negotiations between Norway and Russia. Assessment of the state of the stocks and quota advices are given by the International Council for the Exploration of the Sea (ICES). Their work is based on survey results and international landings statistics. The results from the demersal fish winter surveys in the Barents Sea are an important source of information for the annual stock assessment.

The development of the survey started in the early 1970s and focused on acoustic measurements of cod and haddock. Since 1981 it has been designed to produce both acoustic and swept area estimates of fish abundance. Some development has taken place since then, both in area coverage and in methodology. The development is described in detail by Jakobsen *et al*. (1997), Johannesen *et al*. (2009) and Appendix 2. At present the survey provides the main data input for several projects at the Institute of Marine Research, Bergen:

- monitoring abundance of the Barents Sea demersal fish stocks
- mapping fish distribution in relation to climate and prey abundance
- monitoring food consumption and growth
- estimating predation mortality caused by cod

This report presents the main results from the surveys in January-March 2019. The surveys were performed with the Norwegian research vessels “Helmer Hanssen” and “Johan Hjort” and Russian research vessel “Vilnyus”. Annual survey reports since 1981 are listed in Appendix 1.

1 Introduction

The Institute of Marine Research (IMR), Bergen, has performed acoustic measurements of demersal fish in the Barents Sea since 1976. Since 1981 a bottom trawl survey has been combined with the acoustic survey. Typical effort of the combined survey has been 10-14 vessel-weeks, and about 350 bottom trawl hauls have been made each year. Most years three vessels have participated from about 1 February to 15 March.

The purpose of the investigations is presently:

- Obtain acoustic abundance indices by length and age for cod and haddock
- Obtain swept area abundance indices by length (and age) for cod, haddock, redfish, Greenland halibut and blue whiting
- Map the geographical distribution of those fish stocks
- Estimate length, weight and maturity at age for cod and haddock
- Collect stomach samples from cod, for estimating predation by cod. Results of such analyses for the period 1984-2017 are given in the 2017 survey report.
- Map the distribution of maturing/prespawning capelin

Data and results from the survey are used both for stock assessments in the ICES Arctic Fisheries Working Group AFWG and by several research projects at IMR and PINRO.

From 1981 to 1992 the survey area was fixed (strata 1-12, main areas ABCD in Fig. 2.1). Due to warmer climate and increasing stock size in the early 1990s, the cod distribution area increased. Consequently, in 1993 and further in 1994 the survey area was extended to the north and east (strata 13-23, main areas D'ES in Fig. 2.1) to obtain a more complete coverage of the younger age groups of cod, and since then the survey has aimed at covering the whole cod distribution area in open water. For the same reason, the survey area was extended further northwards in the western part in 2014 (strata 24-26 in Fig. 2.1). In many years since 1997 Norwegian research vessels have had limited access to the Russian EEZ, and in 1997, 1998, 2007 and 2016 the vessels were not allowed to work in the Russian EEZ. In 1999 a rather unusually wide ice-extension partly limited the coverage. Since 2000, except in 2006, 2007 and 2017, Russian research vessels have participated in the survey and the coverage has been better, but for various reasons not complete in most years. In 2008-2015 Norwegian vessels had access to major parts of the Russian EEZ. The coverage was more complete in these years, especially in 2008, 2011 and 2014. Table 3.6 summarizes degree of coverage and main reasons for incomplete coverage in the Barents Sea winter 1981-2019.

2 Methods

2.1 Acoustic measurements

The method is explained by Dalen and Smedstad (1979, 1983), Dalen and Nakken (1983), MacLennan and Simmonds (1991) and Jakobsen et al. (1997). The acoustic equipment has been continuously improved. Since the early 1990s Simrad EK500 echo sounder and Bergen Echo Integrator (BEI, Knudsen 1990) were used. The Simrad EK60 echo sounder replaced the EK500 on R/V “Johan Hjort” in 2005 and on R/V “Helmer Hanssen” since the 2008 survey. The latest R/V “G.O. Sars” has used EK60 since it replaced R/V “Sarsen” (former R/V “G.O. Sars”) in 2004. The Large Scale Survey System (LSSS, Korneliussen *et al*. 2016) replaced BEI on R/V “G.O. Sars” and R/V “Johan Hjort” in 2007 and on R/V “Helmer Hanssen” since the 2008 survey. On the Russian vessels EK 500 was used from 2000 to 2004 and ER60 since 2005. The new Simrad EK80 echo sounder has been used on R/V “G.O. Sars” since 2017 and on R/V “Johan Hjort” since 2018.

In the mid-1990s the echo sounder transducers were moved from the hull to a retractable centreboard, on R/V “Johan Hjort” since the 1994 survey, on R/V “Sarsen” (former R/V “G.O. Sars”) since 1997, on the latest R/V “G.O. Sars in 2004 and on R/V “Helmer Hanssen” since the 2008 survey. This latter change has largely reduced the signal loss due to air bubbles in the close to surface layer. None of the Russian vessels have retractable centreboards.

On the Norwegian vessels, acoustic backscattering values (s_A = nautical area scattering coefficient NASC) are stored at high resolution in LSSS. After scrutinizing and allocating the values to species or species groups, the values are stored with 10 m vertical resolution and 1 nautical mile (NM) horizontal resolution. The procedure for allocation by species is based on:

- composition in trawl catches (pelagic and demersal hauls)
- the appearance of the echo recordings
- inspection of target strength distributions
- inspection of target frequency responses

For each trawl catch the relative s_A-contribution from each species is calculated (Korsbrekke 1996) and used as a guideline for the allocation. In these calculations, the fish length dependent catching efficiency of cod and haddock in the bottom trawl (Aglen and Nakken 1997) is taken into account. There is no reason to believe that trawl catches give an accurate representation of species composition in the sea, so the calculated s_A-contribution from the trawl hauls are used as a guidance only.

The new Sea2Data software StoX has been applied to estimate acoustic indices with CVs for cod and haddock. Acoustic estimates for the period 1994-2017 were re-estimated using StoX (Mehl *et al*. 2018). The main difference between the SAS based BEAM Program (Totland and Godø 2001) used until 2017 and StoX acoustic abundance estimation is that in BEAM the survey area is divided into rectangles, and for each rectangle an average acoustic density (s_A) is calculated, while in StoX transects are defined within each stratum (Figure 2.1) as primary sampling units (PSUs) and used to calculate acoustic density (Jolly and Hampton 1990).

The survey area is divided into eight Main Areas (A, B, C, D, E, S and N, Fig 2.1) and 26 strata. In 2014, the investigated area was enlarged by three new strata in northwest, 24-26 (Main Area N, Fig. 2.1). Within each stratum, the acoustic course tracks are divided into transects, separated by the trawl stations in the stratum since the course tracks run through the net of fixed bottom trawl stations in the bottom trawl survey. An area of about 2 nautical miles around each station is not included in the transects. For the time series 2004-2017 this was done by first running a R-script tagging all the transects and then the transects were inspected and edited manually in StoX if necessary. Minimum length of a transect is 4 nautical miles. In this process miles with obvious errors in the s_A-values, e.g. bottom contribution, were removed from the transects.

For each transect and stratum, an arithmetic mean s_A is calculated for the demersal zone (less than 10 m above bottom) and the pelagic zone (more than 10 m above bottom).

The conversion of mean NASC (m^2 nmi^{-2}) to density of fish followed a standard procedure where all trawl stations within a stratum with a catch of more than 5 individuals were assigned to each PSU. If less than 3 trawl stations had been carried out in a stratum, stations in neighbouring strata were assigned to the PSUs such that at least 3 stations were assigned to each PSU.

The combined length distribution (d) was calculated for each transect (PSU (j)) as:

$$d_{l,j} = \sum_{s=1}^{s} d_{l,s,j}$$

where $d_{l,s,j}$ is density (number by 1 NM tow distance) by 1 cm length group (l) for the stations (s) assigned to PSU (j).

The trawl catches are normalised to 1 NM towing distance and adjusted for length dependent catch efficiency (Aglen and Nakken 1997, Dickson 1993a,) using the parameters given in the text table below:

Species	α	β	l_{min}	l_{max}
Cod	5.91	0.43	15 cm	62 cm
Haddock	2.08	0.75	15 cm	48 cm

The areal density of fish (ρ) (n per nmi^2) by length group l by transect j was calculated as

$$\rho_{j,l} = \frac{\mathrm{NASC}_{j,l}}{\sigma_l}$$

where $\mathrm{NASC}_{j,l}$ is the mean nautical area scattering coefficient by transect (j) and length group (l) and σ_l is the acoustic backscattering cross-section for a fish of length l.

$NASC_{j,l}$ is calculated as:

$$\mathrm{NASC}_{j,l} = \mathrm{NASC}_j \frac{\sigma_{l,p}}{\sum_l \sigma_{l,p}}$$

where $\sigma_{l,p}$ is the acoustic backscattering cross-section for a fish of length *l* multiplied with the proportion (*p*) of a fish of length *l* in the total length distribution and $NASC_j$ is the mean nautical area scattering coefficient in transect *j*.

The acoustic backscattering cross-section (m^2) for a fish of length *l* is calculated as

$$\sigma_l = 4\pi 10^{\left(\frac{TS_l}{10}\right)}$$

where the target strength, *TS*, for a fish of length *l* (cm) is calculated as

$$TS_l = m \log_{10}(l) + a$$

Where *m* and *a* are constants. For cod and haddock we applied

$$TS = 20 \log(l) - 68 \quad \text{(Foote, 1987),}$$

The fish abundance (*N*) by length group (*l*) for stratum *k* is:

$$N_{k,l} = \rho_{k,l} A_k ,$$

where *A* is stratum area and the mean density of fish of length group *l* and stratum *k* is:

$$\rho_{k,l} = \frac{1}{n_k} \cdot \sum_{k=1}^{n_k} w_{kj} \rho_{kj,l}$$

where $w_{kj} = L_{kj} / \overline{L}_k$ (j= 1,2, n_k) are the lengths of the n_k sample transects.

Estimates by length are converted to estimates by age using available age-length data from all selected (filtered) stations in the stratum, weighted by station density. The total biomass is estimated by multiplying the numbers at age by weight at age. The abundance by stratum is then summed for defined main areas (Figure 2.1).

2.2 Swept area measurements

All vessels were equipped with the standard research bottom trawl Campelen 1800 shrimp trawl with 80 mm (stretched) mesh size in the front. Prior to 1994 a cod-end with 35-40 mm (stretched) mesh size and a cover net with 70 mm mesh size were mostly used. Since this mesh size may lead to considerable escapement of 1-year-old cod, the cod-ends were in 1994 replaced by cod-ends with 22 mm mesh size. At present a cover net with 116 mm meshes is mostly used.

The trawl is now equipped with a rockhopper ground gear (Engås and Godø 1989). Until and including 1988 a bobbins gear was used, and the cod and haddock indices from the period 1981-1988 have since been recalculated to 'rockhopper indices' and adjusted for length dependent catch efficiency and/or sweep width (Godø and Sunnanå 1992, Aglen and Nakken 1997). The sweep wire length is 40 m, plus 12 m wire for connection to the doors.

In the Norwegian Barents Sea shrimp survey (Aschan and Sunnanå 1997) the Campelen trawl has been rigged with some extra floats (45 along the ground rope and 18 along the under belly and trunk, all with 20mm diameter) to reduce problems on very soft bottom. This rigging has been referred to as "Tromsø rigging". When the shrimp survey was terminated 2004 and later merged with the Barents Sea Ecosystem survey in 2005, improved shrimp data were also requested from the winter survey, and the "Tromsø rigging" was used in parts of the shrimp areas in 2004 (11 stations) and 2005 (9 stations). In 2006-2014 "Tromsø rigging" was used for nearly all bottom trawl stations taken by Norwegian vessels in the winter survey, while since 2015 "Tromsø rigging" has not been applied.

Vaco doors (6 m^2, 1500kg), were previously standard trawl doors on board the Norwegian research vessels. On the Russian vessels and hired vessels V-type doors (ca 7 m^2) have been used. In 2004, R/V "Johan Hjort" and R/V "G.O. Sars" started using a V-type door for bottom trawling (Steinshamn W-9, 7.1m^2, 2050 kg), the same type as used on the Russian research vessels. In 2010 the V-doors were replaced by 125" Thyborøn trawl doors. R/V "Helmer Hanssen" has used Thyborøn trawl doors since the 2008 survey. To achieve constant sampling width of a trawl haul independent of e.g. depth and wire length, a 10-15 m rope "locks" the distance between the trawl wires 80-150 m in front of the trawl doors on the Norwegian vessels. This is called "strapping". The distance between the trawl doors is then in most hauls restricted to the range 48-52 m regardless of depth (Engås and Ona 1993, Engås 1995). Strapping was first attempted in the 1993 survey on board one vessel, in 1994 it was used on every third haul and in 1995-1997 on every second haul on all vessels. Since 1998 it has been used on all hauls when weather conditions permitted. Strapping is not applied on the Russians vessels, but the normal distance between the doors is about 50 m (D. Prozorkevich, pers. comm.).

Standard tow duration is now 15 minutes (until 1985 the tow duration was 60 min. and from 1986 to 2010 30 min.). Trawl performance is constantly monitored by Scanmar trawl sensors, i.e., distance between the doors, vertical opening of the trawl and bottom contact control. In 2005-2008 sensors monitoring the roll and pitch angle of the doors were used due to problems with the Steinshamn W-9 doors. The data is logged on files, but have so far not been used for further evaluation of the quality of the trawl hauls.

At the start of the survey at least two of the trawls on the Norwegian vessels should go through a “sea test”. The purpose of the test is to check that the geometry of the trawl is within the specified limits and that the trawl performance is satisfactory, especially that the bottom contact is stable. It is further checked that the trawl sensors operate as they should.

The positions of the trawl stations are pre-defined. When the swept area investigations started in 1981 the survey area was divided into four main areas (A, B, C and D, Fig 2.1) and 35 strata.

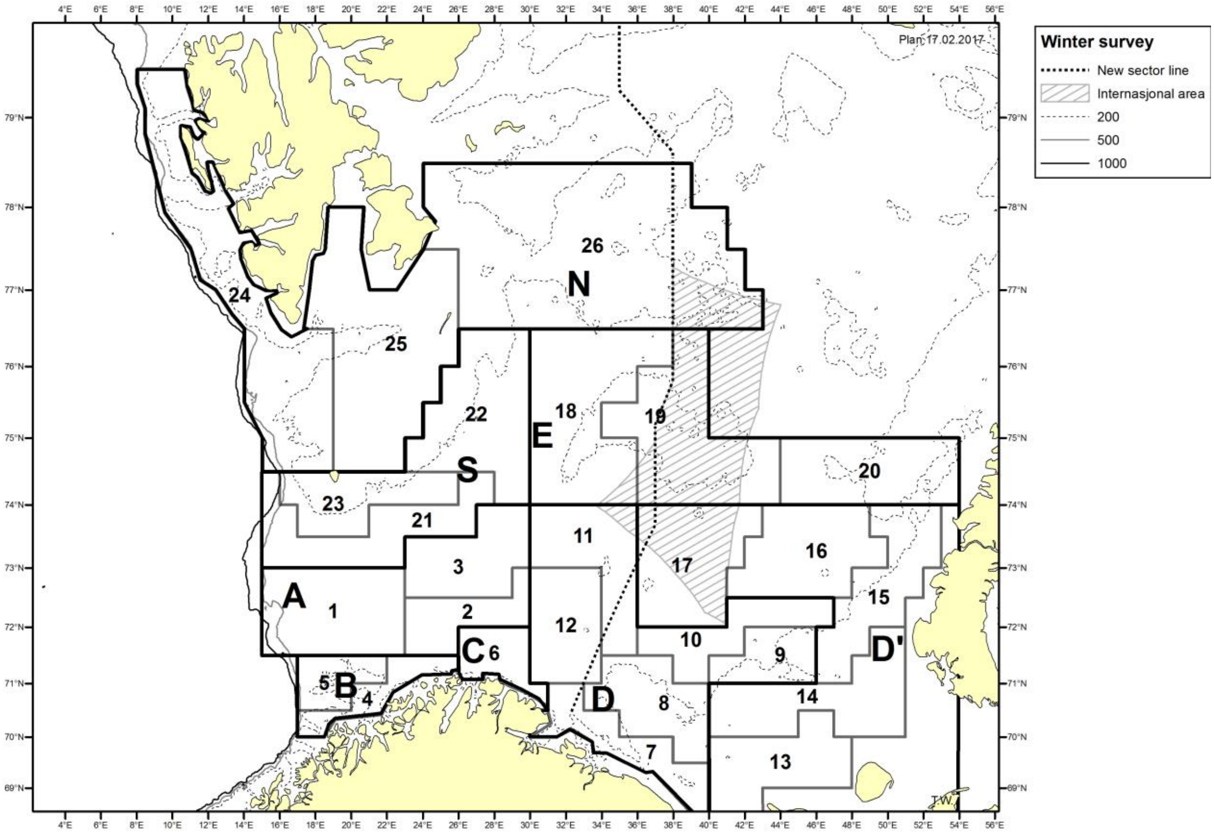

Figure 2.1. Strata (1-23) and main areas (A,B,C,D,D’,E and S) used for swept area estimations and acoustic estimations with StoX. Additional strata (24-26, main area N) are covered since 2014, but not included in the standard time series.

During the first years, the number of trawl stations in each stratum was set based on expected fish distribution to reduce the variance, i.e., more hauls in strata where high and variable fish densities were expected to occur. During the 1990s trawl stations were spread out more evenly, yet the distance between stations in the most important cod strata is shorter (16 or 20 NM) compared to the less important strata (24, 30 or 32 NM). Considerable amounts of young cod were now distributed outside the initial four main areas, and in 1993 the investigated area was therefore enlarged by areas D’, E, and the ice-free part of Svalbard (S) (Fig. 2.1 and

Table 3.5), 28 strata altogether. In the 1993-1995 survey reports, the Svalbard area was included in area A' and the western part of area E (west of 30°E). Since 1996 a revised strata system with 23 strata has been used (Figure 2.1). The main reason for reducing the number of strata was the need for enough trawl stations in each stratum to get reliable estimates of density and variance. In 2014 the investigated area was enlarged by three new strata in northwest, 24-26 (main area N, Fig. 2.1). However, the data are due to few years so far not included in the standard time series of standard abundance indices used in the assessments.

Swept area fish density estimation

Swept area fish density estimates ($\rho_{s,l}$) by species (*s*) and length (*l*) were estimated for each bottom trawl haul by the equation:

$$\rho_{s,l} = \frac{f_{s,l}}{a_{s,l}}$$

$\rho_{s,l}$ number of fish of length *l* per n.m.^{2} observed on trawl station *s*

$f_{s,l}$ estimated frequency of length *l*

$a_{s,l}$ swept area:

$$a_{s,l} = \frac{d_s \cdot EW_l}{1852}$$

d_s towed distance (nm)

EW_l length dependent effective fishing width:

$$EW_l = \alpha \cdot l^{\beta} \text{ for } l_{\min} < l < l_{\max}$$

$$EW_l = EW_{l_{\min}} = \alpha \cdot l_{\min}^{\beta} \text{ for } l \le l_{\min}$$

$$EW_l = EW_{l_{\max}} = \alpha \cdot l_{\max}^{\beta} \text{ for } l \ge l_{\max}$$

The parameters are given in the text table below:

Species	α	β	$l_{\min}$	$l_{\max}$
Cod	5.91	0.43	15 cm	62 cm
Haddock	2.08	0.75	15 cm	48 cm

The fishing width was previously fixed to 25 m = 0.0135 nm. Based on Dickson (1993a,b), length dependent effective fishing width for cod and haddock was included in the calculations in 1995 (Korsbrekke *et al.*, 1995). Aglen and Nakken (1997) have adjusted both the acoustic and swept area time series back to 1981 for this length dependency based on mean-length-at-age information. In 1999, the swept area 1983-1995 time series was recalculated for cod and haddock using the new area and strata divisions (Bogstad *et al.* 1999).
For redfish, Greenland halibut and other species, a fishing width of 25 m was applied, independent of fish length.

The Sea2Data software StoX has been applied to estimate swept area indices with CVs for cod, haddock, golden redfish, beaked redfish, Norway redfish, Greenland halibut and blue whiting. Swept-area estimates for the period 1994-2016 was re-estimated using StoX (Mehl *et al*. 2016), and so was length and weight at age for cod and haddock. All estimates for 2017 and updated estimates for 2016 and strata 24-26 in 2014-2015 were estimated with StoX version 2.3, Rstox 1.5, while StoX version 2.5 and Rstox 1.8 were used in 2018. Input data downloaded from DataSet Explorer:
https://datasetexplorer.hi.no/apps/datasetexplorer/v2/navigation

The main difference between the SAS based Survey Program previously used (years 1981-1993 of the time-series, see earlier reports for results and method details) and StoX swept area estimation is in the use of the age-length data. StoX does not use age-length keys (ALK) in the traditional sense with ALKs estimated for large areas. Missing age information is imputed from known age-length data within station. If age information is still missing StoX searches within strata, or lastly within all strata. If no age is available for a length group, the abundance estimate is presented as unknown age. StoX does also allow for uncertainty estimation by bootstrapping primary sampling units (PSUs).

2.3 StoX input, filters and settings

StoX version 2.7 and Rstox 1.11 were used for acoustic, swept-area, length and weight at age and CV estimations for 2019 (http://www.imr.no/forskning/prosjekter/stox/). R for Windows version 3.5.2 was used in the R calls (https://www.r-project.org/).

In **FilterAcoustic, FreqExpr** was set to **frequency=38000 or frequency=37879**. In **NASCExpr, acocat** was **31** for cod and **30** for haddock.

In **NASC and LayerType** was set to **DepthLayer**.

Under **FilterBiotic** and **FishStationExpr**, in the acoustic estimations was applied: **fs.getLengthSampleCount('TORSK') > 5** for cod and **fs.getLengthSampleCount('HYSE') > 5 for haddock** and **fishstationtype !~ ['1', '2', '3']**, filtering out stations with less than six specimen and stations with experiments, (see Johnsen et al. 2016 and Mjanger et al. 2019 for more info about filters and codes).

In the swept area estimations was used: **FilterBiotic** and **FishStationExpr**, **gear** =~['3270','3271'] and **gearcondition** < 3 and **trawlquality** =~['1','3'] and **fishstationtype** != 2. In **DefineStrata**, **vintertokt_barentshavny.txt** was used as basis for strata definition. Nodes for strata towards north and east have been adjusted to reduce the strata according to coverage and ice border in each year.

In **StratumArea** and **AreaMethod**, **Accurate** was applied.

Under **StationLengthDist** and **LengthDistType**, **NormalLengthDist** was used, and under **RegroupLengthDis**t and **LengthInterval**, **1.0** is applied in the acoustic estimations and **5.0** in the swept area estimations.

Under **Catchability** and **Catchability Method**, **LengthDependentSweepWidth** was used for cod and haddock with the parameters given above.

In the swept area estimates, for **SweptAreaDensity, LengthDependent** was use, and for **SweepWidthMethod, Predetermined** was applied for cod and haddock and **Constant** with **SweepWidth 25 m** for the other species.

In the acoustic estimates, for **BioStationAssignment** and **AssignmentMethod**, **Stratum** was used. **EstLayers** was set to **1~PEL 2~BOT**.

Under **BioStationWeighting** and **WeightingMethod, SumWeightedCount** was used.

In **AcusticDensity**, **m** was set to **20** and a to **-68**.

Under **SuperIndAbundance** and **AbundWeightMethod**, **StationDensity** was used, with **LengthDist** set to **RegroupLengthDist**.

2.4 Estimation of variance.

The acoustic and swept area survey indices are presented together with an estimate of uncertainty (coefficient of variation; CV). These estimates were obtained by using StoX with a stratified bootstrap routine treating each transect as the primary sampling unit. In addition, a bootstrap routine for all trawl stations by strata was carried out within each run.

The estimated CV (Standard Deviation · 100/mean) is estimated from 500 iterations and is strongly dependent on the choice of estimator for the indices. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength.

2.5 Sampling of catch and age-length keys.

Sorting, weighing, measuring and sampling of the catch are done according to instructions given in Mjanger *et al*. (2019). Since 1999 all data except age are recorded electronically by Scantrol Fishmeter measuring board, connected to stabilized scales. The whole catch or a representative sub sample of most species was length measured on each station.

At each trawl station age (otoliths) and stomach were sampled from one cod per 5 cm length-group. In 2007-2009, all cod above 80 cm were sampled, and in 2010 all above 90 cm, limited to 10 per station. The stomach samples were frozen and analysed after the survey. Haddock and Greenland halibut otoliths were also sampled from one specimen per 5 cm length-group.

Regarding the redfish species *Sebastes norvegicus* and *S. mentella*, otoliths for age determination were sampled from two fish in every 5-cm length-group on every station. Table 3.3 gives an account of the sampled material.

2.6 Raising of indices

In 1997, 1998 and 2007 only the Norwegian EEZ (NEZ) and parts of the Svalbard area (S) was covered. The swept-area indices for cod, haddock, golden redfish, beaked redfish and Greenland halibut has therefore been raised to also represent the Russian EEZ (REZ) (Mehl *et al*. 2016).

In 2006, there was not a complete coverage in southeast due to restrictions. The observations in the partially covered strata 7 were extrapolated to the full strata, and the observations in the partially covered strata 13 were extrapolated to the same area as covered in 2005. In 2012 the coverage was incomplete in the eastern areas, and the cod and haddock swept area estimates within the covered area were raised by the “index ratio by age” observed for the same area in 2008-2011 (ICES 2012). The scaling factor (“index ratio”) for estimating adjusted total from <Total – area D’> was the average ratio by age for Total/(Total – area D’) in the years 2008-2011 (Aglen et al. 2012).

In 2017, the Norwegian vessel was not allowed to operate south of 70º 10’ N and west of 41º 00 º E, and no Russian vessel participated in the survey. Only a small part of strata 7 was covered, and strata 13, 15, 17 and 20 were not covered. The cod, haddock, Greenland halibut and beaked redfish swept area estimates and cod and haddock acoustic estimates within the covered area were raised following the same procedure as for 2012. The scaling factor for estimating adjusted total from <Total –strata 7 > was the average ratio by age for Total/(Total – (strata 7+13+15+17+20)) swept area indices in the years 2014-2016.

3 Survey operation and material

Table 3.1 presents the vessels participating in the survey in 2019 and IMR trawl station series numbers, and Figure 3.1 shows survey tracks, trawl stations and ice cover.

Table 3.1. Vessel participation by period and trawl station series numbers by vessel for the winter survey in 2019.

	Period	Series no.
Johan Hjort	31.01-18.03	70001-70259
Helmer Hanssen	23.01-25.02	70301-70189
Vilnyus	23.02-20.03	00001-00132

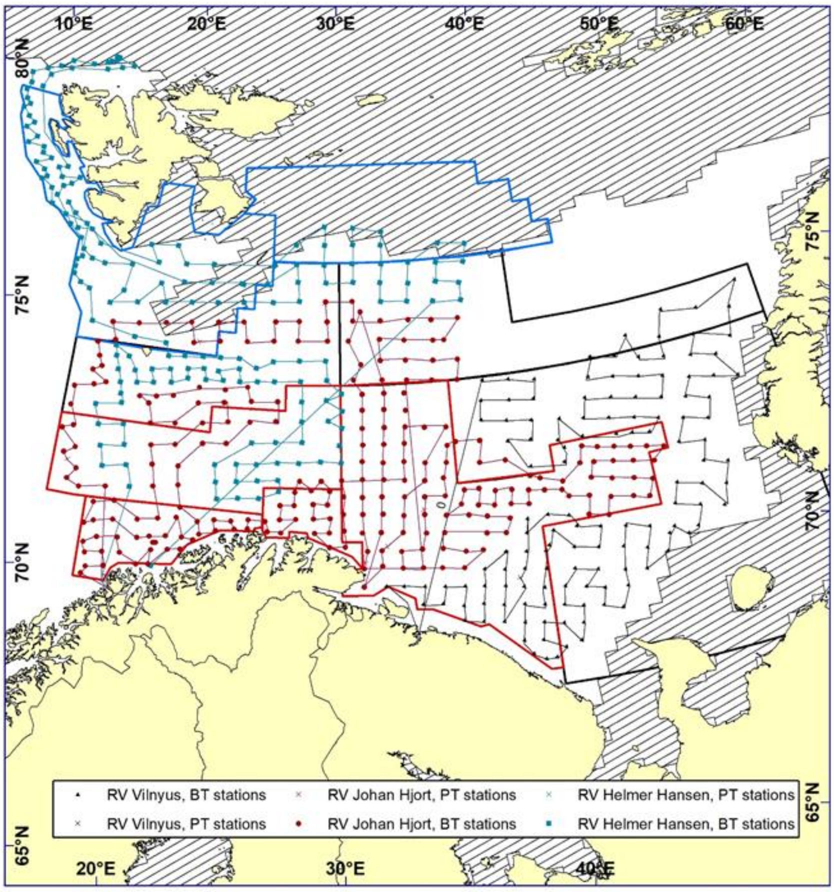

Figure 3.1. Survey tracks and all trawl stations in the winter survey 2019. Data source for the ice cover: ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/monthly/shapefiles/shp_extent/02_Feb/

Table 3.2 presents the number of swept area trawl stations, other bottom trawl stations and pelagic trawl stations taken in the different main areas. For the calculation of swept area indices to be used in the assessments, only the successful pre-defined bottom trawl stations within the standard strata system (strata 1-23) were used. The number of stations in the new strata 24-26 are also given.

Table 3.2. Number of trawl stations by main area in the Barents Sea winter 2019. B_1= swept area bottom trawl (quality=1 and condition<3), B_2=other bottom trawl, P=pelagic trawl, N=trawl stations in new strata.

Main area	**Trawl type**	
A	B_1 B_2 P	48 6 1
B	B_1 B_2 P	33 13 -
C	B_1 B_2 P	17 - -
D	B_1 B_2 P	146 - 5
D'	B_1 B_2 P	91 1 -
E	B_1 B_2 P	35 3 2
S	B_1 B_2 P	72 3 1
Inside standard strata system	B_1 B_2 P	442 26 9
N	B_1 B_2 P	85 1 1
Outside strata system	B_1 B_2	11 3
Total	B_1+B_2 P	568 10

Table 3.3 gives an account of the sampled length- and age material from bottom hauls and pelagic hauls.

Table 3.3. Number of fish measured for length (L) and age (A) in the Barents Sea winter survey 1994-2019.

	Cod		Haddock		Golden redfish	Beaked redfish	Greenland halibut	Blue whiting
Year	**L**	**A**	**L**	**A**	**L**	**L**	**L**	**L**
1994	57290	3400	40608	1808	3157	12389	525	
1995	66264	3547	37775	1692	3785	9622	583	
1996	61559	3304	34497	1416	2510	10206	587	
1997	35381	2381	30054	1003	5429	10997	675	
1998	39044	2843	12512	859	1739	9664	649	
1999	22971	2321	12752	926	1266	6677	397	
2000	31543	2871	25881	1426	1161	8739	546	
2001	36789	2998	30921	1657	1173	7323	499	
2002	45399	3730	58464	2057	1143	6660	688	
2003	59573	2857	54838	1883	1102	4654	657	
2004	40851	3175	51705	1874	1438	5507	459	
2005	33582	3216	67921	2060	835	5166	832	
2006	19319	2683	23611	1899	728	3356	962	
2007	16556	2954	26610	2023	798	4544	973	4657
2008	26844	3809	50195	2490	897	8568	1020	1350
2009	22528	3486	40872	2433	455	9205	807	891
2010	30209	4085	35881	2367	429	8564	984	626
2011	26913	3959	29180	2260	286	6885	607	105
2012	17139	3020	33524	1854	574	5721	354	2441
2013	14525	2451	19142	1671	479	6087	263	1091
2014	22624	4501	35940	2586	563	9310	444	1846
2015	25401	3795	18483	2038	395	8933	541	1991
2016	16636	3368	25423	2067	614	8668	425	2396
2017	12402	2851	15689	1955	576	8898	448	4799
2018	42462	5178	43294	3307	1211	11500	548	1443
2019	16217		15967		761	8981	413	886

The coverage of the most northern and most eastern strata differs from year to year. The areas of these strata are therefore calculated according to the coverage each year. Table 3.4 gives the area covered by the survey every year since 1981. In that table "Extrapolated area" reflects the size of areas where some kind of extrapolations/adjustments have been made to take account of incomplete coverage (see also section 2.6). Table 3.5 summarizes the degree of coverage and main reasons for incomplete coverage in the whole period.

Table 3.4. Area (NM^2) covered in the bottom trawl surveys in the Barents Sea winter 1981-2019, 1994-2019 are StoX estimates.

	Main Area									Extra-
Year	**A**	**B**	**C**	**D**	**D'**	**E**	**S**	**N**	**Total excluding N**	**polated area**
1981-92	23299	8372	5348	51116	-	-	-		88135	
1993	23929	8372	5348	51186	23152	8965	16690		137642	
1994	27180	9854	5165	53394	36543	11417	17557		161110	
1995	26797	9854	5165	53394	58605	13304	24783		191904	
1996	26182	9854	5165	53394	54047	5738	11809		166190	
1997[1]	27785	9854	5165	23964	2670	0	18932		88371	56200
1998[1]	27785	9854	5165	23964	5911	3829	23931		100440	51100
1999	27785	9854	5165	43230	8031	5742	18737		118545	
2000	27173	9854	5165	52314	29438	14207	25053		163204	
2001	26609	9854	5165	53394	29694	15777	24157		164652	
2002	26594	9854	5165	53394	21914	15757	24689		157369	
2003	26621	9897	5165	52072	23947	6259	23400		147361	
2004	27785	9854	5165	53394	42731	4739	20760		164428	
2005	27785	9854	5165	53394	39104	19931	24648		179883	
2006[2]	27785	9854	5165	53394	35302	13872	24691		170064	18100
2007[1]	27785	9854	5165	23911	8498	20822	27858		123894	56700
2008	27785	9854	5165	53394	23792	18873	26313		165176	
2009	27785	9854	5165	53394	31978	15739	27858		171774	
2010	27785	9854	5165	53394	17882	18562	27858		160501	
2011	27785	9854	5165	53394	33432	16835	27858		174324	
2012[2]	27785	9854	5165	53394	9917	17289	27858		151263	16700
2013	27785	9854	5165	53394	58183	21118	27858		203358	
2014[3]	27785	9854	5165	53394	54800	29897	27858	58048	208754	
2015[3]	27785	9854	5165	53394	45449	26541	27858	47263	196047	
2016[3]	27785	9854	5165	53526	29266	20342	27630	54387	173568	
2017[2,3]	27785	9854	5165	45493	12223	18524	27858	38786	146903	37460
2018[3]	27785	9854	5165	53394	45193	23095	27630	44186	192117	
2019[3]	27785	9854	5165	53394	56452	26788	27630	34035	207121	

[1]REZ not covered

[2]REZ not completely covered (Strata 7 and 13 in 2006, Area D' in 2012 and strata 7, 13, 15, 7 and 20 in 2017).

[3] Additional northern areas (N) covered, not included in total and standard survey index calculations.

Table 3.5. Barents Sea winter surveys 1981-2019. Main Areas covered, and comments on incomplete coverage.

Year	Coverage	Comments
1981-1992	ABCD	
1993-1996	ABCDD’ES	
1997	Norwegian EEZ (NEZ), S	Not allowed access to Russian EEZ (REZ)
1998	NEZ, S, minor part of REZ	Not allowed access to most of REZ
1999	ABCDD’ES	Partly limited coverage due to westerly ice extension
2000	ABCDD’ES	Russian participation starts
2001-2005	ABCDD’ES	Russian vessel covered where Norwegians had no access
2006	ABCDD’ES	No Russian vessel, not allowed access to Murman coast
2007	NEZ, S	No Russian vessel, not allowed access to REZ
2008	ABCDD’ES	Russian vessel covered where Norwegians had no access
2009	ABCDD’ES	Reduced Norwegian coverage of REZ due to catch handling
2010	ABCDD’ES	Reduced Norwegian coverage of REZ due to bad weather
2011	ABCDD’ES	Russian vessel covered where Norwegians had no access
2012	ABCDD’ES	No Norwegian coverage of REZ due to vessel problems
2013	ABCDD’ES	No Norwegian coverage of REZ due to vessel shortage
2014	ABCDD’ESN	Strata 24-26 (N) covered for the first time
2015	ABCDD’ESN	Slightly reduced/more open coverage due to bad weather
2016	ABCDD’ESN	No access to REZ, Russian vessel covered most of REZ
2017	ABCDD’ESN	No Russian vessel, not allowed access to southwestern REZ
2018	ABCDD’ESN	Russian vessel covered where Norwegians had no access
2019	ABCDD’ESN	Russian vessel covered where Norwegians had no access

4 Total echo abundance of cod and haddock

Table 4.1 presents the time series of total echo abundance (mean s_A multiplied by strata area and summed over all strata) of cod and haddock in the investigated areas.

Table 4.1. Cod and haddock. Total echo abundance in the Barents Sea winter 1994-2019 (m^2 reflecting surface · 10^{-3}) estimated by StoX. Observations outside main areas A-S are not included.

	StoX		
Year	**Cod**	**Haddock**	**Sum**
1994	5282	3898	9180
1995	3671	2948	6619
1996	2789	1248	4037
1997[1]	1355	832	2187
1998[1]	2254	543	2797
1999	1517	771	2288
2000	2833	1534	4367
2001	2158	1488	3646
2002	1976	2247	4223
2003	3717	3570	7287
2004	1174	2087	3261
2005	1370	2519	3889
2006	1116	2541	3657
2007[1]	675	2311	2986
2008	3510	6195	9705
2009	2452	5300	7752
2010	3526	5939	9465
2011	2967	3715	6682
2012	3478	4182	7660
2013	5026	3604	9656
2014	4847	2915	7762
2015	5245	2161	7406
2016	2879	1587	4466
2017[1]	2139	2588	4732
2018	3537	2851	6388
2019	3282	3039	6321

[1] not scaled for uncovered areas

Since 1993 the acoustic values have been split between the two species during the scrutinizing. The values for cod have showed an increasing trend since the late 2000s, with a peak in 2013-2015. Total echo abundance was 40% lower in 2016 compared to 2015 and decreased further from 2016 to 2017, while there was an increase of more than 50% from 2017 to 2018 and a small decrease in 2019. The values for haddock increased gradually from the end of the 1990s to 2008, decreased gradually to less than one third of the 2008 value in 2016 but increased considerably in 2017 and further in 2018 and 2019.

5 Distribution and abundance of cod

5.1 Acoustic estimation

Surveys in the Barents Sea at this time of the year mainly cover the immature part of the cod stock. Most of the mature cod (age 7 and older) have started on their spawning migration southwards out of the investigated area and are therefore to a lesser extent covered. There are indications that a higher proportion than normal spawned along Finnmark in some of the previous years, e.g. 2004-2006. Thereby a higher proportion of the spawners might have been covered by the survey these years.

Table 5.1 shows the acoustic indices for each age group by main areas in 2019. A rather high proportion of the 1-year olds was found in the extended area (N). The time series (1994-2019) is presented in Table 5.2. The estimates have been variable and increasing in later years, with a peak in biomass in 2013, and this may partly be explained by variable and not complete coverage of the distribution area towards north and east in several years. As cod grow older it gets a more south-westerly distribution during winter, it so to say “grows” into the incomplete survey. This is especially evident for the strong 2004 and 2005 year-classes, which as 6-11-year olds stand out as the strongest in the time series. Of more recent year-classes 2011 seems to be strong. 2014 seemed strong at age 1, while at age 2 it appears rather moderate. Table 5.4 shows indices for strata 24-26 in 2014-2019.

Table 5.4 presents estimated coefficients of variation (CV) for cod age groups 1-15 in 1994-2019. These estimates were obtained by using StoX with a stratified bootstrap routine treating each transect as the primary sampling unit. In addition, a bootstrap routine for all trawl stations by strata was carried out within each run. The estimated CV (Standard Deviation · 100/mean) is estimated from 500 iterations and is strongly dependent on the choice of estimator for the indices. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In all years, CVs for age groups older than 10 years are above what could be considered as acceptable.

Table 5.1. COD. Abundance indices (numbers in millions) for the main areas of the Barents Sea from acoustic survey winter 2019 estimated by StoX software.

	Age group																
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
A																	
B																	
C																	
D																	
D'																	
E																	
S																	
ABCD																	
AS																	
N																	
Total																	

Table 5.2. COD. Abundance indices (numbers in millions) from acoustic surveys in the Barents Sea standard area winter 1994-2019 estimated by StoX software.

	Age group															Total	Biomass ('000 t)
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+		
1994	823.5	586.9	307.2	384.4	207.0	68.0	12.1	3.53	2.55	0.81	1.11	0.11	0.12	0	0	2397.4	1053.8
1995	2106.6	217.9	143.0	138.0	198.3	67.0	16.1	2.46	0.90	0.32	0.53	0.16	0	0	0	2891.2	669.3
1996	1748.9	261.1	110.0	89.5	115.0	83.3	23.0	2.20	0.27	0.08	0.05	0.05	0.06	0.01	0	2433.4	509.2
1997[1]	2832.9	842.9	209.2	49.2	51.5	43.1	24.9	5.73	1.00	0.23	0.22	0	0	0.03	0	4060.9	358.6
1998[1]	2633.1	555.8	444.5	210.8	46.6	44.4	28.6	16.90	1.85	0.46	0.16	0	0.02	0	0.07	3983.2	572.9
1999	351.1	227.0	151.6	133.3	51.8	12.0	7.02	3.98	1.54	0.32	0.02	0.01	0.01	0	0	939.6	265.4
2000	142.4	248.1	301.1	168.8	147.1	49.0	12.1	4.48	2.85	0.80	0.18	0.12	0.03	0	0	1077.0	546.7
2001	348.3	50.8	179.0	162.3	81.1	44.0	11.3	1.73	0.47	0.18	0.10	0	0	0	0.01	879.4	436.9
2002	18.4	208.8	62.4	105.5	98.0	53.4	20.2	2.96	0.30	0.53	0.12	0	0	0	0.02	570.6	430.7
2003	1399.7	52.0	307.0	120.6	121.8	118.7	39.1	9.32	1.84	0.33	0.07	0	0.07	0.05	0	2170.5	756.7
2004	147.1	111.2	33.3	85.2	33.5	28.5	18.0	5.35	1.15	0.36	0.06	0.01	+	0	0	463.8	245.5
2005	438.2	123.2	129.8	34.9	69.1	21.2	15.0	4.95	0.95	0.27	0.04	0.06	0.05	0.03	0	837.7	263.5
2006[2]	369.5	158.3	64.4	54.5	18.6	29.7	9.57	4.83	1.22	0.19	0.11	0.22	0	0	0	711.2	226.4
2007[1]	88.9	53.7	63.9	35.7	32.7	9.68	18.8	6.57	2.74	0.51	0.24	0.09	0.04	0	0	313.6	239.2
2008	48.5	91.9	196.1	292.0	116.0	73.7	21.1	14.1	2.62	0.72	0.05	0.02	0.01	0	0	856.8	819.8
2009	195.5	23.2	104.6	191.6	139.7	40.9	14.1	4.70	4.38	0.48	0.13	0.02	0.01	0	0	719.4	543.8
2010	696.1	41.8	21.8	86.9	161.8	153.8	46.2	14.4	3.87	2.86	0.91	0.11	0.14	0.09	0.01	1230.9	890.2
2011	248.5	88.7	39.1	28.7	65.4	106.6	102.4	19.4	6.71	1.49	1.07	0.28	0.13	0.10	0.02	708.5	790.0
2012[3]	508.1	45.3	87.8	47.6	35.1	70.9	135.8	60.3	8.19	5.19	1.26	0.66	0.45	0.01	0.10	1006.7	961.8
2013	293.3	82.4	59.1	85.4	70.6	50.2	100.0	129.9	57.0	5.37	3.98	1.63	0.70	0.21	0.05	939.8	1511.9
2014	582.2	154.2	234.0	115.9	96.0	68.4	37.7	84.7	55.3	24.1	2.46	1.51	0.17	0.04	0.16	1456.8	1336.6
2015	1183.0	107.6	110.2	188.0	119.5	130.2	84.9	33.8	51.7	23.0	6.27	0.57	0.14	0.04	0.01	2038.9	1374.6
2016	106.2	111.5	35.2	61.6	101.2	64.5	49.2	23.1	11.9	16.3	7.37	2.25	0.69	0.25	0.09	591.4	806.1
2017[3,4]	441.3	50.9	95.6	36.6	40.1	61.5	35.2	23.5	10.9	3.71	3.11	3.55	0.63	0.16	0.10	807.0	641.5
2018	1492.0	221.2	93.3	134.0	46.7	51.9	56.1	35.1	10.0	6.65	1.38	2.14	1.55	0.14	0.25	2152.4	817.7
2019	1000.3	287.4	182.1	97.7	124.3	53.4	33.7	31.6	8.7	2.83	0.38	0.33	0.20	0.23	0.16	1823.3	731.2

[1]Indices raised to also represent the Russian EEZ. [2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005.
[3]Indices raised to also represent uncovered parts of the Russian EEZ. [4]Indices corrected due to typing error

Table 5.3. COD. Abundance indices (numbers in millions) for new strata 24-26 from acoustic surveys in the Barents Sea winter 2014-2019 estimated by StoX software.

	Age group																
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
2014	1112.5	54.0	54.5	11.7	14.6	7.31	2.26	4.73	2.98	0.27	0.02	0	0	0	0	1264.9	103.4
2015	589.7	88.3	25.2	49.0	12.7	11.2	5.34	1.08	3.40	1.16	0.77	0.05	0	0	0	787.9	122.4
2016	104.9	84.6	18.0	14.6	16.8	2.47	2.94	1.86	0.30	0.67	0.17	0.02	0.01	0	0	247.3	60.2
2017	31.1	28.7	26.5	5.44	5.68	4.13	1.54	0.65	0.24	0.05	0.28	0.04	0	0	0	104.4	40.1
2018	514.2	50.6	16.2	16.7	6.96	4.35	8.64	0.99	0.76	0.25	0.08	0.12	0.01	0	0	619.9	76.1
2019	371.4	75.3	20.9	27.8	20.5	7.98	3.63	5.27	0.42	0.44	0.14	0.04	0.01	0.03	0.05	533.9	112.1

Table 5.4. COD. Estimates of coefficients of variation (%) for acoustic abundance indices. Barents Sea standard area winter 1994-2019.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	33	40	29	12	7	10	12	18	20	29	27	73	97	-
1995	14	20	11	9	7	9	11	21	25	31	55	48	-	-
1996	10	15	14	11	11	10	13	15	29	43	61	60	111	117
1997[1]	33	22	13	12	11	9	9	13	25	55	74	-	-	118
1998[1]	24	17	10	8	10	9	8	10	21	44	57	-	97	-
1999	22	23	17	15	10	11	11	13	25	58	114	121	107	-
2000	31	26	17	10	7	10	17	21	22	42	72	68	110	-
2001	13	15	11	9	10	9	13	22	32	35	77	-	-	-
2002	18	16	10	6	7	10	15	17	32	78	72	-	-	-
2003	26	31	15	13	8	8	13	17	20	40	59	-	99	94
2004	17	16	13	10	10	10	9	13	16	45	58	95	125	-
2005	26	50	19	14	14	14	12	20	26	24	62	90	49	91
2006[2]	21	15	13	10	10	11	15	15	23	37	57	68	-	-
2007[1]	32	27	14	13	11	17	19	21	24	29	40	46	94	-
2008	18	24	15	16	13	10	16	14	20	44	75	65	100	-
2009	21	20	26	22	18	17	13	14	19	32	45	71	112	0
2010	36	17	19	25	16	12	11	12	17	22	28	86	74	70
2011	13	27	12	11	11	10	9	15	28	29	35	39	66	86
2012[2]	36	14	53	11	19	19	17	13	19	35	33	55	52	81
2013	12	24	15	9	21	25	21	18	22	41	49	59	75	111
2014	13	10	11	12	12	8	11	13	15	19	33	53	58	95
2015	17	24	16	16	12	20	18	20	24	25	50	64	71	82
2016	21	15	13	12	11	15	15	16	23	23	29	47	58	87
2017[2]	15	21	13	9	10	11	14	11	18	34	43	55	66	108
2018	10	11	8	8	10	11	10	14	16	23	26	36	50	56
2019	9	11	7	8	7	14	13	12	12	20	37	53	52	68

[1]REZ not covered

[2] REZ partly covered

5.2 Swept area estimation

Figures 5.1 - 5.4 show the geographic distribution of bottom trawl catch rates (number of fish per NM^2, for cod size groups < 20 cm, 20-34 cm, 35-49 cm and ≥ 50 cm. As in previous years, a high proportion of the smallest cod (less than 35 cm) were found in the eastern part of the survey area within the Russian EEZ and near the northern borders of the standard strata system (strata 1-23). In 2019 **% of the number of cod < 20 cm found in the standard survey area was found in the extended area. Mehl *et al*. (2013, 2014, 2015, 2016, 2017, 2018) found that since 2009 more of the largest cod had been found in the north-western part of the survey area (main areas S and N), and this trend is confirmed by the 2019 estimates.

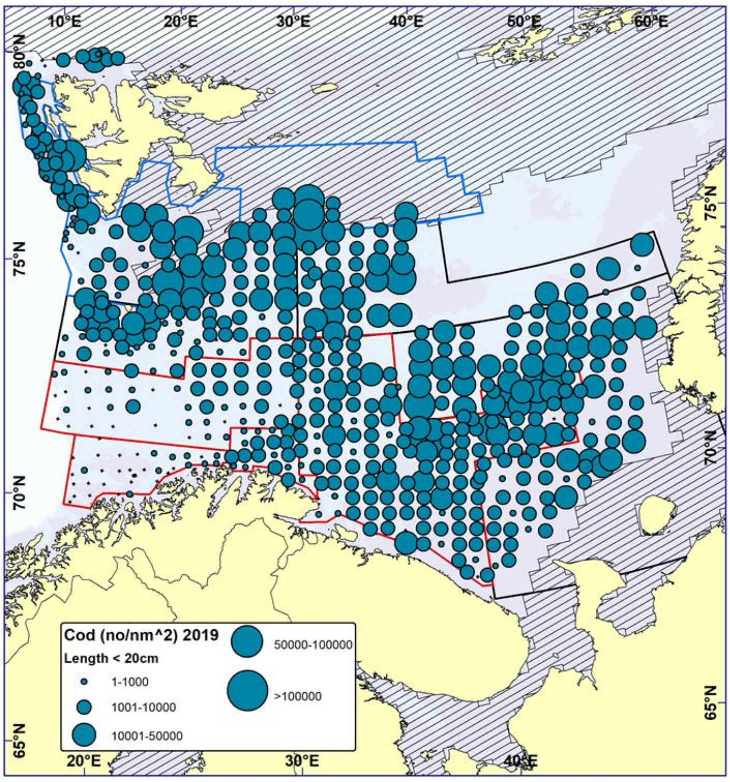

Figure 5.1. COD < 20 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

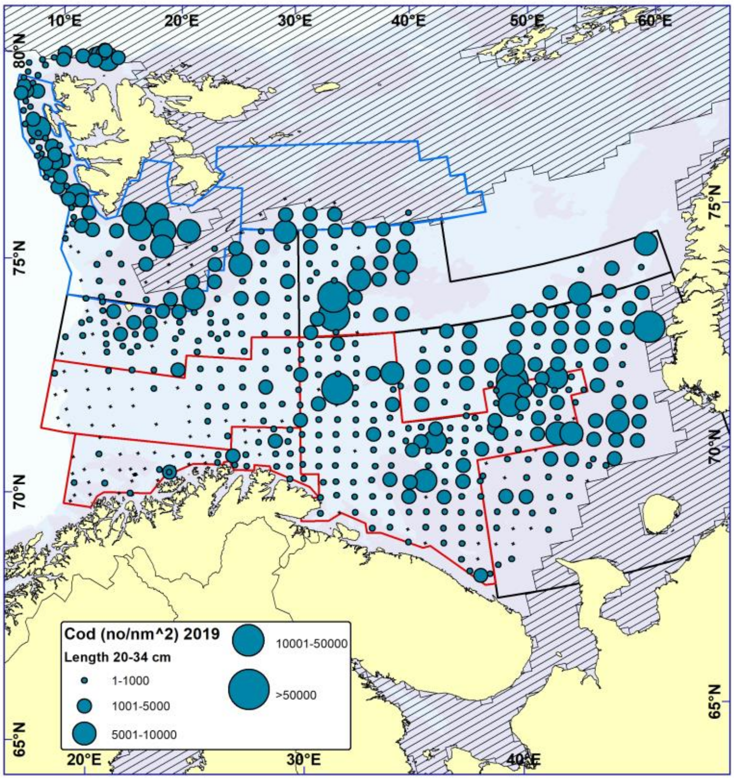

Figure 5.2. COD 20-34 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

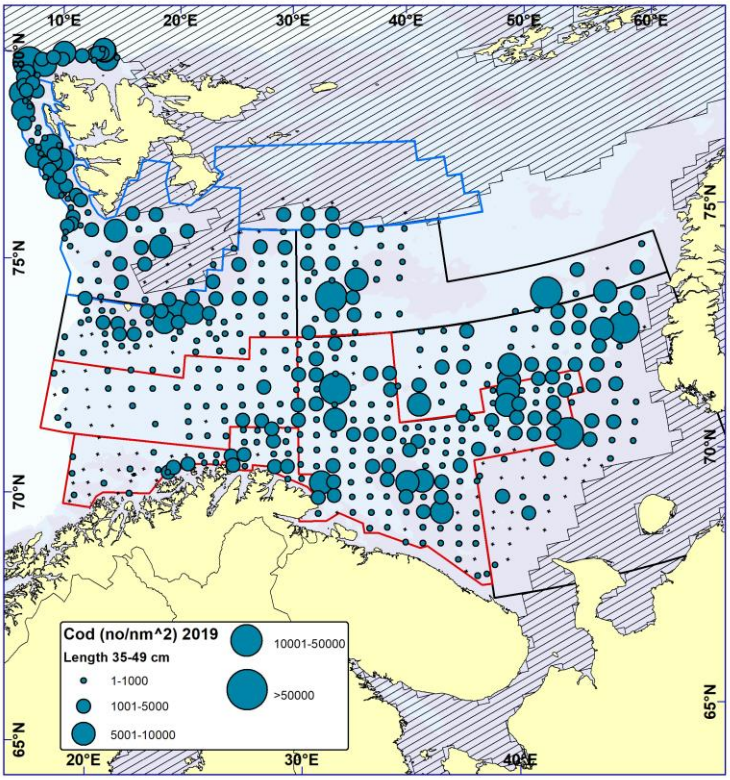

Figure 5.3. COD 35-49 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

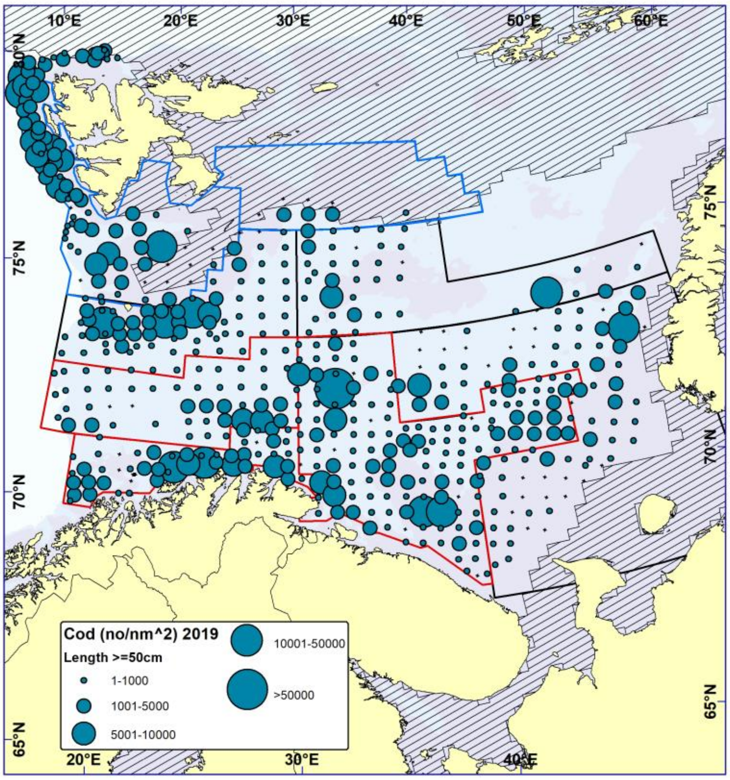

Figure 5.4. COD ≥ 50 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

Table 5.5 presents the distribution of the indices by main areas and age and the time series 1994-2019 is shown in Table 5.6. The bottom trawl indices have fluctuated somewhat due to the same reasons as for the acoustic indices, and the 2004 and 2005 year-classes stand out as the strongest in the time series. The 2009, 2011 and 2014 year-classes seemed to be strong as 1-year olds but have later been reduced to average level or below. A considerable amount of cod was found in the extended survey area (Table 5.3), on average over all age groups about **% of the amount found in the standard survey area by numbers and about **% by biomass. Tables 5.7 present swept area abundance indices by age for new strata 24-26 in 2014-2019.

Table 5.8 presents estimated coefficients of variation (CV) for cod age groups 1-15 in 1994-2019. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In all years, CVs for age groups older than 10 years are above what could be considered as acceptable.

Table 5.5. COD. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2019 (numbers in millions).

	Age group																
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
A																	
B																	
C																	
D																	
D'																	
E																	
S																	
ABCD																	
AS																	
N																	
Total																	

Table 5.6. COD. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

	Age group															Total	Biomass ('000 t)
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+		
1994	1044.5	545.5	296.8	307.6	152.6	46.8	8.13	2.59	1.32	0.55	0.52	0.11	0.05	0	0	2407.0	760.2
1995	5343.8	540.2	280.4	242.1	252.3	77.1	17.9	2.33	1.13	0.55	0.59	0.19	0	0	0	6758.7	937.5
1996	5908.3	778.6	164.0	116.7	140.7	111.2	24.8	2.79	0.37	0.16	0.08	0.08	0.05	0.02	0	7247.9	725.4
1997[1]	5122.8	1413.7	315.4	69.2	75.0	60.7	26.8	4.95	0.63	0.68	0.46	0.00	0.00	0.00	0.00	7090.2	502.4
1998[1]	2512.1	492.5	355.2	167.4	31.7	26.4	17.5	8.26	0.79	0.52	0.65	0.00	0.35	0.00	0.04	3613.4	405.9
1999	479.7	353.6	189.6	181.9	61.3	12.8	6.83	5.19	0.98	0.27	0.02	0.03	0.02	0	0	1292.2	324.2
2000	128.2	242.8	247.5	130.0	112.0	27.0	4.73	1.82	1.23	0.36	0.10	0.03	0.02	0	0	895.8	364.7
2001	715.8	77.6	182.0	194.5	81.6	38.0	9.58	1.19	0.45	0.19	0.04	0	0	0	0.01	1300.9	433.8
2002	34.2	416.2	118.0	137.7	108.6	46.5	14.5	2.19	0.34	0.19	0.05	0	0	0	0.02	878.5	448.5
2003	3021.4	61.2	380.8	125.4	95.2	66.6	17.9	4.72	1.02	0.16	0.04	0	0.02	0.02	0	3774.3	546.9
2004	321.3	236.3	65.5	186.1	53.6	43.2	30.9	6.92	1.66	0.29	0.08	0.01	0.01	0	0	945.8	417.2
2005	846.8	216.4	244.8	54.8	102.7	22.4	16.4	3.80	0.88	0.30	0.04	0.02	0.03	0.04	0	1509.5	357.9
2006[2]	676.9	283.8	115.6	114.0	28.1	43.3	14.0	5.19	1.34	0.22	0.21	0.08	0	0	0	1282.6	332.2
2007[1]	584.2	369.9	365.8	127.3	68.9	13.7	23.6	6.85	2.20	0.40	0.31	0.08	0.00	0.00	0.00	1563.2	459.2
2008	69.0	103.3	192.5	300.0	115.6	40.8	18.0	8.29	1.86	0.35	0.02	0.02	0.01	0	0	850.0	694.5
2009	389.4	35.5	124.3	196.1	218.0	58.2	17.5	8.44	5.27	0.50	0.18	0.03	0.03	0	0	1053.4	740.3
2010	1031.5	96.5	37.0	114.9	155.5	144.5	39.8	11.2	3.70	1.64	0.57	0.05	0.02	0.03	0.02	1637.0	831.1
2011	615.3	225.6	85.4	50.7	129.9	138.0	103.1	16.7	4.34	1.17	0.79	0.20	0.17	0.04	0.02	1371.4	890.1
2012[3]	728.4	124.8	83.1	70.3	36.4	93.9	136.3	49.6	9.38	2.33	0.87	0.60	0.47	0.02	0.05	1336.6	901.6
2013	439.1	147.2	70.3	119.8	64.0	41.0	65.0	76.2	33.6	2.21	2.83	0.41	0.35	0.06	0.03	1062.0	958.1
2014	499.8	148.8	180.6	85.1	67.9	47.8	32.6	46.9	31.7	9.36	1.01	0.97	0.15	0.04	0.07	1153.0	789.0
2015	1295.0	196.8	125.4	170.2	135.7	99.8	71.2	27.4	52.8	17.0	2.86	0.72	0.10	0.07	0.04	2194.8	1220.0
2016	212.3	232.9	53.4	112.3	151.3	109.0	66.1	26.6	12.8	15.0	6.43	0.96	0.50	0.17	0.14	1000.0	979.3
2017[3]	471.5	71.0	116.1	39.7	48.7	56.6	27.8	18.9	7.63	3.01	2.22	3.49	0.53	0.17	0.06	867.5	540.9
2018	1686.2	394.8	107.6	148.7	46.1	55.7	53.4	23.9	7.48	5.41	1.13	2.24	1.19	0.13	0.39	2534.3	739.9
2019	1291.7	446.0	253.7	132.0	188.6	66.4	27.0	28.8	7.6	1.72	0.34	0.17	0.14	0.13	0.10	2444.3	789.5

[1]Indices raised to also represent the Russian EEZ. [2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005
[3]Indices raised to also represent uncovered parts of the Russian EEZ.

Table 5.7. COD. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

	Age group															**Biomass ('000 t)**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	
2014	748.1	43.0	48.6	10.1	20.4	9.27	1.32	5.43	4.64	0.30	0.03	0	0	0	0	891.1	116.8
2015	348.8	147.0	19.1	56.4	12.4	14.1	5.43	1.59	2.22	1.27	0.41	0.05	0	0	0	608.8	132.5
2016	102.7	77.4	37.6	23.6	37.2	4.30	6.17	2.73	0.50	1.24	0.30	0.02	0.02	0	0	293.7	108.9
2017	181.9	52.4	58.1	20.6	33.4	31.0	9.20	7.25	0.58	0.23	0.33	0.05	0	0	0	395.0	183.6
2018	1024.9	106.2	32.7	34.2	15.8	8.09	19.9	1.82	1.96	0.56	0.15	0.24	0.02	0	0	1246.6	166.7
2019	500.3	115.4	30.1	47.2	33.9	13.6	6.0	9.58	0.53	0.82	0.19	0.07	0.04	0.05	0	757.8	187.5

Table 5.8. COD. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

	Age group														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1994	11	17	13	8	7	8	13	21	23	25	22	67	66	-	-
1995	8	14	11	12	10	10	12	23	33	27	43	39	-	-	-
1996	7	12	19	10	12	10	13	13	25	44	51	42	59	106	-
1997[1]	27	28	16	14	13	10	9	14	21	55	70	-	-	-	-
1998[1]	8	12	15	11	11	10	8	10	17	48	61	-	95	-	68
1999	18	28	17	14	8	10	14	29	22	62	105	94	91	-	-
2000	12	18	13	8	8	9	13	10	14	32	59	61	84	-	-
2001	11	14	17	14	9	10	13	23	25	35	59	-	-	-	-
2002	14	24	25	8	9	12	9	15	25	40	70	93	-	-	-
2003	25	33	26	18	7	7	9	11	15	39	56	65	65	-	-
2004	13	15	17	14	11	12	15	14	16	35	39	100	95	-	-
2005	9	15	26	16	16	14	12	11	17	23	60	66	43	50	-
2006[2]	12	13	14	26	17	12	20	12	17	27	54	76	-	-	-
2007[1]	26	21	15	25	7	9	14	17	19	19	33	49	84	-	-
2008	9	16	17	23	33	10	35	14	26	23	74	83	97	-	-
2009	10	9	18	12	19	14	17	25	22	26	34	62	97	-	-
2010	33	9	11	18	13	11	22	13	24	21	27	64	57	57	97
2011	7	30	11	15	16	11	9	11	26	19	49	38	58	64	99
2012[2]	46	13	65	12	14	19	20	12	24	19	23	31	48	80	92
2013	10	18	16	19	12	10	11	10	18	22	55	35	59	102	99
2014	16	10	12	12	10	10	17	13	10	17	27	34	60	132	80
2015	7	24	9	9	14	13	30	21	42	20	20	34	95	82	87
2016	9	10	9	12	9	20	22	10	14	28	21	31	30	54	57
2017[2]	8	10	8	9	15	10	16	18	13	22	23	27	45	35	97
2018	8	18	9	11	12	14	9	13	16	33	21	40	46	43	44
2019	7	12	9	10	18	20	12	12	12	14	27	45	39	54	84

[1] REZ not covered

[2] REZ partly covered

5.3 Growth and survey mortalities

Tables 5.9 and 5.10 present the time series for mean length (1994-2019) and mean weight (1994-2019) at age for the standard area. There have only been moderate fluctuations, but with a decreasing trend for older fish (8+) in later year. The same pattern is reflected in the annual weight increments (Table 5.11). In 2017 weight and yearly weight increment increased, especially for fish older than six years, and decreased again in 2018. A higher proportion of mature cod in the southwestern area in 2017 may have caused this.

Table 5.12 gives the time series of survey based mortalities (log ratios between survey indices of the same year class in two successive years) since 1994. These mortalities are influenced by natural and fishing mortality, age reading errors, and the catchability and availability (coverage) at age for the survey. In the period 1994-1999 there was an increasing trend in the survey mortalities. The trend appears most consistent for the age groups 3-7 in the swept area estimates. Most later surveys show lower mortalities, but there are some fluctuations for the same reasons as mentioned for the acoustic and swept area indices. Presumably the mortality of the youngest age groups (ages 1-3) is mainly caused by predation, while for the older age groups the fishery mainly causes it. Before 2001 the survey mortalities for age 4 and older were well above the mortalities estimated in the ICES stock assessment. Decreasing survey catchability at increasing age could be one reason for this. Another possible reason could be that the assessment does not include all sources of mortality, like discards, unreported catches, or poorly quantified predation. The low survey mortalities in the most recent years, even with “impossible” negative values, could partly be caused by fish gradually “growing into” the covered area at increasing age. In 2017, the estimated mortalities increased to the same high levels as observed before 2001, while in 2018 estimated mortalities were negative for ages 2-7. The 2017 coverage in area D’ and E was not complete, and the indices were raised (extrapolated) by the “index ratio by age” observed for the same area in 2014-2016. However, in 2018 the coverage was even better than in 2014-2016, and the 2017 indices may have been underestimated compared to 2018.

The observed mortality rates in the acoustic investigations have been more variable, and the rates in 2017 were lower than in 2016 and mainly negative in 2018. This might be caused by changes in fish behaviour and how available the fish is for acoustic registration.

Table 5.9 COD. Length (cm) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2019. + indicates few samples.

Age/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	11.3	17.9	30.2	44.6	55.1	65.5	73.8	78.5	87.5	97.9	97.7	100.8	122.1	-
1995	12.2	18.0	28.8	42.1	54.0	63.7	75.7	80.2	83.9	99.1	+	109.0	-	-
1996	12.1	18.9	28.7	40.6	49.3	60.9	71.7	84.8	92.2	92.2	99.5	104.6	108.7	121.0
1997[1]	10.9	15.9	26.8	39.9	49.5	59.2	69.9	81.6	91.8	+	+	-	-	-
1998[1]	9.8	18.0	29.3	40.0	50.9	58.9	67.7	76.7	87.4	+	+	-	+	-
1999	12.0	18.3	29.0	39.9	50.4	59.4	70.4	78.5	88.7	88.4	+	+	+	-
2000	12.9	20.7	28.4	39.7	51.5	61.4	70.5	76.2	84.8	81.8	99.7	+	+	-
2001	11.6	22.6	33.0	41.1	52.2	63.3	70.2	77.7	86.0	96.2	103.8	-	-	-
2002	12.0	19.5	28.6	43.6	52.1	62.0	71.3	79.5	91.0	89.3	102.3	-	-	-
2003	11.4	18.0	28.9	39.4	53.4	61.7	70.6	80.8	89.1	90.6	104.5	-	105.8	111.6
2004	10.6	18.4	31.7	40.6	51.7	61.6	68.6	79.7	90.9	88.5	91.7	+	+	-
2005	11.2	18.3	29.5	43.5	51.1	60.3	71.0	79.6	88.9	96.2	109.4	+	+	+
2006	12.0	19.5	30.9	42.1	53.6	60.2	66.4	76.5	84.5	98.8	93.2	96.3	-	-
2007[1]	13.1	21.0	29.4	40.2	53.1	62.9	68.7	76.6	87.6	94.9	102.4	+	-	-
2008	12.1	22.4	33.1	43.2	51.7	64.1	69.0	81.3	88.4	94.6	108.9	+	+	-
2009	11.2	21.2	32.1	42.6	53.1	61.7	76.5	81.8	89.3	97.9	99.9	+	+	-
2010	11.2	18.2	31.5	42.7	52.4	60.7	70.6	80.4	88.5	96.2	102.7	+	+	+
2011	11.9	19.4	29.5	41.9	51.0	60.7	68.1	78.3	85.9	95.2	101.3	111.1	111.7	119.0
2012	10.6	18.4	29.7	41.0	52.4	58.0	66.5	75.7	86.0	91.4	106.2	113.4	119.7	+
2013	11.2	19.2	31.0	41.0	51.6	62.1	69.7	76.5	81.1	95.2	92.2	110.7	110.7	+
2014	9.8	17.3	29.1	40.1	51.8	59.5	70.3	77.0	81.9	87.1	96.7	98.1	110.5	+
2015	10.5	16.2	30.0	39.9	51.2	60.5	69.0	77.6	80.1	88.9	95.4	101.4	+	+
2016	12.2	18.5	29.9	40.6	50.0	60.6	68.3	76.7	85.6	86.0	90.0	92.6	111.8	122.2
2017	12.4	21.8	31.4	42.3	51.9	60.8	69.7	79.5	85.9	90.6	96.3	91.9	106.9	108.7
2018	11.2	18.6	31.9	42.2	51.1	61.5	68.9	77.6	83.7	87.9	97.0	98.8	100.1	105.8
2019	11.8	17.2	31.1	41.6	50.8	59.6	69.6	77.0	83.6	89.6	100.1	102.1	107.3	104.5

[1)] Adjusted lengths, REZ not covered

Table 5.10. COD. Weight (g) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2019. + indicates few samples.

Age/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1994	12	55	260	796	1463	2372	3477	4624	6782	8420	8530	13516	20786	-
1995	15	53	239	656	1341	2194	3628	4577	5315	8907	+	12176	-	-
1996	15	62	232	632	1079	1979	3327	5479	7655	8192	9760	13013	13614	14650
1997[1]	13	46	181	592	1097	1785	2917	4928	7290	+	+	-	-	-
1998[1]	8	50	256	608	1184	1749	2601	4040	6383	+	+	-	+	-
1999	14	58	231	588	1178	1827	2994	4123	6343	7326	+	+	+	-
2000	16	74	210	558	1210	1961	3042	3842	5384	5727	9960	+	+	-
2001	14	106	336	642	1288	2233	3090	4332	5727	8571	11022	-	-	-
2002	14	67	233	747	1225	2065	3189	4577	7472	6431	11645	-	-	-
2003	13	59	229	586	1313	2013	2982	4725	6511	7552	12467	-	12885	16112
2004	10	59	276	607	1142	1946	2618	4139	6684	6988	7957	+	+	-
2005	13	61	245	724	1145	1857	2953	4224	6418	8607	12488	+	+	+
2006	13	69	280	663	1413	1965	2599	4244	5783	10131	8620	10735	-	-
2007[1]	17	71	226	638	1370	2270	2918	4254	6556	8727	11130	+	-	-
2008	15	90	336	799	1410	2449	3144	5218	6793	9494	12918	+	+	-
2009	13	84	294	704	1293	2030	4061	5082	6884	9504	9614	+	+	-
2010	11	64	307	702	1297	2031	3165	4736	6501	9016	10417	+	+	+
2011	15	65	247	667	1129	1940	2725	4003	5914	8233	9888	13213	13814	+
2012	13	62	251	609	1278	1673	2480	3772	5923	7783	12298	14876	17868	+
2013	11	65	264	591	1201	2064	2804	3839	4814	8433	8759	15101	14729	+
2014	8	49	238	592	1234	1776	2849	3942	4946	6181	8368	9212	12578	+
2015	10	47	242	574	1250	1971	2760	4077	4621	6901	8096	11366	+	+
2016	13	54	239	602	1063	1952	2701	3855	5553	6034	6963	8061	15330	21950
2017	16	92	287	739	1253	2017	3092	4645	6088	7403	9186	8413	12416	14916
2018	12	66	305	687	1237	2074	2867	4180	5536	6793	9222	10497	11164	12268
2019	12	46	272	652	1157	1883	2916	3994	5303	6926	10034	11535	13243	11926

[1)] Adjusted weights, REZ not covered

Table 5.11. COD. Yearly weight increment (g) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

Year\Age	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1994-95	41	184	396	545	731	1256	1100	691	2125
1995-96	47	179	393	423	638	1133	1851	3078	2877
1996-97	31	119	360	465	706	938	1601	1811	-
1997-98	37	210	427	592	652	816	1123	1455	-
1998-99	50	181	332	570	643	1245	1522	2303	943
1999-00	60	152	327	622	783	1215	848	1261	-616
2000-01	90	262	432	730	1023	1129	1290	1885	3187
2001-02	53	127	411	583	777	956	1487	3140	704
2002-03	45	162	353	566	788	917	1536	1934	80
2003-04	46	217	378	556	633	605	1157	1959	477
2004-05	51	186	448	538	715	1007	1606	2279	1923
2005-06	56	219	418	689	820	742	1291	1559	3713
2006-07	58	157	358	707	857	953	1655	2312	2944
2007-08	73	265	573	772	1079	874	2300	2539	2938
2008-09	69	204	368	494	620	1612	1938	1666	2711
2009-10	51	223	408	593	738	1135	675	1419	2132
2010-11	54	183	360	427	643	694	838	1178	1732
2011-12	47	186	362	611	544	540	1047	1920	1869
2012-13	52	202	340	592	786	1131	1359	1042	2510
2013-14	38	173	328	643	575	785	1138	1107	1367
2014-15	39	193	336	658	737	984	1228	679	1955
2015-16	44	192	360	489	702	730	1095	1476	1413
2016-17	79	233	500	651	954	1140	1944	2233	1850
2017-18	50	213	400	498	821	850	1088	891	705
2018-19	34	206	347	470	646	842	1127	1123	1390

Table 5.12. COD. Survey mortality from surveys in the Barents Sea standard area winter 1994-2019.

	Age						
Year	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**
				Acoustic investigations				
1994-95	1.33	1.41	0.80	0.66	1.13	1.44	1.59	1.37
1995-96	2.09	0.68	0.47	0.18	0.87	1.07	1.99	2.21
1996-97	0.73	0.22	0.80	0.55	0.98	1.21	1.39	0.79
1997-98	1.63	0.64	-0.01	0.05	0.15	0.41	0.39	1.13
1998-99	2.45	1.30	1.20	1.40	1.36	1.84	1.97	2.40
1999-00	0.35	-0.28	-0.11	-0.10	0.06	-0.01	0.45	0.33
2000-01	1.03	0.33	0.62	0.73	1.21	1.47	1.95	2.25
2001-02	0.51	-0.21	0.53	0.50	0.42	0.78	1.34	1.75
2002-03	-1.04	-0.39	-0.66	-0.14	-0.19	0.31	0.77	0.48
2003-04	2.53	0.45	1.28	1.28	1.45	1.89	1.99	2.09
2004-05	0.18	-0.15	-0.05	0.21	0.46	0.64	1.29	1.73
2005-06	1.02	0.65	0.87	0.63	0.84	0.80	1.13	1.40
2006-07	1.93	0.91	0.59	0.51	0.65	0.46	0.38	0.57
2007-08	-0.03	-1.30	-1.52	-1.18	-0.81	-0.78	0.29	0.92
2008-09	0.74	-0.13	0.02	0.74	1.04	1.65	1.50	1.17
2009-10	1.54	0.06	0.19	0.17	-0.10	-0.12	-0.02	0.19
2010-11	2.06	0.07	-0.27	0.28	0.42	0.41	0.87	0.76
2011-12	1.70	0.01	-0.20	-0.20	-0.08	-0.24	0.53	0.86
2012-13	1.82	-0.27	0.03	-0.39	-0.36	-0.34	0.04	0.06
2013-14	0.64	-1.04	-0.67	-0.12	0.03	0.29	0.17	0.85
2014-15	1.69	0.34	0.22	-0.03	-0.30	-0.22	0.11	0.49
2015-16	2.36	1.12	0.58	0.62	0.62	0.97	1.30	1.04
2016-17	0.74	0.15	-0.04	0.43	0.50	0.61	0.74	0.75
2017-18	0.69	-0.61	-0.34	-0.24	-0.26	0.09	0.00	0.85
2018-19	1.64	0.19	-0.05	0.08	-0.13	0.43	0.57	0.13
				Bottom trawl investigations				
1994-95	0.66	0.67	0.20	0.20	0.68	0.96	1.25	0.83
1995-96	1.93	1.19	0.88	0.54	0.82	1.13	1.86	1.84
1996-97	1.43	0.90	0.86	0.44	0.84	1.42	1.61	1.49
1997-98	2.34	1.38	0.63	0.78	1.04	1.24	1.18	1.84
1998-99	1.96	0.95	0.67	1.00	0.91	1.35	1.22	2.13
1999-00	0.68	0.36	0.38	0.48	0.82	1.00	1.32	1.44
2000-01	0.50	0.29	0.24	0.47	1.08	1.04	1.38	1.40
2001-02	0.54	-0.42	0.28	0.58	0.56	0.96	1.48	1.25
2002-03	-0.58	0.09	-0.06	0.37	0.49	0.95	1.12	0.76
2003-04	2.55	-0.07	0.72	0.85	0.79	0.77	0.95	1.04
2004-05	0.40	-0.04	0.18	0.59	0.87	0.97	2.10	2.06
2005-06	1.09	0.63	0.76	0.67	0.86	0.47	1.15	1.04
2006-07	0.60	-0.25	-0.10	0.50	0.72	0.61	0.71	0.86
2007-08	1.73	0.65	0.20	0.10	0.52	-0.27	1.05	1.30
2008-09	0.66	-0.19	-0.02	0.32	0.69	0.85	0.76	0.45
2009-10	1.40	-0.04	0.08	0.23	0.41	0.38	0.45	0.82
2010-11	1.52	0.12	-0.32	-0.12	0.12	0.34	0.87	0.95
2011-12	1.60	-0.14	0.19	0.33	0.32	0.01	0.73	0.58
2012-13	1.60	0.57	-0.37	0.09	-0.12	0.37	0.58	0.39
2013-14	1.08	-0.20	-0.19	0.57	0.29	0.23	0.33	0.88
2014-15	0.93	0.17	0.06	-0.47	-0.39	-0.40	0.17	-0.12
2015-16	1.72	1.30	0.11	0.12	0.22	0.41	0.98	0.76
2016-17	1.09	0.70	0.30	0.84	0.98	1.37	1.25	1.25
2017-18	0.18	-0.42	-0.25	-0.15	-0.13	0.06	0.15	0.93
2018-19	1.33	0.44	-0.20	-0.24	-0.36	0.72	0.62	1.15

6 Distribution and abundance of haddock

6.1 Acoustic estimation

Like for cod it is expected that the survey best covers the immature part of the stock. This time of the year a large proportion of the mature haddock (age 6 and older) are on its spawning migration south-westwards out of the investigated area. In some earlier years, e.g. 2004 and 2005, concentrations of mature haddock have been observed pelagically rather far above bottom along the shelf edge. The bottom trawl sampling poorly covers these concentrations. There are indications that the distribution of age groups 1 and 2 in some years are concentrated in coastal areas not well covered by the survey. This occurred in the late 1990s and will have strongest effect on poor year-classes. In the later surveys, small haddock have been widely distributed, and the strong year-classes have been found unusually far to the north. Favourably hydrographic conditions and/or density dependent mechanisms might cause this. However, it is difficult to separate the two factors. Table 6.1 shows the acoustic abundance indices by age within the main areas. As in most of the previous years the highest abundance was observed in main area D. The time series (1994-2019) are presented in Table 6.2. The strong 2004-2006 year-classes can be followed through the time series. In later years, the 2009, 2011, and 2013-2017 year-classes seem to be fairly strong.

Table 6.3 shows indices for strata 24-26 in 2014-2019. The contribution from main area N was rather low in all years, except from age 1 in 2018, when 41% of the number of haddock < 20 cm found in the standard survey area was found in the extended area.

Table 6.4 presents estimated coefficients of variation (CV) for haddock age groups 1-14 in 1994-2019. These estimates were obtained by using StoX with a stratified bootstrap routine treating each transect as the primary sampling unit. In addition, a bootstrap routine for all trawl stations by strata was carried out within each run. The estimated CV (Standard Deviation · 100/mean) is estimated from 500 iterations and is strongly dependent on the choice of estimator for the indices. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years, CVs for age groups older than 7 years are above what could be considered as acceptable.

Table 6.1. HADDOCK. Abundance indices (numbers in millions) for the main areas of the Barents Sea from acoustic survey winter 2019 estimated by StoX software.

	Age group																
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass (‘000 t)**
A B C D D' E S																	
ABCD																	
AS																	
N																	
Total																	

Table 6.2. HADDOCK. Abundance indices (numbers in millions) from acoustic surveys in the Barents Sea standard area winter 1994-2019 estimated by StoX software.

	Age group															Biomass
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	('000 t)
1994	887.8	188.0	348.7	626.6	121.4	8.55	0.70	0.33	0.61	0.48	1.46	0.16	0	0	0	2184.8	643.5
1995	1198.2	88.6	41.5	121.5	395.4	47.6	2.80	0.05	0.12	0.03	0.00	0.54	0.14	0	0	1896.4	508.8
1996	132.6	94.5	30.0	22.1	68.7	143.7	5.67	0.94	0	0.01	0	0.02	0.04	0	0.0	498.2	248.3
1997[1]	508.9	26.5	57.3	22.2	15.5	56.1	62.8	4.68	0.07	0	0	0.01	0.05	0.06	0	754.1	217.2
1998[1]	211.0	151.0	33.8	58.8	24.2	7.70	14.1	20.7	1.44	0.02	0.04	0	0	0	0.12	522.8	152.1
1999	653.4	30.1	83.7	21.6	22.1	6.17	1.55	3.88	2.72	0.03	0	0.02	0	0	0	825.3	107.9
2000	1063.0	404.8	36.4	75.5	14.0	12.6	1.57	0.53	2.01	0.69	0.17	0.13	0.02	0	0	1611.5	189.8
2001	753.0	266.1	233.5	40.2	41.4	2.20	1.61	0.16	0.09	0.14	0.28	0.09	0.09	0	0.02	1338.8	206.5
2002	1315.2	267.9	255.2	201.8	18.5	11.7	1.59	0.29	0.03	0.13	0.26	0.09	0.05	0	0	2072.7	298.2
2003	2743.7	362.3	203.7	184.6	136.0	12.3	6.01	0.26	0.14	0.26	0.34	0.09	0.07	0	0	3649.8	444.5
2004	529.0	466.5	151.0	101.8	107.8	57.7	7.62	1.15	0.29	0.04	0.05	0.05	0.04	0.08	0	1423.2	323.0
2005	2276.5	144.0	221.3	115.7	57.4	56.7	12.7	0.38	0.32	0.01	0	0	0	0	0	2885.0	306.0
2006[2]	2091.1	624.8	56.3	123.8	47.4	19.3	13.6	3.23	0.08	0.15	0	0.03	0	0	0.09	2979.9	297.9
2007[1]	2015.7	953.5	209.3	46.1	80.6	28.9	10.00	5.05	2.26	0.30	0.18	0.00	0.00	0.00	0.05	3352.0	406.0
2008	778.4	1753.5	812.4	303.0	90.0	74.1	7.41	12.8	1.63	0.14	0.16	0.18	0	0	0	3833.8	920.4
2009	443.9	209.1	883.7	630.0	266.6	38.9	14.6	1.26	0.34	0.66	0.66	0	0.05	0	0	2489.0	865.4
2010	1559.4	86.0	128.1	631.0	604.0	167.0	12.1	2.94	0.96	0.99	0.10	0.06	0	0	0	3192.6	1035.9
2011	428.5	288.3	54.2	84.2	313.0	292.2	54.9	1.72	0.96	0.23	0	0.21	0.07	0	0	1518.4	712.1
2012[3]	1583.4	94.5	191.6	48.8	88.1	310.6	172.5	30.1	0.52	0.34	0.02	0.13	0	0	0	2520.8	814.6
2013	292.7	407.2	67.3	146.8	35.4	53.0	223.8	102.7	14.1	0.25	0	0	0	0	0	1343.2	759.6
2014	1703.7	109.0	324.5	38.2	107.9	22.4	33.8	84.5	35.3	1.46	0.50	0	0	0.01	0	2461.4	566.4
2015	1521.9	224.4	23.6	171.5	25.5	39.4	8.32	21.1	17.3	6.83	0.42	0.15	0	0	0	2060.5	339.5
2016	1260.3	105.4	68.5	11.8	56.0	11.8	16.6	6.86	15.5	11.9	2.43	0.48	0	0.03	0.02	1567.5	258.3
2017[3]	3263.8	323.2	79.9	62.8	4.4	32.2	5.84	7.01	1.50	6.43	5.48	2.01	0.44	0	0	3795.1	308.6
2018	2074.8	759.2	158.7	60.3	60.7	5.73	12.8	2.30	2.22	1.28	5.00	2.56	1.42	0.15	0	3147.1	355.8
2019	1472.7	663.5	490.6	142.0	29.7	21.2	4.45	3.38	0.97	1.49	0.42	0.46	0.33	0.20	0.08	2832.2	379.5

[1]Indices raised to also represent the Russian EEZ. [2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005
[3]Indices raised to also represent uncovered parts of the Russian EEZ.

Table 6.3. HADDOCK. Abundance indices (numbers in millions) for new strata 24-26 from acoustic surveys in the Barents Sea winter 2014-2019 estimated by StoX software.

	Age group																
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
2014	135.0	0.88	10.3	0.92	0.81	0.80	0.96	1.84	1.31	0.20	0.02	0	0	0	0	153.0	17.9
2015	71.2	22.2	0.71	17.9	1.10	6.77	0.90	1.31	4.01	3.03	0.14	0	0.09	0	0	129.4	48.2
2016	15.7	1.77	3.32	0.26	3.67	0.70	0.71	0.62	1.75	0.83	0.33	0	0	0	0	29.7	16.1
2017	80.1	8.20	1.23	2.28	0.40	2.60	0.40	0.92	0.29	0.64	0.61	0.33	0	0	0	98.0	18.1
2018	855.7	46.4	11.7	2.57	3.48	1.15	2.97	0.45	0.33	0.25	0.54	0.39	0.38	0	0	926.4	54.6
2019	67.5	25.5	16.2	6.1	1.2	1.00	0.14	0.12	0.06	0.06	0.04	0.08	0.03	0.03	0.01	118.1	17.9

Table 6.4. HADDOCK. Estimates of coefficients of variation (%) for acoustic abundance indices. Barents Sea standard area winter 1994-2019.

	Age group													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	11	12	10	9	12	21	44	53	39	55	31	103	-	-
1995	16	22	24	15	10	15	34	128	85	114	-	55	90	-
1996	20	27	31	23	16	15	22	44	-	120	-	98	108	-
1997[1]	12	17	14	16	16	12	14	33	53	-	-	121	63	74
1998[1]	14	15	15	13	14	21	17	15	50	107	109	-	-	-
1999	19	24	21	28	22	23	32	34	26	118	-	123	-	-
2000	9	9	21	12	18	17	28	45	30	39	72	102	104	-
2001	17	16	16	25	16	30	35	65	66	96	62	94	86	-
2002	8	10	12	10	16	16	29	51	111	69	60	53	71	-
2003	11	11	11	9	15	25	38	80	106	90	76	102	107	-
2004	37	23	23	30	33	17	21	26	45	65	65	86	64	66
2005	10	16	11	15	12	16	19	59	76	104	-	-	-	-
2006[2]	12	10	27	20	12	15	20	33	66	67	-	78	-	-
2007[1]	9	7	9	12	12	15	21	29	40	52	88	-	-	-
2008	13	10	10	10	21	24	29	62	94	263	84	137	-	-
2009	14	13	9	11	14	19	19	43	79	48	-	107	-	-
2010	15	17	10	10	9	13	27	34	49	49	108	92	-	-
2011	15	13	16	12	11	10	15	40	58	94	-	84	115	-
2012[2]	16	28	16	35	24	20	20	27	86	50	105	68	-	-
2013	14	13	22	11	22	16	13	15	26	59	-	-	-	-
2014	13	19	12	20	18	17	16	15	15	44	79	-	-	109
2015	14	17	24	13	23	21	27	23	20	55	64	65	-	-
2016	11	15	15	19	12	14	15	19	17	15	30	43	-	70
2017[2]	6	9	15	13	22	16	22	23	34	29	24	36	67	-
2018	8	8	9	13	17	29	22	29	34	30	27	28	54	81
2019	9	8	9	11	16	15	29	31	44	30	63	56	77	114

[1] REZ not covered

[2] REZ partly covered

6.2 Swept area estimation

Figures 6.1 - 6.4 show the geographic distribution of bottom trawl catch rates (number of fish per NM^2) for haddock size groups < 20 cm, 20-34 cm, 35-49 cm and ≥ 50 cm. Like in previous years (Mehl *et al*. 2013, 2014, 2015, 2016, 2017, 2018), the distribution extends further to the north and to the east than what was usual in the 1990s. To a certain degree, one can follow the high densities through the size groups, especially the northern and eastern distributions.

Table 6.5 presents the indices for each age group by main areas. The time series (1994-2019) are shown in Table 6.6. As with the acoustic indices, the strong 2004-2006 year-classes dominates bottom trawl indices. Overall, this survey tracks both strong and poor year-classes fairly well. In later years, the 2009, 2011 and 2013-2017 year-classes are stronger than the 2007, 2008, 2010 and 2012 year-classes. Compared to cod a lower proportion of haddock was found in the extended survey area (Table 6.7). This difference is most pronounced for the young ages. The extended area represents about **% of the numbers in the standard area and about **% of the biomass.

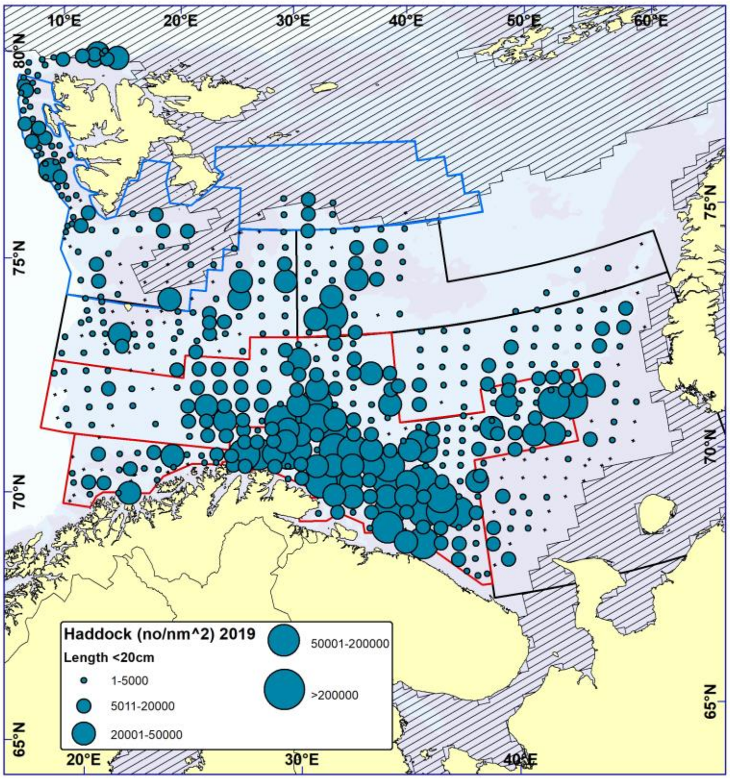

Figure 6.1. HADDOCK < 20 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

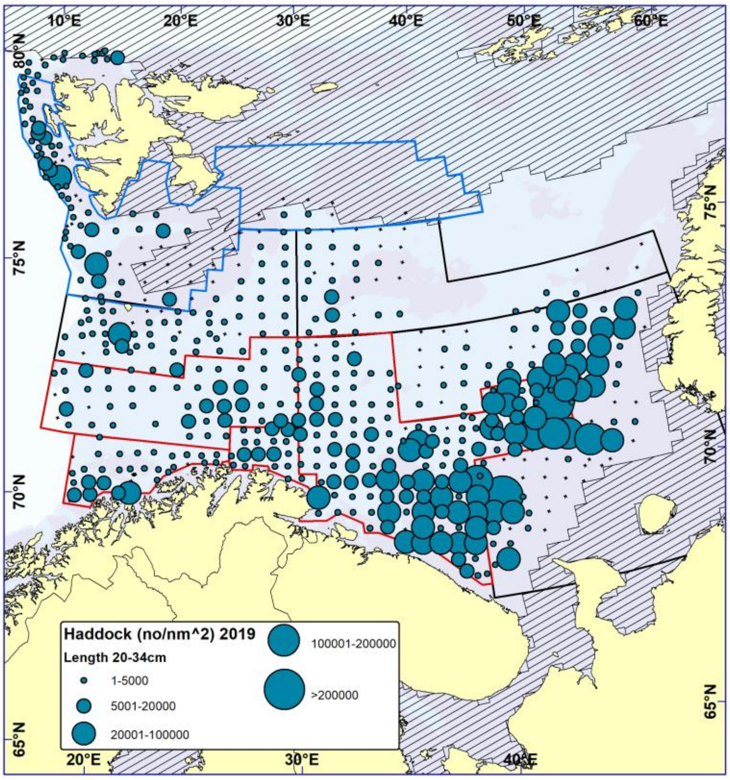

Figure 6.2. HADDOCK 20-34 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

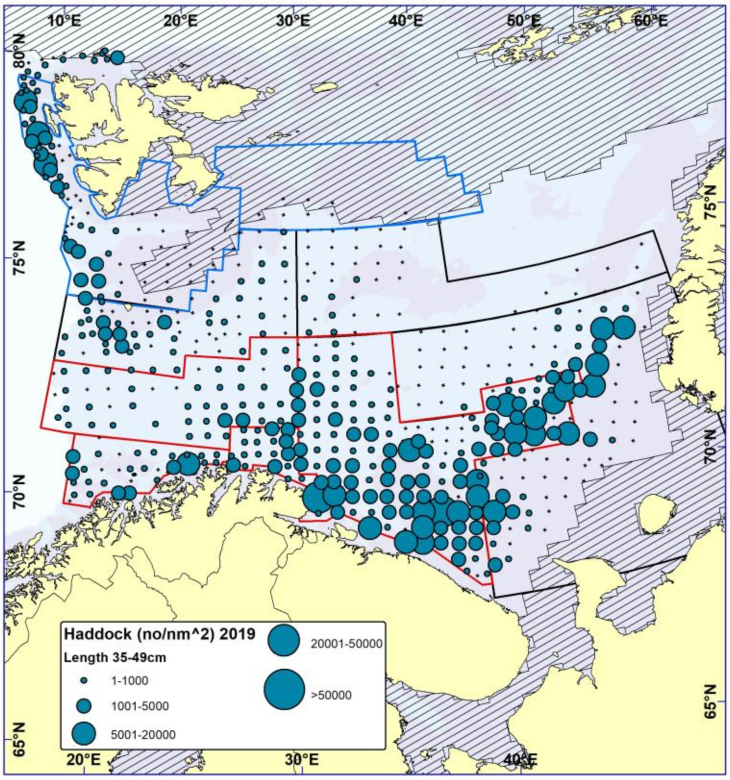

Figure 6.3. HADDOCK 35-49 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

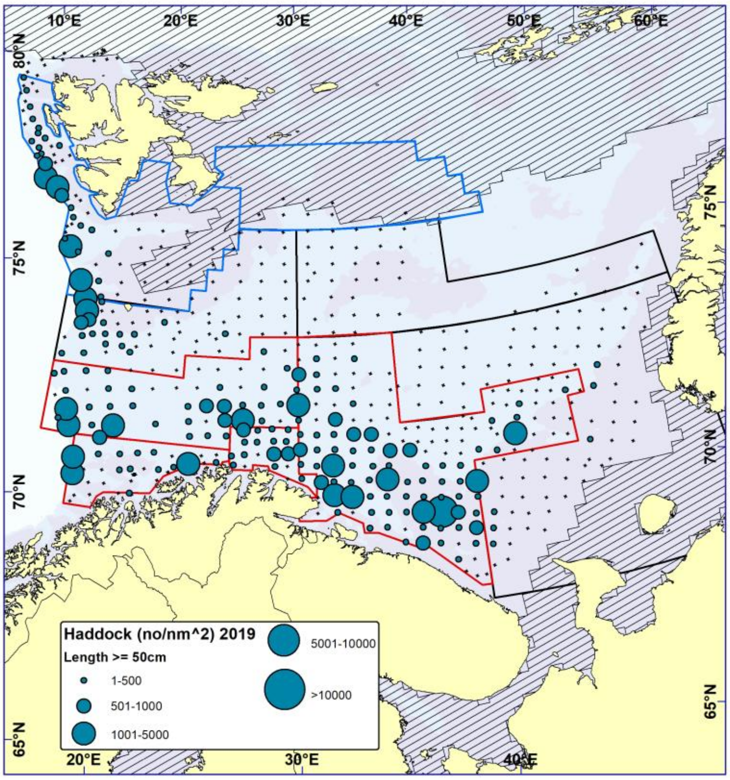

Figure 6.4. HADDOCK ≥ 50 cm. Distribution in valid bottom trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

Table 6.8 presents estimated coefficients of variation (CV) for haddock age groups 1-14 in 1994-2019. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years, CVs for age groups older than 7 years are above what could be considered as acceptable.

Table 6.5. HADDOCK. Abundance indices from bottom trawl hauls for main areas of the Barents Sea winter 2019 (numbers in millions).

	Age group																
Area	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass ('000 t)**
A																	
B																	
C																	
D																	
D'																	
E																	
S																	
ABCD																	
AS																	
N																	
Total																	

Table 6.6. HADDOCK. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

	Age group																Biomass
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**('000 t)**
1994	593.5	220.9	315.2	427.9	48.3	3.39	0.14	0.17	0.16	0.14	0.45	0.04	0	0	0	1610.4	402.5
1995	1392.8	182.1	57.6	163.0	338.4	28.8	1.87	0.03	0.04	0.04	0	0.25	0.11	0	0	2165.1	435.7
1996	295.5	245.0	55.5	32.5	161.0	250.9	18.3	1.11	0	0.01	0	0.03	0.03	0	0	1059.9	453.3
1997[1]	1068.7	93.5	80.9	39.6	18.2	61.4	87.3	3.22	0.08	0	0	0	0.03	0.02	0	1452.8	284.5
1998[1]	239.2	196.0	21.2	36.1	12.8	3.24	8.15	5.94	0.56	0.03	0.02	0	0	0	0.05	523.3	85.2
1999	1186.4	79.8	57.1	15.6	9.36	2.87	0.86	1.30	0.74	0.01	0	0.02	0	0	0	1354.2	85.5
2000	817.0	429.8	24.1	35.8	6.91	4.05	0.65	0.01	0.81	0.24	0.03	0.03	0.01	0	0	1319.5	123.3
2001	1215.5	450.0	291.8	26.1	22.7	1.73	0.78	0.06	0.06	0.05	0.16	0.10	0.02	0	0.01	2009.1	226.6
2002	1652.1	464.5	313.8	186.8	11.9	8.43	0.86	0.19	0	0.10	0.15	0.04	0.04	0	0	2638.9	307.0
2003	3254.4	481.3	337.8	175.1	72.3	5.04	1.73	0.12	0.09	0.09	0.09	0.01	0.01	0	0	4328.1	408.3
2004	705.1	707.3	174.9	99.3	77.7	50.9	7.37	0.89	0.13	0.04	0.05	0.04	0.04	0.07	0	1824.2	307.5
2005	4400.9	369.6	315.7	140.1	50.9	61.7	10.2	0.25	0.08	0.01	0	0	0	0	0	5349.5	427.1
2006[2]	4879.2	1296.8	78.8	129.8	45.5	22.6	15.9	3.20	0.09	0.14	0	0.04	0	0	0.07	6470.4	449.1
2007[1]	3654.3	1679.9	459.1	81.0	84.8	26.1	5.38	2.23	1.35	0.77	0.07	0	0	0	0.03	5995.0	677.3
2008	831.1	2072.2	1578.8	581.3	52.9	54.0	7.05	10.6	0.16	0.04	0.08	0.05	0	0	0	5189.1	1099.2
2009	550.0	329.1	1237.3	760.1	372.3	25.8	12.3	0.85	0.09	0.34	0	0.01	0	0	0	3288.1	986.5
2010	1586.4	81.4	96.1	492.8	454.6	149.4	7.80	0.99	0.35	0.42	0.03	0.02	0	0	0	2870.5	760.6
2011	670.9	354.4	52.6	125.7	472.5	293.6	66.3	1.45	1.11	0	0	0.14	0.03	0	0	2038.6	834.4
2012[3]	1844.8	137.3	321.6	29.1	76.1	270.9	156.4	24.5	2.64	0.31	0.04	0.07	0	0	0	2863.7	747.2
2013	335.7	480.2	55.5	146.0	20.9	34.2	193.8	68.6	6.00	0.08	0	0	0	0	0	1340.9	602.3
2014	1129.0	119.8	370.6	30.3	100.4	21.9	46.5	95.2	40.0	1.52	0.46	0	0	0.02	0	1955.7	631.3
2015	1071.7	315.2	30.2	176.7	44.1	35.6	13.6	18.3	27.7	7.76	0.28	0.13	0	0	0	1741.2	373.2
2016	2202.8	509.2	152.7	32.9	105.8	19.6	40.0	10.3	27.5	24.7	4.04	0.92	0	0.14	0.06	3130.8	518.8
2017[3]	4676.6	734.6	127.5	95.8	4.32	45.1	8.72	13.0	1.20	8.02	5.94	3.18	0.72	0	0	5742.8	485.2
2018	2690.3	1608.3	321.2	84.0	61.0	5.57	11.9	2.75	2.01	1.33	3.95	3.46	0.82	0.13	0.0	4796.8	497.6
2019	1791.0	1076.2	1038.3	179.7	45.9	15.8	3.78	2.79	0.69	0.97	0.14	0.29	0.17	0.01	0.03	4155.8	567.4

[1]Indices raised to also represent the Russian EEZ. [2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005
[3]Indices raised to also represent uncovered parts of the Russian EEZ.

Table 6.7. HADDOCK. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

	Age group															Biomass ('000 t)
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	
2014	125.6	1.21	12.4	0.68	2.22	0.12	3.38	1.16	0.75	0.07	0.03	0	0	0	0	147.6	20.8
2015	48.0	17.4	0.32	13.1	0.46	4.30	0.88	0.56	3.51	2.16	0.05	0	0.02	0	0	90.8	34.4
2016	41.4	4.51	10.1	0.52	9.68	2.45	1.36	2.41	4.87	3.13	0.36	0	0	0	0	80.8	45.7
2017	191.3	15.6	3.79	5.80	2.18	7.56	0.80	2.03	1.06	1.85	2.41	0.72	0	0	0	235.0	51.2
2018	1141.1	66.1	17.9	3.20	5.03	2.27	3.66	0.90	0.54	0.36	0.72	0.48	0.56	0	0	1242.8	78.0
2019	115.3	45.6	30.1	7.74	3.03	1.13	0.15	0.15	0.03	0.07	0.05	0.06	0.04	0.04	0.02	203.4	29.9

Table 6.8. HADDOCK. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

	Age group													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	12	13	13	13	15	25	47	45	34	61	39	100	-	-
1995	12	19	28	29	16	21	38	181	75	97	-	58	97	-
1996	14	12	11	26	29	25	60	64	-	98	-	95	96	-
1997[1]	12	34	13	15	17	21	18	57	55	-	-	-	65	92
1998[1]	15	13	13	14	16	25	18	16	35	107	106	-	-	-
1999	15	37	14	24	21	23	25	31	22	88	-	97	-	-
2000	9	11	21	10	18	14	32	51	32	35	65	91	105	-
2001	11	15	11	18	11	40	34	46	59	51	47	86	62	-
2002	9	12	11	12	19	17	27	44	-	57	52	54	80	-
2003	18	26	25	12	11	20	35	62	60	69	56	91	93	-
2004	10	12	16	14	11	12	28	26	43	56	56	94	59	51
2005	9	16	11	19	13	22	15	71	48	93	-	-	-	-
2006[2]	14	14	18	12	13	16	20	30	44	70	-	63	-	-
2007[1]	11	7	10	20	12	12	24	25	46	51	58	-	-	-
2008	12	18	17	17	20	29	29	80	45	81	67	88	-	-
2009	13	21	16	17	19	19	33	25	91	68	-	94	-	-
2010	11	17	18	23	21	22	24	32	49	64	126	150	-	-
2011	10	10	16	25	17	13	18	33	73	-	-	83	84	-
2012[2]	20	29	16	17	14	12	15	34	73	47	83	62	-	-
2013	12	12	15	15	28	25	28	14	26	49	-	-	-	-
2014	9	24	14	19	17	22	21	17	24	41	62	-	-	99
2015	8	13	26	12	40	14	27	19	21	32	44	50	-	-
2016	22	26	15	46	11	17	20	16	17	21	29	46	-	62
2017[2]	5	13	16	13	21	15	21	31	31	22	27	45	77	-
2018	6	17	14	12	10	20	17	21	19	21	20	23	40	52
2019	10	11	16	14	29	11	38	21	31	28	40	39	45	92

[1] REZ not covered
[2] REZ partly covered

6.3 Growth and survey mortalities

Tables 6.9 and 6.10 present the time series (1994-2019) for mean length and mean weight at age for the standard area. Length estimates have been variable with no specific trends in the latest years. However, the variation is less than what it has been in earlier periods. Weight estimates also show less variation in later years. Annual weight increments are shown in Table 6.11, these are highly variable and show no trends.

Survey mortalities based on the acoustic indices (Table 6.12) have varied between years, and for most age groups there are no obvious trends. However, there are signs of co-variability within years. Survey mortalities based on the bottom trawl indices increased considerably from 2016 to 2017 to among the highest in the ten last years, but decreased somewhat from 2017 to 2018.

Table 6.9. HADDOCK. Length (cm) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2019. + indicates few samples.

Age/ Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	14.5	20.1	29.4	38.0	47.6	54.3	61.7	65.2	70.7	64.4	64.6	72.0	-	-
1995	15.1	18.4	28.7	34.0	42.8	51.0	59.6	60.0	67.2	68.0	-	64.7	78.6	-
1996	15.3	20.9	28.0	37.0	41.3	47.2	53.8	58.7	-	76.0	-	74.0	75.0	-
1997[1]	15.8	19.4	27.0	33.5	40.5	46.9	47.6	53.3	62.0	-	-	-	75.6	78.0
1998[1]	14.1	19.6	28.9	34.2	41.6	46.5	50.3	52.8	58.2	72.1	65.0	-	-	-
1999	14.3	18.0	32.3	38.6	46.5	51.9	56.1	55.1	58.8	62.0	-	72.0	-	-
2000	15.5	21.7	29.9	42.0	47.1	51.1	52.7	59.3	59.4	62.0	63.3	+	+	-
2001	14.6	22.1	32.1	37.6	48.0	50.1	59.2	55.0	64.9	66.3	67.7	+	+	-
2002	15.0	20.9	29.2	39.8	45.6	51.5	58.0	58.6	-	62.0	64.4	67.7	70.1	-
2003	15.8	24.0	26.4	36.5	45.8	49.8	54.5	61.2	62.6	60.3	66.0	70.0	+	-
2004	14.1	22.1	30.1	35.7	42.7	49.9	49.6	58.8	63.3	73.6	75.7	+	+	+
2005	14.8	20.6	29.9	36.1	40.4	48.4	51.5	56.2	60.8	67.0	-	-	-	-
2006	14.4	22.1	30.7	37.9	43.3	47.3	50.7	56.6	60.5	69.9	-	+	-	-
2007[1]	15.2	23.5	28.2	31.2	43.5	43.9	50.0	58.0	58.1	+	62.0	-	-	-
2008	15.7	23.7	29.6	37.9	42.7	46.0	52.9	52.5	58.5	+	63.3	63.0	-	-
2009	14.2	22.6	29.7	35.5	41.8	48.1	48.9	56.4	65.0	62.3	-	62.0	-	-
2010	14.4	19.8	30.6	36.8	40.8	45.1	49.9	59.9	58.9	62.3	+	66.5	-	-
2011	13.6	23.3	28.5	39.5	42.9	46.1	48.2	62.7	+	-	-	63.3	+	-
2012	14.6	19.2	31.6	35.1	43.7	47.1	50.2	50.8	47.6	65.0	67.0	72.0	-	-
2013	14.5	22.8	30.0	40.9	42.8	48.6	52.3	52.8	55.6	67.3	-	-	-	-
2014	15.5	18.6	31.9	39.0	46.5	52.7	53.5	55.3	54.9	60.3	59.2	-	-	75.0
2015	14.5	20.4	26.1	39.8	45.3	52.6	53.4	57.6	56.9	60.2	59.6	67.4	-	-
2016	14.8	18.5	30.7	35.8	47.8	53.0	56.0	58.4	61.0	60.4	59.8	64.5	-	72.0
2017	15.8	20.6	30.4	39.7	49.4	52.7	55.8	60.4	59.8	63.0	62.1	63.9	69.0	-
2018	14.3	22.1	30.4	39.5	47.6	54.1	57.7	61.1	64.3	66.0	64.4	63.4	67.1	68.6
2019	14.8	21.5	29.7	37.0	46.0	52.5	52.9	60.4	64.5	65.8	67.4	68.1	69.5	75.0

[1)] Adjusted lengths, REZ not covered

Table 6.10. HADDOCK. Weight (g) at age from bottom trawl surveys in the Barents Sea standard area winter 1994-2019. + indicates few samples.

Age/ Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1994	25	87	248	539	1056	1601	2201	2846	3439	2680	2712	3890	-	-
1995	30	71	221	380	775	1331	2005	2070	2685	2905	-	2502	3972	-
1996	32	93	218	472	668	1020	1537	1768	-	4630	-	4018	3626	-
1997[1]	35	85	188	329	619	1034	1064	1532	2474	-	-	-	3731	4130
1998[1]	24	89	232	416	815	1032	1298	1559	2006	3740	3040	-	-	-
1999	27	75	335	570	1022	1435	1791	1722	2011	2440	-	3525	-	-
2000	32	110	275	736	1061	1366	1521	2123	2239	2588	2741	+	+	-
2001	28	107	337	581	1145	1402	2147	1896	2903	3110	2965	+	+	-
2002	30	85	245	618	940	1375	1940	2048	-	2352	2670	3252	3497	-
2003	36	129	192	490	958	1209	1479	1933	2479	2533	3055	3470	+	-
2004	23	98	271	456	750	1162	1204	1958	2658	3926	4157	+	+	+
2005	29	98	261	474	666	1093	1372	1976	2120	2730	-	-	-	-
2006	25	109	302	561	810	1083	1358	1917	2102	3991	-	+	-	-
2007[1]	30	114	246	356	894	956	1388	2135	2508	+	2959	-	-	-
2008	32	113	245	553	832	1080	1573	1417	2120	+	2280	2840	-	-
2009	26	96	225	442	747	1147	1275	1726	2377	2563	-	2594	-	-
2010	27	87	270	466	658	949	1260	1897	2143	2512	+	3184	-	-
2011	21	117	220	520	727	939	1163	2285	+	-	-	+	2805	-
2012	28	73	305	432	816	1015	1285	1282	1219	2683	2980	3264	-	-
2013	24	113	272	644	783	1130	1350	1495	1836	3098	-	-	-	-
2014	32	68	357	611	1014	1424	1551	1677	1671	2141	2184	-	-	4800
2015	23	88	201	588	848	1423	1465	1921	1834	2078	2256	3133	-	-
2016	27	74	282	458	1057	1457	1752	2078	2280	2266	2404	2843	-	3555
2017	33	95	290	621	1220	1520	1785	2280	2309	2610	2594	2789	3369	-
2018	25	97	273	625	1040	1637	1941	2327	2697	2853	2667	2577	2997	3369
2019	25	90	242	507	965	1407	1558	2059	2712	2941	3001	3404	3412	3980

1) Adjusted weights, REZ not covered

Table 6.11. HADDOCK. Yearly weight increment (g) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

Year\Age	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
1994-95	46	134	132	236	275	404	-131	-161	-534
1995-96	63	147	251	288	245	206	-237	-	1945
1996-97	53	95	111	147	366	44	-5	706	-
1997-98	54	147	228	486	413	264	495	474	1266
1998-99	51	246	338	606	620	759	424	452	434
1999-00	83	200	401	491	344	86	332	517	577
2000-01	75	227	306	409	341	781	375	780	871
2001-02	57	138	281	359	230	538	-99	-	-551
2002-03	99	107	245	340	269	104	-7	431	-
2003-04	62	142	264	260	204	-5	479	725	1447
2004-05	75	163	203	210	343	210	772	162	72
2005-06	80	204	300	336	417	265	545	126	1871
2006-07	89	137	54	333	146	305	777	591	-
2007-08	83	131	307	476	186	617	29	-15	-
2008-09	64	112	197	194	315	195	153	960	443
2009-10	61	174	241	216	202	113	622	417	135
2010-11	90	133	250	261	281	214	1025	-	-
2011-12	52	188	212	296	288	346	119	-1066	-
2012-13	85	199	339	351	314	335	210	554	1879
2013-14	44	244	339	370	641	421	327	176	305
2014-15	56	133	231	237	409	41	370	157	407
2015-16	51	194	257	469	609	329	613	359	432
2016-17	68	216	339	762	463	328	528	231	330
2017-18	64	178	335	419	417	421	542	417	544
2018-19	65	145	234	340	367	-79	118	385	244

Table 6.12. HADDOCK. Survey mortality from surveys in the Barents Sea standard area winter 1994-2019.

Year	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**6-7**	**7-8**	**8-9**
			Acoustic investigations					
1994-95	2.30	1.51	1.05	0.46	0.94	1.12	2.64	1.01
1995-96	2.54	1.08	0.63	0.57	1.01	2.13	1.09	-
1996-97	1.61	0.50	0.30	0.35	0.20	0.83	0.19	2.60
1997-98	1.21	-0.24	-0.03	-0.09	0.70	1.38	1.11	1.18
1998-99	1.95	0.59	0.45	0.98	1.37	1.60	1.29	2.03
1999-00	0.48	-0.19	0.10	0.43	0.56	1.37	1.07	0.66
2000-01	1.38	0.55	-0.10	0.60	1.85	2.06	2.28	1.77
2001-02	1.03	0.04	0.15	0.78	1.26	0.32	1.71	1.67
2002-03	1.29	0.27	0.32	0.39	0.41	0.67	1.81	0.73
2003-04	1.77	0.88	0.69	0.54	0.86	0.48	1.65	-0.11
2004-05	1.30	0.75	0.27	0.57	0.64	1.51	3.00	1.28
2005-06	1.29	0.94	0.58	0.89	1.09	1.43	1.37	1.56
2006-07	0.79	1.09	0.20	0.43	0.49	0.66	0.99	0.36
2007-08	0.14	0.16	-0.37	-0.67	0.08	1.36	-0.25	1.13
2008-09	1.31	0.69	0.25	0.13	0.84	1.62	1.77	3.63
2009-10	1.64	0.49	0.34	0.04	0.47	1.17	1.60	0.27
2010-11	1.69	0.46	0.42	0.70	0.73	1.11	1.95	1.12
2011-12	1.51	0.41	0.10	-0.05	0.01	0.53	0.60	1.20
2012-13	1.36	0.34	0.27	0.32	0.51	0.33	0.52	0.76
2013-14	0.99	0.23	0.57	0.31	0.46	0.45	0.97	1.07
2014-15	2.03	1.53	0.64	0.40	1.01	0.99	0.47	1.59
2015-16	2.67	1.19	0.69	1.12	0.77	0.86	0.19	0.31
2016-17	1.36	0.28	0.09	0.99	0.55	0.70	0.86	1.52
2017-18	1.46	0.71	0.28	0.03	-0.26	0.92	0.93	1.15
2018-19	1.14	0.44	0.11	0.71	1.05	0.25	1.33	0.86
			Bottom trawl investigations					
1994-95	1.18	1.34	0.66	0.23	0.52	0.59	1.54	1.45
1995-96	1.74	1.19	0.57	0.01	0.30	0.45	0.52	-
1996-97	1.15	1.11	0.34	0.58	0.96	1.06	1.74	2.63
1997-98	1.70	1.48	0.81	1.13	1.73	2.02	2.69	1.75
1998-99	1.10	1.23	0.31	1.35	1.50	1.33	1.84	2.08
1999-00	1.02	1.20	0.47	0.81	0.84	1.49	4.45	0.47
2000-01	0.60	0.39	-0.08	0.46	1.38	1.65	2.38	-1.79
2001-02	0.96	0.36	0.45	0.79	0.99	0.70	1.41	-
2002-03	1.23	0.32	0.58	0.95	0.86	1.58	1.97	0.75
2003-04	1.53	1.01	1.22	0.81	0.35	-0.38	0.66	-0.08
2004-05	0.65	0.81	0.22	0.67	0.23	1.61	3.38	2.41
2005-06	1.22	1.55	0.89	1.12	0.81	1.36	1.16	1.02
2006-07	1.07	1.04	-0.03	0.43	0.56	1.44	1.96	0.86
2007-08	0.57	0.06	-0.24	0.43	0.45	1.31	-0.68	2.63
2008-09	0.93	0.52	0.73	0.45	0.72	1.48	2.12	4.77
2009-10	1.91	1.23	0.92	0.51	0.91	1.20	2.52	0.89
2010-11	1.50	0.44	-0.27	0.04	0.44	0.81	1.68	-0.11
2011-12	1.59	0.10	0.59	0.50	0.56	0.63	1.00	-0.60
2012-13	1.35	0.91	0.79	0.33	0.80	0.33	0.82	1.41
2013-14	1.03	0.26	0.61	0.37	-0.05	-0.31	0.71	0.54
2014-15	1.28	1.38	0.74	-0.38	1.04	0.48	0.93	1.23
2015-16	0.74	0.72	-0.09	0.51	0.81	-0.12	0.28	-0.41
2016-17	1.10	1.38	0.47	2.03	0.85	0.81	1.12	2.15
2017-18	1.07	0.83	0.42	0.45	-0.25	1.33	1.15	1.87
2018-19	0.92	0.44	0.58	0.60	1.35	0.39	1.45	1.38

7 Distribution and abundance of redfish

Earlier reports from this survey has presented distribution maps and abundance indices based on acoustic observations of redfish. In recent years, blue whiting has dominated the acoustic records in some of the main redfish areas. Due to incomplete pelagic trawl sampling the splitting of acoustic records between blue whiting and redfish has been very uncertain. The uncertainty relates mainly to the redfish, since it only makes up a minor proportion of the total value. This has been the case since the 2003 survey, and the acoustic results for redfish are therefore not included in the reports.

7.1 Golden redfish (*Sebastes norvegicus)*

Figure 7.1 shows the geographical distribution of golden redfish based on the catch rates in bottom trawl. In most years, the distribution is completely covered except towards northwest. Golden redfish was found in the extended survey area in 2014-2019, mainly west of Spitsbergen (strata 24). On average over all size groups about 16% of the amount found in the standard survey area by numbers was found in the extended area in 2019. Table 7.1 presents the time series (1994-2019) of swept area indices by 5 cm length groups for the standard area. The indices were low in many years since 1999 for all length groups. However, in 2016 and 2017 there was an increase in the indices of fish above 25 cm, and in 2018 the total index was at the same level as in 2017, while the total biomass was slightly lower. In 2019 the indices for fish between 35 and 50 cm increased further, and the total index and biomass were the highest since 1998. Table 7.2 present swept area abundance indices by length groups for new strata 24-26 in 2014-2019.

Table 7.3 presents estimates of coefficients of variation (%) by length groups. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years, except in 2018 and 2019, CVs for most length groups are above what could be considered as acceptable.

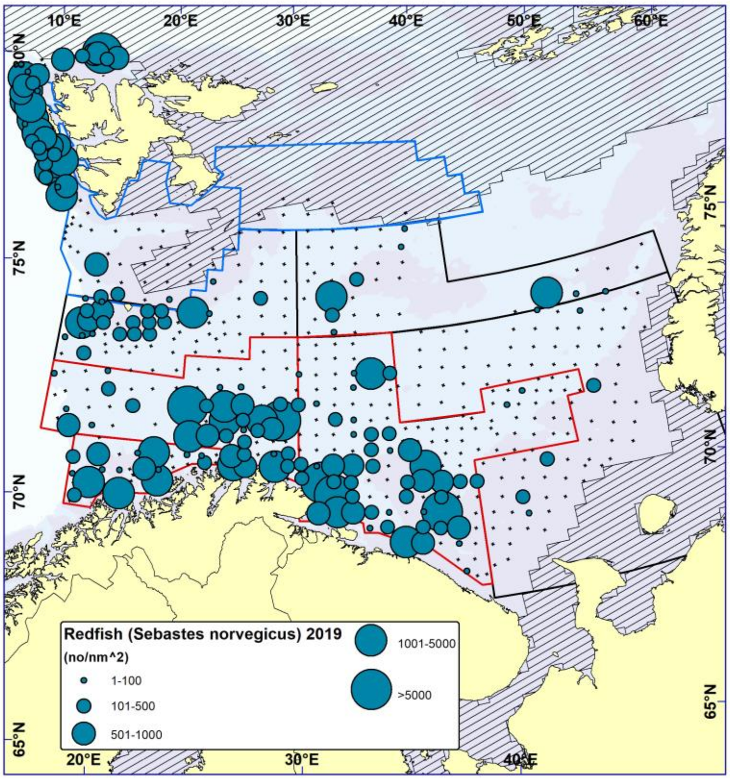

Figure 7.1. GOLDEN REDFISH (*Sebastes norvegicus)*. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

Table 7.1. GOLDEN REDFISH (S*ebastes norvegicus)*. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

Year	Length group (cm)												Total	Biomass (tons)
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	≥60		
1994	675	7493	10100	12840	10914	17834	10065	4799	1645	937	202	121	77623	31841
1995	387	4658	13515	13118	10398	15429	16223	10587	3112	852	455	148	88883	42151
1996	40	715	3291	5983	8863	14089	15709	7502	2692	893	168	165	60010	35775
1997[1]	0	500	1197	2809	6522	22751	28797	8235	1747	1092	239	97	73985	44977
1998[1]	51	4525	2043	10795	73085	30862	14707	6984	1712	456	142	0	145363	49253
1999	181	928	2070	4002	4351	6275	6143	5474	2618	738	75	0	32854	20330
2000	533	1122	1506	4196	4895	5146	3611	1908	620	466	89	0	24092	10946
2001	55	411	398	2452	5802	5463	4509	3239	1154	343	96	37	23960	13896
2002	133	1053	2043	1854	3955	4204	3335	3654	1656	619	192	28	22726	13242
2003	0	478	1303	1538	4192	4081	2765	3204	1996	548	123	327	20554	13399
2004	700	195	420	973	2842	4365	5404	3858	2281	562	140	45	21786	15758
2005	0	119	203	362	1110	2090	3849	4664	2730	1276	299	128	16831	16389
2006[2]	0	0	0	178	2495	5534	6307	4155	3179	950	124	12	22934	18790
2007[1]	0	97	453	214	772	1526	2823	4275	2742	1194	197	58	14351	14553
2008	1736	2540	201	171	440	710	1969	2547	3049	1231	157	19	14768	12647
2009	0	0	86	0	39	436	1745	3779	4200	1959	267	101	12728	17237
2010	372	2017	1168	527	136	60	833	1062	2073	1596	205	128	10175	9787
2011	342	3187	2068	288	402	125	274	2329	3030	1912	131	243	14332	13302
2012[3]	805	4375	3995	1835	550	316	881	3645	4083	1775	320	85	22664	16011
2013	75	7418	4896	3952	1550	355	878	821	1284	1594	384	451	23658	11456
2014	128	1043	1440	3005	3363	1023	507	1427	2139	1176	633	193	16077	12087
2015	139	881	1467	3019	2603	2013	458	720	1237	1216	874	82	14710	10120
2016	748	1291	1484	2396	4290	3673	3391	1658	2147	2307	1114	250	24749	19847
2017[3]	341	1304	898	1065	4462	9060	6661	2980	2087	1776	604	498	31735	25050
2018	1129	2750	1799	1678	3282	4693	6335	4323	2012	1630	715	299	30645	22871
2019	671	3212	1700	2409	2515	3910	9024	9693	6709	1544	477	415	42279	36241

[1] Indices raised to also represent the Russian EEZ
[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005
[3]Indices not raised to also represent uncovered parts of the Russian EEZ.

Table 7.2. GOLDEN REDFISH (S*ebastes norvegicus)*. Abundance indices (numbers in thousands) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

Year	Length group (cm)									Total	Biomass (tons)
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45		
2014	35	333	358	1440	2594	1315	211	501	379	7166	2913
2015	0	202	197	127	804	804	363	0	154	2651	1261
2016	0	0	103	300	597	1186	828	107	32	3151	1405
2017	0	66	93	587	519	679	547	96	66	2654	1053
2018	58	824	750	647	639	964	1855	546	50	6331	2598
2019	76	974	1445	567	666	1446	1043	519	112	6838	2525

Table 7.3. GOLDEN REDFISH (S*ebastes norvegicus)*. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

	Length group (cm)										
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**
1994	51	42	22	27	18	34	13	29	20	23	40
1995	47	39	38	31	16	33	31	33	21	22	34
1996	68	51	47	25	16	27	25	20	16	24	46
1997[1]	-	40	30	28	20	64	71	37	14	19	34
1998[1]	67	28	25	56	82	64	48	42	27	28	44
1999	62	38	37	35	33	25	33	59	57	29	70
2000	46	27	21	24	22	28	28	26	22	21	56
2001	53	28	31	24	31	27	38	50	29	26	45
2002	54	61	51	25	29	23	28	39	49	26	41
2003	-	29	34	34	27	23	16	20	27	36	70
2004	72	38	26	32	35	54	52	26	30	22	54
2005	-	73	46	32	20	25	31	22	23	34	65
2006[2]	-	-	-	46	46	45	37	30	22	18	43
2007[1]	-	69	61	56	31	21	23	27	23	17	32
2008	33	30	41	60	42	27	22	23	17	24	64
2009	-	-	69	-	73	31	30	24	23	24	29
2010	54	31	45	51	41	70	31	34	17	19	31
2011	45	37	23	48	30	55	40	66	44	33	48
2012[2]	38	41	21	21	35	40	28	40	45	29	43
2013	55	40	27	17	22	45	38	39	38	27	44
2014	61	35	31	22	21	26	37	35	28	26	26
2015	64	44	33	29	26	24	30	36	27	18	37
2016	50	28	22	24	26	25	19	23	28	20	29
2017[2]	100	40	45	31	33	71	40	32	31	41	30
2018	37	24	19	25	20	17	22	19	23	21	24
2019	43	33	22	27	21	19	22	32	32	19	36

[1] REZ not covered

[2] REZ partly covered

7.2 **Beaked redfish** (*Sebastes mentella)*

The coverage of beaked redfish (Figure 7.2) was not complete west and north of Spitsbergen. About 3% of the amount found in the standard survey area by numbers was found in the extended survey area in 2019, which is less than what was found in previous years. Table 7.4 presents the time series (1994-2019) of swept area abundance indices by 5 cm length group in the standard area, while table 7.5 present indices for new strata 24-26 in 2014-2019. In 2015 and 2016, the estimated indices for 20-39 cm beaked redfish were among the highest in the time series, and in 2017 the indices for 30-39 cm beaked redfish were the highest in the time series, as were the total index and total biomass. The indices for most length groups decreased somewhat from 2017 to 2018 and remained at about the same level in 2019.

Table 7.6 presents estimates of coefficients of variation (%) by length groups. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years, CVs for length groups between 10 and 29 cm are at a level that could be considered as acceptable, and in most recent years up to 44 cm.

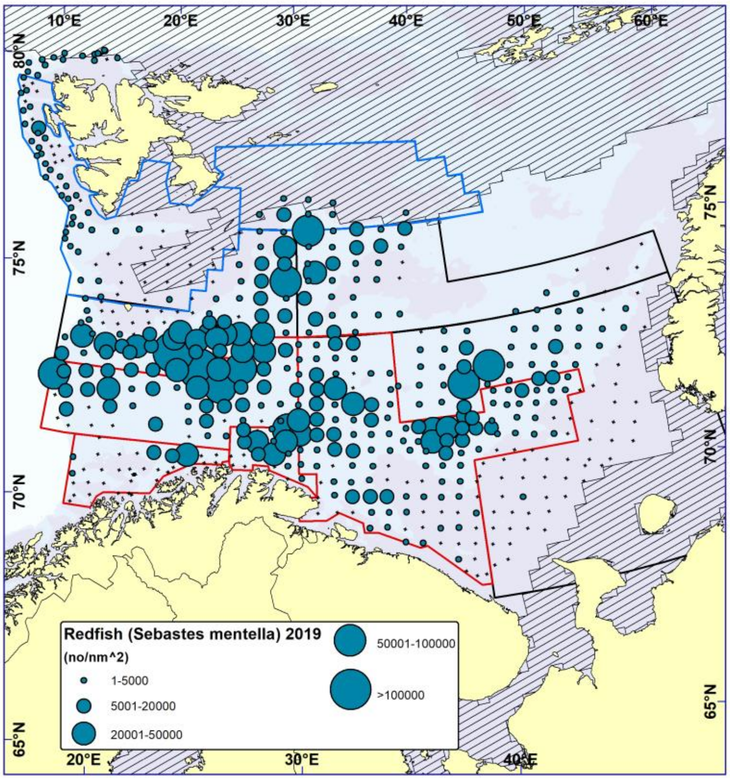

Figure 7.2. BEAKED REDFISH (*Sebastes mentella)*. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

Table 7.4. BEAKED REDFISH *(Sebastes mentella)*[1]. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	≥45	Total	Biomass ('000 t)
1994	8.3	295.7	479.4	488.4	74.4	74.4	17.1	2.6	0.1	1440.4	161.2
1995	310.1	83.9	570.6	390.5	82.7	57.7	23.9	2.8	0.4	1522.5	153.0
1996	214.6	101.5	198.5	342.9	136.0	42.0	16.6	1.4	0.2	1053.8	127.9
1997[2]	64.6	118.45	22.0	242.4	258.2	70.2	39.1	4.4	0.1	819.4	165.3
1998[2]	1.0	88.0	62.4	101.4	203.2	40.0	12.9	1.7	0.2	510.7	96.1
1999	2.1	6.8	69.5	36.8	171.2	73.9	21.8	3.2	0.7	385.4	98.8
2000	9.2	12.9	40.2	78.0	142.2	94.8	24.5	7.0	1.5	410.3	111.5
2001	9.8	23.1	7.2	56.8	78.8	74.7	9.6	0.6	0.1	260.8	65.3
2002	16.5	7.5	19.3	36.5	96.2	116.7	23.9	1.4	0.03	318.1	90.2
2003	3.8	4.1	10.3	12.6	70.4	198.1	45.9	5.7	0.3	351.1	139.4
2004	2.2	3.0	6.9	18.5	32.8	86.3	31.6	1.9	0.8	183.4	68.4
2005	0	6.3	7.4	10.7	28.4	153.7	86.2	3.8	0.2	296.6	131.3
2006[3]	100.0	1.9	9.6	14.6	22.8	103.8	82.8	2.7	0.7	338.8	108.2
2007[2]	374.2	121.8	2.8	6.7	12.3	121.0	120.7	7.1	0	766.7	136.6
2008	858.2	359.1	26.8	4.6	11.5	103.6	165.4	4.7	0.1	1533.9	169.3
2009	95.3	324.7	135.5	5.4	8.8	67.1	162.6	5.8	0.4	805.7	155.1
2010	652.2	276.0	214.7	64.2	7.1	73.6	191.3	5.9	0.4	1485.4	198.1
2011	501.6	229.7	212.5	149.0	14.1	46.6	157.3	4.9	0.2	1315.8	177.8
2012[4]	129.4	280.1	86.4	125.3	47.3	14.4	153.9	17.7	0.2	854.7	170.7
2013	249.6	226.6	245.4	159.2	143.2	35.2	193.3	27.1	0.3	1279.8	242.2
2014	90.7	175.3	250.1	113.7	124.6	50.6	115.1	13.8	0.2	934.1	170.2
2015	175.2	110.7	216.2	302.2	289.8	214.8	170.9	18.1	0.2	1498.0	344.6
2016	615.1	105.3	148.6	331.5	213.1	162.7	123.6	14.1	0.6	1714.6	262.5
2017[5]	603.6	201.9	70.4	198.5	286.9	308.9	231.5	10.6	0.23	1914.9	403.9
2018	189.9	253.3	83.2	110.1	191.3	270.4	216.6	22.6	1.14	1338.5	348.6
2019	42.4	294.4	270.0	92.0	158.1	255.1	210.8	20.0	2.63	1343.2	340.3

[1] Includes unidentified _Sebastes_ specimens, mostly less than 10cm
[2] Indices raised to also represent the Russian EEZ
[3] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005
[4] Indices not raised to represent uncovered parts of the Russian EEZ
[5]Indices raised to also represent uncovered parts of the Russian EEZ

Table 7.5. BEAKED REDFISH (*Sebastes mentella)*[1]. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	>45	Total	Biomass ('000 t)
2014	19.6	9.19	11.5	6.80	5.43	1.67	2.31	0.36	0	56.9	5.5
2015	13.5	5.51	8.27	11.3	11.4	5.23	3.43	0.12	0.03	58.9	9.4
2016	54.6	3.10	2.17	4.48	4.82	4.15	1.42	0.34	0	75.0	4.5
2017	81.9	13.1	1.32	4.45	6.01	6.44	3.59	0.60	0.03	117.4	7.8
2018	47.9	74.0	2.33	1.76	4.58	5.91	5.83	0.63	0	143.0	8.6
2019	10.9	10.1	7.02	0.71	1.38	1.32	2.07	0.18	0.03	33.7	3.0

[1] Includes unidentified _Sebastes_ specimens, mostly less than 10cm

Table 7.6. BEAKED REDFISH (*Sebastes mentella*)[1]. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

Year	Length group (cm)								
	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
1994	40	14	25	28	20	23	26	49	53
1995	18	25	23	25	17	20	18	34	39
1996	18	23	27	22	19	36	23	37	58
1997[2]	18	15	13	11	14	17	26	53	53
1998[2]	28	16	21	14	17	16	21	31	77
1999	20	17	15	11	18	22	29	56	65
2000	16	12	17	12	16	21	31	64	76
2001	17	14	14	12	13	19	17	26	67
2002	57	13	15	18	16	21	19	31	65
2003	56	17	18	17	18	27	27	43	88
2004	19	15	15	19	16	14	18	21	59
2005	-	23	15	16	16	17	21	38	40
2006[3]	11	49	25	28	18	17	16	24	85
2007[2]	15	23	18	13	15	24	19	41	59
2008	14	15	29	23	20	23	22	24	45
2009	13	10	18	22	40	28	22	24	46
2010	14	12	12	18	22	31	31	22	80
2011	10	12	10	15	16	32	25	27	56
2012[3]	16	12	13	11	21	32	37	54	44
2013	15	15	35	23	32	29	39	41	49
2014	10	12	11	15	21	22	30	27	48
2015	14	11	14	18	26	22	19	29	52
2016	10	11	13	20	16	16	18	18	58
2017[3]	10	16	16	14	17	16	16	15	97
2018	8	9	11	14	11	14	17	21	33
2019	11	12	15	12	16	18	19	21	59

[1] Includes unidentified *Sebastes* specimens, mostly less than 10cm

[2] REZ not covered

[3] REZ partly covered

7.3 Norway redfish (*Sebastes viviparus)*

Figure 7.3 shows the geographical distribution of Norway redfish and Table 7.7 presents the time series (1994-2019) of swept area indices by 5 cm length groups in the standard area. Almost all Norway redfish are found in areas ABCD, mainly in main area B, and almost nothing in the extended survey area (Table 7.8). A few large catches often drive the indices. There was a large and unexplained increase in the indices of most length groups from 2013 to 2014 and 2015 to among the highest levels in the time series. In 2016 and 2017 the indices for most length groups were somewhat lower, while in 2018 there was a new increase for most length groups and the total index was the second highest in time series. In 2019 the indices of fish above 19 cm decreased somewhat compared to 2018, but the total index is still among the highest in the time series.

Table 7.11 presents estimates of coefficients of variation (%) by length groups. A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years, CVs for most length groups are far above what could be considered as acceptable.

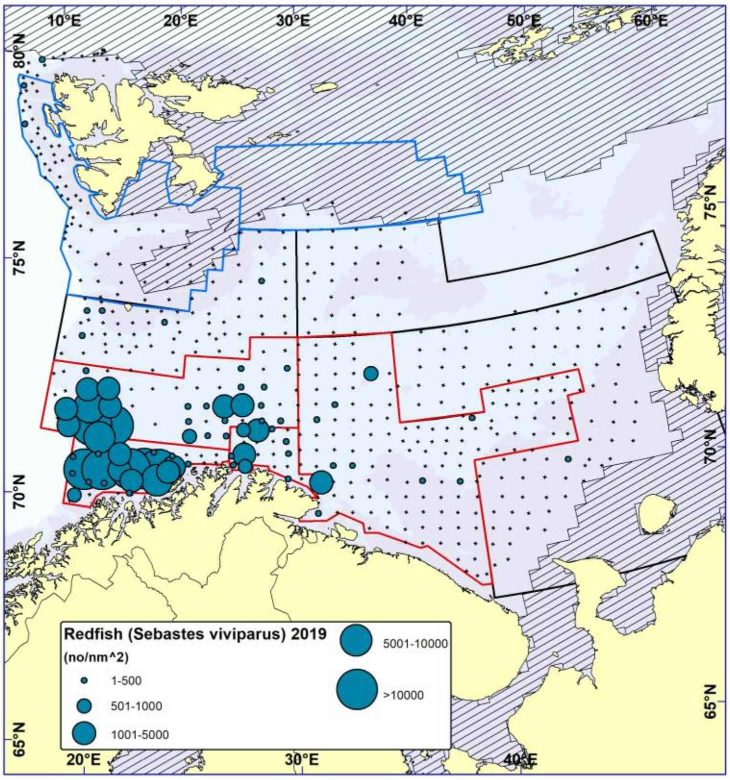

Figure 7.3. NORWAY REDFISH (*Sebastes viviparus)*. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

Table 7.7. NORWAY REDFISH *(Sebastes viviparus)*. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	≥30	Total
1994	75355	94809	17218	12818	1377	279	201857
1995	10716	68713	22737	9349	3306	503	115325
1996	439	45798	43673	35921	5498	87	131417
1997[1]	898	24202	28857	18768	4397	0	77122
1998[1]	703	9835	42183	20801	2939	91	76102
1999	1577	10134	11675	2921	707	35	27049
2000	1011	5127	37429	22122	2118	140	67947
2001	249	2243	30082	34405	3802	120	70901
2002	332	3345	17674	15168	1276	88	37884
2003	234	4306	22603	31019	4277	181	62619
2004	102	1794	24462	32769	3294	291	62712
2005	172	1582	16444	37360	6153	356	62068
2006[2]	819	4480	3653	10381	2244	205	21782
2007[1]	704	5238	15652	34395	2448	80	58517
2008	0	1882	5910	21022	4561	30	33344
2009	506	528	3096	11032	3405	419	18988
2010	1712	455	10134	53181	7572	22	73076
2011	533	1250	2169	7758	2197	106	14013
2012[1]	586	3950	4080	29157	6212	74	44059
2013	1211	9522	3302	23464	8545	100	46144
2014	11388	17755	21079	64094	15135	1990	131441
2015	7384	27351	30768	65870	9048	88	140509
2016	2795	26824	18396	29229	11286	933	89464
2017[1]	3848	58422	21556	22580	5685	426	112518
2018	700	24371	61515	37470	26283	1344	151763
2019	730	14679	58653	31991	6469	1250	113773

[1] Indices not raised to represent the Russian EEZ or uncovered parts, *Sebastes viviparus* is mainly found in NEZ
[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

Table 7.8. NORWAY REDFISH (*Sebastes viviparus)*. Abundance indices (numbers in thousands) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	≥30	Total
2014	0	87	44	0	0	0	131
2015	0	0	35	0	0	0	35
2016	0	0	111	0	0	0	111
2017	0	0	0	0	0	0	0
2018	0	0	160	126	32	0	318
2019	0	0	51	0	0	0	51

Table 7.9. NORWAY REDFISH (*Sebastes viviparous*). Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

	Length group (cm)					
Year	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**
1994	34	52	25	39	41	70
1995	42	31	43	34	70	89
1996	62	24	31	36	51	57
1997[1]	84	31	27	48	56	-
1998[1]	39	20	43	68	71	79
1999	78	58	32	25	37	65
2000	52	29	47	48	41	51
2001	39	26	31	30	34	85
2002	61	34	20	23	46	83
2003	73	34	35	30	31	76
2004	57	36	38	35	24	66
2005	69	35	40	31	34	69
2006[2]	75	75	25	30	21	58
2007[1]	75	78	39	39	29	87
2008	-	58	32	28	42	73
2009	61	48	25	24	27	61
2010	47	42	47	52	57	97
2011	51	59	50	48	45	75
2012[2]	45	30	48	45	43	100
2013	58	32	25	41	51	98
2014	43	36	40	40	41	79
2015	38	32	34	43	53	100
2016	37	28	29	28	23	46
2017[2]	46	62	23	30	27	52
2018	46	46	47	54	40	60
2019	64	57	44	29	32	68

[1] REZ not covered

[2] REZ partly covered

8 Distribution and abundance of Greenland halibut

Figure 8.1 shows the distribution of bottom trawl catch rates of Greenland halibut. The most important distribution areas for the adult fish (depths between 500 and 1000 m along the western slope), are not covered by the survey. The observed distribution pattern in 2018 was similar to those observed in previous years' surveys. Greenland halibut was also found in the extended survey area in 2014-2019. In 2018, a higher number of fish less than 40 cm was found in the extended area than in the standard area (strata 1-23). On average over all size groups about 25% of the amount found in the standard survey area by numbers was found in the extended area in 2019.

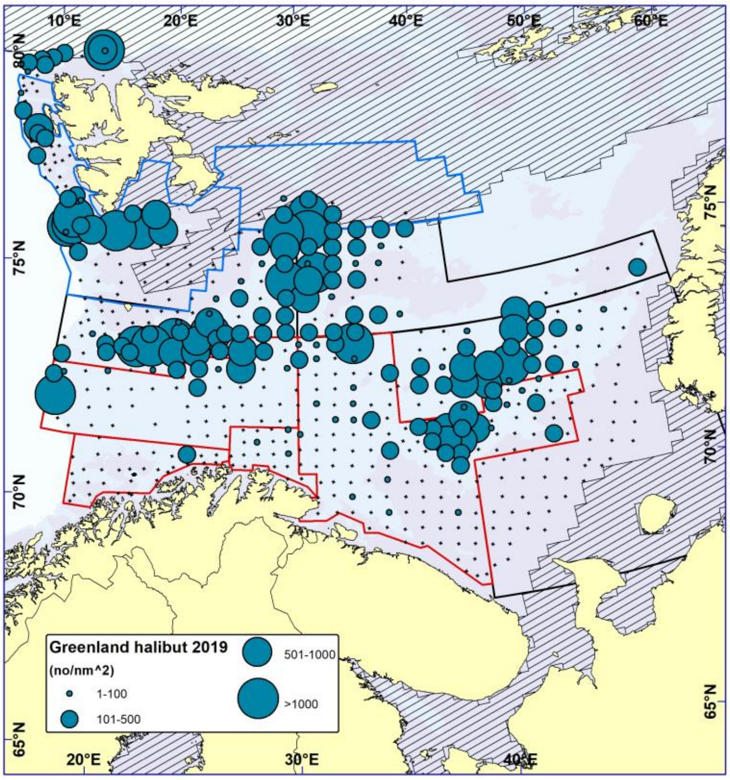

Figure 8.1 GREENLAND HALIBUT. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

The time series (1994-2019) of swept area abundance indices by 5 cm length groups in the standard area is presented in Table 8.1. Abundance indices have been low in the whole period, with few signs of improved recruitment in the covered area. However, recruitment from more northern areas has led to an increase in abundance indices of length groups above 30 cm since about 2005. There was a large increase in the indices of most length groups between 30 and 79 cm from 2014 to 2015, and the total index was the highest in the time series back to 1994. In 2016, the indices of length groups between 25 and 44 cm showed an increase, while the indices of fish between 45 and 69 cm were lower than in 2015. The indices for most length groups decreased from 2016 to 2017 and the total index was the second lowest since 2004. In 2018 the indices were quite like those from 2017 but on average slightly lower, and the total index was the lowest since 2004. In 2019 the indices of all length groups above 34 cm increased, and the total index and biomass were at the same level as in 2015 and among the highest in the time series. Table 8.2 present swept area abundance indices by length groups for new strata 24-26 in 2014-2019.

Table 8.3 presents estimates of coefficients of variation (%) for length groups. Estimates are based on a stratified bootstrap approach with 500 replicates (with trawl stations being primary sampling unit). A CV of 20% or less could be viewed as acceptable in a traditional stock assessment approach if the indices are unbiased (conditional on a catchability model). Values above this indicate a highly uncertain index with little information regarding year class strength. In most years, only CVs for length groups between 40 and 59 cm are at a level that could be considered as acceptable.

Table 8.1. GREENLAND HALIBUT. Abundance indices (numbers in thousands) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

	Length group (cm)																Biomass
Year	**≤14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**≥ 80**	**Total**	**(tons)**
1994	0	0	21	76	148	1117	3139	4740	3615	1941	889	541	21	0	0	16248	19228
1995	298	0	0	0	90	129	2877	7182	5739	2027	1622	839	489	86	0	21378	27459
1996	4121	0	0	0	62	124	1214	4086	4634	1871	1112	638	337	74	12	18285	20256
1997[1]	0	68	0	0	55	163	949	4313	5629	2912	1609	643	300	65	21	16728	24214
1998[1]	68	220	945	578	481	487	1088	4016	6591	3076	1798	707	326	93	44	20518	27248
1999	43	84	241	436	566	269	784	1701	3097	1669	1094	491	89	75	0	10640	14681
2000	140	184	344	836	1722	3857	2253	1560	2144	1714	1191	615	249	76	0	16883	17246
2001	68	49	147	179	737	1525	3716	3271	2302	2010	1088	529	160	50	39	15871	18224
2002	271	0	70	34	382	1015	1916	3803	3250	2279	1138	976	242	159	114	15648	21198
2003	51	0	74	19	304	715	1842	3008	4765	2235	714	561	245	146	0	14678	19635
2004	106	104	15	0	319	1253	1229	1717	2277	1227	798	298	148	94	26	9615	11872
2005	263	70	159	1139	2235	2621	4206	3782	3847	2037	917	585	336	118	0	22314	22293
2006[2]	0	72	94	414	1968	5149	4613	5743	4283	2132	891	449	258	34	18	26118	25579
2007[1]	0	18	146	1869	1418	3114	5710	5947	4287	2205	963	658	391	80	89	26896	28006
2008	0	0	0	243	1708	5974	4654	6136	5198	3403	827	638	174	82	50	29088	30153
2009	55	0	0	26	1044	4327	8133	4551	4084	2266	996	627	442	253	154	26960	28919
2010	0	0	0	99	678	3648	5729	6560	4897	2467	1064	552	229	128	41	26092	25979
2011	51	0	0	0	216	4396	5864	5498	5237	3698	699	936	327	252	97	27271	31552
2012[3]	77	0	0	0	51	1145	4524	5366	4517	2774	1147	195	73	0	48	19917	22656
2013	0	0	0	0	0	511	5368	4868	5374	3687	1944	939	348	313	154	23504	31748
2014	0	0	46	92	156	368	2271	5587	5903	3555	2251	1369	154	260	79	22090	31112
2015	367	0	61	0	284	1612	3187	6452	7249	6752	3350	1936	587	334	0	32172	46828
2016	205	0	124	511	950	1953	3486	4539	5479	5613	1999	1973	646	98	80	27657	35831
2017[4]	52	0	0	78	592	1328	1885	3850	4852	4550	1721	1455	317	190	23	20827	29756
2018	0	0	62	0	383	1333	2049	3445	4258	3573	1904	1366	736	196	20	19325	28688
2019	0	0	0	375	272	1671	3285	4034	5177	4265	3570	2526	1328	535	137	27176	45912

[1] Indices raised to also represent the Russian EEZ
[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005
[3] Indices not raised to also represent uncovered parts of the Russian EEZ.
[4] Indices raised to also represent uncovered parts of the Russian EEZ

Table 8.2. GREENLAND HALIBUT. Abundance indices (numbers in thousands) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

Year	Length group (cm)															Biomass (tons)
	≤14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	≥ 80	Total	
2014	0	134	141	0	138	453	1350	1443	1351	293	803	39	117	0	0	6261	7366
2015	0	0	0	269	30	263	550	863	597	567	555	66	107	38	0	3903	5092
2016	678	933	607	436	336	431	331	728	340	254	68	34	140	0	34	5349	3059
2017	31	0	0	193	583	861	662	456	301	33	298	30	0	34	0	3485	2990
2018	136	28	0	434	775	1840	1099	1042	776	634	360	511	0	0	0	7636	7528
2019	296	92	81	78	137	1072	1144	1384	896	649	638	297	24	40	0	6826	8118

Table 8.3. GREENLAND HALIBUT. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

	Length group (cm)														
Year	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**
1994	0	0	105	57	46	28	17	20	17	15	20	26	97	-	-
1995	91	-	-	-	71	40	18	22	25	24	27	41	63	94	-
1996	33	-	-	-	69	45	22	25	18	19	36	29	40	58	-
1997[1]	-	53	-	-	82	48	26	23	18	16	16	24	28	73	101
1998[1]	66	53	26	44	42	18	22	23	28	26	28	31	33	50	101
1999	91	54	53	26	32	31	24	21	18	16	18	25	52	51	-
2000	71	66	72	83	56	58	41	20	22	23	21	36	45	54	-
2001	92	99	85	47	40	48	44	46	37	14	17	34	43	56	-
2002	71	-	70	104	29	27	17	13	16	16	14	27	24	37	55
2003	66	-	63	95	30	27	20	44	34	32	44	28	38	37	-
2004	78	59	97	-	26	17	16	16	17	17	15	29	39	46	92
2005	66	70	37	46	33	15	19	17	16	20	25	24	28	64	-
2006[2]	-	81	81	67	32	18	18	11	11	16	22	22	30	67	-
2007[1]	-	99	52	23	20	13	12	12	14	14	24	37	26	44	99
2008	-	-	-	36	20	21	15	14	18	14	22	20	43	56	68
2009	98	-	-	103	23	14	16	16	19	18	17	21	26	46	53
2010	-	-	-	57	26	18	13	12	14	18	19	23	45	57	101
2011	66	-	-	-	43	18	15	14	17	14	25	26	33	46	70
2012[2]	93	-	-	-	100	23	13	14	14	11	24	70	72	-	-
2013	-	-	-	-	-	44	39	12	16	20	19	33	50	50	-
2014	-	-	99	68	68	37	20	14	20	18	18	24	53	51	72
2015	83	-	99	-	49	24	22	15	13	18	34	37	33	46	-
2016	-	-	101	50	43	31	21	34	26	31	16	20	36	70	98
2017[2]	102	-	-	72	42	25	23	13	14	17	21	26	45	65	95
2018	-	-	107	-	51	24	15	18	18	15	17	23	32	54	93
2019	-	-	-	54	37	20	20	24	21	17	16	17	23	31	68

[1] REZ not covered [2] REZ partly covered.

9 Distribution and abundance of capelin, polar cod and blue whiting

9.1 Capelin

Although capelin is primarily a pelagic species, small amounts of capelin are normally caught in the bottom trawl throughout most of the investigated area. In Figure 9.1 catch rates of capelin smaller and larger than 14 cm are shown for the winter survey in 2019. Capelin smaller than 14 cm during this period will mainly comprise the immature stock component, while the larger capelin constitutes the prespawning capelin stock. Some few trawl hauls show large capelin catches (numbers exceeding 100 000 individuals) and these can probably not be considered representative for the density in the area, because such hauls will either result from hitting a capelin school at the bottom or up in the water column. For this reason, we chose not to present swept-area based indices for capelin in this report.

At this time of the year, mature capelin has started their approach to the spawning areas along the coast of Troms, Finnmark and the Kola peninsula, while immature capelin will normally be found further north and east, in the wintering areas. This is reflected on the maps of capelin distribution, even though some large capelin is always found north of 75°N, and smaller capelin are found sporadically in near-coastal areas. The geographical coverage of the total capelin stock is incomplete, but the maturing component is probably best covered.

It has been noted during several surveys that when sampling capelin from demersal and pelagic trawls, the individuals from demersal trawls are normally larger (and older) than those sampled pelagically. This has led to formation of a hypothesis saying that larger individuals tend to stay deeper than smaller individuals and some even to take up a demersal life. This hypothesis has not been tested, and during the winter surveys there are probably too few pelagic hauls to study the vertical distribution of capelin in a systematic way.

9.2 Polar cod

Polar cod are not well represented in the trawl hauls conducted during the winter surveys (Figure 9.2). This reflects the more northern and eastern distribution area of this endemic arctic species. During this time of the year, the polar cod is known to be spawning under the ice-covered areas of the Pechora Sea and close to Novaya Zemlya. It is not clear whether the concentrations found in open water this time of the year are mature fish either on their way to spawning or from the spawning areas, or if this is immature fish.

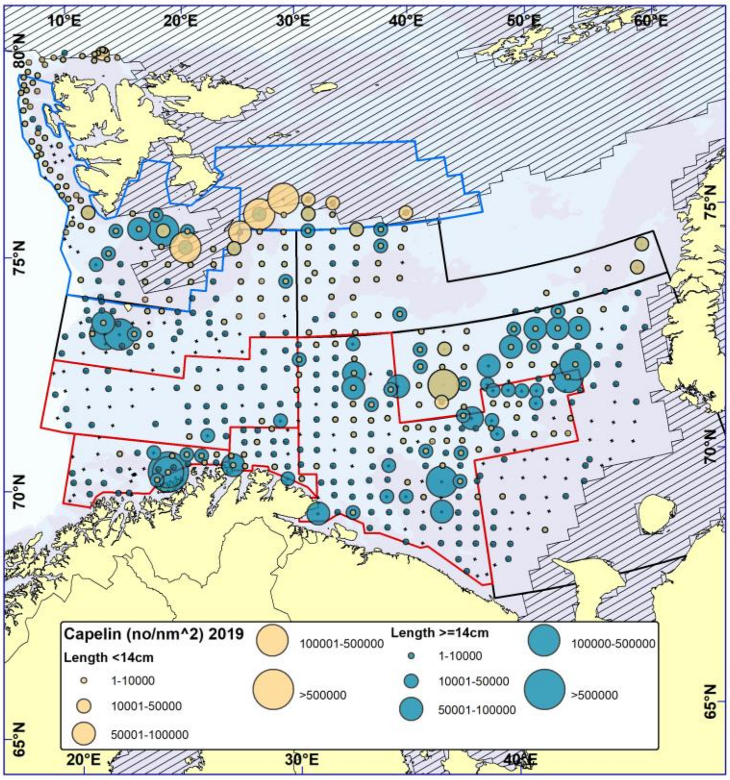

Figure 9.1. CAPELIN. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

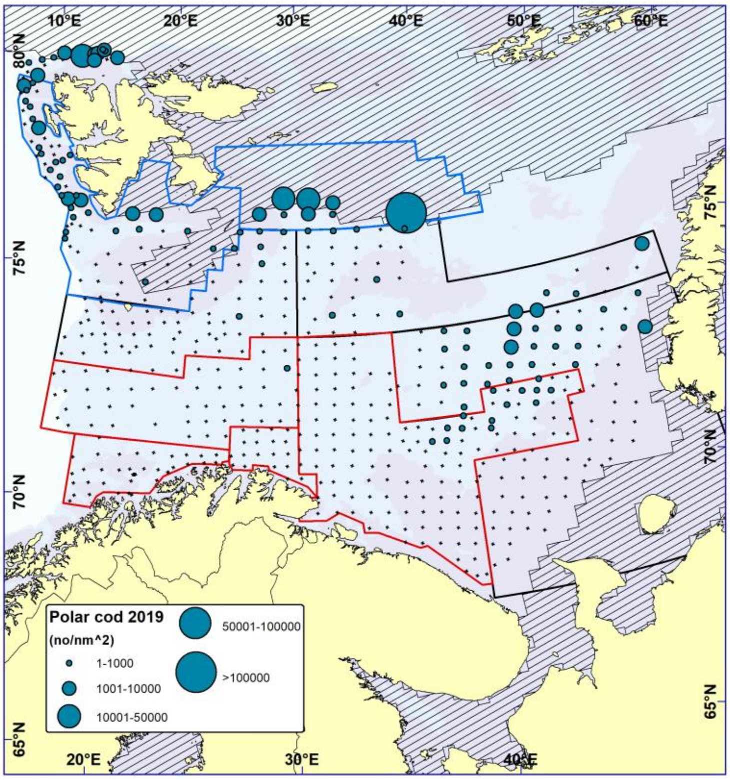

Figure 9.2 POLAR COD. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

9.3 Blue whiting

Since the second part of the 1990s, blue whiting has shown a wider distribution than previously, and echo recordings indicated higher abundance in the Barents Sea. Figure 9.3 shows the geographical distribution of the bottom trawl catch rates of blue whiting in 2019. Since the fish is mainly found pelagically, the bottom trawl does not reflect the real density distribution but gives some indication of the distribution limits. Acoustic observations would better reflect the relative density distribution. The number of pelagic hauls has, however, been too low to properly separate the pelagic recordings. During the years with high abundance of blue whiting, dense concentrations of blue whiting might have masked recordings of pelagic redfish, haddock and small cod.

Table 9.1 shows the bottom trawl swept area estimates by 5 cm length groups for the years 1994-2019. High abundance of fish below 20 cm in 2001, 2002, 2004, 2005, 2012 and 2015 reflects abundant recruiting (age 1) year classes. These recruits are observed in the survey as larger fish in the following years. As for some of the other target species in the survey, there was a large increase in the indices for most length groups from 2014 to 2015. The recruitment signal was less in 2017, while the total index of fish above 20 cm and total biomass were the largest since 2006. In 2018 and 2019 the indices were the lowest since 2011. Only small amounts of blue whiting were found in the extended survey area (Tables 9.2). Table 9.3 presents estimates of coefficients of variation (%) by length groups. In most years, CVs for most length groups are far above what could be considered as acceptable for stock assessment.

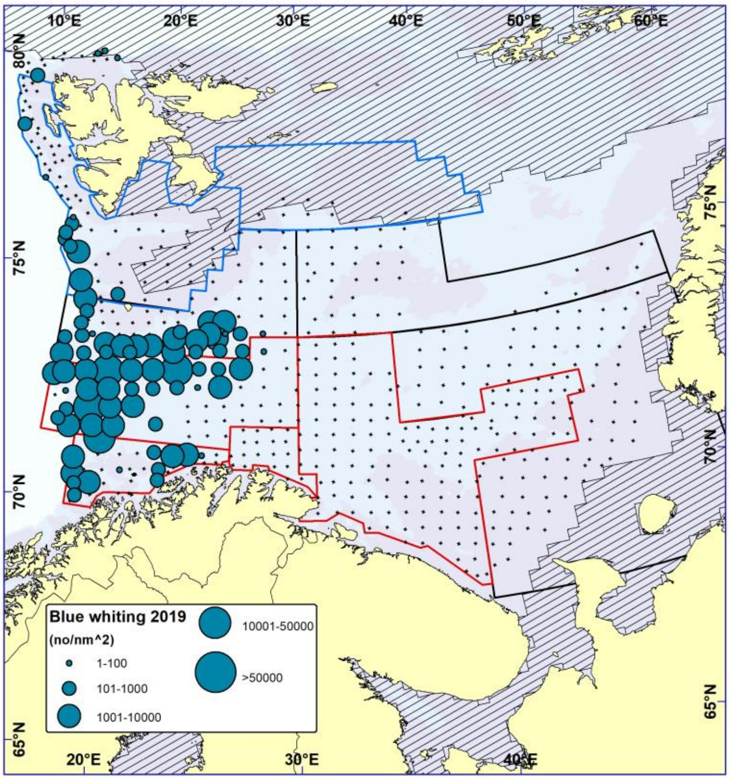

Figure 9.3 BLUE WHITING. Distribution in the trawl catches winter 2019 (number per nm^2). Black crosses indicate zero catches.

Table 9.1. BLUE WHITING. Abundance indices (numbers in millions) from bottom trawl surveys in the Barents Sea standard area winter 1994-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40	Total	Biomass ('000 t)
1994	0	0	1.2	13.6	25.7	10.9	1.1	0.1	52.6	NA
1995	0	0.5	0.8	2.4	10.3	10.8	3.9	0.2	29.0	NA
1996	0	80.0	1371.8	8.4	18.6	7.1	3.8	0.1	1489.9	38.2
1997[1]	0	608.7	681.5	273.8	3.1	5.3	1.8	0.1	1574.3	NA
1998[1]	0	1.2	34.5	42.2	3.6	1.5	1.4	0.1	84.5	NA
1999	0	0.02	11.0	40.0	16.1	5.0	1.7	0.1	74.0	NA
2000	0	12.3	557.5	44.1	25.7	4.4	0.7	0.1	644.9	NA
2001	0.04	311.6	1420.8	631.5	46.0	5.4	1.6	0.1	2417.0	NA
2002	0	0.9	428.9	636.3	77.6	17.5	3.2	0.1	1164.4	56.6
2003	0	3.9	220.5	493.4	73.4	28.0	4.0	0.3	823.4	48.1
2004	0	7.1	712.0	821.6	276.2	37.8	1.1	0.2	1856.0	95.8
2005	0	125.1	717.2	984.7	223.3	31.8	0.1	0.1	2082.4	105.0
2006[2]	0	0	164.4	1500.5	598.0	69.0	2.0	0.1	2333.9	172.9
2007[1]	0	0	4.0	628.0	299.3	23.5	1.6	0.4	956.8	79.8
2008	0	0	0.3	12.1	126.1	19.8	1.3	0.1	159.7	20.6
2009	0	0	0.02	2.7	50.6	21.2	1.5	0.02	76.1	11.4
2010	0	0	0.5	1.6	9.4	16.9	1.0	0	29.4	5.2
2011	0	0	0.1	0.3	2.8	5.1	2.5	0	10.6	2.2
2012[1]	0	85.6	674.6	1.1	1.8	5.3	2.0	0.3	770.7	18.2
2013	0	0	75.3	395.9	12.6	11.5	6.8	0.1	502.2	28.6
2014	0	0	182.1	34.2	9.7	1.6	1.5	0.04	229.2	8.5
2015	0	115.6	907.4	141.2	40.8	8.8	7.4	0	1221.3	34.2
2016	0	0.1	260.0	367.6	38.0	6.3	3.0	0.1	674.9	39.1
2017[1]	0	0	29.1	939.6	279.2	26.1	11.5	0.05	1285.6	99.7
2018	0	0.02	0.8	45.4	50.2	8.3	1.7	0	106.5	10.5
2019	0.13	1.7	54.4	4.5	35.9	13.0	1.0	0.09	110.7	9.2

[1] Indices not raised to represent the Russian EEZ or uncovered parts, blue whiting is mainly found in areas A, B, C and S

[2] Not complete coverage in southeast due to restrictions, strata 7 area set to default and strata 13 as in 2005

Table 9.2. BLUE WHITING. Abundance indices (numbers in millions) for new strata 24-26 from bottom trawl surveys in the Barents Sea winter 2014-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	≥40	Total	Biomass ('000 t)
2014	0	0	0.29	0.28	0.10	0.19	0.13	0	1.0	0.12
2015	0	0	0.16	0.10	0.25	0.78	0.42	0	1.7	0.27
2016	0	0	2.12	5.35	1.54	0.46	0.35	0	9.8	0.84
2017	0	0	0.08	20.91	4.10	1.34	0.39	0	26.8	1.98
2018	0	0	0	0.16	0.37	0.23	0.16	0	0.9	0.13
2019	0	0	0.03	0.21	0.71	0.70	0.24	0	1.9	0.34

Table 9.3. BLUE WHITING. Estimates of coefficients of variation (%) for swept area abundance indices. Barents Sea standard area winter 1994-2019.

Year	Length group (cm) 5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44
1994	-	-	94	68	51	28	31	49
1995	-	59	55	51	66	32	28	48
1996	-	49	79	56	49	30	33	59
1997[1]	-	30	29	33	36	29	37	70
1998[1]	-	91	60	33	35	33	28	70
1999	-	98	26	27	28	31	43	71
2000	-	37	21	20	25	29	31	95
2001	69	21	18	25	26	35	39	90
2002	-	56	25	17	20	33	52	69
2003	-	87	47	23	17	27	58	83
2004	-	86	23	19	15	14	30	61
2005	-	28	25	16	24	24	71	90
2006[2]	-	-	17	12	13	26	46	61
2007[1]	-	-	50	16	12	17	42	84
2008	-	-	51	59	27	22	47	82
2009	-	-	97	60	21	20	61	95
2010	-	-	91	80	29	25	33	-
2011	-	-	100	88	45	48	62	-
2012[2]	-	32	30	39	45	38	29	98
2013	-	-	70	31	57	44	44	99
2014	-	-	23	23	24	27	18	137
2015	-	50	21	21	31	31	37	-
2016	-	96	33	24	17	27	29	97
2017[2]	-	-	24	16	16	16	42	101
2018	-	102	49	25	17	19	32	-
2019	68	37	38	29	35	31	50	101

[1] REZ not covered

[2] REZ partly covered

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Appendix 2. Changes in survey design, methods, gear etc.

Year	Change from	To
1984	Representative age sample, 100 per station	Stratified age sample, 5 per 5-cm length group
1986	1 research vessel, 2 commercial trawlers	2 research vessels, 1 commercial trawler
1987	60 min. tow duration	30 min. tow duration
1989	Bobbins gear	Rock-hopper gear (time series adjusted for cod and haddock)
1990	Random stratified bottom trawl stations	Fixed station grid, 20 nm distance
	Simrad EK400 echo sounder	Simrad EK500 echo sounder and BEI post processing
1993	TS = 21.8 log L – 74.9 for cod and haddock	TS = 20 log L – 68 for all demersal species (time series corrected)
	Fixed survey area (ABCD), 1 strata system, 35 strata	Extended, variable survey area (ABCDD'ES) 2 strata systems, 53 + 10 strata
	Fixed station grid, 20 nm distance	Fixed station grid, 20/30/40 nm distance
	No constraint technique (strapping) on bottom trawl doors	Constraint technique on some bottom trawl hauls
	5 age samples per 5-cm group, 2 per stratum	2 age samples per 5-cm group, 4 per stratum (cod and haddock)
	Weighting of age-length keys by total catch	Weighting of ALK by swept area estimate
1994	35-40 mm mesh size in cod-end	22 mm mesh size in cod-end
	Strapping on some hauls	Strapping on every 3. haul
	Hull mounted transducers	Keel mounted transducers Johan Hjort
1995	Variable use of trawl sensors	Trawl manual specifying use of sensors
	Constant effective fishing width of the trawl	Fish size dependent effective fishing width (time series corrected)
	Strapping on every 3. haul	Strapping on every 2. haul
	2 research vessels, 1 commercial trawler	3 research vessels
1996	2 strata systems and 63 strata, 20/30/40 nm distance	1 strata system and 23 strata, 16/24/32 nm distance
	2 age samples per 5-cm group, 4 per stratum	1 age sample per 5-cm group, all stations with > 10 specimens (cod and haddock)
1997	16/24/32 nm distance	20 nm distance
	Hull mounted transducers	Keel mounted transducers G.O. Sars (Sarsen)
1998	Strapping on every 2. haul	Strapping on every haul
	20 nm distance	20/30 nm distance
2000	3 Norwegian research vessels	2 Norwegian and 1 Russian research vessel
2002	20/30 nm distance station grid	16/20/24/32 nm distance station grid
2003	Height trawl sensor for opening and bottom contact	Trawl eye for opening and bottom contact
2004	Vaco trawl doors	V- doors G.O. Sars and Johan Hjort
	EK 500 Sarsen	ER60 G.O. Sars
2005	EK 500	ER60 Johan Hjort and Russian vessels
2006	Standard Campelen rigging	"Tromsø rigging" on Norwegian vessels
2007	BEI	LSSS Norwegian vessels
2008	V trawl doors	Thyborøn doors Jan Mayen/Helmer Hanssen
2010	V trawl doors	Thyborøn doors G.O. Sars and Johan Hjort
2011	30 min. tow duration	15 min. tow duration
2015	"Tromsø rigging" on Norwegian vessels	Standard Campelen rigging
2017	Swept-area estimates by the Survey Program	Swept-area and CV estimates by StoX software
	EK 60 on G.O. Sars	EK80 in EK 60 modus on G.O. Sars
2018	Acoustic estimates by the BEAM Program	Acoustic and CV estimates by StoX software
	EK 60 on Johan Hjort	EK80 in EK 60 modus on Johan Hjort

WD:05
ICES AFWG 2019

The Spanish NE Arctic Cod Fishery in 2018

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In 2018 the Spanish fleet targeting for cod was composed by 5 single trawls. The activity of this fleet was carried out in ICES fishing areas I, IIa and IIb throughout year.

Scientific sampling in 2018 was carried out on board of one vessel. The observers recorded catch, effort and biological data from April to May in ICES Division Ib and from April to July in ICES Division IIb.

Table 1 shows catches of cod and by-catches by month and Division along with the effort distribution (number of otter trawls, number of days and estimated hours of activity), and the overall monthly yield of the otter trawls for the target species, V. gr. cod. Catch and effort data (by fishing days and hours), for the whole fleet have been estimated from the data provided by the Spanish General Secretary of Fisheries and the information gathered by the scientific observers on board. In Figure 1 the percentage of cod landings by each fishing grounds exploited is represented.

Tables 2 and 3 show the length and age distribution of cod catches by areas and quarters from on-board sampling. 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 (2001-2017). In Figure 2, the cod length distribution as percentage by each fishing ground is shown.

Table 1.- Cod catches (kg) and estimated by-catch of the Spanish fleet in ICES Subarea I, Divisions IIa and IIb in 2018

BARENTS SEA SUBAREA (I)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
COD				519940	574104		105119	970641	444867		665	4021	2619356
HADDOCK				15124	8591		191	799	214				24920
REDFISH				2518	2150								4668
WOLFFISH				1863	1883			74	96		85	73	4074
LONG ROUGH DAB				65	65		122	1670	1042		14		2979
GREENLAND HALIBUT				916	537						42	126	1621
POLLOCK				573	343								916
Number of **otter trawls**				2	2		1	2	2		1	1	5
Fishing days (**otter trawls**)				19	20		4	32	25		1	1	102
Fishing hours (**otter trawls**)				366	352		58	544	435		3	4	1762
CPUE (kg/h) (**otter trawls**)				1422	1629		1823	1784	1022		222	1005	1486

NORWAY ZEE NORTH OF 62º (IIA)	**Jan**	**Feb**	**Mar**	**Apr**	**May**[1]	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
COD		62665	1139809	208031	50869								1461374
POLLOCK		4433	35245	19243									58920
REDFISH		32	760	846	41348								42986
HADDOCK		3075	2513	55	343								5985
ATLANTIC HALIBUT			1266	419									1685
LING		100	51										151
WOLFFISH					82								82
Number of **otter trawls**		1	1	1	2								2
Fishing days (**otter trawls**)		4	31	8	4								45
Fishing hours (**otter trawls**)		55	548	162	45								787
CPUE (kg/h) (**otter trawls**)		1138	2080	1282	1141								1857

[1] direct fisheries to redfish

Table 1 Cont.

SVALBARD (DIVISION IIB)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
COD				227627	1727441	2221804	1429722	791932	454224		909170	1300703	9062624
HADDOCK				217	20078	32799	27070	755			42266	15149	138334
GREENLAND HALIBUT				94	13300	18434	582	96			12503	13055	58065
WOLFFISH				1100	4851	6278	7890	513			14273	15995	50898
LONG ROUGH DAB				510	9250	7840	3034	1390	1050		1638	2590	27303
REDFISH				4076	945	4600					7938	3528	21087
GOLDEN REDFISH					573	178	38						789
POLLOCK				230									230
ATLANTIC HALIBUT					86						42	10	138
Number of **otter trawls**				2	4	4	3	2	2		1	1	5
Fishing days (**otter trawls**)				9	66	68	58	27	21		29	31	309
Fishing hours (**otter trawls**)				178	1262	1249	1045	432	359		494	544	5561
CPUE (kg/h) (**otter trawls**)				1282	1369	1780	1368	1834	1264		1842	2393	1630

Table 2: Length distribution of cod Spanish catches in ICES Subarea I, 2018

Length group (cm)	1st Q.	2nd Q.	3rd Q.	4th Q.	ALL
31-33					
34-36			0		0
37-39			289		289
40-42			1209		1209
43-45			2103		2103
46-48			3093		3093
49-51			4529		4529
52-54			5880		5880
55-57			8115		8115
58-60			12217		12217
61-63			14935		14935
64-66			15261		15261
67-69			14542		14542
70-72			15564		15564
73-75			11120		11120
76-78			8372		8372
79-81			5874		5874
82-84			3268		3268
85-87			1985		1985
88-90			1298		1298
91-93			710		710
94-96			529		529
97-99			224		224
100-102			128		128
103-105			109		109
106-108			13		13
109-111			25		25
112-114			0		0
115-117			6		6
118-120			11		11
121-123					
124-126					
127-129					
130-132					
133-135					
136-139					
Total			131404		131404
No. Samples			35		35
No. F. Measured			7412		7412
[1]Sampling Weight (kg)			294671		294671
Mean Length (cm)			66.1		66.1

[1]Weights corresponding to the length distributions

Table 2(cont.): Length distribution of cod Spanish catches in ICES Subarea IIb, 2018

Length group (cm)	1st Q.	2nd Q.	3rd Q.	4th Q.	ALL
22-24		0	76		76
25-27		362	377		739
28-30		861	718		1579
31-33		0	1321		1321
34-36		65	3336		3401
37-39		164	5051		5215
40-42		765	7704		8469
43-45		1535	9770		11306
46-48		2483	10164		12647
49-51		5900	13389		19290
52-54		10582	15184		25767
55-57		20442	14217		34660
58-60		27237	19032		46270
61-63		40121	19695		59816
64-66		44655	23175		67829
67-69		49966	19300		69267
70-72		46044	21199		67243
73-75		32706	14011		46718
76-78		21186	11274		32461
79-81		10666	5461		16127
82-84		5156	3051		8207
85-87		3765	2856		6622
88-90		2017	1534		3552
91-93		1009	1012		2021
94-96		696	343		1039
97-99		508	414		922
100-102		491	246		737
103-105		164	163		327
106-108		89	76		165
109-111		76	0		76
112-114		0	0		0
115-117		20	38		58
Total		329731	224187		553918
No. Samples		82	25		107
No. F. Measured		15982	2539		18521
[1]Sampling Weight (kg)		760824	446950		1207774
Mean Length (cm)		66.9	61.3		64.6

[1]Weights corresponding to the length distributions

Table 3: Age distribution of cod Spanish catches in ICES in ICES Subarea I, 2018

BARENTS SEA SUBAREA (I)	*1st QUARTER*			*2nd QUARTER*			*3rd QUARTER[1]*			*4th QUARTER[1]*			*TOTAL[1]*		
AGE	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g
1															
2															
3				2.674	41.5	554	3.716	41.5	554	0.011	41.5	554	6.402	41.5	554
4				39.877	48.3	869	55.425	48.3	869	0.171	48.3	869	95.472	48.3	869
5				64.948	55.8	1304	90.273	55.8	1304	0.278	55.8	1304	155.499	55.8	1304
6				133.765	63.0	1851	185.921	63.0	1851	0.573	63.0	1851	320.259	63.0	1851
7				185.997	70.8	2592	258.519	70.8	2592	0.797	70.8	2592	445.313	70.8	2592
8				44.987	79.6	3622	62.528	79.6	3622	0.193	79.6	3622	107.707	79.6	3622
9				11.803	88.6	4930	16.405	88.6	4930	0.051	88.6	4930	28.259	88.6	4930
10				2.915	90.7	5329	4.051	90.7	5329	0.012	90.7	5329	6.979	90.7	5329
11				0.335	103.5	7763	0.466	103.5	7763	0.001	103.5	7763	0.802	103.5	7763
12				0.491	99.1	6873	0.682	99.1	6873	0.002	99.1	6873	1.176	99.1	6873
13				0.101	104.7	8026	0.141	104.7	8026	0.000	104.7	8026	0.242	104.7	8026
14															
15															
16															
17															
T. NUMBER (‘000)					487.892			678.127			2.090			1168.108	
No. of fish measured					7412			-			-			7412	
TOTAL CATCH (t)					1094.044			1520.626			4.686			2619.356	
SAMPLED CATCH (t)					294.671			-			-			294.671	
#OTOLITHS[2]					911			911			911			911	
MEAN WEIGHT (g)					2242			-			-			2242	

[1] length samples from I and 2nd quarter
[2] otolith samples from I and II, 2nd and 3rd quarter

Table 3 (cont): Age distribution of cod Spanish catches in ICES in ICES Division IIa, 2018

NORWAY ZEE NORTH OF 62º (IIA)	1st QUARTER[1]			2nd QUARTER[1]			3rd QUARTER			4th QUARTER			TOTAL		
AGE	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g
1															
2	1.933	28.0	180	0.416	28.0	180							2.349	28.0	180
3	0.863	41.0	540	0.186	41.0	540							1.049	41.0	540
4	19.435	50.1	962	4.184	50.1	962							23.620	50.1	962
5	59.520	56.4	1347	12.815	56.4	1347							72.335	56.4	1347
6	154.796	63.4	1883	33.328	63.4	1883							188.124	63.4	1883
7	232.548	70.5	2558	50.069	70.5	2558							282.616	70.5	2558
8	40.749	78.7	3503	8.774	78.7	3503							49.523	78.7	3503
9	8.007	88.3	4893	1.724	88.3	4893							9.731	88.3	4893
10	2.428	92.5	5653	0.523	92.5	5653							2.951	92.5	5653
11	0.415	103.6	7768	0.089	103.6	7768							0.504	103.6	7768
12	0.342	100.3	7119	0.074	100.3	7119							0.416	100.3	7119
13	0.105	100.6	7085	0.023	100.6	7085							0.127	100.6	7085
14															
15+															
T. NUMBER (‘000)		521.140			112.205									633.345	
TOTAL CATCH (t)		1202.474			258.900									1461.374	
SAMPLED CATCH (t)		-			-									-	
#OTOLITHS[2]		-			-									-	
MEAN WEIGHT (g)		-			-									-	

[1] length samples from IIB 2nd quarter
[2] otolith samples from I and II, 2nd and 3rd quarter

Table 3 (cont): Age distribution of cod Spanish catches in ICES Division IIb, 2018

SVALBARD (IIB)	*1st QUARTER*			*2nd QUARTER*			*3rd QUARTER*			*4th QUARTER[1]*			*TOTAL*		
AGE	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g	Number ´000	M Length cm	M. Weight g	Number ´000	M. Length cm	M. Weight g
1															
2				6.714	28.0	180	9.585	28.5	170	7.916	28.5	170	21.191	28.3	186
3				2.999	41.0	540	57.942	37.8	406	47.851	37.8	406	76.719	38.0	435
4				67.509	50.1	962	239.257	46.3	764	197.591	46.3	764	392.138	47.2	818
5				206.745	56.4	1347	209.143	54.9	1264	172.721	54.9	1264	544.700	55.7	1297
6				537.693	63.4	1883	312.321	62.8	1912	257.930	62.8	1912	1126.349	63.2	1865
7				807.769	70.5	2558	398.723	70.6	2745	329.285	70.6	2745	1603.774	70.5	2561
8				141.545	78.7	3503	84.203	79.2	3903	69.539	79.2	3903	298.994	78.9	3526
9				27.812	88.3	4893	22.882	88.8	5548	18.897	88.8	5548	66.691	88.5	4922
10				8.434	92.5	5653	5.656	91.2	6080	4.671	91.2	6080	18.616	92.0	5557
11				1.440	103.6	7768	1.001	104.7	9265	0.827	104.7	9265	3.223	104.1	7864
12				1.189	100.3	7119	1.288	100.4	8228	1.064	100.4	8228	3.239	100.4	7142
13				0.364	100.6	7085	0.236	100.7	8139	0.195	100.7	8139	0.794	100.7	7092
14															
15+															
T. NUMBER ('000)					1810.213			1342.237			1108.486			4156.428	
No. of fish measured					15982			2539			-			18521	
TOTAL CATCH (t)					4176.872			2675.878			2209.874			9062.624	
SAMPLED CATCH (t)					96.749			230.600			-			327.349	
# OTOLITHS[2]					911			911			911			911	
MEAN WEIGHT (g)					2280			1885			1885			2120	

[1] length samples from IIB 3rd quarter
[2] otolith samples from I and II, 2nd and 3rd quarter

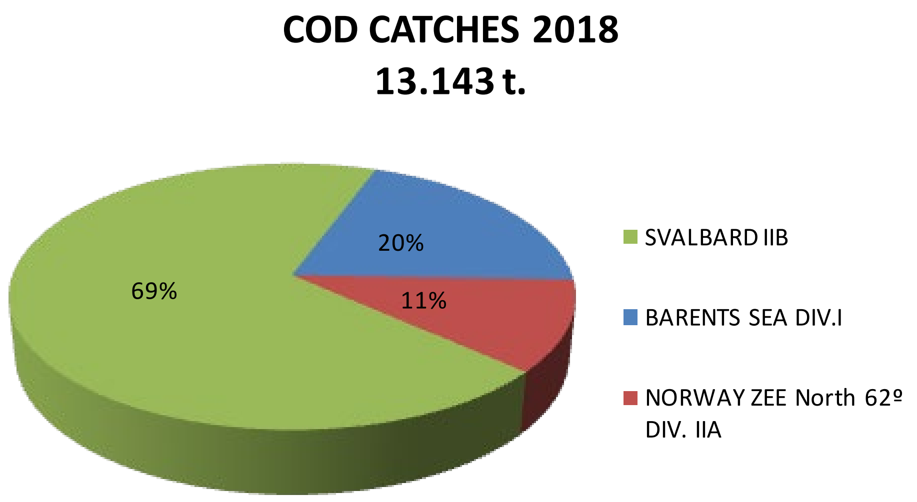

Figure 1: Catches of cod (%) by Spanish fleet in different fishing grounds during 2018.

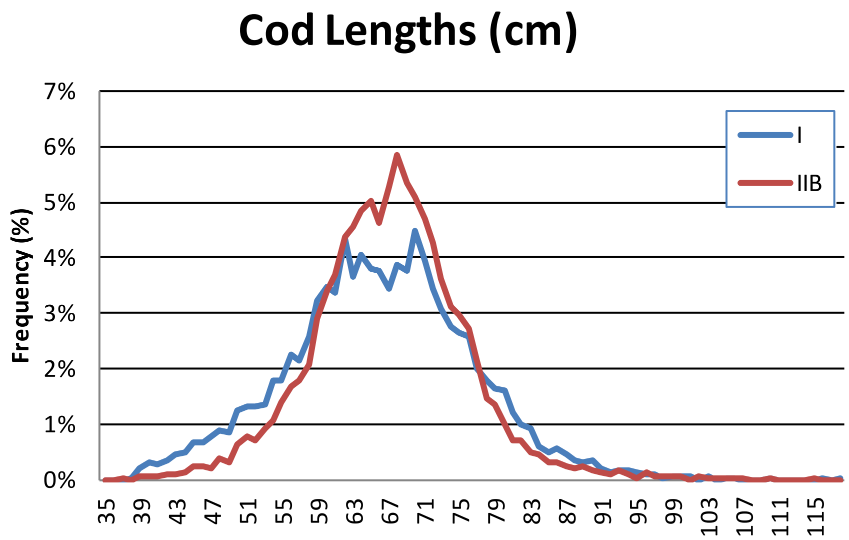

Figure 2: Length distributions of cod (%) in sampled fishing grounds during 2018.

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ICES AFWG 2019

The Spanish Pelagic Redfish Fishery in 2018

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In 2018 the Spanish fleet targeting for pelagic redfish in ICES Division IIa was composed by 3 single trawls. The activity of this fleet was carried out in the Norwegian Sea outside EEZs from June to September.

Scientific sampling was carried out on board one of this vessel during 4 months from June to September. The observer recorded catch, effort and biological data (length distribution, sex ratio and length-weight relationship).

Table 1 shows catches of pelagic redfish and main by-catches of other species by month (estimated from the observer data), together with the distribution of effort (number of otter trawls, number of days and hours of activity) as well as the overall monthly yield of the otter trawls for the target species, V. gr. redfish. Catch and effort data for the whole fleet have been estimated from the data provided by the Spanish General Secretary of Fisheries.

Table 1.- Pelagic redfish catches and main bycatch species (kg) of the Spanish fleet in ICES Divisions IIa in 2018.

NORWAY ZEE NORTH OF 62º (IIA)	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
PELAGIC REDFISH	158338	982326	920716	337723	2399103
POLLOCK		1258	580		1839
COD		422	356		778
HADDOCK			42		42
NORTHERN WOLFFISH			70	86	156
BLUE WHITING				882	882
Number of vessels	2	3	3	2	3
Fishing days	17	62	86	34	199
Fishing hours	277	1311	1860	689	4137
CPUE (kg/h)	572	749	495	490	580

Table 2.- Pelagic Redfish length distributions by sex and month of the Spanish catches carried out in ICES Division IIa in 2018.

	June		July		August		September		Total	
Total length (cm)	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
28	0	0	0	0	0	465	0	0	0	373
29	0	110	0	0	711	281	133	193	703	553
30	0	61	241	0	0	131	301	216	571	392
31	339	392	121	222	3013	281	879	875	3838	1825
32	665	171	4750	3259	4853	699	3062	1914	13184	6393
33	1794	1263	9695	6371	14596	5026	11594	2592	36414	15486
34	4325	2141	21749	13654	29344	11900	23502	5741	76902	33568
35	10122	3674	53670	27497	70680	21663	50992	12868	180888	66223
36	18563	7782	110301	47024	117372	44882	88623	16505	330846	116078
37	22975	17320	149696	97298	167323	90307	98993	21037	432015	226903
38	17225	32230	110299	161347	135270	142669	62251	34139	317936	374237
39	10639	29898	68464	219133	79431	161955	26214	23236	181572	442906
40	4309	21984	27298	147144	32352	110375	12617	16867	75128	302325
41	719	8049	8890	73809	8321	60358	3588	6930	21326	150449
42	525	3858	1335	37500	1443	20253	927	418	4256	64773
43	0	1297	136	7239	1224	4436	0	412	1143	13937
44	0	173	0	1274	0	470	0	0	0	2063
45	0	0	0	168	0	653	0	0	0	719
46	0	0	0	0	0	88	0	0	0	71
TOTAL	92200	130403	566645	842938	665931	676894	383676	143943	1676720	1819274
No. of fish measured	598	765	1571	2324	2001	2184	1561	634	5731	5907
No. Samples	11		26		28		15		80	
Total catch (kg)	158338		982326		920716		140057		2399103	

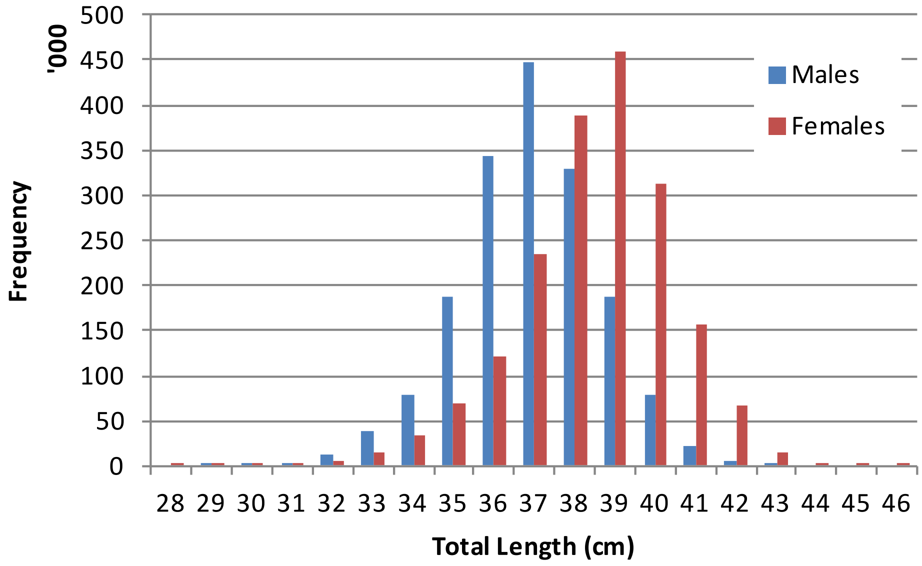

Figure 1.- Length composition of the Pelagic Redfish *S. mentella* on Division IIa in 2018.

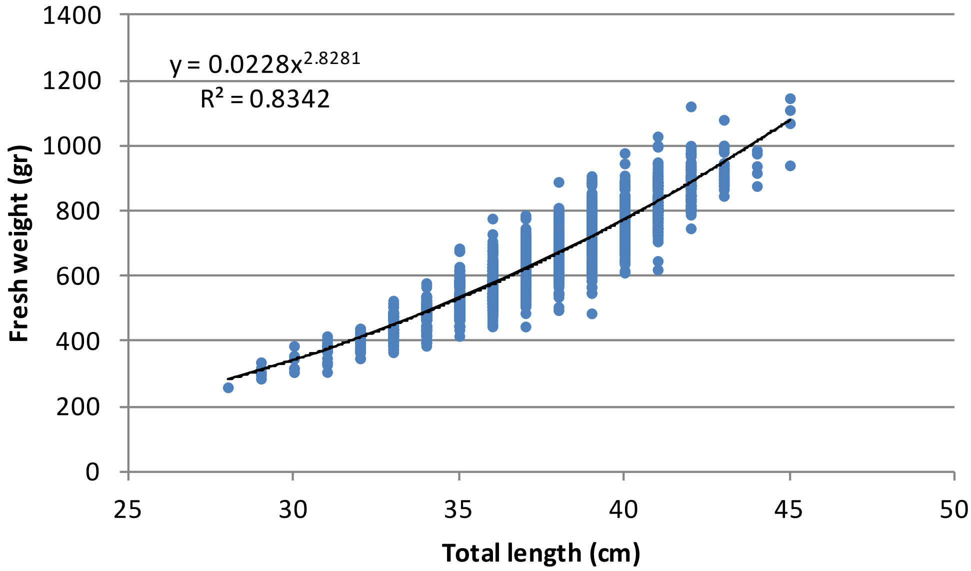

Figure 2.- Length weight relationship from pelagic redfish in ICES Division IIa 2018

Working document for AFWG2019: Using structures from XSAM in the NEA cod assessment

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1 Introduction

Input data in the NEA cod assessment are point estimates of the indices and commercial catches. There exists data on the uncertainty of these point estimates, and these are currently *not* utilised in the assessment. It is possible to include external uncertainty structures in the SAM framework (Berg et al., 2014), and it is the inclusion of these structures which is the main idea behind XSAM (Aanes, 2016a).

Anders Nielsen and Olav Nikolai Breivik has collaborated to include all options from XSAM into SAM before AFWG2019. During AFWG2019, Olav Nikolai Breivik will run SAM with some XSAM options to investigate how the assessment is affected.

2 Data

The data we have available are uncertainty estimates of is the FLT15 index and the commercial catches. These time series with uncertainty estimates are currently *not* utilized in the assessment. The resolution of the covariance data are year and age, meaning we have separate variance estimates for each age in each year. Within each year and fleet, we further have an estimate of the correlation structure. The variance time series are uploaded to SharePoint in files named "varCatch" and "varFLT15", and the correlation time series are uploaded in a file named "corFLT15". Note that only variance estimates of the commercial catch are included.

The time series representing the covariance structures uploaded at SharePoint are smoothed versions of the yearly estimated covariance structures. In section 4 we elaborate the smoothing procedure.

Note that all data used in this working document is based on data from the 2018 NEA cod assessment. During AFWG2019, the data will be updated.

3 Merging XSAM into SAM

In this subsection we elaborate the new features implemented in SAM, which enables us to run SAM with XSAM options. The source code is available at github (https://github.com/fishfollower/SAM). We start with the most important part, the inclusion of covariance structures as input to the assessment model.

3.1 Utilizing covariance structures

The observation equations in SAM are given by

$$\begin{aligned}\log C_{a,y} &= \log\left(\frac{F_{a,y}}{F_{a,y}+M_{a,y}}(1-e^{-F_{a,y}-M_{a,y}})N_{a,y}\right)+\epsilon^{c}_{a,y}\\ \log I^{(s)}_{y} &= \log(Q^{(s)}_{a}e^{-(F_{a,y}+M_{a,y})day^{(s)}/365}N_{a,y})+\epsilon^{s}_{a,y}.\end{aligned} \tag{1}$$

XSAM assumes that the covariance structures of the error terms in (1) can be expressed as

$$\boldsymbol{\epsilon}_y \sim N(0,c\boldsymbol{\Sigma}_y), \tag{2}$$

were $\{\boldsymbol{\Sigma}_y\}$ is a given time series of covariance matrices. Further is c a parameter estimated by the model. For brevity we do not included subscripts for surveys and catch in (2). Note further that the usage of external covariance matrices trough (2) is the same as the option given by equation (8) in Berg et al. (2014). In SAM, $\boldsymbol{\Sigma}_y$ is typically estimated inside the assessment model. Anders Nielsen and Olav Nikolai Breivik included the option for including external time series with covariance structures trough (2) in SAM during AFWG2018.

The option for including a time series with covariance matrices, $\boldsymbol{\Sigma}_y$, is included in SAM at the master branch at github.

3.2 Separate F-structure

The model for fishing mortality in XSAM builds on the formulation by Gudmundsson (1994) which assumes

$$\log \mathbf{F}_y = \log \mathbf{U}_y + \log \mathbf{V}_y + \boldsymbol{\epsilon}_y^{(F)} \tag{3}$$

Here both $\log \mathbf{U}$ and $\log \mathbf{V}$ follows standard Gaussian AR1 structures in time, and $\boldsymbol{\epsilon}^{(F)}$ is Gaussian noise. It is further imposed the restrictions that $\sum_a \log U_{a,y} = 0$ and $\log \mathbf{V}_{a_1,y} = \log \mathbf{V}_{a_2,y}$ for all a_1 and a_2. In (3), $\log \mathbf{U}$ can therefore be interpreted as the selectivity, and $\log \mathbf{V}$ as the effort.

The separable fishing mortality (3) is implemented as an option in SAM. We have however not yet found an example were the variance of $\boldsymbol{\epsilon}_y^{(F)}$ converge to any sensible value other than zero. XSAM is used for assessment of Norwegian Spring Spawning herring, and also for that stock does the variance of $\boldsymbol{\epsilon}_y^{(F)}$ converge to zero.

The separable fishing mortality (3) is currently included in SAM at a development branch at github.

3.3 Process error

The process equations in SAM are given by

$$\begin{aligned}
\log N_{1,y} &= \log R(\mathbf{N}_{y-1}) + \eta_{1,y} \\
\log N_{a,y} &= \log N_{a-1,y-1} - F_{a-1,y-1} - M_{a-1,y-1} + \eta_{a,y} \\
\log N_{A,y} &= \log \Big(\sum_{a=A-1}^{A} N_{a,y-1} \exp(-F_{a,y-1} - M_{a,y-1}) \Big) + \eta_{A,y}.
\end{aligned}$$

XSAM does not include η_a for $a > 1$. The removal of η_a for $a > 1$ is currently included in SAM at a development branch.

3.4 Recruitment function

XSAM includes an option for recruitment given by:

$$\log N_{1,y} \sim N(\mu_r, \sigma_r^2) \tag{4}$$

The recruitment function given by (4) is implemented in SAM, and can be used by setting the recruitment option equal 3 in the configurations. This structure is included in SAM at the master branch.

4 Smoothing covariance structures

It is reasonable that the yearly estimated covariance structures include noise and thereby should be smoothed before included in the assessment. In this section we describe how the covariance structures are smoothed. Let $v_{a,y,f}$ be the empirical variance of of the index at age a in year y by fleet f. We smooth the variance by assuming the log-variance can be expressed as a function of the log-index given by $\alpha_f + \beta_f \log(\mu)$. We further estimate β_f and α_f by means of least square. In SAM we need the standard deviation of the log-index. The variance on log scale, σ^2, is obtained by assuming the log-index is normally distributed and thereby is

$$\begin{aligned}\sigma^2 &= \log(CV_{obs}^2 + 1) \\ &= \log(e^{\alpha}\mu^{\beta-2} + 1).\end{aligned} \tag{5}$$

Here CV_{obs} is the CV at the original scale, and μ is the index at original scale.

The parameters α_f and β_f for the FLT15 survey index are estimated as -0.868 and 1.613 respectively. These estimates are based on 500 bootstrap samples from Rstox in the period 1994 to 2018 (except for year 2015 and 2016 because of issues related to extracting bootstrap samples from those years).

The parameters α_f and β_f for catch at age are estimated based on samples from R-ECA (Hirst et al., 2005), which is a program that currently estimates Norwegian catch at age. It is further assumed that the parameters in (5) for the international catch at age is the same as for the

Model	Log-likelihood
Current	-1342.6
Current+varC	-1162.6
Current+varC+varI	-1121.6
Current+varC+covI	-1135.4

Table 1: Log-likelihood obtained with different selections of covariance structures. The term "varC" and "varI" implies that the variance of the catches and indices are included. The term "covI" implies that the smoothed empirical correlation is included. An AR1 structure is assumed if the empirical covariance is not used.

Norwegian catch at age. We estimate α_f and β_f based on 500 samples from R-ECA for the years 2001 to 2011, and obtain $\alpha_f = 0.0814$ and $\beta = 1.475$. Note that these estimates differs from Aanes (2017), the difference is caused by that we use the same scale for catch at age as used in assessment when estimating α and β.

In this working document the correlation matrix is further smoothed by using a common average empirical correlation matrix for all years. We base the average empirical correlation matrix on log-index samples in years we have observations from all ages, and simply take the average of all those correlation matrices.

5 NEA cod assessment with variance time series

In this section we illustrate assessment results for NEA cod when utilizing variance time series in SAM, and compare these with the original assessment. The comparison is only based on including external variance estimates in the original assessment. We have not included correlation structures in this working document because the best likelihood is obtained with estimating the correlation structure inside SAM, see table 1. In Aanes (2017) the external covariance structures was also not used for NEA cod assessment. At AFWG2019, results with using more structures will be illustrated.

Figure 1 illustrates the estimated SSB based on the 2018-assessment with use of the variance time series for FLT15 survey and the commercial catches. Figure 2 further illustrates the one-step-ahead residuals, and figure 3 shows retrospective plots.

The scaling parameter c in (2) is estimated to be 2.0 (1.6, 2.5) for catch at age, and 6.8 (4,9, 9.9) for the FLT15 index. Numbers in parentheses are 95% confidence intervals. Table 2 gives a summary of the assessment.

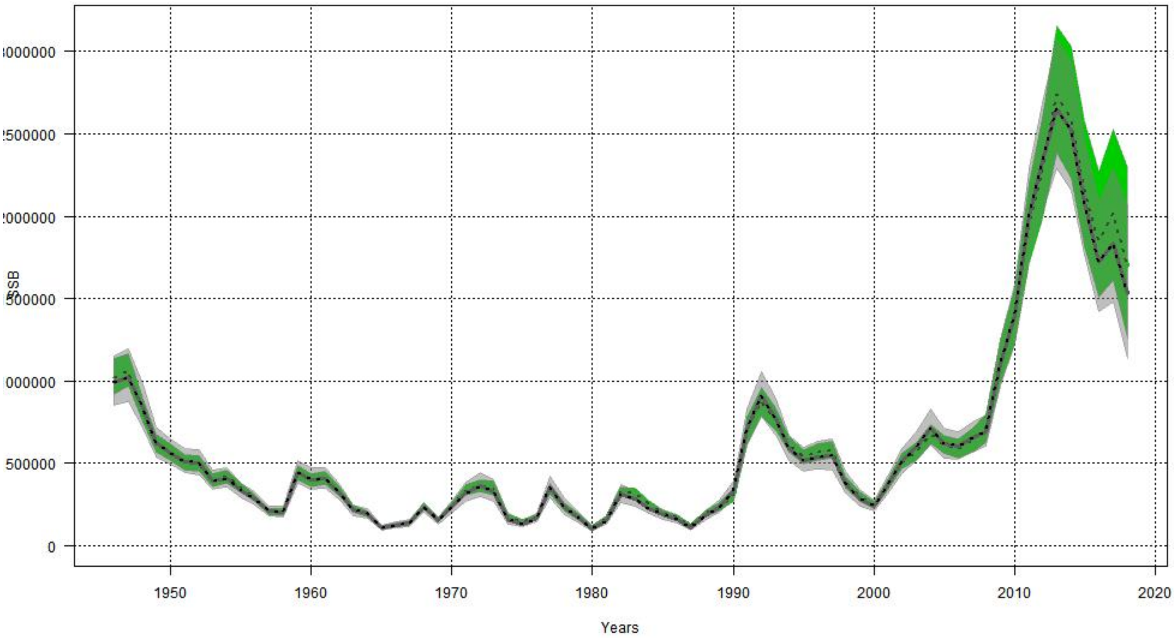
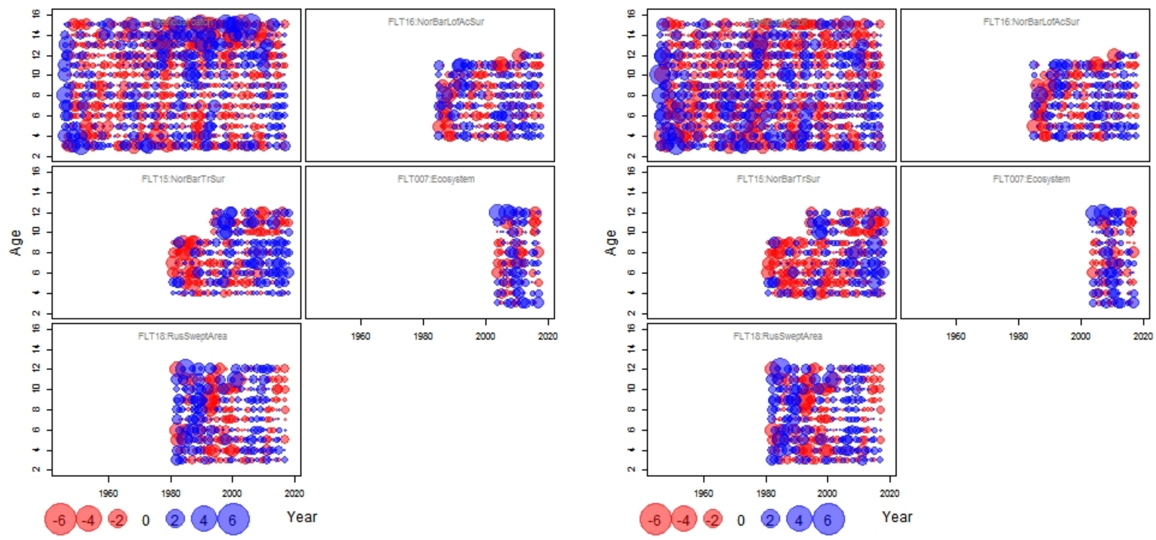
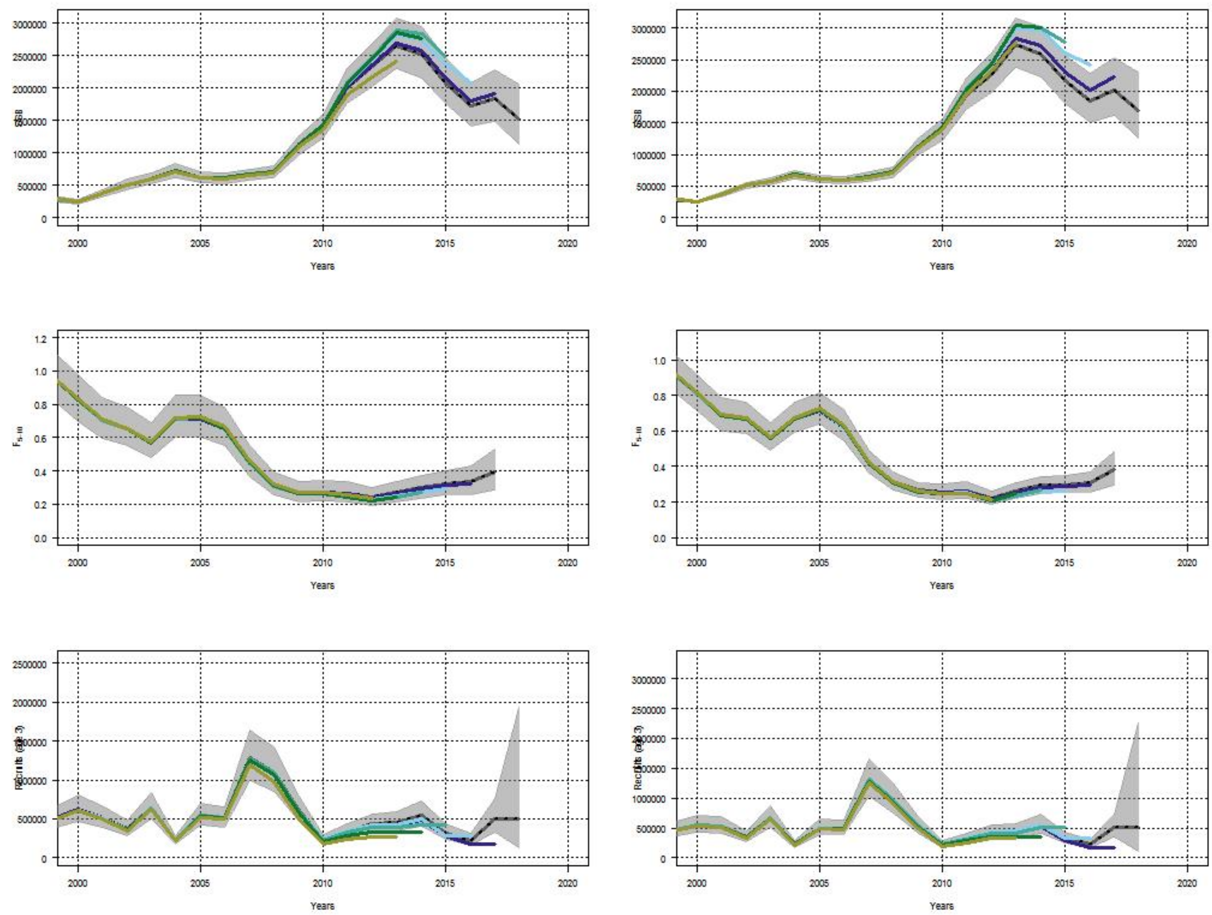


Figure 1: Estimated SSB with the current assessment compared with estimated SSB when including external variance structures. Black line and grey area represent point estimate and 95% C.I. with current assessment. Dotted line and green area represent point estimate and 95% C.I. when utlizing external variances.



(a) (b)

Figure 2: Leave-out-one residuals obtained with a) SAM with 2018 assessment configurations, and b) by also utilizing external variance structures.



(a) (b)

Figure 3: Retrospective plots obtained with a) SAM with 2018 assessment configurations, and b) by also utilizing external variance structures.

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	R(age 3)	Low	High	SSB	Low	High	Fbar(5-10)	Low	High
1980	116758	87577	155663	107544	95664	120899	0.734	0.647	0.832
1981	152521	115094	202120	165834	150058	183268	0.775	0.682	0.881
1982	206228	158908	267640	323451	293840	356047	0.772	0.680	0.876
1983	146841	112614	191470	316224	286896	348551	0.735	0.648	0.834
1984	350153	271995	450770	250293	228583	274066	0.876	0.772	0.993
1985	628778	493067	801843	196535	178513	216376	0.766	0.669	0.876
1986	882988	694944	1121916	173816	159134	189851	0.869	0.763	0.989
1987	300862	233990	386846	120243	110451	130904	0.990	0.876	1.120
1988	289644	223380	375565	192910	175323	212262	0.892	0.776	1.024
1989	188376	144422	245708	232137	207736	259405	0.637	0.544	0.746
1990	150952	113884	200084	305867	267435	349823	0.299	0.250	0.356
1991	362248	279769	469042	689946	611755	778131	0.329	0.283	0.382
1992	810617	632694	1038574	870310	785338	964476	0.462	0.406	0.526
1993	762897	593955	979891	762224	696666	833952	0.561	0.497	0.634
1994	544401	420481	704842	611264	566245	659862	0.825	0.737	0.923
1995	330386	256101	426218	534497	492092	580557	0.759	0.672	0.858
1996	332489	257741	428916	564234	516029	616943	0.701	0.620	0.793
1997	517362	406430	658573	577811	528496	631726	0.956	0.856	1.067
1998	878514	685284	1126228	385663	350491	424365	0.918	0.820	1.028
1999	457593	355242	589432	295869	268027	326603	0.930	0.829	1.042
2000	547618	422120	710426	247841	226539	271145	0.809	0.712	0.919
2001	528470	407986	684535	363799	330484	400473	0.686	0.598	0.787
2002	348056	267059	453619	510451	464663	560751	0.667	0.584	0.762
2003	670768	520525	864376	569125	517756	625591	0.563	0.493	0.644
2004	222647	174176	284607	675190	618237	737389	0.671	0.592	0.760
2005	507619	397456	648316	610825	559758	666551	0.721	0.637	0.815
2006	491890	386210	626488	588026	533944	647586	0.626	0.546	0.718
2007	1309499	1030522	1663999	638600	569539	716036	0.419	0.359	0.488
2008	974340	757839	1252692	707523	625520	800276	0.314	0.268	0.369
2009	535177	413649	692409	1107717	981496	1250170	0.265	0.225	0.312
2010	218195	166625	285726	1385294	1223703	1568223	0.256	0.217	0.303
2011	311907	237329	409920	1941269	1708831	2205323	0.264	0.222	0.313
2012	418131	323182	540976	2269966	1982290	2599390	0.222	0.187	0.262
2013	433982	334429	563169	2741904	2380726	3157876	0.262	0.223	0.308
2014	546555	413819	721866	2598013	2227584	3030042	0.293	0.250	0.344
2015	323954	245265	427888	2162719	1814180	2578219	0.298	0.252	0.352
2016	221005	160679	303980	1854525	1511214	2275827	0.306	0.253	0.371
2017	510352	358665	726191	2018434	1612206	2527020	0.381	0.298	0.486
2018	510352	115391	2257186	1699175	1257766	2295497	0.376	0.206	0.686

Table 2: Summary of 2018 NEA cod assessment with use of external variance structures.

Working document: New time series for bycatch of juvenile fish in the Barens Sea shrimp fishery

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1 Introduction

During AFWG2019, new time series for bycatch in the Barents Sea shrimp fishery will be presented. This working document describes how the new time series for bycatch are calculated, and the new time series are shown in section 4.

Background

In around year 2009, IMR and the Norwegian Computing Center started collaborating to construct a spatio-temporal model for bycatch in the Barents Sea shrimp fishery (Aldrin et al., 2012). That model was further extended and improved in Breivik et al. (2016a). In Breivik et al. (2016b), the model was further used in combination with Norwegian commercial catch data to estimate historical bycatch in the Norwegian shrimp fishery. With thorough model validation, it was illustrated that the estimation procedure in Breivik et al. (2016b) gives reliable bycatch estimates, also with respect to uncertainty. During 2018, authors of Breivik et al. (2016a) and Breivik et al. (2016b) have worked on combining data from international fleets and Norwegian landing statistics to scale up the estimated Norwegian bycatch to the total bycatch taken by all countries. Results of this work are presented in this working document, and will be presented at AFWG2019.

Motivation

Previous estimates of bycatch in AFWG reports are based on the assumption that observed bycatch rates from research vessels and surveillance service are representative for commercial bycatch rates. It is reasonable that this assumption is violated since the commercial fishery target the shrimps better compared with the research vessels and surveillance service. In Breivik et al. (2016a) it was e.g. highlighted that the commercial fishery was 128 more times efficient catching shrimps compared with the surveillance service in an area north in the Barents Sea in 2004. The surveillance service had taken five observations in that area which resulted in a bycatch rate of 38.9 cod per kg of shrimp. Removing those five observations resulted in a reduction of the estimate from 30.6 million cod to 3.9 million cod taken as bycatch by Norwegian landings in 2004 with the ratio method used in previous AFWG reports. The new estimates presented in this working document is however not sensitive to observations with high bycatch rates for low shrimp catches.

Description of the model

In Aldrin et al. (2012); Breivik et al. (2016a,b) it was shown that there exists covariates which have predictive power for bycatch, e.g. season and depth. When all important covariates are included in the proposed model, there is still spatio-temporal unexplained structures in the bycatch data (Aldrin et al., 2012; Breivik et al., 2016a,b). We accommodate for these spatio-temporal dependence structures by including latent spatio-temporal Gaussian fields in the model. The modelling is done with usage of R-INLA (Rue et al., 2009).

We shall now go trough technical parts of the model. Let $B(\mathbf{s},t)$ be the number of juvenile fish of a specific species caught in a haul at location $\mathbf{s}$ and time t. We assume that:

$$\mathrm{P}(B(\mathbf{s},t)) = \begin{cases} \pi\big(\mu_\pi(\mathbf{s},t)\big), & B(\mathbf{s},t) = 0 \\ [1-\pi\big(\mu_\pi(\mathbf{s},t)\big)]\mathrm{NB}^+(B(\mathbf{s},t);\mu_B(\mathbf{s},t),\varsigma), & B(\mathbf{s},t) > 0. \end{cases}$$

Here $\mathrm{NB}^+(\mu,\varsigma)$ represents the density of a conditional positive negative binomial distribution with mean μ and with overdispersion parameter ς and $\pi(\cdot)$ represents a binomial distribution. For brevity the we will refer to the expectation for a zero probability (μ_π) and for the positive part (μ_B) with a common $\mu(\mathbf{s},t)$. As in Breivik et al. (2016a,b), we assume that:

$$\mu(\mathbf{s},t) = \mathbf{X}(\mathbf{s},t)^T\boldsymbol{\beta} + \alpha(\mathbf{s}) + \upsilon(t) + \gamma(\mathbf{s},t), \tag{1}$$

where $\mathbf{X}(\mathbf{s},t)$ is a vector of covariates and $\boldsymbol{\beta}$ the vector of corresponding regression coefficients. The variables $\alpha(\mathbf{s})$, $\upsilon(t)$ and $\gamma(\mathbf{s},t)$ are Gaussian random fields in space, time and space-time. See Breivik et al. (2016b) for details regarding the covariates and the Gaussian random fields in (1), and for a description of the prediction procedure.

2 New data combined with Breivik et al. (2016b)

We have four data sources on shrimp catch and bycatch available.: 1) Observations from the Norwegian Surveillance Service, which consists of both shrimp catch and bycatch. 2) Norwegian catch log books, 3) Norwegian landing statistics, and 4) international catch data. Note that the three last data sources contain only information about shrimp catch, and *not* bycatch. It is the bycatch in the shrimp fishery elaborated in these three data sources we want to estimate. Compared with the bycatch estimation procedure in Breivik et al. (2016b), Norwegian landing statistics and international catch data are new data sources and will be elaborated in this section. Detailed explanation of the observations from the Norwegian Surveillance Service and Norwegian catch log books age given in Breivik et al. (2016b).

The landing statistics data contains shrimp catches aggregated over areas and quarters. See table 1 for a summary of the data given in the landing statistics. Note that the landing statistics include all catches in the log books, and in addition catches from boats smaller then 15 meters. However, the data in the landing statistics posses a much lower spatial and temporal resolution compared with the log books.

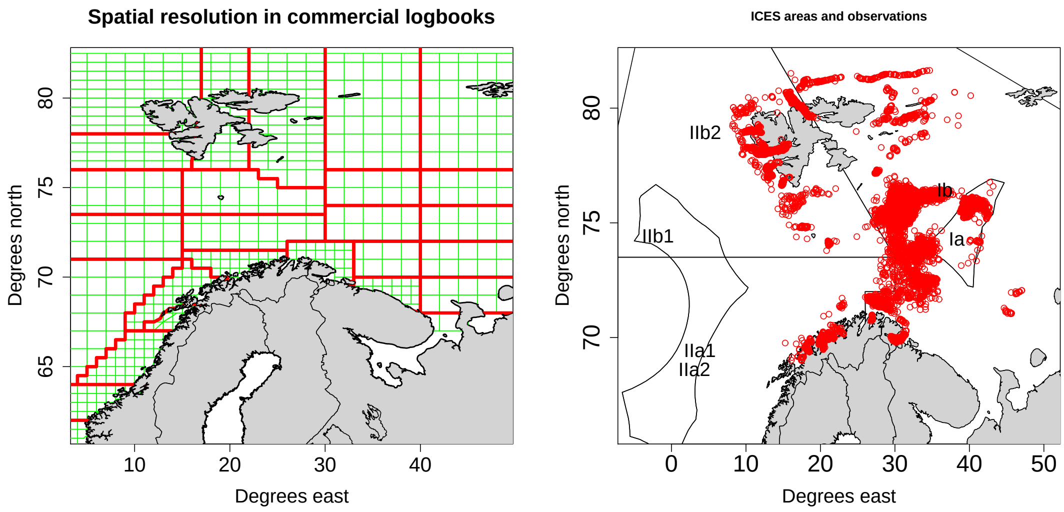
The international catch data contains international catches aggregated over ICES-areas and years. A summary of the international catch data is given in table 2.

Data	**Description**
Target catch	Aggregated shrimp catch in a given area, quarter and year by boats of a given type
Year	Year of aggregated catch
Quarter	Quarter of aggregated catch
Area	Area where the aggregated catch was taken (see large red areas in Figure 1a)
Boat type	Larger or smaller than 15 meters

Table 1: *Summary of landing statistics.*

Data	**Description**
Target catch	Aggregated shrimp catch in a given area and year by each nation
Year	Year of catch
Area	ICES region the catch was taken (see Figure 1b)

Table 2: *Summary of ICES-data.*



(a) (b)

Figure 1: *a) Map of the Barents Sea with small green rectangles describing the spatial resolution of the Fishery log books. The larger red Illustrates the spatial resolution of the landing statistics. b) Map of the Barents Sea with ICES areas, red dots illustrate the spatial distribution of the Norwegian Surveillance Service data.*

3 Estimation procedure

The estimation procedure elaborated in Breivik et al. (2016b) is used and combined with Norwegian catch log books and international catch data. The procedure can be divided into three parts: 1) bycatch by Norwegian boats larger than 15 meters, 2) bycatch by Norwegian boats smaller than 15 meters, and 3) bycatch from other nations than Norway.

3.1 Landing statistics

3.1.1 Boats larger than 15 meters

Data from boats larger than 15 meters are included in both the Norwegian log books and in the Norwegian landing statistics. It is assumed that the yearly aggregated catches from the landing statistics are more accurate compared with the log books. However, the opposite is the case for spatio-temporal resolution. To utilise both the spatio-temporal resolution in the catch log books and the aggregated catch in the landing statistics, the catches in the Norwegian log books are scaled such that the yearly aggregated catch in the log books equals the yearly aggregated catch the landing statistics. The procedure elaborated in Breivik et al. (2016b) is then followed with the scaled shrimp catch to estimate historical bycatch taken by Norwegian boats larger than 15 meters.

3.1.2 Boats smaller than 15 meters

Data from boats smaller than 15 meters are only given in the landing statistics. Unfortunately, the data in the landing statistics has a lower resolution compared to the log books. The effort, defined as hours trawled in a fine scaled spatio-temporal resolution, is not given in landing statistics. To follow the procedure in Breivik et al. (2016b), we must define the effort. We define the effort by assuming that the average shrimp catch per hour trawl by boats smaller than 15 meters is the same as the average catch per hour trawl by the surveillance service south of 72N. We further divide the aggregated quarterly catches into daily catches, and randomly sample the location of these daily catches along the coast in the corresponding reported area and quarter. The procedure elaborated in Breivik et al. (2016b) is then followed with the sampled daily catches to estimate historical bycatch taken by Norwegian boats smaller than 15 meters.

3.2 International catches

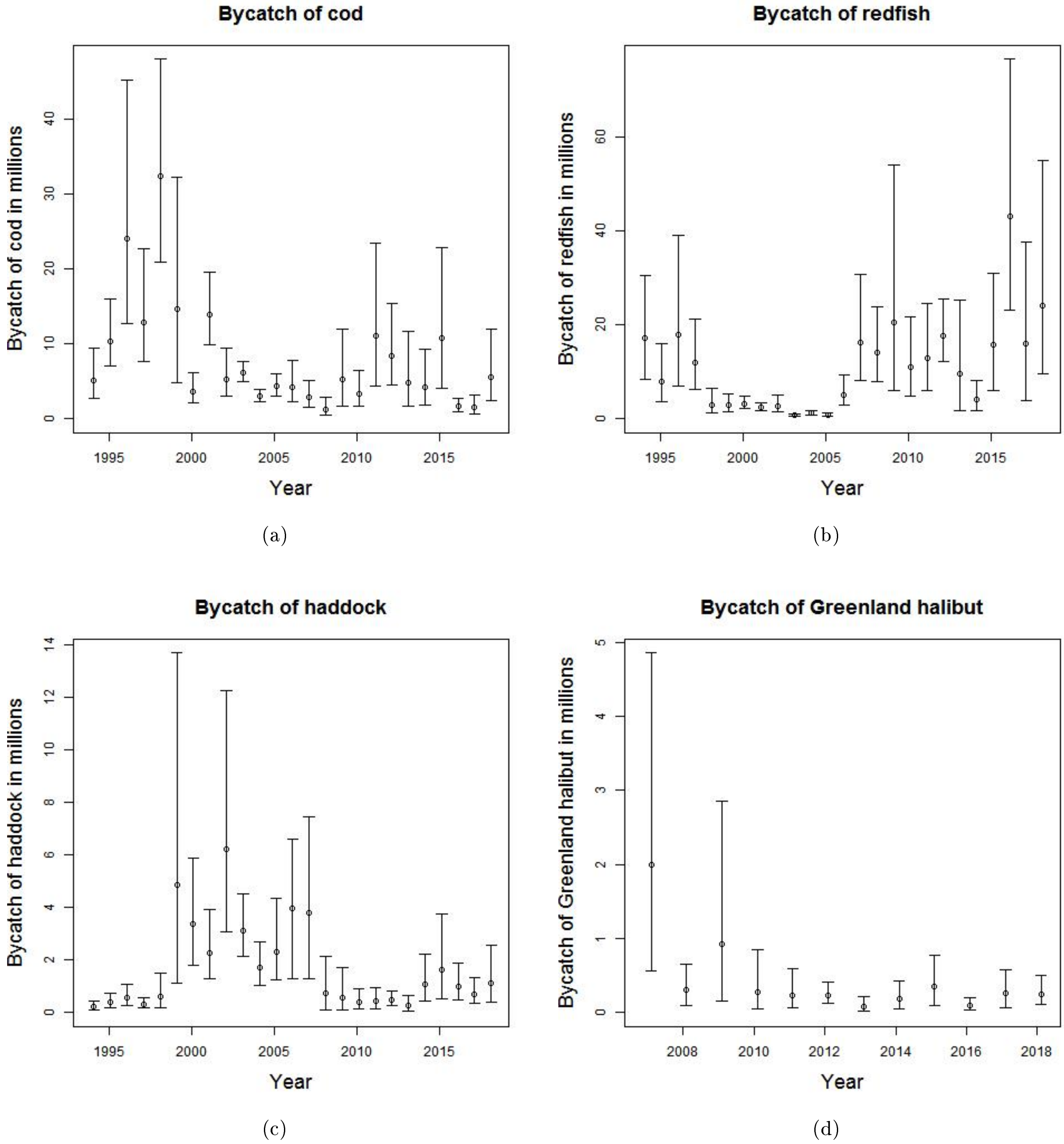
Bycatch taken by other nations than Norway is estimated by scaling the estimated bycatch by Norwegian boats larger than 15 meters. Define the ratio

$$C_{y,a} = \frac{I_{y,a}}{d_{y,a}}, \tag{2}$$

were $I_{y,a}$ is the aggregated international catch and $d_{y,a}$ is the aggregated catch from the scaled log books in year y and ICES-area a. Bycatch from other nations than Norway is estimated by scaling the estimated bycatch in the Norwegian fishery in year y and ICES area a with $C_{y,a}$.

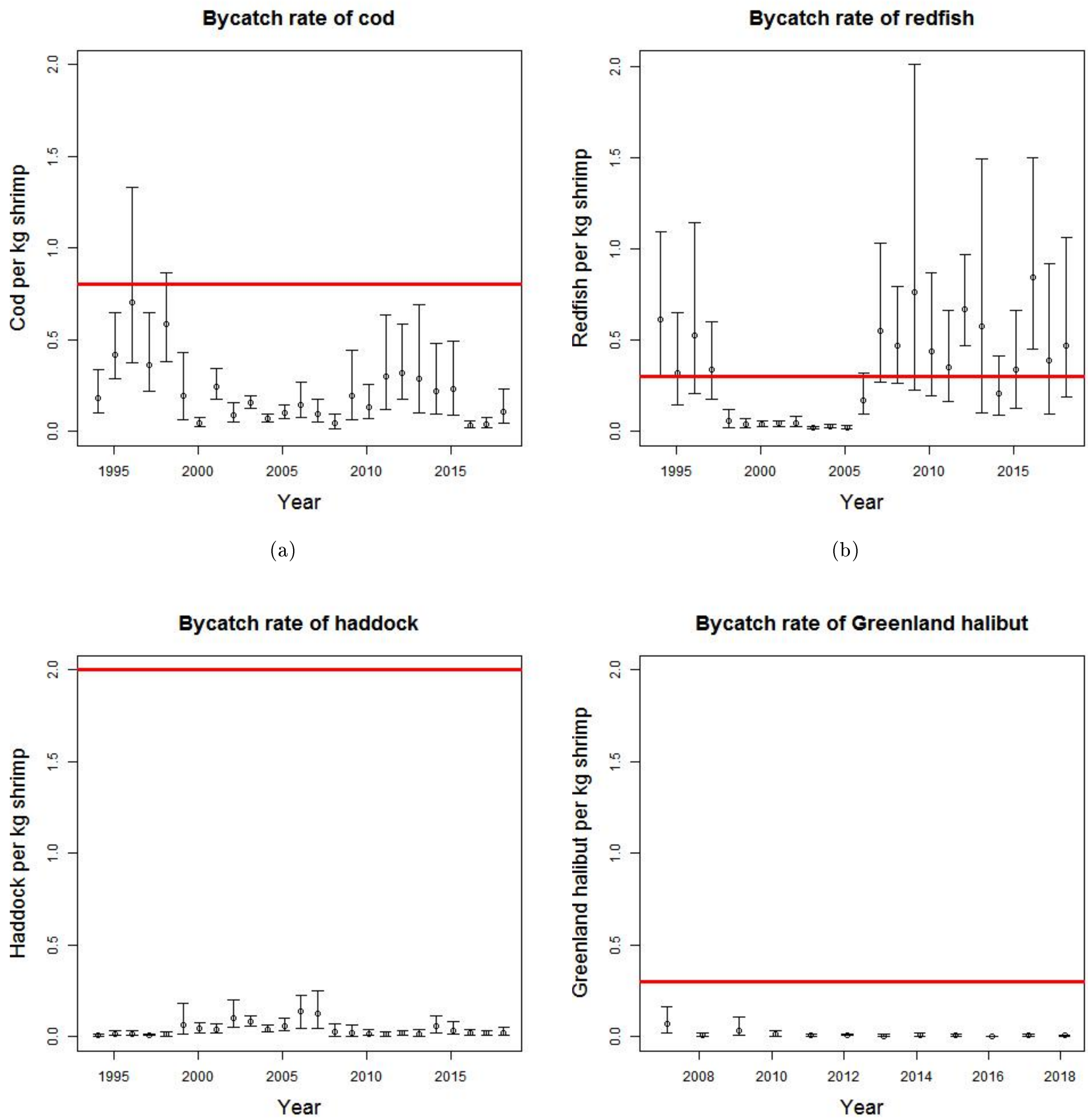
4 Results

Figur 2 shows the estimated yearly bycatch with 90% confidence intervals for each species. Figure 3 shows the bycatch estimates divided by the yearly shrimp catch, and thereby illustrates the average bycatch rate in each year. All estimates are also available on a finer spatial and temporal resolution, but this is not illustrated in this working document.



(a) (b) (c) (d)

Figure 2: Estimated bycatch in millions, intervals are 90% confidence intervals. Note that the axis in the figures have different scale.



(a) (b)

(c) (d)

Figure 3: Estimated average yearly bycatch rate. Intervals are 90% confidence intervals. Red horisontal lines illustrate current upper limit of allowed bycatch rate of the specific species.

5 Discussion

5.1 Assumptions

A key assumption in the international scaling procedure in section 3.2 is that the Norwegian landings are representative for the international landings. This assumption was made because the international catches are given in a low spatio-temporal resolution. The spatial resolution of the international catches is illustrated by figure 1b. If the international vessels in a relative high degree trawl at locations not trawled by Norwegian vessels, the bycatch estimates illustrated in figure 2 may be biased in an unknown direction.

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AFWG 2019 WD_09

NEA cod stock assessment by means of TISVPA

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The TISVPA (Triple Instantaneous Separable VPA) model (Vasilyev, 2005; 2006) represents fishing mortality coefficients (more precisely – exploitation rates) as a product of three parameters: f(year)*s(age)*g(cohort). The generation - dependent parameters, which are estimated within the model, are intended to adapt traditional separable representation of fishing mortality to situations when several year classes may have peculiarities in their interaction with fishing fleets caused by different spatial distribution, higher attractiveness of more abundant schools to fishermen, or by some other reasons.

The model was first presented and tested at the ICES Working Group on Methods of Fish Stock Assessments (WGMG 2006) and was used for data exploration and stock assessment for several ICES stocks, including North - East Atlantic mackerel, blue whiting, Norwegian spring spawning herring.

To NEA cod stock the TISVPA model was applied at AFWG in 1998; at benchmark group for arctic stocks (WKARST) in 2015 and at AFWG in 2015 and 2016.

The TISVPA model is applied to NEA cod using the same data as SAM. 4 sets of age - structured tuning data were included into analysis: ecosystem survey (“fleet 007”); joint bottom trawl surveys (“fleet 15”); joint acoustic surveys (Barents Sea and Lofoten) – “fleet 16”, and Russian bottom trawl surveys (“fleet 18”). The All the input data, including catch-at-age, weight-at-age in stock and in catches, maturity-at-age were taken the same as for stock assessment by means of SAM.

Settings of the TISVPA model were used basically the same as in AFWG 2015 - 2018 assessments: so called “mixed” version, assuming errors both in catch-at-age and in separable approximation. Additional restriction on the solution was unbiased model approximation of logarithmic catch-at-age. The generation - dependent factors in triple - separable representation of fishing mortality coefficients were estimated for age groups from 3 to 12. For catch-at-age data the measure of closeness of fit was absolute median deviation (AMD) of distribution of residuals which is known as one of most robust measures of scale, free from the assumption about the distribution.

For the “fleets” the traditional sums of logarithmic squared residuals were used assuming lognormal errors. For the (terminal+1) year (year with surveys but without catch-at-age) the assumption of equal F in terminal terminal+1 years was used.

Profiles of the components of the TISVPA loss function with respect to SSB in 2019 are shown in Figure 1. As previously, fleet 18 indicates much lower stock biomass in comparison to other sources. In objective function it was down weighted by factor of 0.05.

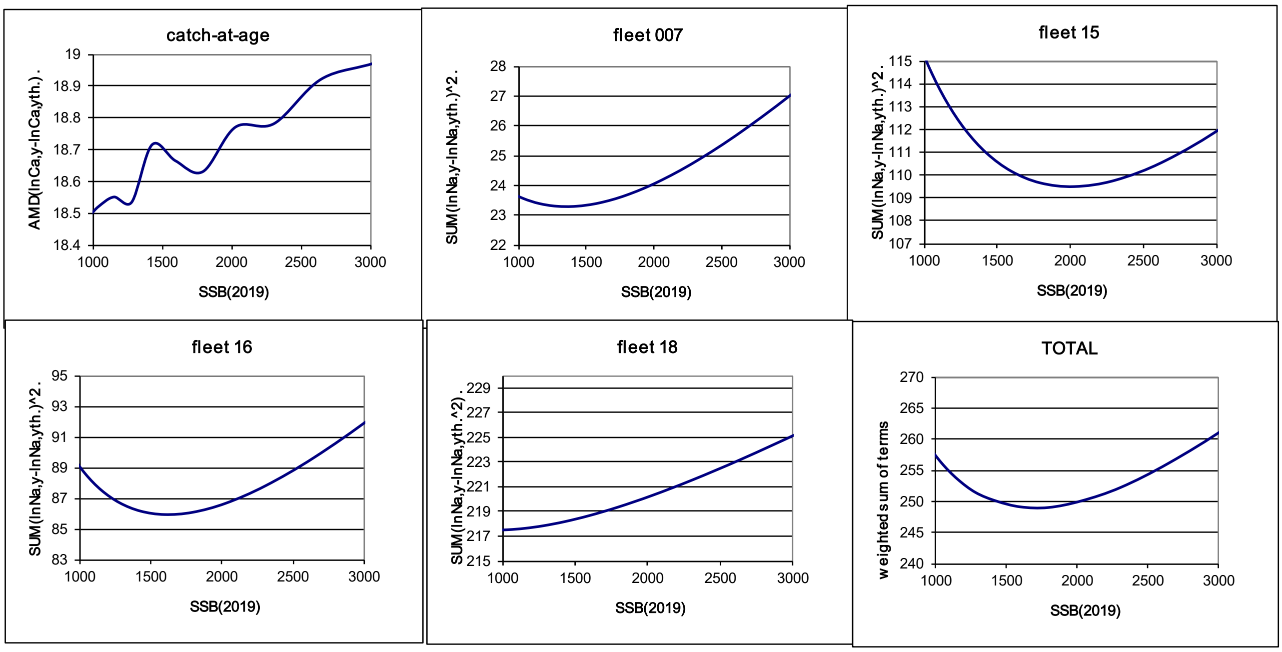

Figure 1. Profiles of the components of the TISVPA objective function

Figure 2 represents the results of retrospective runs.

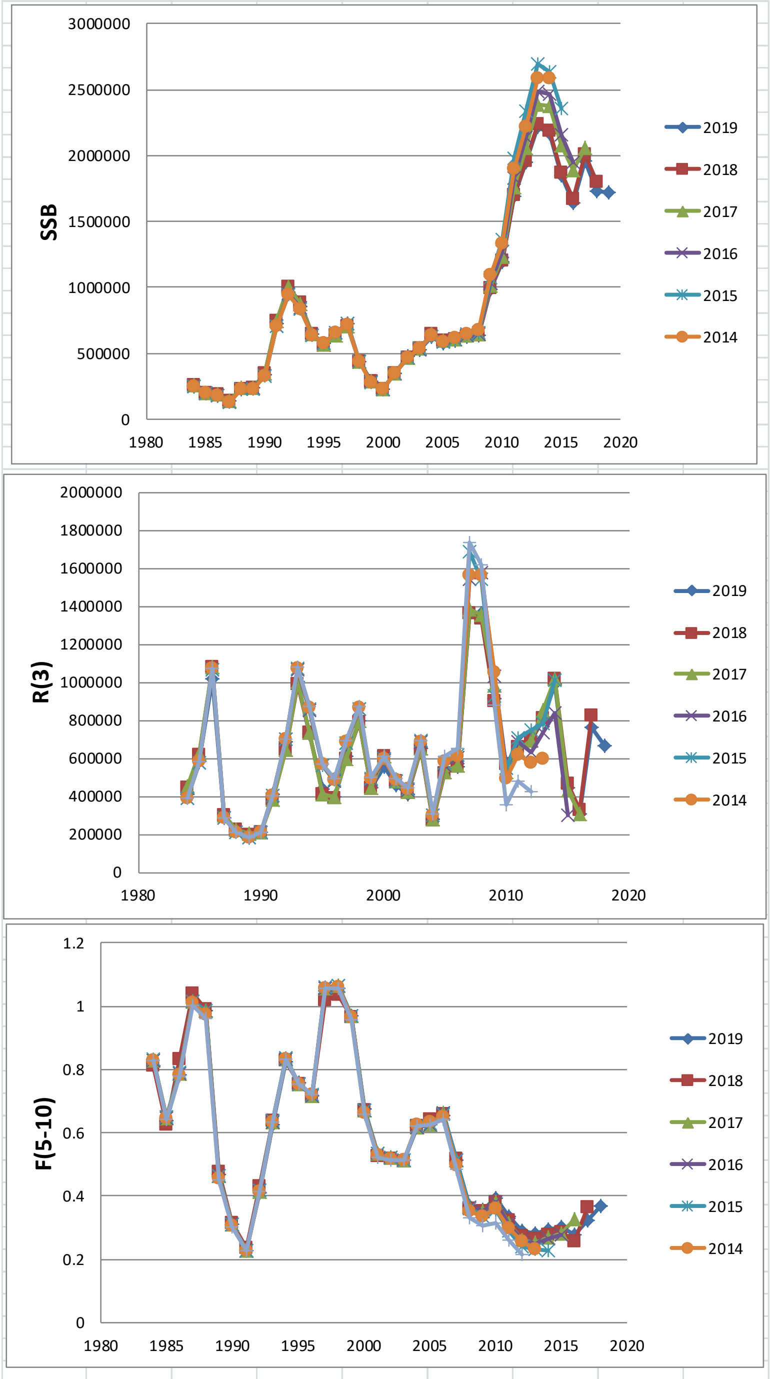

Figure 2. TISVPA retrospective runs

The residuals of the model approximation of catch-at-age and “fleets” data are presented in Figure 3.

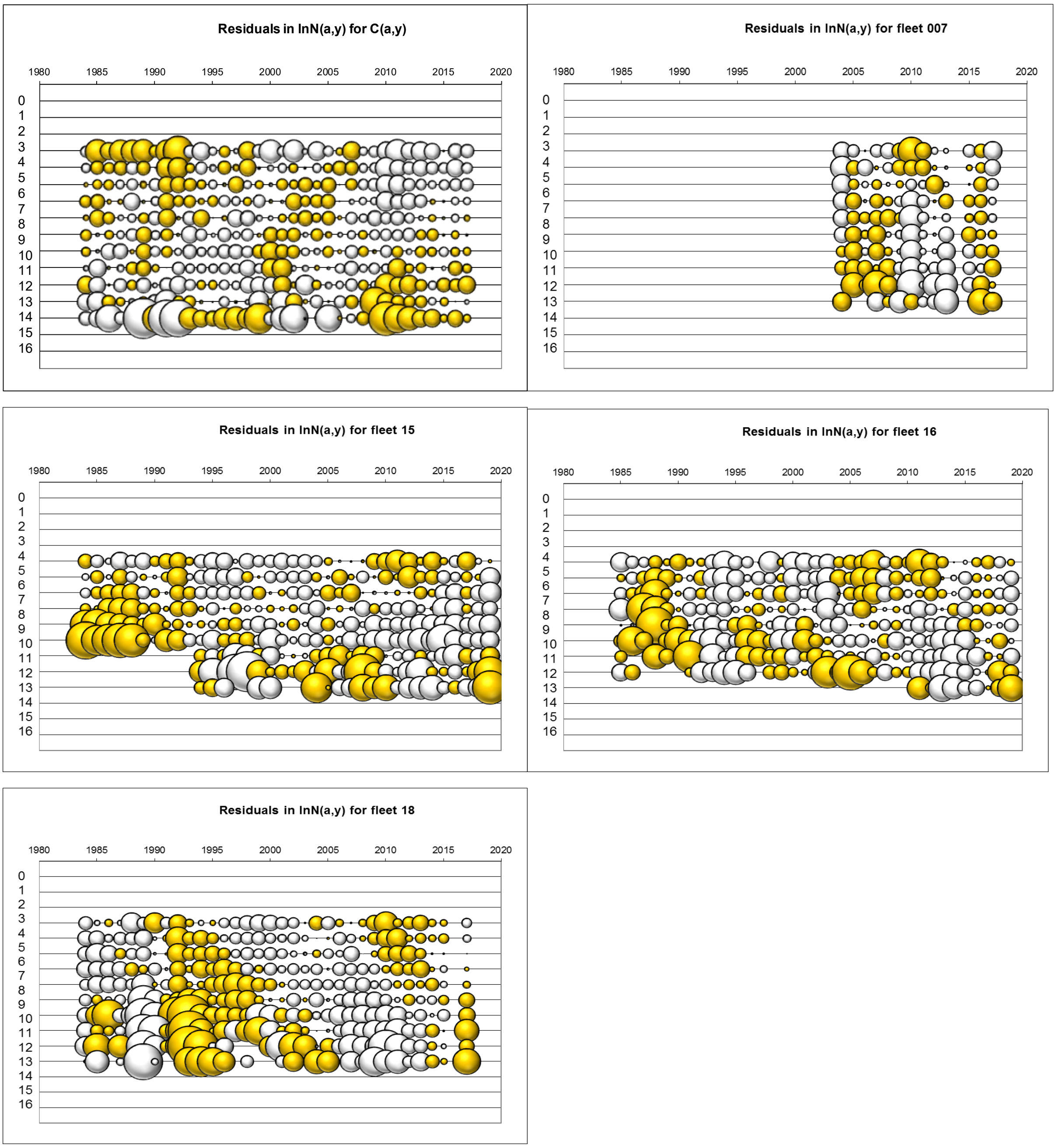

Figure 3. Residuals of the TISVPA data approximation.

The estimates of uncertainty in the results (parametric conditional bootstrap with respect to catch-at-age; “fleet” data were noised by lognormal noise with sigma=0.3) are presented on Figure 4.

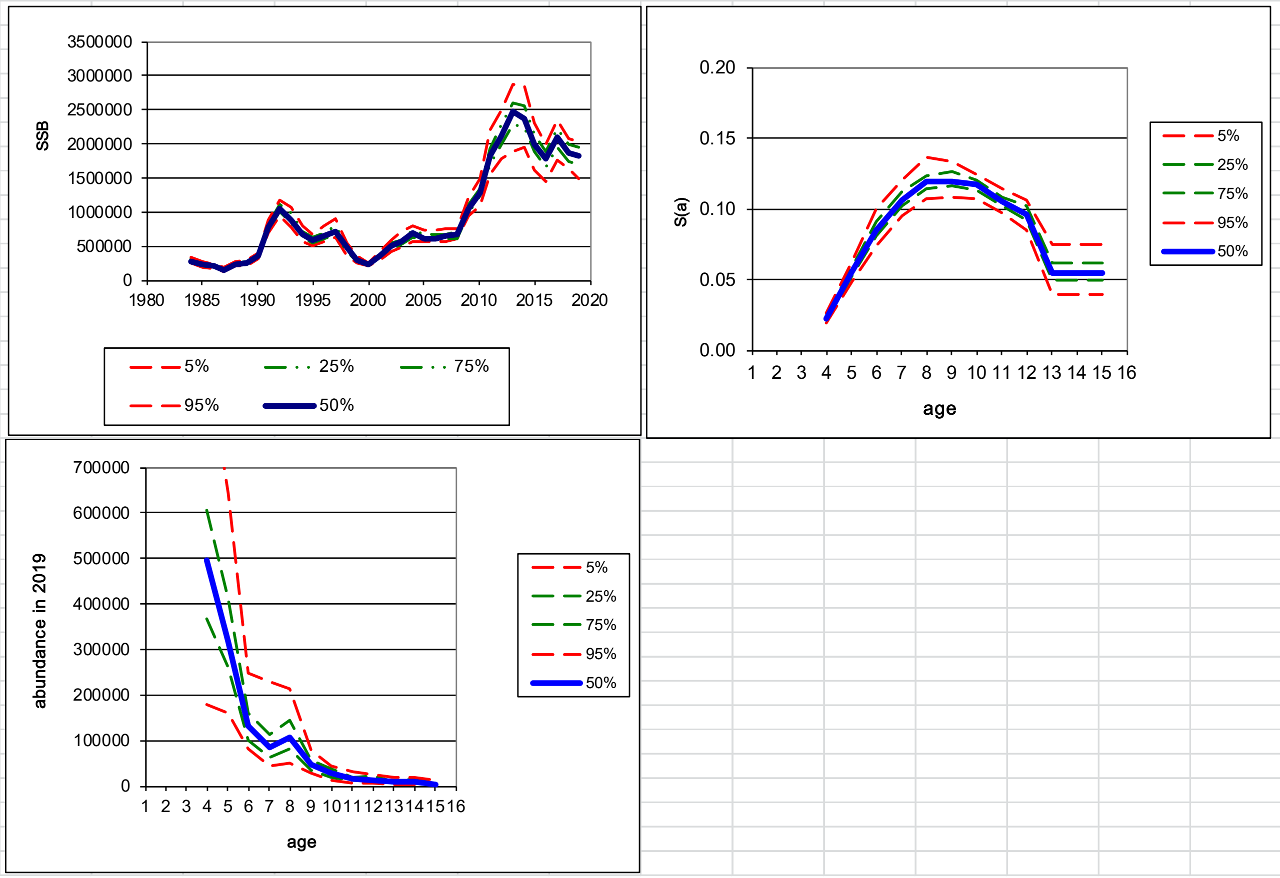

Figure 4. Bootstrap- estimates of uncertainty in the results.

Tables 1-3 represent the results of NEA cod stock assessment by means of TISVPA.

Year	B(3+)	SSB	R(3)	F(5-10)
1984	813201.9	251607.5	411969	0.812
1985	990155.5	199707.4	583047	0.639
1986	1363640	182246.7	1015891	0.785
1987	1223679	135358.6	284049	1.017
1988	1005886	225778.7	215992	0.987
1989	913902.6	237312.3	182324	0.467
1990	996936.9	334589.2	211590	0.311
1991	1569125	721824.8	408357	0.228
1992	1965822	964711	688971	0.411
1993	2455778	853206.1	1000433	0.624
1994	2232270	643640.6	728736	0.826
1995	1922693	579859.7	435074	0.756
1996	1856793	658311.5	394762	0.719
1997	1718566	721897.8	608997	1.048
1998	1287720	440631.1	793938	1.058
1999	1090944	286921.1	446610	0.970
2000	1062428	230196.1	557965	0.675
2001	1293487	351235.5	457530	0.536
2002	1425295	473949.2	409553	0.522
2003	1516577	532777.5	654027	0.515
2004	1481568	623001.2	276911	0.619
2005	1485127	580450.7	531612	0.625
2006	1523745	597825.6	552067	0.653
2007	1881561	625058.5	1368644	0.513
2008	2619874	633097.4	1360508	0.368
2009	3347953	987172.5	913069	0.355
2010	3695017	1196468	566554	0.393
2011	3802508	1690494	661291	0.334
2012	3879741	1949245	694998	0.288
2013	4132734	2220948	801536	0.283
2014	3843732	2171555	990962	0.294
2015	3671185	1850850	447642	0.301
2016	3325412	1638149	307976	0.278
2017	3420527	1958815	760154	0.321
2018	3060426	1731796	668649	0.368
2019	2796874	1717853		

Table 1. NEA cod stock assessments results by means of TISVPA

	3	4	5	6	7	8	9	10	11	12	13	14	15
1984	411969	139061	72716	41672	24693	12142	9031	1477	697	457	216	39	26
1985	583047	330380	99084	42263	18172	7060	3359	2485	476	404	185	123	31
1986	1015891	459773	230876	56920	20067	6805	2325	1317	1063	223	282	115	47
1987	284049	770659	311592	115323	23465	7158	2196	715	431	371	80	176	60
1988	215992	213745	519539	155444	36581	6232	2088	716	145	146	115	43	15
1989	182324	167846	150484	283707	59066	9080	1504	619	189	34	54	58	85
1990	211590	145761	121659	95349	156221	25788	3483	630	292	109	17	38	15
1991	408357	171671	112179	85629	60730	96049	14419	2020	361	184	72	10	20
1992	688971	330643	132991	79454	54531	35758	58492	8621	1267	243	133	55	6
1993	1000433	546892	245909	88345	44936	28326	17170	30413	4387	716	132	97	4
1994	728736	773315	408791	148380	45562	20319	11546	6693	12358	1781	289	68	14
1995	435074	510456	541471	243402	66668	14633	6112	3263	1805	3862	572	149	4
1996	394762	254975	336244	325503	118830	25532	5192	1897	944	506	1430	302	4
1997	608997	232904	164250	196273	159688	49521	9286	2006	585	307	179	659	3
1998	793938	390105	147310	81142	78757	47764	12972	2097	465	109	61	61	147
1999	446610	498114	237003	71986	31013	24240	10433	3675	496	140	25	24	88
2000	557965	337286	326568	111180	25495	10413	5833	2040	1146	159	55	4	55
2001	457530	429821	242950	172082	48475	9058	3672	1694	590	564	69	34	106
2002	409553	356582	312497	148332	80361	20298	3288	1653	632	246	337	47	31
2003	654027	305973	263507	191691	70741	31541	7725	1294	860	324	116	235	5
2004	276911	507948	231246	166165	97114	30891	12732	3537	596	515	179	76	38
2005	531612	212848	373710	146092	82715	37363	11203	4468	1362	243	287	112	33
2006	552067	388863	155248	218840	72806	33573	12813	4139	1507	580	109	195	673
2007	1368644	443401	272777	96627	108305	31457	12850	4080	1597	523	256	66	179
2008	1360508	1054614	328478	164233	54580	53275	14848	6134	1780	779	208	167	83
2009	913069	1045014	803297	228447	98346	31036	26307	7646	3286	868	432	137	131
2010	566554	684848	806110	567748	142615	57314	17060	13598	4282	1846	209	290	207
2011	661291	417158	516246	583683	365706	79198	29461	9041	6868	1685	877	77	0
2012	694998	426781	293097	379790	399285	219117	43412	14649	4033	3292	915	472	162
2013	801536	472156	297971	217208	265209	257380	128105	24020	7640	1989	1796	552	899
2014	990962	528033	354238	217297	156168	166721	148935	66554	12131	3883	1073	1144	855
2015	447642	658834	367932	247867	145615	102018	91610	82161	33714	6317	2058	654	1239
2016	307976	301749	469848	246795	155035	89009	63312	51657	44562	15285	3051	1285	1589
2017	760154	244223	217284	301657	154696	93021	52840	39519	27109	24123	8170	1852	1323
2018	668649	471549	180507	147182	183834	86526	50168	30203	23854	13510	13745	5031	1623
2019	0	472611	357359	123240	86972	101352	45214	26408	15931	13077	7677	9177	3359

Table 2. NEA cod. TISVPA. Estimates of abundance-at-age

F(a,y)	3	4	5	6	7	8	9	10	11	12	13	14
1984	0.0226	0.1381	0.3244	0.5624	1.0246	0.9882	1.0190	0.9539	0.2674	0.8280	0.4149	0.4149
1985	0.0202	0.1250	0.3151	0.4531	0.6211	0.9217	0.7453	0.7764	0.6621	0.2036	0.3397	0.3397
1986	0.0211	0.1526	0.4014	0.6484	0.7466	0.8757	1.1290	0.9064	0.8463	0.7143	0.3973	0.3973
1987	0.0257	0.1585	0.5043	0.8684	1.1553	1.0779	1.0555	1.4410	0.9857	0.9128	0.4640	0.4640
1988	0.0243	0.1662	0.4333	0.9068	1.2536	1.3342	0.9999	0.9959	1.1657	0.8288	0.4469	0.4469
1989	0.0135	0.0900	0.2461	0.3775	0.5728	0.6096	0.5435	0.4513	0.4122	0.4582	0.2330	0.2330
1990	0.0081	0.0593	0.1591	0.2664	0.3225	0.4063	0.3732	0.3408	0.2656	0.2437	0.1551	0.1551
1991	0.0063	0.0386	0.1135	0.1887	0.2532	0.2617	0.2857	0.2666	0.2260	0.1777	0.1147	0.1147
1992	0.0094	0.0669	0.1684	0.3225	0.4486	0.5286	0.4726	0.5282	0.4466	0.3717	0.1979	0.1979
1993	0.0145	0.0847	0.2535	0.4103	0.6726	0.8228	0.8384	0.7457	0.7632	0.6295	0.2897	0.2897
1994	0.0173	0.1157	0.2812	0.5516	0.7365	1.0854	1.1267	1.1730	0.9067	0.9253	0.3670	0.3670
1995	0.0163	0.1114	0.3113	0.4726	0.7609	0.8487	1.0430	1.1003	1.0093	0.7917	0.3629	0.3629
1996	0.0209	0.1065	0.3051	0.5427	0.6584	0.9062	0.8443	1.0544	0.9832	0.9021	0.3672	0.3672
1997	0.0277	0.1825	0.3922	0.7547	1.1720	1.1850	1.4455	1.3402	1.5442	1.3987	0.5098	0.5098
1998	0.0308	0.1851	0.5295	0.6965	1.1092	1.4377	1.1501	1.4251	1.1515	1.2958	0.5081	0.5081
1999	0.0251	0.1958	0.5015	0.9215	0.9186	1.2077	1.2408	1.0303	1.0976	0.9115	0.4720	0.4720
2000	0.0206	0.1230	0.4004	0.6145	0.8515	0.6925	0.7329	0.7586	0.5950	0.6221	0.3319	0.3319
2001	0.0147	0.1083	0.2638	0.5360	0.6389	0.7234	0.5108	0.5443	0.5117	0.4106	0.2602	0.2602
2002	0.0131	0.0881	0.2699	0.4085	0.6748	0.6689	0.6424	0.4647	0.4520	0.4245	0.2403	0.2403
2003	0.0133	0.0795	0.2198	0.4269	0.5156	0.7234	0.6088	0.5930	0.3960	0.3841	0.2261	0.2261
2004	0.0144	0.0992	0.2446	0.4329	0.7055	0.7187	0.8765	0.7379	0.6488	0.4274	0.2646	0.2646
2005	0.0152	0.0945	0.2707	0.4183	0.6029	0.8431	0.7217	0.8939	0.6783	0.5961	0.2695	0.2695
2006	0.0157	0.1061	0.2746	0.5042	0.6291	0.7770	0.9303	0.8022	0.8946	0.6757	0.2936	0.2936
2007	0.0125	0.0859	0.2375	0.3804	0.5566	0.5790	0.6035	0.7190	0.5718	0.6259	0.2436	0.2436
2008	0.0080	0.0635	0.1768	0.3029	0.3855	0.4731	0.4244	0.4461	0.4775	0.3878	0.1892	0.1892
2009	0.0075	0.0495	0.1615	0.2830	0.3931	0.4269	0.4538	0.4124	0.3972	0.4228	0.1852	0.1852
2010	0.0060	0.0525	0.1414	0.2954	0.4241	0.5077	0.4769	0.5141	0.4264	0.4090	0.2070	0.2070
2011	0.0064	0.0346	0.1241	0.2094	0.3562	0.4364	0.4510	0.4294	0.4230	0.3522	0.1896	0.1896
2012	0.0071	0.0381	0.0832	0.1883	0.2578	0.3781	0.4022	0.4202	0.3676	0.3609	0.1789	0.1789
2013	0.0077	0.0489	0.1061	0.1447	0.2704	0.3202	0.4129	0.4449	0.4260	0.3711	0.1964	0.1964
2014	0.0095	0.0555	0.1441	0.1955	0.2162	0.3548	0.3679	0.4838	0.4775	0.4550	0.2268	0.2268
2015	0.0117	0.0679	0.1614	0.2644	0.2895	0.2750	0.3990	0.4191	0.5070	0.4982	0.2569	0.2569
2016	0.0105	0.0704	0.1666	0.2465	0.3265	0.3055	0.2541	0.3710	0.3576	0.4279	0.2410	0.2410
2017	0.0141	0.0749	0.2068	0.3072	0.3682	0.4201	0.3409	0.2857	0.3858	0.3703	0.2720	0.2720
2018	0.0109	0.0696	0.1816	0.2978	0.3954	0.4491	0.4417	0.4397	0.4011	0.3652	0.2040	0.2040

Table 3. NEA cod. TISVPA. Estimates of fishing mortality coefficients

References

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3. Vasilyev D. 2006. Change in catchability caused by year class peculiarities: how stock assessment based on separable cohort models is able to take it into account? (Some illustrations fo triple-separable case of the ISVPA model - TISVPA). ICES CM 2006/O:18. 35 pp

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NEA haddock stock assessment by means of TISVPA

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The TISVPA model (Vasilyev, 2005; 2006) was applied to the same northeast arctic haddock data as XSA and SAM models, except the natural mortality values from cannibalism were taken from the SAM runs. The 4 sets of age - structured tuning data were included into analysis: Russian bottom trawl survey (“fleet 01”); Joint Barents Sea acoustic survey (“fleet 02), Joint Barents Sea bottom trawl survey (“fleet 04”), and Joined Russian-Norwegian ecosystem autumn bottom trawl survey in the Barents Sea (“fleet 007”).

The TISVPA model was applied to northeast arctic haddock with the settings which gave in 2018 stock assessment more historically stable results – the case which was named TISVPA-2 in AFWG-2018 Report and in WD15 to AFWG-2018: so called “mixed” version, assuming errors both in catch-at-age and in separable approximation; additional restriction on the solution was the unbiased model approximation of separable representation of fishing mortality coefficients. The generation - dependent factors in triple - separable representation of fishing mortality coefficients were estimated and applied for age groups from 3 to 9. The tuning on surveys data was made not at abundance but at age proportions because of probable change in effective survey catchability the absolute median deviation (AMD) was used for catch-at-age and fleets 01 and 04. The profiles of the components of the TISVPA loss function for such model settings are shown in Figure 1.

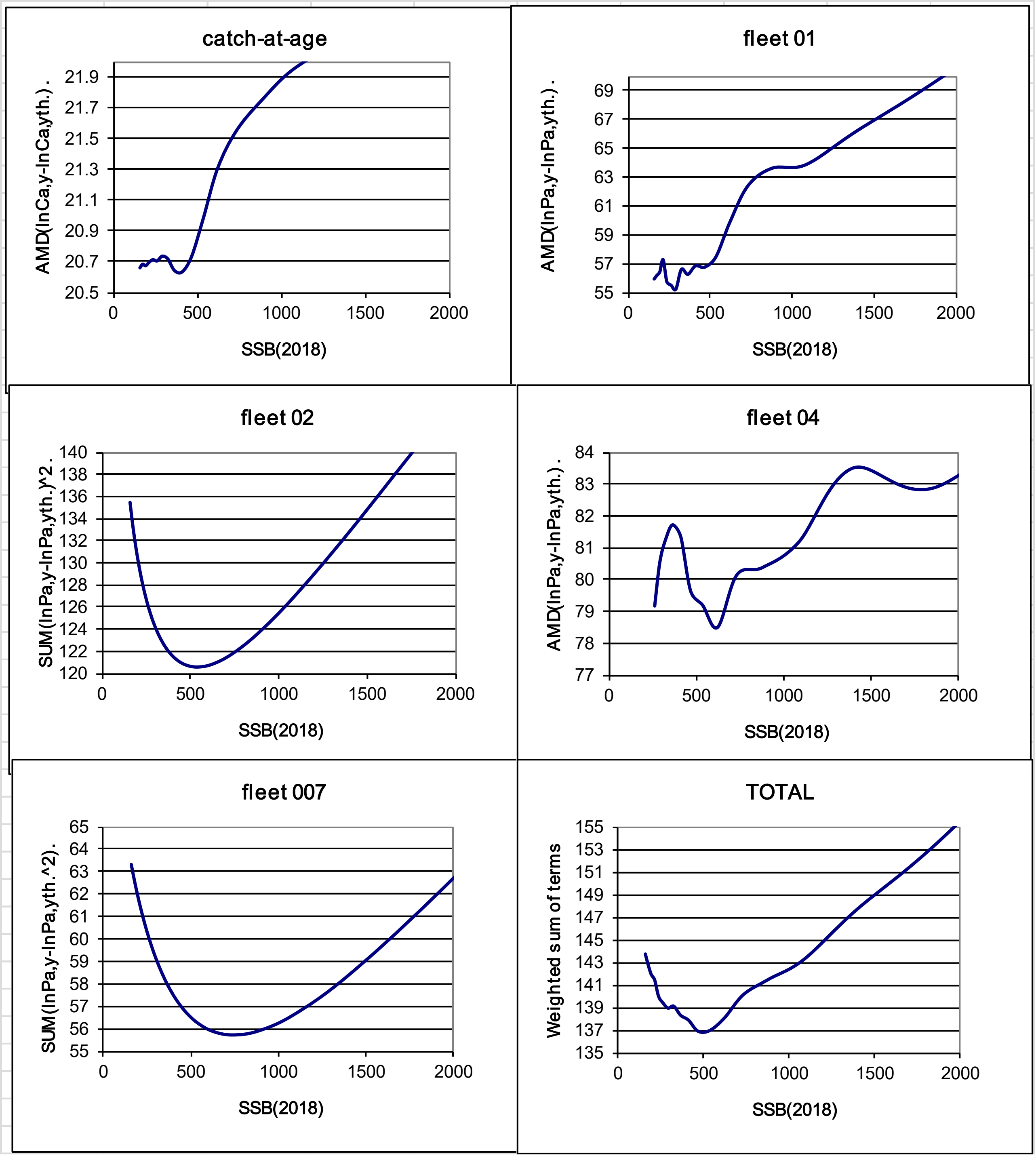

Figure 1. Profiles of the components of the TISVPA objective function for the preliminary model run.

As it can be seen, the catch-at-age data and surveys 02, 04 and 07 give rather similar indications about the stock.

Figure 2 represents the results of retrospective runs..

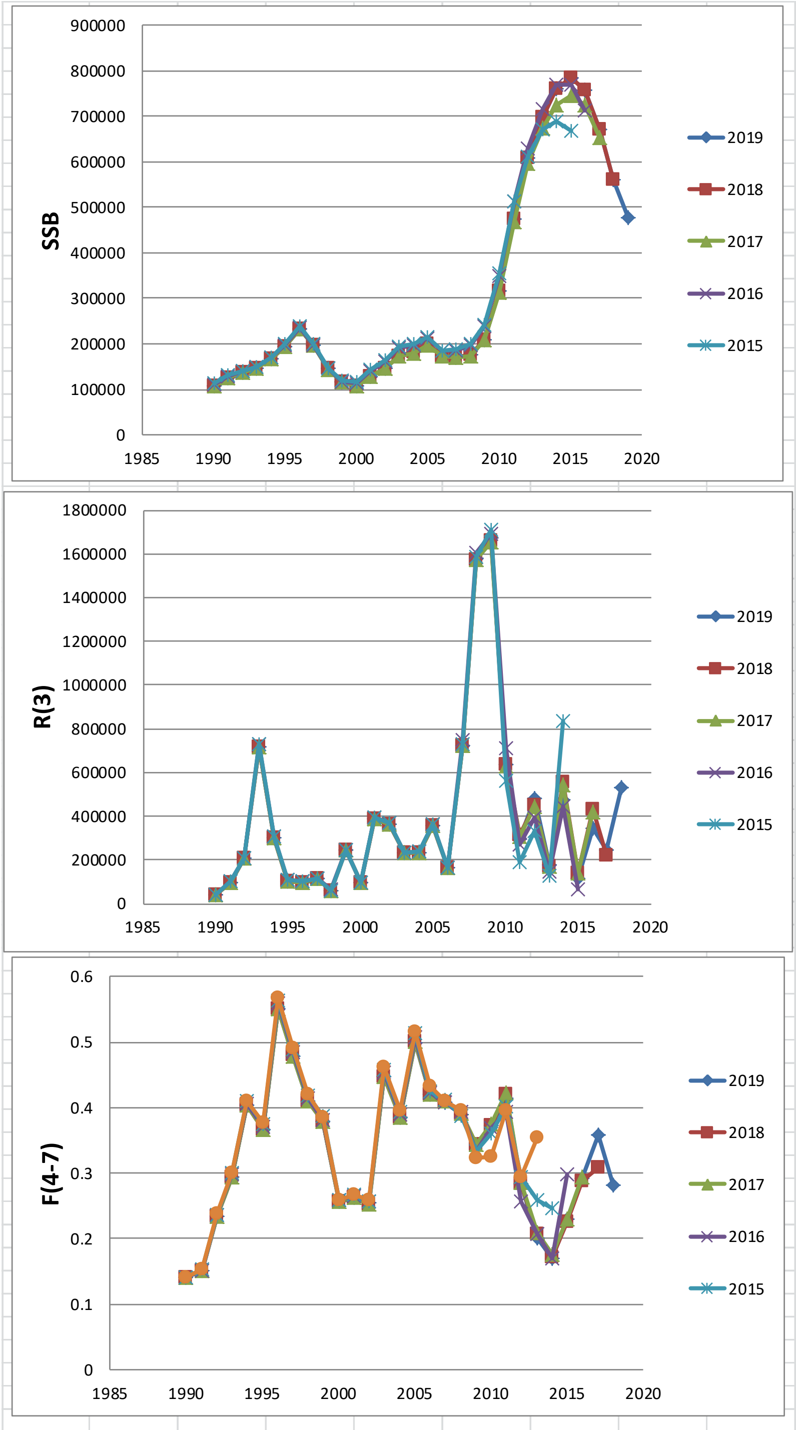

Figure 2. TISVPA retrospective runs

The residuals of the model approximation of catch-at-age and “fleets” data are presented in Figure 3. For “fleets” 01, 02, 04 and 007 the year-effect in abundance-derived residuals is apparent, that is why the age-proportions are highly likely more appropriate for tuning for the “fleets”.

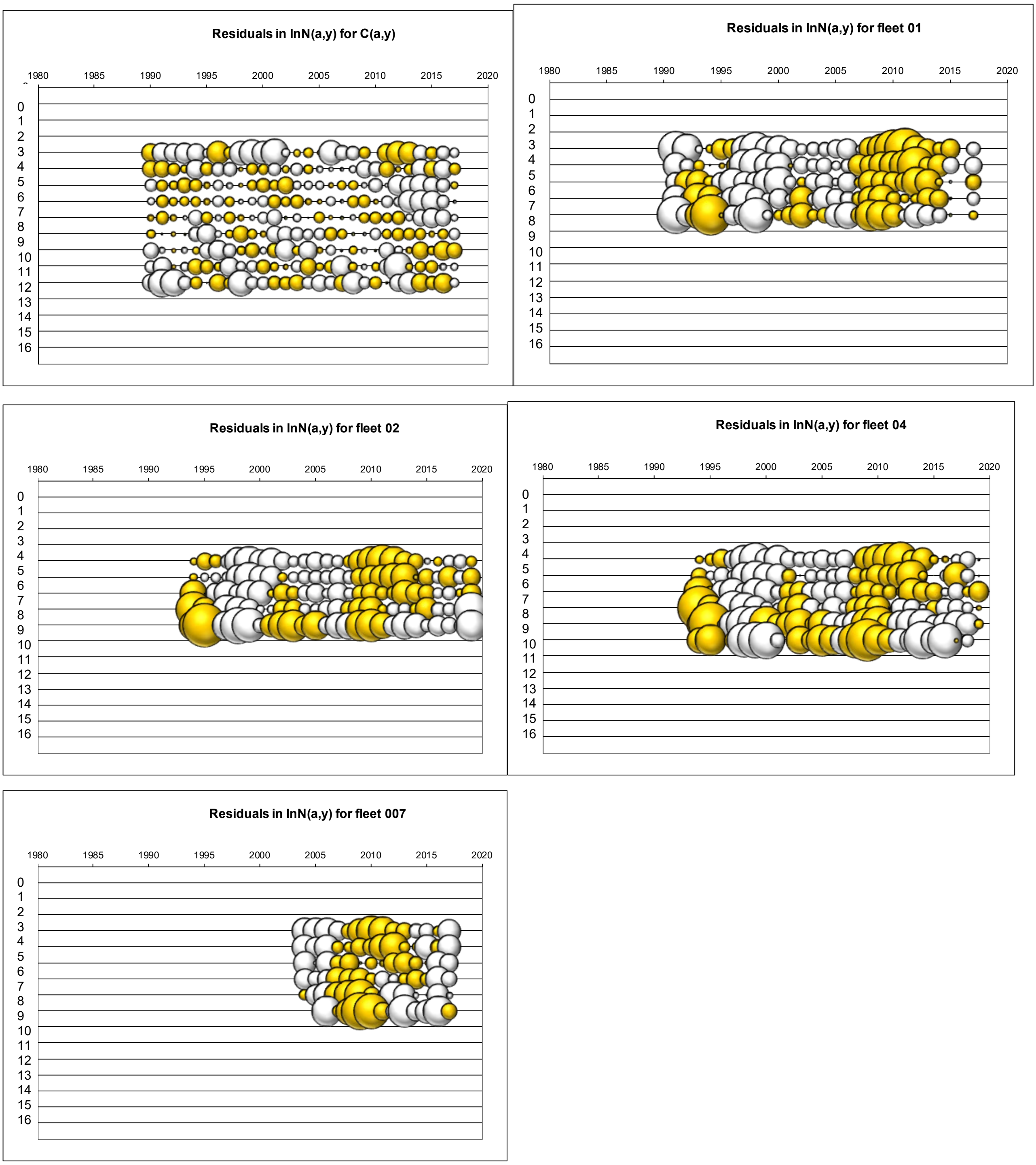

Figure 3. Residuals of the TISVPA data approximation.

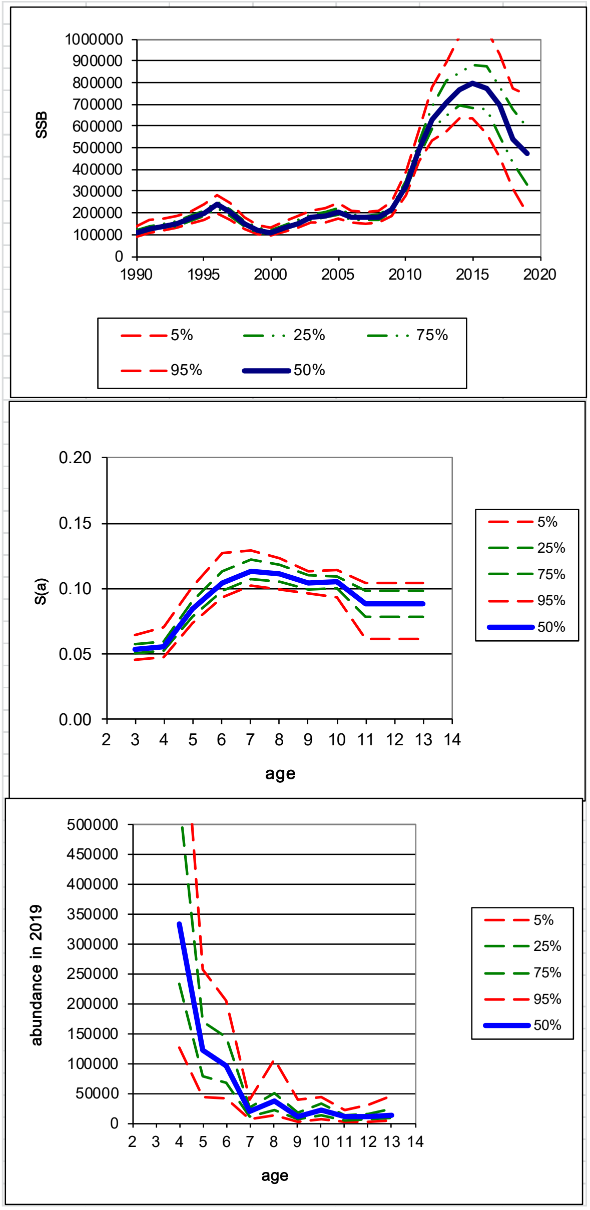

Figure 4. Bootstrap- estimates of uncertainty in the results.

The estimates of uncertainty in the results (parametric conditional bootstrap with respect to catch-at-age; “fleet” data were noised by lognormal noise with sigma=0.3) are presented on Figure 4.

The results of the assessment are presented in the Tables 1-3.

Year	B(3+)	SSB	R(3)	F(4-7)
1990	188070	108230	40142	0.142
1991	215798	126891	99216	0.152
1992	276807	137489	207046	0.234
1993	469862	145635	716991	0.295
1994	575643	166847	301700	0.404
1995	569952	193453	104291	0.367
1996	504478	232654	99178	0.551
1997	366738	196421	114112	0.479
1998	263418	145175	61542	0.411
1999	278358	116339	244415	0.379
2000	272560	108357	94737	0.257
2001	369207	128969	388783	0.263
2002	455951	146362	363343	0.254
2003	511771	172930	231364	0.447
2004	489815	180843	233723	0.386
2005	505404	199125	356330	0.500
2006	436697	174707	163008	0.420
2007	528412	171695	722207	0.408
2008	855545	175476	1577310	0.390
2009	1286152	210524	1672724	0.344
2010	1513396	315332	637295	0.373
2011	1509417	475206	296639	0.415
2012	1419155	609995	478493	0.284
2013	1274599	697956	174556	0.202
2014	1303659	759707	476817	0.170
2015	1231945	785417	112567	0.231
2016	1164762	758272	343297	0.293
2017	1034321	670447	243292	0.359
2018	973103	562375	531790	0.2816
2019		477428		

Table 1. Haddock. The results of the assessment by TISVPA

	3	4	5	6	7	8	9	10	11	12	13
1990	40142	19939	24424	34759	37219	5597	1606	459	267	156	528
1991	99216	29528	14415	17786	24625	25077	3873	1165	333	202	303
1992	207046	75555	21541	9842	11913	16483	16974	2737	850	254	143
1993	716991	153873	52592	14186	5826	7253	10546	10790	1809	630	164
1994	301700	520256	106468	30667	8191	3155	4246	6654	6912	1263	239
1995	104291	211647	354593	58045	14257	4328	1568	2231	3427	4224	609
1996	99178	72019	138721	203721	30721	6547	2522	869	1230	2215	2840
1997	114112	55263	45757	74011	86929	12314	2529	1279	407	632	1851
1998	61542	71169	37267	24774	33142	32192	5292	1213	718	232	1618
1999	244415	44629	45664	21857	12239	15189	12495	2568	664	478	966
2000	94737	168814	30019	24798	12054	5842	7198	5592	1434	420	1103
2001	388783	72144	112630	19460	14968	7425	3338	4399	3244	980	1671
2002	363343	281547	53537	65936	11808	8872	4728	1855	2614	2074	582
2003	231364	251742	188547	35442	35614	7337	5421	3176	1125	1685	1611
2004	233723	147225	159040	97950	19897	15036	4229	2630	1710	620	2074
2005	356330	149543	93808	87313	44491	11835	7300	2688	1264	1087	4378
2006	163008	231162	94760	52122	37966	16809	7215	3381	1361	798	1464
2007	722207	116916	152709	52340	27308	16887	7160	4650	1749	874	821
2008	1577310	475260	78177	84797	25609	12881	7377	3517	2783	993	771
2009	1672724	1015065	302951	45800	41998	12375	6510	3639	1890	1863	1695
2010	637295	1117465	672545	174710	25329	21798	6641	3760	2148	1253	3215
2011	296639	447211	771254	381365	87052	13399	12407	3682	2135	1336	3517
2012	478493	197513	295439	455715	182750	38723	7304	7432	2227	1357	3567
2013	174556	307233	142343	206178	275810	85849	20330	4698	5079	1558	3933
2014	476817	116925	218538	102746	143071	170397	46446	12342	3023	3683	4562
2015	112567	346834	87259	157176	73844	98324	107187	26334	8113	2040	2157
2016	343297	78313	225029	59224	104633	50103	62588	66203	16268	5423	1535
2017	243292	248531	56020	138121	36102	64504	31083	36278	41422	10073	1706
2018	531790	168916	167249	32948	68088	19540	37507	18359	21659	27371	8228
2019	0	372884	117197	105559	19301	38661	11362	22653	11298	14508	18334

Table 2. Haddock. Estimates of abundance-at-age

F	3	4	5	6	7	8	9	10	11	12	13
1990	0.0794	0.0980	0.1307	0.1507	0.1872	0.1575	0.1426	0.1345	0.0967	0.0967	0.0967
1991	0.0929	0.0907	0.1623	0.1774	0.1757	0.1893	0.1520	0.1444	0.1037	0.1037	0.1037
1992	0.1213	0.1427	0.2030	0.3046	0.2839	0.2420	0.2489	0.2104	0.1496	0.1496	0.1496
1993	0.1566	0.1592	0.2774	0.3239	0.4201	0.3333	0.2692	0.2615	0.1846	0.1846	0.1846
1994	0.1946	0.2323	0.3528	0.5186	0.5124	0.5731	0.4233	0.3705	0.2571	0.2571	0.2571
1995	0.1819	0.1916	0.3407	0.4193	0.5182	0.4334	0.4563	0.3386	0.2362	0.2362	0.2362
1996	0.2267	0.2886	0.4643	0.7108	0.7413	0.7819	0.6009	0.5234	0.3544	0.3544	0.3544
1997	0.2421	0.2228	0.4288	0.5573	0.7085	0.6133	0.6067	0.4739	0.3236	0.3236	0.3236
1998	0.1685	0.2394	0.3277	0.5166	0.5600	0.5927	0.4888	0.4334	0.2978	0.2978	0.2978
1999	0.2459	0.1757	0.3747	0.4143	0.5532	0.5047	0.5037	0.4213	0.2901	0.2901	0.2901
2000	0.0999	0.1858	0.1949	0.3342	0.3112	0.3482	0.3046	0.2899	0.2037	0.2037	0.2037
2001	0.1843	0.1103	0.3055	0.2579	0.3803	0.3029	0.3218	0.3013	0.2113	0.2113	0.2113
2002	0.1770	0.1919	0.1662	0.3844	0.2732	0.3453	0.2626	0.2930	0.2058	0.2058	0.2058
2003	0.2409	0.2893	0.4814	0.3243	0.6948	0.3994	0.4862	0.4620	0.3160	0.3160	0.3160
2004	0.2283	0.2332	0.4231	0.5690	0.3187	0.5675	0.3183	0.4131	0.2848	0.2848	0.2848
2005	0.2278	0.2666	0.4110	0.6203	0.7018	0.3262	0.5498	0.4542	0.3111	0.3111	0.3111
2006	0.1861	0.2185	0.3835	0.4771	0.6004	0.5660	0.2593	0.4019	0.2775	0.2775	0.2775
2007	0.2563	0.2051	0.3606	0.5215	0.5446	0.5771	0.5142	0.4155	0.2864	0.2864	0.2864
2008	0.2759	0.2611	0.3096	0.4455	0.5423	0.4774	0.4772	0.3932	0.2719	0.2719	0.2719
2009	0.1819	0.2552	0.3615	0.3435	0.4163	0.4277	0.3598	0.3367	0.2349	0.2349	0.2349
2010	0.1542	0.1988	0.4230	0.4848	0.3847	0.3979	0.3875	0.3446	0.2401	0.2401	0.2401
2011	0.1491	0.1723	0.3314	0.5913	0.5643	0.3778	0.3706	0.3621	0.2516	0.2516	0.2516
2012	0.1423	0.1238	0.2083	0.3245	0.4786	0.3894	0.2553	0.2748	0.1935	0.1935	0.1935
2013	0.1278	0.1283	0.1618	0.2225	0.2944	0.3671	0.2870	0.2298	0.1629	0.1629	0.1629
2014	0.1395	0.1188	0.1730	0.1778	0.2091	0.2379	0.2801	0.1988	0.1416	0.1416	0.1416
2015	0.1420	0.1833	0.2276	0.2728	0.2388	0.2433	0.2640	0.2462	0.1742	0.1742	0.1742
2016	0.1407	0.1710	0.3297	0.3318	0.3386	0.2541	0.2464	0.2794	0.1967	0.1967	0.1967
2017	0.1769	0.1750	0.3167	0.5129	0.4307	0.3746	0.2661	0.3292	0.2299	0.2299	0.2299
2018	0.1550	0.1656	0.2602	0.3348	0.3660	0.3422	0.3042	0.2855	0.2007	0.2007	0.2007

Table 3. Haddock. Estimates of fishing mortality coefficients

References

. Vasilyev D. 2005 Key aspects of robust fish stock assessment. M: VNIRO Publishing, 2005. 105 p.

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What does NEA cod want for prediction - Fsq or TAC constrain?

WD 11 to ICES AFWG, 24-30 April 2019

Yury Kovalev, Anatolii Chetyrkin (Polar branch of VNIRO, Russia)

Introduction

Prediction of TSB and SSB in stock assessment and TAC estimation often producing using two approaches. ”F status quo” method (FSQ) which assumed F for “intermediate year” (a year after terminal year in assessment) equal to the F of previous year or average F for number of previous years. The second method – “TAC constrained” approach assumed F for intermediate year corresponding to actual/predicted catch at this year. Usually catch is taken as TAC for that year.

TAC for NEA cod for many years is predicted using FSQ method. It is stated in Quality Handbook for NEA cod. Historically it was observed that in some years predicted catch for intermediate year was significantly differ from TAC/actual catch. The reason for using FSQ method was that it gives more accurate prediction of TSB and SSB for beginning of the first year of prediction (TAC year).

At this WD we explore if the used reason is still valid.

Method

The main assessment model for NEA cod is SAM [1]. The work is done using the SAM model with same model configuration as used at AFWG-2018 [2]. The assessment and prediction are simulated in a way maximally corresponding to AFWG-2018 [2]. Terminal values of TSB and SSB as well as F pattern and Fsq were taken from SAM retro runs.

Retro runs were made for the period from 2012 to 2018 due to the fact that when we move backward there are not enough years with data on ecosystem surveys. Historical TAC values were taken from ACOM Advice table while biological data from AFWG-2018 [2]. Prediction of weight in stock, weight in catch, maturity ogives, fishing pattern and natural mortality were made like at AFWG-2018 (Table A.4-A.8). Recruitment was not modeled and taken from AFWG-2018 (Table A.1-A.3).

The forecast of catch and stock dynamics for intermediate year is made by 2 methods:

1 - F taken from the last year of the retro run (FSQ method),

2 - F matched accordingly the TAC of this year (TAC constrained).

Tables with the results of predictions are given below (Table A.1-A.3). The “true” SSB and TSB assumed equal the last group assessment values.

Comparison of the results of both prediction methods quality (Figures 1-4) is done visually and using Mohn`s rho and SSQ criteria (Table 1):

Mohn`s rho - the average deviation of the predicted values from the "true" run (AFWG 2018);

SSQ - the standard deviation of the predicted values from the “true” run (AFWG 2018).

Results:

The results of calculations of the TSB and SSB predicted values using two forecast methods are presented in figures 1-4.

Figures 3-4 shows the “true” terminal values of TSB and SSB in comparing with same data predicted by two methods for the beginning of “TAC year” started from terminal retro values. A systematic underestimation of TSB is noticeable compared with the “true” values. In contrast to TSB, for SSB in retro prediction there were deviations in both directions (over/underestimation).

According to the Mohn`s rho and SSQ criteria the FSQ method gives more adequate prediction of TSB and SSB at the beginning of TAC year.

Table 1. Mohn`s rho and SSQ criteria values for FSQ and TAC prediction methods in comparison with “true” assessment

		Rho	SSQ
TSB	Fsq	-0,148	0,18
	TAC constrained	-0,182	0,20
SSB	Fsq	-0,020	0,13
	TAC constrained	-0,068	0,14

It was also verified that with calculation F as average for 5 previous years the rho\ssq criteria values became slightly worse.

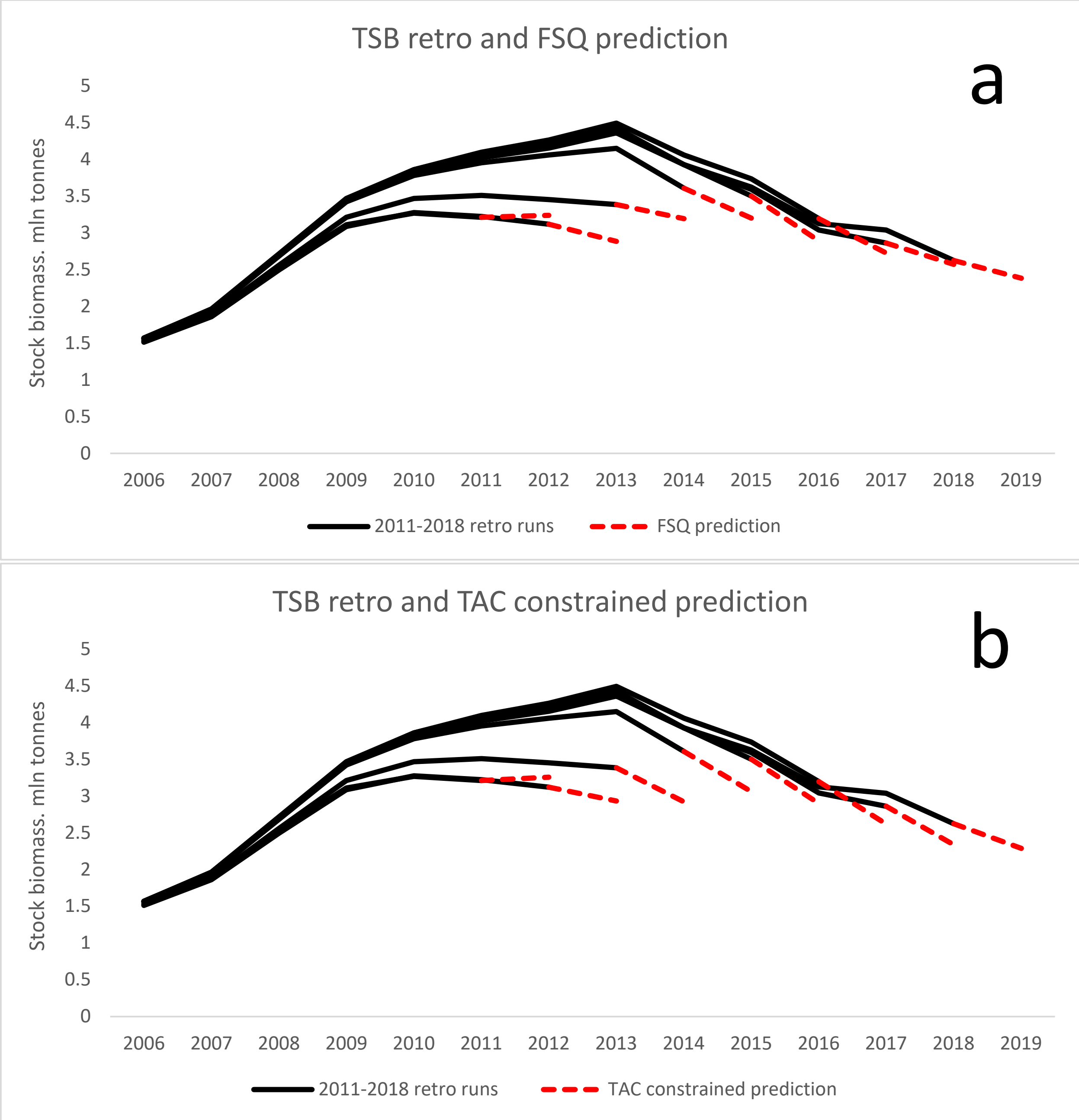


Figure 1. TSB values from retro run and FSQ (a), TAC constrained (b) methods of prediction

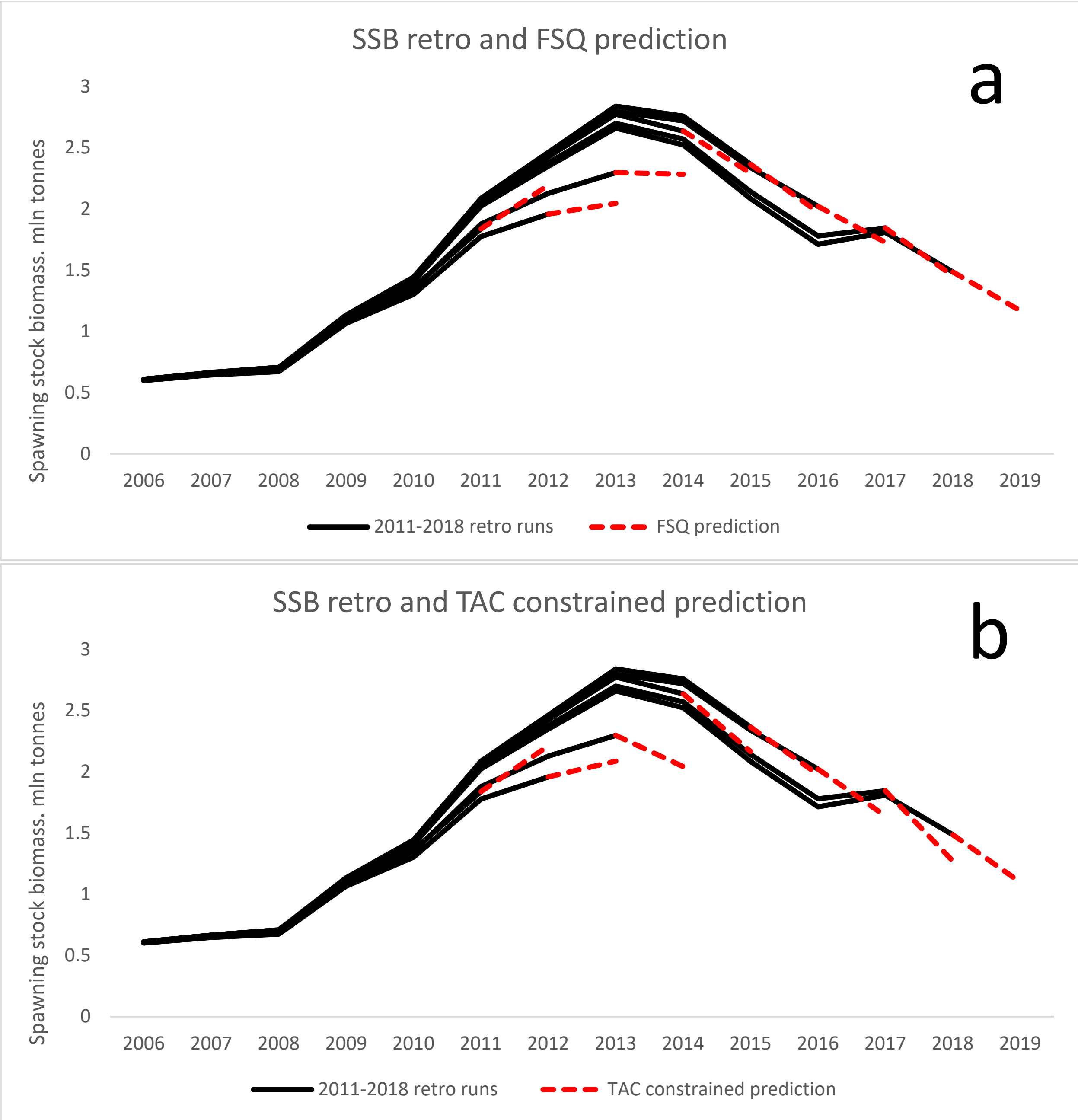


Figure 2. SSB values from retro run and FSQ (a), TAC constrained (b) methods of prediction

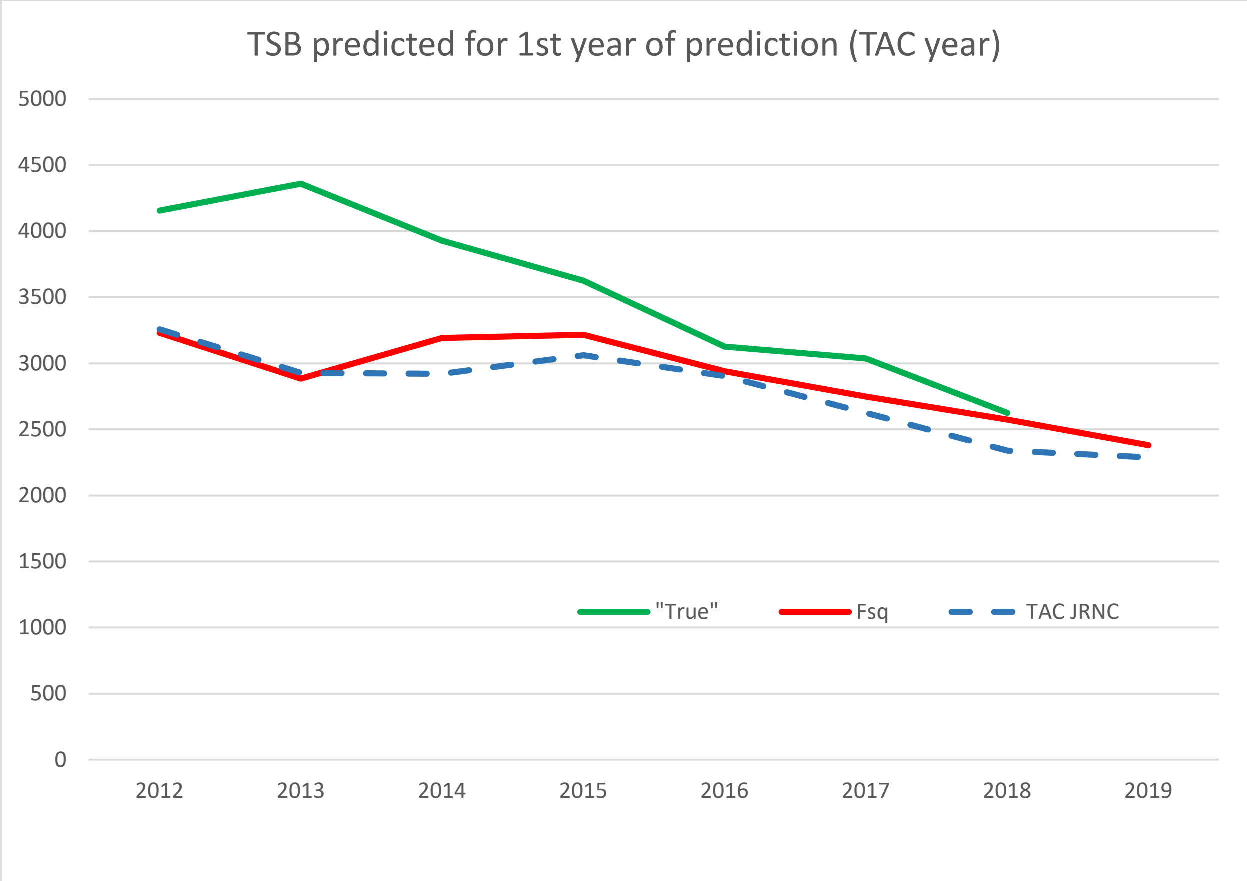


Figure 3. TSB predicted for 1st year of prediction

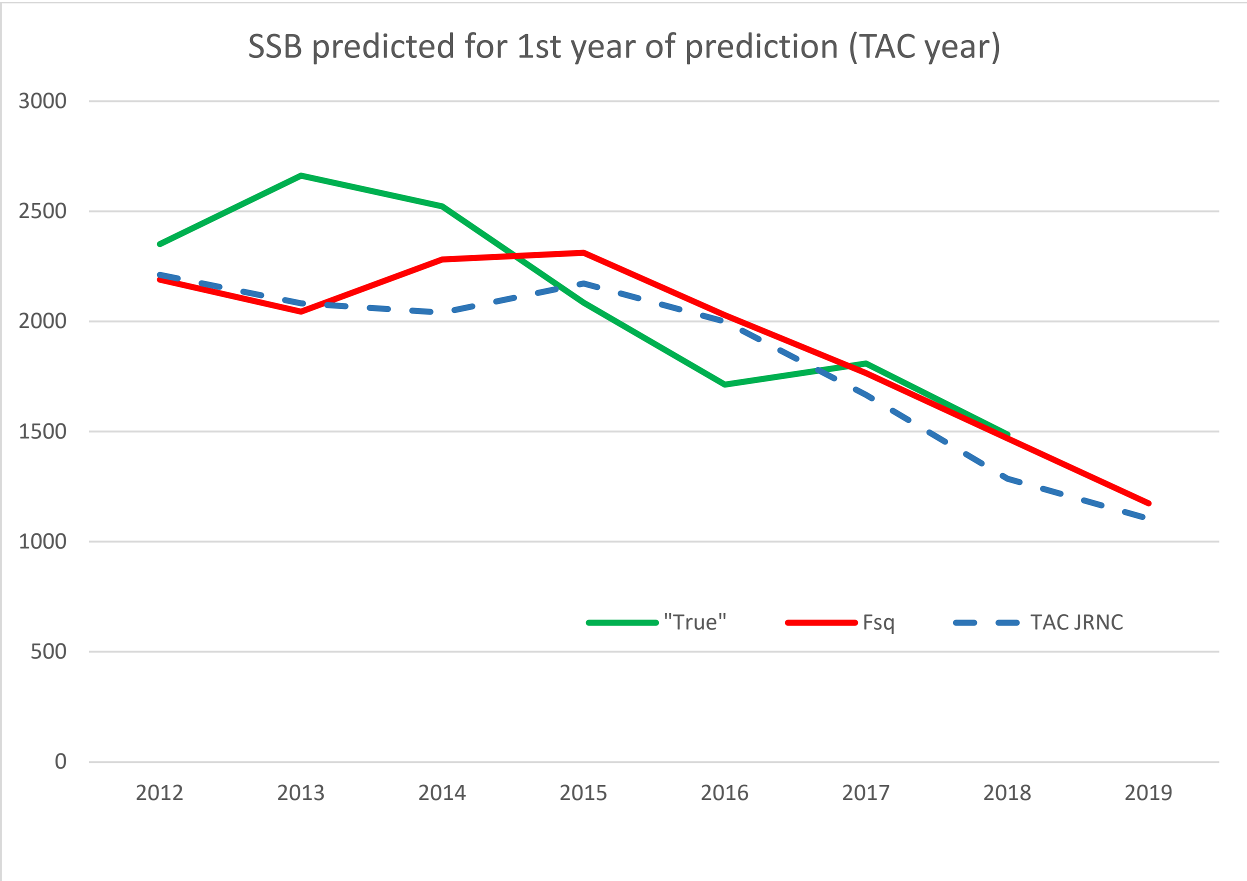


Figure 4. SSB predicted for 1st year of prediction

Appendix

Table A.1. Terminal values of abundance, TSB and SSB from SAM retro run

	Terminal stock assessment values							
	N							
	2011	2012	2013	2014	2015	2016	2017	2018
3*	473404	553893	613740	718586	399021	245294	688190	691000
4	97516	134484	193276	235228	298461	209331	134444	405639
5	250506	78787	118249	177960	203324	275231	151748	130203
6	363640	191019	77851	116186	151390	171182	191404	135076
7	372530	304819	153570	72811	104310	114604	102531	140551
8	119801	236480	233791	143583	54137	72187	77921	80112
9	37832	59287	160124	184310	113830	42647	45747	38865
10	13287	20675	34821	115504	117646	76294	27146	25304
11	12168	6449	13745	20529	57125	62392	31703	11296
12	2370	4479	3933	8446	11221	26193	25858	12574
13	611	984	2763	2763	5021	5908	10959	12097
14	271	344	661	2091	1835	2791	3339	6527
15	135	204	392	1146	2567	3160	3972	4783
TSB	3210	3119	3385	3607	3501	3194	2860	2624
SSB	1839	1959	2298	2637	2365	2022	1846	1486
"True"								
TSB 2018	**4021**	**4154**	**4360**	**3926**	**3624**	**3125**	**3037**	**2624**
SSB 2018	**2024**	**2350**	**2662**	**2523**	**2085**	**1713**	**1809**	**1486**

* recruitment is taken from AFWG-2018 report

Table A.2. Terminal values of abundance, TSB and SSB assessed by Fsq method

	N	Forecast on the end of intermediate year (TAC year)							
	2011	2012	2013	2014	2015	2016	2017	2018	2019
3*		553893	613740	718586	399021	245294	688190	691000	617000
4		323258	346667	385577	415865	236757	152860	472319	466535
5		71735	90923	125280	155934	197107	141564	91678	286328
6		176575	55391	82638	123405	138021	182080	96238	83548
7		246570	129944	53908	79640	100275	109405	116427	80076
8		239594	192369	100121	47141	64268	69491	61096	79385
9		72296	139673	144883	87879	31721	41650	44351	41391
10		22436	33327	95911	108897	64524	24414	25313	20002
11		7727	10919	19891	65993	65227	41470	13720	11243
12		6290	3039	7190	11569	32655	33732	15923	4885
13		1054	1923	2006	5010	6942	15826	14988	6694
14		358	486	1469	1751	3320	3984	7306	7724
15		151	208	421	1475	1312	2023	2421	4631
TSB		3230	2883	3190	3216	2939	2748	2573	2381
SSB		2189	2043	2281	2312	2029	1765	1469	1174
"True"									

TSB 2018		4154	4360	3926	3624	3125	3037	2624	
SSB 2018		2350	2662	2523	2085	1713	1809	1486	

* recruitment is taken from AFWG-2018 report

Table A.3. Terminal values of abundance, TSB and SSB assessed by TAC constrained method

	N	Forecast on the end of intermediate year (TAC year)							
	2011	2012	2013	2014	2015	2016	2017	2018	2019
3*		553893	613740	718586	399021	245294	688190	691000	617000
4		323391	346865	384442	415230	236661	152587	470196	465655
5		71900	91260	122851	154307	196566	139920	89228	282956
6		177476	55836	79024	120419	137112	177207	90061	81126
7		248296	131404	50630	76917	99350	105032	105260	76390
8		241830	195433	91752	44965	63465	66074	54266	74964
9		73150	142470	130216	82878	31255	39273	38725	38552
10		22716	34096	85085	101972	63483	22990	21870	18619
11		7829	11213	17328	61381	64112	38714	11460	10231
12		6402	3143	6055	10731	32140	31462	13269	4426
13		1079	1999	1673	4695	6857	15039	13175	6264
14		363	501	1245	1663	3289	3856	6767	7433
15		153	211	382	1432	1304	1982	2314	4530
TSB		3256	2929	2919	3060	2904	2625	2340	2288
SSB		2211	2083	2040	2172	1999	1666	1287	1104
"True"									
TSB 2018		4154	4360	3926	3624	3125	3037	2624	
SSB 2018		2350	2662	2523	2085	1713	1809	1486	

* recruitment is taken from AFWG-2018 report

Table A.4. Simulated predicted data of maturity ogive

	Mat								
	Avarage for last 3 years								
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
3	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	
4	0,002	0,001	0,001	0,001	0,001	0,002	0,001	0,001	
5	0,061	0,053	0,043	0,030	0,024	0,013	0,012	0,007	
6	0,326	0,346	0,294	0,237	0,169	0,128	0,096	0,100	
7	0,622	0,656	0,590	0,561	0,519	0,427	0,350	0,343	
8	0,853	0,837	0,814	0,785	0,781	0,753	0,694	0,686	
9	0,944	0,948	0,925	0,919	0,915	0,907	0,872	0,876	
10	0,987	0,977	0,966	0,970	0,975	0,976	0,968	0,971	
11	0,985	0,982	0,985	0,990	0,992	0,992	0,991	0,991	
12	0,995	0,992	0,988	0,993	0,996	0,998	0,998	0,997	
13	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
14	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
15	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	

Table A.5 Simulated predicted data of weight in stock

	WEST								(	
	Increament = Avarage for last 3 years + last year data									
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**		
3	0,246	0,231	0,225	0,235	0,222	0,234	0,223	0,271		
4	0,642	0,563	0,543	0,605	0,569	0,577	0,548	0,609		
5	1,196	1,139	1,081	1,125	1,143	1,121	1,072	1,218		
6	2,091	1,898	1,812	1,923	1,899	1,958	1,740	1,955		
7	3,181	2,895	2,562	2,913	2,751	2,918	2,677	2,941		
8	4,685	4,108	3,927	4,088	4,010	3,972	3,776	4,309		
9	6,563	6,011	5,770	5,738	5,317	5,312	5,335	6,301		
10	8,707	8,357	7,870	7,625	7,000	6,935	7,142	7,711		
11	8,405	9,828	10,803	10,481	8,858	8,332	8,640	9,298		
12	12,591	13,190	14,478	12,432	10,946	11,222	11,819	13,048		
13	14,544	14,544	14,544	14,544	14,544	14,544	14,544	14,544		
14	16,466	16,466	16,466	16,466	16,466	16,466	16,466	16,466		
15	18,388	18,388	18,388	18,388	18,388	18,388	18,388	18,388		

Table A.6. Weight in catch data for prediction

	WECA									
				Forecast on internal year (for other years – constant)						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
2										
3	0,7781	0,832	0,635	0,679	0,882	0,914	0,777	0,787		
4	1,235	1,240	1,116	1,163	1,246	1,235	1,219	1,136		
5	1,762	1,863	1,685	1,696	1,735	1,617	1,672	1,665		
6	2,514	2,459	2,468	2,379	2,444	2,250	2,344	2,315		
7	3,532	3,416	3,367	3,341	3,336	3,172	3,249	3,271		
8	4,756	4,541	4,451	4,474	4,558	4,416	4,534	4,572		
9	6,464	6,002	5,804	5,582	5,532	5,764	5,856	5,988		
10	7,801	7,680	7,816	7,018	6,913	6,998	7,479	7,486		
11	8,548	8,681	9,577	8,422	8,133	7,633	8,557	8,269		
12	10,997	10,988	12,816	11,422	11,178	9,894	11,334	10,854		
13	12,800	12,800	12,800	12,800	12,800	12,800	12,800	12,800		
14	14,180	14,180	14,180	14,180	14,180	14,180	14,180	14,180		
15	15,550	15,550	15,550	15,550	15,550	15,550	15,550	15,550		

Table A.7. F pattern for prediction

	mean relative F for previous 3 years							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
3	0,042	0,033	0,032	0,030	0,032	0,035	0,036	0,031
4	0,235	0,213	0,210	0,208	0,215	0,229	0,217	0,192
5	0,521	0,461	0,480	0,485	0,517	0,532	0,532	0,476

6	0,713	0,643	0,673	0,688	0,724	0,800	0,809	0,762
7	0,950	0,910	0,937	0,935	0,983	0,989	0,952	0,927
8	1,201	1,141	1,145	1,159	1,157	1,152	1,089	1,149
9	1,269	1,314	1,285	1,300	1,271	1,178	1,173	1,159
10	1,346	1,532	1,480	1,433	1,348	1,349	1,445	1,526
11	1,810	1,930	1,842	1,488	1,242	1,366	1,463	1,594
12	2,402	2,256	1,946	1,284	0,969	1,000	1,034	1,075
13	1,312	1,766	1,776	1,020	0,739	0,639	0,615	0,621
14	1,522	1,067	1,033	0,593	0,469	0,402	0,364	0,357
15	1,522	1,067	1,033	0,593	0,469	0,402	0,364	0,357
Fbar	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Table A.8. Natural mortality data for prediction

	Natural mortality			**mean value for previous 3 years**				
	2011	2012	2013	2014	2015	2016	2017	2018
3	0,371	0,459	0,457	0,539	0,513	0,462	0,364	0,381
4	0,247	0,331	0,382	0,359	0,353	0,322	0,310	0,272
5	0,217	0,221	0,242	0,244	0,238	0,252	0,278	0,253
6	0,207	0,201	0,204	0,205	0,202	0,205	0,227	0,218
7	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
8	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
9	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
10	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
11	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
12	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
13	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
14	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
15	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2

References

1. Nielsen, A., Berg, C.W., 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fish. Res. 158:96-101.

2. ICES 2018 Report of the Arctic Fisheries Working Group (AFWG), 18–24 April 2018, Ispra, Italy. ICES CM 2018/ACOM:06. 859 pp.

WD_12_AFWG2019_Coastal cod data from coastal areas between Senja and Stad

Coastal cod data from coastal areas between Senja and Stad

1. Survey data 2011-2018 collected by gillnet and fyke net surveys by small vessels in shallow areas, where large research vessels cannot operate

Gill net surveys in shallow areas between Senja (69 deg 30 min N) and Lofoten (68 deg N) in November 2011 and November 2012;

As a part of the KILO-project (Sundby et al 2013) five local vessels (35-45 ft) in the Lofoten-Senja region were hired in November 2011 for fishing with rather small meshed trammel nets at bottom depths between 5 and 30m. In addition, some fyke nets were tested out. The five vessels worked in separate regions (Figure 3). The skippers were asked to define some “priority areas” good for cod fishing. Half of the fishing stations were worked within these “priority areas”, and the other half was fished at similar depths in neighbor areas, at least 1 nautical mile outside the “priority areas”. In November 2012 most of these stations were repeated by the research vessel “Fangst” (50 ft).

Each gill net setting was rigged with 2 nets of 45 mm bar length meshes and 2 nets of 36 mm bar length meshes. A 10 m rope was used to separate the panels of different mesh size (Figure 1).

The experience in 2011 was that lots of brown crabs destroyed both the fish in the nets, and the net material. Therefore, in 2012 the nets were raised about ca 35 cm above bottom (Figure 2) to avoid catching too much brown crab. For the same reason soaking time was limited to 12 hours.

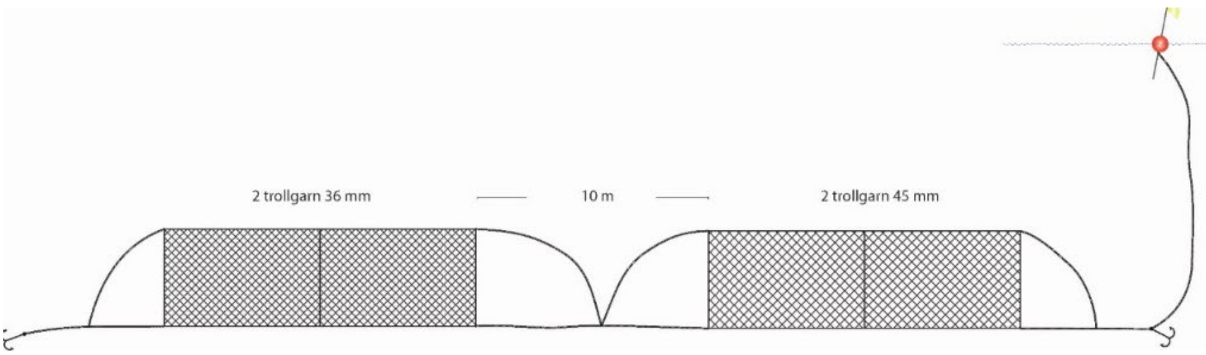


Figure 1. Gill net rigging: 2 nets of 36mm bar length meshes and 2 nets of 45mm bar length meshes.

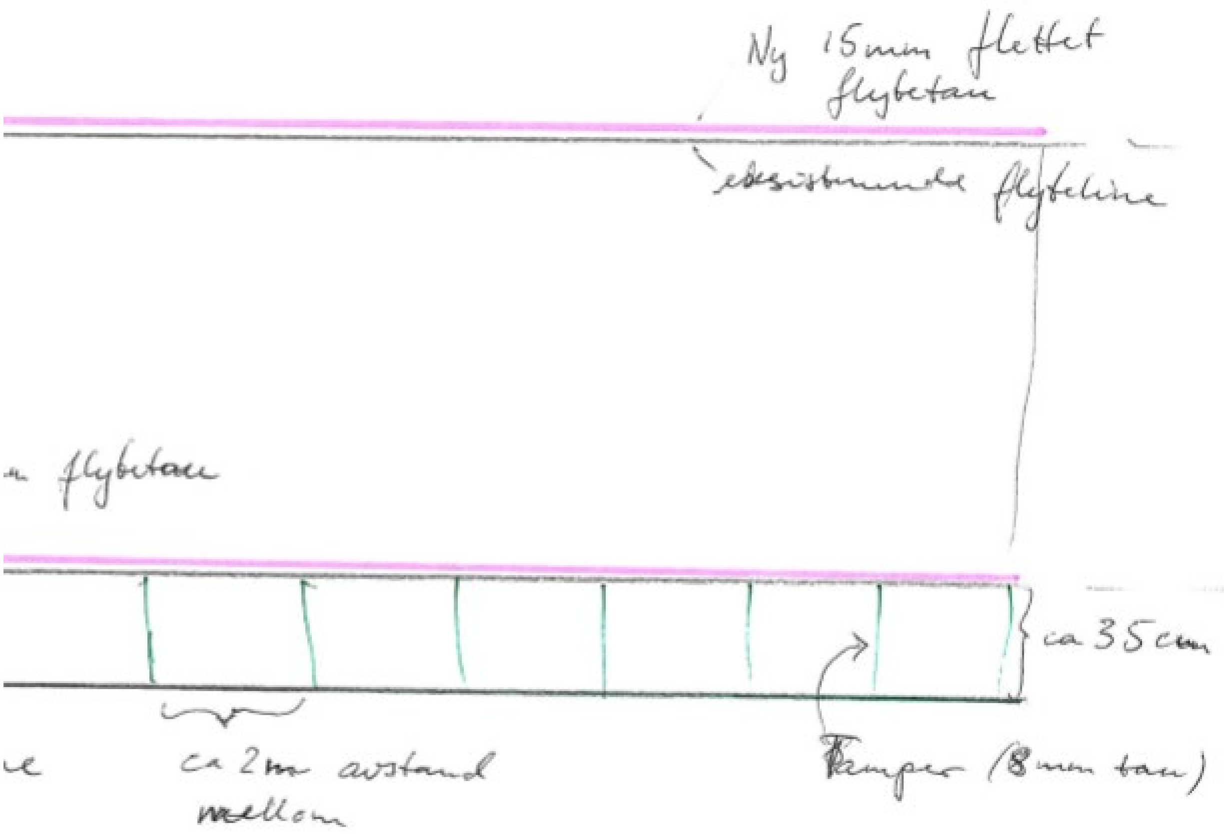


Figure 2. Modified rigging raising the gill net about 35 cm above bottom used in the 2012 surveys and later.

Results November 2011 and November 2012

Figure 3 and 4 show (by regions) the numbers of cod per gill net setting in November 2011 and 2012.

Table 1 and 2 show average catch rates (in numbers) and CV for the various regions in November 2011 and 2012. In regions with less than 8 stations the CV was rather high. The tables do not provide any proof that the preselected “priority areas” gave higher catch rates than the “other areas”.

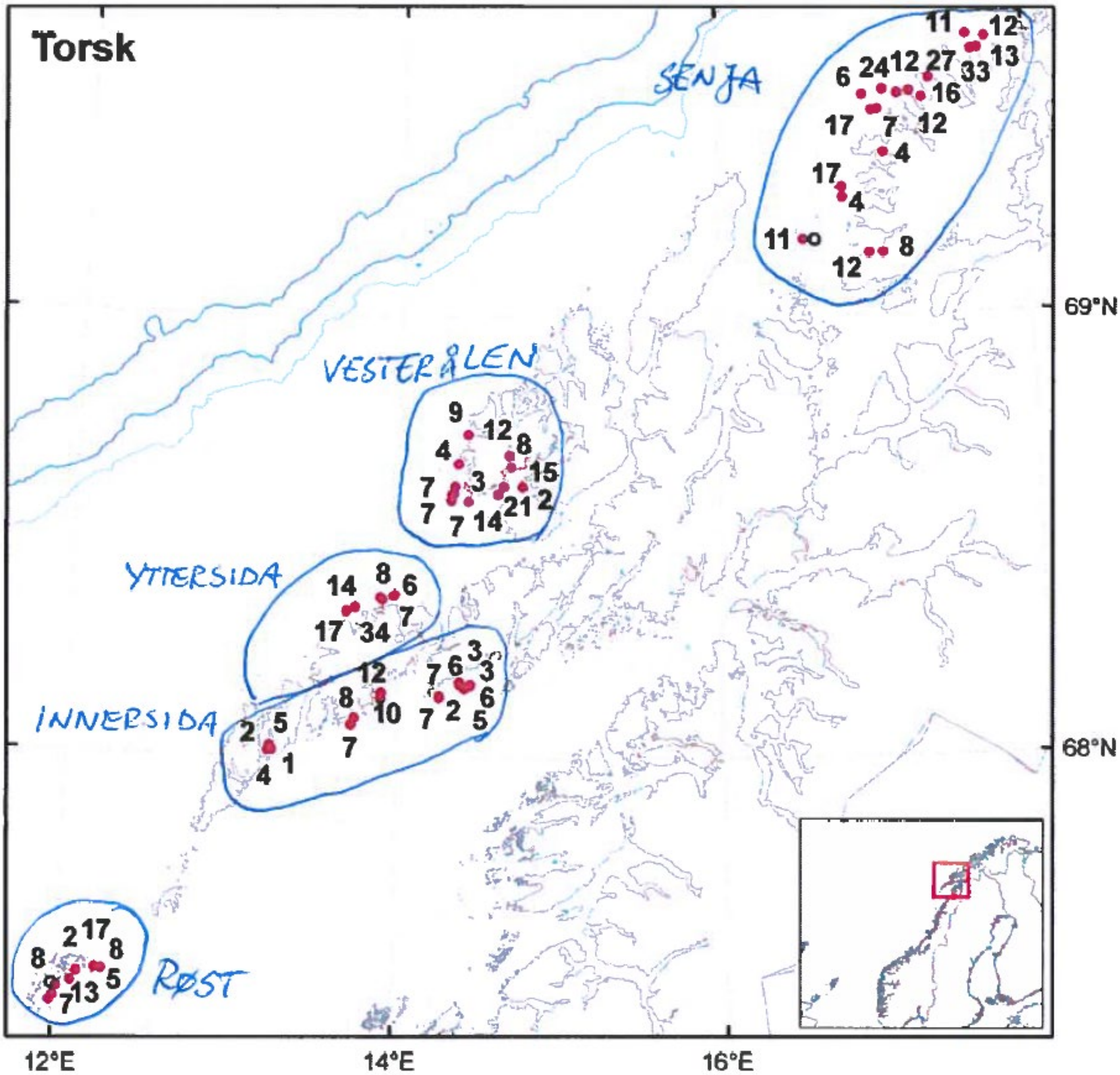


Figure 3. Number of cod per gill-net setting (2 nets of 45 mm bar length meshes and 2 nets of 36 mm bar length meshes), **November 2011**

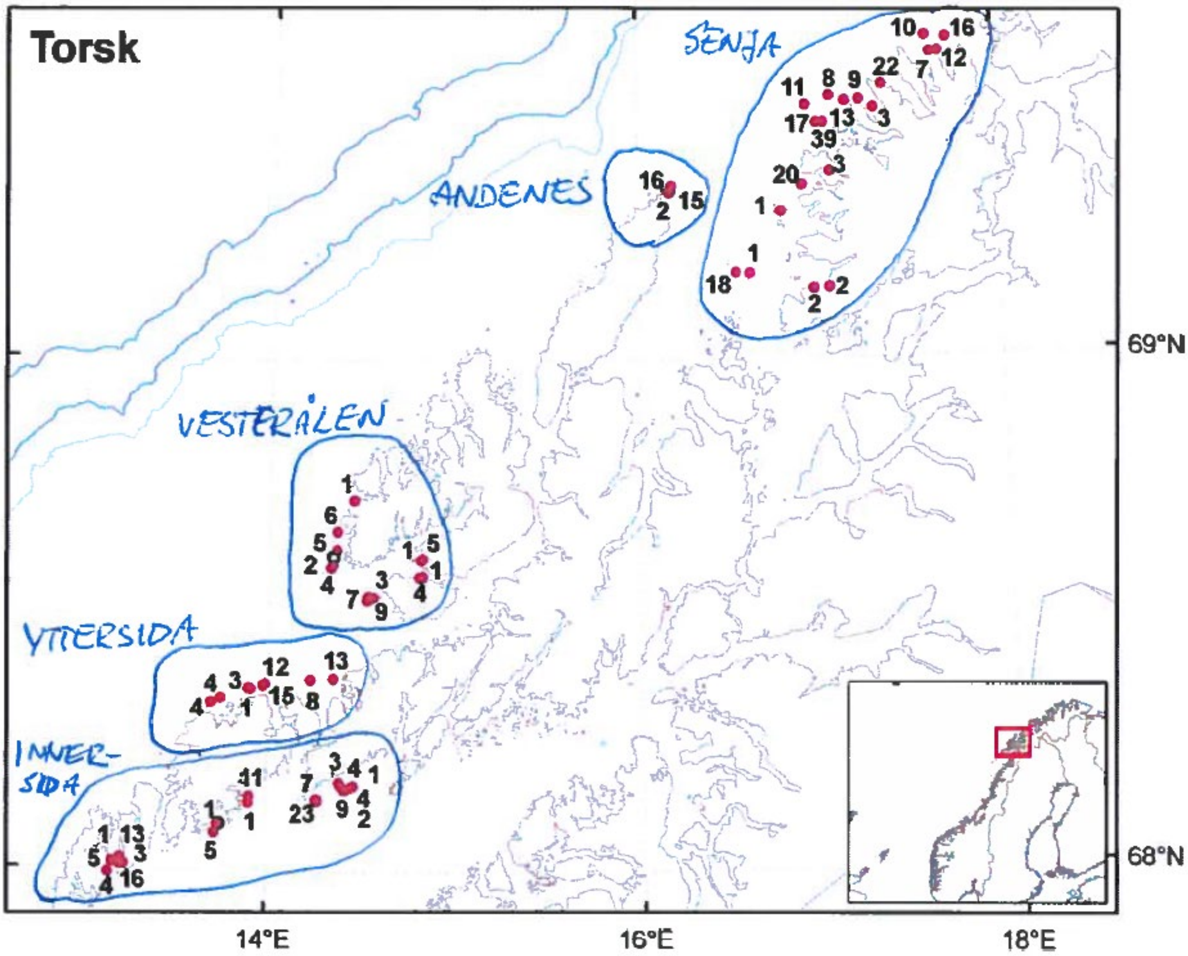


Figure 4. Number of cod per gill-net setting. (2 nets of 45 mm bar length meshes and 2 nets of 36 mm bar length meshes), **November 2012**.

Table 1. **Nov 2011**: Mean and CV for **Number of cod per gill-net station** (2 nets 36mm meshes, and 2 nets 45 mm meshes).

Region	Innersida preselected	Innersida others	Røst preselected	Røst others	Yttersida preselected	Yttersida others	Vesterål preselected	Vesterål others	Senja preselected	Senja others
Number of stations	8	8	4	4	3	3	10	9	10	9
av. Catch rate (#)	5.25	5.75	7.25	7.75	18.00	10.67	10.40	8.14	11.90	14.11
SD	2.92	3.28	7.14	4.50	14.42	5.51	3.85	6.62	7.03	9.64
SDmean	1.03	1.16	3.57	2.25	8.33	3.18	1.22	2.21	2.22	3.21
CV	**0.20**	**0.20**	0.49	**0.29**	0.46	0.30	**0.12**	**0.27**	**0.19**	**0.23**
av. Per single net	1.31	1.44	1.81	1.94	4.50	2.67	2.60	2.04	2.98	3.53

Table 2. **Nov 2012**: Mean and CV for **Number of cod per gill-net station** (2 nets 36mm meshes, and 2 nets 45 mm meshes).

Region	Innersida preselected	Innersida others	Andenes preselected	Andenes others	Yttersida preselected	Yttersida others	Vesterål preselected	Vesterål others	Senja preselected	Senja others
Number of stations	8	11	0	4	5	3	8	5	9	10
av. Catch rate (#)	7.00	5.70		11.00	10.40	2.67	3.88	4.25	13.22	9.50
SD	3.74	7.56		7.81	4.39	1.53	2.85	2.22	11.53	7.38
SDmean	1.32	2.28		3.91	1.96	0.88	1.01	0.99	3.84	2.33
CV	**0.19**	0.40		0.36	**0.19**	0.33	**0.26**	**0.23**	**0.29**	**0.25**
av. Per single net	1.75	1.43		2.75	2.60	0.67	0.97	1.06	3.31	2.38

Fishing with fyke nets in shallow areas between Senja (69 deg 30 min N) and Lofoten (68 deg N) in August 2012

In August 2012 R/V“Fangst” was used, -with an additional 17 ft boat used for fishing with fyke nets in some of the areas covered by the November surveys.

At the previously described survey in November 2011 also fyke nets were used, both the typical fyke nets designed for cod fishing and the smaller types designed for fishing eel. The experience was that catches of fish in fyke nets were quite low, mainly due to short day-light period in the high north in winter. In bad weather with heavy waves there was also problems caused by lot of sea-weed and kelps filling both the guiding net and the fish chambers of the fyke net. A separate survey was conducted with the “eel” fyke nets (Figure 5) during august2012. At that time of the year there are about 20 hours daylight per day and the weather is much more calm, compared to November.

10 double “eel” fyke nets (with a total of 40 “fish chambers”) were operated each day. Figures 6 and 7 show the distribution of catches of cod per 5 double fyke nets (Fish lengths less than 20 cm and above 20 cm in different plots). Innersida was the region with highest catch rates both for the small (<20 cm) and larger (>20cm) cod.

Figure 5. <u>Double «eel» fyke net</u>: From left; 1 fish chamber and 3 trunks, then guiding net, then 3 trunks and fish chamber. The second half mirrors the first. In total there are 4 fish chambers. (from van der Meeren, 2018).

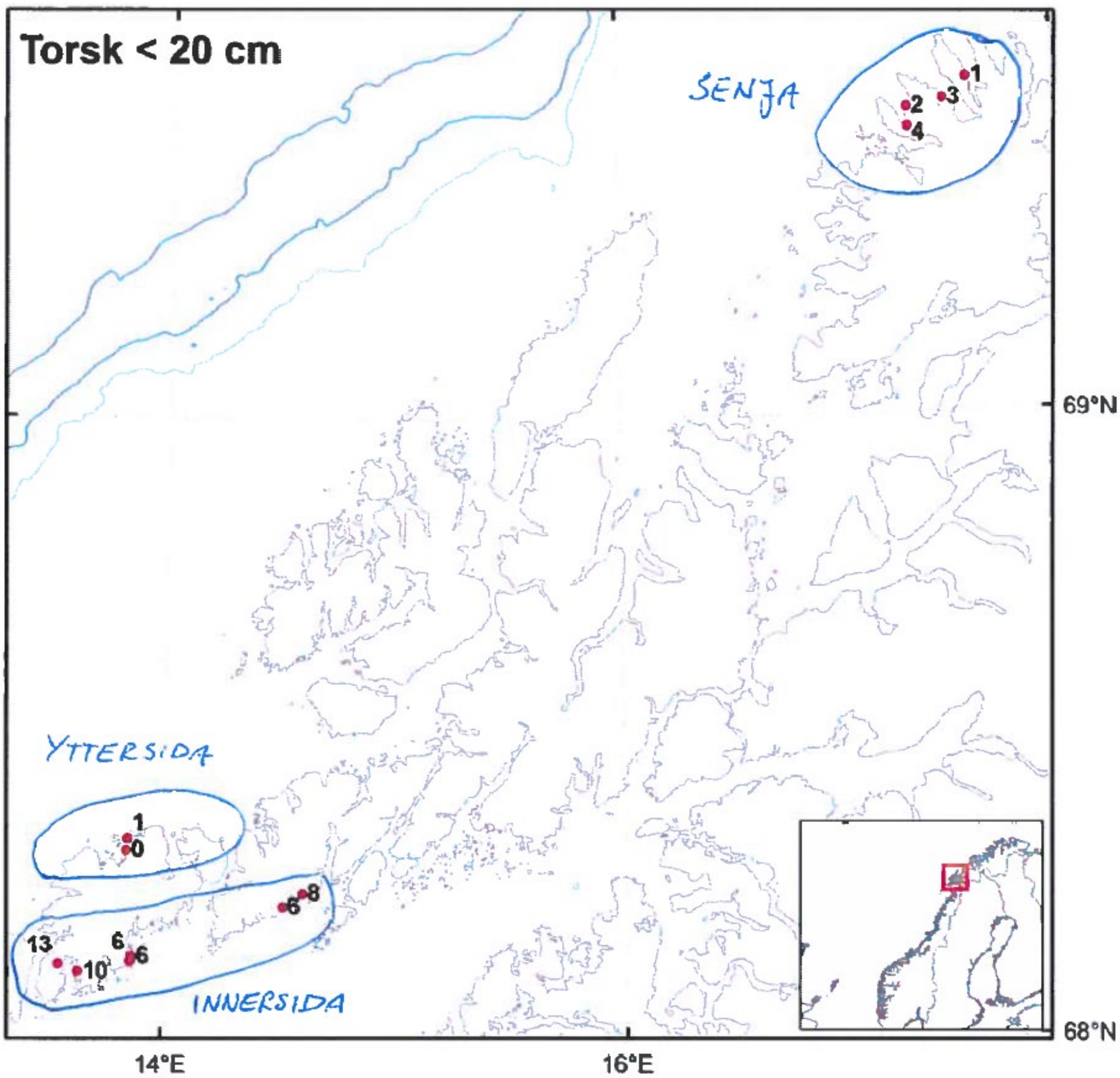


Figure 6. Number of cod<20cm in sets of 5 double “eel” fyke nets, August 2012.

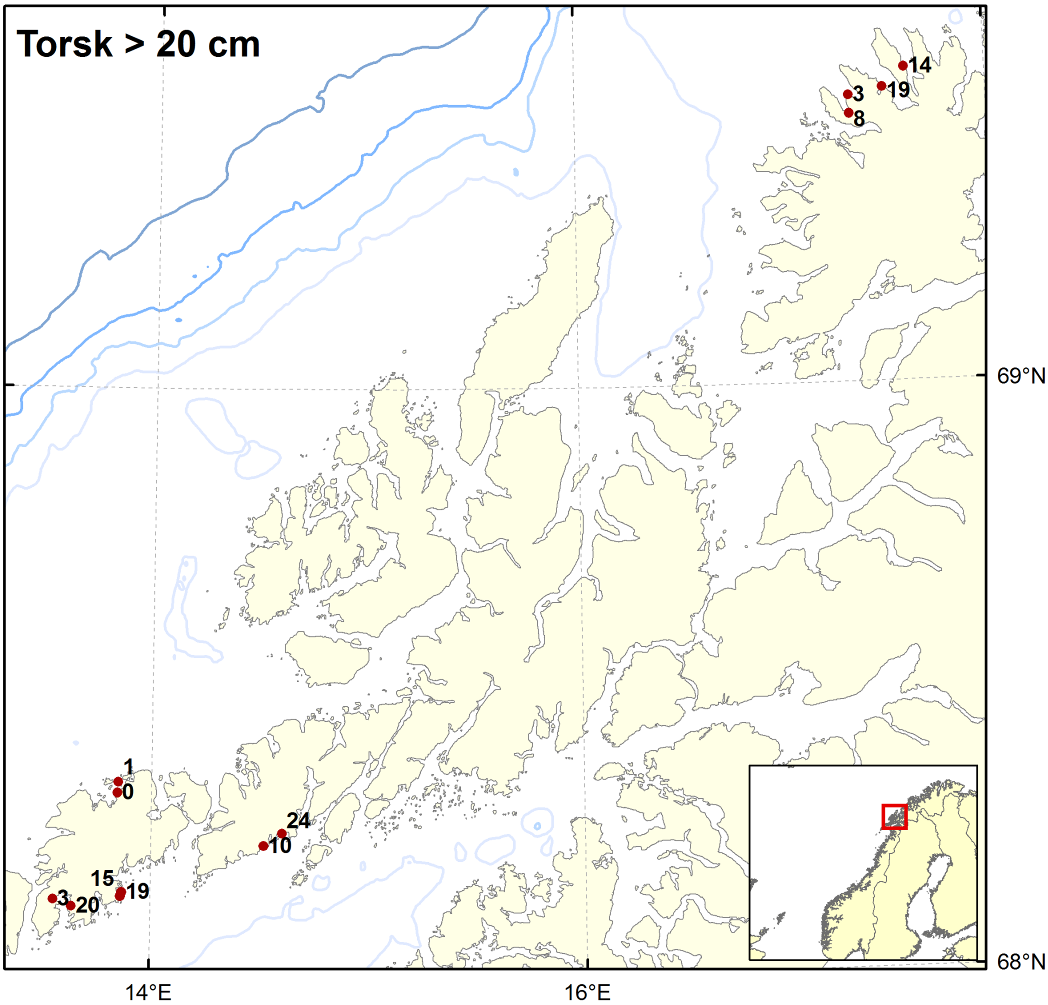


Figure 7. Number of cod>20cm in sets of 5 double “eel” fyke nets, August 2012.

Fishing with trammel nets and fyke nets in shallow areas between Steigen (68 deg N) and Vikna (65 deg N) in August 2013, 2016 and 2018

Based on the experience in Lofoten-Senja similar surveys have been conducted in the shallow areas between Steigen (68 deg N) and Vikna (65 degN) in 2013, 2016 and 2018, and in the shallow areas between Vikna and Stad (62 deg N) in 2015 and 2017.

It was decided to use 6 double fyke nets (Figure 5) and 2 gill net sets (as Figure 2) per fishing day. Within the Steigen-Vikna area 49 candidate fishing areas were defined, each suitable for one day fishing (Figure 8). Among those areas, 12 were fished in 2013, 21 in 2016 and 20 in 2018. Among those 20 fished in 2018; 11 have been fished in all 3 years, 8 in 2 years and 4 has been fished only one year. R/V “Fangst” was used in all surveys.

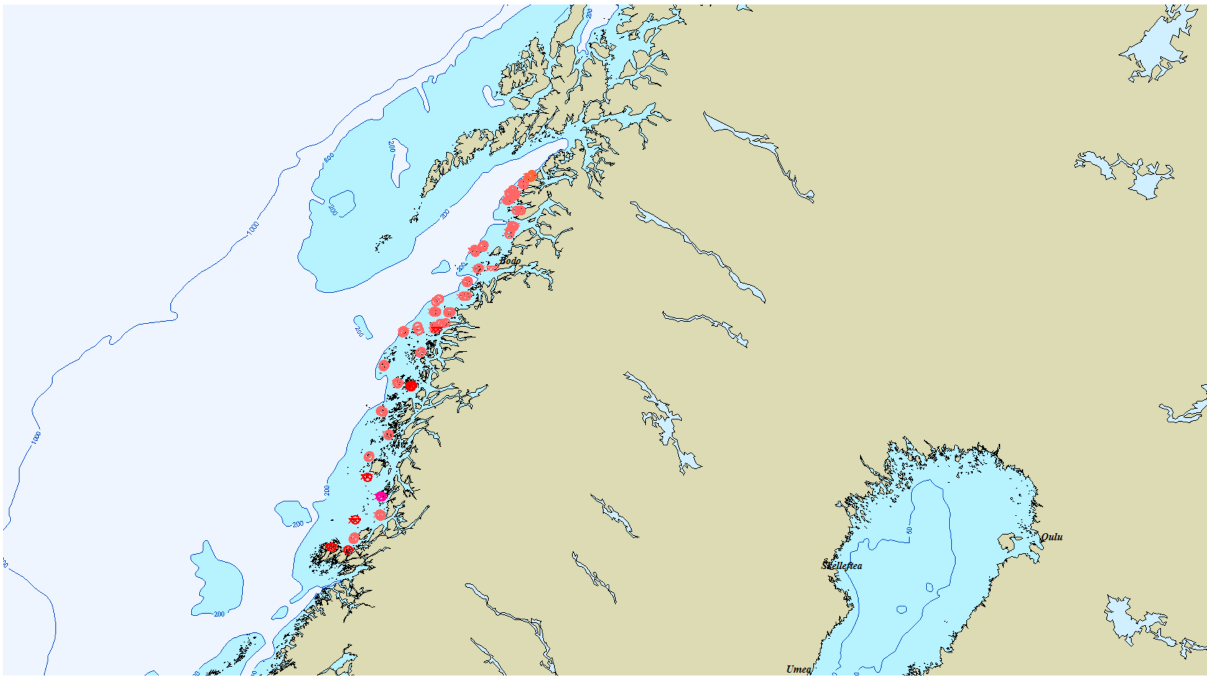


Figure 8. Predefined fishing areas Steigen-Vikna. (Scaling Max Sea; 1:1.5 mill).

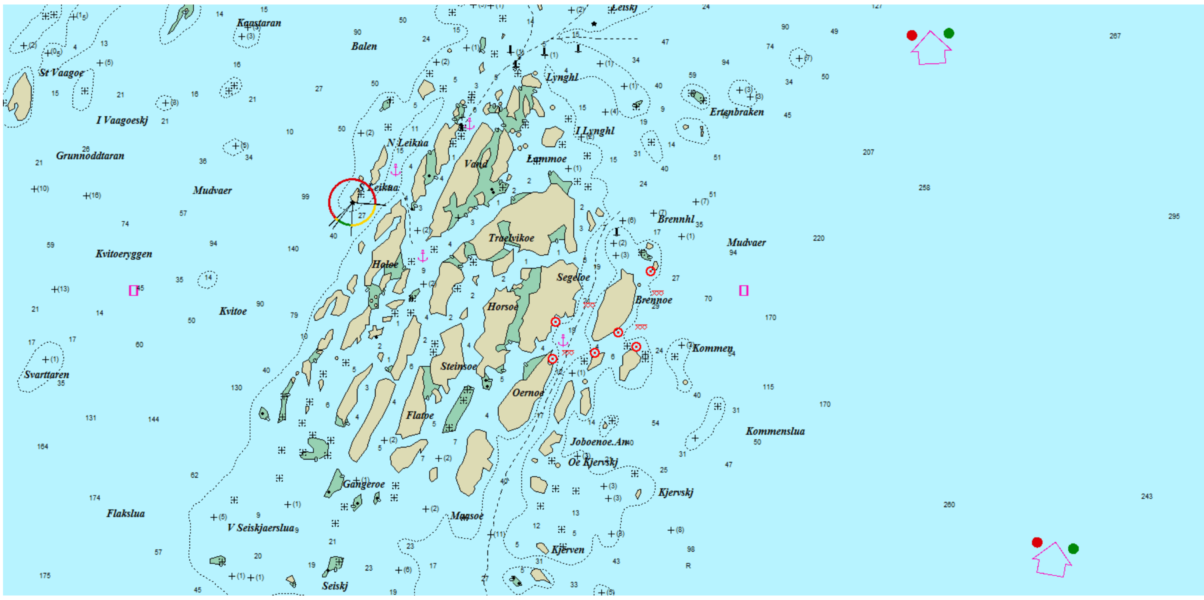


Figure 9. Mudvær, Vega; Example of fishing area. Red circles are fyke net positions, and xxx are start point and end point for trammel nets. (Scaling Max Sea; 1:25000).

Results cod

Table 3. Average catch of cod pr fishing day Steigen-Vikna

Year	# fishing days	av. Number of cod pr day	CV %
2013	12	**42.8**	**17**
2016	21	**41.6**	**14**
2018	20	**47.5**	**12**

Table 4. Average catch of cod at age (per fishing day) for each of the surveys

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
2013	2.8	16.4	10.8	6.6	3.5	1.3	0.9	0.2	0.2	0.2	42.8
2016	2.9	11.3	12.0	7.0	5.6	1.0	1.2	0.4	0.3	0.1	41.6
2018	6.8	13.2	13.7	5.6	3.4	1.8	2.2	0.3	0.2	0.3	47.5

Summed over all ages the catch rates of cod appear rather stable over the 2013-2018 period. Compared to the two first surveys the 2018 results indicate some increase for age 0 and decrease for ages 3 and 4. The CVs for all ages merged (Table 3) indicate that large to moderate changes in abundance are likely to be significant, while small changes may not be significant.

Fishing with trammel nets and fyke nets in shallow areas between Vikna (65 deg N) and Stad (62 deg N) in August 2015 and 2017

Within the Vikna-Stad area 46 candidate fishing areas were defined, each suitable for one day fishing (Figure 8). Among those areas, 23 were fished in 2015, and 21 were fished in 2017. Among those 21 fished in 2017; 13 was also fished in 2015. The remaining 8 stations in 2017 have been fished only one year.

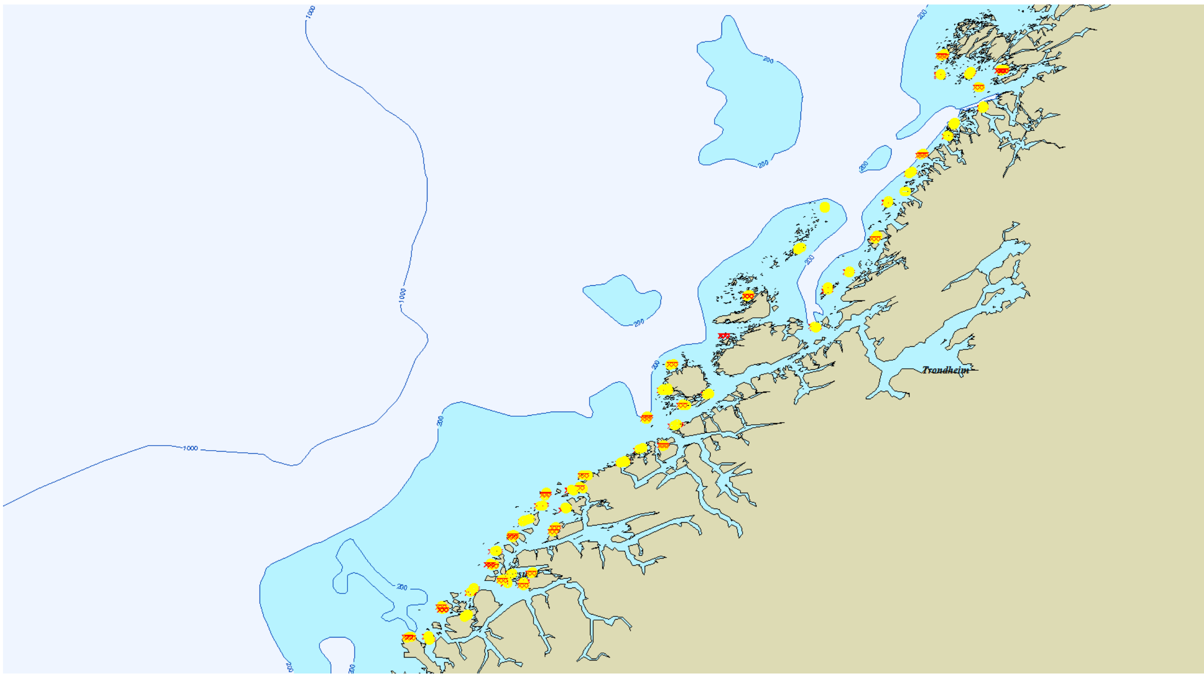


Figure 10. Predefined fishing areas Vikna-Stad. (Scaling Max Sea; 1:1.5 mill).

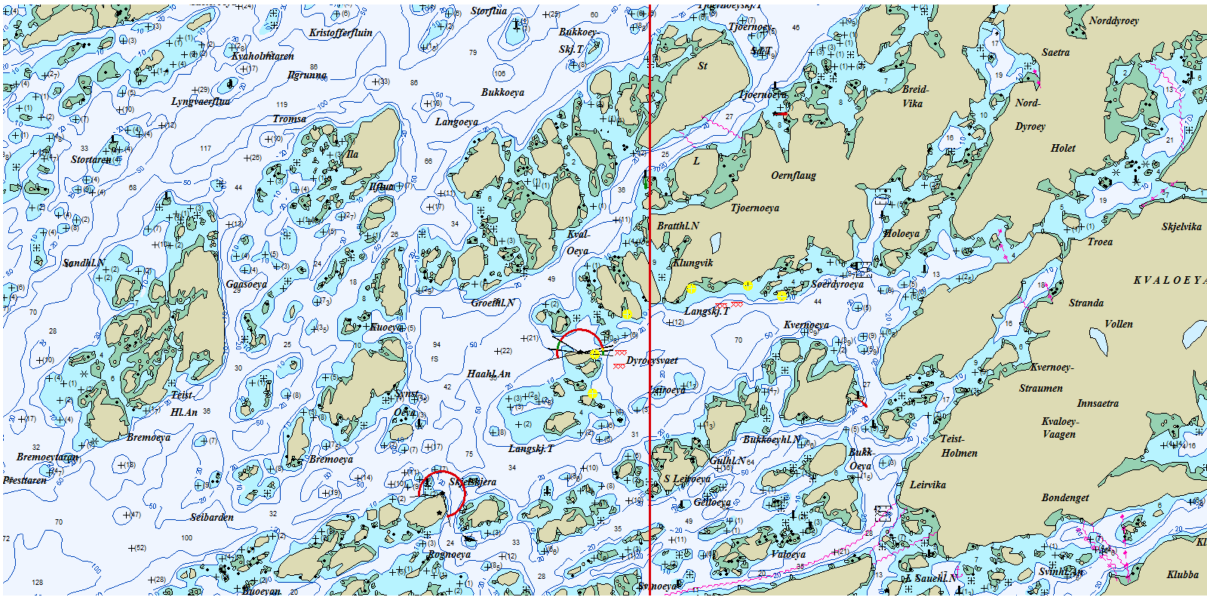


Figure 11. Dyrøysvaet, Frøya; Example of fishing area. Yellow circles are fyke net positions and xxx are start point and end point for trammel nets. (Scaling Max Sea; 1:25000).

Results cod

Table 5. Average catch of cod per fishing day Vikna-Stad

Year	# fishing days	av. Number of cod pr day	CV %
2015	23	**19.6**	**13**
2017	21	**22.1**	**11**

Table 6. Average catch of cod at age (per fishing day) for each of the surveys

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
2015	0.10	6.57	5.76	3.34	1.31	1.31	0.71	0.20	0.20	0.00	19.6
2017	3.52	9.92	3.85	1.90	1.20	0.86	0.41	0.19	0.14	0.05	22.1

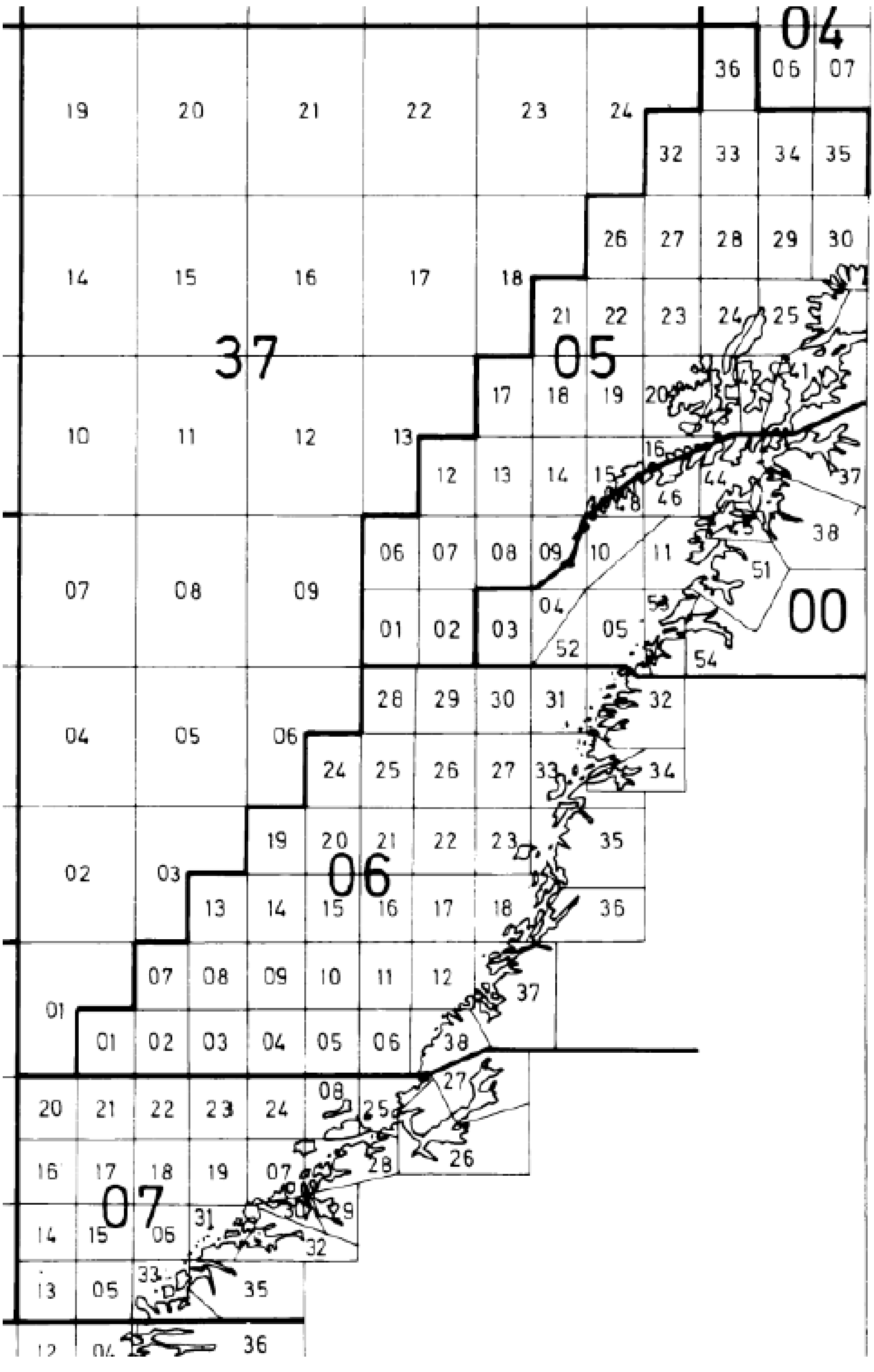
Summed over all ages the catch rates of cod appear rather similar for the two years. As for the Steigen-Vikna area, the between year relative difference is largest for age 0, which in this area is highest in 2017. Age 1 also indicate some increase, while the older ages show lower catch rates in 2017 compared to 2015.

The CVs for all ages merged (Table 5) indicate that large to moderate changes in abundance are likely to be significant, while small changes may not be significant.

2. cod results from the coastal “trawl-acoustic survey”

This survey covers the coastal area from the Norway-Russia border to Stad, in deeper waters (50-500 m) than the shallow water surveys (Mehl et al. 2018). Figure 14 shows the standard acoustic transects used in the survey. Some of these transects are adjacent to the areas covered by the shallow water surveys, but the bottom depths are considerably larger. The coastal cod results from the trawl-acoustic survey have traditionally been estimated within the “Norwegian Statistical Main Areas” (00,05,06,07 in Figure 12), but for the future, the plan is to use the regions A,B,C and D (Figure 13), that are implemented in the STOX-software. (Johnsen et al 2016). These areas are already in use for the saithe estimate from the same survey. A project has started for recalculating the coastal survey acoustic estimates using Stox. Another objective for that project is to obtain swept area estimates of cod based on the fixed trawl stations in the survey series.

Statistical Main Area 05 and 00 (Figure 12) cover areas adjacent to the shallow water areas Senja-Lofoten. Statistical Main Area 06 covers areas adjacent to the shallow water areas Steigen-Vikna. Statistical Main Area 07 covers areas adjacent to the shallow water areas Vikna-Stad.



Figur 12. Norwegian Statistical main areas 00,05, 06, 07. The small rectangles are used for reporting commercial catch.

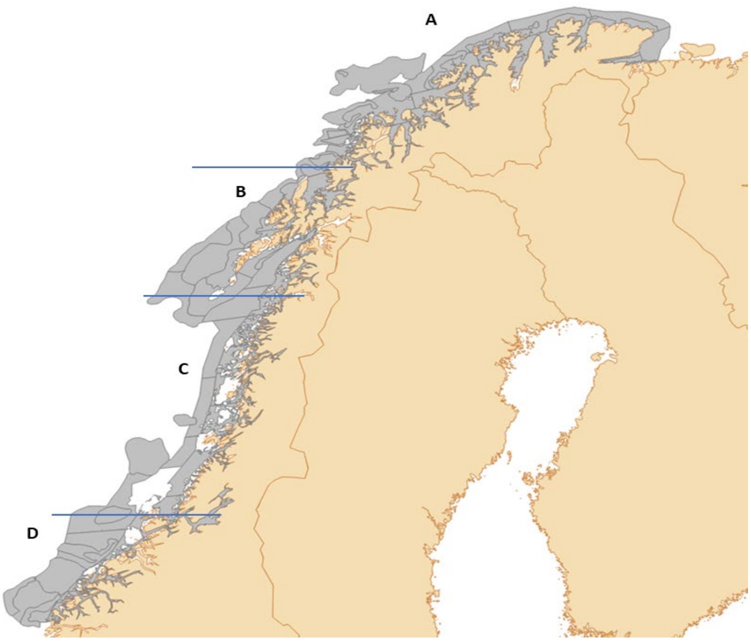


Figure 13. Sub-regions A-D used in the STOX-software.

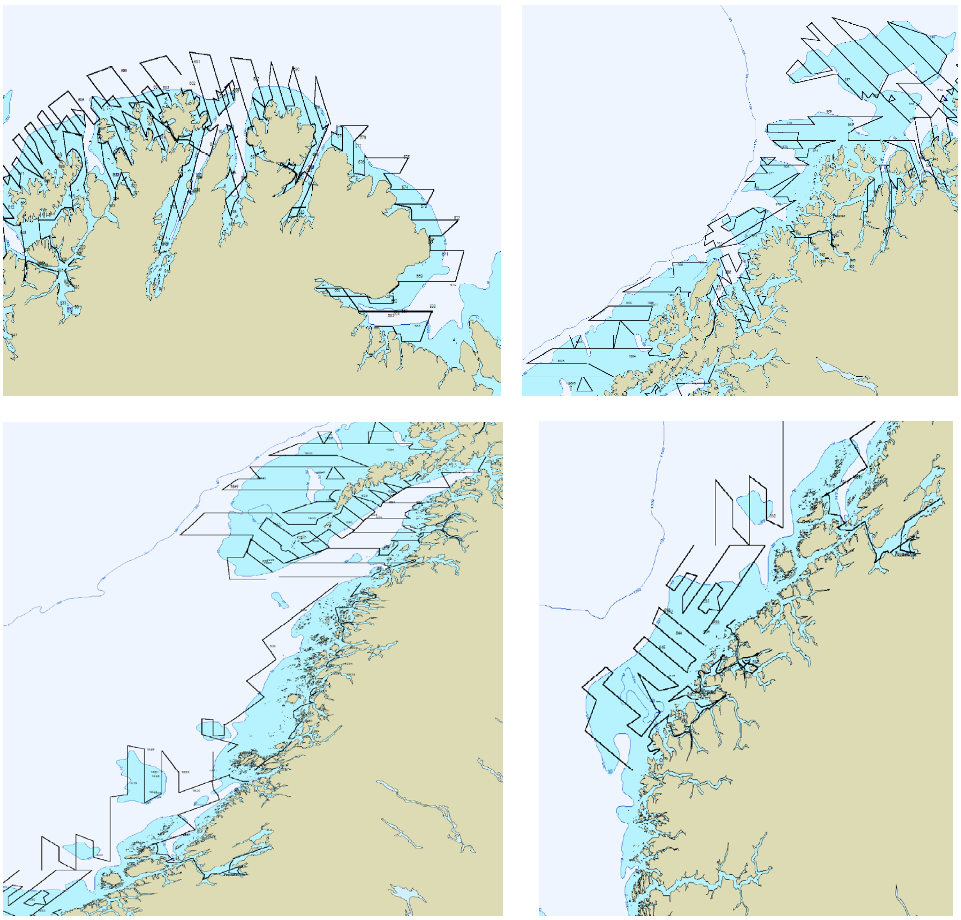


Figure 14. Standard transects in the coastal “trawl-acoustic” survey

Table 7. Trawl-acoustic survey. Coastal cod estimates (numbers in thousands) for Statistical Area 05 + 00, (adjacent to shallow waters in Senja-Lofoten)

Area 05+00	Age										
Year	1	2	3	4	5	6	7	8	9	10+	Total	3+
2011	1939	333	848	1115	701	633	60	187	0	43	5859	3587
2012	2129	354	513	1494	966	250	89	68	52	36	10048	3468
2013	2067	287	301	440	573	482	203	167	165	76	9465	2407
2014	792	557	603	769	1199	887	939	611	557	487	7401	6052
2015	1591	505	634	935	353	631	509	261	126	247	5793	3696
2016	508	136	561	1497	1482	753	415	504	21	124	6001	5357
2017	407	867	1111	590	964	598	301	177	86	41	5142	3868
2018	2004	433	582	669	488	638	276	232	84	164	5569	3133

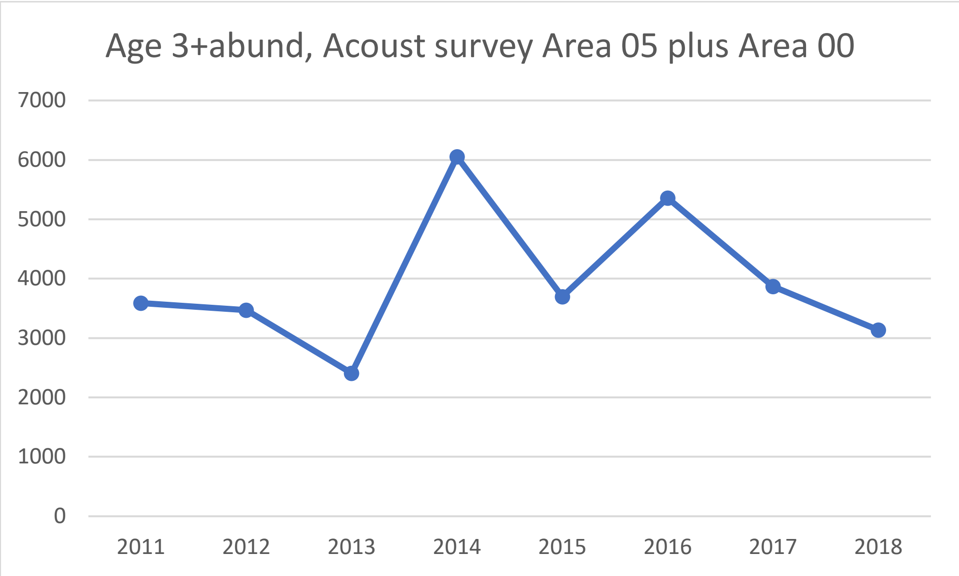


Figure 15. Trawl-acoustic survey estimates (thousands) 2011-2018 for areas 00 and 05 merged, sum of ages 3 and older.

Table 8. Trawl-acoustic survey. Coastal cod estimates (numbers in thousands) for Statistical Area 06 (adjacent to shallow waters in Steigen-Vikna).

Area 06	Age											
Year	1	2	3	4	5	6	7	8	9	10+	Total	3+
2011	2242	784	1544	1785	1033	231	18	69	10	28	7744	4718
2012	70	31	102	30	159	49	91	20	4	71	626	526
2013	3223	388	620	623	425	209	59	197	0	12	7711	2145
2014	162	505	243	86	387	14	46	35	0	0	1478	811
2015	1328	1298	785	865	613	415	52	20	28	0	5405	2778
2016	177	434	722	62	162	138	86	41	22	10	1855	1243
2017	15	41	60	31	27	22	12	15	10	0	234	177
2018	1859	248	248	124	124	0	0	0	0	0	2603	496

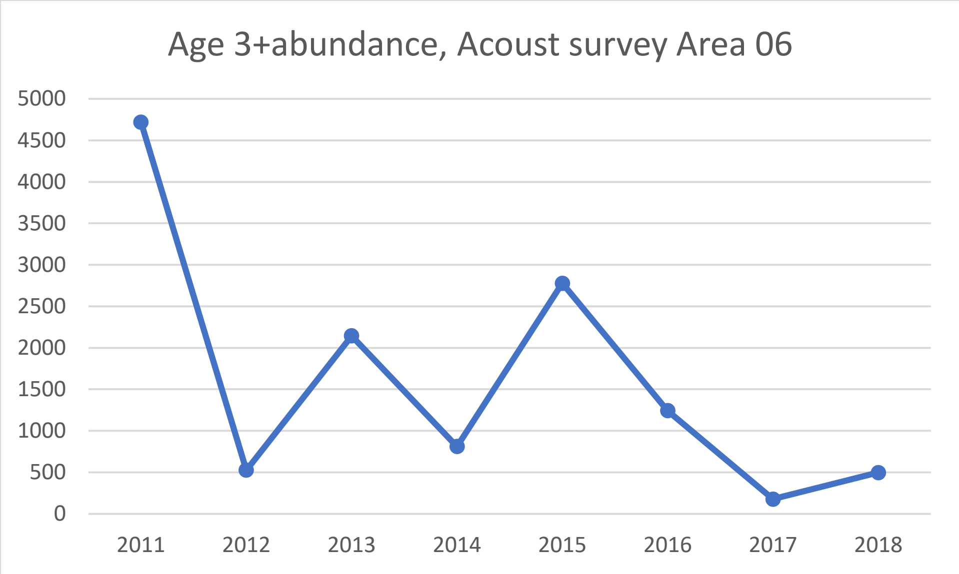


Figure 16. Trawl-acoustic survey estimates (thousands) 2011-2018, sum of ages 3 and older.

Table 9. Trawl-acoustic survey Statistical. Coastal cod estimates (numbers in thousands) for Area 07 (adjacent to shallow waters in Vikna-Stad).

Area 07	Age											
Year	1	2	3	4	5	6	7	8	9	10+	Total	3+
2011	0	17	70	82	28	46	14	7	4	7	275	258
2012	0	5	93	100	91	81	25	5	0	0	401	395
2013	0	0	0	0	0	4	23	4	0	0	30	31
2014	89	30	111	114	246	146	36	136	32	6	946	827
2015	0	5	48	174	42	55	17	61	60	3	465	460
2016	6	0	303	289	220	36	21	51	15	111	1050	1046
2017	0	41	28	142	61	75	65	15	1	1	430	388
2018	0	0	0	0	203	124	27	21	0	0	376	375

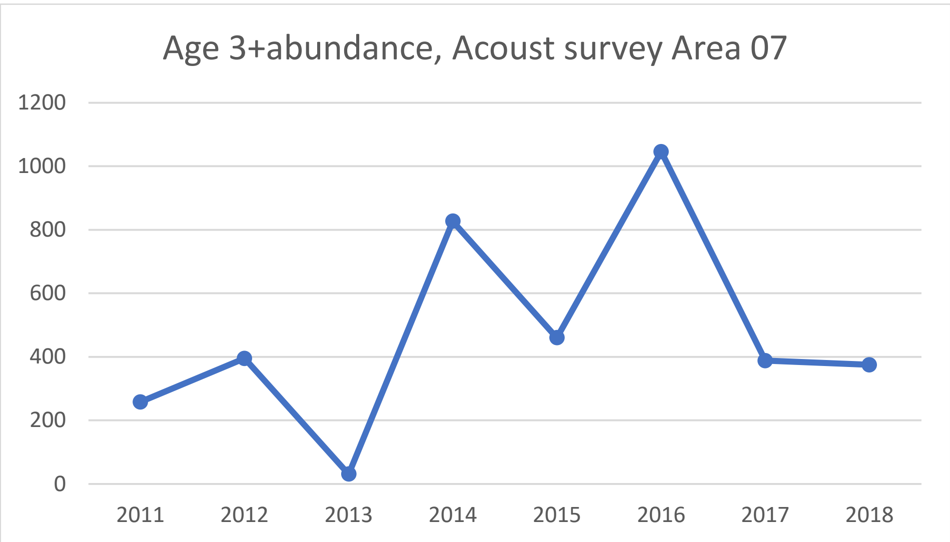


Figure 17. Trawl-acoustic survey estimates (thousands) 2011-2018, sum of ages 3 and older.

The acoustic results for Areas 00 and 05 (Table 7 and Figure 15) may contain some useful information for evaluation of stock status.

The patterns seen in Tables 8-9 and Figures 16-17 indicate that the acoustic survey results in areas 06 and 07 have rather high variability between years and between ages. Even when merging ages 3 and older, the between year variability in areas 06 and 07 seems to be dominated by “noise”.

With several more years of shallow water surveys (fyke nets and gill nets) the basis for evaluating stock status in areas 06 and 07 would improve. Probably would more shallow water surveys in area 00 and 05 also improve the stock status evaluations for those areas.

3. Catch at age data from commercial fishery

Table 10. Estimated catch in tonnes of coastal cod by Area and quarter based on reported catches of NEAC+NCC, split by the fraction of NCC otolith-type (Rollefsen, 1933). Such estimates exist back to 1984 (Berg et al 1998).

Year		2010				
Qu./Area	03	04	00	05	06-07	Total
1	425	1141	1585	3442	3344	**9939**
2	1564	1341	1262	1385	1711	**7263**
3	853	603	225	480	362	**2523**
4	993	696	192	975	343	**3199**
Total	**3836**	**3781**	**3265**	**6282**	**5761**	**22925**

Year		2011				
Qu./Area	03	04	00	05	06-07	Total
1	1231	1888	2328	2762	4236	**12445**
2	2241	2289	1458	801	1785	**8573**
3	400	466	293	475	384	**2018**
4	1949	1330	430	1594	256	**5559**
Total	**5820**	**5973**	**4509**	**5632**	**6660**	**28594**

Year		2012				
Qu./Area	03	04	00	05	06-07	Total
1	1489	2031	2124	3268	4408	**13320**
2	1125	3282	3036	545	1330	**9318**
3	1166	810	255	626	347	**3204**
4	2351	1343	212	1810	350	**6066**
Total	**6131**	**7467**	**5627**	**6248**	**6434**	**31907**

Year		2013				
Qu./Area	03	04	00	05	06-07	Total
1	705	1003	568	3808	3204	**9288**
2	2035	738	1691	489	890	**5843**
3	1035	365	202	615	278	**2495**
4	1543	1609	182	1275	228	**4838**
Total	**5318**	**3714**	**2644**	**6188**	**4599**	**22464**

Year		2014				
Qu./Area	03	04	00	05	06-07	Total
1	826	1123	934	2613	3347	**8843**
2	2151	546	437	541	1118	**4793**
3	1164	854	251	831	209	**3309**
4	2621	1775	218	1363	247	**6225**
Total	**6762**	**4299**	**1839**	**5348**	**4922**	**23169**

Year		2015				
Qu./Area	03	04	00	05	06-07	Total
1	1516	3630	2146	8729	3201	**19222**
2	3363	2303	2294	612	926	**9499**
3	1698	1469	457	504	403	**4531**
4	2816	1679	124	1314	268	**6201**
Total	**9393**	**9082**	**5022**	**11159**	**4798**	**39455**

Year		2016				
Qu./Area	03	04	00	05	06-07	Total
1	3490	8601	7940	7697	3762	**31491**
2	1072	530	146	117	221	**2088**
3	1051	1638	270	501	327	**3790**
4	4419	1620	139	803	267	**7253**
Total	**10032**	**12388**	**8495**	**9118**	**4577**	**44610**

Year		2017				
Qu./Area	03	04	00	05	06-07	Total
1	4620	6806	11264	7053	2195	**31938**
2	1986	4732	255	1507	542	**9022**
3	1883	836	208	478	334	**3739**
4	4789	2513	184	466	236	**8188**
Total	**13278**	**14887**	**11911**	**9504**	**3307**	**52887**

Based on the catch reporting by area (Figure 12) and the age sampling program, catch numbers by age and otolith-type has been calculated, and a time series for catch numbers at age for NCC and for NEAC has been calculated for each of the main areas, both by a traditional method and by using ECA (Hirst et al. 2012). Those catch at age data for the entire coastal cod area have been used for "exploratory" stock assessments ICES Arctic Fisheries Working Group (ICES 2018). Figure 18 show $\log_e$ (catch numbers) by age and cohorts for all areas merged. The slope of the lines reflects total mortality.

These data may also provide some information on mortality rates within each of the statistical areas 05, 00, 06 and 07. However, the sampling data are for some years rather incomplete and the results prior to 1990 is considered rather uncertain, particularly in the statistical areas 06 and 07.

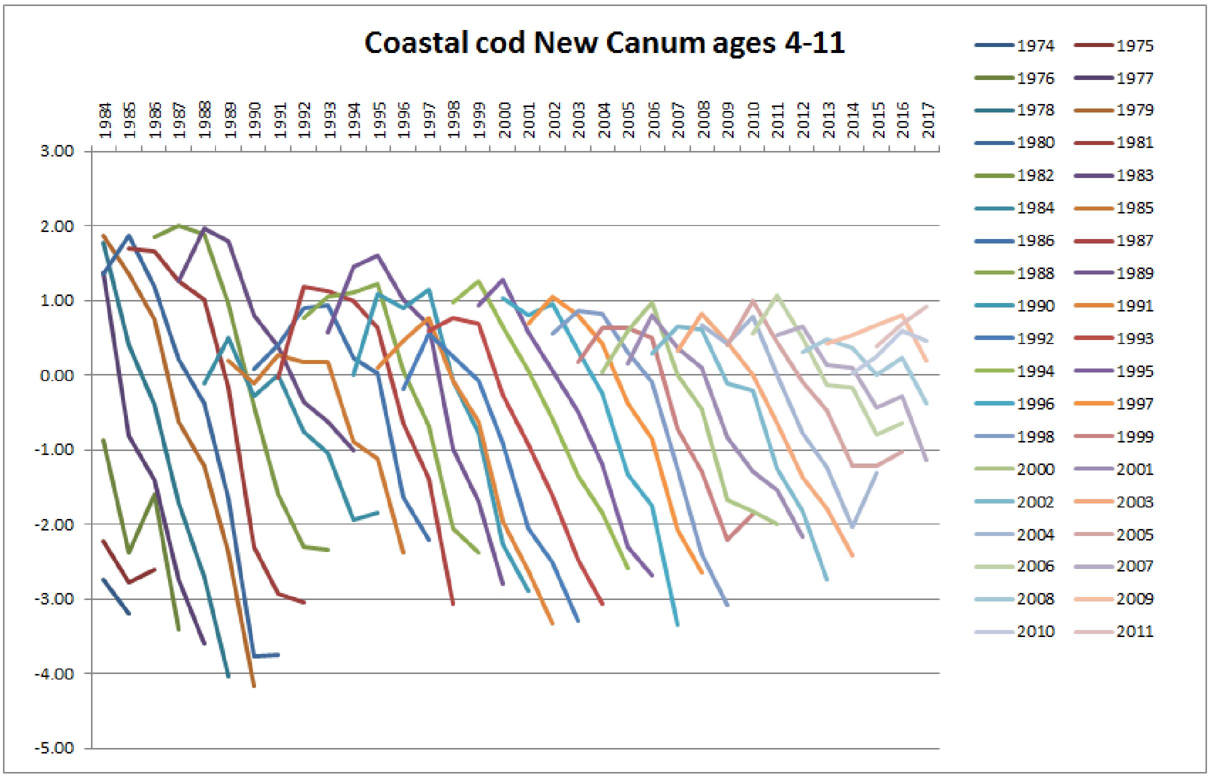


Figure 18. Log catch numbers-at-age by cohort (series names) and catch years (x-axis). ECA estimates.

4. Stock units / Genetics

Coastal cod north of 62 degrees N has so far been treated as one stock unit / management unit. Several genetic studies have, for several genetic markers, revealed large variations along the coast (Dahle et al 2018, Dahle 1991, Møller 1968). Some markers indicate trends when moving from north to south (Dahle et al 2018).

Many coastal cod spawning areas has been identified (Espeland et al 2013). Maps of coastal cod spawning areas are available at https://kart.fiskeridir.no/fiskeri. It is not feasible to manage all spawning sites separately, but some degree of regional management would reduce the risk of fishing down some of the potentially more vulnerable stock components.

Splitting the management area in several units would allow for adjusting the management to the more local needs, and for better utilizing smaller scale survey data. Defining one area north of 67 would correspond to the area where the trawl acoustic survey provides reasonable data. The area south of 67 could then make use of less expensive shallow water surveys. With the existing fyke net/gill net surveys alternating between years, it could be useful to define one stock unit from 67 N to 65 N (Bodø-Vikna) and one unit from 65 N to 62 N (Vikna-Stad).

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Asgeir Aglen, December 2018

Revision of acoustic Northeast Arctic saithe indices from the Norwegian coastal survey 2003–2009 applying the Sea2Data StoX software

Sigbjørn Mehl and Åsmund Skålevik

StoX input, settings and filters

Acoustic XML-files for the period 2003-2009 (mainly prior to the introduction of LSSS) were updated from BEI ListUserFile05 DB-reports on \\ces.imr.no\cruise_data due to errors or missing data in the XML-files based on LSSS DB-reports. Biotic and updated acoustic XML-files were then downloaded from https://datasetexplorer.hi.no/apps/datasetexplorer/v2/navigation.

StoX version 2.6 and Rstox 1.9 was used for estimation of revised acoustic indices with CVs, lengths and weights at age (http://www.imr.no/forskning/prosjekter/stox/). R for Windows version 3.4.3 was used in the R calls (https://www.r-project.org/).

In **FilterAcoustic, FreqExpr** was set to **frequency=38000**. In **NASCExpr, acocat** was 22 for saithe.

In **NASC, LayerType** was set to **WaterColumn**.

Under **FilterBiotic** and **FishStationExpr**, the following filter were applied: **fs.getLengthSampleCount('SEI') > 2** filtering out stations with less than three specimen (see Johnsen et al. 2016 for more info about filters).

Under **StationLengthDist** and **LengthDistType**, **NormLengthDist** was used, and under **RegroupLengthDis**t and **LengthInterval**, **1.0** was applied.

A process called **RelLengthDist** was then added, with function RelLengthDist and **LengthDist** = **RegroupLengthDis**t.

In **DefineStrata**, **kysttokt_strata.txt**. In **StratumArea** and **AreaMethod**, **Accurate** was applied.

Under **BioStationAssignment** and **AssignmentMethod**, **UseProcessData** was used, i.e. assignments from the KT-program with adjustments for 2003-2016. **EstLayers** was set to **1~PELBOT**.

Under **BioStationWeighting** and **WeightingMethod, SumWeightedCount** was used, with **LengthDist** = **RegroupLengthDis**t.

TotalLengthDist was set to **RelLengthDist.**

In Acustic**Density**, **m** was set to **20** and a to **-68**.

Under **SuperIndAbundance** and **AbundWeightMethod**, **StationDensity** was used, with **LengthDist** set to **RegroupLengthDist**.

Results

The revised estimates resulted in only minor changes in indices with CVs, lengths and weights at age for Northeast Arctic saithe. However, it is recommended that the new estimates are applied since they are now based on the official input files from the Norwegian coastal survey.

Table 1. SAITHE. Abundance indices (numbers in millions) from the Norwegian coastal acoustic surveys 2003-2017 estimated by StoX software. + indicates < 0.005.

	Age group																**Biomass ('000 t)**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	
2003	**19.3**	**51.2**	**130.5**	**162.3**	**42.6**	**7.73**	**7.94**	**2.56**	**1.69**	**1.21**	**0.72**	**0.31**	**0.15**	**0.05**	**0.07**	**428.4**	**348.7**
2004	**0.01**	**153.3**	**191.2**	**107.6**	**44.3**	**15.2**	**4.25**	**2.06**	**3.56**	**0.77**	**1.36**	**0.61**	**0.27**	**0.21**	**0.11**	**524.8**	**425.7**
2005	**11.1**	**24.1**	**198.5**	**51.9**	**17.6**	**13.2**	**7.68**	**1.40**	**1.12**	**0.36**	**0.10**	**0.10**	**0**	**0**	**0**	**327.2**	**261.6**
2006	**2.89**	**83.9**	**40.9**	**129.9**	**14.4**	**4.62**	**9.49**	**6.13**	**2.39**	**1.05**	**0.83**	**0.17**	**0.31**	**0.01**	**0.02**	**297.0**	**258.7**
2007	**2.48**	**37.9**	**93.5**	**23.9**	**58.5**	**6.51**	**3.95**	**4.00**	**4.22**	**0.30**	**0.76**	**0.06**	**0**	**0**	**0**	**236.0**	**224.2**
2008	**0.01**	**50.7**	**55.9**	**15.9**	**7.84**	**9.99**	**3.06**	**0.97**	**1.41**	**0.98**	**0.13**	**0.15**	**0**	**0.06**	**0**	**147.1**	**124.1**
2009	**0**	**54.7**	**96.9**	**61.4**	**6.99**	**4.01**	**7.62**	**1.95**	**1.00**	**1.08**	**1.10**	**0.35**	**0.18**	**0**	**0**	**237.2**	**212.6**
2010	0.02	7.60	143.0	22.5	17.1	3.95	1.68	3.58	0.43	0.25	0.18	0.30	0.01	0.20	0	200.8	167.1
2011	0	15.2	42.7	59.6	4.61	4.23	1.07	0.81	0.78	0.19	0.03	0.06	0	0	0	129.4	117.7
2012	0.08	68.5	69.0	29.7	18.8	3.48	2.83	0.32	0.58	0.56	0.08	0.05	0	0	0	193.9	148.6
2013	5.02	12.3	77.1	16.5	13.3	11.6	2.19	1.21	0.61	0.39	0.02	+	0.10	0.14	0	140.5	139.1
2014	2.95	28.4	40.1	70.8	8.73	5.62	5.44	1.61	0.55	0.18	0.43	0.10	0	0	0.02	165.0	166.0
2015	0.06	93.5	72.4	22.7	30.1	6.08	4.22	1.85	0.20	0.14	0.07	0.05	0	0	0	231.4	177.6
2016	0.76	72.6	145.7	32.0	10.5	11.2	4.15	2.04	1.46	0.15	0.22	0.12	0.02	0.05	0	281.1	196.0
2017	35.4	23.6	91.1	63.9	13.3	2.76	5.35	2.21	0.62	0.46	0.01	0.02	0.04	0	0.05	238.8	177.2

Table 2. SAITHE. Ratio new/old acoustic abundance indices and total biomass from the Norwegian coastal acoustic surveys 2003-2016.

	Age group										Total	Biomass
Year	1	2	3	4	5	6	7	8	9	10+		
2003	**1.28**	**1.65**	**1.49**	**1.07**	**1.63**	**1.25**	**1.24**	**2.13**	**2.42**	**1.93**	**1.37**	**1.37**
2004	-	**1.01**	**0.90**	**0.91**	**0.90**	**0.79**	**0.90**	**0.69**	**1.16**	**1.07**	**0.93**	**0.96**
2005	**10.14**	**1.09**	**0.87**	**0.77**	**0.87**	**0.80**	**0.99**	**0.64**	**0.67**	**0.60**	**0.89**	**0.88**
2006	**0.66**	**0.85**	**0.96**	**0.91**	**0.75**	**1.01**	**1.12**	**1.09**	**1.16**	**0.68**	**0.91**	**0.96**
2007	**0.49**	**0.83**	**0.84**	**0.88**	**0.96**	**0.82**	**0.68**	**0.97**	**0.97**	**1.06**	**0.88**	**0.93**
2008	**0.54**	**0.91**	**0.58**	**0.55**	**0.57**	**0.84**	**0.76**	**0.90**	**1.35**	**0.82**	**0.68**	**0.74**
2009	**-**	**1.03**	**0.78**	**0.79**	**0.95**	**0.77**	**1.14**	**2.29**	**1.36**	**1.62**	**0.86**	**0.94**
2010	0.08	0.97	0.77	0.73	0.77	0.99	0.88	1.08	1.62	0.65	0.78	0.83
2011	-	1.19	0.91	0.77	0.89	0.74	1.11	0.25	0.39	2.39	0.84	0.80
2012	1.98	0.94	0.69	0.84	0.80	0.92	0.90	1.04	0.79	1.41	0.81	0.86
2013	1.81	0.96	0.68	0.83	1.22	1.04	0.77	0.89	0.80	0.93	0.81	0.86
2014	0.87	1.13	1.00	0.81	0.59	0.65	0.63	0.63	0.50	0.78	0.87	0.81
2015	0.54	1.18	1.00	0.78	0.88	0.81	0.73	0.58	0.59	0.65	1.00	0.92
2016	0.63	1.35	1.08	0.75	0.68	0.70	0.55	0.66	0.70	0.62	1.02	0.88

Table 3. SAITHE. Estimates of coefficients of variation (%) for acoustic abundance indices from Norwegian coastal acoustic surveys 2003-2017.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2003	**0.35**	**0.21**	**0.19**	**0.22**	**0.16**	**0.36**	**0.33**	**0.60**	**0.30**	**0.39**	**0.43**	**0.43**	**0.49**	**0.99**
2004	**1.98**	**0.26**	**0.16**	**0.28**	**0.25**	**0.22**	**0.39**	**0.59**	**0.43**	**0.40**	**0.35**	**0.39**	**0.39**	**0.70**
2005	**0.58**	**0.47**	**0.12**	**0.20**	**0.12**	**0.19**	**0.25**	**0.45**	**0.59**	**0.75**	**0.89**	**0.89**	-	-
2006	**0.53**	**0.13**	**0.40**	**0.30**	**0.23**	**0.35**	**0.34**	**0.46**	**0.42**	**0.46**	**0.36**	**1.02**	**0.65**	**0.88**
2007	**0.50**	**0.28**	**0.21**	**0.17**	**0.23**	**0.27**	**0.39**	**0.37**	**0.31**	**0.54**	**0.47**	**0.81**	-	-
2008	**1.31**	**0.19**	**0.21**	**0.27**	**0.27**	**0.14**	**0.19**	**0.37**	**0.36**	**0.37**	**0.60**	**0.50**	**-**	**1.16**
2009	**-**	**0.34**	**0.20**	**0.15**	**0.25**	**0.30**	**0.22**	**0.37**	**0.45**	**0.43**	**0.54**	**0.96**	**0.44**	**-**
2010	1.68	0.32	0.19	0.19	0.20	0.22	0.20	0.27	0.60	0.35	0.75	0.84	1.20	0.76
2011	-	0.23	0.18	0.16	0.24	0.38	0.40	0.48	0.33	1.11	1.04	1.00	-	-
2012	0.68	0.16	0.15	0.18	0.24	0.21	0.34	0.68	0.33	0.60	0.79	1.29	-	-
2013	0.56	0.17	0.12	0.13	0.31	0.19	0.34	0.41	0.42	0.62	1.09	3.11	0.93	0.82
2014	0.73	0.21	0.22	0.24	0.18	0.21	0.18	0.31	0.43	0.56	0.44	0.83	-	-
2015	1.60	0.17	0.16	0.20	0.22	0.26	0.25	0.31	0.30	0.72	0.49	0.58	-	-
2016	2.23	0.17	0.10	0.14	0.17	0.19	0.22	0.30	0.23	0.81	0.84	0.60	0.65	0.58
2017	0.34	0.61	0.13	0.17	0.20	0.34	0.48	0.45	0.39	0.26	0.73	0.94	0.92	-

Table 4. SAITHE. Length at age in the Norwegian coastal acoustic surveys 2003-2017 estimated by StoX software. + indicates few samples.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2003	**25.8**	**33.9**	**39.6**	**44.2**	**49.3**	**60.1**	**64.1**	**66.1**	**70.4**	**75.7**	**82.2**	+	+	+
2004	**28.0**	**32.3**	**39.7**	**46.3**	**53.6**	**58.9**	**69.7**	**74.4**	**74.6**	**78.1**	**77.8**	+	+	+
2005	**27.9**	**36.0**	**39.3**	**45.8**	**51.4**	**59.0**	**62.5**	**67.5**	**71.3**	**69.8**	**80.0**	+	-	-
2006	**26.3**	**35.2**	**40.9**	**43.5**	**51.2**	**57.8**	**64.4**	**66.8**	**70.0**	**73.1**	**76.5**	+	+	+
2007	**26.8**	**36.0**	**40.7**	**46.7**	**51.0**	**58.1**	**65.8**	**67.4**	**69.0**	**72.8**	**81.5**	+	-	-
2008	**26.0**	**36.8**	**41.7**	**47.9**	**51.9**	**58.4**	**61.2**	**68.6**	**73.3**	**77.2**	+	+	-	+
2009	-	**33.8**	**41.6**	**47.6**	**57.6**	**63.3**	**66.5**	**64.9**	**69.6**	**75.1**	**72.2**	**78.7**	+	-
2010	24.2	34.5	38.4	47.1	57.4	61.0	65.0	66.9	68.9	75.8	+	+	+	+
2011	-	36.8	41.7	44.7	56.7	62.8	69.5	65.7	76.0	+	+	+	-	-
2012	29.0	36.4	42.3	47.3	51.6	60.5	66.5	71.8	66.9	79.5	82.9	87.0	-	-
2013	26.0	36.7	41.1	48.7	55.2	60.0	68.8	74.5	75.3	75.4	78.8	+	+	+
2014	24.3	35.8	44.0	46.7	54.8	60.6	61.4	72.3	76.6	80.2	79.3	85.8	-	-
2015	29.3	34.7	41.1	48.8	53.6	60.0	65.8	71.5	+	+	+	+	-	-
2016	28.5	33.2	38.8	47.1	54.1	60.0	67.0	70.5	72.5	81.8	+	+	+	+
2017	25.1	32.6	39.9	45.7	53.5	63.7	69.6	69.6	69.8	73.1	+	+	+	-

Table 5. SAITHE. Weight at age in the Norwegian coastal acoustic surveys 2003-2017 estimated by StoX software. + indicates few samples.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2003	**161**	**388**	**568**	**832**	**1156**	**21662**	**2559**	**2895**	**3607**	**4300**	**6019**	+	+	+
2004	**230**	**339**	**616**	**929**	**1515**	**2055**	**3393**	**4119**	**4414**	**4822**	**4785**	+	+	+
2005	**229**	**482**	**612**	**912**	**1308**	**2029**	**2427**	**2941**	**3648**	**3130**	**3475**	+	-	-
2006	**181**	**434**	**699**	**793**	**1336**	**1877**	**2668**	**2808**	**3413**	**4072**	**4492**	+	+	+
2007	**183**	**468**	**644**	**924**	**1235**	**1815**	**2584**	**2854**	**2995**	**3661**	**4852**	+	-	-
2008	**193**	**461**	**644**	**982**	**1256**	**1870**	**2158**	**2977**	**3787**	**4349**	+	+	-	+
2009	-	**375**	**689**	**1012**	**1814**	**2525**	**2899**	**2652**	**3118**	**4046**	**3299**	**3960**	+	-
2010	146	409	556	1016	1814	2227	2624	2851	3116	4363	+	+	+	+
2011	-	503	735	853	1744	2267	3302	2598	4524	+	+	+	-	-
2012	240	456	682	954	1212	1907	2481	3088	2448	4573	4783	4870	-	-
2013	171	481	690	1097	1551	2050	3170	3799	4020	3840	5044	+	+	+
2014	135	445	826	1006	1538	2096	2201	3428	4269	4679	4762	5647	-	-
2015	237	380	624	1042	1361	1955	2674	3390	+	+	+	+	-	-
2016	227	338	518	944	1422	2009	2730	3411	3690	5757	+	+	+	+
2017	142	335	576	882	1477	2511	3165	3277	3246	3576	+	+	+	-

Working Document No. 14

ICES Arctic Fisheries Working Group (AFWG), April 2019

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Adjustment method for estimation stock weight at age and maturity at age for Northeast Arctic haddock assessment in 2019.

The Russian autumn trawl-acoustic survey (TAS) was not conducted in the Barents Sea in 2016 and 2018 due to financial reasons. Russian haddock abundance indices, weight/length at age and maturity at age data that are supposed to be sources for stock assessments (for SAM and VPA model tuning as well as for calculation of combined data on weights in stock and maturity ogives) were not available for 2016/2017 and 2018/2019.

AFWG members have decided by correspondence to compute average historic difference in stock weight and maturity at age between Joint Barents Sea surveys – BS-NoRu-Q1 (further "Norwegian") in January-March and Russian TAS (RU-BTr-Q4 in November-December) (further "Russian") surveys, and to correct "Norwegian" 2017 and 2019 survey values by this difference.

The EXCEL program was used for calculations.

Weight at age

According the previous investigations it was decides to use some smoothing procedures for mean weight in stock and maturity data for NEA haddock in order to remove some of the sampling variability of the estimates. Raw data from surveys smoothed separately by Russia and Norway and smoothed data combined afterwards and used in assessment (further "final data"). Such procedure well described in Stock annex.

If we have not Russian or Norwegian data, we can estimate final data using ratios (relationships) between available set (Norwegian in 2019) and final data for previous years. In 2019 Norwegian data smoothed using new information for yearclasses 1993 upwards (marked in yellow) and values for years 2020 and 2021 estimated using regressions (Table 1). Thus, we need estimate mean ratios for period 1980-2018 and recalculate "final" set for yearclasses 1993 upwards until 2021 (Table 2). For ages 12-14 weight fixed as at age 11.

Maturity at age

As for weight at age, estimates were produced separately for the Russian and Norwegian survey and were later combined using an arithmetic average. These averages are assumed to give representative values for the beginning of the year.

The Norwegian maturity ogives for haddock tend to give a higher percent mature at age compared to the Russian ogives, which is consistent with the generally higher growth rates observed in haddock sampled by the Norwegian surveys. Also the methodology and timing for calculating the ogives is different which may lead to systematic differences.

The same approach was used for estimation of ratios for maturity at age as described above. Smoothed values from 1980 onwards (and ages 3- 10) were used. Values for yearclasses 1993 upwards (marked in yellow) and values for years 2020 and 2021 changed from 2018 (Table 3)

Ratios between final 2018 and Norwegian data were calculated. Than mean ratios for period 1980-2018 was used for restoring final values for yearclasses 1993 onwards for 2019 assessment (Table 4).

Table 1. Smoothed weight data from Norwegian surveys (kg) and final weight data used in 2018 (kg)

Year	2019 smoothed weight data from Norwegian surveys (kg)											2018 final weight data (kg)										
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11
1980	0.062	0.240	0.437	0.930	1.313	1.923	2.701	3.908	3.776	3.781		0.063	0.262	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792
1981	0.045	0.273	0.547	0.764	1.357	1.738	2.352	3.096	4.177	4.034	4.015	0.051	0.274	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904
1982	0.040	0.203	0.615	0.935	1.136	1.790	2.150	2.745	3.437	4.382	4.240	0.036	0.224	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016
1983	0.039	0.183	0.471	1.038	1.362	1.526	2.207	2.535	3.095	3.724	4.537	0.035	0.164	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165
1984	0.029	0.176	0.427	0.818	1.495	1.797	1.913	2.595	2.886	3.401	3.964	0.028	0.158	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878
1985	0.032	0.135	0.414	0.748	1.208	1.951	2.215	2.284	2.945	3.198	3.665	0.03	0.127	0.379	0.7	1.394	2.195	2.626	2.572	3.158	3.261	3.728
1986	0.042	0.149	0.323	0.727	1.115	1.613	2.383	2.603	2.629	3.256	3.472	0.035	0.136	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632
1987	0.049	0.189	0.356	0.579	1.086	1.500	2.011	2.776	2.953	2.943	3.527	0.042	0.161	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946
1988	0.045	0.221	0.441	0.633	0.882	1.465	1.885	2.388	3.126	3.264	3.225	0.039	0.189	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787
1989	0.040	0.202	0.508	0.770	0.957	1.213	1.844	2.253	2.736	3.431	3.535	0.037	0.175	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449
1990	0.031	0.184	0.469	0.875	1.144	1.306	1.553	2.210	2.597	3.050	3.692	0.031	0.169	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73
1991	0.027	0.143	0.430	0.814	1.284	1.536	1.662	1.890	2.552	2.911	3.330	0.025	0.141	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256
1992	0.025	0.125	0.343	0.752	1.203	1.704	1.925	2.011	2.215	2.866	3.194	0.023	0.114	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491
1993	0.025	0.120	0.302	0.612	1.120	1.607	2.113	2.297	2.343	2.522	3.149	0.025	0.107	0.279	0.616	1.1	1.537	2.08	2.308	2.54	2.831	3.531
1994	0.031	0.120	0.290	0.545	0.928	1.507	2.004	2.496	2.642	2.654	2.806	0.029	0.115	0.262	0.512	0.952	1.518	1.969	2.527	2.729	2.945	3.213
1995	0.037	0.135	0.290	0.525	0.834	1.269	1.892	2.381	2.846	2.956	2.939	0.033	0.126	0.282	0.484	0.8	1.327	1.952	2.401	2.959	3.135	3.335
1996	0.038	0.159	0.318	0.524	0.806	1.151	1.619	2.261	2.729	3.158	3.238	0.036	0.14	0.302	0.52	0.76	1.128	1.724	2.388	2.82	3.369	3.52
1997	0.037	0.162	0.369	0.568	0.804	1.115	1.481	1.964	2.605	3.043	3.434	0.036	0.157	0.332	0.551	0.816	1.076	1.481	2.127	2.814	3.22	3.751
1998	0.030	0.158	0.376	0.651	0.866	1.114	1.438	1.810	2.293	2.919	3.323	0.03	0.158	0.371	0.601	0.859	1.155	1.418	1.847	2.526	3.221	3.595
1999	0.029	0.131	0.367	0.663	0.983	1.196	1.436	1.762	2.129	2.602	3.202	0.029	0.131	0.371	0.664	0.929	1.21	1.523	1.775	2.215	2.911	3.604
2000	0.027	0.125	0.309	0.648	0.999	1.342	1.539	1.760	2.077	2.432	2.887	0.027	0.13	0.314	0.662	1.014	1.299	1.589	1.905	2.137	2.578	3.278
2001	0.032	0.116	0.296	0.554	0.978	1.363	1.711	1.884	2.075	2.378	2.715	0.03	0.12	0.31	0.567	1.009	1.399	1.695	1.983	2.292	2.495	2.929
2002	0.031	0.137	0.276	0.531	0.846	1.337	1.735	2.076	2.221	2.375	2.660	0.03	0.13	0.289	0.56	0.874	1.39	1.801	2.102	2.381	2.676	2.845
2003	0.029	0.134	0.323	0.497	0.815	1.170	1.705	2.103	2.427	2.542	2.657	0.03	0.134	0.31	0.524	0.864	1.218	1.785	2.205	2.51	2.775	3.049
2004	0.026	0.124	0.315	0.575	0.767	1.130	1.509	2.069	2.455	2.756	2.844	0.029	0.132	0.319	0.56	0.813	1.203	1.582	2.18	2.599	2.911	3.157
2005	0.022	0.112	0.293	0.563	0.877	1.068	1.461	1.850	2.419	2.785	3.061	0.025	0.128	0.315	0.575	0.864	1.138	1.562	1.952	2.564	2.975	3.297
2006	0.024	0.099	0.267	0.527	0.860	1.209	1.387	1.796	2.184	2.748	3.090	0.024	0.113	0.307	0.569	0.885	1.203	1.484	1.928	2.318	2.929	3.328
2007	0.026	0.104	0.237	0.483	0.809	1.187	1.556	1.712	2.125	2.504	3.053	0.025	0.107	0.272	0.556	0.877	1.232	1.561	1.838	2.289	2.672	3.27
2008	0.032	0.113	0.250	0.433	0.746	1.122	1.529	1.903	2.033	2.442	2.804	0.028	0.111	0.26	0.496	0.858	1.222	1.597	1.926	2.191	2.638	3.008
2009	0.030	0.136	0.268	0.454	0.674	1.042	1.452	1.873	2.241	2.344	2.741	0.028	0.125	0.269	0.474	0.772	1.197	1.587	1.968	2.286	2.535	2.97
2010	0.041	0.129	0.320	0.485	0.705	0.947	1.355	1.786	2.209	2.563	2.640	0.037	0.125	0.3	0.489	0.739	1.083	1.556	1.958	2.333	2.635	2.863
2011	0.036	0.172	0.304	0.571	0.749	0.988	1.241	1.676	2.114	2.530	2.865	0.034	0.158	0.3	0.542	0.761	1.04	1.416	1.922	2.325	2.686	2.966
2012	0.040	0.156	0.396	0.551	0.871	1.056	1.325	1.549	1.970	2.448	2.842	0.038	0.151	0.372	0.544	0.838	1.068	1.364	1.758	2.284	2.679	3.021
2013	0.033	0.171	0.363	0.694	0.848	1.207	1.371	1.644	1.854	2.281	2.743	0.032	0.163	0.357	0.661	0.842	1.169	1.397	1.697	2.101	2.635	3.016
2014	0.037	0.139	0.396	0.641	1.043	1.171	1.549	1.697	1.960	2.153	2.575	0.035	0.142	0.383	0.64	1.005	1.176	1.52	1.735	2.032	2.435	2.968
2015	0.033	0.161	0.328	0.699	0.973	1.426	1.516	1.901	2.019	2.270	2.448	0.031	0.151	0.339	0.682	0.979	1.382	1.531	1.879	2.073	2.36	2.755
2016	0.030	0.143	0.376	0.586	1.049	1.325	1.807	1.854	2.237	2.335	2.563	0.029	0.135	0.357	0.611	1.038	1.354	1.772	1.894	2.235	2.404	2.677
2017	0.031	0.131	0.338	0.664	0.894	1.426	1.697	2.184	2.195	2.563	2.634	0.032	0.127	0.32	0.64	0.941	1.427	1.747	2.161	2.255	2.58	2.721
2018	0.029	0.133	0.308	0.599	0.998	1.236	1.816	2.060	2.540	2.516	2.868	0.034	0.138	0.303	0.578	0.979	1.308	1.832	2.143	2.539	2.605	2.91
2019	0.038	0.128	0.313	0.555	0.912	1.363	1.583	2.195	2.414	2.880	2.817	0.033	0.147	0.327	0.550	0.891	1.354	1.696	2.238	2.533	2.900	2.942
2020*	0.035	0.164	0.303	0.559	0.847	1.256	1.742	1.937	2.551	2.747	3.188	0.033	0.143	0.345	0.587	0.850	1.239	1.746	2.089	2.631	2.904	3.235
2021*	0.035	0.149	0.382	0.544	0.856	1.173	1.613	2.112	2.280	2.887	3.055											

* - forecasted values using regressions

Table 2. Ratios between Norwegian and final data 2018 and restored data for 2019

Year	Ratio											2019 final weight data (kg)										
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11+
1980	1.01	1.09	1.04	0.94	0.88	0.87	0.85	0.80	0.88	0.94	1.00	0.063	0.262	0.454	0.878	1.159	1.675	2.292	3.134	3.31	3.553	3.792
1981	1.13	1.00	1.10	1.05	0.97	0.91	0.90	0.88	0.84	0.91	0.97	0.051	0.274	0.603	0.805	1.315	1.582	2.118	2.728	3.51	3.679	3.904
1982	0.90	1.10	1.03	1.12	1.07	1.00	0.94	0.93	0.91	0.88	0.95	0.036	0.224	0.631	1.049	1.217	1.782	2.017	2.553	3.14	3.853	4.016
1983	0.91	0.90	1.11	1.06	1.14	1.09	1.02	0.97	0.96	0.95	0.92	0.035	0.164	0.524	1.098	1.558	1.663	2.255	2.448	2.97	3.524	4.165
1984	0.98	0.90	0.91	1.13	1.09	1.16	1.11	1.05	0.99	0.99	0.98	0.028	0.158	0.391	0.926	1.632	2.093	2.121	2.718	2.865	3.363	3.878
1985	0.93	0.94	0.92	0.94	1.15	1.12	1.19	1.13	1.07	1.02	1.02	0.03	0.127	0.379	0.7	1.394	2.195	2.626	2.572	3.158	3.261	3.728
1986	0.84	0.91	0.96	0.94	0.96	1.18	1.16	1.21	1.14	1.10	1.05	0.035	0.136	0.311	0.682	1.069	1.898	2.761	3.138	3.005	3.568	3.632
1987	0.85	0.85	0.93	0.98	0.96	0.98	1.20	1.19	1.22	1.16	1.12	0.042	0.161	0.331	0.569	1.047	1.473	2.411	3.307	3.616	3.412	3.946
1988	0.87	0.86	0.87	0.95	1.01	0.99	1.01	1.22	1.22	1.24	1.17	0.039	0.189	0.383	0.603	0.887	1.452	1.895	2.915	3.822	4.054	3.787
1989	0.92	0.87	0.88	0.89	0.98	1.03	1.02	1.03	1.24	1.25	1.26	0.037	0.175	0.445	0.689	0.936	1.248	1.878	2.317	3.395	4.297	4.449
1990	1.01	0.92	0.88	0.90	0.92	1.00	1.05	1.04	1.05	1.26	1.28	0.031	0.169	0.413	0.789	1.054	1.312	1.635	2.308	2.728	3.844	4.73
1991	0.94	0.98	0.94	0.91	0.93	0.95	1.03	1.08	1.07	1.07	1.28	0.025	0.141	0.402	0.737	1.193	1.458	1.714	2.035	2.732	3.122	4.256
1992	0.91	0.91	0.99	0.96	0.93	0.96	0.98	1.06	1.10	1.10	1.09	0.023	0.114	0.34	0.721	1.119	1.63	1.881	2.127	2.437	3.142	3.491
1993	0.99	0.89	0.92	1.01	0.98	0.96	0.98	1.00	1.08	1.12	1.12	0.025	0.107	0.279	0.616	1.1	1.537	2.08	2.308	2.54	2.831	3.531
1994	0.93	0.96	0.90	0.94	1.03	1.01	0.98	1.01	1.03	1.11	1.15	0.030	0.115	0.262	0.512	0.952	1.518	1.969	2.527	2.729	2.945	3.213
1995	0.89	0.93	0.97	0.92	0.96	1.05	1.03	1.01	1.04	1.06	1.13	0.036	0.131	0.282	0.484	0.8	1.327	1.952	2.401	2.959	3.135	3.335
1996	0.94	0.88	0.95	0.99	0.94	0.98	1.06	1.06	1.03	1.07	1.09	0.037	0.154	0.313	0.52	0.76	1.128	1.724	2.388	2.82	3.369	3.52
1997	0.97	0.97	0.90	0.97	1.01	0.96	1.00	1.08	1.08	1.06	1.09	0.036	0.158	0.363	0.567	0.816	1.076	1.481	2.127	2.814	3.22	3.751
1998	0.99	1.00	0.99	0.92	0.99	1.04	0.99	1.02	1.10	1.10	1.08	0.029	0.153	0.371	0.650	0.879	1.155	1.418	1.847	2.526	3.221	3.595
1999	1.01	1.00	1.01	1.00	0.95	1.01	1.06	1.01	1.04	1.12	1.13	0.028	0.128	0.361	0.662	0.998	1.225	1.523	1.775	2.215	2.911	3.604
2000	1.02	1.04	1.01	1.02	1.01	0.97	1.03	1.08	1.03	1.06	1.14	0.026	0.122	0.305	0.647	1.014	1.375	1.592	1.905	2.137	2.578	3.278
2001	0.94	1.04	1.05	1.02	1.03	1.03	0.99	1.05	1.10	1.05	1.08	0.031	0.113	0.292	0.553	0.993	1.396	1.770	1.969	2.292	2.495	2.929
2002	0.97	0.95	1.05	1.05	1.03	1.04	1.04	1.01	1.07	1.13	1.07	0.030	0.133	0.272	0.531	0.859	1.369	1.795	2.170	2.349	2.676	2.845
2003	1.05	1.00	0.96	1.05	1.06	1.04	1.05	1.05	1.03	1.09	1.15	0.028	0.130	0.318	0.497	0.827	1.199	1.763	2.197	2.567	2.727	3.049
2004	1.13	1.07	1.01	0.97	1.06	1.06	1.05	1.05	1.06	1.06	1.11	0.025	0.120	0.310	0.575	0.778	1.157	1.561	2.162	2.597	2.956	3.095
2005	1.12	1.14	1.07	1.02	0.98	1.07	1.07	1.05	1.06	1.07	1.08	0.022	0.109	0.289	0.562	0.891	1.094	1.511	1.934	2.559	2.988	3.332
2006	1.01	1.14	1.15	1.08	1.03	0.99	1.07	1.07	1.06	1.07	1.08	0.023	0.096	0.263	0.526	0.873	1.239	1.434	1.877	2.310	2.948	3.363
2007	0.97	1.02	1.15	1.15	1.08	1.04	1.00	1.07	1.08	1.07	1.07	0.025	0.101	0.234	0.483	0.821	1.216	1.609	1.789	2.248	2.686	3.323
2008	0.89	0.99	1.04	1.15	1.15	1.09	1.04	1.01	1.08	1.08	1.07	0.031	0.109	0.246	0.432	0.758	1.150	1.582	1.988	2.151	2.619	3.052
2009	0.94	0.92	1.00	1.04	1.15	1.15	1.09	1.05	1.02	1.08	1.08	0.029	0.132	0.264	0.454	0.684	1.067	1.502	1.958	2.370	2.514	2.983
2010	0.91	0.97	0.94	1.01	1.05	1.14	1.15	1.10	1.06	1.03	1.08	0.039	0.125	0.315	0.484	0.715	0.970	1.402	1.866	2.336	2.749	2.873
2011	0.95	0.92	0.99	0.95	1.02	1.05	1.14	1.15	1.10	1.06	1.04	0.034	0.167	0.300	0.571	0.760	1.012	1.283	1.751	2.236	2.713	3.118
2012	0.94	0.97	0.94	0.99	0.96	1.01	1.03	1.13	1.16	1.09	1.06	0.039	0.151	0.391	0.550	0.884	1.082	1.370	1.619	2.084	2.625	3.094
2013	0.98	0.95	0.98	0.95	0.99	0.97	1.02	1.03	1.13	1.16	1.10	0.032	0.166	0.358	0.693	0.861	1.236	1.418	1.718	1.961	2.446	2.985
2014	0.93	1.02	0.97	1.00	0.96	1.00	0.98	1.02	1.04	1.13	1.15	0.036	0.136	0.391	0.640	1.059	1.200	1.602	1.773	2.073	2.309	2.802
2015	0.93	0.94	1.03	0.98	1.01	0.97	1.01	0.99	1.03	1.04	1.13	0.032	0.157	0.324	0.698	0.988	1.461	1.568	1.987	2.136	2.435	2.664
2016	0.97	0.94	0.95	1.04	0.99	1.02	0.98	1.02	1.00	1.03	1.04	0.029	0.139	0.371	0.585	1.065	1.357	1.869	1.937	2.367	2.505	2.790
2017	1.05	0.97	0.95	0.96	1.05	1.00	1.03	0.99	1.03	1.01	1.03	0.030	0.127	0.333	0.664	0.908	1.461	1.755	2.283	2.322	2.749	2.867
2018	1.16	1.04	0.99	0.97	0.98	1.06	1.01	1.04	1.00	1.04	1.01	0.028	0.129	0.303	0.598	1.013	1.266	1.878	2.153	2.686	2.699	3.121
2019												0.037	0.124	0.309	0.554	0.926	1.397	1.638	2.294	2.553	3.089	3.066
2020*												0.034	0.160	0.298	0.558	0.860	1.287	1.801	2.024	2.699	2.947	3.469
2021*												0.034	0.145	0.376	0.543	0.868	1.202	1.668	2.207	2.412	3.097	3.325
Mean	0.969	0.972	0.985	0.999	1.012	1.025	1.034	1.045	1.058	1.073	1.088											

* - forecasted restored values

Table 3. Smoothed maturity data from Norwegian surveys and final maturity data used in 2018

Year	2019 smoothed maturity data from Norwegian surveys									2018 final maturity data								
	3	4	5	6	7	8	9	10	11	3	4	5	6	7	8	9	10	11
1980	0.02	0.10	0.35	0.79	0.96	0.99	1.00	1.00	1.00	0.03	0.08	0.24	0.65	0.86	0.95	0.98	1.00	1
1981	0.02	0.11	0.45	0.77	0.96	0.99	1.00	1.00	1.00	0.06	0.10	0.30	0.55	0.86	0.95	0.98	1.00	1
1982	0.02	0.09	0.40	0.78	0.94	0.98	1.00	1.00	1.00	0.05	0.16	0.33	0.58	0.77	0.95	0.98	1.00	1
1983	0.02	0.14	0.45	0.80	0.95	0.99	1.00	1.00	1.00	0.06	0.18	0.47	0.67	0.80	0.91	0.98	1.00	1
1984	0.02	0.16	0.53	0.85	0.95	0.99	1.00	1.00	1.00	0.04	0.20	0.51	0.80	0.86	0.92	0.97	1.00	1
1985	0.02	0.11	0.55	0.84	0.95	0.99	1.00	1.00	1.00	0.03	0.15	0.52	0.80	0.93	0.95	0.97	0.99	1
1986	0.02	0.12	0.49	0.76	0.95	0.99	1.00	1.00	1.00	0.02	0.10	0.45	0.76	0.93	0.98	0.98	0.99	1
1987	0.02	0.08	0.36	0.74	0.93	0.99	1.00	1.00	1.00	0.02	0.08	0.29	0.71	0.92	0.98	0.99	0.99	1
1988	0.02	0.07	0.29	0.68	0.92	0.98	1.00	1.00	1.00	0.03	0.07	0.24	0.58	0.90	0.98	0.99	1.00	1
1989	0.02	0.08	0.29	0.65	0.90	0.98	1.00	1.00	1.00	0.03	0.09	0.25	0.53	0.82	0.97	0.99	1.00	1
1990	0.02	0.12	0.35	0.70	0.90	0.97	0.99	1.00	1.00	0.05	0.13	0.31	0.58	0.80	0.94	0.99	1.00	1
1991	0.03	0.13	0.40	0.73	0.92	0.97	0.99	1.00	1.00	0.04	0.16	0.36	0.62	0.82	0.93	0.98	1.00	1
1992	0.02	0.14	0.47	0.81	0.94	0.98	0.99	1.00	1.00	0.03	0.15	0.45	0.70	0.86	0.94	0.98	0.99	1
1993	0.02	0.12	0.42	0.78	0.93	0.99	0.99	1.00	1.00	0.02	0.11	0.40	0.74	0.88	0.95	0.98	0.99	1
1994	0.02	0.09	0.38	0.76	0.93	0.98	1.00	1.00	1.00	0.02	0.07	0.33	0.70	0.90	0.96	0.98	0.99	1
1995	0.02	0.07	0.31	0.72	0.92	0.98	1.00	1.00	1.00	0.02	0.06	0.23	0.63	0.89	0.97	0.99	1.00	1
1996	0.02	0.09	0.29	0.64	0.92	0.98	1.00	1.00	1.00	0.02	0.07	0.21	0.50	0.86	0.96	0.99	1.00	1
1997	0.03	0.09	0.27	0.66	0.89	0.97	0.99	1.00	1.00	0.03	0.08	0.20	0.50	0.76	0.95	0.99	1.00	1
1998	0.03	0.12	0.30	0.67	0.89	0.97	0.99	1.00	1.00	0.04	0.12	0.25	0.50	0.75	0.91	0.98	1.00	1
1999	0.03	0.12	0.36	0.61	0.91	0.97	0.99	1.00	1.00	0.05	0.13	0.32	0.52	0.76	0.90	0.97	1.00	1
2000	0.02	0.12	0.37	0.67	0.84	0.97	0.99	1.00	1.00	0.03	0.15	0.35	0.60	0.77	0.90	0.97	0.99	1
2001	0.02	0.09	0.36	0.68	0.87	0.94	1.00	1.00	1.00	0.03	0.11	0.39	0.64	0.82	0.91	0.97	0.99	1
2002	0.02	0.08	0.29	0.67	0.88	0.95	0.98	1.00	1.00	0.02	0.10	0.29	0.67	0.85	0.93	0.97	0.99	1
2003	0.02	0.07	0.27	0.59	0.87	0.96	0.98	0.99	1.00	0.03	0.08	0.28	0.58	0.87	0.94	0.98	0.99	1
2004	0.02	0.09	0.24	0.57	0.83	0.95	0.98	0.99	1.00	0.03	0.09	0.23	0.57	0.81	0.95	0.98	0.99	1
2005	0.02	0.09	0.30	0.54	0.82	0.94	0.98	0.99	1.00	0.03	0.10	0.26	0.50	0.80	0.93	0.98	0.99	1
2006	0.02	0.08	0.29	0.61	0.79	0.93	0.98	0.99	1.00	0.03	0.10	0.27	0.54	0.75	0.93	0.97	0.99	1
2007	0.01	0.07	0.27	0.60	0.84	0.92	0.97	0.99	1.00	0.02	0.09	0.27	0.55	0.78	0.90	0.97	0.99	1
2008	0.01	0.06	0.23	0.57	0.83	0.94	0.97	0.99	1.00	0.02	0.07	0.25	0.55	0.79	0.91	0.96	0.99	1
2009	0.02	0.06	0.20	0.52	0.81	0.94	0.98	0.99	1.00	0.02	0.06	0.21	0.52	0.80	0.92	0.97	0.99	1
2010	0.02	0.07	0.21	0.47	0.78	0.93	0.98	0.99	1.00	0.02	0.07	0.19	0.46	0.77	0.92	0.97	0.99	1
2011	0.02	0.09	0.24	0.49	0.74	0.92	0.97	0.99	1.00	0.02	0.08	0.20	0.44	0.73	0.91	0.97	0.99	1
2012	0.03	0.08	0.29	0.53	0.78	0.91	0.97	0.99	1.00	0.03	0.08	0.24	0.45	0.71	0.89	0.97	0.99	1
2013	0.02	0.12	0.28	0.61	0.80	0.92	0.97	0.99	1.00	0.03	0.12	0.24	0.50	0.71	0.88	0.96	0.99	1
2014	0.03	0.11	0.38	0.59	0.84	0.92	0.97	0.99	1.00	0.03	0.10	0.32	0.50	0.75	0.88	0.95	0.99	1
2015	0.02	0.13	0.34	0.70	0.83	0.94	0.97	0.99	1.00	0.03	0.12	0.29	0.61	0.75	0.89	0.95	0.98	1
2016	0.03	0.09	0.38	0.66	0.89	0.94	0.98	0.99	1.00	0.04	0.10	0.33	0.57	0.82	0.90	0.96	0.98	1
2017	0.02	0.12	0.30	0.70	0.87	0.96	0.98	0.99	1.00	0.04	0.12	0.27	0.61	0.80	0.93	0.96	0.99	1
2018	0.02	0.10	0.35	0.62	0.89	0.95	0.99	0.99	1.00	0.03	0.11	0.33	0.55	0.83	0.92	0.98	0.99	1
2019	0.02	0.09	0.31	0.67	0.85	0.96	0.98	0.99	1.00	0.03	0.10	0.30	0.61	0.79	0.93	0.97	0.99	1
2020*	0.02	0.09	0.28	0.63	0.88	0.95	0.99	0.99	1.00	0.03	0.10	0.29	0.59	0.83	0.92	0.98	0.99	1
2021*	0.03	0.08	0.28	0.59	0.85	0.96	0.98	0.99	1.00									

* - forecasted values using regressions

Table 4. Ratios between Norwegian and final data 2018 and restored data for 2019

	Ratio									2019 final maturity data								
Year	3	4	5	6	7	8	9	10	11	3	4	5	6	7	8	9	10	11+
1980	1.46	0.80	0.69	0.82	0.90	0.96	0.99	1.00	1.00	0.026	0.076	0.243	0.649	0.86	0.95	0.984	0.995	1
1981	2.51	0.98	0.68	0.71	0.90	0.96	0.99	1.00	1.00	0.056	0.104	0.303	0.549	0.857	0.948	0.984	0.995	1
1982	2.72	1.84	0.83	0.74	0.82	0.96	0.99	1.00	1.00	0.053	0.161	0.332	0.577	0.77	0.947	0.983	0.995	1
1983	2.36	1.35	1.04	0.83	0.85	0.92	0.99	1.00	1.00	0.057	0.183	0.472	0.665	0.8	0.906	0.983	0.995	1
1984	2.12	1.24	0.96	0.94	0.91	0.93	0.97	1.00	1.00	0.044	0.196	0.51	0.801	0.862	0.921	0.967	0.995	1
1985	1.08	1.30	0.94	0.94	0.98	0.96	0.98	0.99	1.00	0.027	0.149	0.522	0.796	0.928	0.953	0.973	0.989	1
1986	1.09	0.85	0.92	0.99	0.97	0.99	0.99	0.99	1.00	0.021	0.103	0.454	0.758	0.928	0.977	0.984	0.991	1
1987	1.29	0.91	0.81	0.97	0.99	0.99	1.00	1.00	1.00	0.021	0.076	0.294	0.713	0.918	0.976	0.993	0.994	1
1988	1.55	1.04	0.82	0.85	0.97	0.99	1.00	1.00	1.00	0.025	0.074	0.24	0.576	0.898	0.975	0.993	0.998	1
1989	1.73	1.10	0.86	0.83	0.91	0.99	1.00	1.00	1.00	0.032	0.09	0.25	0.534	0.822	0.966	0.993	0.998	1
1990	2.23	1.02	0.86	0.82	0.89	0.96	1.00	1.00	1.00	0.046	0.127	0.305	0.578	0.798	0.937	0.99	0.997	1
1991	1.57	1.22	0.90	0.86	0.89	0.95	0.99	1.00	1.00	0.041	0.164	0.358	0.623	0.82	0.925	0.98	0.997	1
1992	1.31	1.08	0.96	0.87	0.91	0.95	0.98	0.99	1.00	0.03	0.147	0.449	0.704	0.855	0.936	0.976	0.994	1
1993	0.92	0.97	0.94	0.95	0.94	0.96	0.98	0.99	1.00	0.018	0.113	0.396	0.741	0.878	0.95	0.979	0.992	1
1994	0.92	0.78	0.87	0.93	0.98	0.98	0.99	0.99	1.00	0.016	0.073	0.329	0.702	0.903	0.96	0.984	0.993	1
1995	1.00	0.83	0.74	0.88	0.96	0.99	0.99	1.00	1.00	0.016	0.059	0.227	0.633	0.885	0.969	0.987	0.995	1
1996	1.08	0.76	0.73	0.78	0.93	0.98	1.00	1.00	1.00	0.032	0.069	0.213	0.497	0.855	0.964	0.991	0.996	1
1997	1.27	0.89	0.75	0.75	0.86	0.97	0.99	1.00	1.00	0.040	0.098	0.204	0.495	0.76	0.948	0.989	0.997	1
1998	1.48	0.98	0.83	0.75	0.84	0.93	0.99	1.00	1.00	0.041	0.125	0.264	0.502	0.75	0.907	0.984	0.997	1
1999	1.88	1.09	0.88	0.86	0.83	0.93	0.98	1.00	1.00	0.039	0.129	0.320	0.535	0.76	0.898	0.969	0.995	1
2000	1.62	1.32	0.96	0.89	0.92	0.93	0.97	0.99	1.00	0.030	0.124	0.328	0.594	0.775	0.9	0.966	0.99	1
2001	1.68	1.19	1.08	0.94	0.94	0.97	0.97	0.99	1.00	0.028	0.094	0.318	0.601	0.808	0.909	0.967	0.989	1
2002	1.40	1.24	1.02	1.00	0.97	0.98	0.99	0.99	1.00	0.026	0.088	0.255	0.592	0.812	0.923	0.966	0.989	1
2003	1.24	1.08	1.05	0.97	1.00	0.99	0.99	1.00	1.00	0.032	0.078	0.240	0.524	0.807	0.925	0.972	0.988	1
2004	1.38	0.97	0.95	0.99	0.98	1.00	1.00	1.00	1.00	0.031	0.101	0.218	0.505	0.768	0.923	0.972	0.990	1
2005	1.59	1.05	0.87	0.92	0.98	0.99	1.00	1.00	1.00	0.028	0.097	0.269	0.476	0.756	0.906	0.971	0.990	1
2006	1.64	1.20	0.93	0.88	0.95	0.99	1.00	1.00	1.00	0.024	0.087	0.261	0.541	0.736	0.901	0.965	0.990	1
2007	1.58	1.26	1.03	0.92	0.93	0.98	1.00	1.00	1.00	0.021	0.075	0.237	0.531	0.778	0.892	0.963	0.987	1
2008	1.27	1.21	1.06	0.97	0.95	0.97	0.99	1.00	1.00	0.022	0.062	0.209	0.502	0.773	0.911	0.960	0.986	1
2009	1.15	1.01	1.04	0.99	0.98	0.98	0.99	1.00	1.00	0.025	0.067	0.177	0.463	0.754	0.908	0.967	0.985	1
2010	1.02	0.93	0.91	0.98	0.99	0.99	0.99	1.00	1.00	0.032	0.075	0.190	0.415	0.727	0.900	0.966	0.988	1
2011	1.16	0.85	0.85	0.89	0.98	0.99	1.00	1.00	1.00	0.029	0.099	0.210	0.436	0.690	0.888	0.963	0.987	1
2012	1.21	0.94	0.81	0.84	0.90	0.98	1.00	1.00	1.00	0.042	0.090	0.260	0.472	0.724	0.878	0.960	0.988	1
2013	1.22	0.95	0.84	0.82	0.89	0.95	0.99	1.00	1.00	0.037	0.132	0.250	0.537	0.737	0.889	0.955	0.986	1
2014	1.21	0.96	0.86	0.84	0.89	0.95	0.98	1.00	1.00	0.042	0.115	0.336	0.522	0.778	0.895	0.960	0.984	1
2015	1.32	0.96	0.86	0.87	0.90	0.95	0.98	0.99	1.00	0.032	0.133	0.305	0.616	0.771	0.913	0.962	0.986	1
2016	1.39	1.02	0.86	0.87	0.93	0.96	0.98	0.99	1.00	0.039	0.099	0.339	0.581	0.822	0.909	0.968	0.986	1
2017	1.58	1.04	0.90	0.88	0.92	0.97	0.98	0.99	1.00	0.033	0.122	0.270	0.616	0.805	0.930	0.967	0.989	1
2018	1.65	1.14	0.92	0.89	0.93	0.97	0.99	0.99	1.00	0.029	0.103	0.316	0.548	0.823	0.923	0.975	0.988	1
2019										0.029	0.091	0.278	0.595	0.785	0.930	0.972	0.991	1
2020*										0.028	0.092	0.250	0.556	0.812	0.915	0.975	0.990	1
2021*										0.039	0.088	0.253	0.523	0.791	0.926	0.969	0.991	1
Mean	1.48	1.06	0.89	0.88	0.93	0.97	0.99	1.00	1.00									

* - forecasted restored values

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Working Document No. 15

ICES Arctic Fisheries Working Group (AFWG), April 2019

Updated mean ratios between the combined and Norwegian data on weight at age and maturity at age in Northeast Arctic cod

The Russian autumn trawl-acoustic survey (TAS) in the Barents Sea was not conducted in 2018. Russian cod abundance indices, weight at age and maturity at age data used for stock assessment were not available for 2018/2019.

Combined data on weight at age and maturity at age for 2018/2019 were adjusted using the same method as described in the WD 10 presented at the AFWG meeting in 2017. The mean 2019 ratios calculated between combined and Norwegian data differed slightly from the mean 2017 ratios (Table 1 -2).

There are the final NEA cod weight at age and maturity at age values for 2018/2019 in this WD (Table 3).

Table 1. NEA cod. Mean ratios between the combined and Norwegian data on weight at age with some statistical characteristics for years 1985-2016, 2018

Age, years	Number of years with data	Mean Ratio this year (2019)	Ratio 2017	95% confidence limits	St deviation	Coefficient of variation, %
1	33	0.93	0.91	0.87-0.99	0.17	18.24
2	33	0.93	0.93	0.89-0.98	0.12	12.46
3	33	0.88	0.88	0.85-0.91	0.09	10.34
4	33	0.88	0.88	0.85-0.90	0.07	8.23
5	33	0.93	0.93	0.91-0.95	0.06	6.22
6	33	0.95	0.95	0.93-0.97	0.06	6.34
7	33	0.96	0.96	0.94-0.98	0.06	6.04
8	33	0.98	0.98	0.96-1.00	0.06	5.82
9	33	1.01	1.01	0.99-1.04	0.08	7.53
10	31	1.01	1.01	0.98-1.04	0.08	7.99
11	30	1.10	1.11	1.04-1.16	0.17	15.02
12	29	1.01	1.01	1.00-1.02	0.03	2.92

Table 2. NEA cod. Mean ratios between the combined and Norwegian data on maturity at age with some statistical characteristics for years 1989-2016, 2018

Age, years	Number of years with data	Mean Ratio this year (2019)	Ratio 2017	95% confidence limits	St deviation	Coefficient of variation, %
3	14	0.88	0.88	0.11-1.65	1.33	151.71
4	25	0.94	0.90	0.71-1.17	0.56	59.09
5	29	0.82	0.82	0.74-0.91	0.21	25.74
6	29	0.83	0.82	0.79-0.88	0.12	14.40
7	29	0.91	0.90	0.87-0.94	0.09	9.42
8	29	0.96	0.96	0.94-0.99	0.07	7.26
9	29	0.98	0.98	0.97-0.99	0.03	2.87
10	29	0.99	0.99	0.99-1.00	0.01	0.96
11	29	1.00	1.00	0.99-1.00	0.01	1.17
12	29	1.00	1.00	1.00-1.00	0.00	0.39

Table 3. NEA cod. The combined data on weight at age in stock and maturity at age in 2019

Age, years	1	2	3	4	5	6	7	8	9	10	11	12
W,g	10	43	274	659	1188	1950	3101	4381	5928	7361	9632	11226
Maturity, portion			0.000	0.003	0.033	0.199	0.624	0.894	0.947	0.988	0.997	1.000

ICES Arctic Fisheries Working Group 2019

Working Document 16

Use of RStoX for estimating numbers@age of *Sebastes mentella* from the Barents Sea Ecosystem survey

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1. Introduction

1.1. Barents Sea Ecosystem Survey: Eco-NoRu-Q3 (BTr)

The joint autumn ecosystem survey of the Barents Sea started in 2003 by combining five previous surveys into a single investigation. These five surveys comprised the joint Russian–Norwegian surveys for 0-group fish and capelin together with the Norwegian surveys for shrimp, Greenland halibut and redfish. Combining these surveys enabled the whole ice-free Barents Sea to be covered by oceanographic, acoustic, pelagic and demersal trawl investigations. Investigations on plankton, seabirds, marine mammals, marine pollution and benthos have also been carried out, but with various degrees of coverage. The survey is carried out in August and September each year, with the aim of covering the whole area before the cod and haddock 0-group starts to settle on the bottom. The survey data are also used as direct input to the capelin assessment, which is carried out in the first week of October. The survey is carried out during the period of minimum ice coverage, leading to a survey area on the order of 1.5 million square kilometres. The survey coverage and demersal trawl sampling for 2018 are illustrated in Figure 1. Data from the earlier Norwegian Svalbard (Division 2.b) bottom trawl survey (August-September) are available annually since 1986 (incl.) at fishing depths of 100–500 m, disaggregated by age only since 1992. The redfish and Greenland halibut survey covers the Norwegian Economic Zone (NEZ) and Svalbard including north and east of Spitsbergen during August down to 800 m depth.

The combined survey data provide swept area abundance estimates for *S. mentella* and *S. norvegicus* in the Barents Sea during summer. In addition, the 0-group component of the dataset is used to estimate the abundance of 0-group redfish for the two species combined.

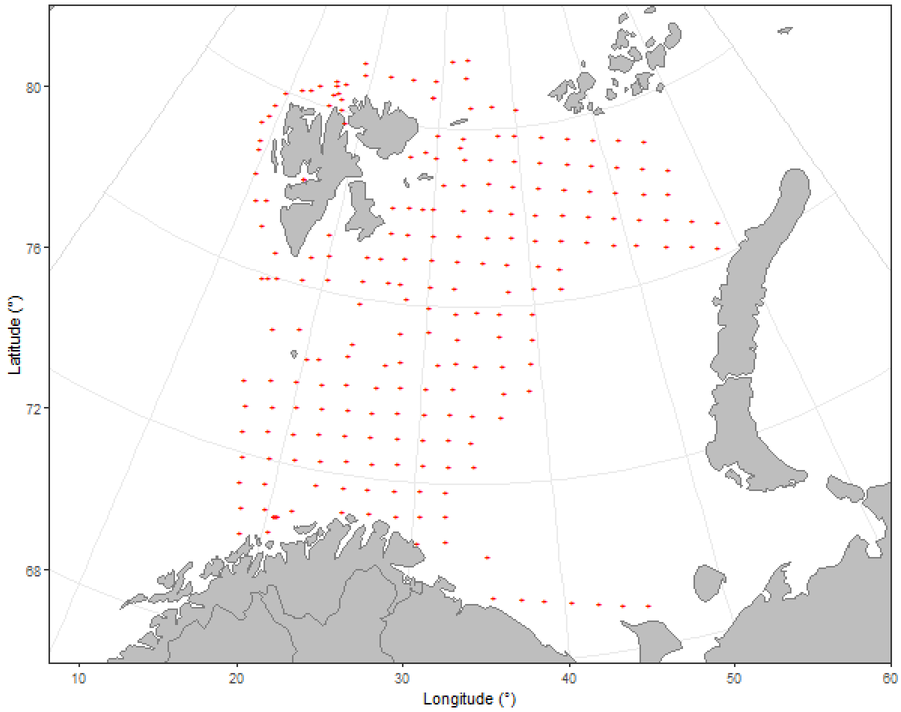

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Figure 1. Trawl stations at the Ecosystem survey, August-October 2018. Missing coverage in the south-eastern part was low due to delays in the Russian part of the survey.

1.2. Rational for this working document

Until 2018, numbers-at-length and age were derived from historical runs of the 'SAS-survey-program' (referred as 'SAS' from here on). However, this program is outdated and produced results that were not reproducible (Planque et al. 2018). Therefore, it is desirable to phase out SAS in favour of StoX. The StoX software is developed to produce reproducible results and offers an R-port version (RStoX) making it easier to run several years using similar parameters and offers integration with other elements of the software suite, such as ECA and SCAA.

The implementation of StoX for numbers-at-age should make the data preparation from the Barents Sea Ecosystem Survey survey more transparent and reproducible in the future. A downside of StoX is that, at the moment, it can only use strata systems defined by geographical coordinates alone, whilst SAS could use geographical **and** bathymetric coordinates. The strata systems used by SAS, Arctic (Arc15), Svalbard (Sva31) and Barents (Bar32), corresponding to different regions of the Barents Sea (Fig. 2), where not only defined by geography but also by depth intervals. Arc15 used intervals 100-300 m, 300-500 m and >500 m. The other two systems used 100 m intervals for the depth range of 0-500 m.

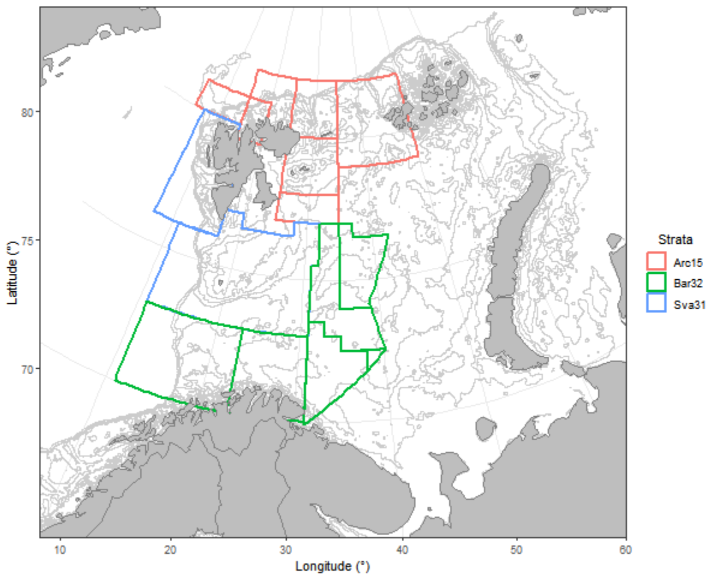

Figure 2. The SAS strata systems 15, 31 and 32 used for the Barents Sea ecosystem survey in summer. The strata are defined as a combination of geographical polygons (coloured lines) and depth ranges (grey lines).

Here we present two possible approaches to recalculate the numbers-at-length and age in RStoX. Firstly, using a strata system created for the 2017 survey, called Barents_Sea_Ecosystem_Survey_Areas_v2017 ('BESA17', *pers. comm.* Johansen). Secondly, we continue using the SAS strata as defined by geography but recalculate the numbers-at-length and age using the areas (n.mi.$^{-2}$) for 100 m depth intervals within these strata. This had to be done outside the RStoX system, because StoX only accepts strata in the form of wkt-formatted polygons.

1.3. Survey indices used in SCA

Data from the Ecosystem Survey as used in the Statistical Catch at Age mode (SCA) consists of numbers-at-age for *S. mentella* from 1996-to present and for ages between 2 and 15.

Numbers-at-length and age for the period before the introduction of the Ecosystem survey were not recalculated. Abundance indices for fish older than 15 years were calculated but not used in the assessment model, because older fish tend to migrate out of the Barents Sea and thus abundance estimates for them are not considered reliable.

Age reading of redfish otoliths has been inadequate due to lack of personnel, but the situation will be improved by the 2020 assessment. No otoliths were collected in 2010 and, consequently, age estimates are not provided for this year. The re-estimations done for this document cover the time from the beginning of the survey proper, 2003-2015.

2. RStoX configuration, input, settings and filters

Estimates of proportions-at-age are performed with RStoX, the R version of StoX (2015). This is done to allow a better integration of all the assessment steps, and to ease the work with several years of data. The code was run in R version 3.5.2 and RStoX version 1.11.

2.1. Parameters

RStoX uses horizontal strata-systems with separate regions treated as separate sampling strata. The BESA17 strata system (Fig. 3) was created to fulfil the requirements of the TIBIA project and is therefore based on both hydrographic and ecological criteria. The strata system was not developed for the calculation of trawl indices and a new system ('Basic') has recently been developed. The chosen parameters are presented in Table 1.

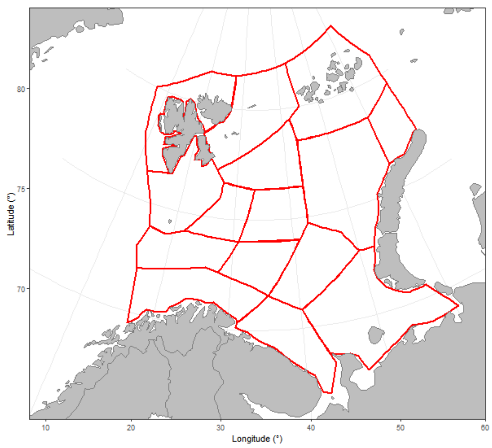

Figure 3. The strata system defined for the survey in 2017. Although it is only defined geographically, it does take some limited account of bathygraphy by being cut off at the shelf edge and having separate areas for features such as the Bear Island trench.

2.2. The RStoX process

After downloading the project-data and defining the parameters, RStoX produces numbers-at-length and age with just a few lines of R-code (Figure 4). Whilst this makes it easy to use, it also reduces transparency. However, results of all the calculation steps are stored in the R-object, a list that we usually name ‘X’. Regardless of the name, the content of the list is always the same and the output of the calculation steps are stored under the list-object ‘outputData’. With the output available every step of the calculation of numbers-at-age can be retraced with any spreadsheet software. Since numbers-at-age are derived by bootstrapping and imputation, retracing with a spreadsheet is not easily possible beyond the initial calculation of numbers-at-age. The calculated numbers-at-length are proportionally redistributed over the stations corresponding to the stratum and size class. These abundances are then bootstrapped and the age and other missing data imputed for each of the 50 bootstrap runs. The numbers-at-age are then the mean of these abundances over the number of bootstraps a given age has been imputed for.

2.3. Alternative estimation

The alternative calculation process begins with the creation of the depth strata, 100 m intervals between zero and 500 m across all strata, and the determination of the number of stations in each of them. The result is then stored in an R-object. After running the standard RStoX process with the Arc15, Sva31 and Bar32 strata systems, we extract the weighted count after it has been standardized to the abundance of desired length group per nautical mile (n.mi.) from the data frame ‘RegroupLengthDist’. The standardization is done at this point because it is the last step in RStoX in which the serial numbers are attached, rather than a running number for the Primary Sampling Units (PSU = 1 Haul). The stored number of stations per stratum, the depth category and the stratum name and area are attached to the extracted table.

Table 1: Parameters for estimation of the Barents Sea ecosystem cruise indices. All calculation methods had the same settings except for the strata-systems.

Process	Parameter	Value
Retrieving data	RStoX configuration	*SweptAreaTemplate*
Baseline	Gear code	*<3500*
	Gear condition	*<3*[1]
	Trawl quality	*1*[2]
	Fish station type	*NOT 2 or C*
	Taxa	*166756 (Snabeluer) & 166705 (Uerslekten)*
	Strata system	*BESA17; Arc15 & Sva31 & Bar32, Basic, Basic + 500-750 m layer and depth-based polygons*
	Swept area function	*SweptAreaDensity*
	Fishing width	*Constant 25 m*
	Area calculation	*Accurate*
	Length Intervals	*5 cm*
Bootstrapping	n	*50*
	Seed	*1234*
	bioticMethod	*PSU~Stratum*
	bootstrapMethod	*SweptAreaLength*
	Length Intervals	*5 cm*

[1] Gear functioning properly

[2] Trawl at predetermined location

Using the weighted count *(f)* per station *(s)* and length group *(l)* the numbers per length group and n.mi.^{2} ($P_{s,l}$) are calculated with a fixed trawl width (25 m):

$$P_{s,l} = \frac{f_{s,l} \times 25}{1852}$$

These numbers for each PSU are then averaged over all stations with stratum and raised to the abundance for the stratum by:

$$L_{p,l} = A_p \times \sum \bar{P}_{s,l} \times \frac{S_{p,l}}{S_p}$$

Where $L_{p,l}$ is the index for stratum p and length group l, A_p is the area of the stratum, $\bar{P}_{s,l}$ the mean number per length of group and n.mi.^{2} for stratum. $S_{p,l}$ the number of stations for stratum and length group and S_p the number of stations for the stratum. The resulting index represents estimated number of fish at length/over the entire stratum p.

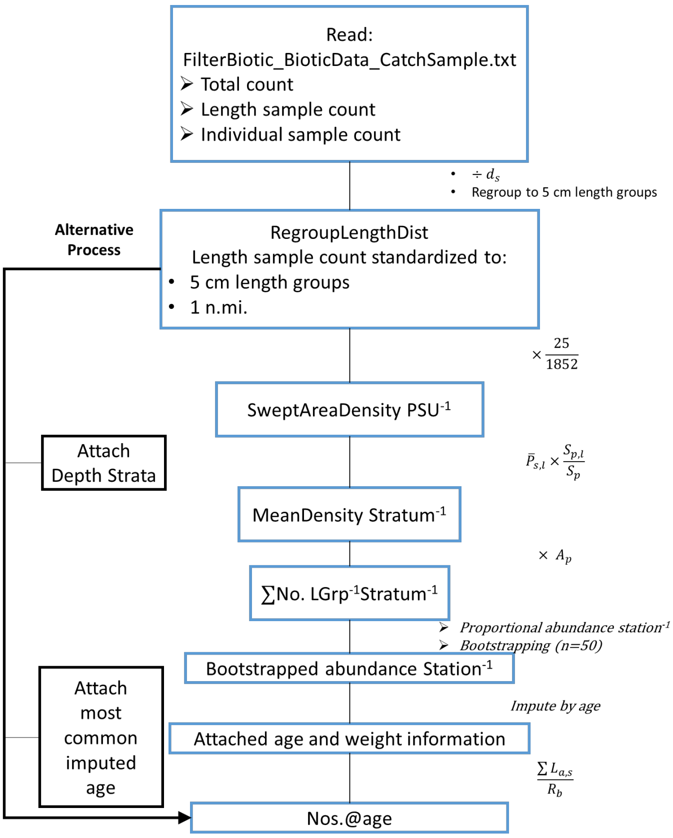

Figure 4. Flow chart of the RStoX and alternative calculation processes.

To estimate numbers-at-age, the age most commonly imputed to a length group at a certain station was extracted and attached to the table containing the numbers-at-length for each station. These numbers are then summed up to arrive at the numbers-at-age. This method provides the advantage that numbers-at-length and at age are the same, but at the cost of losing the uncertainty estimates.

3. Other strata systems considered

3.1. Depth-based strata

A further development of the alternative calculation is the creation of a new strata system, that is completely based on depth, due to the observation that the density distribution of *S. mentella* catches as related to depth is similar across the Barents Sea, here divided into four quadrants (Fig. 5), and across years (Fig. 6).

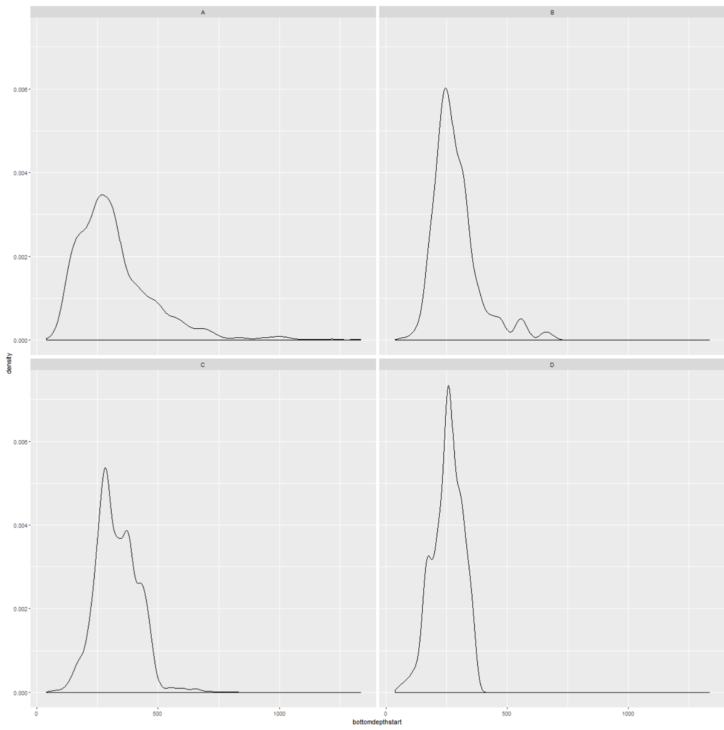

Figure 5. Density distribution of *S. mentella* catches plotted on the depth range across the Barents Sea, subdivided at 35° longitude and the 76th parallel.

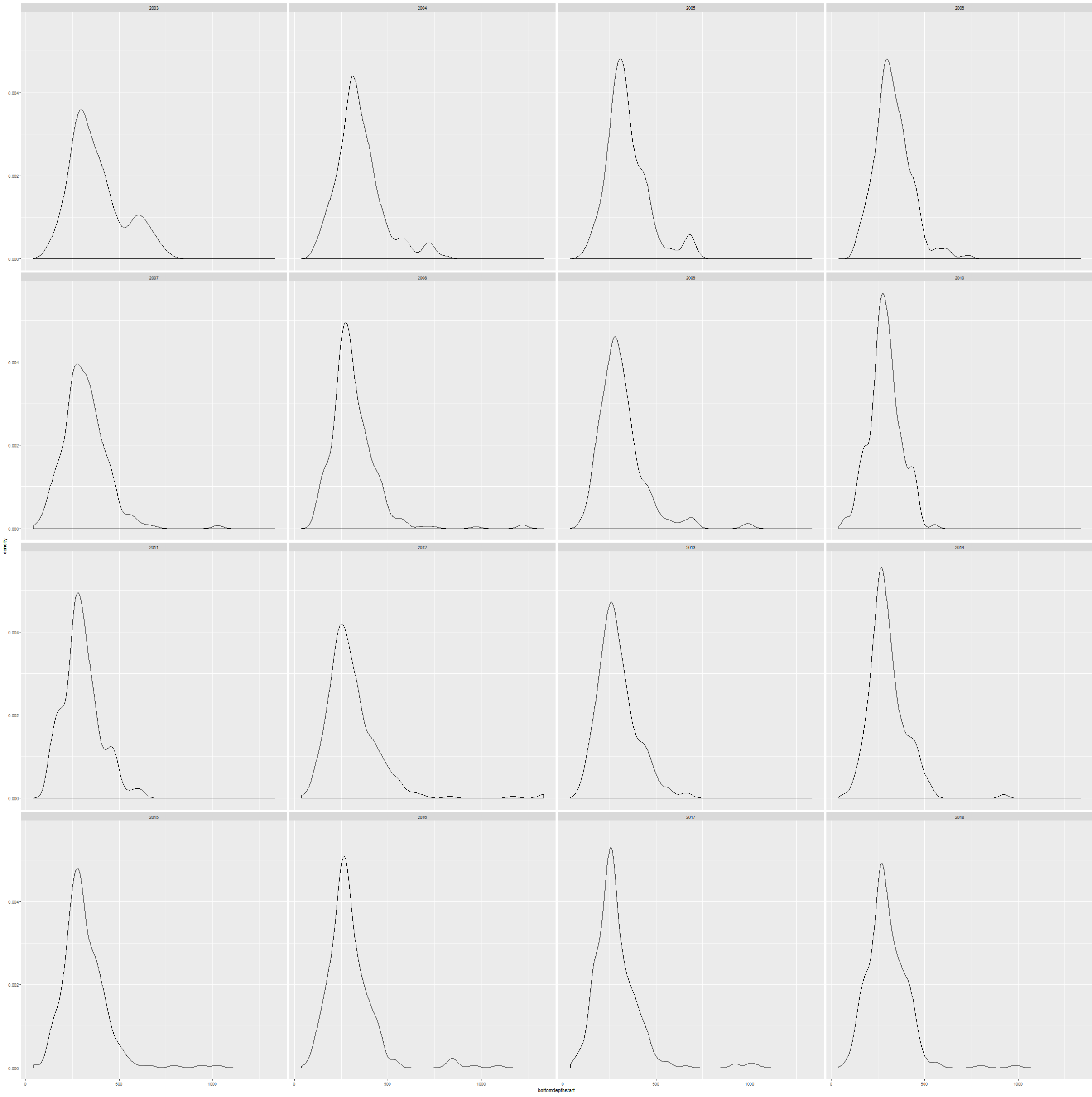

Figure 6. Density distribution of *S. mentella* catches plotted on the depth range across the Barents Sea for each year 2003 to 2018. The distribution is fairly homogenous.

The suggested strata system (Fig. 7), appears more ‘organic’ than the others, but combines very large with very small areas, giving an overweight to some.

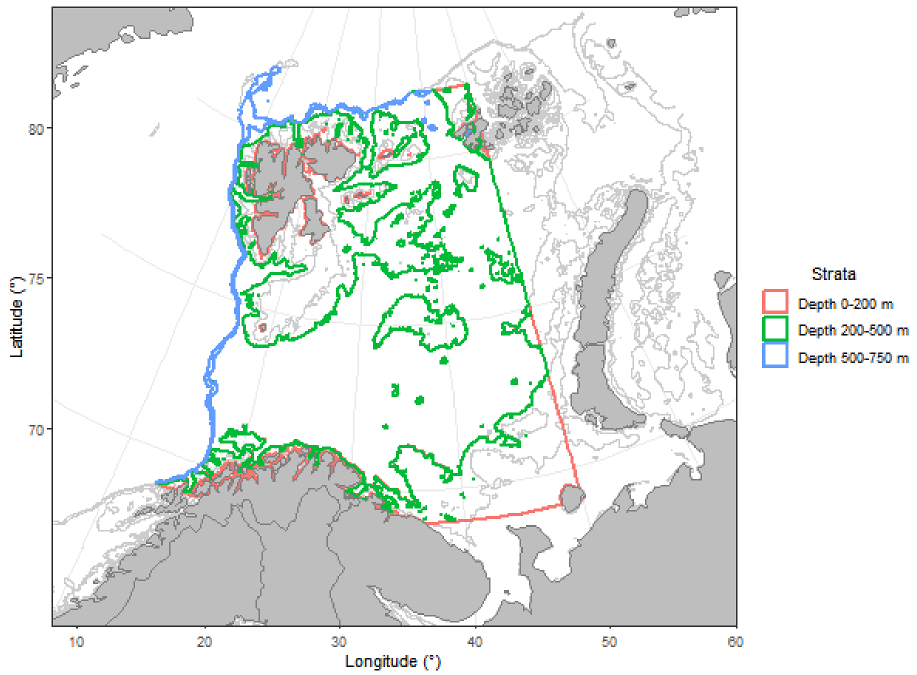

Figure 7. Suggested strata system based on depth as the sole criterion.

3.2. Basic ecosystem survey strata

Very recently, the basic strata system for the Ecosystem survey (WKT_Basic_ECO; *pers. comm.* Johansen) has been developed (Fig. 8). However, it is more targeted at correctly reflecting the distribution of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). It is similar to, but simpler than the 2017 strata-system, with 9 rather than 15 polygons and it cuts off at 500 m depth. Since this depth-limit does not fully cover the distribution of beaked redfish we attached the 500-750 m stratum from the depth-based system to it (Fig. 9).

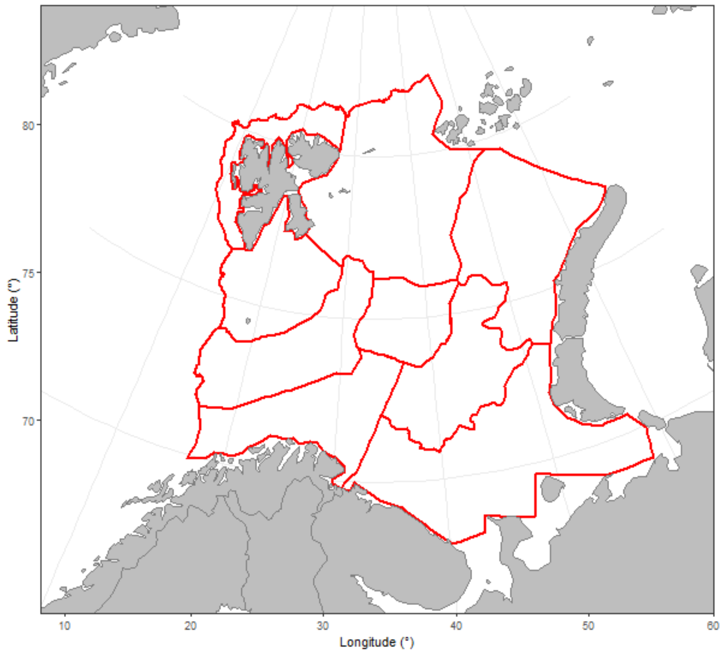

Figure 8. Basic strata system for the Barents Sea ecosystem survey, for the depth range 0-500 m.

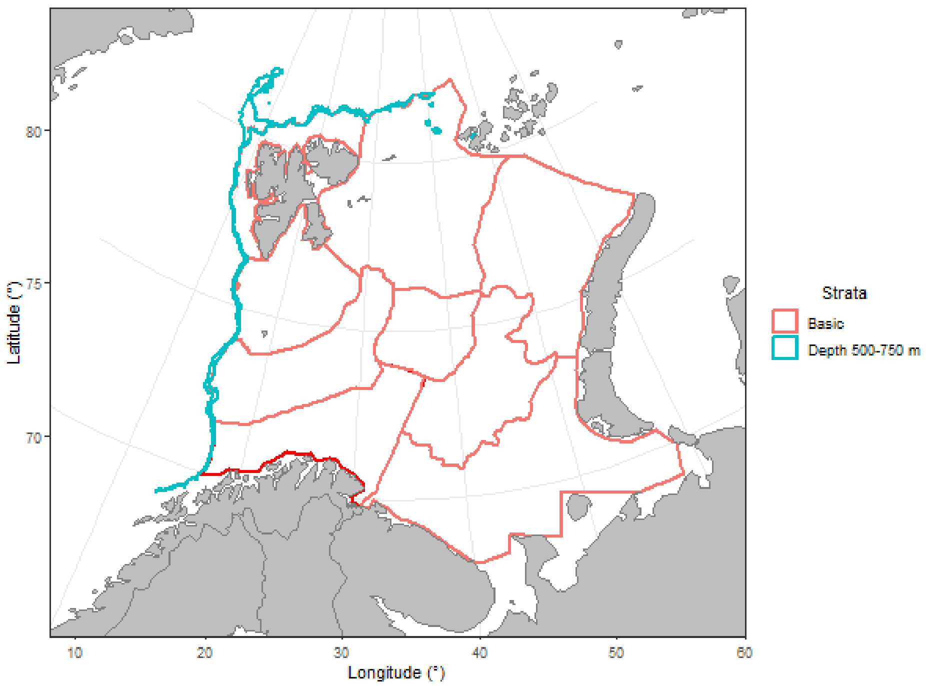

Figure 9. Basic strata system extended by the 500-750 m stratum to cover all *S. mentella* areas.

4. Results

Survey indices estimated with RStoX and the alternative approach are visually compared with the numbers-at-length, in 5 cm bins (0-45+ cm) and numbers-at-age given in the AFWG report 2018 (ages 2-16+, ICES 2018) in Figures 10 and 11. Numbers-at-age across the 2-16+ age range are likewise presented in the appendix (Table 1a). Comparing the new estimates to those from the SAS-system shows that the estimates using other strata systems tend to compare well to the SAS-estimates across most of the age range, but deviate for the ages 2 and 3 and in the alternative approach also for the ages 16+ (Fig. 10 & Fig. 11).

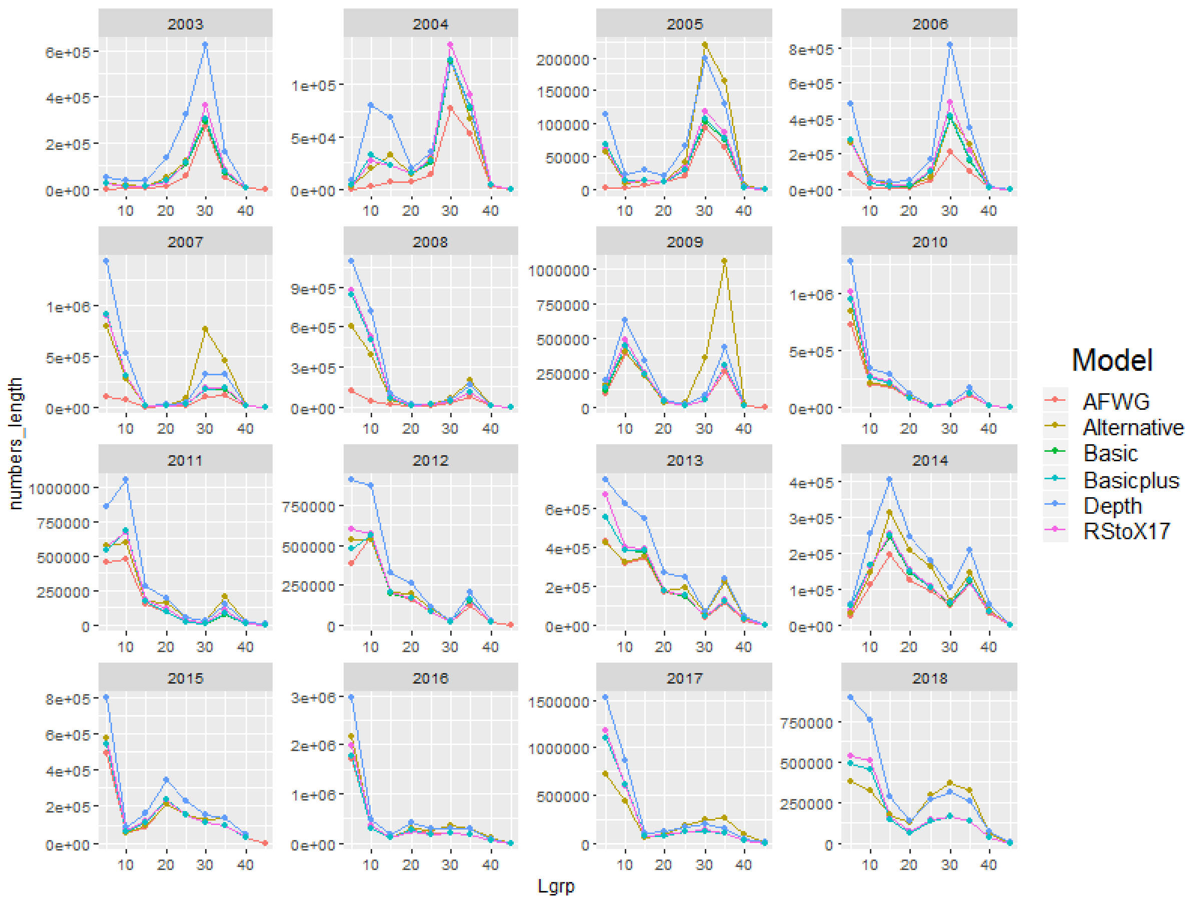

Figure 10. Comparison of estimates for numbers-at-length using different strata systems as well as the alternative estimation approach with the numbers presented in the 2018 AFWG-report. Whilst the RStoX estimates usually deviate from the earlier number at the low ages, the alternative approach tends to deviate more in the latter ages.
Abbr.: AFWG=Estimates from the SAS survey-system; Alternative = Estimates using depth strata without geographical coordinates; Basic = Strata system developed in 2019; Basic+ = Combination of the 'Basic' strata system with strata defined by depth, using polygons; and RStoX17 = Strata system developed for the Survey.

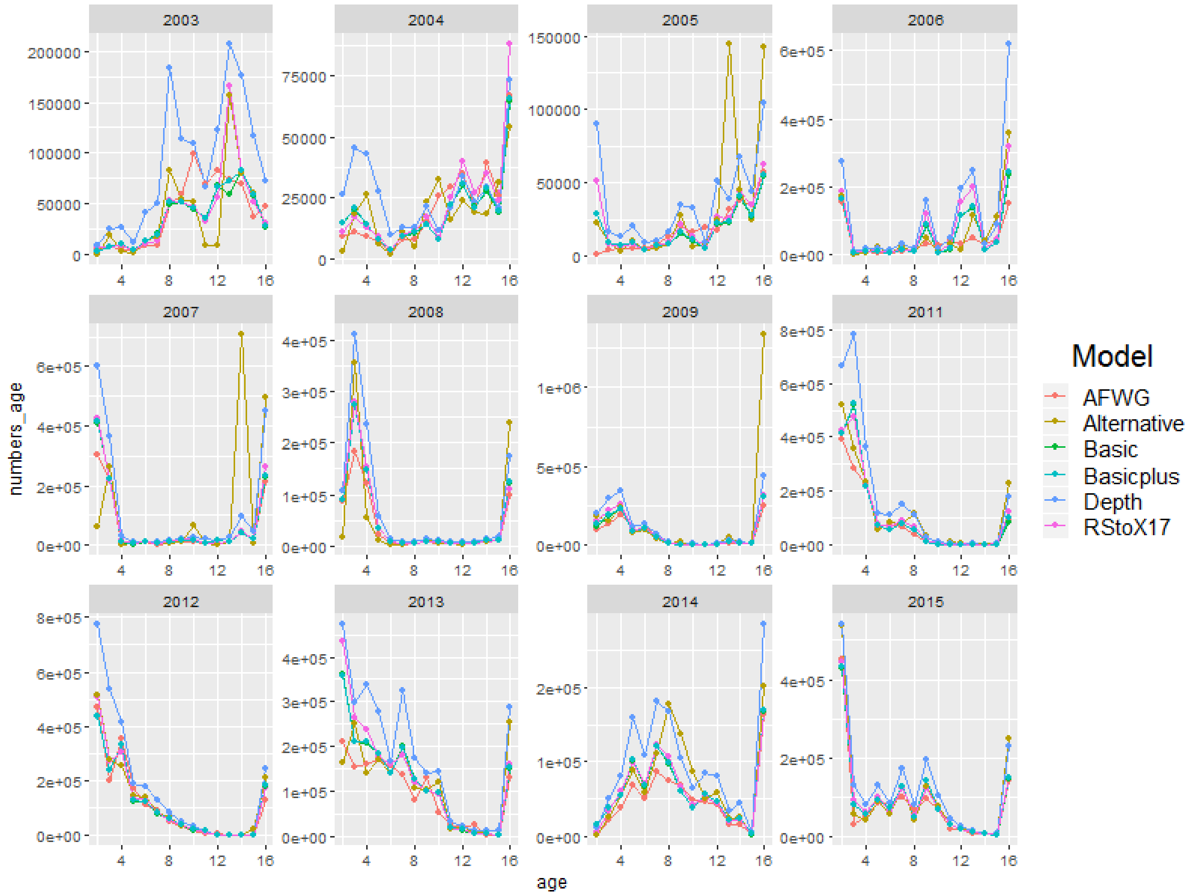

Figure 11. Comparison of estimates for numbers-at-age using different strata systems as well as the alternative estimation approach with the numbers presented in the 2018 AFWG-report. Whilst the RStoX estimates are more similar to the AFWG-numbers than for numbers-at-length, the alternative approach is still deviating much more.
Abbr.: AFWG=Estimates from the SAS survey-system; Alternative = Estimates using depth strata without geographical coordinates; Basic = Strata system developed in 2019; Basic+ = Combination of the 'Basic' strata system with strata defined by depth, using polygons and RStoX17 = Strata system developed for the Survey.

The strata system based on depth delivers higher numbers than any other method, even above the 95th-percentile of the 2017 strata system (Figs. 10 & 11). It also deviates from the pre-existing estimates at the youngest and oldest ages, similar to the 2017-strata and the alternative calculations, respectively. Both may be an effect of the 200-500 m stratum covering a large area of the Barents Sea. As this is also the depth stratum where the majority of redfish resides it provides a high integrated abundance estimate. Other strata systems use smaller regions, not affording any one region such a large influence. Therefore, reintroducing arbitrary boundaries into this strata system may be further investigated.

The basic strata system and the variant using the basic strata system extended by the 500 – 750 m provide nearly identical results (Fig. 12).

Figure 12. Estimates for numbers-at-age using the basic strata system and its variant extended by the 500 – 750 m depth interval. The results are nearly identical.

Comparing only the estimates produced by RStoX with confidence levels, represented by the 5th and 95th percentiles, shows that the AFWG-numbers are often within this interval, but also that the pattern in the numbers is more often reflected in the estimates for latter years, as well as being more in agreement for the different approaches (Fig. 13).

Pending further development of the depth-based strata system and considering that results hardly differ between the basic and the extended basic system we consider the basic and the

2017-strata systems as the best possible candidates to use for re-estimating the Barents Sea ecosystem survey indices (Fig. 14).

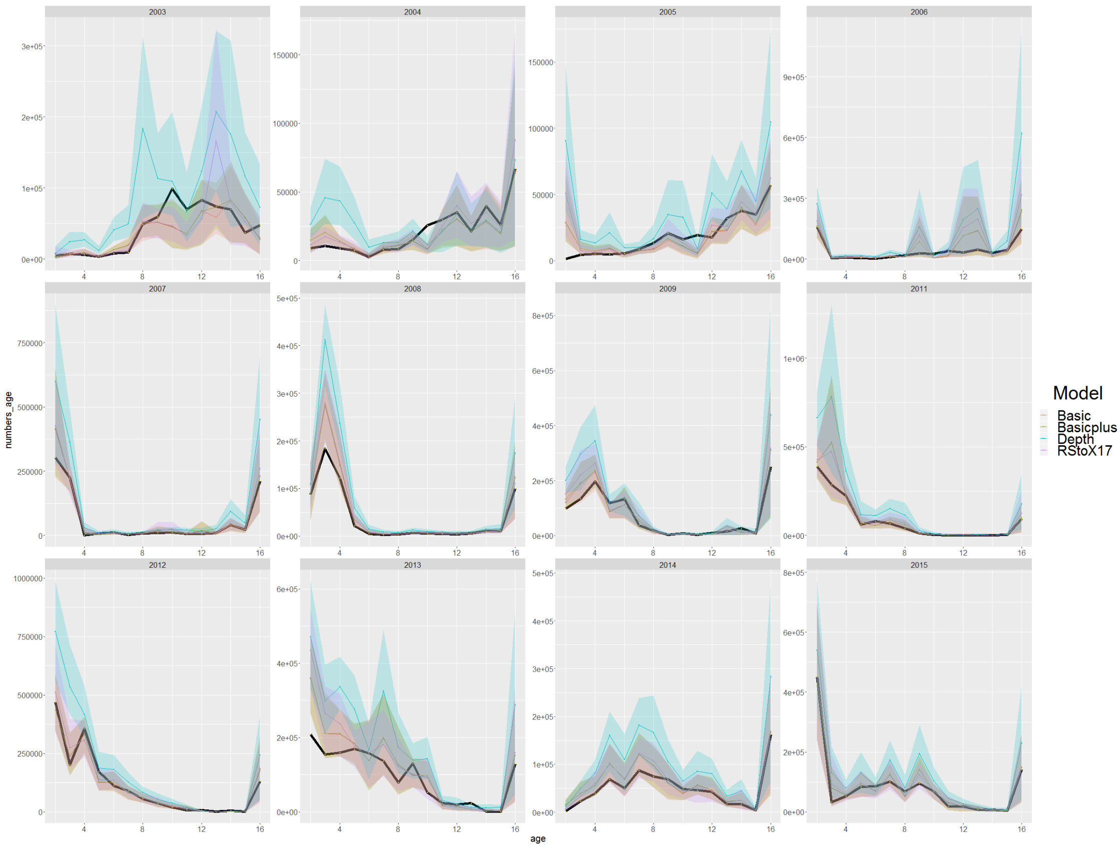

Figure 13. Comparison of numbers-at-age for different strata systems. The shaded areas are bounded by the 5th and 95th percentile. The black line shows the numbers-at-age as reported in earlier years.

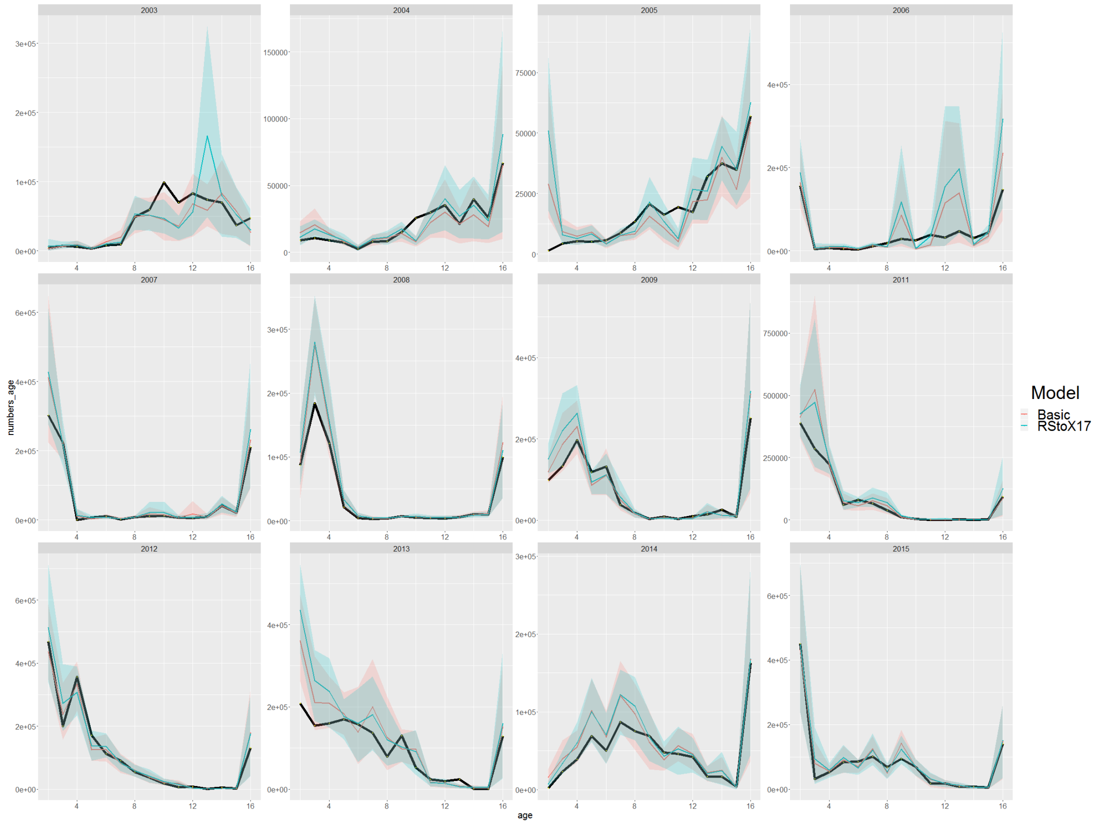

Figure 14. Comparison of numbers-at-age for strata systems ‘basic’ and for the 2017 strata system with the AFWG numbers-at-age as reference (black line). The shaded areas are bounded by the 5th and 95th percentile.

5. References

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Planque B., Nedreaas K., Vollen T., Filin A., Hallfredsson E., Berg E., Eriksen E. (2018). Description of scientific surveys used for the assessment of beaked and golden redfishes in ICES subareas 27.1 and 27.2. Working Document2, ICES WKREDFISH Copenhagen 29 January-2 February 2018. 12 pp.

StoX (2015) StoX: An open source approach to acoustic and swept area survey calculations. Institute of Marine Research, Bergen, Norway. URL: https://www.imr.no/forskning/prosjekter/stox/nb-no

6. Appendix 1: Summary table

Table 1a. Estimates of numbers-at-age (N) with RStoX for the different estimation approaches and strata systems as well as their standard deviation and %-difference to the numbers reported to ICES in earlier years. Highest and lowest differences for each approach are marked in red.

Abbr.: AFWG=Estimates from the SAS survey-system; Alternative = Estimates using depth strata without geographical coordinates; Basic = Strata system developed in 2019; Basic+ = Combination of the 'Basic' strata system with strata defined by depth, using polygons and RStoX17 = Strata system developed for the

Survey.

Year	Age	AFWG	Alternative		Basic			Basic+			Depth			RStoX17		
		N	N	%diff.	N	sd	%diff.	N	sd	%diff.	N	sd	%diff.	N	sd	%diff.
	2	3 954	111	-97.2	3 244	2.77	-17.9	2 892	2.64	-26.9	8 131	6.86	105.6	6 610	6.29	67.2
	3	7 394	18 841	154.8	6 851	1.71	-7.3	7 118	1.79	-3.7	24 314	8.52	228.8	7 760	3.12	5.0
	4	6 142	2 523	-58.9	9 481	2.92	54.4	9 599	2.85	56.3	26 956	6.13	338.9	8 984	3.12	46.3
	5	3 540	1 745	-50.7	3 705	1.28	4.7	3 727	1.21	5.3	12 123	3.59	242.5	3 572	1.29	0.9
	6	8 030	12 549	56.3	13 493	2.74	68.0	13 580	2.75	69.1	41 149	10.47	412.4	9 726	2.10	21.1
	7	9 388	17 018	81.3	19 918	6.13	112.2	19 505	5.64	107.8	49 758	14.52	430.0	12 655	3.75	34.8
	8	48 564	82 621	70.1	49 459	16.60	1.8	51 163	15.71	5.4	183 559	90.69	278.0	53 324	15.98	9.8
2003	9	59 051	54 491	-7.7	51 720	14.44	-12.4	52 321	14.04	-11.4	113 573	34.75	92.3	51 215	13.35	-13.3
	10	98 554	52 009	-47.2	44 890	20.48	-54.5	45 668	19.88	-53.7	109 421	43.40	11.0	47 071	16.59	-52.2
	11	69 901	9 331	-86.7	35 345	18.96	-49.4	35 332	17.57	-49.5	66 224	32.44	-5.3	32 927	12.73	-52.9
	12	83 192	8 822	-89.4	68 184	30.21	-18.0	67 057	29.36	-19.4	122 930	49.65	47.8	56 233	25.48	-32.4
	13	73 521	156 795	113.3	58 732	20.51	-20.1	73 058	25.13	-0.6	207 548	73.78	182.3	165 640	90.27	125.3
	14	69 970	80 333	14.8	82 700	36.25	18.2	83 220	36.58	18.9	175 705	84.25	151.1	79 856	38.73	14.1
	15	37 162	60 451	62.7	57 465	23.01	54.6	58 477	23.14	57.4	116 898	41.62	214.6	52 092	21.89	40.2
	16+	47 323	26 796	-43.4	26 964	1.50	-43.0	28 239	1.55	-40.3	72 550	3.38	53.3	30 269	1.55	-36.0
	2	9 068	3 139	-65.4	14 745	7.54	62.6	14 736	7.92	62.5	26 378	9.24	190.9	11 313	4.59	24.8
	3	10 837	18 602	71.6	20 518	6.00	89.3	20 721	6.30	91.2	45 669	15.44	321.4	17 375	3.85	60.3
2004	4	9 008	26 550	194.7	14 157	2.86	57.2	13 933	2.82	54.7	43 325	15.13	381.0	13 075	3.06	45.1
	5	7 292	5 786	-20.6	8 019	1.94	10.0	8 218	2.07	12.7	27 352	8.54	275.1	8 946	2.62	22.7
	6	2 510	1 887	-24.8	3 705	1.22	47.6	3 837	1.20	52.9	9 737	4.36	287.9	3 380	1.50	34.7
	7	7 896	10 974	39.0	9 156	2.54	16.0	9 227	2.57	16.9	13 142	3.30	66.4	9 992	1.86	26.5

	8	8 193	4 739	-42.2	10 618	2.74	29.6	10 881	2.79	32.8	12 907	4.38	57.5	11 445	3.19	39.7
	9	15 268	23 206	52.0	14 177	4.03	-7.1	14 365	4.09	-5.9	21 307	6.13	39.6	17 378	3.79	13.8
	10	25 544	32 858	28.6	7 893	2.53	-69.1	8 202	2.56	-67.9	11 399	3.52	-55.4	8 552	2.20	-66.5
	11	29 654	16 160	-45.5	22 137	8.36	-25.4	22 366	8.53	-24.6	20 798	9.81	-29.9	25 295	8.16	-14.7
	12	35 249	23 672	-32.8	30 069	15.25	-14.7	30 502	15.44	-13.5	33 875	16.69	-3.9	39 854	15.03	13.1
	13	21 142	19 205	-9.2	21 310	9.46	0.8	21 166	9.47	0.1	23 114	9.79	9.3	27 151	11.53	28.4
	14	39 581	18 664	-52.8	27 950	15.43	-29.4	28 643	15.27	-27.6	29 477	13.86	-25.5	35 324	14.61	-10.8
	15	25 976	31 630	21.8	19 149	9.24	-26.3	19 536	9.29	-24.8	20 657	9.82	-20.5	23 653	11.08	-8.9
	16+	66 792	54 124	-19.0	64 830	4.07	-2.9	65 523	4.09	-1.9	73 362	4.00	9.8	88 144	4.11	32.0
	2	1 310	23 015	1656.9	28 766	18.92	2095.9	28 474	18.39	2073.6	90 589	40.01	6815.2	50 811	19.75	3778.7
	3	4 406	9 044	105.3	9 209	3.17	109.0	9 296	3.14	111.0	16 228	4.42	268.3	7 868	2.49	78.6
	4	5 241	2 826	-46.1	7 314	2.35	39.5	7 231	2.32	38.0	13 194	3.80	151.8	6 380	1.86	21.7
	5	5 031	9 884	96.5	9 134	2.26	81.6	9 313	2.25	85.1	21 063	8.64	318.7	8 289	2.19	64.8
	6	5 722	4 614	-19.4	4 280	1.20	-25.2	4 235	1.18	-26.0	9 721	2.10	69.9	4 197	1.11	-26.7
	7	8 740	5 723	-34.5	7 536	1.59	-13.8	7 505	1.59	-14.1	10 345	2.55	18.4	7 727	1.90	-11.6
	8	13 452	7 856	-41.6	8 382	1.76	-37.7	8 657	1.78	-35.6	16 494	5.28	22.6	9 475	1.93	-29.6
2005	9	20 672	27 724	34.1	15 642	3.54	-24.3	16 806	3.45	-18.7	34 976	13.10	69.2	21 408	6.42	3.6
	10	16 207	6 518	-59.8	10 758	3.52	-33.6	11 293	3.39	-30.3	32 746	14.63	102.0	13 403	5.13	-17.3
	11	19 353	7 854	-59.4	5 195	2.32	-73.2	5 628	2.48	-70.9	9 272	4.14	-52.1	6 464	2.46	-66.6
	12	17 430	25 138	44.2	21 759	6.43	24.8	22 286	6.34	27.9	50 958	16.29	192.4	26 792	7.66	53.7
	13	32 028	144 675	351.7	22 440	5.57	-29.9	23 342	5.62	-27.1	39 247	11.59	22.5	25 971	7.43	-18.9
	14	37 564	45 328	20.7	39 928	10.04	6.3	40 581	10.01	8.0	67 667	19.02	80.1	44 512	9.63	18.5
	15	34 815	24 539	-29.5	26 707	6.45	-23.3	28 081	6.52	-19.3	44 628	12.30	28.2	35 025	9.52	0.6
	16+	57 103	142 616	149.8	54 376	1.06	-4.8	55 804	1.05	-2.3	104 616	2.02	83.2	62 415	0.97	9.3
	2	156 578	172 516	10.2	163 150	43.47	4.2	163 148	44.13	4.2	273 039	63.97	74.4	187 575	44.46	19.8
	3	5 162	509	-90.1	5 391	4.80	4.4	5 406	4.82	4.7	10 169	7.58	97.0	6 870	7.20	33.1
	4	6 695	4 540	-32.2	8 599	3.54	28.4	8 931	3.72	33.4	17 669	5.49	163.9	10 562	4.88	57.8
	5	5 217	19 952	282.4	7 914	2.23	51.7	8 725	2.23	67.2	16 441	3.86	215.1	11 034	3.26	111.5
2006	6	3 768	2 410	-36.0	4 527	1.14	20.1	5 041	1.19	33.8	11 021	2.84	192.5	5 935	1.67	57.5
	7	10 754	20 320	89.0	14 302	2.76	33.0	14 644	2.87	36.2	32 379	9.06	201.1	16 011	2.94	48.9
	8	18 771	7 867	-58.1	8 666	1.70	-53.8	8 868	1.67	-52.8	19 260	5.65	2.6	10 115	2.16	-46.1
	9	29 174	50 133	71.8	85 931	67.09	194.5	86 469	67.02	196.4	157 146	112.55	438.7	117 565	78.03	303.0
	10	25 278	9 469	-62.5	4 823	1.34	-80.9	4 923	1.22	-80.5	16 714	5.77	-33.9	5 817	1.71	-77.0

	11	38 958	31 575	-19.0	14 852	4.90	-61.9	19 452	6.79	-50.1	48 524	19.31	24.6	35 265	15.78	-9.5
	12	31 869	14 739	-53.7	115 398	97.23	262.1	115 308	96.94	261.8	194 748	149.64	511.1	154 290	107.22	384.1
	13	46 885	113 023	141.1	138 991	100.75	196.5	141 661	100.51	202.1	248 650	147.78	430.3	196 735	110.57	319.6
	14	30 895	39 339	27.3	13 001	3.18	-57.9	13 188	3.22	-57.3	31 350	9.99	1.5	16 003	4.07	-48.2
	15	44 299	109 710	147.7	35 255	9.06	-20.4	35 326	9.49	-20.3	88 819	30.05	100.5	44 641	11.24	0.8
	16+	147 951	357 280	141.5	234 311	5.27	58.4	242 457	5.02	63.9	620 189	14.60	319.2	316 105	6.51	113.7
2007	2	302 988	62 562	-79.4	410 775	133.38	35.6	414 737	131.75	36.9	599 518	201.83	97.9	426 522	100.97	40.8
	3	224 153	264 912	18.2	221 643	35.46	-1.1	222 827	35.93	-0.6	363 036	76.81	62.0	219 153	45.83	-2.2
	4	290	1 726	495.1	11 080	13.10	3720.7	10 713	12.03	3594.3	29 913	18.29	10214.9	14 006	11.72	4729.7
	5	7 686	7 840	2.0	3 097	1.93	-59.7	3 493	2.09	-54.6	9 293	4.21	20.9	6 697	3.93	-12.9
	6	11 346	8 311	-26.8	8 543	5.06	-24.7	8 609	4.84	-24.1	13 345	5.52	17.6	8 322	3.77	-26.7
	7	2 031	3 367	65.8	4 182	2.02	105.9	4 246	1.87	109.0	8 788	3.25	332.7	3 821	1.00	88.1
	8	7 903	5 261	-33.4	8 487	3.13	7.4	8 732	3.49	10.5	13 476	2.63	70.5	8 893	2.73	12.5
	9	10 770	9 151	-15.0	18 014	12.77	67.3	18 297	12.60	69.9	21 058	4.43	95.5	21 876	16.35	103.1
	10	12 182	65 396	436.8	15 184	7.00	24.6	15 264	6.90	25.3	24 075	7.35	97.6	22 222	14.44	82.4
	11	6 578	3 959	-39.8	6 794	3.49	3.3	7 042	3.49	7.1	20 015	6.86	204.3	7 308	3.10	11.1
	12	6 367	1 571	-75.3	17 779	18.91	179.2	18 135	19.17	184.8	16 096	8.11	152.8	7 666	4.33	20.4
	13	9 998	10 233	2.4	8 902	4.68	-11.0	9 136	4.74	-8.6	26 465	9.61	164.7	10 451	5.92	4.5
	14	41 425	707 918	1608.9	41 466	15.13	0.1	42 152	15.07	1.8	94 321	27.68	127.7	46 266	15.91	11.7
	15	22 090	7 769	-64.8	20 548	8.66	-7.0	20 693	8.50	-6.3	48 072	16.27	117.6	22 962	8.62	3.9
	16+	211 178	497 693	135.7	230 425	5.48	9.1	231 638	5.54	9.7	452 455	8.83	114.3	261 226	6.53	23.7
2008	2	86 880	16 150	-81.4	91 150	37.27	4.9	90 012	37.90	3.6	108 677	29.64	25.1	107 385	38.21	23.6
	3	183 796	357 215	94.4	275 160	43.84	49.7	275 710	42.27	50.0	412 498	56.97	124.4	279 178	54.88	51.9
	4	121 430	55 580	-54.2	147 561	33.10	21.5	149 132	32.58	22.8	236 766	44.22	95.0	155 311	35.90	27.9
	5	21 430	11 846	-44.7	33 817	9.09	57.8	33 182	8.69	54.8	58 880	15.28	174.8	33 110	7.89	54.5
	6	4 178	3 101	-25.8	7 875	2.96	88.5	8 069	3.38	93.1	14 360	5.12	243.7	8 266	2.99	97.8
	7	3 009	1 493	-50.4	4 564	1.94	51.7	4 243	1.85	41.0	8 231	3.06	173.5	4 110	1.68	36.6
	8	3 334	7 050	111.5	3 661	0.74	9.8	3 659	0.72	9.7	7 638	1.79	129.1	4 007	1.01	20.2
	9	6 991	13 755	96.7	6 940	1.18	-0.7	7 004	1.20	0.2	12 529	2.86	79.2	6 756	1.14	-3.4
	10	5 120	3 833	-25.1	6 357	1.79	24.2	6 476	1.82	26.5	9 908	2.55	93.5	6 908	2.29	34.9
	11	4 441	3 400	-23.4	5 159	1.73	16.2	5 139	1.69	15.7	8 090	2.52	82.2	5 077	1.84	14.3
	12	3 581	2 114	-41.0	5 027	2.36	40.4	4 954	2.19	38.3	6 176	2.39	72.5	4 775	2.04	33.3
	13	6 008	7 028	17.0	5 818	1.69	-3.2	5 827	1.72	-3.0	8 781	2.38	46.2	5 743	1.47	-4.4

	14	10 352	6 926	-33.1	9 445	2.82	-8.8	9 464	2.83	-8.6	14 255	5.00	37.7	8 747	2.59	-15.5
	15	10 172	11 777	15.8	11 137	2.94	9.5	11 141	2.96	9.5	15 818	5.60	55.5	10 263	3.15	0.9
	16+	99 808	240 856	141.3	122 106	2.27	22.3	123 695	2.19	23.9	174 755	3.19	75.1	110 214	2.06	10.4
	2	98 726	181 471	83.8	120 219	21.66	21.8	131 988	23.52	33.7	199 742	35.15	102.3	151 099	24.31	53.0
	3	133 218	157 250	18.0	186 393	47.84	39.9	191 620	46.42	43.8	296 208	75.27	122.3	220 097	59.80	65.2
	4	196 908	236 971	20.3	230 549	40.34	17.1	235 083	40.39	19.4	344 680	72.24	75.0	262 529	46.54	33.3
	5	118 322	77 548	-34.5	86 297	15.20	-27.1	87 602	16.53	-26.0	118 294	23.18	0.0	93 487	19.69	-21.0
	6	131 668	98 519	-25.2	111 276	36.04	-15.5	110 955	36.03	-15.7	139 562	37.70	6.0	111 619	35.00	-15.2
	7	37 586	42 377	12.7	50 799	16.58	35.2	50 874	16.65	35.4	73 059	25.24	94.4	57 109	22.48	51.9
	8	18 194	16 473	-9.5	15 950	5.50	-12.3	16 105	5.53	-11.5	24 007	6.03	32.0	17 490	6.78	-3.9
2009	9	3 679	24 936	577.8	2 788	1.02	-24.2	2 843	1.08	-22.7	4 077	1.63	10.8	3 034	0.93	-17.5
	10	8 633	1 519	-82.4	6 172	3.17	-28.5	6 242	3.16	-27.7	7 442	3.32	-13.8	5 852	3.33	-32.2
	11	3 494	6 948	98.8	3 445	1.39	-1.4	3 444	1.41	-1.4	5 785	1.89	65.6	3 314	1.25	-5.1
	12	9 736	12 341	26.8	5 499	2.46	-43.5	5 522	2.47	-43.3	8 216	4.35	-15.6	4 757	2.87	-51.1
	13	14 091	48 466	243.9	21 063	14.95	49.5	21 142	14.98	50.0	32 781	23.60	132.6	20 951	16.10	48.7
	14	25 949	12 165	-53.1	11 789	6.07	-54.6	11 733	6.05	-54.8	17 244	9.19	-33.5	12 708	5.29	-51.0
	15	8 384	15 915	89.8	11 040	3.83	31.7	10 996	3.76	31.2	15 016	7.74	79.1	10 074	4.13	20.2
	16+	251 370	1 336 152	431.5	309 719	9.69	23.2	309 950	9.71	23.3	439 526	15.36	74.9	316 427	9.29	25.9
	2	389 536	517 591	32.9	413 501	65.87	6.2	411 508	65.50	5.6	663 175	100.26	70.2	426 676	67.28	9.5
	3	285 787	358 520	25.5	522 270	201.05	82.7	524 842	203.19	83.6	781 817	294.14	173.6	472 151	183.58	65.2
	4	222 753	236 739	6.3	220 379	40.56	-1.1	218 641	39.92	-1.8	361 685	90.31	62.4	237 047	40.96	6.4
	5	60 809	54 662	-10.1	70 815	20.70	16.5	71 353	21.06	17.3	118 449	39.88	94.8	77 078	25.16	26.8
	6	80 266	85 451	6.5	56 975	12.07	-29.0	57 774	11.80	-28.0	112 537	22.56	40.2	69 737	13.18	-13.1
	7	67 419	79 460	17.9	76 782	19.73	13.9	77 411	19.62	14.8	151 438	40.00	124.6	89 154	22.98	32.2
	8	39 695	115 413	190.7	57 923	22.47	45.9	58 082	22.47	46.3	114 657	40.45	188.8	69 267	25.60	74.5
2011	9	12 409	35 829	188.7	12 551	3.46	1.1	12 606	3.43	1.6	28 532	10.46	129.9	16 539	5.16	33.3
	10	4 144	3 089	-25.5	3 295	1.49	-20.5	3 287	1.47	-20.7	10 285	5.74	148.2	3 567	2.13	-13.9
	11	1 175	9 684	724.2	2 277	1.27	93.8	2 245	1.17	91.1	3 675	2.15	212.8	3 327	1.84	183.2
	12	1 174	4 719	302.0	857	0.85	-27.0	1 782	1.16	51.8	2 209	1.41	88.2	3 685	3.16	213.9
	13	2 246	3 705	65.0	1 503	0.84	-33.1	1 520	0.83	-32.3	5 570	2.80	148.0	1 323	0.91	-41.1
	14	324	-	-	141	0.10	-56.5	135	0.09	-58.4	331	0.49	2.0	109	0.10	-66.3
	15	3 379	6 554	94.0	2 901	1.13	-14.2	2 901	1.12	-14.2	6 778	3.45	100.6	3 389	1.13	0.3
	16+	93 382	227 037	143.1	86 499	1.76	-7.4	99 237	2.08	6.3	178 726	3.60	91.4	125 294	2.80	34.2

	2	469 000	514 537	9.7	435 666	73.56	-7.1	436 014	73.68	-7.0	772 769	149.57	64.8	512 249	125.03	9.2
	3	201 000	276 000	37.3	237 979	51.35	18.4	239 139	52.00	19.0	535 727	110.96	166.5	272 601	69.00	35.6
	4	356 000	255 975	-28.1	332 668	50.86	-6.6	332 397	50.65	-6.6	416 649	72.69	17.0	307 260	48.08	-13.7
	5	172 000	147 225	-14.4	125 613	21.50	-27.0	126 972	22.20	-26.2	187 524	39.99	9.0	137 635	30.00	-20.0
	6	112 000	141 252	26.1	125 685	24.40	12.2	124 996	24.43	11.6	180 785	33.62	61.4	134 698	24.20	20.3
	7	90 000	85 520	-5.0	81 470	19.94	-9.5	82 669	19.74	-8.1	127 568	28.94	41.7	83 156	16.28	-7.6
	8	55 000	67 930	23.5	60 658	13.24	10.3	61 201	13.10	11.3	84 285	16.11	53.2	59 461	11.66	8.1
2012	9	37 000	36 390	-1.6	39 273	11.42	6.1	38 853	11.43	5.0	54 086	16.88	46.2	41 253	14.28	11.5
	10	19 000	32 828	72.8	21 916	7.28	15.3	23 182	7.51	22.0	38 193	8.32	101.0	24 739	6.28	30.2
	11	7 000	17 483	149.8	17 744	7.00	153.5	17 677	6.94	152.5	20 154	7.35	187.9	15 110	5.75	115.9
	12	8 000	3 286	-58.9	3 623	2.38	-54.7	3 650	2.42	-54.4	4 524	2.49	-43.5	3 304	2.31	-58.7
	13	838	1 116	33.2	1 293	0.67	54.3	1 280	0.64	52.7	1 670	0.84	99.3	1 028	0.68	22.7
	14	5 000	3 323	-33.5	1 881	0.99	-62.4	2 311	1.12	-53.8	2 965	1.22	-40.7	2 444	1.30	-51.1
	15	2 000	24 405	1120.2	3 339	2.31	66.9	3 339	2.32	66.9	3 956	2.79	97.8	3 413	2.15	70.7
	16+	131 000	214 200	63.5	179 090	3.34	36.7	184 709	3.36	41.0	244 531	4.44	86.7	176 144	3.14	34.5
	2	209 000	162 641	-22.2	360 736	62.92	72.6	357 967	63.64	71.3	471 595	83.25	125.6	434 385	74.47	107.8
	3	154 000	250 702	62.8	210 630	55.10	36.8	211 348	56.12	37.2	298 353	58.48	93.7	264 465	70.71	71.7
	4	160 000	138 918	-13.2	208 508	40.40	30.3	211 526	39.93	32.2	336 841	49.55	110.5	237 164	50.37	48.2
	5	170 000	171 357	0.8	183 655	35.17	8.0	184 012	37.63	8.2	276 901	56.48	62.9	176 864	34.26	4.0
	6	158 000	139 872	-11.5	138 589	58.37	-12.3	138 538	60.53	-12.3	166 248	52.38	5.2	159 784	66.22	1.1
	7	137 000	201 838	47.3	199 698	68.28	45.8	198 629	67.92	45.0	326 045	101.35	138.0	181 085	60.24	32.2
	8	79 000	105 341	33.3	125 398	60.09	58.7	126 248	59.91	59.8	173 405	52.27	119.5	120 120	46.82	52.1
2013	9	130 000	103 366	-20.5	98 018	25.03	-24.6	98 714	25.66	-24.1	139 250	28.87	7.1	102 114	21.02	-21.5
	10	53 000	120 999	128.3	96 952	29.94	82.9	96 364	29.18	81.8	143 160	38.22	170.1	91 458	32.58	72.6
	11	24 000	14 575	-39.3	17 419	5.63	-27.4	17 482	5.76	-27.2	31 004	10.50	29.2	16 233	6.39	-32.4
	12	20 000	23 594	18.0	13 807	5.26	-31.0	13 991	5.29	-30.0	20 902	10.03	4.5	14 454	6.25	-27.7
	13	24 000	6 069	-74.7	6 912	3.44	-71.2	6 706	3.18	-72.1	11 837	4.89	-50.7	6 744	3.62	-71.9
	14	1 000	10 802	980.2	4 440	2.65	344.0	4 397	2.56	339.7	11 431	7.09	1043.1	4 315	3.03	331.5
	15	1 000	11 550	1055.0	3 481	2.20	248.1	3 506	2.23	250.6	11 585	5.37	1058.5	3 690	2.29	269.0
	16+	129 000	252 814	96.0	151 284	3.65	17.3	151 816	3.63	17.7	289 215	6.36	124.2	159 370	3.96	23.5
	2	2 000	1 539	-23.0	16 270	6.32	713.5	16 352	6.19	717.6	12 300	5.51	515.0	7 212	2.65	260.6
2014	3	23 000	26 267	14.2	39 279	12.57	70.8	39 204	12.59	70.5	50 405	11.20	119.2	33 886	9.23	47.3
	4	39 000	54 541	39.8	54 859	13.20	40.7	54 830	13.51	40.6	81 448	20.00	108.8	60 327	14.96	54.7

	5	69 000	88 387	28.1	101 788	27.69	47.5	102 031	27.63	47.9	160 134	47.33	132.1	99 768	26.68	44.6
	6	50 000	58 511	17.0	67 583	20.87	35.2	67 857	21.13	35.7	109 505	36.28	119.0	70 337	21.34	40.7
	7	87 000	111 053	27.6	120 766	28.04	38.8	120 666	28.02	38.7	181 843	44.32	109.0	122 203	27.62	40.5
	8	75 000	176 964	136.0	97 360	31.79	29.8	98 416	31.74	31.2	166 355	55.30	121.8	107 686	28.52	43.6
	9	69 000	137 752	99.6	60 873	22.00	-11.8	61 432	21.87	-11.0	105 423	32.39	52.8	67 290	22.89	-2.5
	10	48 000	87 495	82.3	38 556	8.60	-19.7	38 921	8.56	-18.9	65 238	14.49	35.9	42 781	10.98	-10.9
	11	46 000	50 795	10.4	56 253	13.43	22.3	56 750	13.64	23.4	85 092	26.90	85.0	52 261	19.64	13.6
	12	42 000	57 916	37.9	45 939	15.52	9.4	46 289	15.53	10.2	79 990	18.90	90.5	44 607	14.59	6.2
	13	17 000	24 425	43.7	22 134	5.70	30.2	22 399	5.69	31.8	33 678	9.55	98.1	20 646	5.82	21.4
	14	17 000	25 488	49.9	24 683	10.95	45.2	24 935	10.86	46.7	44 514	15.76	161.8	24 362	12.85	43.3
	15	4 000	2 358	-41.1	3 082	1.28	-22.9	3 271	1.29	-18.2	6 360	2.98	59.0	2 871	1.47	-28.2
	16+	163 000	201 297	23.5	166 922	3.99	2.4	168 438	4.03	3.3	283 394	6.81	73.9	167 449	3.93	2.7
	2	451 000	535 122	18.7	430 323	148.49	-4.6	430 969	148.84	-4.4	539 129	149.43	19.5	446 203	142.60	-1.1
	3	32 000	58 055	81.4	80 525	47.94	151.6	79 170	45.05	147.4	130 474	55.69	307.7	93 626	52.80	192.6
	4	53 000	40 028	-24.5	55 926	10.07	5.5	55 563	9.98	4.8	78 875	17.14	48.8	59 442	13.70	12.2
	5	84 000	87 130	3.7	91 465	33.49	8.9	91 998	31.91	9.5	131 366	46.11	56.4	98 077	30.38	16.8
	6	85 000	56 755	-33.2	70 724	16.13	-16.8	70 819	16.31	-16.7	84 482	19.28	-0.6	66 026	15.91	-22.3
	7	101 000	125 452	24.2	125 505	22.96	24.3	125 601	23.00	24.4	173 185	37.40	71.5	121 474	32.06	20.3
	8	68 000	43 599	-35.9	50 990	14.68	-25.0	50 582	14.33	-25.6	80 518	22.94	18.4	55 116	16.69	-18.9
2015	9	94 000	125 068	33.1	142 260	27.52	51.3	142 147	28.19	51.2	194 648	55.16	107.1	123 751	31.99	31.7
	10	69 000	77 792	12.7	68 594	15.84	-0.6	68 942	15.51	-0.1	102 133	26.68	48.0	67 964	15.70	-1.5
	11	18 000	32 268	79.3	29 946	14.17	66.4	29 607	14.18	64.5	44 829	18.89	149.1	32 029	12.57	77.9
	12	18 000	20 546	14.1	18 281	8.65	a1.6	18 290	8.52	1.6	26 345	11.04	46.4	17 878	6.97	-0.7
	13	8 000	15 656	95.7	10 777	6.17	34.7	10 674	6.17	33.4	15 068	8.10	88.3	11 870	5.88	48.4
	14	8 000	7 812	-2.3	5 761	3.43	-28.0	5 805	3.51	-27.4	8 422	4.64	5.3	5 615	4.00	-29.8
	15	5 000	2 262	-54.8	4 994	2.68	-0.1	4 972	2.72	-0.6	6 820	3.63	36.4	5 816	3.48	16.3
	16+	141 000	250 418	77.6	147 247	3.88	4.4	149 016	3.93	5.7	230 442	5.87	63.4	150 006	3.79	6.4

7. Appendix 2: RstoX code for the estimates of numbers-at-length and age

The following code was run in R version 3.5.2 and RStoX version 1.11. The code is shown in blue and the console output in black and red. Note that the results presented in the working document are for the years 2003 to 2015. The range covered in this example (2003:2003) was chosen for demonstration purposes. Further note that the RStoX projects were downloaded previously and are called up from a list-object ('allpr') rather than being downloaded afresh. The relevant commands for the downloading are commented out (with #).

```
> library(Rstox)
> #library(rJava)
> require(plyr)
> require(tidyverse)
> require(ggplot2)
>
> #Set working directory
> setwd("R:/_Dyphavsarter/Arter/Uer/AFWG2019/Toktindex/Økotokt")
>
> ## Clean up and overall settings
> rm(list=ls())
>
> CS <- getNMDinfo("cs", recursive=FALSE) # Toktserieinfo ("cruise series")
> CS                                      # Nummerert liste over toktserier i database
n
 [1] "Atlantic Ocean West of British Isles INT blue whiting spawning survey in spring"
 [2] "Barents Sea NOR demersal fish cruise in August-September"
 [3] "Barents Sea NOR demersel fish cruise in October-November"
 [4] "Barents Sea NOR-RUS 0-group cruise in autumn"
 [5] "Barents Sea NOR-RUS ecosystem cruise in autumn"
 [6] "North Sea International ecosystem cruise in Q2_Q3"
 [7] "North Sea International IBTS cruise in Q1"
 [8] "North Sea International IBTS cruise in Q2_Q3"
 [9] "North Sea International IBTS cruise in Q4"
[10] "North Sea NOR mackerel cruise in summer"
[11] "North Sea NOR Sandeel cruise in Apr_May"
[12] "North Sea NOR seiskalle cruise in spring"
[13] "North Sea NOR shrimp NDSK cruise in Jan_Nov"
[14] "Norwegian Sea continental slope NOR deep-sea fish cruise in autumn"
[15] "Norwegian Sea International ecosystem cruise in May"
[16] "Norwegian Sea NOR mackerel cruise in summer"
[17] "Norwegian Sea NOR Norwegian spring-spawning herring spawning cruise in Feb_Mar"
[18] "Norwegian Sea NOR pelagic deep-sea fish cruise in summer"
[19] "Norwegian Sea NOR salmon cruise in summer"
[20] "Skagerrak NOR beach seine survey in autumn"
[21] "Varanger Stad NOR coastal cruise in autumn"
[22] "Barents Sea NOR-RUS demersal fish cruise in winter"
[23] "Lofoten NOR demersal fish cruise in Mar_Apr"
[24] "North Sea NOR Herring Acoustic Survey in summer"
[25] "Norwegian Sea continental slope NOR deep-sea fish cruise in spring"
>
> myCS<-CS[5]                            # Velger Ã¸kotoktet
> getNMDinfo(c("cs", myCS))
$`Barents Sea NOR-RUS ecosystem cruise in autumn`
   code               Cruise        ShipName Year
3     1 0087_2003_UFVZ_TSIVI        Tsivilsk 2003
6     2              2003110        G.O.Sars 2003
1     3              2003209     Johan Hjort 2003
4     4              2003703       Jan Mayen 2003
2     5              2003705       Jan Mayen 2003
5     6 0115_2003_UFFJ_SMOLE        Smolensk 2003
9     1              2004210     Johan Hjort 2004
7     2              2004702       Jan Mayen 2004
10    3              2004703       Jan Mayen 2004
```

```
8      4 0118_2004_UFFJ_SMOLE        Smolensk 2004
11     5 0088_2004_UANA_NANSE Fridtjof Nansen 2004
15     1              2005111        G.O.Sars 2005
12     2              2005209     Johan Hjort 2005
16     3              2005702       Jan Mayen 2005
13     4              2005703       Jan Mayen 2005
17     5 0093_2005_UANA_NANSE Fridtjof Nansen 2005
14     6 0092_2005_UFJJ_SMOLE        Smolensk 2005
18     1              2006702       Jan Mayen 2006
21     2              2006211     Johan Hjort 2006
19     3              2006704       Jan Mayen 2006
23     4              2006113        G.O.Sars 2006
20     5 0095_2006_UFJJ_SMOLE        Smolensk 2006
22     6 0094_2006_UANA_NANSE Fridtjof Nansen 2006
26     1              2007110        G.O.Sars 2007
24     2              2007210     Johan Hjort 2007
27     3              2007702       Jan Mayen 2007
25     4 0096_2007_UFJJ_SMOLE        Smolensk 2007
28     5 0097_2007_UFJN_VILNY         Vilnyus 2007
29     1              2008106        G.O.Sars 2008
32     2              2008703       Jan Mayen 2008
30     3              2008208     Johan Hjort 2008
33     4              2008822   Atlantic Star 2008
31     5 0100_2008_UFJN_VILNY         Vilnyus 2008
34     1              2009208     Johan Hjort 2009
36     2              2009702       Jan Mayen 2009
35     3 0105_2009_UFJN_VILNY         Vilnyus 2009
37     4              2009109        G.O.Sars 2009
40     1              2010111        G.O.Sars 2010
38     2              2010210     Johan Hjort 2010
41     3              2010703       Jan Mayen 2010
39     4 0106_2010_UFJN_VILNY         Vilnyus 2010
42     5 0107_2010_UANA_NANSE Fridtjof Nansen 2010
45     1              2011717  Helmer Hanssen 2011
43     2 0109_2011_UFJN_VILNY         Vilnyus 2011
44     3              2011830     Christina E 2011
46     4              2011213     Johan Hjort 2011
47     1              2012845  Helmer Hanssen 2012
48     2              2012209     Johan Hjort 2012
50     3              2012111        G.O.Sars 2012
49     4 0110_2012_UFJN_VILNY         Vilnyus 2012
51     1              2013843  Helmer Hanssen 2013
52     2              2013208     Johan Hjort 2013
54     3              2013111        G.O.Sars 2013
53     4 0112_2013_UFJN_VILNY         Vilnyus 2013
55     1              2014212     Johan Hjort 2014
57     2              2014806  Helmer Hanssen 2014
56     3              2014116        G.O.Sars 2014
58     4 0116_2014_UFJN_VILNY         Vilnyus 2014
61     1              2015210     Johan Hjort 2015
59     2              2015843  Helmer Hanssen 2015
62     3              2015114        G.O.Sars 2015
60     4 0117_2015_UFJN_VILNY         Vilnyus 2015
63     1              2016209     Johan Hjort 2016
65     2              2016847  Helmer Hanssen 2016
64     3              2016842            Eros 2016
66     4 0142_2016_UANA_NANSE Fridtjof Nansen 2016
69     1              2017209     Johan Hjort 2017
67     2              2017113        G.O.Sars 2017
70     3              2017856  Helmer Hanssen 2017
68     4  0143_2017_UFJN_VLNY         Vilnyus 2017
71     1              2018209     Johan Hjort 2018
72     2              2018110        G.O.Sars 2018
73     3              2018838  Helmer Hanssen 2018
74     4  0145_2018_UFJN_VLNY         Vilnyus 2018

>
> ## set years
> pre <- 2002
> years <- 2003:2003
> #years <- years[-8]
> years
[1] 2003
>
```

```
> #prepare lists for results
> allpr <- list()
> atlength <- list()
> atage <- list()
> age_uncertain <- list()
> age_uncertainv2 <- list()
> age_uncertainv3 <- list()
> basiclength <- list()
> basicage <- list()
> mikkolength <- list()
> mikkoage <- list()
> mikkolengthv2 <- list()
> mikkoagev2 <- list()
> basicpluslength <- list()
> basicplusage <- list()
> age_uncertainv4 <- list()
>
> load("Data/project_paths.rdata")
>
> for (i in years){
+
+   #lengthlist <- list()
+   #agelist <- list()
+
+   ######### Strata system 2017 - Barents_Sea_Ecosystem_Survey_Areas_v2017.txt ######
#################
+
+   ## Extract data
+   #system.time(projects<-getNMDdata(cruise=myCS, group="year", subset = i, model="Sw
eptAreaTemplate", subdir=TRUE, abbrev=T, ow=TRUE,run = TRUE))
+
+   #allpr[[i-pre]] <- projects
+   projects <- allpr[[i-pre]]
+
+   cruise.path=projects
+
+   ################## Setting of parameters - checked and confirmed with Tone #######
##############
+
+
+   ### Different Strata options - replace strata line in code below
+
+   # FileName="${STOX}/reference/stratum/Barents_Sea_Ecosystem_Survey_Areas_v2017.txt
"),
+   # FileName="${STOX}/reference/stratum/eco_strata.wkt"),
+   #FileName="${STOX}/reference/stratum/eco_afwg.txt"),
+
+   ## parameters
+   params <- list(FilterBiotic=list(functionName="FilterBiotic",
+                                     BioticData="Process(ReadBioticXML)",
+                                     #FishStationExpr="gear=~['3270','3271'] and gearc
ondition < 3 and trawlquality =~['1'] and fishstationtype != ['2','C']",
+                                     FishStationExpr="gear<'3500' and gearcondition <
3 and trawlquality =~['1'] and fishstationtype != ['2','C']",
+                                     CatchExpr="species =~['166756', '166705']"),
+                   DefineStrata=list(functionName="DefineStrata",
+                                     ProcessData="Process(ReadProcessData)",
+                                     UseProcessData=FALSE,
+                                     FileName="${STOX}/reference/stratum/Barents_Sea_E
cosystem_Survey_Areas_v2017.txt"),
+                   SweptAreaDensity=list(functionName="SweptAreaDensity",
+                                         FishingWidthMethod="Constant",
+                                         FishingWidth="25"),
+                   StratumArea=list(AreaMethod="Accurate"),
+                   RegroupLengthDist=list(LengthInterval="5"))
+
+   ## run Baseline
+   runBaseline(projects, parlist=params, save=TRUE) # Test
+
+   readBaselineParametersJava(projects) # this will show the updated baseline paramet
ers in Java
+
+   # get the output
+   X=getBaseline(projects)
```

```
+
+   # Show superindividuals:
+   head(X$outputData$SuperIndAbundance)
+
+   ### Numbers-at-length
+   Y=data.frame(stratum=X$outputData$Abundance$SampleUnit,area=X$outputData$Abundance
$Area, Lgrp=X$outputData$Abundance$LengthGroup,abundance=X$outputData$Abundance$Abunda
nce)
+   print(Y)
+
+   # group_by
+   Y <- subset(Y, abundance!="NA")
+   dim(Y)
+
+   Y_length <- Y %>%
+     ddply("Lgrp", summarise,
+           numbers_length=sum(abundance))
+
+   Y_length$year <- i
+
+   Y_length <- Y_length[,c(3,1,2)]
+
+   #Y_strata <- Y %>%
+   #  group_by(length, stratum) %>%
+   #  summarise(numbers_length=sum(abundance)) #and then by stratum - similar to sumi
f()
+
+   #Y_length <- Y %>%
+    # group_by(Lgrp) %>%
+     #summarise(numbers_length=sum(abundance)) #calculates numbers per lenght class -
similar to sumif()
+
+   #write.table(Y, file=paste("index_length_rstox", year, ".txt", sep=""), sep="\t")
+
+
+   ### Bootstrapping and numbers-at-age ################
+
+   # Run the bootstrapping to generate estimates of the variability in the data (cv):
+   rb1 <- runBootstrap(projects, nboot=50, cores=1, seed=1234, bioticMethod=PSU~Strat
um, bootstrapMethod="SweptAreaLength")
+   # Fill in missing data (missing length, weight and so on) based on the age informa
tion:
+   rb2 <- imputeByAge(projects,seed = 1234, cores =1, saveInd = TRUE)
+
+   # Save the bootstrap data:
+   saveProjectData(projects)
+
+   # Generate plots and reports:
+   plotfiles <- getPlots(projects)
+   reportfiles <- getReports(projects)
+
+   ### Extract rstox table for comparison
+   age_table=read.delim(paste0(cruise.path,"/output/r/report/bootstrapImpute_Abundanc
e_age.txt"),skip=9)
+
+   age_table$year <- i
+   age_table <- age_table[,c(8,1,2,3,4,5,6,7)]
+   age_uncertain[[i-pre]] <- age_table
+
+   #write.table(age_table, file=paste("index_age_rstox", year, ".txt", sep=""), sep="
\t")
+
+   Y_age <-  data.frame(age_table$age)
+   Y_age$numbers_age <- age_table$Ab.Sum.mean
+   Y_age$year <- i
+   names(Y_age) <- c("age", "numbers_age", "year")
+
+   Y_age <- Y_age[,c(3,1,2)]
+
+
+   atlength[[i-pre]] <-Y_length
+   atage[[i-pre]] <- Y_age
+
+   ############### End of standard RStox process ###################
```

```
+
+
+  ##################### End of Strata 17 ##############################
+
+
+ }
Running baseline process 1 to 15 (out of 15 processes)
Reading:
Baseline parameters
Process output ReadProcessData
Process output ReadBioticXML
Process output FilterBiotic
Process output StationLengthDist
Process output RegroupLengthDist
Process output DefineStrata
Process output StratumArea
Process output DefineSweptAreaPSU
Process output TotalLengthDist
Process output SweptAreaDensity
Process output MeanDensity_Stratum
Process output Abundance
Process output IndividualDataStations
Process output IndividualData
Process output SuperIndAbundance
Process output WriteProcessData
Process data bioticassignment
Process data suassignment
Process data assignmentresolution
Process data edsupsu
Process data psustratum
Process data stratumpolygon
Process data temporal
Process data gearfactor
Process data spatial
Process data platformfactor
Process data covparam
Process data ageerror
Process data stratumneighbour
                 stratum     area Lgrp    abundance
1      Bear_Island_Trench 24083.83    5   1243322.48
2      Bear_Island_Trench 24083.83   10   1734452.25
3      Bear_Island_Trench 24083.83   15   3171940.18
4      Bear_Island_Trench 24083.83   20   7862324.88
5      Bear_Island_Trench 24083.83   25  51714225.09
6      Bear_Island_Trench 24083.83   30 184248601.84
7      Bear_Island_Trench 24083.83   35  49264553.20
8      Bear_Island_Trench 24083.83   40    987815.89
9            Central_Bank 22680.97   15    116680.98
10 Franz_Victoria_Trough 37212.30    5   5742343.10
11 Franz_Victoria_Trough 37212.30   10    755878.83
12 Franz_Victoria_Trough 37212.30   20    146604.45
13 Franz_Victoria_Trough 37212.30   25     63812.20
14             Great_Bank 26970.90   NA           NA
15             Hopen_Deep 16654.82    5    137087.66
16             Hopen_Deep 16654.82   10    843750.80
17             Hopen_Deep 16654.82   15   2127700.98
18             Hopen_Deep 16654.82   20    389617.56
19             Hopen_Deep 16654.82   25   1316485.53
20             Hopen_Deep 16654.82   30    432908.40
21             Hopen_Deep 16654.82   35    144302.80
22             South_East 30709.67   30   1421857.76
23             South_East 30709.67   35   1421857.76
24             South_West 35050.37    5     92733.26
25             South_West 35050.37   10    439417.74
26             South_West 35050.37   15    464921.33
27             South_West 35050.37   20   2407434.82
28             South_West 35050.37   25   9260506.03
29             South_West 35050.37   30  26428233.06
30             South_West 35050.37   35   4553177.66
31             South_West 35050.37   40    456306.51
32      Southeastern_Basin 30050.12   NA           NA
33          Svalbard_North 22343.14    5   1183557.77
34          Svalbard_North 22343.14   10   4049730.49
35          Svalbard_North 22343.14   15   3602818.38
```

```
36         Svalbard_North 22343.14   20  18548427.09
37         Svalbard_North 22343.14   25  30935321.11
38         Svalbard_North 22343.14   30  19726578.48
39         Svalbard_North 22343.14   35   4633281.28
40         Svalbard_North 22343.14   40    302541.54
41         Svalbard_South 31940.90    5    144405.74
42         Svalbard_South 31940.90   10   2358302.02
43         Svalbard_South 31940.90   15   1096318.02
44         Svalbard_South 31940.90   20   2632328.85
45         Svalbard_South 31940.90   25  19466322.13
46         Svalbard_South 31940.90   30 129772272.95
47         Svalbard_South 31940.90   35  21727278.48
48         Svalbard_South 31940.90   40    711190.90
49      Thor_Iversen_Bank 19954.71   10    872256.47
50      Thor_Iversen_Bank 19954.71   15    527944.71
51      Thor_Iversen_Bank 19954.71   20    692449.22
52      Thor_Iversen_Bank 19954.71   25    242061.61
53      Thor_Iversen_Bank 19954.71   30     91816.47
54      Thor_Iversen_Bank 19954.71   35     91816.47
55     Bear_Island_Trench 24083.83    5   1081525.48
56     Bear_Island_Trench 24083.83   10     69692.57
57           Central_Bank 22680.97   NA           NA
58 Franz_Victoria_Trough 37212.30    5   2591757.17
59 Franz_Victoria_Trough 37212.30   10    812542.05
60             Great_Bank 26970.90   10     88800.19
61             Hopen_Deep 16654.82    5    189397.42
62             South_East 30709.67   NA           NA
63             South_West 35050.37    5   7248502.46
64             South_West 35050.37   10    752169.76
65     Southeastern_Basin 30050.12   NA           NA
66         Svalbard_North 22343.14    5   3039164.91
67         Svalbard_North 22343.14   10    934278.94
68         Svalbard_South 31940.90   15     50995.30
69         Svalbard_South 31940.90   30     50995.30
70      Thor_Iversen_Bank 19954.71    5     91816.47
Reading:
Process output SuperIndAbundance
Running 50 bootstrap replicates:
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 09s
Imputing missing data (50 replicates):
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 13s
Abundance by age for  bootstrap
 Abundance by age for  bootstrapImpute
    age    Ab.Sum.5%   Ab.Sum.50%   Ab.Sum.95%  Ab.Sum.mean    Ab.Sum.sd Ab.Sum.cv
1    NA 373.38465425 572.09862599 756.48668850 568.86748822 135.73319538 0.2386025
2     1   0.21263251   0.51245896   0.97099683   0.54756114   0.28031790 0.5119390
3     2   0.00000000   0.16223711   0.34418208   0.17725776   0.11145606 0.6287796
4     3   0.56057250   1.22548418   1.65362736   1.18764803   0.36921664 0.3108805
5     4   1.13053891   1.60209174   2.34287490   1.64057751   0.39745164 0.2422632
6     5   0.38523444   0.82715666   1.27412103   0.82443574   0.26629919 0.3230078
7     6   1.72613891   2.35065312   3.30421147   2.38240241   0.52311508 0.2195746
8     7   1.99192022   2.56807136   3.33523416   2.60165713   0.41373694 0.1590282
9     8   3.83977702   7.22316105   9.81100946   7.11997083   1.95154646 0.2740947
10    9   6.09051799  10.41927912  14.04866212  10.03488907   2.73994097 0.2730415
11   10   1.63194108   2.25549629   3.10391806   2.31342965   0.48901751 0.2113821
12   11   1.01120225   1.74505324   2.40047926   1.75044896   0.46397323 0.2650596
13   12   1.26111138   3.10576570   4.41204665   2.89699617   1.11423265 0.3846165
14   13   2.04062070   7.14244983  13.81959050   7.47196546   3.95720064 0.5296064
15   14   4.38611325   9.96787077  14.99220153   9.87494718   3.23515271 0.3276122
16   15   3.74001493   6.94184593  10.35101202   7.06366230   2.37881237 0.3367676
17   16   0.90558340   1.46810430   1.88888795   1.44790240   0.31849481 0.2199698
18   17   0.03788648   0.16342039   0.37311171   0.18748083   0.10122511 0.5399224
19   18   0.40975127   0.76785991   1.11159331   0.77902026   0.25353884 0.3254586
20   19   0.02590185   0.16977922   0.30684838   0.17071892   0.09368253 0.5487531
21   20   0.00000000   2.10884278   3.77000735   1.51529290   1.43158991 0.9447612
22   21   0.00000000   0.12181904   0.25556089   0.10549487   0.08914584 0.8450253
23   22   0.00000000   0.11840168   0.35219923   0.16593663   0.11773329 0.7095075
24   23   0.29018986   1.98988582   3.64414603   1.94052458   1.06028982 0.5463934
25   24   0.13978569   0.56459675   0.96741080   0.57797341   0.27333030 0.4729116
26   27   0.00000000   0.02528161   0.04721843   0.02023780   0.01929402 0.9533656
27   28   0.00000000   0.24126479   0.65205628   0.25108641   0.26835067 1.0687583
28   43   0.00000000   0.03854643   0.05798316   0.03254492   0.02350403 0.7222027
   age    Ab.Sum.5%  Ab.Sum.50%  Ab.Sum.95% Ab.Sum.mean  Ab.Sum.sd Ab.Sum.cv
1    1   6.97092938  14.0734806  26.0830836  16.0148920  6.9109991 0.4315358
```

```
2     2  0.00000000   5.6603225  17.4343623   6.6097735  6.2879671 0.9513136
3     3  3.72329992   7.0618118  13.5684635   7.7601223  3.1211713 0.4022065
4     4  5.07654203   8.3938365  14.3483081   8.9843860  3.1170971 0.3469460
5     5  1.81268989   3.5517214   6.0551429   3.5722882  1.2892771 0.3609107
6     6  6.80508083   9.6656405  12.8372907   9.7263261  2.1043576 0.2163569
7     7  8.72940592  11.6196204  20.2038621  12.6546383  3.7453833 0.2959692
8     8 30.24026161  52.3461346  79.6400169  53.3235146 15.9798026 0.2996765
9     9 29.22051043  53.3437307  70.4565370  51.2147995 13.3537258 0.2607396
10   10 25.40970654  42.1675230  74.3554910  47.0711385 16.5865727 0.3523725
11   11 15.32720086  33.6883757  51.0068272  32.9274381 12.7315461 0.3866546
12   12 22.54278632  52.9067935  90.2467477  56.2332105 25.4794193 0.4531027
13   13 48.49220419 149.0395282 324.2316027 165.6396333 90.2668120 0.5449590
14   14 20.46702690  76.2233478 139.3113983  79.8564225 38.7292816 0.4849864
15   15 18.60628571  49.8814947  91.4545498  52.0922553 21.8883252 0.4201839
16   16  5.41831504  11.3010937  18.4216096  11.6235206  3.9192359 0.3371815
17   17  0.04299694   0.3376919   1.0170244   0.4325655  0.3441703 0.7956488
18   18  0.47246122   1.4902428   3.3970433   1.6516732  0.9629827 0.5830346
19   19  0.12176092   1.1884477   3.0852044   1.4347505  1.1153516 0.7773836
20   20  0.00000000  11.1291633  19.2910367   7.9346474  7.7092876 0.9715980
21   21  0.00000000   0.2259387   0.7713422   0.2867386  0.2745526 0.9575013
22   22  0.00000000   0.1469758   0.6249804   0.2415486  0.2613426 1.0819461
23   23  0.71749096   2.9997262   4.6902317   2.8315914  1.2175546 0.4299895
24   24  0.85567204   2.4343285   6.1510952   2.9102178  1.8423595 0.6330659
25   27  0.00000000   0.1115587   0.4846137   0.1569713  0.1861909 1.1861461
26   28  0.00000000   0.2412648   1.4362456   0.5038530  0.5447486 1.0811656
27   43  0.00000000   0.3025415   0.5598579   0.2606349  0.2069867 0.7941635
>
> ## check content of lists
> summary(atlength)
     Length Class      Mode
[1,] 3      data.frame list
> summary(atage)
     Length Class      Mode
[1,] 3      data.frame list
>
>
> ## Create length table for all years - AFWG strata
> length_rstox <- atlength[[1]]
> head(length_rstox)
  year Lgrp numbers_length
1 2003    5       22785614
2 2003   10       13711272
3 2003   15       11159320
4 2003   20       32679187
5 2003   25      112998734
6 2003   30      362173264
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   length_rstox <- rbind(length_rstox, atlength[[i]])
+ }
>
>
> ## Create 45+ group
> dim(length_rstox)
[1] 8 3
> length_rstox <- subset(length_rstox, Lgrp!="NA")
> dim(length_rstox)
[1] 8 3
>
>
> length_low <- subset(length_rstox, Lgrp<45)
> length_high <- subset(length_rstox, Lgrp>=45)
> dim(length_low)
[1] 8 3
> dim(length_high)
[1] 0 3
>
> temp <- length_high %>%
```

```
+   ddply("year", summarise,
+         numbers_length=sum(numbers_length))
>
> temp$Lgrp <- 45
>
> temp <- temp[,c(1,3,2)]
>
> length_rstox <- rbind(length_low, temp)
> length_rstox$model <- "RStoX17"
> length_rstox$numbers_length <- (length_rstox$numbers_length)/1000
> length_rstox <- subset(length_rstox, Lgrp!=0)
>
> ## Create age table for all years - AFWG strata
> age_rstox <- atage[[1]]
>
> for (i in ivec){
+   age_rstox <- rbind(age_rstox, atage[[i]])
+ }
>
>
> ## Create 16+ group
> dim(age_rstox)
[1] 27  3
> age_rstox <- subset(age_rstox, age!="NA")
> dim(age_rstox)
[1] 27  3
>
> age_low <- subset(age_rstox, age<16)
> age_high <- subset(age_rstox, age>=16)
> dim(age_low)
[1] 15  3
> dim(age_high)
[1] 12  3
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         numbers_age=sum(numbers_age))
>
> temp$age <- 16
>
> temp <- temp[,c(1,3,2)]
>
> age_rstox <- rbind(age_low, temp)
> age_rstox$model <- "RStoX17"
> age_rstox$numbers_age <- age_rstox$numbers_age*1000
> age_rstox <- subset(age_rstox, age!=1)
>
>
>   ## Create age table with uncertainties - Rstox17
>   uncertain_age <- age_uncertain[[1]]
>   head(uncertain_age)
  year age Ab.Sum.5. Ab.Sum.50. Ab.Sum.95. Ab.Sum.mean Ab.Sum.sd Ab.Sum.cv
1 2003   1  6.970929  14.073481  26.083084   16.014892  6.910999 0.4315358
2 2003   2  0.000000   5.660323  17.434362    6.609773  6.287967 0.9513136
3 2003   3  3.723300   7.061812  13.568464    7.760122  3.121171 0.4022065
4 2003   4  5.076542   8.393836  14.348308    8.984386  3.117097 0.3469460
5 2003   5  1.812690   3.551721   6.055143    3.572288  1.289277 0.3609107
6 2003   6  6.805081   9.665641  12.837291    9.726326  2.104358 0.2163569
>
>   #ivec <- 2:(length(years)+1)
>   #ivec <- ivec[-7]
>   ivec <- 2:(length(years))
>   ivec
[1] 2 1
>
>   for (i in ivec){
+     uncertain_age <- rbind(uncertain_age, age_uncertain[[i]])
+   }
>
>   names(uncertain_age) <- c("year", "age", "p05", "p50", "p95", "mean", "sd", "cv")
>
>
>   ## Create 16+ group
>   dim(uncertain_age)
```

```
[1] 27  8
>   uncertain_age <- subset(uncertain_age, age!="NA")
>   dim(uncertain_age)
[1] 27  8
>
>   age_low <- subset(uncertain_age, age<16)
>   age_high <- subset(uncertain_age, age>=16)
>   dim(age_low)
[1] 15  8
>   dim(age_high)
[1] 12  8
>
>   temp <- age_high %>%
+     ddply("year", summarise,
+           p05=sum(p05), p50=sum(p50), p95=sum(p95),
+           mean=sum(mean), sd=mean(sd), cv=mean(cv))
>
>   temp$age <- 16
>
>   temp <- temp[,c(1,8,2,3,4,5,6,7)]
>
>   uncertain_age <- rbind(age_low, temp)
>   uncertain_age$model <- "RStoX17"
>   uncertain_age$mean <- uncertain_age$mean*1000
>   uncertain_age$p05 <- uncertain_age$p05*1000
>   uncertain_age$p95 <- uncertain_age$p95*1000
>   uncertain_age <- subset(uncertain_age, age!=1)
>

>



> for (i in years){
+
+     #lengthlist <- list()
+     #agelist <- list()
+
+
+   ######## Old AFWG system - eco_afwg.txt #####################
+
+   ## Extract data
+   #system.time(projects<-getNMDdata(cruise=myCS, group="year", subset = i, model="Sw
eptAreaTemplate", subdir=TRUE, abbrev=T, ow=TRUE,run = TRUE))
+
+   projects <- allpr[[i-pre]]
+
+   cruise.path=projects
+
+   ################## Setting of parameters - checked and confirmed with Tone #######
##############
+
+
+   ### Different Strata options - replace strata line in code below
+
+   # FileName="${STOX}/reference/stratum/Barents_Sea_Ecosystem_Survey_Areas_v2017.txt
"),
+   # FileName="${STOX}/reference/stratum/eco_strata.wkt"),
+   #FileName="${STOX}/reference/stratum/eco_afwg.txt"),
+
+   ## parameters
+   params <- list(FilterBiotic=list(functionName="FilterBiotic",
+                                    BioticData="Process(ReadBioticXML)",
+                                    #FishStationExpr="gear=~['3270','3271'] and gearc
ondition < 3 and trawlquality =~['1'] and fishstationtype != ['2','C']",
+                                    FishStationExpr="gear<'3500' and gearcondition <
3 and trawlquality =~['1'] and fishstationtype != ['2','C']",
+                                    CatchExpr="species =~['166756', '166705']"),
+                  DefineStrata=list(functionName="DefineStrata",
+                                    ProcessData="Process(ReadProcessData)",
+                                    UseProcessData=FALSE,
+                                    FileName="${STOX}/reference/stratum/eco_afwg.txt"
),
+                  SweptAreaDensity=list(functionName="SweptAreaDensity",
```

```
+                                      FishingWidthMethod="Constant",
+                                      FishingWidth="25"),
+                    StratumArea=list(AreaMethod="Accurate"),
+                    RegroupLengthDist=list(LengthInterval="5"))
+
+   ## run Baseline
+   runBaseline(projects, parlist=params, save=TRUE) # Test
+
+   readBaselineParametersJava(projects) # this will show the updated baseline paramet
ers in Java
+
+   # get the output
+   X=getBaseline(projects)
+
+   # Show superindividuals:
+   head(X$outputData$SuperIndAbundance)
+
+   ### Numbers-at-length
+   Y=data.frame(stratum=X$outputData$Abundance$SampleUnit,area=X$outputData$Abundance
$Area, Lgrp=X$outputData$Abundance$LengthGroup,abundance=X$outputData$Abundance$Abunda
nce)
+   print(Y)
+
+   # group_by
+   Y <- subset(Y, abundance!="NA")
+   dim(Y)
+
+   Y_length <- Y %>%
+     ddply("Lgrp", summarise,
+           numbers_length=sum(abundance))
+
+   Y_length$year <- i
+
+   Y_length <- Y_length[,c(3,1,2)]
+
+   #Y_strata <- Y %>%
+   #  group_by(length, stratum) %>%
+   #  summarise(numbers_length=sum(abundance)) #and then by stratum - similar to sumi
f()
+
+   #Y_length <- Y %>%
+   # group_by(Lgrp) %>%
+   #summarise(numbers_length=sum(abundance)) #calculates numbers per lenght class - s
imilar to sumif()
+
+   #write.table(Y, file=paste("index_length_rstox", year, ".txt", sep=""), sep="\t")
+
+
+   ### Bootstrapping and numbers-at-age ###############
+
+   # Run the bootstrapping to generate estimates of the variability in the data (cv):
+   rb1 <- runBootstrap(projects, nboot=50, cores=1, seed=1234, bioticMethod=PSU~Strat
um, bootstrapMethod="SweptAreaLength")
+   # Fill in missing data (missing length, weight and so on) based on the age informa
tion:
+   rb2 <- imputeByAge(projects,seed = 1234, cores =1, saveInd = TRUE)
+
+   # Save the bootstrap data:
+   saveProjectData(projects)
+
+   # Generate plots and reports:
+   plotfiles <- getPlots(projects)
+   reportfiles <- getReports(projects)
+
+   ### Extract rstox table for comparison
+   age_table=read.delim(paste0(cruise.path,"/output/r/report/bootstrapImpute_Abundanc
e_age.txt"),skip=9)
+
+   #write.table(age_table, file=paste("index_age_rstox", year, ".txt", sep=""), sep="
\t")
+
+   Y_age <-  data.frame(age_table$age)
+   Y_age$numbers_age <- age_table$Ab.Sum.mean
+   Y_age$year <- i
```

```
+   names(Y_age) <- c("age", "numbers_age", "year")
+
+   Y_age <- Y_age[,c(3,1,2)]
+
+
+   #atlength[[i-pre]] <-Y_length
+   #atage[[i-pre]] <- Y_age
+
+   ############### End of standard RStoX process ###################
+
+   ############### Alternative calculation - using areas created by Mikko ###########
#####
+
+   ### Numbers-at-length ###
+   ### Extract numbers standardized to nautical mile
+   numbers <- X$outputData$RegroupLengthDist
+   dim(numbers)
+   names(numbers)
+
+   ### Create id
+   numbers <- numbers %>%
+     mutate(serialno=sub("^[^/]*", "", Station)) %>%
+     mutate(serialno=gsub("/","",serialno))
+
+
+   #numbers$serialno <- str_sub(numbers$Station,-4,-1)
+   numbers$year <- as.character(i)
+   numbers$id <- paste(numbers$year, numbers$serialno, sep = "_")
+
+   ## load station data to attach
+   #load("Data/ecostations_allgears.rda")
+   load("Data/ecostations_bunntral.rda")
+   x <- x_list[[i-2002]]
+
+   ### Create data frame for swept area ###
+   ### By merging with station data - based on id ###
+
+
+   swept <- merge(numbers, unique(x)[, c("id", "distance", "stratum", "depth_cat", "a
rea", "nstation_st")], by="id", all.x=TRUE)
+   swept$Lgrp <- swept$LengthGroup
+   swept$LengthGroup <- NULL
+
+   ### Calculate swept area densities ######
+
+   #Calculate swept area
+   #swept$area <- (swept$distance * 25)/1852 #general formula for swept area
+   swept$sweep_area <- (1 * 25)/1852 #as the count is already standardized to 1 n.mi.
towing distance
+
+   #Calculate swept area density and subset for non existent length groups and out of
area stations
+   swept$estimate <- swept$WeightedCount/swept$sweep_area
+   swept <- subset(swept, estimate!="NA")
+   swept <- subset(swept, nstation_st!="NA")
+
+   swept <- swept %>%
+     add_count(SpecCat, Lgrp, stratum, depth_cat, name="nstation_x")
+
+   #Calculate multiplier to get to area abundance
+   #nstations_x = number of stations with the species
+   #nstations_st = number of stations in the stratum
+   swept$multiplier <- swept$area*(swept$nstation_x/swept$nstation_st)
+
+   ##### calculate proportion of weighted count #####
+   swept <- swept %>%
+     group_by(SpecCat, stratum, depth_cat, multiplier, Lgrp) %>%
+     mutate(sum_count=sum(WeightedCount)) %>%
+     mutate(prop_count = WeightedCount/sum_count)
+
+
+   #Calculate mean swept area density for stratum, depth_category and length group an
d calculate abundance in the stratum
+   sweep_mean <- swept %>%
```

```
+     group_by(SpecCat, stratum, depth_cat, multiplier, Lgrp) %>%
+     summarise(mean_stratum = mean(estimate)) %>%
+     mutate(abundance = mean_stratum*multiplier)
+
+
+   ##### calculate abundance per stratum #####
+   abundance_stratum <- sweep_mean %>%
+     group_by(SpecCat, stratum, depth_cat, Lgrp) %>%
+     summarise(abundance_stratum=sum(abundance))
+
+
+
+
+   ### Merge swept and stratum abundance and calculate abundance per station
+   swept <- merge(swept, unique(abundance_stratum)[, c("SpecCat", "stratum", "depth_c
at", "Lgrp", "abundance_stratum")], by=c("SpecCat", "stratum", "depth_cat", "Lgrp"), a
ll.x=TRUE)
+
+   swept <- swept %>%
+     mutate(abundance_station=abundance_stratum*prop_count)
+
+   ##### calculate index #####
+   #index_length <- sweep_mean %>%
+   #  group_by(Lgrp) %>%
+   #  summarise(index_length=sum(abundance))
+
+
+   index_length <- sweep_mean %>%
+     ddply("Lgrp", summarise,
+           numbers_length=sum(abundance))
+
+   index_length$year <- i
+
+   index_length <- index_length[,c(3,1,2)]
+
+   mikkolength[[i-pre]] <- index_length
+
+   #write.table(index_length, file=paste("index_length_customs", year, ".txt", sep=""
), sep="\t")
+
+
+   ############### Numbers-at-age ##################################
+
+   #extract and create list of imputed ages
+   ageimpute_list <- getProjectData(projectName = projects,
+                                   var = "bootstrapImpute")
+
+
+   for (q in 1:50){
+     ageimpute_list$SuperIndAbundance[[q]]$run <- q
+   }
+
+   agerun <- ageimpute_list$SuperIndAbundance[[1]]
+
+   for (q in 2:50){
+     agerun <- rbind(agerun,ageimpute_list$SuperIndAbundance[[q]])
+   }
+
+   #Count and attach number of occurrences for species, serial number, length group a
nd imputed age
+   agerun$Lgrp <- agerun$LenGrp
+
+   agerun <- agerun %>%
+     add_count(SpecCat, serialno, Lgrp, age, name="agecount")
+
+
+   ### reduce to most common age
+   agemax <- agerun %>%
+     #select(-c(23:34,36:39)) %>%
+     group_by(serialno, SpecCat, Lgrp) %>%
+     slice(which.max(agecount))
+
+   ##Create id
+   agemax$year <- as.character(i)
```

```
+   agemax$id <- paste(agemax$year, agemax$serialno, sep = "_")
+
+   agemax <- agemax %>%
+     select(id, SpecCat, serialno, Lgrp, age)
+
+
+   ###attaching age to swept densities ###
+   swept$serialno <- as.integer(swept$serialno)
+
+   swept <- merge(swept, agemax, by=c("id","SpecCat", "serialno", "Lgrp"), all.x=TRUE
)
+
+   swept <- swept %>%
+     mutate(abundance_station=abundance_stratum*prop_count)
+
+   ##### calculate index #####
+   #index_age <- swept %>%
+   #  group_by(age) %>%
+   # summarise(numbers_age=sum(abundance_station))
+
+
+   index_age <- swept %>%
+     ddply("age", summarise,
+           numbers_age=sum(abundance_station))
+
+   index_age$year <- i
+
+   index_age <- index_age[,c(3,1,2)]
+
+   mikkoage[[i-pre]] <- index_age
+
+
+   #write.table(index_age, file=paste("index_age_customs", year, ".txt", sep=""), sep
="\t")
+
+   ##################### End of old AFWG ##############################
+
+
+ }
Running baseline process 6 to 15 (out of 15 processes)
Reading:
Baseline parameters
Process output ReadProcessData
Process output ReadBioticXML
Process output FilterBiotic
Process output StationLengthDist
Process output RegroupLengthDist
Process output DefineStrata
Process output StratumArea
Process output DefineSweptAreaPSU
Process output TotalLengthDist
Process output SweptAreaDensity
Process output MeanDensity_Stratum
Process output Abundance
Process output IndividualDataStations
Process output IndividualData
Process output SuperIndAbundance
Process output WriteProcessData
Process data bioticassignment
Process data suassignment
Process data assignmentresolution
Process data edsupsu
Process data psustratum
Process data stratumpolygon
Process data temporal
Process data gearfactor
Process data spatial
Process data platformfactor
Process data covparam
Process data ageerror
Process data stratumneighbour
       stratum      area Lgrp    abundance
1     15_Arc_1  5971.373    5    987409.19
2     15_Arc_1  5971.373   10    567473.62
```

3	15_Arc_1	5971.373	15	642111.61
4	15_Arc_1	5971.373	20	2545113.92
5	15_Arc_1	5971.373	25	634539.45
6	15_Arc_1	5971.373	30	96775.90
7	15_Arc_1	5971.373	35	50909.15
8	15_Arc_1	5971.373	40	110153.70
9	15_Arc_2	4612.001	5	367313.88
10	15_Arc_2	4612.001	10	2134640.04
11	15_Arc_2	4612.001	15	149386.56
12	15_Arc_2	4612.001	20	66433.31
13	15_Arc_2	4612.001	25	37961.89
14	15_Arc_2	4612.001	30	26211.78
15	15_Arc_3	8440.135	5	142101.18
16	15_Arc_3	8440.135	10	426303.54
17	15_Arc_3	8440.135	15	142101.18
18	15_Arc_3	8440.135	20	568404.72
19	15_Arc_3	8440.135	30	142101.18
20	15_Arc_6	13804.491	5	2396489.59
21	15_Arc_6	13804.491	10	315455.85
22	15_Arc_6	13804.491	20	61183.39
23	15_Arc_6	13804.491	25	26631.16
24	15_Arc_7	7829.537	NA	NA
25	31_Sva_1	28673.309	5	358933.27
26	31_Sva_1	28673.309	10	2451878.68
27	31_Sva_1	28673.309	15	5114869.80
28	31_Sva_1	28673.309	20	28084582.79
29	31_Sva_1	28673.309	25	52660060.59
30	31_Sva_1	28673.309	30	47924798.59
31	31_Sva_1	28673.309	35	12030276.02
32	31_Sva_1	28673.309	40	578159.45
33	31_Sva_2	64860.486	5	596613.69
34	31_Sva_2	64860.486	10	4145739.25
35	31_Sva_2	64860.486	15	4713715.86
36	31_Sva_2	64860.486	20	6295006.85
37	31_Sva_2	64860.486	25	43071578.85
38	31_Sva_2	64860.486	30	232762428.35
39	31_Sva_2	64860.486	35	42077341.32
40	31_Sva_2	64860.486	40	1424006.35
41	32_Bar_1	19828.811	10	667690.15
42	32_Bar_1	19828.811	15	560382.81
43	32_Bar_1	19828.811	20	302050.31
44	32_Bar_1	19828.811	25	190768.61
45	32_Bar_2	13027.506	NA	NA
46	32_Bar_32_5	27573.849	5	1402678.11
47	32_Bar_32_5	27573.849	10	1202844.04
48	32_Bar_32_5	27573.849	15	1637598.69
49	32_Bar_32_5	27573.849	20	8136999.07
50	32_Bar_32_5	27573.849	25	6708930.43
51	32_Bar_32_5	27573.849	30	18886216.96
52	32_Bar_32_5	27573.849	35	3410346.36
53	32_Bar_32_5	27573.849	40	232121.67
54	32_Bar_32_6	15994.080	10	225189.17
55	32_Bar_32_6	15994.080	15	155900.19
56	32_Bar_32_6	15994.080	20	847327.67
57	32_Bar_32_6	15994.080	25	134641.08
58	32_Bar_32_6	15994.080	30	1561476.53
59	32_Bar_32_6	15994.080	35	949011.49
60	32_Bar_32_6	15994.080	40	158374.80
61	32_Bar_4	41211.946	10	579232.29
62	32_Bar_4	41211.946	15	94227.81
63	32_Bar_4	41211.946	20	892774.96
64	32_Bar_4	41211.946	25	41938782.62
65	32_Bar_4	41211.946	30	106050310.47
66	32_Bar_4	41211.946	35	37982998.52
67	32_Bar_4	41211.946	40	1364182.72
68	15_Arc_1	5971.373	5	90740.37
69	15_Arc_1	5971.373	10	421294.59
70	15_Arc_2	4612.001	5	2214178.55
71	15_Arc_2	4612.001	10	470308.52
72	15_Arc_3	8440.135	5	10453318.06
73	15_Arc_3	8440.135	10	2459604.25
74	15_Arc_6	13804.491	5	1081634.96
75	15_Arc_6	13804.491	10	367510.06
76	15_Arc_7	7829.537	NA	NA

```
77     31_Sva_1 28673.309    5    100126.81
78     31_Sva_1 28673.309   10     64367.23
79     31_Sva_2 64860.486    5    126178.17
80     31_Sva_2 64860.486   10     58883.15
81     31_Sva_2 64860.486   15     58883.15
82     31_Sva_2 64860.486   30     58883.15
83     32_Bar_1 19828.811    5    194742.96
84     32_Bar_2 13027.506   NA           NA
85 32_Bar_32_5 27573.849    5    167029.35
86 32_Bar_32_6 15994.080   NA           NA
87     32_Bar_4 41211.946    5   9672484.37
88     32_Bar_4 41211.946   10    859828.74
Reading:
Process output SuperIndAbundance
Running 50 bootstrap replicates:
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 09s
Imputing missing data (50 replicates):
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 12s
Abundance by age for  bootstrap
 Abundance by age for  bootstrapImpute
    age    Ab.Sum.5%   Ab.Sum.50%   Ab.Sum.95%  Ab.Sum.mean    Ab.Sum.sd Ab.Sum.cv
1    NA 420.70830013 647.42418455 994.56797715 671.15053791 182.80751942 0.2723793
2     1   0.29778656   0.75810726   1.59818978   0.79877113   0.38380442 0.4804936
3     2   0.00000000   0.13807195   0.37631796   0.16692158   0.12206806 0.7312899
4     3   0.45654839   1.27956923   2.07956806   1.24567700   0.54352534 0.4363293
5     4   1.25410344   1.81431436   2.64361985   1.84820660   0.49758908 0.2692281
6     5   0.40775256   0.68818270   1.01614875   0.68714667   0.20161682 0.2934116
7     6   1.86159353   2.34695885   3.39351719   2.45728607   0.50542896 0.2056858
8     7   2.22529222   2.97171887   4.51157237   3.14540669   0.76548559 0.2433662
9     8   3.35769153   8.53869615  12.87795349   8.26667196   3.03887248 0.3676053
10    9   7.07964864  12.50759239  19.01256883  12.37103287   4.11878602 0.3329379
11   10   1.64632988   2.84660004   4.90020596   3.12094238   0.97835998 0.3134822
12   11   0.94118185   1.57687477   2.81024388   1.70842646   0.57619788 0.3372682
13   12   1.58615370   4.29665750   8.86561953   4.39299744   2.14807529 0.4889771
14   13   1.81107737   8.32216810  14.62308676   7.77899137   4.49360052 0.5776585
15   14   4.67015652  10.43614309  18.18947557  10.80906899   4.84079469 0.4478457
16   15   4.21576460   8.30608674  12.97947878   8.24278521   2.78047182 0.3373219
17   16   0.94321039   1.51421085   1.95098322   1.49208260   0.31453149 0.2108003
18   17   0.00000000   0.21041797   0.44785356   0.21362792   0.13619066 0.6375134
19   18   0.32524780   0.93413045   1.78844879   1.00541324   0.48748298 0.4848583
20   19   0.07213216   0.24194793   0.38220069   0.23675775   0.09346633 0.3947762
21   20   0.02649742   1.69247399   3.12136473   1.31875134   1.21885452 0.9242489
22   21   0.00000000   0.11606084   0.40885628   0.15436106   0.11604592 0.7517824
23   22   0.00000000   0.11224353   0.27747265   0.12998138   0.08553237 0.6580356
24   23   0.41068812   0.87008948   1.41653104   0.88598029   0.33369201 0.3766359
25   24   0.21213543   0.82806629   1.38286693   0.82904275   0.37399610 0.4511180
26   27   0.00000000   0.04950592   0.07874092   0.03597901   0.03133150 0.8708274
27   28   0.00000000   0.20338144   0.44816271   0.17643883   0.16743854 0.9489892
28   43   0.00000000   0.05090915   0.10393707   0.04542471   0.03946778 0.8688614
   age   Ab.Sum.5%   Ab.Sum.50%  Ab.Sum.95%  Ab.Sum.mean  Ab.Sum.sd Ab.Sum.cv
1    1 13.87428354  27.96651724  41.3620149  27.54334733  8.5831978 0.3116251
2    2  0.00000000   2.43557752   7.5469323   3.00964194  3.0433757 1.0112086
3    3  6.04030464  10.50081764  15.3878215  10.46708725  3.3926058 0.3241213
4    4  7.98039852  11.39240045  19.5085006  12.60316352  4.2380681 0.3362702
5    5  2.50410547   3.94272111   5.5530841   4.06373362  1.2038715 0.2962477
6    6  8.17896455  11.63740828  16.3254433  11.90041797  2.4853891 0.2088489
7    7  9.68193951  13.79122833  20.8448137  14.52375765  3.7287977 0.2567378
8    8 31.36681423  67.04003037 111.1485123  70.83332712 28.1588847 0.3975372
9    9 43.33765020  67.29587341 103.1538272  70.37030784 19.5476924 0.2777832
10  10 27.87011645  50.70706823  93.5477832  54.03249677 19.7924029 0.3663055
11  11 14.40574136  32.84376603  60.8439480  33.88123764 16.2862596 0.4806867
12  12 32.06761915  71.07261013 148.8429805  74.93374752 36.9871550 0.4935981
13  13 37.66019993 165.61955193 331.4244552 161.56700188 96.0793523 0.5946719
14  14 20.73776664  97.74432457 200.7798106 103.14438227 59.7185888 0.5789805
15  15 29.53875458  53.38613862  88.1895243  57.08859369 18.5600087 0.3251089
16  16  8.15702934  12.40334777  22.2427827  14.09415085  4.7600162 0.3377299
17  17  0.00000000   0.66980777   3.3149744   0.98148038  1.1129956 1.1339968
18  18  0.49656601   2.28087203   5.3573107   2.56116449  1.6123048 0.6295202
19  19  0.42779832   1.79185094   4.1515171   1.87671143  1.2753563 0.6795697
20  20  0.03595542   9.12706122  17.3060595   7.25582373  6.8474448 0.9437171
21  21  0.00000000   0.52863114   1.2881797   0.55042079  0.4196719 0.7624565
22  22  0.00000000   0.51262599   1.7520922   0.67305695  0.6508889 0.9670637
23  23  0.90207687   2.82508188   5.6031755   2.96938725  1.3748362 0.4630033
24  24  0.81860152   2.74091451   5.5266284   2.91700471  1.4560105 0.4991457
```

```
25  27  0.00000000   0.23025161   1.0419066   0.33012917  0.3881895 1.1758716
26  28  0.00000000   0.47847284   1.0770939   0.44793203  0.4288414 0.9573806
27  43  0.00000000   0.05090915   0.2293238   0.09520542  0.1055346 1.1084938
>
>
>
> ## check content of lists
> summary(mikkolength)
     Length Class      Mode
[1,] 3      data.frame list
> summary(mikkoage)
     Length Class      Mode
[1,] 3      data.frame list
>
> ## Create length table for all years - Mikko areas
> length_mikko <- mikkolength[[1]]
> head(length_mikko)
  year Lgrp numbers_length
1 2003    5       27453157
2 2003   10       19771775
3 2003   15       12014735
4 2003   20       48852291
5 2003   25      121960748
6 2003   30      304966096
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   length_mikko <- rbind(length_mikko, mikkolength[[i]])
+ }
>
>
> ## Create 45+ group
> dim(length_mikko)
[1] 8 3
> length_mikko <- subset(length_mikko, Lgrp!="NA")
> dim(length_mikko)
[1] 8 3
>
>
> length_low <- subset(length_mikko, Lgrp<45)
> length_high <- subset(length_mikko, Lgrp>=45)
> dim(length_low)
[1] 8 3
> dim(length_high)
[1] 0 3
>
> temp <- length_high %>%
+   ddply("year", summarise,
+         numbers_length=sum(numbers_length))
>
> temp$Lgrp <- 45
>
> temp <- temp[,c(1,3,2)]
>
> length_mikko <- rbind(length_low, temp)
> length_mikko$model <- "Alternative"
> length_mikko$numbers_length <- (length_mikko$numbers_length)/1000
> length_mikko <- subset(length_mikko, Lgrp!=0)
>
> ## Create age table for all years - Mikko areas
> age_mikko <- mikkoage[[1]]
>
> for (i in ivec){
+   age_mikko <- rbind(age_mikko, mikkoage[[i]])
+ }
>
>
> ## Create 16+ group
> dim(age_mikko)
```

```
[1] 27  3
> age_mikko <- subset(age_mikko, age!="NA")
> dim(age_mikko)
[1] 27  3
>
> age_low <- subset(age_mikko, age<16)
> age_high <- subset(age_mikko, age>=16)
> dim(age_low)
[1] 15  3
> dim(age_high)
[1] 12  3
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         numbers_age=sum(numbers_age))
>
> temp$age <- 16
>
> temp <- temp[,c(1,3,2)]
>
> age_mikko <- rbind(age_low, temp)
> age_mikko$model <- "Alternative"
> age_mikko$numbers_age <- age_mikko$numbers_age/1000
> age_mikko <- subset(age_mikko, age!=1)
> for (i in years){
+
+   #lengthlist <- list()
+   #agelist <- list()
+
+   ######### New strata polygons - polygon_output_test.txt #######################
+
+   ## Extract data
+   #system.time(projects<-getNMDdata(cruise=myCS, group="year", subset = i, model="Sw
eptAreaTemplate", subdir=TRUE, abbrev=T, ow=TRUE,run = TRUE))
+
+   projects <- allpr[[i-pre]]
+
+   cruise.path=projects
+
+   ################# Setting of parameters - checked and confirmed with Tone #######
##############
+
+
+   ### Different Strata options - replace strata line in code below
+
+   # FileName="${STOX}/reference/stratum/Barents_Sea_Ecosystem_Survey_Areas_v2017.txt
"),
+   # FileName="${STOX}/reference/stratum/eco_strata.wkt"),
+   #FileName="${STOX}/reference/stratum/eco_afwg.txt"),
+
+   ## parameters
+   params <- list(FilterBiotic=list(functionName="FilterBiotic",
+                                    BioticData="Process(ReadBioticXML)",
+                                    #FishStationExpr="gear=~['3270','3271'] and gearc
ondition < 3 and trawlquality =~['1'] and fishstationtype != ['2','C']",
+                                    FishStationExpr="gear<'3500' and gearcondition <
3 and trawlquality =~['1'] and fishstationtype != ['2','C']",
+                                    CatchExpr="species =~['166756', '166705']"),
+                  DefineStrata=list(functionName="DefineStrata",
+                                    ProcessData="Process(ReadProcessData)",
+                                    UseProcessData=FALSE,
+                                    FileName="${STOX}/reference/stratum/polygon_outpu
t_test.txt"),
+                  SweptAreaDensity=list(functionName="SweptAreaDensity",
+                                        FishingWidthMethod="Constant",
+                                        FishingWidth="25"),
+                  StratumArea=list(AreaMethod="Accurate"),
+                  RegroupLengthDist=list(LengthInterval="5"))
+
+   ## run Baseline
+   runBaseline(projects, parlist=params, save=TRUE) # Test
+
+   readBaselineParametersJava(projects) # this will show the updated baseline paramet
ers in Java
```

```
+
+   # get the output
+   X=getBaseline(projects)
+
+   # Show superindividuals:
+   head(X$outputData$SuperIndAbundance)
+
+   ### Numbers-at-length
+   Y=data.frame(stratum=X$outputData$Abundance$SampleUnit,area=X$outputData$Abundance
$Area, Lgrp=X$outputData$Abundance$LengthGroup,abundance=X$outputData$Abundance$Abunda
nce)
+   print(Y)
+
+   # group_by
+   Y <- subset(Y, abundance!="NA")
+   dim(Y)
+
+   Y_length <- Y %>%
+     ddply("Lgrp", summarise,
+           numbers_length=sum(abundance))
+
+   Y_length$year <- i
+
+   Y_length <- Y_length[,c(3,1,2)]
+
+   #Y_strata <- Y %>%
+   #  group_by(length, stratum) %>%
+   #  summarise(numbers_length=sum(abundance)) #and then by stratum - similar to sumi
f()
+
+   #Y_length <- Y %>%
+   # group_by(Lgrp) %>%
+   #summarise(numbers_length=sum(abundance)) #calculates numbers per lenght class - s
imilar to sumif()
+
+   #write.table(Y, file=paste("index_length_rstox", year, ".txt", sep=""), sep="\t")
+
+
+   ### Bootstrapping and numbers-at-age ###############
+
+   # Run the bootstrapping to generate estimates of the variability in the data (cv):
+   rb1 <- runBootstrap(projects, nboot=50, cores=1, seed=1234, bioticMethod=PSU~Strat
um, bootstrapMethod="SweptAreaLength")
+   # Fill in missing data (missing length, weight and so on) based on the age informa
tion:
+   rb2 <- imputeByAge(projects,seed = 1234, cores =1, saveInd = TRUE)
+
+   # Save the bootstrap data:
+   saveProjectData(projects)
+
+   # Generate plots and reports:
+   plotfiles <- getPlots(projects)
+   reportfiles <- getReports(projects)
+
+   ### Extract rstox table for comparison
+   age_table=read.delim(paste0(cruise.path,"/output/r/report/bootstrapImpute_Abundanc
e_age.txt"),skip=9)
+
+   age_table$year <- i
+   age_table <- age_table[,c(8,1,2,3,4,5,6,7)]
+   age_uncertainv2[[i-pre]] <- age_table
+
+   #write.table(age_table, file=paste("index_age_rstox", year, ".txt", sep=""), sep="
\t")
+
+   Y_age <-  data.frame(age_table$age)
+   Y_age$numbers_age <- age_table$Ab.Sum.mean
+   Y_age$year <- i
+   names(Y_age) <- c("age", "numbers_age", "year")
+
+   Y_age <- Y_age[,c(3,1,2)]
+
+
+   mikkolengthv2[[i-pre]] <-Y_length
```

```
+   mikkoagev2[[i-pre]] <- Y_age
+
+   ############### End of standard RStoX process ###################
+
+ }
Running baseline process 6 to 15 (out of 15 processes)
Reading:
Baseline parameters
Process output ReadProcessData
Process output ReadBioticXML
Process output FilterBiotic
Process output StationLengthDist
Process output RegroupLengthDist
Process output DefineStrata
Process output StratumArea
Process output DefineSweptAreaPSU
Process output TotalLengthDist
Process output SweptAreaDensity
Process output MeanDensity_Stratum
Process output Abundance
Process output IndividualDataStations
Process output IndividualData
Process output SuperIndAbundance
Process output WriteProcessData
Process data bioticassignment
Process data suassignment
Process data assignmentresolution
Process data edsupsu
Process data psustratum
Process data stratumpolygon
Process data temporal
Process data gearfactor
Process data spatial
Process data platformfactor
Process data covparam
Process data ageerror
Process data stratumneighbour
        stratum       area Lgrp    abundance
1     D0-200_247  56290.186   NA           NA
2      D0-200_53   1359.868   NA           NA
3   D200-500_149 320225.719    5 6.576091e+06
4   D200-500_149 320225.719   10 3.053675e+07
5   D200-500_149 320225.719   15 3.201878e+07
6   D200-500_149 320225.719   20 1.322820e+08
7   D200-500_149 320225.719   25 3.193532e+08
8   D200-500_149 320225.719   30 6.118315e+08
9   D200-500_149 320225.719   35 1.590828e+08
10  D200-500_149 320225.719   40 6.190928e+06
11  D200-500_150   9431.042   NA           NA
12  D200-500_151  87075.956    5 1.017121e+07
13  D200-500_151  87075.956   10 1.235177e+06
14  D200-500_151  87075.956   15 3.401218e+06
15  D200-500_151  87075.956   20 8.209838e+05
16  D200-500_151  87075.956   25 4.300391e+05
17  D200-500_151  87075.956   30 1.303149e+05
18  D200-500_159     74.351   NA           NA
19   D500-750_20    264.069    5 8.891929e+03
20   D500-750_20    264.069   10 2.667579e+04
21   D500-750_20    264.069   15 8.891929e+03
22   D500-750_20    264.069   20 3.556771e+04
23   D500-750_20    264.069   30 8.891929e+03
24   D500-750_25   5200.698   10 3.255238e+05
25   D500-750_25   5200.698   15 2.140376e+03
26   D500-750_25   5200.698   20 8.530719e+04
27   D500-750_25   5200.698   25 1.759336e+06
28   D500-750_25   5200.698   30 1.553293e+07
29   D500-750_25   5200.698   35 2.183820e+06
30   D500-750_25   5200.698   40 1.105606e+05
31    D0-200_247  56290.186   NA           NA
32     D0-200_53   1359.868   NA           NA
33  D200-500_149 320225.719    5 1.859510e+07
34  D200-500_149 320225.719   10 5.656807e+06
35  D200-500_150   9431.042   NA           NA
36  D200-500_151  87075.956    5 1.594400e+07
```

```
37 D200-500_151  87075.956   10 2.017389e+06
38 D200-500_151  87075.956   15 1.466042e+05
39 D200-500_151  87075.956   30 1.466042e+05
40 D200-500_159     74.351  NA            NA
41   D500-750_20    264.069  NA            NA
42   D500-750_25   5200.698  NA            NA
Reading:
Process output SuperIndAbundance
Running 50 bootstrap replicates:
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 09s
Imputing missing data (50 replicates):
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 13s
Abundance by age for  bootstrap
 Abundance by age for  bootstrapImpute
    age    Ab.Sum.5%    Ab.Sum.50%    Ab.Sum.95%  Ab.Sum.mean     Ab.Sum.sd Ab.Sum.cv
1    NA 852.5598713 1.192205e+03 1852.9286571 1.259498e+03 3.024151e+02 0.2401077
2     1   0.4949455 9.905071e-01    1.7846258 1.068175e+00 4.123663e-01 0.3860477
3     2   0.0000000 3.023228e-01    0.6140623 3.206297e-01 1.910223e-01 0.5957722
4     3   1.2461782 2.267718e+00    3.6584590 2.308953e+00 7.785959e-01 0.3372074
5     4   2.1801774 3.058495e+00    4.0800217 3.102747e+00 7.187245e-01 0.2316413
6     5   0.8295220 1.474522e+00    2.0677159 1.443573e+00 4.176425e-01 0.2893117
7     6   3.0797492 4.523918e+00    6.2935628 4.499433e+00 1.011365e+00 0.2247761
8     7   3.9132220 5.413227e+00    7.9823251 5.600642e+00 1.278260e+00 0.2282345
9     8   6.4659741 1.678121e+01   27.9486923 1.595487e+01 6.622911e+00 0.4151027
10    9   8.2904826 1.558937e+01   26.8587724 1.663841e+01 6.206226e+00 0.3730059
11   10   2.3927647 4.996600e+00    7.4687025 4.881954e+00 1.537974e+00 0.3150324
12   11   1.4404720 3.405440e+00    5.1049598 3.290295e+00 1.212811e+00 0.3686024
13   12   2.6324636 5.924707e+00   10.5015517 6.093463e+00 2.520726e+00 0.4136772
14   13   4.3188211 1.203326e+01   19.7134556 1.181800e+01 4.444249e+00 0.3760577
15   14   7.4996584 1.461614e+01   26.7711053 1.528374e+01 6.048217e+00 0.3957290
16   15   5.9252979 1.305089e+01   18.3571142 1.273881e+01 4.413983e+00 0.3464987
17   16   2.1179686 2.762177e+00    3.8399927 2.903583e+00 5.525837e-01 0.1903110
18   17   0.0000000 2.886478e-01    0.4983460 2.962843e-01 1.587536e-01 0.5358153
19   18   0.3187162 1.256214e+00    1.9796634 1.208259e+00 5.055103e-01 0.4183790
20   19   0.0443591 2.781435e-01    0.4924706 2.833291e-01 1.412407e-01 0.4985039
21   20   0.0000000 4.795495e+00    6.5721233 3.516629e+00 2.750288e+00 0.7820808
22   21   0.0000000 1.909856e-01    0.2968137 1.404562e-01 1.221444e-01 0.8696263
23   22   0.0000000 2.771559e-01    0.5757714 3.053534e-01 1.733908e-01 0.5678364
24   23   1.0321308 2.766072e+00    3.9379232 2.638105e+00 9.844345e-01 0.3731597
25   24   0.5825101 2.177306e+00    2.9822346 1.984862e+00 7.660279e-01 0.3859351
26   27   0.0000000 9.728829e-03    0.0209812 1.025871e-02 6.553456e-03 0.6388185
27   28   0.0000000 9.801897e-01    1.4049677 7.494470e-01 5.489474e-01 0.7324700
28   43   0.0000000 2.495919e-01    0.3655553 1.929497e-01 1.464456e-01 0.7589834
   age  Ab.Sum.5%  Ab.Sum.50%  Ab.Sum.95% Ab.Sum.mean  Ab.Sum.sd Ab.Sum.cv
1    1 29.5625169  47.3756969  69.2779432  47.9332180 12.3255485 0.2571400
2    2  0.0000000   8.4289890  18.5257700   8.1305192  6.8637135 0.8441913
3    3 13.2998144  22.8810430  38.3469472  24.3141328  8.5200962 0.3504174
4    4 17.0584728  26.3948203  37.3559356  26.9555741  6.1335088 0.2275414
5    5  6.5028653  12.2764665  18.5046558  12.1230313  3.5860724 0.2958066
6    6 25.4212006  39.4728146  58.5083646  41.1493651 10.4713028 0.2544706
7    7 30.4462995  46.4712235  75.6792338  49.7579469 14.5220586 0.2918541
8    8 56.7062528 198.5552054 312.8588570 183.5585742 90.6929957 0.4940820
9    9 67.5484317 108.2350258 177.1392570 113.5727757 34.7456638 0.3059330
10  10 61.4572070 105.4324489 206.6988468 109.4211931 43.4015897 0.3966470
11  11 24.4979637  66.5511738 121.5305546  66.2235148 32.4367733 0.4898075
12  12 54.8686821 113.3368121 214.7652136 122.9304105 49.6463400 0.4038573
13  13 95.3590343 199.0956192 321.2356246 207.5484428 73.7792477 0.3554796
14  14 44.9535549 169.5211257 307.3238160 175.7047815 84.2461144 0.4794754
15  15 48.7878442 119.5653972 178.3041838 116.8980280 41.6191778 0.3560298
16  16 12.8169478  21.8626726  36.4043224  23.2216471  7.6595934 0.3298471
17  17  0.0000000   1.4115692   4.7212346   1.8156181  1.5642829 0.8615704
18  18  0.6015320   4.1301551   9.7895479   4.5343299  2.9150266 0.6428793
19  19  0.7016476   2.1695300   6.4668253   2.7921912  1.9277157 0.6903953
20  20  0.0000000  24.2590036  34.1308443  18.2452013 14.5537515 0.7976756
21  21  0.0000000   0.3963979   2.1613341   0.6418016  0.6601986 1.0286647
22  22  0.0000000   0.9490052   2.4534763   1.1059308  0.8818401 0.7973736
23  23  3.2635070   8.5224048  14.5157181   8.6799322  3.5703148 0.4113298
24  24  1.6378148   9.0640835  18.2466666   9.8768083  5.1754497 0.5240002
25  27  0.0000000   0.1732369   0.5018545   0.1826857  0.1584396 0.8672801
26  28  0.0000000   1.1364827   2.6101954   1.0041824  0.8483925 0.8448590
27  43  0.0000000   0.3105339   1.3223569   0.4492651  0.6078020 1.3528806
>
>
> ## check content of lists
```

```
> summary(mikkolengthv2)
     Length Class      Mode
[1,] 3      data.frame list
> summary(mikkoagev2)
     Length Class      Mode
[1,] 3      data.frame list
>
>
> ## Create length table for all years - AFWG strata
> length_mikkov2 <- mikkolengthv2[[1]]
> head(length_mikkov2)
  year Lgrp numbers_length
1 2003    5       51295291
2 2003   10       39798325
3 2003   15       35577632
4 2003   20      133223874
5 2003   25      321542606
6 2003   30      627650272
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   length_mikkov2 <- rbind(length_mikkov2, mikkolengthv2[[i]])
+ }
>
>
> ## Create 45+ group
> dim(length_mikkov2)
[1] 8 3
> length_mikkov2 <- subset(length_mikkov2, Lgrp!="NA")
> dim(length_mikkov2)
[1] 8 3
>
>
> length_low <- subset(length_mikkov2, Lgrp<45)
> length_high <- subset(length_mikkov2, Lgrp>=45)
> dim(length_low)
[1] 8 3
> dim(length_high)
[1] 0 3
>
> temp <- length_high %>%
+   ddply("year", summarise,
+         numbers_length=sum(numbers_length))
>
> temp$Lgrp <- 45
>
> temp <- temp[,c(1,3,2)]
>
> length_mikkov2 <- rbind(length_low, temp)
> length_mikkov2$model <- "Depth"
> length_mikkov2$numbers_length <- (length_mikkov2$numbers_length)/1000
> length_mikkov2 <- subset(length_mikkov2, Lgrp!=0)
>
> ## Create age table for all years - AFWG strata
> age_mikkov2 <- mikkoagev2[[1]]
>
> for (i in ivec){
+   age_mikkov2 <- rbind(age_mikkov2, mikkoagev2[[i]])
+ }
>
>
> ## Create 16+ group
> dim(age_mikkov2)
[1] 27  3
> age_mikkov2 <- subset(age_mikkov2, age!="NA")
> dim(age_mikkov2)
[1] 27  3
>
> age_low <- subset(age_mikkov2, age<16)
```

```
> age_high <- subset(age_mikkov2, age>=16)
> dim(age_low)
[1] 15  3
> dim(age_high)
[1] 12  3
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         numbers_age=sum(numbers_age))
>
> temp$age <- 16
>
> temp <- temp[,c(1,3,2)]
>
> age_mikkov2 <- rbind(age_low, temp)
> age_mikkov2$numbers_age <- age_mikkov2$numbers_age*1000
> age_mikkov2$model <- "Depth"
> age_mikkov2 <- subset(age_mikkov2, age!=1)
>
> ## Create age table with uncertainties - Mikkov2
> uncertainv2_age <- age_uncertainv2[[1]]
> head(uncertainv2_age)
  year age Ab.Sum.5. Ab.Sum.50. Ab.Sum.95. Ab.Sum.mean Ab.Sum.sd Ab.Sum.cv
1 2003   1 29.562517  47.375697   69.27794   47.933218 12.325548 0.2571400
2 2003   2  0.000000   8.428989   18.52577    8.130519  6.863713 0.8441913
3 2003   3 13.299814  22.881043   38.34695   24.314133  8.520096 0.3504174
4 2003   4 17.058473  26.394820   37.35594   26.955574  6.133509 0.2275414
5 2003   5  6.502865  12.276467   18.50466   12.123031  3.586072 0.2958066
6 2003   6 25.421201  39.472815   58.50836   41.149365 10.471303 0.2544706
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   uncertainv2_age <- rbind(uncertainv2_age, age_uncertainv2[[i]])
+ }
>
> names(uncertainv2_age) <- c("year", "age", "p05", "p50", "p95", "mean", "sd", "cv")
>
>
> ## Create 16+ group
> dim(uncertainv2_age)
[1] 27  8
> uncertainv2_age <- subset(uncertainv2_age, age!="NA")
> dim(uncertainv2_age)
[1] 27  8
>
> age_low <- subset(uncertainv2_age, age<16)
> age_high <- subset(uncertainv2_age, age>=16)
> dim(age_low)
[1] 15  8
> dim(age_high)
[1] 12  8
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         p05=sum(p05), p50=sum(p50), p95=sum(p95),
+         mean=sum(mean), sd=mean(sd), cv=mean(cv))
>
> temp$age <- 16
>
> temp <- temp[,c(1,8,2,3,4,5,6,7)]
>
> uncertainv2_age <- rbind(age_low, temp)
> uncertainv2_age$model <- "Depth"
> uncertainv2_age$mean <- uncertainv2_age$mean*1000
> uncertainv2_age$p05 <- uncertainv2_age$p05*1000
> uncertainv2_age$p95 <- uncertainv2_age$p95*1000
> uncertainv2_age <- subset(uncertainv2_age, age!=1)
>
```

```
> for (i in years){
+
+   #lengthlist <- list()
+   #agelist <- list()
+
+   ######### New standard strata - WKT_Basic_ECO.txt ######################
+
+   ## Extract data
+   #system.time(projects<-getNMDdata(cruise=myCS, group="year", subset = i, model="SweptAre
TRUE, abbrev=T, ow=TRUE,run = TRUE))
+
+   projects <- allpr[[i-pre]]
+
+   cruise.path=projects
+
+   ################## Setting of parameters - checked and confirmed with Tone #############
+
+
+   ### Different Strata options - replace strata line in code below
+
+   # FileName="${STOX}/reference/stratum/Barents_Sea_Ecosystem_Survey_Areas_v2017.txt"),
+   # FileName="${STOX}/reference/stratum/eco_strata.wkt"),
+   #FileName="${STOX}/reference/stratum/eco_afwg.txt"),
+
+   ## parameters
+   params <- list(FilterBiotic=list(functionName="FilterBiotic",
+                                    BioticData="Process(ReadBioticXML)",
+                                    #FishStationExpr="gear=~['3270','3271'] and gearconditi
lity =~['1'] and fishstationtype != ['2','C']",
+                                    FishStationExpr="gear<'3500' and gearcondition < 3 and
] and fishstationtype != ['2','C']",
+                                    CatchExpr="species =~['166756', '166705']"),
+                  DefineStrata=list(functionName="DefineStrata",
+                                    ProcessData="Process(ReadProcessData)",
+                                    UseProcessData=FALSE,
+                                    FileName="${STOX}/reference/stratum/WKT_Basic_ECO.txt")
+                  SweptAreaDensity=list(functionName="SweptAreaDensity",
+                                        FishingWidthMethod="Constant",
+                                        FishingWidth="25"),
+                  StratumArea=list(AreaMethod="Accurate"),
+                  RegroupLengthDist=list(LengthInterval="5"))
+
+   ## run Baseline
+   runBaseline(projects, parlist=params, save=TRUE) # Test
+
+   readBaselineParametersJava(projects) # this will show the updated baseline parameters in
+
+   # get the output
+   X=getBaseline(projects)
+
+   # Show superindividuals:
+   head(X$outputData$SuperIndAbundance)
+
+   ### Numbers-at-length
+   Y=data.frame(stratum=X$outputData$Abundance$SampleUnit,area=X$outputData$Abundance$Area,
Abundance$LengthGroup,abundance=X$outputData$Abundance$Abundance)
+   print(Y)
+
+   # group_by
+   Y <- subset(Y, abundance!="NA")
+   dim(Y)
+
+   Y_length <- Y %>%
+     ddply("Lgrp", summarise,
+           numbers_length=sum(abundance))
+
+   Y_length$year <- i
+
+   Y_length <- Y_length[,c(3,1,2)]
+
+   #Y_strata <- Y %>%
+   #  group_by(length, stratum) %>%
+   #  summarise(numbers_length=sum(abundance)) #and then by stratum - similar to sumif()
+
```

```
+   #Y_length <- Y %>%
+   # group_by(Lgrp) %>%
+   #summarise(numbers_length=sum(abundance)) #calculates numbers per lenght class - similar
+
+   #write.table(Y, file=paste("index_length_rstox", year, ".txt", sep=""), sep="\t")
+
+
+   ### Bootstrapping and numbers-at-age ###############
+
+   # Run the bootstrapping to generate estimates of the variability in the data (cv):
+   rb1 <- runBootstrap(projects, nboot=50, cores=1, seed=1234, bioticMethod=PSU~Stratum, bo
tAreaLength")
+   # Fill in missing data (missing length, weight and so on) based on the age information:
+   rb2 <- imputeByAge(projects,seed = 1234, cores =1, saveInd = TRUE)
+
+   # Save the bootstrap data:
+   saveProjectData(projects)
+
+   # Generate plots and reports:
+   plotfiles <- getPlots(projects)
+   reportfiles <- getReports(projects)
+
+   ### Extract rstox table for comparison
+   age_table=read.delim(paste0(cruise.path,"/output/r/report/bootstrapImpute_Abundance_age.
+
+   age_table$year <- i
+   age_table <- age_table[,c(8,1,2,3,4,5,6,7)]
+   age_uncertainv3[[i-pre]] <- age_table
+
+   #write.table(age_table, file=paste("index_age_rstox", year, ".txt", sep=""), sep="\t")
+
+   Y_age <-  data.frame(age_table$age)
+   Y_age$numbers_age <- age_table$Ab.Sum.mean
+   Y_age$year <- i
+   names(Y_age) <- c("age", "numbers_age", "year")
+
+   Y_age <- Y_age[,c(3,1,2)]
+
+
+   basiclength[[i-pre]] <-Y_length
+   basicage[[i-pre]] <- Y_age
+
+   ############### End of standard RStoX process ###################
+
+ }
Running baseline process 6 to 15 (out of 15 processes)
Reading:
Baseline parameters
Process output ReadProcessData
Process output ReadBioticXML
Process output FilterBiotic
Process output StationLengthDist
Process output RegroupLengthDist
Process output DefineStrata
Process output StratumArea
Process output DefineSweptAreaPSU
Process output TotalLengthDist
Process output SweptAreaDensity
Process output MeanDensity_Stratum
Process output Abundance
Process output IndividualDataStations
Process output IndividualData
Process output SuperIndAbundance
Process output WriteProcessData
Process data bioticassignment
Process data suassignment
Process data assignmentresolution
Process data edsupsu
Process data psustratum
Process data stratumpolygon
Process data temporal
Process data gearfactor
Process data spatial
Process data platformfactor
```

```
Process data covparam
Process data ageerror
Process data stratumneighbour
   stratum     area Lgrp    abundance
1        1 42347.07    5    983446.78
2        1 42347.07   10   1856966.49
3        1 42347.07   15   1706650.34
4        1 42347.07   20   6523853.91
5        1 42347.07   25   8616004.41
6        1 42347.07   30  23098541.67
7        1 42347.07   35   3798072.58
8        1 42347.07   40    351329.79
9        2 85314.83   20   5266768.95
10       2 85314.83   25   2633384.48
11       2 85314.83   30   2633384.48
12       3 16326.97    5   1027664.53
13       3 16326.97   10   3496868.41
14       3 16326.97   15   3144098.04
15       3 16326.97   20  15988292.43
16       3 16326.97   25  24972045.20
17       3 16326.97   30  14055269.27
18       3 16326.97   35   3298816.74
19       3 16326.97   40    243377.34
20       4 41556.31    5    671116.59
21       4 41556.31   10   2146792.07
22       4 41556.31   15   4626893.77
23       4 41556.31   20   5469308.58
24       4 41556.31   25  55271456.18
25       4 41556.31   30 193867316.67
26       4 41556.31   35  52008991.71
27       4 41556.31   40   1093648.19
28       5 42165.29   NA           NA
29       6 34890.13    5    254135.55
30       6 34890.13   10    526505.04
31       6 34890.13   15   1905446.82
32       6 34890.13   20   4552787.10
33       6 34890.13   25  19654021.67
34       6 34890.13   30  58745182.75
35       6 34890.13   35  12460823.01
36       6 34890.13   40    424595.04
37       7 22716.01   15    116861.23
38       8 79168.49    5   7853612.05
39       8 79168.49   10   1033790.38
40       8 79168.49   20    200506.03
41       8 79168.49   25     87273.83
42       1 42347.07    5   5098431.53
43       1 42347.07   10    706809.15
44       2 85314.83   NA           NA
45       3 16326.97    5   2658742.28
46       3 16326.97   10    817332.06
47       4 41556.31    5   2806353.76
48       4 41556.31   10     72605.93
49       5 42165.29   NA           NA
50       6 34890.13   15     89745.18
51       6 34890.13   30     89745.18
52       7 22716.01   NA           NA
53       8 79168.49    5   3544660.25
54       8 79168.49   10   1204378.88
Reading:
Process output SuperIndAbundance
Running 50 bootstrap replicates:
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 08s
Imputing missing data (50 replicates):
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 11s
Abundance by age for  bootstrap
 Abundance by age for  bootstrapImpute
    age    Ab.Sum.5%   Ab.Sum.50%   Ab.Sum.95%  Ab.Sum.mean    Ab.Sum.sd Ab.Sum.cv
1    NA 349.49012202 489.85756184 624.56114399 491.22290165 87.95226171 0.1790476
2     1   0.28913677   0.62534590   1.11160886   0.65337010  0.25559590 0.3911962
3     2   0.00000000   0.17441072   0.33930105   0.17031382  0.10941302 0.6424201
4     3   0.63274998   1.17078450   1.79281165   1.19722488  0.37193615 0.3106652
5     4   1.20154952   1.76184636   2.37321722   1.81120601  0.40179371 0.2218377
6     5   0.42696930   0.80738692   1.21711680   0.79445681  0.24951756 0.3140732
7     6   2.30743801   4.62917116   9.00414484   4.90642088  2.20115087 0.4486266
```

```
8    7   1.99259073  7.71963052 15.71720524  7.62988840 4.58687368 0.6011718
9    8   3.23658134  4.98521502  7.64443939  5.18050561 1.29046681 0.2491006
10   9   5.27322936  8.77132221 13.25706457  8.93681702 2.69733216 0.3018225
11  10   1.62862795  2.42884663  3.48102307  2.51587518 0.63235375 0.2513454
12  11   1.20782144  4.25575155  8.88140218  4.33832715 2.44551862 0.5637008
13  12   1.23464363  3.43029787  5.17539403  3.24553664 1.19680783 0.3687550
14  13   1.90919379  2.59820140  4.32033658  2.84955120 0.78877580 0.2768070
15  14   2.54823963  7.07183725 11.67812639  7.03707564 2.64200159 0.3754403
16  15   2.77153140  5.26496738  7.67133327  5.33093971 1.54799138 0.2903787
17  16   0.77117213  1.43645692  1.93178640  1.39346915 0.35660809 0.2559139
18  17   0.00000000  0.15507499  0.28626069  0.16627173 0.09451653 0.5684462
19  18   0.22123602  0.85482775  1.20003147  0.79742409 0.30956856 0.3882107
20  19   0.05178904  0.16833929  0.29514190  0.16746502 0.08015572 0.4786416
21  20   0.00000000  2.38936270  3.84541819  1.89197773 1.40115225 0.7405754
22  21   0.00000000  0.09991543  0.21926177  0.08610937 0.07903489 0.9178431
23  22   0.00000000  0.14476768  0.29039910  0.14567105 0.09781501 0.6714787
24  23   0.26877801  0.65847866  1.23328519  0.70822865 0.31002398 0.4377456
25  24   0.15985678  0.67376902  1.11093477  0.67934418 0.29213629 0.4300269
26  28   0.00000000  0.42459504  0.84919007  0.39062743 0.34140467 0.8739905
27  43   0.00000000  0.03047677  0.05381288  0.02375597 0.02150848 0.9053924
   age  Ab.Sum.5% Ab.Sum.50%  Ab.Sum.95% Ab.Sum.mean  Ab.Sum.sd Ab.Sum.cv
1    1 10.3971117 22.3104221  34.5969796  22.1198099  7.2517997 0.3278419
2    2  0.0000000  2.6845932   7.9916056   3.2444488  2.7684762 0.8532963
3    3  4.0295061  6.7797150   9.4383936   6.8506484  1.7085359 0.2493977
4    4  6.4824702  8.7840917  14.9757378   9.4810886  2.9199250 0.3079736
5    5  1.6799468  3.7071035   5.7213892   3.7046505  1.2815154 0.3459207
6    6  9.1159099 13.6980243  18.2221155  13.4931611  2.7431042 0.2032959
7    7 10.1935701 19.9129027  30.4686913  19.9178618  6.1264988 0.3075882
8    8 25.1451477 47.0169784  76.5522760  49.4589967 16.5960163 0.3355510
9    9 30.7681949 50.1450841  76.8891091  51.7197394 14.4353942 0.2791080
10  10 15.1538995 43.9756087  84.8549525  44.8898823 20.4793111 0.4562122
11  11 13.6327522 31.3410251  65.6332502  35.3453099 18.9585673 0.5363814
12  12 20.5865405 69.1067920 111.2467288  68.1835203 30.2069861 0.4430247
13  13 35.5273612 55.0204635  96.4947682  58.7323043 20.5138146 0.3492765
14  14 24.7352217 79.4134292 130.9206656  82.6998746 36.2543373 0.4383844
15  15 21.0042965 58.8339402  91.0123874  57.4649872 23.0053892 0.4003375
16  16  4.1980332  9.0180167  15.5493839   9.6306899  3.7396562 0.3883062
17  17  0.0000000  0.6072781   1.3841369   0.6175830  0.4701604 0.7612910
18  18  0.2212360  1.2505590   2.7822192   1.3416186  0.8168378 0.6088450
19  19  0.1104016  0.6780661   1.5279585   0.7757292  0.5101283 0.6576113
20  20  0.0000000 12.3360699  19.7465397   9.7669746  7.4464733 0.7624135
21  21  0.0000000  0.1148675   0.5145826   0.1446322  0.1682553 1.1633317
22  22  0.0000000  0.1510817   0.3253942   0.1641661  0.1225061 0.7462326
23  23  0.5231789  1.3919211   2.4500635   1.5065356  0.5949600 0.3949193
24  24  0.7200635  1.9226789   4.7068880   2.4786340  2.1349143 0.8613270
25  28  0.0000000  0.4245950   0.8888043   0.4008534  0.3480420 0.8682527
26  43  0.0000000  0.1191298   0.3941959   0.1370547  0.1454142 1.0609942
>
>
> ## check content of lists
> summary(basiclength)
     Length Class      Mode
[1,] 3      data.frame list
> summary(basicage)
     Length Class      Mode
[1,] 3      data.frame list
>
>
> ## Create length table for all years - AFWG strata
> length_basic <- basiclength[[1]]
> head(length_basic)
  year Lgrp numbers_length
1 2003    5       24898163
2 2003   10       11862048
3 2003   15       11589695
4 2003   20       38001517
5 2003   25      111234186
6 2003   30      292489440
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
```

```
>
> for (i in ivec){
+   length_basic <- rbind(length_basic, basiclength[[i]])
+ }
>
> write.csv(length_basic, "length_basic.csv")
>
> ## Create 45+ group
> dim(length_basic)
[1] 8 3
> length_basic <- subset(length_basic, Lgrp!="NA")
> dim(length_basic)
[1] 8 3
>
>
> length_low <- subset(length_basic, Lgrp<45)
> length_high <- subset(length_basic, Lgrp>=45)
> dim(length_low)
[1] 8 3
> dim(length_high)
[1] 0 3
>
> temp <- length_high %>%
+   ddply("year", summarise,
+         numbers_length=sum(numbers_length))
>
> temp$Lgrp <- 45
>
> temp <- temp[,c(1,3,2)]
>
> length_basic <- rbind(length_low, temp)
> length_basic$model <- "Basic"
> length_basic$numbers_length <- (length_basic$numbers_length)/1000
> length_basic <- subset(length_basic, Lgrp!=0)
>
> ## Create age table for all years - AFWG strata
> age_basic <- basicage[[1]]
>
> for (i in ivec){
+   age_basic <- rbind(age_basic, basicage[[i]])
+ }
Error in basicage[[i]] : subscript out of bounds
>
>
> ## Create 16+ group
> dim(age_basic)
[1] 26  3
> age_basic <- subset(age_basic, age!="NA")
> dim(age_basic)
[1] 26  3
>
> age_low <- subset(age_basic, age<16)
> age_high <- subset(age_basic, age>=16)
> dim(age_low)
[1] 15  3
> dim(age_high)
[1] 11  3
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         numbers_age=sum(numbers_age))
>
> temp$age <- 16
>
> temp <- temp[,c(1,3,2)]
>
> age_basic <- rbind(age_low, temp)
> age_basic$numbers_age <- age_basic$numbers_age*1000
> age_basic$model <- "Basic"
> age_basic <- subset(age_basic, age!=1)
>
> ## Create age table with uncertainv3ties - basic
> uncertainv3_age <- age_uncertainv3[[1]]
> head(uncertainv3_age)
```

```
  year age Ab.Sum.5. Ab.Sum.50. Ab.Sum.95. Ab.Sum.mean Ab.Sum.sd Ab.Sum.cv
1 2003   1 10.397112 22.310422  34.596980   22.119810  7.251800 0.3278419
2 2003   2  0.000000  2.684593   7.991606    3.244449  2.768476 0.8532963
3 2003   3  4.029506  6.779715   9.438394    6.850648  1.708536 0.2493977
4 2003   4  6.482470  8.784092  14.975738    9.481089  2.919925 0.3079736
5 2003   5  1.679947  3.707104   5.721389    3.704650  1.281515 0.3459207
6 2003   6  9.115910 13.698024  18.222116   13.493161  2.743104 0.2032959
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   uncertainv3_age <- rbind(uncertainv3_age, age_uncertainv3[[i]])
+ }
>
> names(uncertainv3_age) <- c("year", "age", "p05", "p50", "p95", "mean", "sd", "cv")
>
> write.csv(uncertainv3_age, "uncertain_age_basic.csv")
>
> ## Create 16+ group
> dim(uncertainv3_age)
[1] 26  8
> uncertainv3_age <- subset(uncertainv3_age, age!="NA")
> dim(uncertainv3_age)
[1] 26  8
>
> age_low <- subset(uncertainv3_age, age<16)
> age_high <- subset(uncertainv3_age, age>=16)
> dim(age_low)
[1] 15  8
> dim(age_high)
[1] 11  8
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         p05=sum(p05), p50=sum(p50), p95=sum(p95),
+         mean=sum(mean), sd=mean(sd), cv=mean(cv))
>
> temp$age <- 16
>
> temp <- temp[,c(1,8,2,3,4,5,6,7)]
>
> uncertainv3_age <- rbind(age_low, temp)
> uncertainv3_age$model <- "Basic"
> uncertainv3_age$mean <- uncertainv3_age$mean*1000
> uncertainv3_age$p05 <- uncertainv3_age$p05*1000
> uncertainv3_age$p95 <- uncertainv3_age$p95*1000
> uncertainv3_age <- subset(uncertainv3_age, age!=1)
>
>
> for (i in years){
+
+   #lengthlist <- list()
+   #agelist <- list()
+
+   ######### New standard strata - WKT_Basic_plus.txt ######################
+
+   ## Extract data
+   #system.time(projects<-getNMDdata(cruise=myCS, group="year", subset = i, model="SweptAre
TRUE, abbrev=T, ow=TRUE,run = TRUE))
+
+   projects <- allpr[[i-pre]]
+
+   cruise.path=projects
+
+   ################# Setting of parameters - checked and confirmed with Tone ############
+
+
+   ### Different Strata options - replace strata line in code below
+
+   # FileName="${STOX}/reference/stratum/Barents_Sea_Ecosystem_Survey_Areas_v2017.txt"),
```

```
+   # FileName="${STOX}/reference/stratum/eco_strata.wkt"),
+   #FileName="${STOX}/reference/stratum/eco_afwg.txt"),
+
+   ## parameters
+   params <- list(FilterBiotic=list(functionName="FilterBiotic",
+                                    BioticData="Process(ReadBioticXML)",
+                                    #FishStationExpr="gear=~['3270','3271'] and gearconditi
lity =~['1'] and fishstationtype != ['2','C']",
+                                    FishStationExpr="gear<'3500' and gearcondition < 3 and
] and fishstationtype != ['2','C']",
+                                    CatchExpr="species =~['166756', '166705']"),
+                  DefineStrata=list(functionName="DefineStrata",
+                                    ProcessData="Process(ReadProcessData)",
+                                    UseProcessData=FALSE,
+                                    FileName="${STOX}/reference/stratum/WKT_Basic_plus.txt"
+                  SweptAreaDensity=list(functionName="SweptAreaDensity",
+                                        FishingWidthMethod="Constant",
+                                        FishingWidth="25"),
+                  StratumArea=list(AreaMethod="Accurate"),
+                  RegroupLengthDist=list(LengthInterval="5"))
+
+   ## run Baseline
+   runBaseline(projects, parlist=params, save=TRUE) # Test
+
+   readBaselineParametersJava(projects) # this will show the updated baseline parameters in
+
+   # get the output
+   X=getBaseline(projects)
+
+   # Show superindividuals:
+   head(X$outputData$SuperIndAbundance)
+
+   ### Numbers-at-length
+   Y=data.frame(stratum=X$outputData$Abundance$SampleUnit,area=X$outputData$Abundance$Area,
Abundance$LengthGroup,abundance=X$outputData$Abundance$Abundance)
+   print(Y)
+
+   # group_by
+   Y <- subset(Y, abundance!="NA")
+   dim(Y)
+
+   Y_length <- Y %>%
+     ddply("Lgrp", summarise,
+           numbers_length=sum(abundance))
+
+   Y_length$year <- i
+
+   Y_length <- Y_length[,c(3,1,2)]
+
+   #Y_strata <- Y %>%
+   #  group_by(length, stratum) %>%
+   #  summarise(numbers_length=sum(abundance)) #and then by stratum - similar to sumif()
+
+   #Y_length <- Y %>%
+   # group_by(Lgrp) %>%
+   #summarise(numbers_length=sum(abundance)) #calculates numbers per lenght class - similar
+
+   #write.table(Y, file=paste("index_length_rstox", year, ".txt", sep=""), sep="\t")
+
+
+   ### Bootstrapping and numbers-at-age ###############
+
+   # Run the bootstrapping to generate estimates of the variability in the data (cv):
+   rb1 <- runBootstrap(projects, nboot=50, cores=1, seed=1234, bioticMethod=PSU~Stratum, bo
tAreaLength")
+   # Fill in missing data (missing length, weight and so on) based on the age information:
+   rb2 <- imputeByAge(projects,seed = 1234, cores =1, saveInd = TRUE)
+
+   # Save the bootstrap data:
+   saveProjectData(projects)
+
+   # Generate plots and reports:
+   plotfiles <- getPlots(projects)
+   reportfiles <- getReports(projects)
```

```
+
+    ### Extract rstox table for comparison
+    age_table=read.delim(paste0(cruise.path,"/output/r/report/bootstrapImpute_Abundance_age.
+
+    age_table$year <- i
+    age_table <- age_table[,c(8,1,2,3,4,5,6,7)]
+    age_uncertainv4[[i-pre]] <- age_table
+
+    #write.table(age_table, file=paste("index_age_rstox", year, ".txt", sep=""), sep="\t")
+
+    Y_age <-  data.frame(age_table$age)
+    Y_age$numbers_age <- age_table$Ab.Sum.mean
+    Y_age$year <- i
+    names(Y_age) <- c("age", "numbers_age", "year")
+
+    Y_age <- Y_age[,c(3,1,2)]
+
+
+    basicpluslength[[i-pre]] <-Y_length
+    basicplusage[[i-pre]] <- Y_age
+
+    ############### End of standard RStoX process ####################
+
+ }
Running baseline process 6 to 15 (out of 15 processes)
Reading:
Baseline parameters
Process output ReadProcessData
Process output ReadBioticXML
Process output FilterBiotic
Process output StationLengthDist
Process output RegroupLengthDist
Process output DefineStrata
Process output StratumArea
Process output DefineSweptAreaPSU
Process output TotalLengthDist
Process output SweptAreaDensity
Process output MeanDensity_Stratum
Process output Abundance
Process output IndividualDataStations
Process output IndividualData
Process output SuperIndAbundance
Process output WriteProcessData
Process data bioticassignment
Process data suassignment
Process data assignmentresolution
Process data edsupsu
Process data psustratum
Process data stratumpolygon
Process data temporal
Process data gearfactor
Process data spatial
Process data platformfactor
Process data covparam
Process data ageerror
Process data stratumneighbour
       stratum      area Lgrp    abundance
1            1 42347.067    5 9.834468e+05
2            1 42347.067   10 1.856966e+06
3            1 42347.067   15 1.706650e+06
4            1 42347.067   20 6.523854e+06
5            1 42347.067   25 8.616004e+06
6            1 42347.067   30 2.309854e+07
7            1 42347.067   35 3.798073e+06
8            1 42347.067   40 3.513298e+05
9            2 85314.832   20 5.266769e+06
10           2 85314.832   25 2.633384e+06
11           2 85314.832   30 2.633384e+06
12           3 16326.968    5 1.027665e+06
13           3 16326.968   10 3.496868e+06
14           3 16326.968   15 3.144098e+06
15           3 16326.968   20 1.598829e+07
16           3 16326.968   25 2.497205e+07
17           3 16326.968   30 1.405527e+07
```

```
18          3 16326.968   35 3.298817e+06
19          3 16326.968   40 2.433773e+05
20          4 41556.311    5 6.711166e+05
21          4 41556.311   10 2.146792e+06
22          4 41556.311   15 4.626894e+06
23          4 41556.311   20 5.469309e+06
24          4 41556.311   25 5.527146e+07
25          4 41556.311   30 1.938673e+08
26          4 41556.311   35 5.200899e+07
27          4 41556.311   40 1.093648e+06
28          5 42165.290   NA           NA
29          6 34890.134    5 2.541355e+05
30          6 34890.134   10 5.265050e+05
31          6 34890.134   15 1.905447e+06
32          6 34890.134   20 4.552787e+06
33          6 34890.134   25 1.965402e+07
34          6 34890.134   30 5.874518e+07
35          6 34890.134   35 1.246082e+07
36          6 34890.134   40 4.245950e+05
37          7 22716.006   15 1.168612e+05
38          8 79168.487    5 7.853612e+06
39          8 79168.487   10 1.033790e+06
40          8 79168.487   20 2.005060e+05
41          8 79168.487   25 8.727383e+04
42 D500-750_20   264.069    5 8.891929e+03
43 D500-750_20   264.069   10 2.667579e+04
44 D500-750_20   264.069   15 8.891929e+03
45 D500-750_20   264.069   20 3.556771e+04
46 D500-750_20   264.069   30 8.891929e+03
47 D500-750_25  5200.698   10 3.255238e+05
48 D500-750_25  5200.698   15 2.140376e+03
49 D500-750_25  5200.698   20 8.530719e+04
50 D500-750_25  5200.698   25 1.759336e+06
51 D500-750_25  5200.698   30 1.553293e+07
52 D500-750_25  5200.698   35 2.183820e+06
53 D500-750_25  5200.698   40 1.105606e+05
54          1 42347.067    5 5.098432e+06
55          1 42347.067   10 7.068091e+05
56          2 85314.832   NA           NA
57          3 16326.968    5 2.658742e+06
58          3 16326.968   10 8.173321e+05
59          4 41556.311    5 2.806354e+06
60          4 41556.311   10 7.260593e+04
61          5 42165.290   NA           NA
62          6 34890.134   15 8.974518e+04
63          6 34890.134   30 8.974518e+04
64          7 22716.006   NA           NA
65          8 79168.487    5 3.544660e+06
66          8 79168.487   10 1.204379e+06
67 D500-750_20   264.069   NA           NA
68 D500-750_25  5200.698   NA           NA
Reading:
Process output SuperIndAbundance
Running 50 bootstrap replicates:
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 10s
Imputing missing data (50 replicates):
   |++++++++++++++++++++++++++++++++++++++++++++++++++| 100% elapsed = 12s
Abundance by age for  bootstrap
 Abundance by age for  bootstrapImpute
    age    Ab.Sum.5%    Ab.Sum.50%   Ab.Sum.95%  Ab.Sum.mean    Ab.Sum.sd Ab.Sum.cv
1    NA 3.683562e+02 5.033052e+02 653.01655403 508.43325294 92.023376811 0.1809940
2     1 2.891368e-01 6.253459e-01   1.11160886   0.65337010  0.255595896 0.3911962
3     2 0.000000e+00 1.744107e-01   0.33930105   0.17031382  0.109413020 0.6424201
4     3 6.327500e-01 1.170784e+00   1.79281165   1.19722488  0.371936154 0.3106652
5     4 1.201550e+00 1.761846e+00   2.37321722   1.81120601  0.401793710 0.2218377
6     5 4.269693e-01 8.073869e-01   1.21711680   0.79445681  0.249517560 0.3140732
7     6 2.307438e+00 4.629171e+00   9.00414484   4.90642088  2.201150866 0.4486266
8     7 1.992591e+00 7.719631e+00  15.71720524   7.62988840  4.586873676 0.6011718
9     8 3.485090e+00 5.430106e+00   8.21966819   5.49755317  1.419298514 0.2581691
10    9 5.295431e+00 9.079785e+00  13.92751044   9.23429203  2.808024500 0.3040866
11   10 1.628628e+00 2.428847e+00   3.48102307   2.51587518  0.632353751 0.2513454
12   11 1.207821e+00 4.255752e+00   8.88140218   4.33832715  2.445518619 0.5637008
13   12 1.234644e+00 3.430298e+00   5.17539403   3.24553664  1.196807826 0.3687550
14   13 2.041945e+00 3.153448e+00   5.57460267   3.44495209  1.118960219 0.3248115
```

```
15  14 2.562527e+00 7.403695e+00  12.15890515   7.34482121  2.770116362 0.3771523
16  15 2.777382e+00 5.780324e+00   7.83118823   5.63859155  1.632493714 0.2895215
17  16 7.711721e-01 1.436457e+00   1.93178640   1.39346915  0.356608090 0.2559139
18  17 0.000000e+00 1.550750e-01   0.28626069   0.16627173  0.094516529 0.5684462
19  18 2.212360e-01 8.548278e-01   1.20003147   0.79742409  0.309568559 0.3882107
20  19 5.733118e-02 1.893179e-01   0.30671384   0.17752854  0.079389990 0.4471956
21  20 0.000000e+00 2.389363e+00   3.84541819   1.89197773  1.401152248 0.7405754
22  21 8.230572e-03 1.080620e-01   0.22860462   0.09636809  0.078240196 0.8118891
23  22 0.000000e+00 1.447677e-01   0.29039910   0.14567105  0.097815006 0.6714787
24  23 2.687780e-01 6.584787e-01   1.23328519   0.70822865  0.310023978 0.4377456
25  24 1.598568e-01 6.737690e-01   1.11093477   0.67934418  0.292136286 0.4300269
26  27 0.000000e+00 9.728829e-03   0.02098120   0.01025871  0.006553456 0.6388185
27  28 0.000000e+00 4.245950e-01   0.84919007   0.39062743  0.341404671 0.8739905
28  43 0.000000e+00 3.047677e-02   0.05381288   0.02375597  0.021508479 0.9053924
   age   Ab.Sum.5% Ab.Sum.50%  Ab.Sum.95% Ab.Sum.mean  Ab.Sum.sd Ab.Sum.cv
1    1 10.68619467 22.7718417  36.4874442  22.3792370  7.4831372 0.3343786
2    2  0.00000000  2.6483644   7.8907283   2.8920426  2.6410543 0.9132142
3    3  4.69692810  7.1333361  10.3849823   7.1182187  1.7870212 0.2510489
4    4  6.19831468  9.0525743  14.1094641   9.5993841  2.8538250 0.2972925
5    5  1.85177615  3.6304996   5.5014639   3.7266759  1.2114086 0.3250641
6    6  9.19662591 13.5399057  18.7019620  13.5801423  2.7490464 0.2024313
7    7 10.22176034 19.6942106  27.7606108  19.5052781  5.6435375 0.2893339
8    8 30.68314189 48.3810686  76.4990508  51.1629409 15.7134130 0.3071249
9    9 32.92727707 52.7984627  75.8144374  52.3210518 14.0423603 0.2683883
10  10 15.67332457 44.1903620  82.2897785  45.6683769 19.8835031 0.4353889
11  11 12.85260464 30.5032515  65.0009078  35.3319167 17.5650379 0.4971436
12  12 19.78152970 68.5743787 111.7926419  67.0574396 29.3579927 0.4378037
13  13 43.75476267 69.6763888 107.1662634  73.0581830 25.1333783 0.3440187
14  14 22.48492990 80.5600645 136.6341201  83.2201449 36.5795719 0.4395519
15  15 22.16980117 59.1189125  93.0906852  58.4767549 23.1389558 0.3956949
16  16  4.08891103  7.8419936  19.9924560   9.6450901  5.1910173 0.5382031
17  17  0.00000000  0.5551485   1.9573681   0.6941323  0.6327231 0.9115310
18  18  0.23085689  1.1855405   2.1218379   1.2856642  0.7936381 0.6172981
19  19  0.54456955  1.1274368   2.8021421   1.3599772  0.7143934 0.5252980
20  20  0.00000000 12.7099214  19.5527573   9.8418297  7.5448266 0.7666081
21  21  0.06045694  0.3079030   0.6803270   0.3309258  0.1989716 0.6012573
22  22  0.00000000  0.1550794   0.3212508   0.1683708  0.1166878 0.6930406
23  23  0.63634748  1.3913753   2.3974242   1.5225701  0.5812744 0.3817719
24  24  0.59676673  2.1522549   5.2239585   2.6549320  2.1695141 0.8171637
25  27  0.00000000  0.1780568   0.4304465   0.1827380  0.1359340 0.7438736
26  28  0.00000000  0.4319753   0.8805516   0.4067109  0.3566316 0.8768676
27  43  0.00000000  0.1194189   0.4156014   0.1462795  0.1533068 1.0480403
>
>
> ## check content of lists
> summary(basicpluslength)
     Length Class      Mode
[1,] 3      data.frame list
> summary(basicplusage)
     Length Class      Mode
[1,] 3      data.frame list
>
>
> ## Create length table for all years - AFWG strata
> length_basicplus <- basicpluslength[[1]]
> head(length_basicplus)
  year Lgrp numbers_length
1 2003    5       24907055
2 2003   10       12214248
3 2003   15       11600728
4 2003   20       38122392
5 2003   25      112993522
6 2003   30      308031262
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   length_basicplus <- rbind(length_basicplus, basicpluslength[[i]])
+ }
>
```

```
> write.csv(length_basicplus, "length_basicplus.csv")
>
> ## Create 45+ group
> dim(length_basicplus)
[1] 8 3
> length_basicplus <- subset(length_basicplus, Lgrp!="NA")
> dim(length_basicplus)
[1] 8 3
>
>
> length_low <- subset(length_basicplus, Lgrp<45)
> length_high <- subset(length_basicplus, Lgrp>=45)
> dim(length_low)
[1] 8 3
> dim(length_high)
[1] 0 3
>
> temp <- length_high %>%
+   ddply("year", summarise,
+         numbers_length=sum(numbers_length))
>
> temp$Lgrp <- 45
>
> temp <- temp[,c(1,3,2)]
>
> length_basicplus <- rbind(length_low, temp)
> length_basicplus$model <- "Basicplus"
> length_basicplus$numbers_length <- (length_basicplus$numbers_length)/1000
> length_basicplus <- subset(length_basicplus, Lgrp!=0)
>
> ## Create age table for all years - AFWG strata
> age_basicplus <- basicplusage[[1]]
>
> for (i in ivec){
+   age_basicplus <- rbind(age_basicplus, basicplusage[[i]])
+ }
>
> ## Create 16+ group
> dim(age_basicplus)
[1] 27  3
> age_basicplus <- subset(age_basicplus, age!="NA")
> dim(age_basicplus)
[1] 27  3
>
> age_low <- subset(age_basicplus, age<16)
> age_high <- subset(age_basicplus, age>=16)
> dim(age_low)
[1] 15  3
> dim(age_high)
[1] 12  3
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         numbers_age=sum(numbers_age))
>
> temp$age <- 16
>
> temp <- temp[,c(1,3,2)]
>
> age_basicplus <- rbind(age_low, temp)
> age_basicplus$numbers_age <- age_basicplus$numbers_age*1000
> age_basicplus$model <- "Basicplus"
> age_basicplus <- subset(age_basicplus, age!=1)
>
> ## Create age table with uncertainv4ties - basicplus
> uncertainv4_age <- age_uncertainv4[[1]]
> head(uncertainv4_age)
  year age Ab.Sum.5. Ab.Sum.50. Ab.Sum.95. Ab.Sum.mean Ab.Sum.sd Ab.Sum.cv
1 2003   1 10.686195  22.771842  36.487444   22.379237  7.483137 0.3343786
2 2003   2  0.000000   2.648364   7.890728    2.892043  2.641054 0.9132142
3 2003   3  4.696928   7.133336  10.384982    7.118219  1.787021 0.2510489
4 2003   4  6.198315   9.052574  14.109464    9.599384  2.853825 0.2972925
5 2003   5  1.851776   3.630500   5.501464    3.726676  1.211409 0.3250641
6 2003   6  9.196626  13.539906  18.701962   13.580142  2.749046 0.2024313
```

```
>
> #ivec <- 2:(length(years)+1)
> #ivec <- ivec[-7]
> ivec <- 2:(length(years))
> ivec
[1] 2 1
>
> for (i in ivec){
+   uncertainv4_age <- rbind(uncertainv4_age, age_uncertainv4[[i]])
+ }
>
> names(uncertainv4_age) <- c("year", "age", "p05", "p50", "p95", "mean", "sd", "cv")
>
> write.csv(uncertainv4_age, "uncertain_age_basicplus.csv")
>
> ## Create 16+ group
> dim(uncertainv4_age)
[1] 27  8
> uncertainv4_age <- subset(uncertainv4_age, age!="NA")
> dim(uncertainv4_age)
[1] 27  8
>
> age_low <- subset(uncertainv4_age, age<16)
> age_high <- subset(uncertainv4_age, age>=16)
> dim(age_low)
[1] 15  8
> dim(age_high)
[1] 12  8
>
> temp <- age_high %>%
+   ddply("year", summarise,
+         p05=sum(p05), p50=sum(p50), p95=sum(p95),
+         mean=sum(mean), sd=mean(sd), cv=mean(cv))
>
> temp$age <- 16
>
> temp <- temp[,c(1,8,2,3,4,5,6,7)]
>
> uncertainv4_age <- rbind(age_low, temp)
> uncertainv4_age$model <- "Basicplus"
> uncertainv4_age$mean <- uncertainv4_age$mean*1000
> uncertainv4_age$p05 <- uncertainv4_age$p05*1000
> uncertainv4_age$p95 <- uncertainv4_age$p95*1000
> uncertainv4_age <- subset(uncertainv4_age, age!=1)



>
```

```
## Save project list

#save(allpr, file="Data/project_paths.rdata")


save(years, length_rstox, length_mikko, length_mikkov2,  length_basic,
length_basicplus, age_rstox,

           age_mikko, age_mikkov2, age_basic, age_basicplus,
uncertain_age, uncertainv2_age,  uncertainv3_age, uncertainv4_age,
file="Data/ecotokt_output.rdata")

load("Data/ecotokt_output.rdata")

> ################ Plot results ##############################
```

```
> ## load survey indices from report
> length_afwg <- read.table("Data/SurveyIndex_length.csv", header=TRUE, sep=";")
> dim(length_afwg)
[1] 279   3
> head(length_afwg)
  year Lgrp numbers_length
1 1986    5           6000
2 1986   10         101000
3 1986   15         192000
4 1986   20          17000
5 1986   25          10000
6 1986   30           5000
> length_afwg$model <- "AFWG"
>
> age_afwg <- read.table("Data/SurveyIndex_age.csv", header=TRUE, sep=";")
> dim(age_afwg)
[1] 285   3
> head(age_afwg)
  year age numbers_age
1 1996   2      146198
2 1996   3      112742
3 1996   4       22353
4 1996   5       53507
5 1996   6      165531
6 1996   7      181980
> age_afwg$model <- "AFWG"
>
> ## Combine tables
> length_models <- rbind(length_afwg, length_rstox, length_mikko, length_mikkov2, leng
th_basic, length_basicplus)
> age_models <- rbind(age_afwg, age_rstox, age_mikko, age_mikkov2, age_basic, age_basi
cplus)
>
> ## load results list - deliberately commented out to not run involuntarily
> #load("rstoxoutput.rdata")
>
> ################################ Plot comparisons for length and age ##############
#######
> ## Reduce to ecotokt proper
> length_models <- subset(length_models, year>2002)
> age_models <- subset(age_models, year>2002)
>
> ## Length
> p1 <- ggplot()+
+         geom_line(data=length_models, aes(x=Lgrp, y=numbers_length, col=model))+
+         geom_point(data=length_models, aes(x=Lgrp, y=numbers_length, col=model))+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=20), legend.text=ele
ment_text(size=15), text = element_text(size=12))+
+   facet_wrap(year~., scales="free")
>
> p1$labels$colour <- "Model"
>
> png(file="length_models.png", width=800, height=600)
>
> p1
>
> dev.off()
RStudioGD
        2
>
> ## Age
> p1 <- ggplot()+
+   geom_line(data=age_models, aes(x=age, y=numbers_age, col=model))+
+   geom_point(data=age_models, aes(x=age, y=numbers_age, col=model))+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=20), legend.text=ele
ment_text(size=15), text = element_text(size=12))+
+   facet_wrap(year~., scales="free")
>
> p1$labels$colour <- "Model"
>
> png(file="age_models.png", width=800, height=600)
>
> p1
>
```

```
> dev.off()
RStudioGD
        2
>
>
>
> ## Age - no alternative
> age_modelsn <- subset(age_models, model!="Alternative")
>
> p1 <- ggplot()+
+   geom_line(data=age_modelsn, aes(x=age, y=numbers_age, col=model))+
+   geom_point(data=age_modelsn, aes(x=age, y=numbers_age, col=model))+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=20), legend.text=ele
ment_text(size=15), text = element_text(size=12))+
+   facet_wrap(year~., scales="free")
>
> p1$labels$colour <- "Model"
>
> png(file="age_models_alternativlos.png", width=800, height=600)
>
> p1
>
> dev.off()
RStudioGD
        2
>
>
> ## Age - basics only
> age_modelsn <- subset(age_models, model=="Basic" | model=="Basicplus")
>
> p1 <- ggplot()+
+   geom_line(data=age_modelsn, aes(x=age, y=numbers_age, col=model))+
+   geom_point(data=age_modelsn, aes(x=age, y=numbers_age, col=model))+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=20), legend.text=ele
ment_text(size=15), text = element_text(size=12))+
+   facet_wrap(year~.)
>
> p1$labels$colour <- "Model"
>
> png(file="age_models_basics.png", width=600, height=600)
>
> p1
>
> dev.off()
RStudioGD
        2
>
>
>
> ################ compare age with uncertainty intervals 5 and 95 percentile ####
> uncertain_model <- rbind(uncertain_age, uncertainv2_age, uncertainv3_age, uncertainv
4_age)
> uncertain15_model <- subset(uncertain_model, age!=16)
> age_afwg <- subset(age_afwg, year>=2003)
> age15_afwg <- subset(age_afwg, age!=16)
> age15_mikko <- subset(age_mikko, age!=16)
> uncertain15_age <- subset(uncertain_age, age<=15)
> uncertainv215_age <- subset(uncertain_age, age<=15)
> uncertainv315_age <- subset(uncertain_age, age<=15)
>
> ###################### all ages #####################################
> ## all Rstox systems - all ages
> p1 <- ggplot()+
+   geom_line(data=age_afwg, aes(x=age, y=numbers_age, colour="AFWG"), col="black", lw
d=2)+
+   geom_point(data=age_afwg, aes(x=age, y=numbers_age, colour="AFWG"), col="yellow",
cex=1)+
+   geom_line(data=uncertain_model, aes(x=age, y=mean, colour=model), lwd=0.5)+
+   geom_point(data=uncertain_model, aes(x=age, y=mean, colour=model), cex=0.5)+
+   geom_ribbon(data=uncertain_model, aes(x=age, ymin=p05, ymax=p95, fill=model), alph
a=0.2, show.legend=FALSE)+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=40), legend.text=ele
ment_text(size=30), text = element_text(size=20))+
+   facet_wrap(year~., scales="free")
```

```
>
> p1$labels$colour <- "Model"
>
> png(file="age_models_rstox.png", width=2400, height=1800)
> p1
> dev.off()
RStudioGD
        2
>
> ## basic, strata17 - all ages
>
> uncertain_redux <- subset(uncertain_model, model=="Basic"|model=="RStoX17")
>
> p1 <- ggplot()+
+   geom_line(data=age_afwg, aes(x=age, y=numbers_age), col="black", lwd=2)+
+   geom_point(data=age_afwg, aes(x=age, y=numbers_age), col="yellow", cex=1)+
+   geom_line(data=uncertain_redux, aes(x=age, y=mean, colour=model), lwd=1)+
+   geom_point(data=uncertain_redux, aes(x=age, y=mean, colour=model), cex=1)+
+   geom_ribbon(data=uncertain_redux, aes(x=age, ymin=p05, ymax=p95, fill=model), alph
a=0.2, show.legend=FALSE)+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=40), legend.text=ele
ment_text(size=30), text = element_text(size=20))+
+   facet_wrap(year~., scales="free")
>
> p1$labels$colour <- "Model"
>
> png(file="age_models_redux_rstox.png", width=2400, height=1800)
> p1
> dev.off()
RStudioGD
        2
>
> ######################## age 15 #####################################
> ## all Rstox systems - up to 15 yrs
> p1 <- ggplot()+
+   geom_line(data=age15_afwg, aes(x=age, y=numbers_age, colour="AFWG"), col="black",
lwd=2)+
+   geom_point(data=age15_afwg, aes(x=age, y=numbers_age, colour="AFWG"), col="yellow"
, cex=1)+
+     geom_line(data=uncertain15_model, aes(x=age, y=mean, colour=model), lwd=0.5)+
+   geom_point(data=uncertain15_model, aes(x=age, y=mean, colour=model), cex=0.5)+
+   geom_ribbon(data=uncertain15_model, aes(x=age, ymin=p05, ymax=p95, fill=model), al
pha=0.2, show.legend=FALSE)+
+   theme(legend.title.align = 0.5,legend.title=element_text(size=40), legend.text=ele
ment_text(size=30), text = element_text(size=20))+
+   facet_wrap(year~., scales="free")
>
> p1$labels$colour <- "Model"
>
> png(file="age_models_15_rstox.png", width=2400, height=1800)
> p1
> dev.off()
RStudioGD
        2
```

HAVFORSKNINGSINSTITUTTET

AKUSTISK MENGDEMÅLING AV SEI OG KYSTTORSK
FINNMARK – MØRE
HØSTEN 2018

Acoustic abundance of saithe and coastal cod Finnmark – Møre

Autumn 2018

Foreløpig rapport / Preliminary report 14.01.2019

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INNHOLD

1. SAMMENDRAG

Et akustisk tokt med sikte på å framskaffe indekser for antall fisk og data over lengde og vekt for hver aldersgruppe av sei og kysttorsk nord for 62ºN er gjennomført årlig i oktober-november, siden 1985 for sei og siden 1995 for kysttorsk.

Resultater for 2018 viser:

- Ekkomengden av sei økte med 15% fra 2017 til 2018 til gjennomsnittet for 2003-2017. Det var en oppgang i nord og en liten oppgang på Møre og Nordland
- 4 år gammel sei (2014-årsklassen) var mest talrike, fulgt av 5-åringer (2013-årsklassen)
- Indeksene for 2 og 3-åringer var på henholdsvis 39% og 30% av gjennomsnittet for 2003-2017, og det tilsvarer en nedgang på 17% og 60% sammenlignet med 2017-indeksene
- Indeksen for 4 år gammel fisk var på nivå med gjennomsnittet og nokså lik 2017-indeksen, mens indeksene for 5-, 6- og 8-åringer var på henholdsvis 116%, 66% og 119% av gjennomsnittet for 2003-2017
- Lengde og vekt ved alder var litt over gjennomsnittet for 2003-2017 for 3-8 åringer

- For kysttorsk var det en nedgang i indekser for 2-åringer (24%) og 3-åringer (42%) sammenlignet med 2017-indeksene
- Indeksene for 4-5 åringer var det samme som i 2017, men økte for 6-åringer (42%) og 7-åringer (21%)
- Indeksen for totalantall kysttorsk gikk opp i alle områder bortsett fra i Vesterålen (område 05)
- Det var tegn på bedre rekruttering (alder 2) i 2014-2016
- Akustisk estimert biomasse gjekk opp med 11% fra 2017 til 2018
- Lengde og vekt ved alder var ganske lik estimater fra tidligere tokt
- **Det må understrekes at usikkerhet i beregninger for bestanden av kysttorsk er høy**

2. SUMMARY

An acoustic survey to obtain indices of abundance and estimates of length and weight at age of saithe and coastal cod north of 62ºN has been carried out annually in October-November, since 1985 for saithe and since 1995 for coastal cod.

The main results in 2018 were:

- Total echo abundance of saithe increased by about 15 % from 2017 to 2018, and was the same as the average for 2003-2017.
- 4 year old saithe (2014 year-class) was most abundant, followed by 5 year old fish (2013 year-class).
- Indices for 2 and 3 year olds were respectively 39% and 30% of the average for 2003-2017, corresponding to a decrease of 17% and 60% compared to 2017
- The index for 4 year old fish was the same as the 2003-2017 average, and indices for 5-, 6-, and 8 year old fish were respectively 116%, 66%, and 119% of the 2003-2017 average
- Length and weight at age of 3 to 8 year olds were above the 2003-2017 average

- Compared to 2017 the number of coastal cod decreased for age groups 2 (24%) and 3 (42%). Indices for 4 and 5 year old fish were the same as in 2017, while they increased for 6 (42%) and 7 (21%) year olds
- The total number of fish increased in all areas except for area 05 (Vesterålen).
- There were signs of improved recruitment (age 2) in the years 2014-2016.
- Acoustic estimated biomass increased by about 11% from 2017 to 2018.
- Average length and weight were similar to previous estimates
- **It must be emphasized that the uncertainty in acoustic abundance estimates of coastal cod is high**

3. INNLEDNING

Hovedformålet med toktet er å kartlegge geografisk fordeling og framskaffe mål for viktige bestandsvariabler som:

- Antall fisk, gjennomsnittlig lengde, vekt og modning i hver aldersgruppe i bestandene av sei, kysttorsk og hyse i kyst- og fjordområder fra Varanger til Stad

I tillegg ble det i 2018 gjennomført:

- Flere bunntrålhal til overvåking av dypvannsreker i Finnmarksfjordene, Lyngen, Malangen, Ullsfjord og Nordland
- Akustisk dekning av 0- og 1-gruppe sild i Varanger-, Lakse-, Tana- og Porsangerfjord
- Akustisk dekning av brisling i Trondheimsfjorden og Romsdalsfjordene
- Flere forhåndsbestemte bunntrålstasjoner for å forbedre datagrunnlaget for vanlig uer
- Flere CTD og planktonstasjoner i fjorder sør for Lofoten, langs Helgelandkysten og Møre og Romsdal
- Sedimentprøver og vannprøver i Laksefjorden, Vefsnfjorden, Namsenfjorden og Trondheimsfjorden for forurensingsanalyser
- Innsamling av frossen vanlig uer, snabeluer, breiflabb, og lyr
- Innsamling av gonadeprøver av sei og blålange

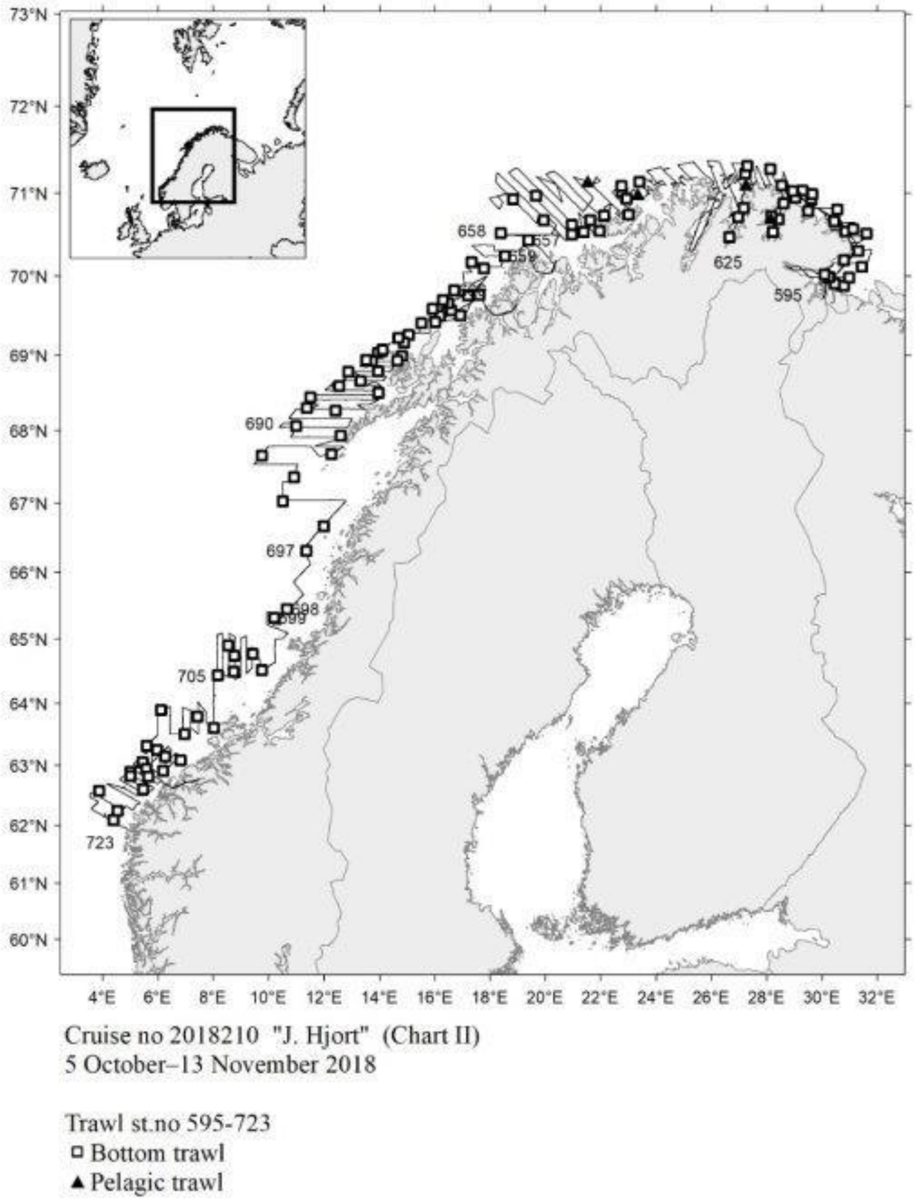
Innsamlete data og tilhørende resultater blir brukt i bestandsanalysene i ICES og i flere av Havforskingsinstituttet sine prosjekter.

4. GJENNOMFØRING OG METODIKK

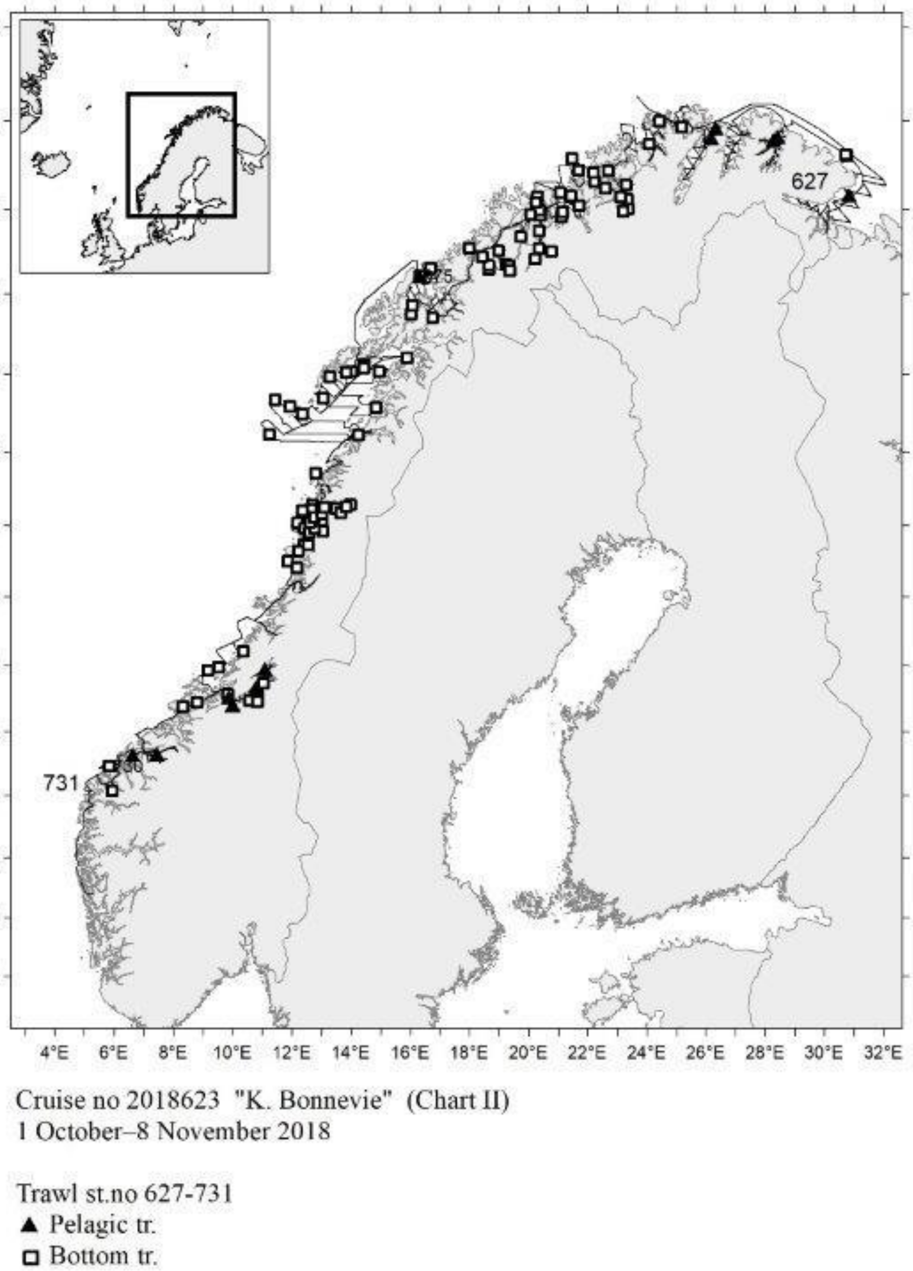
Toktet ble gjennomført med F/F "Johan Hjort" 05.10-13.11 (Toktnr. 2018210, serienr. 55001-55) og F/F ”Kristine Bonnevie” 01.10-07.11 (Toktnr. 2017620, serienr. 55201-55). Det ble i alt tatt 218 bunntrålhal og 16 pelagiske trålhal (Figur 4.1 og 4.2). Det ble dessuten tatt 129 hydrografiske stasjoner (CTD) for måling av temperatur og saltnivå. CTD-målinger ble gjort på en del faste bunntrålstasjoner, alle sedimentstasjoner og WP2 stasjoner og ellers med jevnt mellomrom (ca. 30 NM). Toktopplegget var stort sett det samme som er gjennomført siden 2003, men med tettere kurser i noen strata, ekstra transekter for dekking av ungsild og brisling, 32 ekstra trålstasjoner for å bedre datagrunnlaget for uer, og 22 ekstra trålstasjoner for overvåking av dypvannsreker.

4.1 Integreringskurser

Figur 4.4 presenterer standard integreringskurser for sei- og kysttorsk-undersøkelser etter sammenslåing av de to toktene i 2003. Som i 2017 ble det i 2018 lagt til flere kurser på Røstbanken, Buagrunnen, Kvalsnesdjupet, Eggagrunnen, Haltenbanken, Langgrunna, og Fugløybanken. For å bedre kunne sammenligne resultater med tidligere år, er bare deler av disse transektene (kursene) brukt i de presenterte utregningene for sei og kysttorsk. Kursene er satt ut med ulike avstander og i ulike retninger for best mulig å være representative for hvert enkelt område (stratum), der det også er tatt hensyn til dypet og tidligere fiskeforedling.



Figur 4.1 Kurser og trålstasjoner F/F "Johan Hjort" høsten 2018 (laget av Karen Gjertsen, HI).
Survey tracks and trawl stations R/V "Johan Hjort" autumn 2018 (Karen Gjertsen, IMR)



Figur 4.2. Kurser og trålstasjoner F/F ”Kristine Bonnevie” høsten 2018 (Karen Gjertsen, HI).
Survey tracks and trawl stations R/V “Kristine Bonnevie” autumn 2018 (Karen Gjertsen, IMR)

4.2 Prøvetakingsutstyr

Trål og fiskeutstyr

Som bunntrål blir det brukt standard prøvetakingstrål (Campelen 1800) med 80 mm (strekt) maskevidde i fremre del og 22 mm i posen. Sveipene er 40 m, og det blir brukt rockhopper gir. For pelagisk tråling er det ”Harstadtrål” og ”Åkratrål” som blir brukt. Det blir brukt ”Thyborøn” kombidører til all tråling. Dørspredning, trålåpning og bunnkontakt blir overvåket med Scanmar trålinstrumentering. På noen få stasjoner med dårlig/bløt bunn blir det brukt Tromsørigging for å unngå leire i fangstene og for å få bedre prøver fra fangsten.

4.3 Sortering av fangst, lengdemåling og alder-lengde nøkler

Sortering, veiing, måling og prøvetaking av fangst blir gjort etter gjeldende instrukser for dette (Mjanger *et al*. 2017). Et representativt utvalg av fangsten, eventuelt hele fangsten av viktige arter, blir lengdemålet på hver stasjon. På de fleste stasjonene blir det tatt individprøver med otolitter (øresteiner) av inntil 5 fisk i hver 5 cm-gruppe for sei, torsk, hyse og uerartene. Tilsammen blir det under toktet samlet inn og lest otolitter fra 1488 sei, 2464 torsk og 2903 hyse. Det blir dessuten tatt individprøver av 131 sjøkreps, 111 lysing, 91 kveiter, 25 breiflabb, 888 vanlig uer og 223 snabeluer, samt lengde og fryseprøver av ungsild, brisling, vanlig uer, snabel uer, sjøpølser og reker (7913 dypvannsreker, 1955 vanlig uer, og 783 snabeluer, 1610 sild, og 96 brisling blir lengde målt).

4.4 Innstillinger av det akustiske utstyret, tolking og beregning av mengdeindekser.

Målingene blir gjort med EK80 ekkolodd og ekkointegrering blir utført med ”Large Scale Survey System” (LSSS, Korneliussen *et al*. 2016). Tolkete verdier blir lagret for hver 1 NM med vertikaloppløsning på 10 m i det pelagiske lag og 1 m i bunnkanalen (10 m opp fra bunn). Når det gjelder ekkoloddinnstillingene vises det til instrumentrapportene fra toktet. S_V-terskelen var satt til -82dB, men under tolkning blir denne satt opp til –60dB (±3dB) for som en tilnærming å ta ut stimer med sterke fiskeregistreringer, og som en tommelfingerregel til 69dB (±3dB) for å ta ut planktonet. De akustiske registreringene i LSSS, dvs. gjennomsnittlig total ekkotetthet for hver 5 NM, blir tolket i samsvar med mønsteret på ekkogrammet og artsfordelinga på fiskestasjonene. Sei, torsk, hyse og sild blir skilt ut som egne artsgrupper. I tillegg blir 0-gruppe, 0-gr sild, plankton samt ”andre” brukt som egne tolkekategorier. Til hjelp i artsfordelingen av registrerte ekkotettheter blir alle trålfangster omregnet til relative s_A-verdier for hver art (Korsbrekke 1996). Dersom sammensetningen i trålfangstene gir et rett bilde av den arts- og størrelse sammensetningen som danner den totale ekkotettheten, kan total ekkotetthet deles direkte på art etter slike relative s_A-verdier. Men selv om det blir lagt stor vekt på å få trålfangstene mest mulig representative for ekkoregistreringene, vil variasjon i fordelingen over 5 NM samt trålseleksjon og unnviking med hensyn til art og størrelse alltid påvirke fangstresultatene. Arts- og størrelsesfordelingen av trålfangstene må derfor alltid ses i sammenheng med ekkogrammet og eventuelt målstyrkeobservasjoner fra ekkoloddet.

I estimeringene av akustiske indekser for sei blir programmet StoX brukt. Hele området er delt inn i 4 underområde (A 69°30’-71°30’N, B 67°00’-69°30’N, C 63°30’-67°00’N og D 62°00’-63°30’N, figur 4.4). For å estimere indekser til hver av disse underområdene, kjøres StoX fire ganger og der det for hver kjøring unnlates oppdrag som ikke ligger i de underområdene – dvs. til estimering av underområde A brukes det informasjon fra oppdrag 1,2,4, og 7, til underområde B fra oppdrag 9,10, og 11, til underområde C fra oppdrag 12 og 15, og til underområde D informasjon fra oppdrag 17.

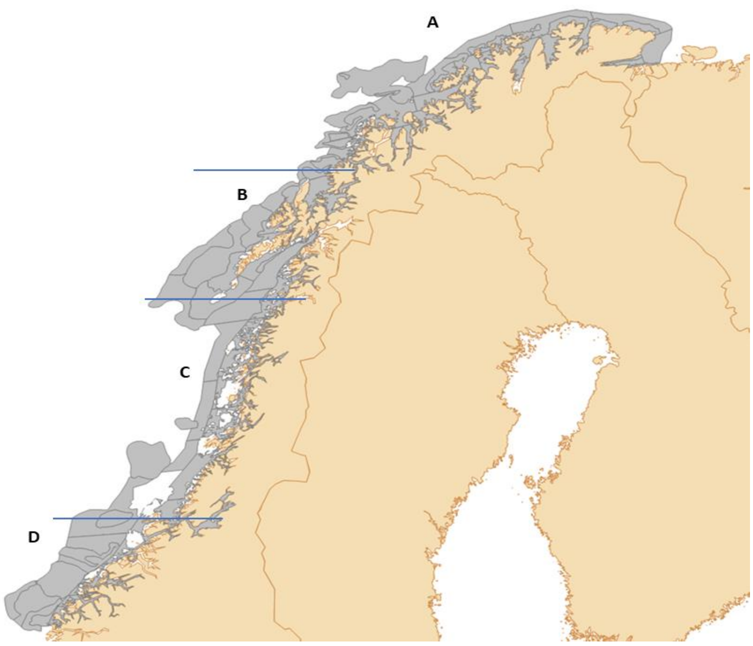
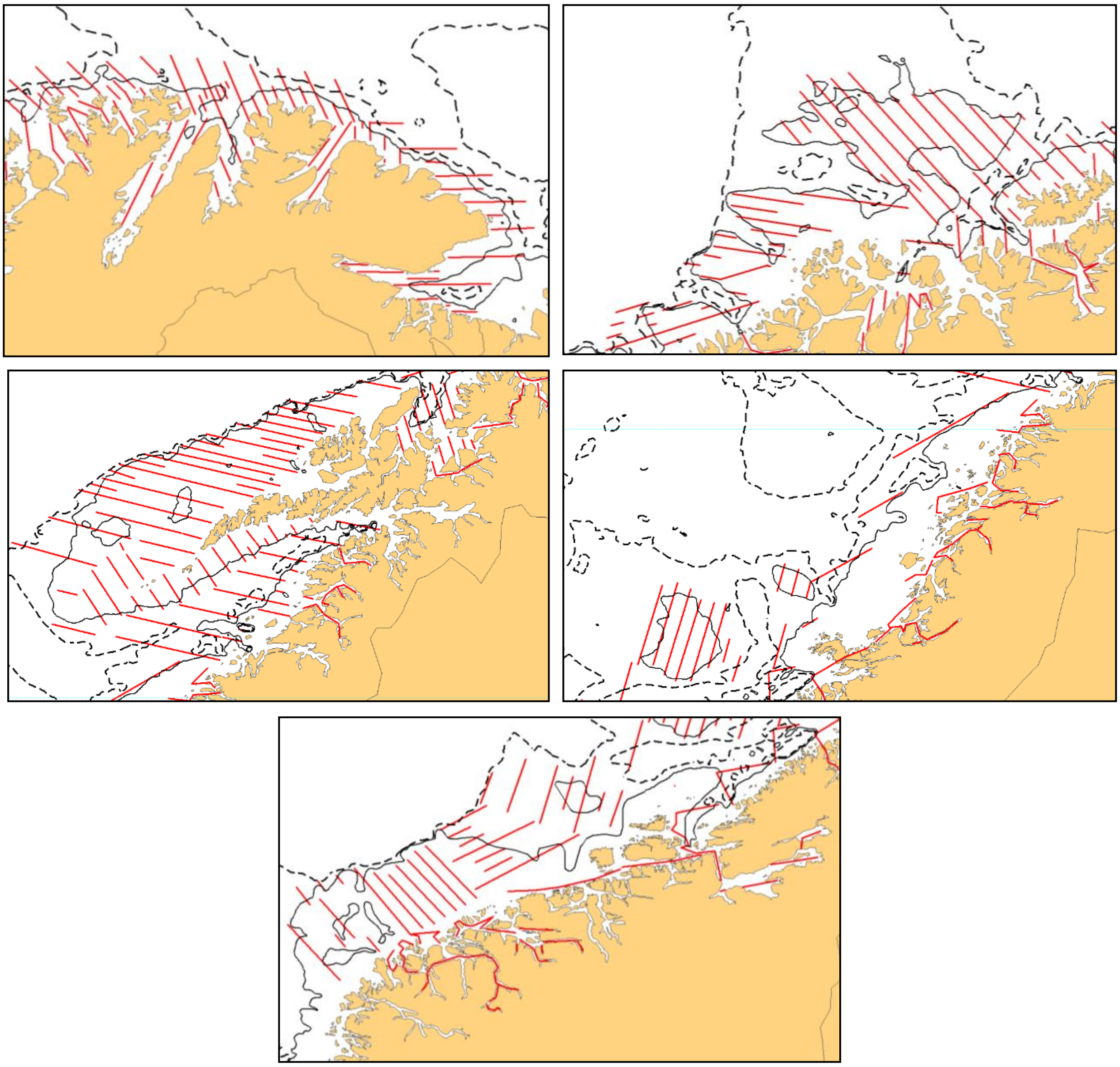


Figure 4.4. Strata og underområde (A,B,C og D) brukt i estimering av akustiske indekser med StoX.



Figur 4.5. Standard transekt i det kombinerte sei- og kysttorsktoktet.

Hvert underområde er delt inn i flere strata, som er definert ut ifra polygon der også ”smultringvarianten” finns. Det vil si at et stratum kan omslutte et annet stratum fullstendig. I hvert stratum blir de akustiske kursene delt opp i transekt (PSU = primary sampling unit) (figur 4.5). Grupper av strata er samlet i praktiske ”oppdrag” som blir gjennomført av enkeltfartøy. Stratanummereringen er unik bare innenfor et oppdrag.

Omregningen av gjennomsnittlig “nautical area scattering coefficient“ (NASC) (m^2 nmi^{-2}) til tetthet av fisk følger en standard prosedyre der minst 3 trålstasjoner (med en fangst på mer enn 2 individ av sei) blir allokert til hver PSU. Som en regel blir alle stasjoner innenfor et stratum allokert til hver PSU i det samme stratum, men dersom det er tatt færre enn 3 trålstasjoner i et stratum, blir også stasjoner i nabostrata allokert slik at minst 3 stasjoner er allokert til hver PSU.

En kombinert lengdefordeling (*d*) blir kalkulert for hvert transekt (PSU (*j*)) som:

$$d_{l,j} = \sum_{s=1}^{s} d_{l,s,j}$$

der $d_{l,s,j}$ er tetthet (tall per 1 NM tauet distanse) for 1 cm lengdegrupper (*l*) for stasjon (*s*) allokert to PSU (*j*).

Arealtetthet av fisk (ρ) (n per nmi^2) for lengdegruppe *l* for transekt *j* blir regnet ut som

$$\rho_{j,l} = \frac{\mathrm{NASC}_{j,l}}{\sigma_l}$$

der $\mathrm{NASC}_{j,l}$ er gjennomsnittlig "nautical area scattering coefficient" for transekt (j) og lengdegruppe (*l*) og σ_l er ekkoevne (backscattering cross-section) for en fisk med lengde *l*.

$\mathrm{NASC}_{j,l}$ er regnet ut som:

$$\mathrm{NASC}_{j,l} = \mathrm{NASC}_j \frac{\sigma_{l,p}}{\sum_l \sigma_{l,p}}$$

der $\sigma_{l,p}$ er ekkoevne for en fisk med lengde *l* multiplisert med delen (*p*) av fisk med lengde *l* i den totale lengdefordelinga og NASC_j er gjennomsnittlig "nautical area scattering coefficient" i transektet.

Ekkoevna (m^2) for en fisk med lengde *l* er regnet ut som

$$\sigma_l = 4\pi 10^{\left(\frac{TS_l}{10}\right)}$$

der målstyrken, *TS*, for en fisk med lengde *l* (cm) er regnet ut som

$$TS_l = m \log_{10}(l) + a$$

der *m* og *a* er konstanter. Det ble benyttet

$$TS = 20 \log(l) - 68 \quad \text{(Foote, 1987)}$$

Mengde(*N*) sei av lengdegruppe (*l*) for stratum *k* er:

$$N_{k,l} = \rho_{k,l} A_k$$

der *A* er arealet av stratum *k* og gjennomsnittlig tetthet av sei i lengdegruppe *l* og stratum *k* er:

$$\rho_{k,l} = \frac{1}{n_k} \cdot \sum_{k=1}^{n_k} w_{kj} \rho_{kj,l}$$

der $w_{kj} = L_{kj} / \overline{L}_k$ (j= 1,2,n_k) er lengde av transekt n_k.

Estimat for lengde blir konvertert til estimat for alder ved å bruke alders-lengde data fra alle valgte stasjoner i hvert stratum, vektet med stasjonstetthet. StoX bruker ikke alder-lengde nøkler (ALKs) i tradisjonell forstand med ALKs estimert for større områder. Manglende aldersinformasjon blir tilregnet («imputed») fra kjente alder-lengde data innen hver stasjon. Dersom aldersinformasjon fremdeles mangler, søker StoX innen stratum, eller til slutt innen alle strata. Dersom ingen alder er tilgjengelig for en lengdegruppe, blir estimatet presentert med ukjent alder. Total biomasse blir estimert ved å multiplisere tallet på fisk i hver aldersgruppe med vekt ved alder. Trålindeksene i hvert stratum blir så summert for definerte underområder (figur 4.3).

StoX estimerer variasjonskoeffisienter ved "bootstrapping" av transekter og allokerte trålstasjoner. Den estimerte CV (standardavvik · 100/gjennomsnitt) er estimert fra 500 iterasjoner og er sterkt avhengig av valget av estimator for indeksene.

StoX er også brukt til å estimere nye akustiske indekser med CV samt lengde og vekt ved alder for sei for perioden 2003 til 2017 (Mehl et al. 2018). Hovedforskjellen mellom det SAS-baserte programmet BEAM (Totland og Godø 2001) brukt for sei fram til 2016 og StoX er at i BEAM er toktområdet delt inn i rektangler (Mehl et al. 2016), og for hvert rektangel blir gjennomsnittlig akustisk tetthet (s_A) regnet ut, mens i StoX blir det for hvert stratum definert transekt som primær prøvetakingsenhet («primary sampling units», PSUs), som så blir brukt til å regne ut akustisk tetthet (Jolly and Hampton 1990). BEAM bruker dessuten tradisjonelle alder-lengde nøkler.

I beregningene for kysttorsk er det undersøkte området delt i 25 underområder med tilhørende areal. Noen av underområdene er fjorder mens andre er åpne bankområder. Integreringskursene er parallelle kurser med 2-12 nautiske mils avstand, avhengig av om det er fjorder eller bankområder. Det blir regnet ut gjennomsnittlige s_A-verdier for hvert av disse underområdene og videre utregninger blir gjort med programpakken SAS. Etter at det totale antall torsk i hver lengdegruppe innenfor hvert område er regnet ut, blir dette fordelt på kysttorsk og nordøstarktisk torsk basert på alderslesing og typebestemmelse ut fra otolitter. Deretter blir de underområdene slått sammen til 6 hovedområder. Disse hovedområdene er de samme som Fiskeridirektoratet sine fangststatistiske områder (03, 04, 05, 00, 06 og 07). Lengdefordelingene er ikke korrigert for lengdeavhengig sveipebredde på bunntrålstasjoner.

5. RESULTAT OG DISKUSJON

5.1 Ekkomengde av sei

Tabell 5.1 viser ekkomengden av sei i hvert underområde for 2003-2018. Nedgangen fra 2007 til 2008 omfattet nesten alle område, så her kan det nok i tillegg være snakk om en årseffekt. Det at toktet i 2008 ble gjennomført en måned senere enn i de andre årene kan ha påvirket resultatet. Total ekkomengden av sei i 2018 var om lag 15% høyere enn i 2017, og er det samme som gjennomsnittet i tidsserien tilbake til 2003. I underområde A (nord for 69°30' N) var den registrerte ekkomengden nærmest det samme som i 2017, og 59% over gjennomsnittsnivå for 2003-2017. I underområde B (Lofoten – Vesterålen) var ekkomengden 43% over 2017-nivå og 17% over snittet. I underområde C (Sklinna-Halten-Frøyabanken) var ekkomengden nesten 21% høyere enn i 2017 (og 80% av snittet for 2003-2017), og var den høyeste ekkomengden siden 2010. Underområde D (Møre) hadde en økning på nesten 60% sammenlignet med 2017, men ekkomengden var den nest laveste i tidsserien, bare 40% av gjennomsnittet for 2003-2017.

Tabell 5.1 SEI**.** Ekkomengde (m^2 reflekterende overflate · 10^{-3}) 2003–2018 estimert med StoX**.**
SAITHE. Echo abundance (m^2 reflecting surface · 10^{-3}) 2003-2018 estimated by StoX.

	Underområde / *Subarea*				
År/*Year*	A	B	C	D	Sum
2003	345	443	178	658	1625
2004	440	605	332	496	1873
2005	366	329	100	384	1179
2006	201	278	337	344	1160
2007	116	379	89	417	1000
2008	93	167	45	299	604
2009	315	286	67	282	951
2010	188	204	89	284	765
2011	151	145	65	173	533
2012	218	210	50	324	801
2013	266	176	24	141	606
2014	172	242	60	245	719
2015	326	291	46	191	853
2016	440	249	51	236	975
2017	464	230	70	75	839
2018	430	330	85	120	965

5.2 Mengdeindeksar med CV og vekst for sei

Tabell 5.2.1 viser de akustiske mengdeindekser for lengde- og aldersgrupper sammenslått for alle de undersøkte områdene (oppdrag), og tabell 5.2.2 viser tall på fisk i hver aldersgruppe for hvert av de 4 underområdene. I det nordligste underområdet A (Finnmark – Troms) ble det funnet mest 2 og 5 år gammel sei (2013 og 2016-årsklassene). Totalt antall fisk estimert i det området var mye lavere enn i 2017. Det gjelder spesielt 1-3 åringer, det ble estimert mye 1-åringer i 2017 og nesten ingen i 2018 og bare 39% av 2017-estimatet for 3-åringer. Estimert antall 4-7+ år gammel fisk var nokså likt estimatet fra 2017. I underområde B (Lofoten – Vesterålen) var det mest 4 år gammel sei (2014 årsklassen, 48% av totalt antall fisk), med en tydelig økning i 4-7+ år gammel fisk sammenlignet med 2017 (160% høyere estimat), og et betydelig lavere estimat for 1-3 åringer (73% av 2017-estimatet). I underområde C (Sklinna-Halten-Frøyabanken) ble det registrert mest 4 og 5 år gammel sei (94% av totalt antall fisk) og 60% mer enn i 2017. Til tross for høyere estimater av eldre fisk i 2018 er total antall fisk litt lavere enn i 2017, siden antall 3-åringer registrert er mye lavere enn i 2017. Helt i sør (underområde D - Møre) blir det registrert mer sei enn i 2017, men fortsatt mye mindre enn i årene før. Det ble estimert mest 4- og 5-åringar (2013- og 2014-årsklassane), mens antall 3-åringer var likt estimatet fra 2017.

Tabell 5.2.1 SEI. Akustiske indekser (i millioner) på alder og lengde i 2018 estimert med StoX.
SAITHE. Acoustic indices (in millions) by length and age in 2018 estimated by StoX.

Lengde *Length* *(cm)*	Alder (Årsklasse) / *Age (Year class)* 1 (17)	2 (16)	3 (15)	4 (14)	5 (13)	6 (12)	7+ (11+)	Sum
20-24	0.002	-	-					0.00
25-30	0.187	0.2						0.35
30-35		12.5						12.50
35-40		6.1	4.8	0.2				11.13
40-45		0.8	19.5	18.0	0.2			38.47
45-50			6.4	31.5	8.0	0.1		45.85
50-55			-	8.9	19.6	0.5		28.98
55-60				1.6	11.1	3.2	0.1	16.02
60-65				0.9	4.8	4.5	1.3	11.60
65-70					1.3	3.1	2.5	6.96
70-75					0.4	0.6	3.2	4.20
75-80						0.2	3.1	3.34
80+							2.5	2.5
Sum:	0.19	19.6	30.6	61.1	45.4	12.3	12.8	181.9

Tabell 5.2.2 SEI. Akustiske indekser (i millioner) i hvert underområde i 2018 estimert med StoX.
SAITHE. Acoustic indices (in millions) by subarea in total in 2018 estimated by StoX.

Underområde *Subarea*	Alder (Årsklasse) / *Age (Year class)* 1 (17)	2 (16)	3 (15)	4 (14)	5 (13)	6 (12)	7+ (11+)	Sum
A	0.19	17.85	14.15	11.64	21.64	7.8	6.03	79.33
B	0	1.03	11.64	31.54	12.91	2.89	5.09	65.1
C	0	0.11	0.05	9.29	4.69	0.43	0.35	14.91
D	0	0.57	4.79	8.63	6.13	1.14	1.32	22.57
Total	0.19	19.55	30.63	61.09	45.36	12.29	12.78	181.9

Tidsserien av mengdeindekser er vist i tabell 5.2.3. Seien er vanligvis ikke "rekruttert til toktet" før den er 3 år, av og til er den ikke fullt rekruttert før som 4-åring. Derfor øker antall på fisk i en og samme årsklasse med alderen, fra 2 til 3 eller 4 år. Dette skyldes hovedsakelig at de yngste aldersgruppene vokser opp helt inne på grunnere områder ved kysten, der de ikke er tilgjengelige for et stort forskningsfartøy. Etter hvert som fisken blir større og eldre trekker den ut og blir tilgjengelig i undersøkelser. Når fisken blir enda eldre og kjønnsmoden, blir den igjen mindre tilgjengelig for toktet på grunn av gyte- og næringsvandringer. Dette kan variere fra år til år.

Summen av indeksene for de yngste aldersgruppene (2-4 åringer) har siden 2007, med unntak av 2016, vært under gjennomsnittet for 2003-2017 og var i 2017 på 52% av dette nivået (sammenlignet med 82% i 2016). Indeksen for 2- og 3-åringar var mye lavere enn i 2017 og på henholdsvis 39% og 70% av snittet. Indeksen for 4 år gammel fisk (2014-årsklassen) var den samme som gjennomsnittet, mens indeksen for 5 åringer (2013 årsklasse) var mye høyere enn i 2017 og på 116% av gjennomsnittet. For 6-åringar var indeksen også mye høyere enn i 2017 og 66% over snittet. Eldre fisk (7+) var 30% høyere enn snittet og 45% større enn i 2017. Eldre sei som er på nærings- og gytevandring på denne tiden blir som før nevnt bare i liten grad dekket av toktet. Totalindeksen var på vel 73% av gjennomsnittet.

Tabell 5.2.4 viser estimat av variasjonskoeffisienter (CV) for aldersgrupper 1-14. En CV på 0.2 (20%) eller mindre kan anses som akseptabel i en tradisjonell bestandsvurdering dersom indeksene er uhildet (avhengig av en modell for fangbarhet). Verdier over dette indikerer indekser med høy usikkerhet med liten informasjon om årsklassestyrke. CV for aldersgruppe 2-5 er på et akseptabelt nivå i de fleste år, for aldersgruppe 6-7 i mindre enn halvparten av årens mens for aldersgruppe 1 og for 8 år gammel og eldre fisk er CV over det som kan anses som akseptabelt i alle år. I 2018 var CV for 4-6-åringer på eller under 0.2 (20%) , mellom 20-30% for 3 og 7 åringer, og høyre enn andre år for 2 åringer.

Gjennomsnittslengder og -vekter for de ulike aldersgruppene vises i tabell 5.2.5 og 5.2.6. I senere år er det stort sett bare registrert små endringer i vekstmønsteret. I 2018 var lengde ved alder for 3-9 år gammel sei over gjennomsnittet for tidsserien 2003-2017 og litt under snittet for 2 år gammel fisk. For vekt ved alder for 3-9 åringer var over gjennomsnittet, mens 2 år gammal sei var litt under gjennomsnittet.

Tabell 5.2.3 SEI. Akustiske indekser (i millioner) for hver aldersgruppe i 2003 – 2018 estimert med StoX. + indikerer < 0.005.

SAITHE. Acoustic abundance indices (in millions) by age in 2003 – 2018 estimated by StoX software. + indicates < 0.005.

	Age group																**Biomass**
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**(‘000 t)**
2003[1]	19.3	51.2	130.5	162.3	42.6	7.73	7.94	2.56	1.69	1.21	0.72	0.31	0.15	0.05	0.07	428.4	348.7
2004[1]	0.01	153.3	191.2	107.6	44.3	15.2	4.25	2.06	3.56	0.77	1.36	0.61	0.27	0.21	0.11	524.8	425.7
2005[1]	11.1	24.1	198.5	51.9	17.6	13.2	7.68	1.40	1.12	0.36	0.10	0.10	0	0	0	327.2	261.6
2006[1]	2.89	83.9	40.9	129.9	14.4	4.62	9.49	6.13	2.39	1.05	0.83	0.17	0.31	0.01	0.02	297.0	258.7
2007[1]	2.48	37.9	93.5	23.9	58.5	6.51	3.95	4.00	4.22	0.30	0.76	0.06	0	0	0	236.0	224.2
2008[1]	0.01	50.7	55.9	15.9	7.84	9.99	3.06	0.97	1.41	0.98	0.13	0.15	0	0.06	0	147.1	124.1
2009[1]	0	54.7	96.9	61.4	6.99	4.01	7.62	1.95	1.00	1.08	1.10	0.35	0.18	0	0	237.2	212.6
2010	0.02	7.60	143.0	22.5	17.1	3.95	1.68	3.58	0.43	0.25	0.18	0.30	0.01	0.20	0	200.8	167.1
2011	0	15.2	42.7	59.6	4.61	4.23	1.07	0.81	0.78	0.19	0.03	0.06	0	0	0	129.4	117.7
2012	0.08	68.5	69.0	29.7	18.8	3.48	2.83	0.32	0.58	0.56	0.08	0.05	0	0	0	193.9	148.6
2013	5.02	12.3	77.1	16.5	13.3	11.6	2.19	1.21	0.61	0.39	0.02	+	0.10	0.14	0	140.5	139.1
2014	2.95	28.4	40.1	70.8	8.73	5.62	5.44	1.61	0.55	0.18	0.43	0.10	0	0	0.02	165.0	166.0
2015	0.06	93.5	72.4	22.7	30.1	6.08	4.22	1.85	0.20	0.14	0.07	0.05	0	0	0	231.4	177.6
2016	0.76	72.6	145.7	32.0	10.5	11.2	4.15	2.04	1.46	0.15	0.22	0.12	0.02	0.05	0	281.1	196.0
2017	35.4	23.6	91.1	63.9	13.3	2.76	5.35	2.21	0.62	0.46	0.01	0.02	0.04	0	0.05	238.8	177.2
2018	0.19	19.6	30.6	61.1	45.4	12.3	4.24	4.62	2.60	0.32	0.44	+	0.19	0.08	0.3	181.9	231.4

[1]Justert høsten 2018 etter oppdatering av data og nye beregninger

[1]*Adjusted autumn 2018 after update of input data and new estimates*

Tabell 5.2.4. SEI. Estimat av variasjonskoeffisient for akustiske indekser for aldersgruppe 1-14 i 2003-2018 estimert med StoX.
SAITHE. Estimates of coefficients of variation for acoustic abundance indices for age groups 1-14 in 2003-2018 estimated by StoX software.

	Aldersgruppe / *Age group*													
År/*Year*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
2003[1]	0.35	0.21	0.19	0.22	0.16	0.36	0.33	0.60	0.30	0.39	0.43	0.43	0.49	0.99
2004[1]	1.98	0.26	0.16	0.28	0.25	0.22	0.39	0.59	0.43	0.40	0.35	0.39	0.39	0.70
2005[1]	0.58	0.47	0.12	0.20	0.12	0.19	0.25	0.45	0.59	0.75	0.89	0.89	-	-
2006[1]	0.53	0.13	0.40	0.30	0.23	0.35	0.34	0.46	0.42	0.46	0.36	1.02	0.65	0.88
2007[1]	0.50	0.28	0.21	0.17	0.23	0.27	0.39	0.37	0.31	0.54	0.47	0.81	-	-
2008[1]	1.31	0.19	0.21	0.27	0.27	0.14	0.19	0.37	0.36	0.37	0.60	0.50	-	1.16
2009[1]	-	0.34	0.20	0.15	0.25	0.30	0.22	0.37	0.45	0.43	0.54	0.96	0.44	-
2010	1.68	0.32	0.19	0.19	0.20	0.22	0.20	0.27	0.60	0.35	0.75	0.84	1.20	0.76
2011	-	0.23	0.18	0.16	0.24	0.38	0.40	0.48	0.33	1.11	1.04	1.00	-	-
2012	0.68	0.16	0.15	0.18	0.24	0.21	0.34	0.68	0.33	0.60	0.79	1.29	-	-
2013	0.56	0.17	0.12	0.13	0.31	0.19	0.34	0.41	0.42	0.62	1.09	3.11	0.93	0.82
2014	0.73	0.21	0.22	0.24	0.18	0.21	0.18	0.31	0.43	0.56	0.44	0.83	-	-
2015	1.60	0.17	0.16	0.20	0.22	0.26	0.25	0.31	0.30	0.72	0.49	0.58	-	-
2016	2.23	0.17	0.10	0.14	0.17	0.19	0.22	0.30	0.23	0.81	0.84	0.60	0.65	0.58
2017	0.34	0.61	0.13	0.17	0.20	0.34	0.48	0.45	0.39	0.26	0.73	0.94	0.92	-
2018	0.98	0.42	0.26	0.20	0.12	0.17	0.26	0.37	0.40	0.98	0.44	-	0.85	1.16

[1]Justert høsten 2018 etter oppdatering av data og nye beregninger
[1]Adjusted autumn 2018 after update of input data and new estimates

Tabell 5.2.5 SEI. Lengde (cm) ved alder i 2003-2018 estimert med StoX. + indikerer få prøver.
SAITHE. Length (cm) at age in 2003-2018 estimated by StoX. + indicates few samples.

	Aldersgruppe / *Age group*													
År/Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
2003[1]	25.8	33.9	39.6	44.2	49.3	60.1	64.1	66.1	70.4	75.7	82.2	+	+	+
2004[1]	28.0	32.3	39.7	46.3	53.6	58.9	69.7	74.4	74.6	78.1	77.8	+	+	+
2005[1]	27.9	36.0	39.3	45.8	51.4	59.0	62.5	67.5	71.3	69.8	80.0	+	-	-
2006[1]	26.3	35.2	40.9	43.5	51.2	57.8	64.4	66.8	70.0	73.1	76.5	+	+	+
2007[1]	26.8	36.0	40.7	46.7	51.0	58.1	65.8	67.4	69.0	72.8	81.5	+	-	-
2008[1]	26.0	36.8	41.7	47.9	51.9	58.4	61.2	68.6	73.3	77.2	+	+	-	+
2009[1]	-	33.8	41.6	47.6	57.6	63.3	66.5	64.9	69.6	75.1	72.2	78.7	+	-
2010	24.2	34.5	38.4	47.1	57.4	61.0	65.0	66.9	68.9	75.8	+	+	+	+
2011	-	36.8	41.7	44.7	56.7	62.8	69.5	65.7	76.0	+	+	+	-	-
2012	29.0	36.4	42.3	47.3	51.6	60.5	66.5	71.8	66.9	79.5	82.9	87.0	-	-
2013	26.0	36.7	41.1	48.7	55.2	60.0	68.8	74.5	75.3	75.4	78.8	+	+	+
2014	24.3	35.8	44.0	46.7	54.8	60.6	61.4	72.3	76.6	80.2	79.3	85.8	-	-
2015	29.3	34.7	41.1	48.8	53.6	60.0	65.8	71.5	+	+	+	+	-	-
2016	28.5	33.2	38.8	47.1	54.1	60.0	67.0	70.5	72.5	81.8	+	+	+	+
2017	25.1	32.6	39.9	45.7	53.5	63.7	69.6	69.6	69.8	73.1	+	+	+	-
2018	26.5	34.1	42.4	46.9	54.2	62.5	71.4	70.1	75.8	74.6	75.5	-	+	+

[1]Justert høsten 2018 etter oppdatering av data og nye beregninger
[1]*Adjusted autumn 2018 after update of input data and new estimates*

Tabell 5.2.6 SEI. Vekt (gram) ved alder i 2003-2018 estimert med StoX. + indikerer få prøver.
SAITHE. Weight (gram) at age in 2003-2018 estimated by StoX. + indicates few samples

	Aldersgruppe / *Age group*													
År/Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
2003[1]	161	388	568	832	1156	21662	2559	2895	3607	4300	6019	+	+	+
2004[1]	230	339	616	929	1515	2055	3393	4119	4414	4822	4785	+	+	+
2005[1]	229	482	612	912	1308	2029	2427	2941	3648	3130	3475	+	-	-
2006[1]	181	434	699	793	1336	1877	2668	2808	3413	4072	4492	+	+	+
2007[1]	183	468	644	924	1235	1815	2584	2854	2995	3661	4852	+	-	-
2008[1]	193	461	644	982	1256	1870	2158	2977	3787	4349	+	+	-	+
2009[1]	-	375	689	1012	1814	2525	2899	2652	3118	4046	3299	3960	+	-
2010	146	409	556	1016	1814	2227	2624	2851	3116	4363	+	+	+	+
2011	-	503	735	853	1744	2267	3302	2598	4524	+	+	+	-	-
2012	240	456	682	954	1212	1907	2481	3088	2448	4573	4783	4870	-	-
2013	171	481	690	1097	1551	2050	3170	3799	4020	3840	5044	+	+	+
2014	135	445	826	1006	1538	2096	2201	3428	4269	4679	4762	5647	-	-
2015	237	380	624	1042	1361	1955	2674	3390	+	+	+	+	-	-
2016	227	338	518	944	1422	2009	2730	3411	3690	5757	+	+	+	+
2017	142	335	576	882	1477	2511	3165	3277	3246	3576	+	+	+	-
2018	175	390	682	958	1504	2238	3342	3313	4060	3481	3576	-	+	+

[1]Justert høsten 2018 etter oppdatering av data og nye beregninger
[1]*Adjusted autumn 2018 after update of input data and new estimates*

5.3 Mengdeindekser og vekst for kysttorsk

Det må understrekes at det fremdeles er vanskelig å beregne mengden av kysttorsk akustisk, fordi registreringene er små på grunn av lav bestand.. Av samme årsak er også beregningene av middelvekt og modning ved alder usikre. I tillegg må det bemerkes at fjordene i Trøndelag/Møre ikke ble undersøkt i 2013 og på Sunnmøre i 2015 på grunn av tidsmangel. Dette gjør selvsagt at torskemengden i område 07 er underestimert i disse åra.

Tabell 5.3.1 viser akustisk estimert tall på kysttorsk fordelt på lengdegrupper og alder for hele det undersøkte området, og tabell 5.3.2 viser tallet på fisk i hver aldersgruppe for hvert av de 6 underområdene.

Tabell 5.3.1 Kysttorsk. Akustiske mengdeindekser (i tusen) på alder og lengde i 2018.
Coastal cod. Acoustic abundance indices (in thousands) by length and age in 2018.

Lengde *Length* *(cm)*	Alder (Årsklasse) / *Age (Year class)* 1 (17)	2 (16)	3 (15)	4 (14)	5 (13)	6 (12)	7 (11)	8 (10)	9 (09)	10+ (08+)	Sum
5-10	1213										1213
10-14	6297										6297
15-19	1746	2									1748
20-24	1608	132									1740
25-29	292	532	2								826
30-34	5	808	92								906
35-39		1067	361	19							1447
40-44		385	369	83	13	11					862
45-49		64	697	393	20	20					1194
50-54		5	437	424	76	49	2				994
55-59			338	613	198	87		36	2		1274
60-64			91	818	358	220	17	18			1523
65-69			149	360	604	310	136	8	36	90	1693
70-74				193	361	579	92	77	44	33	1378
75-79				26	209	302	124	58	47	49	815
80-84				5	282	179	145	95	21	52	781
85-89				6	36	179	132	43	13	19	429
90-94					52	70	100	55	46	50	374
95-99							6	33	11	12	61
100+							51	20	37	64	172
Sum:	11160	2995	2537	2940	2209	2006	805	444	257	371	25725

Tabell 5.3.2 Kysttorsk. Akustiske mengdeindekser (i tusen) i hvert underområde og totalt i 2018.
Coastal cod. Acoustic abundance indices (in thousands) by sub areas and in total in 2018.

Område *Area*	Alder (Årsklasse) / *Age (Year class)* 1 (17)	2 (16)	3 (15)	4 (14)	5 (13)	6 (12)	7 (11)	8 (10)	9 (09)	10+ (08+)	Sum
03	3313	914	883	874	614	401	145	103	65	93	7405
04	3577	1324	753	1147	688	812	329	85	69	115	8900
05	434	304	264	361	414	488	248	153	84	135	2884
00	1572	127	318	308	74	150	32	79	-	28	2688
06	2264	326	302	192	168	31	14	3	-	-	3300
07	-	-	17	58	252	124	37	21	39	-	548
Total	11160	2995	2537	2940	2209	2006	805	444	257	371	25725

Tidsserien av mengdeindekser vises i tabell 5.3.3. Kysttorsken er som seien ikke ”rekruttert til toktet” før den er 2-3 år, fordi den vokser opp på grunt vann og derfor ikke er mulig å fange representativt med trål. Etter hvert som fisken blir større og eldre trekker den ut på dypere vann og blir tilgjengelig i undersøkelser. Derfor øker ofte antall fisk i en og samme årsklasse med alderen fra 1 til 3 år. Rekrutteringen har blitt svakere og svakere i hele perioden fra 1995 og fram til og med 2002. Det var en liten økning i antall 1- og 2-åringar i 2003 og 2004, mens antall i 2005 igjen var nede på om lag samme nivå som i 2002, som er det laveste observerte i tidsserien. I 2006 - 2009 var det igjen en liten økning i antall 1-åringer, og antall fra 2010, 2011 og 2013-2015 er de høyeste siden 2001. Antall 1-åringer i årets tokt er et av de høyeste i hele tidsserien. Det er større usikkerhet i otolitt-type av 1-åringer enn av eldre fisk, men en kan håpe at den økning vi har sett for 1-åringer de forrige årene og i 2018 fortsetter, og at det om noen år vil blir synlig i den eldre delen av bestanden. For 2-åringer er otolitt-type mer sikker og toktmålet for 2-åringar er et bedre mål for rekruttering. Her ser vi en nedgang siden 2014.

Toktindeksen i 2018 for aldersgrupper med moden fisk (4+), er ganske likt gjennomsnittet for 2003-2017, mens indeksen for 7-9 åringer er litt under gjennomsnittet. Sammenlignet med 2017 var det i 2018 en økning i beregnet antall kysttorsk i alle områder utenom område 05 (Vesterålen), stort sett på grunn av en økning i antall 1 åringer. Tar man ikke disse med i betraktning så har antall kysttorsk i områder 04 og 05 gått ned.

Lengde og vekt ved alder for aldersgruppene 1-10+ år vises i tabell 5.3.4 og 5.3.5. Både lengde og vekt ved alder var i 2018 omtrent på same nivå som i 2017 for de flest aldersgruppene.

Totalt registrert akustisk biomasse av kysttorsk er vist i tabell 5.3.6. Det var en kraftig nedgang i 2015 (om lag 40%), mens toktet i 2016 viste en økning på over 20%. 2017-toktet viste en nedgang på om lag 30%, og er den laveste registrerte siden 2010. 2018-toktet viser en økning på 11%, som tilsvarer 93% av gjennomsnittet for perioden 2001-2017.

Andel av kjønnsmoden fisk ved alder er vist i tabell 5.3.7, og beregnet gytebiomasse er vist i tabell 5.3.8. Gytebiomassen beregnet fra toktet i 2018 er 18.4 tusen tonn. Det er 31% høyere enn resultatet fra toktet i 2017, men fortsatt langt under målet i gjenoppbyggingsplanen (60 tusen tonn).

Tabell 5.3.3 Kysttorsk. Akustiske mengdeindekser (i tusen) for hver aldersgruppe 1995 – 2018.
Coastal cod. Acoustic abundance indices (in thousands) by age 1995 – 2018.

År	Alder / *Age*										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	28707	20191	13633	15636	16219	9550	3174	1158	781	579	109628
1996	1756	17378	22815	12382	12514	6817	3180	754	242	5	77843
1997	30694	18827	28913	17334	12379	10612	3928	1515	26	663	124891
1998	14455	13659	15003	13239	7415	3137	1578	315	169	128	69099
1999	6850	11309	12171	10123	7197	3052	850	242	112	54	51960
2000	9587	11528	11612	8974	7984	5451	1365	488	85	97	57171
2001	8366	6729	7994	7578	4751	2567	1493	487	189	116	40270
2002	1329	2990	4103	4940	3617	2593	1470	408	29	128	21607
2003	2084	2145	3545	3880	2788	2389	1144	589	364	80	19008
2004	3217	3541	3696	4320	2758	1940	783	448	98	110	20914
2005	1443	1843	3525	3198	3217	1700	1120	552	330	78	17006
2006	1929	2525	4049	3783	3472	2509	1811	399	229	13	20719
2007	2202	3300	4080	5518	3259	2447	1444	760	197	34	23241
2008	2128	2181	2475	2863	2101	1219	815	403	319	177	14681
2009	3442	2059	2722	3959	2536	1603	1259	793	443	141	18955
2010	7768	2513	2729	2820	2417	1098	501	426	260	305	20837
2011	9015	3266	3950	4571	3012	2185	448	478	171	339	27435
2012	4887	2292	3003	2993	1990	1125	814	339	144	430	18015
2013[1]	10478	3222	2780	3545	2742	2072	1164	971	449	431	27854
2014	5104	5516	3425	2659	4514	2660	2053	1189	980	676	28776
2015[2]	6939	5084	3695	3441	2053	1984	1029	601	529	404	25759
2016	4857	4214	4850	3760	3108	1455	1022	955	187	474	24881
2017	1712	3950	4402	2910	2220	1412	664	436	248	234	18186
2018	11160	2995	2537	2940	2209	2006	805	444	257	371	25725

[1] Fjordene i område 07 ikke dekket i 2013
[2] Sørlige fjorder i område 07 ikke dekket i 2015

Tabell 5.3.4 Kysttorsk. Gjennomsnittslengde (cm) i hver aldersgruppe 1995 – 2018.
Coastal cod. Mean length (cm) at age 1995 – 2018.

År *Year*	Alder / *Age* 1	2	3	4	5	6	7	8	9	10+
1995	21.5	33.0	43.0	52.0	59.1	64.1	76.0	87.4	89.0	108.3
1996	19.0	30.2	41.7	52.5	59.2	65.2	79.1	84.8	87.0	114.2
1997	16.8	28.7	40.8	51.6	58.1	65.9	73.6	80.8	102.0	110.7
1998	20.3	33.3	43.8	51.4	59.1	66.3	74.1	81.0	93.2	116.9
1999	21.5	32.6	43.8	54.6	59.6	65.8	77.9	90.8	99.4	118.0
2000	21.6	33.3	43.4	53.5	61.0	66.1	75.5	90.8	99.1	105.5
2001	21.1	33.3	44.5	53.6	62.9	64.7	88.7	84.2	85.7	102.1
2002	22.5	34.4	44.6	56.0	61.6	67.7	72.4	66.6	89.0	108.3
2003	18.9	33.8	42.1	51.6	60.0	67.2	72.7	76.9	84.9	94.8
2004	20.7	32.9	43.5	54.5	59.9	68.0	71.9	75.0	74.6	91.8
2005	22.5	32.8	42.2	57.9	60.6	64.0	71.3	69.9	73.5	108.4
2006	22.2	36.1	47.0	55.5	61.4	68.0	69.5	77.8	87.0	100.5
2007	21.6	36.0	48.0	57.9	62.2	66.8	71.8	86.6	100.2	106.3
2008	21.9	36.9	49.2	59.0	66.1	70.9	71.7	74.1	77.6	98.8
2009	20.9	34.5	47.8	57.8	65.8	70.5	77.9	78.4	85.1	73.5
2010	20.3	34.9	46.4	57.5	64.6	71.2	76.9	75.2	78.9	82.7
2011	20.6	32.9	47.2	59.5	66.1	71.5	79.9	82.0	81.1	83.9
2012	21.3	32.4	46.9	58.8	66.1	72.0	77.0	77.5	82.2	87.3
2013	21.5	33.6	44.5	56.7	66.2	71.3	74.2	84.2	84.6	88.1
2014	21.7	35.1	47.7	57.3	66.4	73.5	76.6	80.5	81.7	93.0
2015	19.9	33.5	46.9	58.0	66.5	70.3	77.8	77.7	80.5	85.5
2016	20.5	32.9	47.8	58.7	67.8	72.2	75.1	83.0	89.7	86.9
2017	23.5	35.6	47.2	58.3	66.1	72.6	75.2	82.4	82.6	91.2
2018	19.4	35.4	47.7	58.8	68.1	71.3	79.8	80.3	85.5	84.4

Tabell 5.3.5 Kysttorsk. Gjennomsnittsvekt (gram) i hver aldersgruppe 1995 – 2018.
Coastal cod. Mean weight (grams) at age 1995-2018.

År *Year*	Alder / *Age* 1	2	3	4	5	6	7	8	9	10+
1995	81	390	791	1525	2222	2881	4665	6979	6759	9897
1996	59	252	724	1433	2053	2748	4722	6685	6932	9723
1997	43	240	683	1364	1893	2816	4426	6406	7805	1827
1998	52	372	883	1456	2107	2950	4319	5625	8323	12468
1999	70	323	841	1675	2192	2857	4540	6579	9454	12902
2000	72	365	809	1554	2539	3049	4352	6203	8527	12066
2001	51	396	966	1524	2314	3320	3695	6144	8768	12468
2002	103	428	895	1741	2433	3133	4273	4397	7759	12992
2003	62	385	738	1353	2145	3103	3981	4921	6923	9956
2004	83	352	834	1690	2255	3312	4150	4594	4383	9733
2005	112	359	786	2168	2265	2756	4174	3373	4502	15887
2006	105	474	1080	1746	2430	3336	3684	5125	7028	14650
2007	103	518	1185	2011	2500	3160	4241	6806	11051	14931
2008	96	508	1208	2095	2987	3671	3976	4387	5415	11588
2009	85	434	1116	2003	2894	3632	4875	5400	6125	4719
2010	75	419	1026	1996	2839	3665	4868	4895	5685	6504
2011	77	343	1062	2119	2882	3761	5505	6336	6309	6570
2012	89	336	1038	2006	2998	3727	4783	5071	5851	7446
2013	88	365	851	1815	2856	3561	4122	6435	5974	7670
2014	93	423	1071	1845	2886	3905	4495	5249	5871	8762
2015	75	370	1045	1940	2910	3518	4927	4753	5864	7277
2016	77	344	1121	2033	3081	3734	4286	5895	7556	6984
2017	78	421	1026	1868	2687	3746	4419	6050	6887	7637
2018	69	392	1158	1948	3192	3705	5304	5354	6428	6038

Tabell 5.3.6 Kysttorsk. Akustiske biomasseindekser (tonn) i 1995 – 2018.
Coastal cod. Acoustic biomass indices (tons) in 1995 – 2018.

År	Alder / *Age*										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	2337	7868	10786	23846	36039	27515	14445	8761	4933	7779	144309
1996	145	4386	16521	17739	25687	18731	15562	4376	3130	46	106323
1997	1319	4518	19748	23644	23435	29884	15060	8860	249	8643	135360
1998	752	5078	13247	19274	15627	9255	6675	1646	1329	2083	74966
1999	477	3650	10233	16960	15774	8720	4723	2097	1220	567	64421
2000	688	4321	9824	14464	20482	17067	5936	4359	926	1232	79299
2001	425	2662	7724	11548	10993	8521	5517	3010	1705	1917	54022
2002	137	1279	3672	8600	8801	8124	6282	1794	225	1663	40577
2003	125	876	2569	5328	5788	6995	4201	2754	2674	1136	32446
2004	329	1269	3087	7394	6089	6901	3009	1779	454	1058	31405
2005	109	675	2947	6521	7167	4807	3648	1942	1315	1205	30336
2006	202	1197	4374	6605	8435	8367	6672	2045	1602	190	39689
2007	227	1709	4835	11097	8148	7733	6124	5173	2177	508	47731
2008	206	1212	3120	6085	6593	4203	3437	2014	1492	2066	30506
2009	294	893	3037	7933	7335	5821	6137	4282	2707	665	39107
2010	583	1053	2800	5629	6862	4024	2439	2085	1478	1984	28936
2011	695	1120	4195	9686	8681	8218	2466	3029	1079	2227	41396
2012	295	767	2974	5914	5574	4143	3820	1673	775	3265	29199
2013[1]	519	1192	2767	6890	8067	7252	4756	5937	2797	3178	43355
2014	456	2218	3849	5026	13418	9994	9691	6367	7308	6608	64935
2015[2]	424	1972	3872	6423	5646	6546	4587	2747	3172	2794	38183
2016	250	1364	5792	7746	10236	5409	4156	6091	1322	3657	46023
2017	133	1664	4516	5436	5965	5289	2934	2638	1708	1787	32070
2018	770	1173	2939	5726	7051	7433	4270	2377	1652	2240	35631

[1] Fjordene i område 07 ikke dekket i 2013. [2] Sørlige fjorder i område 07 ikke dekket i 2015

Tabell 5.3.7 Kysttorsk. Andel kjønnsmodne ved alder i perioden 1995 – 2018.
Coastal cod. Maturity ogives by age in the period 1995 – 2018.

År	Alder / *Age*									
Year	1	2	3	4	5	6	7	8	9	10+
1995	0.00	0.00	0.01	0.21	0.48	0.71	0.87	0.87	1.00	1.00
1996	0.00	0.00	0.03	0.25	0.56	0.81	0.92	0.99	1.00	1.00
1997	0.00	0.00	0.06	0.29	0.45	0.76	0.97	1.00	1.00	1.00
1998	0.00	0.02	0.15	0.25	0.53	0.74	0.87	0.89	1.00	1.00
1999	0.00	0.02	0.03	0.21	0.43	0.66	0.74	1.00	1.00	1.00
2000	0.00	0.00	0.00	0.16	0.31	0.61	0.76	0.64	0.99	1.00
2001	0.00	0.00	0.00	0.04	0.37	0.78	0.98	0.99	0.97	1.00
2002	0.00	0.02	0.02	0.26	0.88	0.93	0.90	0.97	1.00	1.00
2003	0.00	0.00	0.00	0.05	0.29	0.49	0.90	0.98	0.96	1.00
2004	0.00	0.00	0.01	0.09	0.37	0.76	0.95	0.98	1.00	1.00
2005	0.00	0.00	0.00	0.07	0.40	0.56	0.89	0.98	1.00	1.00
2006	0.00	0.00	0.00	0.14	0.52	0.75	0.91	0.87	0.96	1.00
2007	0.00	0.00	0.00	0.14	0.54	0.76	0.96	0.83	1.00	1.00
2008	0.00	0.00	0.03	0.12	0.48	0.72	0.89	0.94	0.96	1.00
2009	0.00	0.00	0.02	0.06	0.26	0.35	0.59	0.74	0.60	0.92
2010	0.00	0.00	0.00	0.08	0.38	0.66	0.83	0.88	0.95	0.97
2011	0.00	0.01	0.00	0.06	0.42	0.73	0.81	0.53	0.92	0.85
2012	0.00	0.00	0.01	0.05	0.38	0.66	0.90	0.92	0.97	0.99
2013	0.00	0.00	0.00	0.01	0.32	0.65	0.86	0.94	0.99	0.96
2014	0.00	0.00	0.00	0.06	0.24	0.66	0.81	0.94	1.00	0.97
2015	0.00	0.00	0.00	0.07	0.23	0.57	0.75	0.88	0.89	0.94
2016	0.00	0.00	0.00	0.09	0.30	0.59	0.83	0.85	0.97	1.00
2017	0.00	0.00	0.00	0.07	0.30	0.65	0.88	0.94	0.97	0.97
2018	0.00	0.00	0.01	0.15	0.41	0.69	0.83	0.95	1.00	0.92

Endringer i fiskefordeling og fangster siden 2015

I toktet i 2015 utgjorde torsken en ganske liten andel av ekkomengden i blandete registreringer på ekkoloddet. Dette sammen med manglende dekning i grunne områder og stor blindsone i bratte skråninger gjør at det er stor usikkerhet i det akustiske mengdemålet for torsk. Resultata fra toktet i 2015 var likevel lavere enn en kunne vente etter de to foregående toktene. Det er særlig tre årsaker som trolig kan forklare nedgangen. Dårlig dekning i de indre områdene i det sørligste området (07) ga lavere indeks, siden det er i de indre områdene det tidligere har vært registrert mest torsk. Den største nedgangen ble registrert i område 04 og 05. I de indre delene av område 04 ble det under toktet i 2015 registrert svært høye akustiske verdier ($S_{A)}$ på dypt vann som ikke stammet fra fisk (dypere enn 150-200 meter). På det tetteste ble det registrert S_A-verdier på opp mot 30000 per nautisk mil. Det viste seg etter en del forsøk ved Universitetet i Tromsø at det trolig var ribbemaneter og siphonoforer som var årsaka, både levende og delvis dødende/halvt oppløste (Knutsen et al. 2017). I områder med slike tette forekomster var det generelt svært lave fangster av fisk. Det er derfor mulig at fisken i større grad har trukket inn på grunnere vann og dermed sto i bratte kanter og var mindre tilgjengelig for akustisk registrering enn tidligere. Noe av det samme ble registrert i 2017, men ikke i like stor grad. Den tredje årsaken til nedgangen kan være at det i desember 2014 og januar 2015 var et stort fiske av torsk i et område rundt grensa mellom 04 og 05 som trolig i all hovedsak var kysttorsk. Innsiget av skrei var uvanlig seint i 2015, samtidig med at det kom inn nokså mye kysttorsk under innsiget av sild høsten 2014. Hele desember 2014 og januar 2015 ble det fisket nokså store kvanta torsk på et relativt avgrenset område før skreien kom. Siden det ikke var torsk å få i andre områder grunnet sent skrei-innsig, steg prisene dramatisk og mange fartøy kom nord til dette området og fisket hele kvoten her. Det ble landet om lag 17000 tonn torsk i januar i område 04 og 05. Mye av dette var trolig kysttorsk. Det er også i den voksne delen av bestanden som er utsett for kommersiell fangst at vi ser nedgangen. Det var et relativt bra fiske av torsk i perioden november 2015 til februar 2016 nord i område 05 og sør i område 04 hvor silda kom inn til kysten. Selv om skreiinnsiget også i 2016 kom sent til dette området ble det nok landet mindre kysttorsk enn året før. Dette kan nok være noe av årsaken til at en ikke så en videre nedgang for kysttorsken i 2016.

Skreiinnsiget kom sent også i 2017, og det ble fisket «sildetorsk» i et større område enn de foregående årene fordi det i 2017 også kom en del sild inn i fjordene i Nord-Troms. Også i starten av 2018 ble det fisket betydelig mengder kysttorsk i sildeansamlinger i fjordene i Nord-Troms.

Tabell 5.3.8 Kysttorsk. Akustiske gytebiomasseindekser (tonn) i 1995 – 2018.
Coastal cod. Acoustic spawning biomass indices (tons) in 1995 – 2018.

År	Alder / *Age*										
Year	1	2	3	4	5	6	7	8	9	10+	Sum
1995	0	0	96	4925	17424	19614	12573	7648	4933	7779	74992
1996	0	0	468	4467	14320	15130	14365	4311	3130	46	56237
1997	0	0	1185	6857	10546	22712	14608	8860	249	8643	73660
1998	0	92	2026	4870	8252	6804	5774	1461	1329	2083	32691
1999	0	56	315	3544	6778	5716	3478	2097	1220	567	23771
2000	0	0	0	2366	6354	10426	4486	2798	916	1232	28579
2001	0	0	15	508	4102	6662	5398	2978	1650	1917	23230
2002	0	20	87	2240	7702	7551	5650	1747	225	1663	26885
2003	0	0	0	269	1670	3428	3778	2686	2554	1136	15521
2004	0	0	28	679	2252	5253	2853	1736	434	722	13959
2005	0	0	0	447	2844	2670	3247	1898	1315	288	12709
2006	0	0	0	925	4386	6275	6072	1779	1538	571	21546
2007	0	0	0	1554	4400	5877	5879	4294	2177	508	24689
2008	0	0	107	734	3189	3012	3049	1902	1434	2066	15493
2009	0	0	61	476	1907	2037	3621	3169	1624	612	13508
2010	0	0	0	450	2608	2656	2024	1835	1404	1924	12901
2011	0	11	0	581	3646	5999	1997	1605	993	1893	16725
2012	0	0	22	278	2126	2748	3457	1539	755	3219	14143
2013[1]	0	0	0	56	2580	4713	4112	5576	2773	3046	22856
2014	0	0	0	314	3222	6593	7831	5958	7307	6433	37659
2015[2]	0	0	0	457	1301	3719	3436	2414	2811	2627	16763
2016	0	0	0	725	3084	3196	3464	5190	1278	3657	20597
2017	0	0	0	374	1779	3464	2582	2489	1662	1729	14078
2018	0	0	29	859	2891	5129	3544	2258	1652	2061	18423

[1]Fjordene i område 07 ikke dekket i 2013.

[2] Sørlige fjorder i område 07 ikke dekket i 2015

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2017 Acoustic Barents Sea winter survey and Lofoten Acoustic survey

		age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14+	sum (mill)	Biomass (thousand t)
BS_Win_Acoust	N(mill)	396.60	48.50	91.20	40.40	48.40	67.70	36.90	26.20	13.70	5.45	3.14	5.19	0.66	0.56	784.50	721.40
BS_Win_Acoust	meanW(kg)	0.016	0.092	0.297	0.737	1.253	2.016	3.091	4.645	6.088	7.403	9.186	8.412	12.416	16.803		
BS_Win_Acoust	frac.mat	0	0	0	0.0018	0.0020	0.0932	0.3899	0.7253	0.9150	1.0000	1.0000	0.9860	1.0000	1.0000		
Lof Acoust N(mill)						0.18	8.94	12.86	24.07	14.76	12.58	11.58	12.01	3.72	3.51	104.20	636.3
Lof Acoust meanW (kg)						1.958	2.478	2.942	4.804	5.739	7.122	8.160	9.117	10.430	12.308		
Lof Acoust mat	frac.mat					0.9500	0.8400	1.0000	0.9100	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		
Combined BS_Lof N(mill)		396.60	48.50	91.20	40.40	48.58	76.64	49.76	50.27	28.46	18.03	14.72	17.20	4.38	4.07	888.70	1357.66
Combined BS_Lof meanW (kg)		0.016	0.092	0.297	0.737	1.256	2.070	3.052	4.721	5.907	7.207	8.379	8.904	10.729	12.926		
Combined BS_Lof mat	frac.mat	0.000	0.000	0.000	0.002	0.005	0.180	0.548	0.814	0.959	1.000	1.000	0.996	1.000	1.000		

2018 Acoustic Barents Sea winter survey and Lofoten Acoustic survey

		age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14+	sum (mill)	Biomass (thousand t)
BS_Win_Acoust	N(mill)	1492.4	221.3	90	135.9	46.7	51.1	56.3	35	10.1	6.56	1.47	2.16	1.54	0.4	2150.9	818.1
BS_Win_Acoust	meanW(kg	0.011	0.066	0.306	0.688	1.243	2.074	2.85	4.179	5.524	6.791	9.223	10.497	11.164	12.268		
BS_Win_Acoust	frac.mat	0.0000	0.0001	0.0000	0.0014	0.0168	0.1088	0.2633	0.4857	0.8933	0.9750	1.0000	0.9670	0.9811	1.0000		
Lof Acoust N(mill)					0.2	0.6	3.5	11.5	11.2	8.5	7.8	4.4	3.7	2.8	3.1	104.20	380.8
Lof Acoust meanW (kg)					2.237	3.247	2.721	3.408	4.528	6.512	7.943	9.694	12.059	12.053	13.146		
Lof Acoust mat	frac.mat				0.0000	1.0000	0.9500	0.9700	1.0000	0.9900	1.0000	1.0000	1.0000	1.0000	1.0000		
Combined BS_Lof N(mill)		1492.40	221.30	90.00	136.09	47.32	54.58	67.75	46.21	18.58	14.34	5.91	5.89	4.36	3.46	2255.10	1198.90
Combined BS_Lof meanW (kg)		0.011	0.066	0.306	0.690	1.269	2.115	2.944	4.264	5.975	7.416	9.576	11.485	11.739	13.044		
Combined BS_Lof mat	frac.mat	0.000	0.000	0.000	0.001	0.030	0.162	0.383	0.610	0.937	0.989	1.000	0.988	0.993	1.000		

2019 Acoustic Barents Sea winter survey and Lofoten Acoustic survey

		age1	age2	age3	age4	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14+	sum (mill)	Biomass (thousand t)
BS_Win_Acoust	N(mill)	1000.3	287.4	182.1	97.7	124.3	53.4	33.7	31.6	8.7	2.83	0.38	0.33	0.2	0.39	1823.3	731.2
BS_Win_Acoust	meanW(g)	11	46	311	748	1275	2007	3022	4074	5464	6357	9921	11464	13618	12341		730.7
BS_Win_Acoust	frac.mat	0.0000	0.0000	0.0000	0.0035	0.0385	0.2089	0.5828	0.8532	0.8992	0.9876	0.9520	1.0000	1.0000	1.0000		
Lof Acoust N(mill)						0.5	2.9	14.3	36.1	17.7	18.4	6.1	2.5	2.4	5.0	106.02	662.9
Lof Acoust meanW (g)						1896	2888	3721	4817	6069	7432	8684	11069	13867	13420		
Lof Acoust mat	frac.mat					0.4593	0.8157	0.9292	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9787		
Combined BS_Lof N(mill)		1000.30	287.40	182.10	97.70	124.84	56.28	48.03	67.69	26.37	21.24	6.48	2.87	2.64	5.42	1929.32	1394.10
Combined BS_Lof meanW (g)		11	46	311	748	1277	2052	3231	4470	5869	7288	8757	11115	13848	13343		
Combined BS_Lof mat	frac.mat	0.000	0.000	0.000	0.003	0.040	0.240	0.686	0.931	0.967	0.998	0.997	1.000	1.000	0.980		

Greenland halibut EcoJuv survey index

Tone Vollen, Kristin Windsland, Elvar Hallfredsson and Mikko Vihtakari

29 april 2019

1 Why recalculate the EcoJuv index?

Over the last few years, the institute has moved all raw data from a simple text-format (database name “årsmaterialet” with file format = “spd”) to a new database (database name “Sea2Data” with file format xml). The flexibility of the new database and the accompanying software/hardware (Fish2Data) allowed us to improve the somewhat complicated Greenland halibut sampling regime. Since 2016, the sampling regime was changed, and the previous index calculations could not be used on newer data (2016-2018).

Prior to 2016, catch size and length distributions were stored split on “Females”, “Males” or “Unsexed” in the database. With the new sampling regime, catch size and length distributions are no longer split by sex in the database, and the number of samples has decreased a lot. This means that splitting the indices on sex is not as straight-forward as it was earlier.

The EcoJuv-index is based on data from two cruise series, the old Greenland halibut juvenile cruise (1996-2002) and the Ecosystem cruise (2003-pt). ***ICES names***

2 New and old raw data

When comparing raw data from the new and old database, there were differences (Table 1).

- the cruise series definitions differed, and thereby also the extracted dataset (not applicable to EcoJuv data series)
- corrections had been made to the data in the new database (ex. 2004, 2005)
- new errors were introduced when transferring data to the new database (ex. 2005, 2006)
- some data are still missing in the new database (ex 2000, 1998, 1999)

The influence of these difference on the index and length distributions is investigated further in section 6.

Table 1. Number of stations and samples in the two datasets. 2014 survey is excluded due to poor survey coverage.

	Old dataset			**New dataset**		
year	**stations**	**length samples**	**length-sex samples**	**stations**	**length samples**	**length-sex samples**
1996	56	1072	933	56	1081	882
1997	81	1936	1800	81	1958	1786
1998	104	3626	1875	–	–	–
1999	92	2757	1511	–	–	–
2000	82	3264	1873	76	3205	538
2001	87	3034	1910	87	3035	414

	Old dataset			New dataset		
year	stations	length samples	length-sex samples	stations	length samples	length-sex samples
2002	84	3483	2077	75	3452	2048
2003	66	2703	1518	66	2703	1115
2004	203	11644	10238	203	11717	10258
2005	156	10649	4957	156	11400	4957
2006	108	7055	4574	108	7055	4574
2007	122	6492	4421	122	6739	4132
2008	61	1217	1078	61	1217	1078
2009	54	1250	1150	54	1250	1150
2010	77	1799	1527	77	1799	1527
2011	70	1231	811	70	1231	811
2012	91	1777	1136	91	1777	1136
2013	79	1362	750	78	1196	722
2015	48	598	504	48	598	364
2016	–	–	–	47	605	380
2017	–	–	–	61	1309	810
2018	–	–	–	54	489	290

3 Old survey index

The “old index” (1996-2015) is the index used in the last assessment (AFWG 2017). The calculations are based on spd-files extracted from the “årsmaterialet”. Before 2016, all levels of greenland halibut data is split by sex, and the index calculations are done separately for males, females and unsexed. In the biomass index, unsexed were split by sex using the ratio females : males the same year. In the length distributions, unsexed in the length interval 20-45 cm were split using the ratio females : males within the same year and length group. If this was not possible, they were split using the overall ratio females : males withing the interval 20-45 cm the same year. The same ratio was used to split unsexed <20 cm (where sex determination was not trusted), and unsexed >45 cm (very few). In 2015, the number of sexed individuals were few, and the overall ratio females : males in the length interval 20-45 cm (ratio = 0.52) was used to split unsexed in all length groups.

4 New survey index

The “new index” (1996-2018) is based on data from the S2D database. Data were downloaded in xml format using the R-package Rstox, which provides functions for downloading as well as reading xml files into R.

Splitting by sex proved difficult due to the low number of samples the last few years (Table 1). However, we expect the sex ratio to be close to 1:1 in the juvenile area. This was investigated by plotting the yearly sex ratio of each 1 cm length group (Figure 4.1). Sex determination of fish smaller than 20 cm is difficult, and therefore not included. The sex ratio is close to 1:1 for individuals smaller than 50 cm, which is 99.6 % of all individuals in the survey. To keep things simple, ratio females : males was fixed to 1:1 for all years and all length groups. In the future, the higher proportion of females in larger length groups should be accounted for.

Figure 4.2 and 4.3 shows the old and new index together. Both indices are split by sex. In the new index, females and males are identical (e.i. lines are exactly on top of each other). Data for 1998 and 1999 are currently missing in the new database. The new 1:1 ratio calculations are therefore performed on old data for these years.

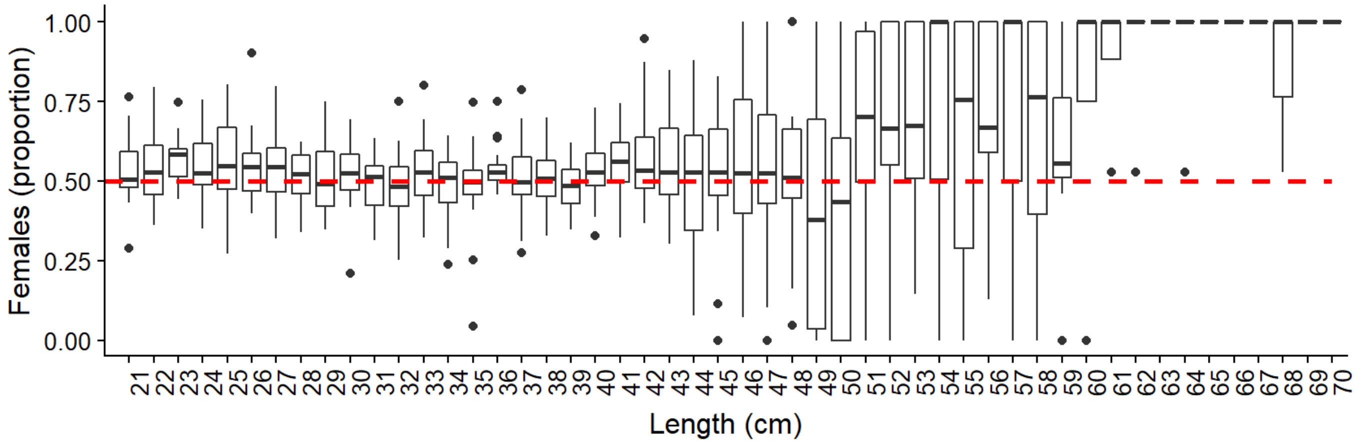

Figure 4.1: Yearly proportion of females by length. Dotted line (red) is ratio 1:1. Individuals < 20 cm are removed because sex determination is not trusted. 99.6 % of individuals are < 50 cm.

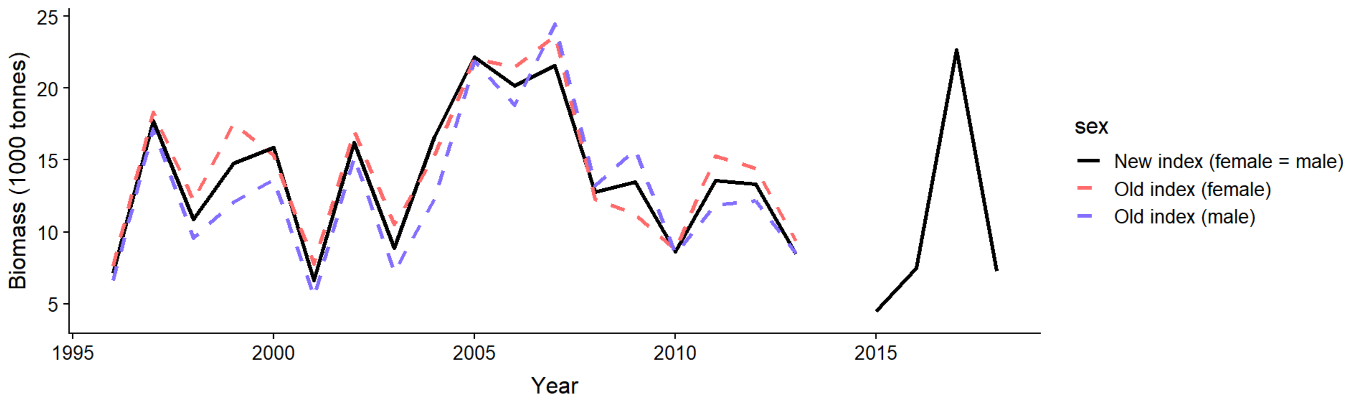

Figure 4.2: Old and new Greenland halibut EcoJuv index, split by sex. Old index in red (females) and blue (males), new index in black (females = males). Old data are used to split sex 1:1 for years 1998 and 1999. 2014 survey is excluded due to poor survey coverage.

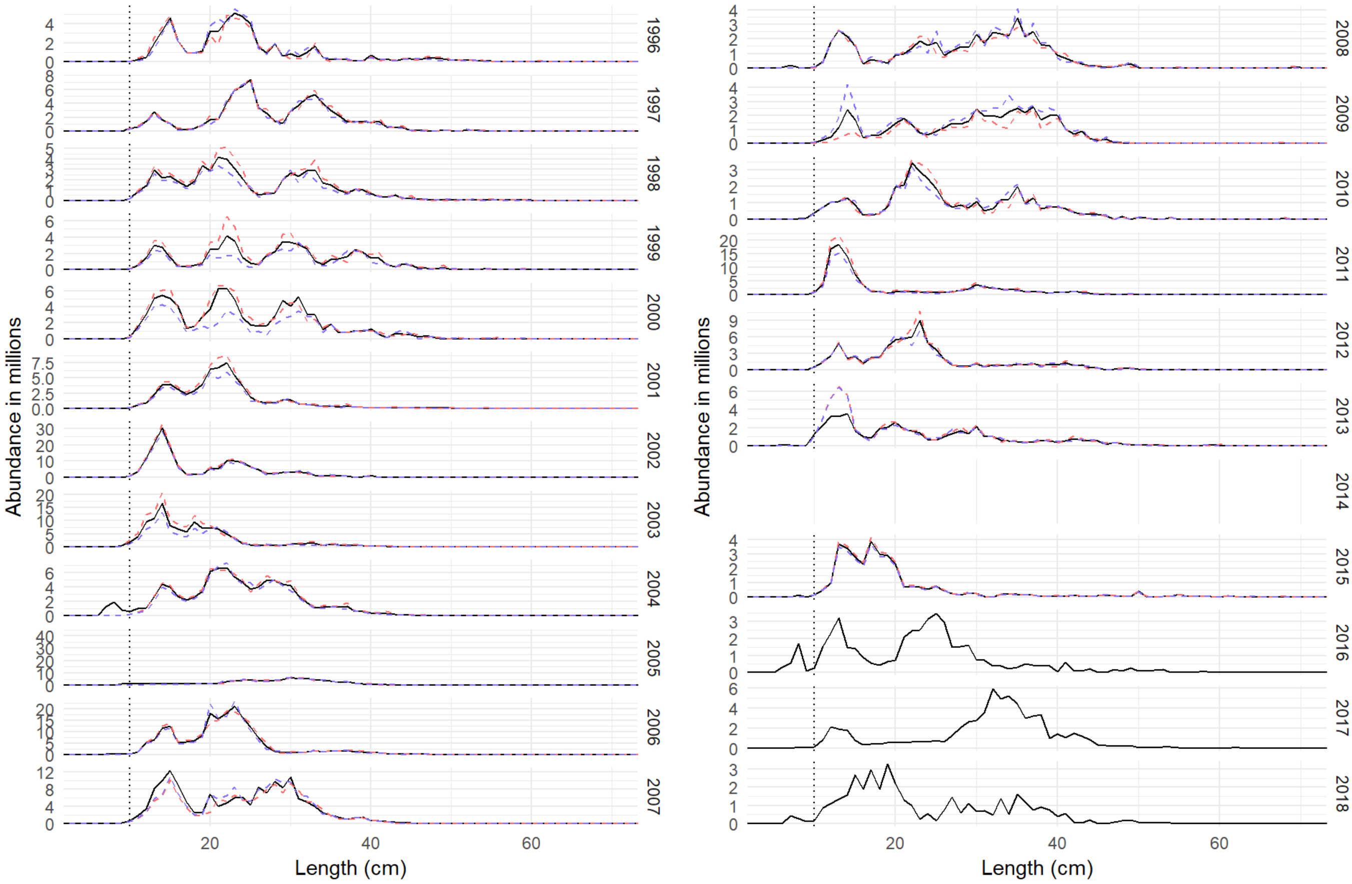

Figure 4.3: Old and new Greenland halibut EcoJuv index, split by sex. Old index in red (females) and blue (males), new index in black (females = males). Dotted line marks the smallest length included in gadget. Smaller lengths are set to 0. Old data are used to split sex 1:1 for years 1998 and 1999. 2014 survey is excluded due to poor survey coverage.

5 Sex ratio

The proportion of females in the new and old biomass index was compared (Figure 5.1 and 5.2). Within years, the indices differed by less than 10 %, so using a 1:1 ratio seems reasonable. The length frequency distributions is much more variable, particlarly for large fish where the sample size is small. The trends seen in fish < 20 cm in 1996 and 2009 are probably due to systematic errors in sex determination. In 2015, a ratio of 0.52 (females : males) was used to split all lengths by sex in the old index.

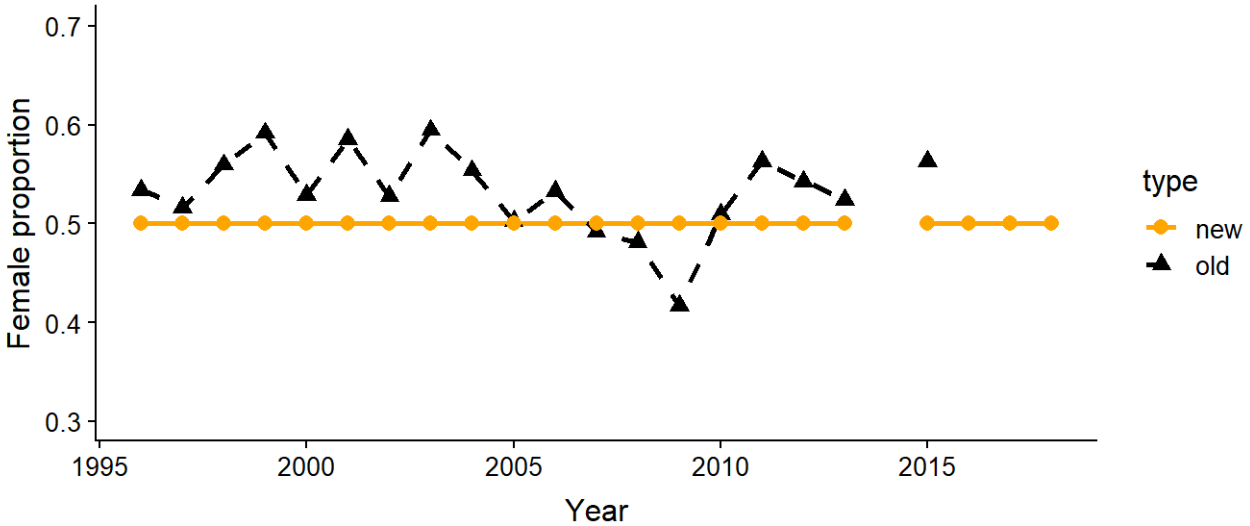

Figure 5.1: Proportion of females in the biomass index, comparison of old and new index.

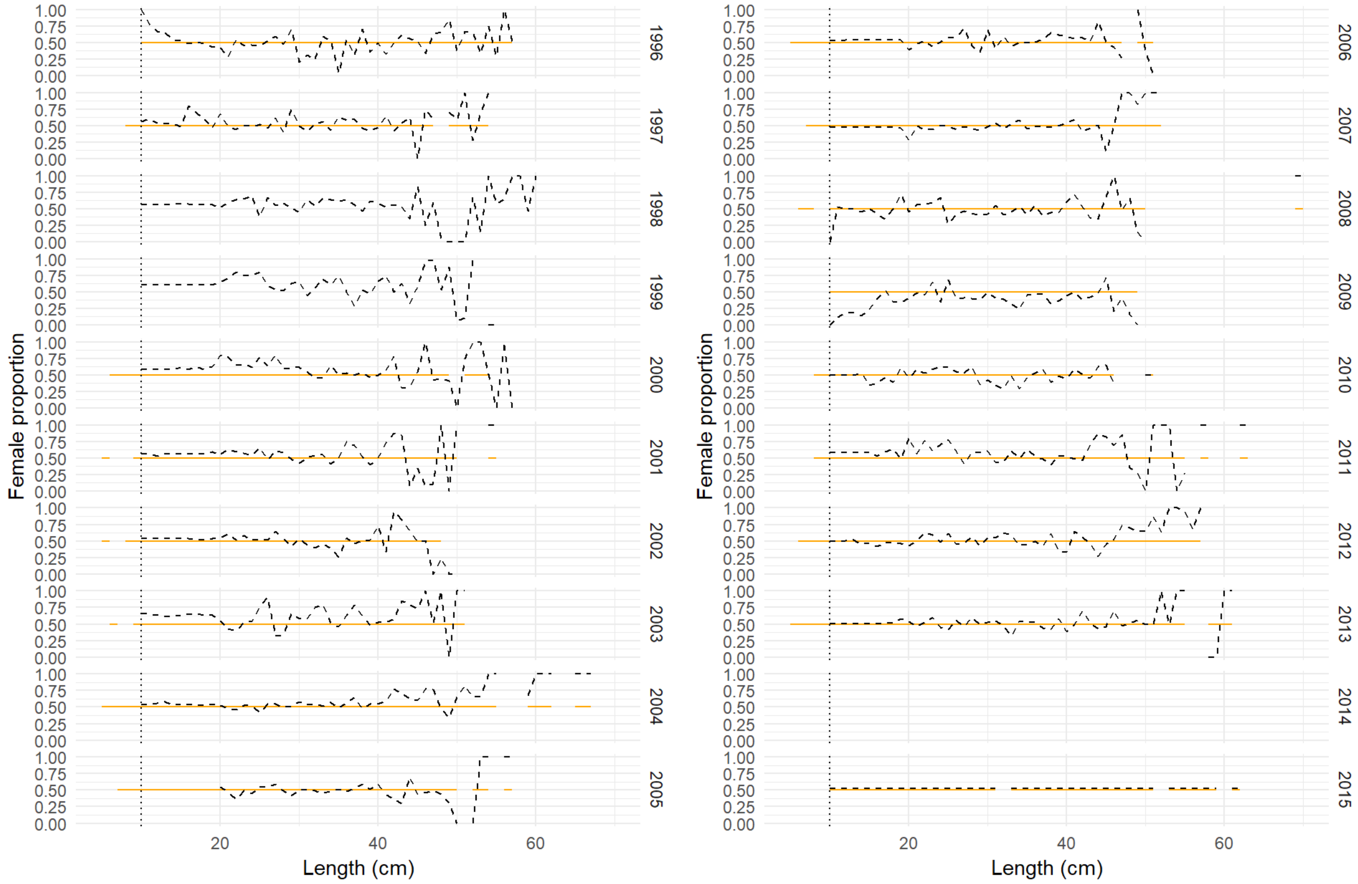

Figure 5.2: Proportion of females in the length distributions, comparison of old and new index. Data for 1998 and 1999 are currently missing in new database.

6 Difference in raw data

Figure 6.1 and 6.2 shows the old and new index and length distributions, sex combined. Differences between the indices are due to data that are partly or completely missing in the new database at this time (1998, 1999, 2000), or due to corrections and/or introduced errors (2004, 2007, 2013). Missing data and introduced errors will corrected before the next AFWG.

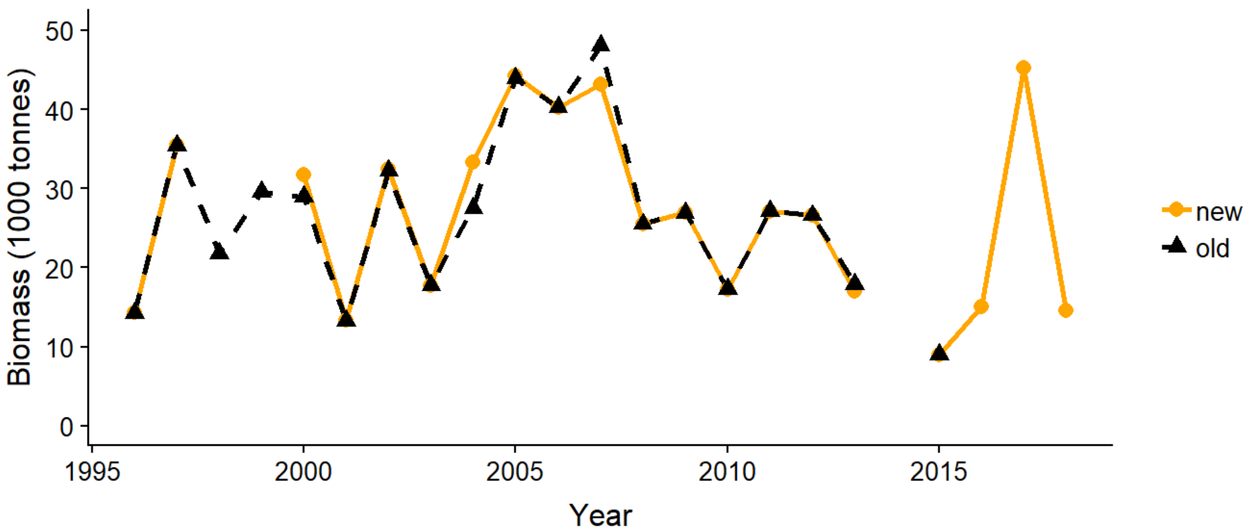

Figure 6.1: Biomass index, sex combined. Comparison of new and old dataset.Data for 1998 and 1999 are currently missing in new database.

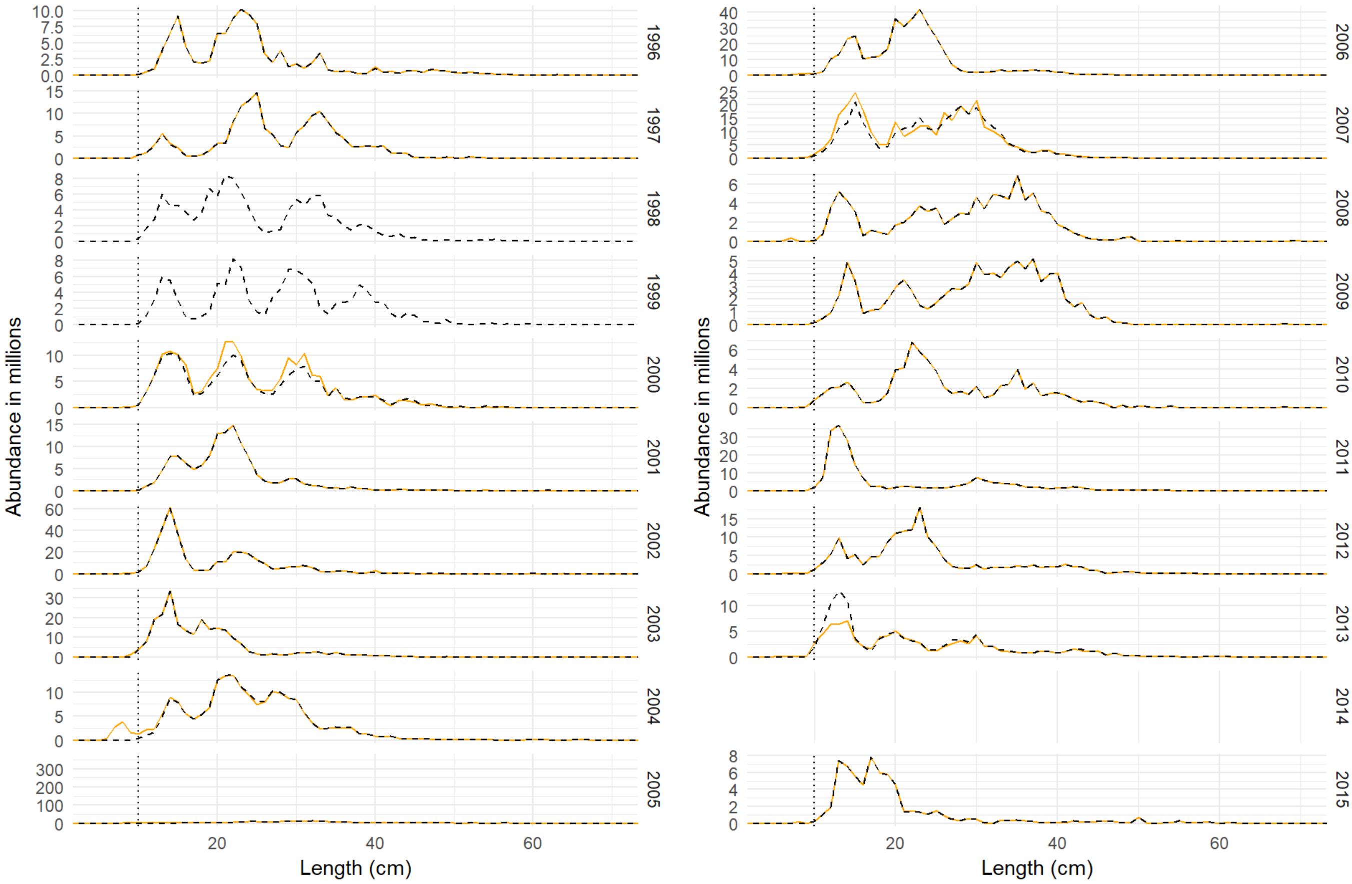

Figure 6.2: Length distributions, sex combined. Comparison of new and old dataset. Data for 1998 and 1999 are currently missing in new database.

7 Conclusion

Due to changes in the sampling regime, the old method used for index calculation could not be used for years 2016 onwards, and changes needed to be made. The new database currently have some flaws such as some missing data and introduced errors, but many of these have been compensated for. At the other hand, errors in the old data and index were also identified.

We recomment that the new index is used for the AFWG 2019 assessment.

Greenland halibut EcoSouth survey index

Tone Vollen, Kristin Windsland, Elvar Hallfredsson and Mikko Vihtakari

29 april 2019

1 Why recalculate the EcoSouth index?

Over the last few years, the institute has moved all raw data from a simple text-format (database name “årsmaterialet” with file format = “spd”) to a new database (database name “Sea2Data” with file format xml). The flexibility of the new database and the accompanying software/hardware (Fish2Data) allowed us to improve the somewhat complicated Greenland halibut sampling regime. Since 2016, the sampling regime was changed, and the previous index calculations could not be used on newer data (2016-2018).

Prior to 2016, catch size and length distributions were stored split on “Females”, “Males” or “Unsexed” in the database. With the new sampling regime, catch size and length distributions are no longer split by sex in the database, and the number of samples has decreased a lot. This means that splitting the indices on sex is not as straight-forward as it was earlier.

The EcoSouth-index is based on data from the Ecosystem cruise (2003-pt). ***ICES names***

2 New and old raw data

When comparing raw data from the new and old database, differences were found (Table 1).

- the cruise series definitions differed, and thereby also the extracted dataset (ex. 2004-2006)
- corrections had been made to the data in the new database (ex. 2005, 2006)
- new errors were introduced when transferring data to the new database (ex. 2005, 2006)
- some data are still missing in the new database

The influence of these difference on the index and length distributions is investigated further in section 6.

Table 1. Number of stations and samples in the two datasets.

	Old dataset			New dataset		
year	**stations**	**length samples**	**length-sex samples**	**stations**	**length samples**	**length-sex samples**
2003	–	–	–	249	670	434
2004	282	504	399	291	652	426
2005	354	1232	726	377	3797	1902
2006	424	1065	1004	472	1341	1278
2007	304	1015	785	304	1065	835
2008	270	494	458	270	494	458
2009	218	394	394	218	394	394
2010	213	413	237	213	440	237

	Old dataset			New dataset		
year	stations	length samples	length-sex samples	stations	length samples	length-sex samples
2011	234	335	306	234	335	306
2012	250	439	434	250	439	434
2013	259	382	374	258	383	372
2014	229	225	223	236	229	227
2015	210	202	185	212	212	195
2016	–	–	–	199	226	130
2017	–	–	–	202	240	213
2018	–	–	–	124	177	151

3 Old survey index

The “old index” (2004-2015) is the index used in the last assessment (AFWG 2017). The calculations are based on spd-files extracted from the “årsmaterialet”. Before 2016, all levels of greenland halibut data is split by sex, and the index calculations are done separately for males, females and unsexed. In the biomass index, unsexed were split by sex using the ratio females : males the same year. In the length distributions, unsexed individuals >20 cm were split using the ratio females : males within the same year and length group. The overall ratio for 20-45 cm (0.49) was used to split unsexed <20 cm, where sex determination was not trusted.

4 New survey index

The “new index” (2003-2018) is based on data from the S2D database. Data were downloaded in xml format using the R-package Rstox, which provides functions for downloading as well as reading xml files into R.

4.1 Sex split

To split the data on sex, a female-proportion-at-length key was needed to split each 1 cm length group of the yearly length frequency distributions. First, separate female-proportion-at-lengths for each year were tested. In the calculations, any proportion based on stations with less than four sexed individuals was discarded. The results are shown with a lowess smoother in Figure 4.1. However, the number of sexed samples in each length group is very low the last few years (Figure 4.2), as well as in the smallest and largest length groups. We therefore decided to make an overall female-proportion-at-length, joining data from all years. A gam (family=quasibinomial) was run on the length interval 30-70 cm, as sex determination may be difficult for smaller individuals. Sex ratio for lengths <20 cm was fixed to 1:1. Individuals > 70 cm were assumed to be females. The resulting overall female_proportions-by-length (Figure 4.3) was used to split all years by sex.

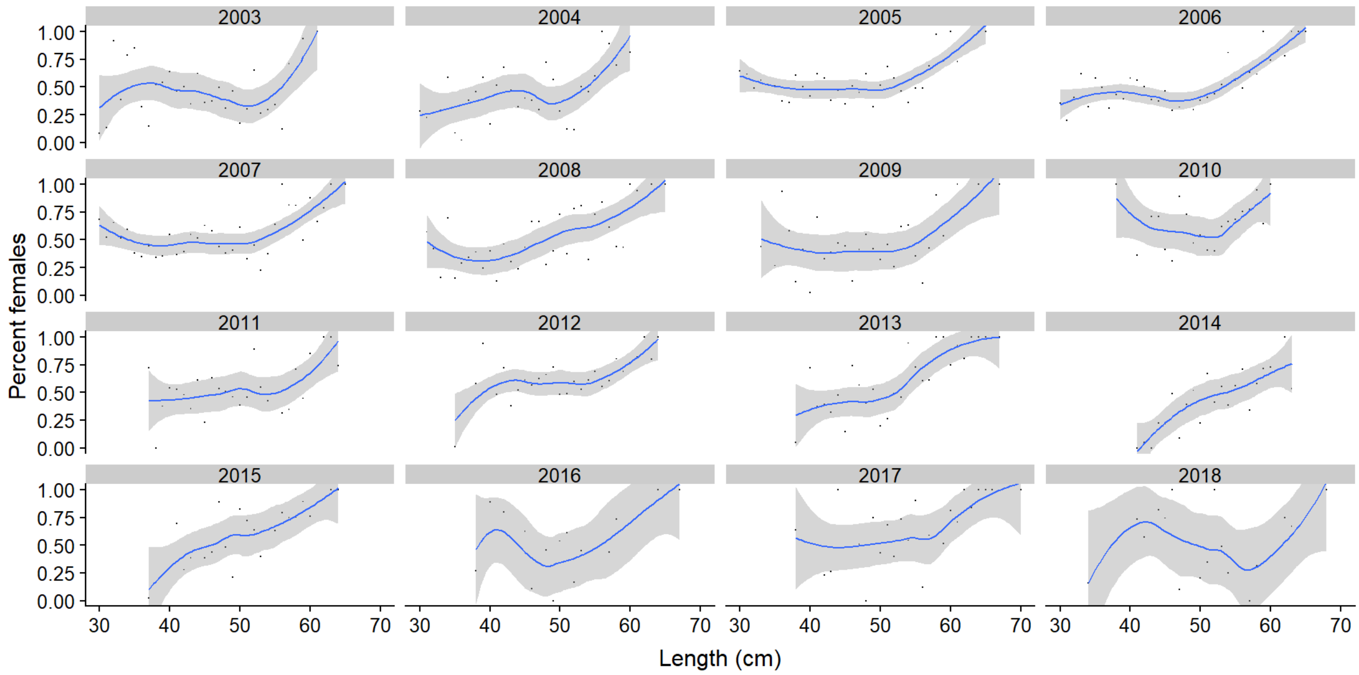

Figure 4.1: Lowess smoother female proportion by 1 cm length group and year.

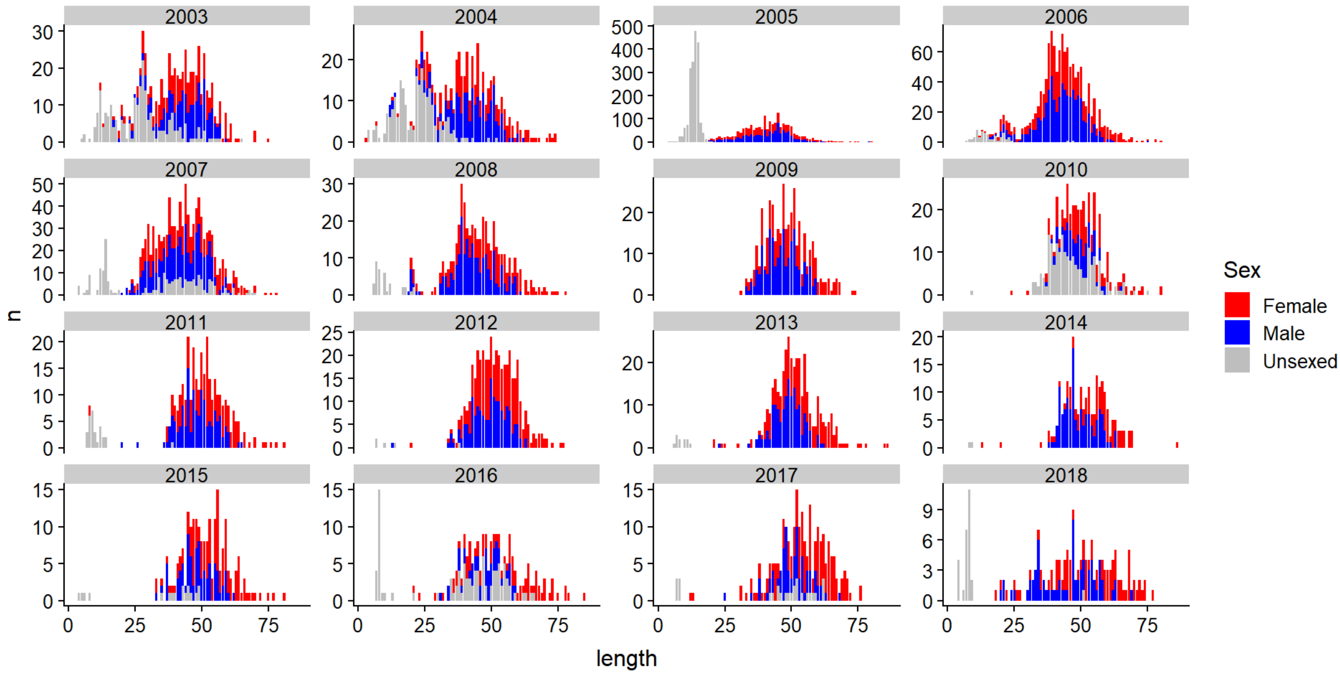

Figure 4.2: Total number of sexed length-samples by year, 1 cm length group, and sex (new dataset).

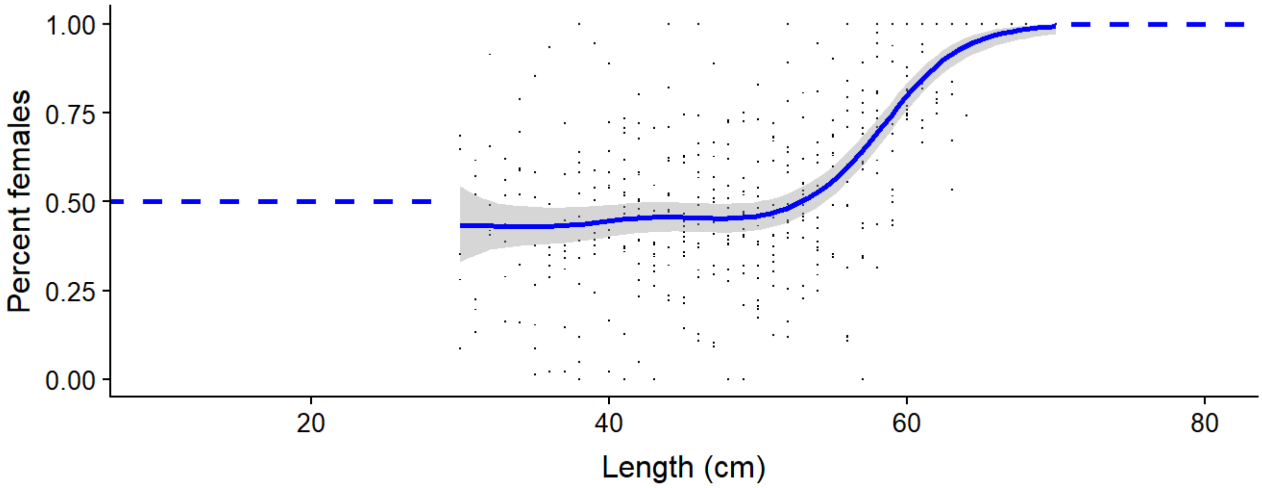

Figure 4.3: Final key for splitting on sex. For 0-30 cm the proportion of females is set to 50%, and for 70-100 cm it's set to 100%. For the interval 30-70 cm, a gam was fitted to all available data.

4.2 Length-weight relationship

In the data from 2016-2018, catch- and sampleweight was not available by sex. The weight ratio of females : males in the samples was therefore needed to calculate a biomass index split by sex. As only a fraction of the individs in the length samples were also weighed, individual weights were derived using a length-weight relationship (Figure 4.4). The LW-relationship was based on all available data from the Norwegian and Barents Sea in the IMR database. There was no difference between sex, so an general LW-relationship was used.

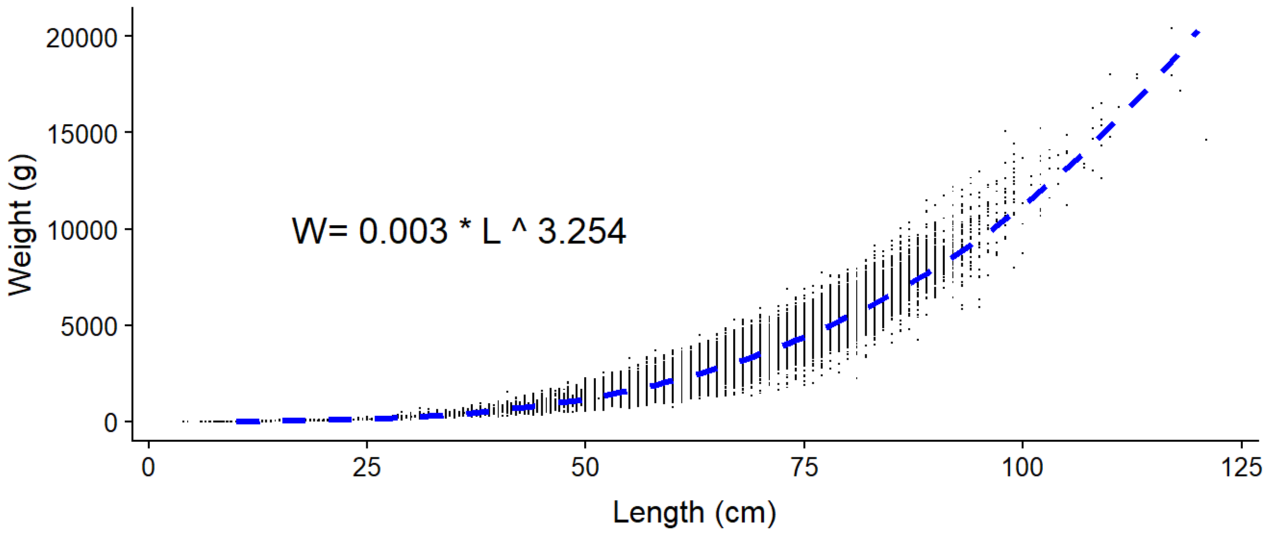

Figure 4.4: Length-weight relationship, linear model: log(W)= + b*log(L), R2=0.9814, p<0.001.

5 Comparing new and old index

Figure 5.1, 5.2 and 5.3 shows the resulting new index together with the old index. The year 2014 stands out in the original data, with a high proportion of males. This may be due to errors in sex determination this particular year, or due to poor survey coverage, which is known to have had an effect on the index of other species this year. This issue is camouflaged in the new survey index, but should be investigated further.

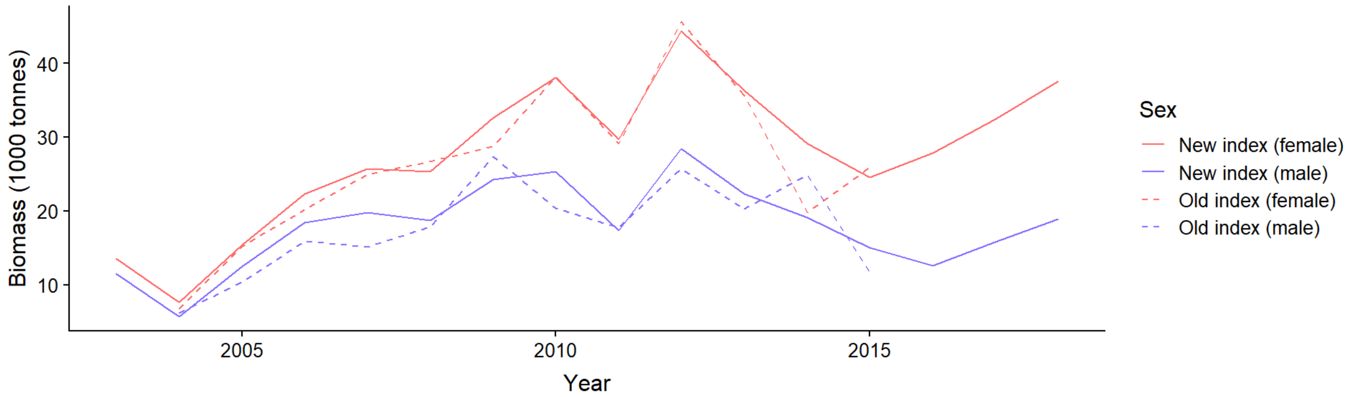

Figure 5.1: Old and new Greenland halibut EcoSouth index.

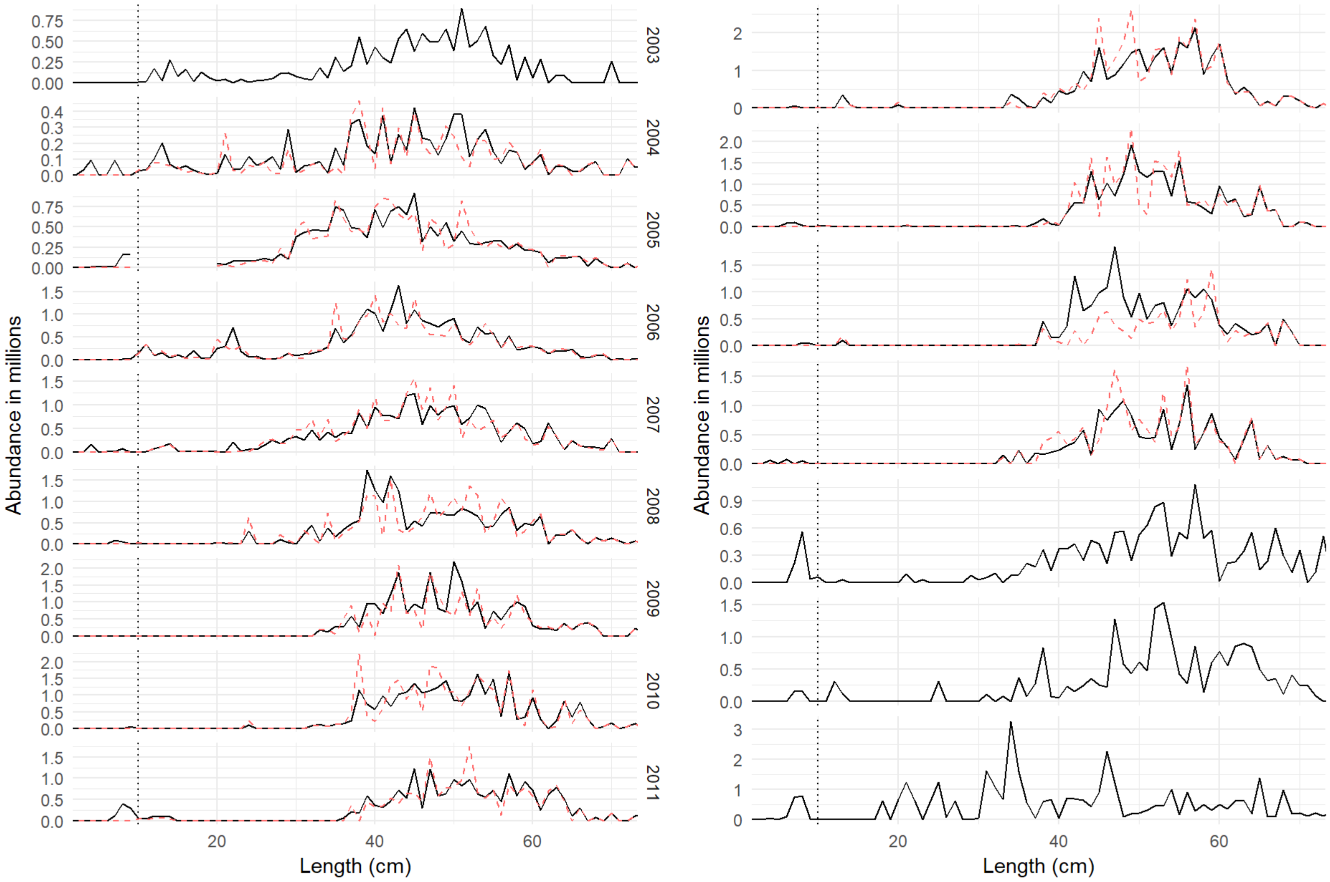

Figure 5.2: Female Greenland halibut, new (black, solid) and old (red, dotted) length distributions. Dotted vertical line marks the lower length limit included in gadget files.

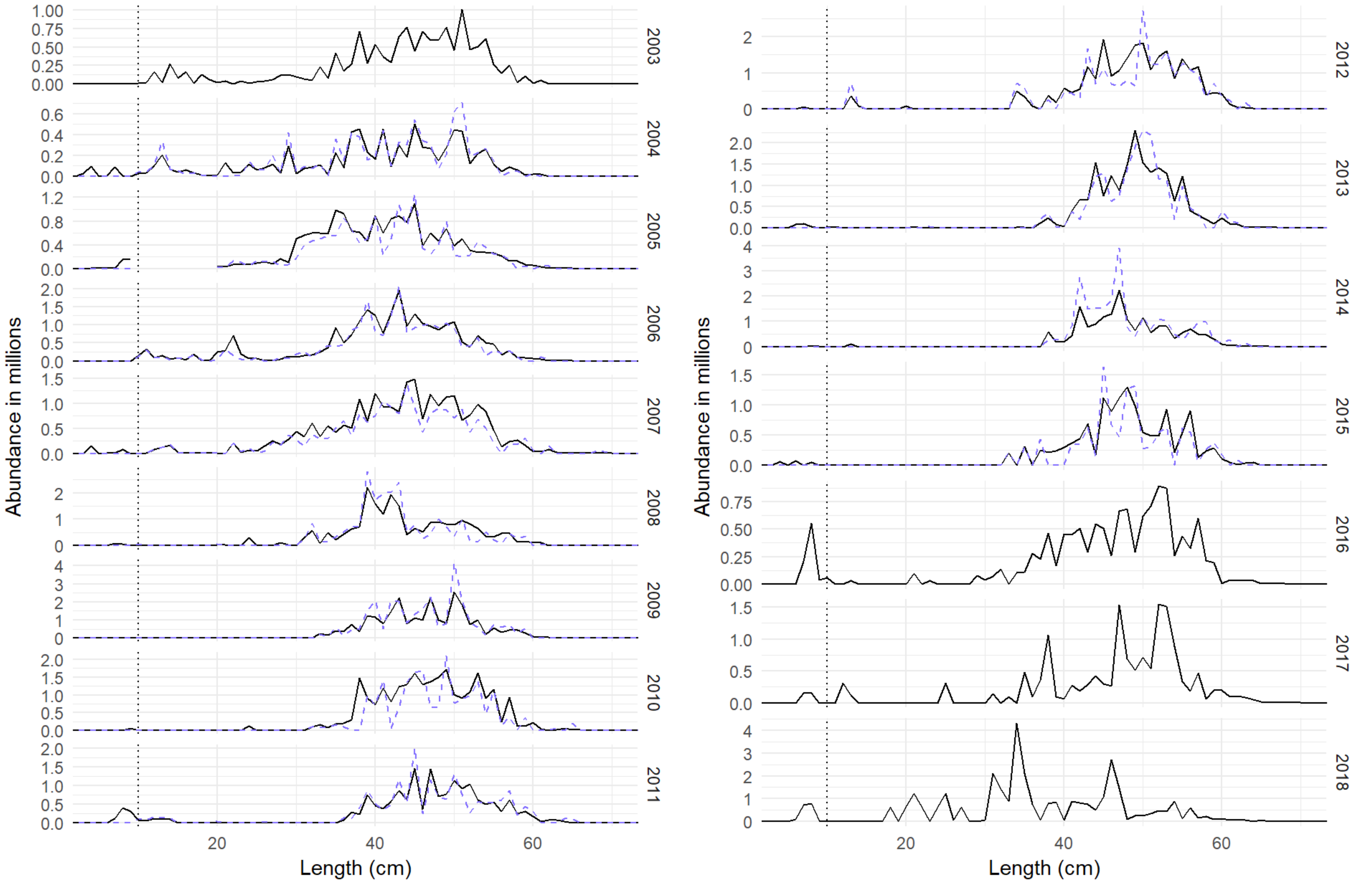

Figure 5.3: Male Greenland halitut, new (black, solid) and old (blue, dotted) length distributions. Dotted vertical line marks the lower length limit included in gadget files.

6 Sex ratio

The proportion of females in the new and old biomass index was compared (Figure 6.1 and 6.2). The new method of splitting by sex using a fixed proportion-of-females-by-length had a smoothing effect on the sex ratio compared to the old index. This is partiularly true when looking at the length distributions.

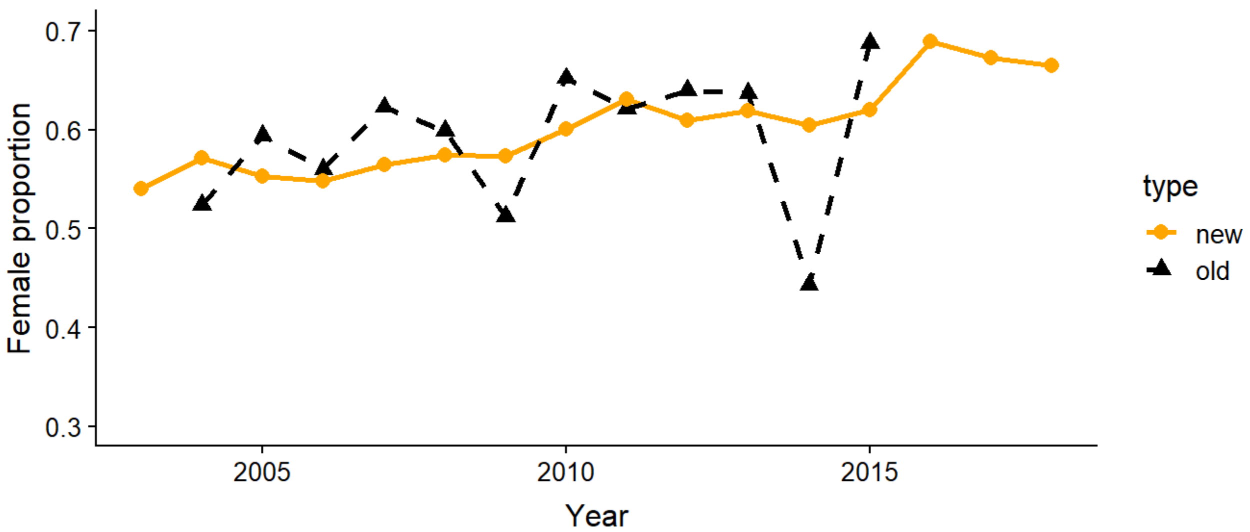

Figure 6.1: Proportion of females in biomass index, comparison of old and new index.

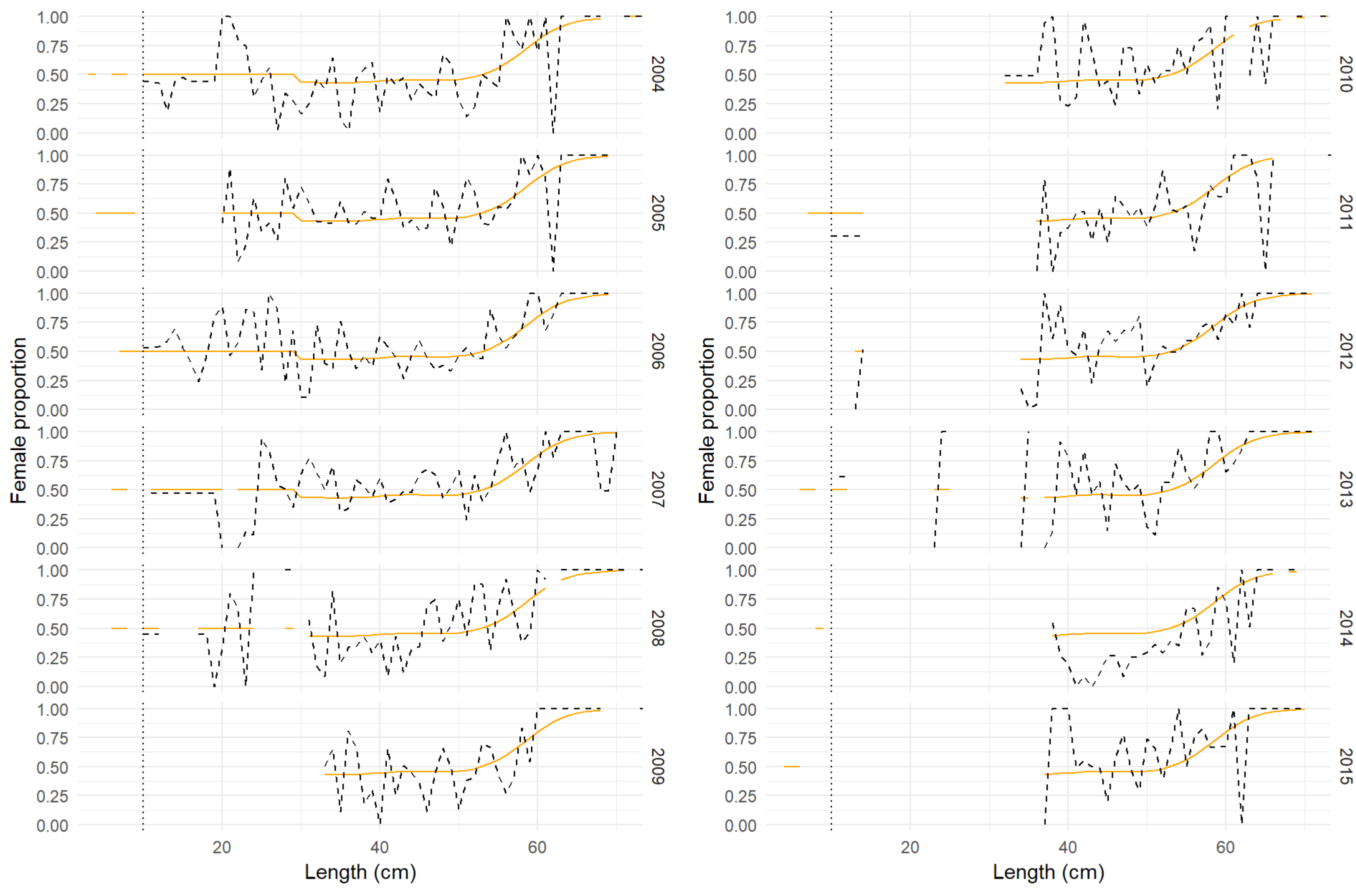

Figure 6.2: Proportion of females in the length distributions, comparison of old and new index.

7 Errors in data

To illustrate the effect of differences in raw data between the new and old database, the indices and length distributions were plotted for sex combined (Figure 7.1 and 7.2). The new index is slightly higher, particularly for 2006 and 2006, whereas the length distributions are almost identical.

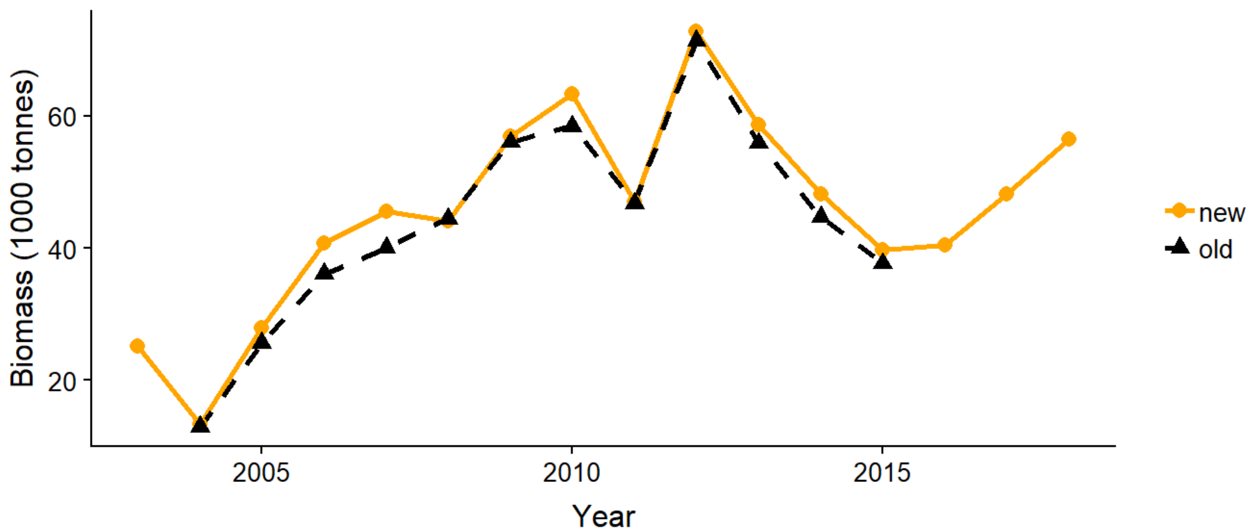

Figure 7.1: Biomass index, sex combined. Comparison of new and old dataset.

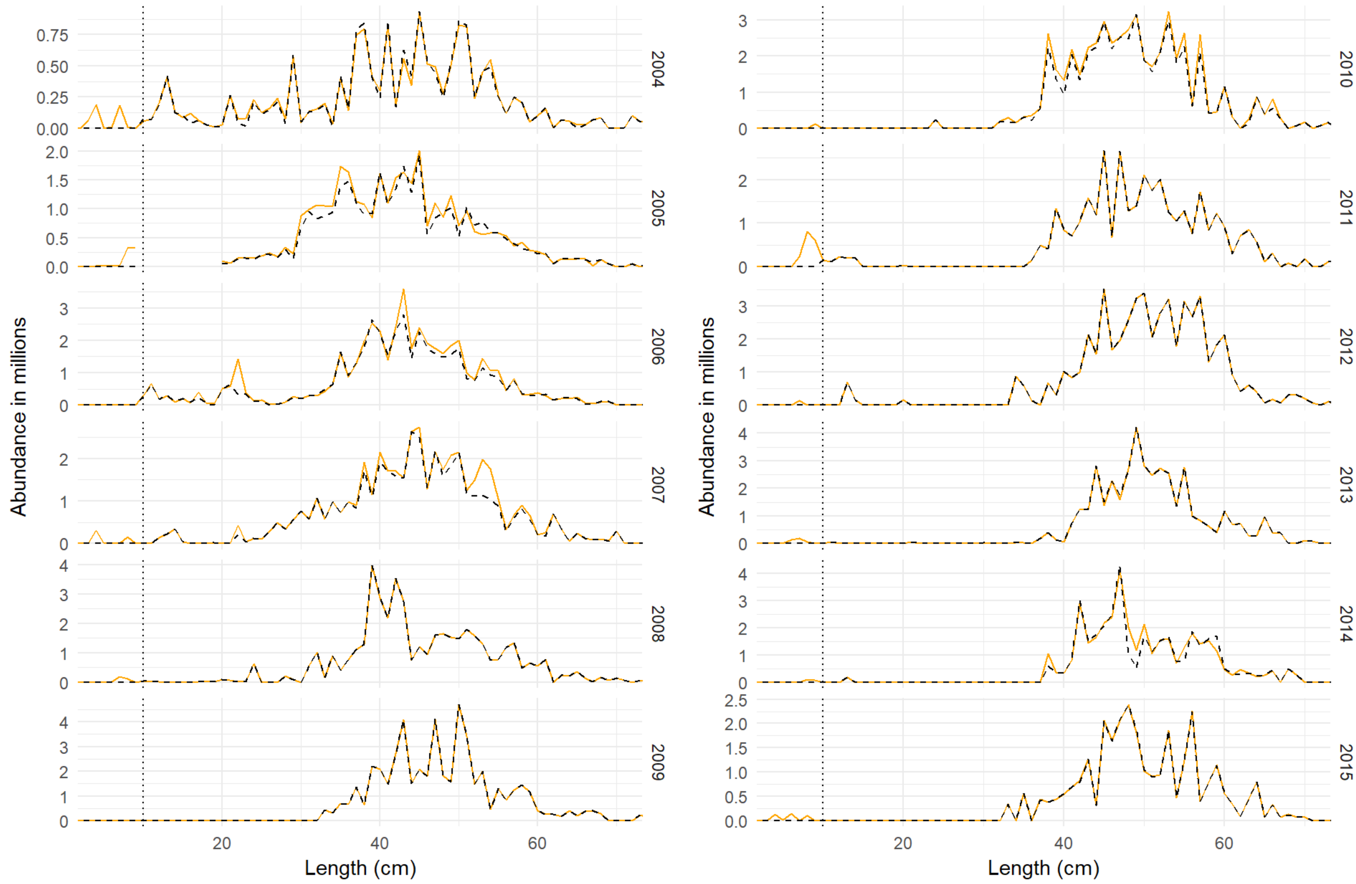

Figure 7.2: Length distributions, sex combined. Comparison of new and old dataset.

8 Conclusions

Due to changes in the sampling regime, the old method used for index calculation could not be used for years 2016 onwards, and changes needed to be made. For 2016-2018, there were not enough data to split the index on sex using same years' samples, so for these years a fixed proportion-of-females-by-length needed to be used. In addition, for all years, the proportion-of-females-by-length needed to be fixed for the smalles and largest length groups. Rather than swithcing methods in the middle of the time series, we chose to use the same method all years.

The new database currently have some flaws such as some missing data and introduced errors, but many of these have been compensated for. At the other hand, errors in the old data and index were also identified.

We recomment that the new index is used for the AFWG 2019 assessment.

AFWG2019 WD_21

Update referent point estimation for Greenland halibut based on production model

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This document presents the update of estimations of referent point for Greenland halibut based on production model. The input data for analysis were the catches for the period from 1935 till 2018 and several series of abundance indices (see Table 1).

Table 1 Catch (thousand tons) and indices (standard units) of the Greenland halibut abundance in the Barents Sea in 1935-2018

Year	Catch, tons	USSR catch/hour trawling (t)		Norwegian catch/hour trawling (t)		CPUE catch/hour trawling (t)
		RT[1]	PST[2]	A[3]	B[4]	
1935	1534	-	-	-	-	-
1936	830	-	-	-	-	-
1937	616	-	-	-	-	-
1938	329	-	-	-	-	-
1939	459	-	-	-	-	-
1940	846	-	-	-	-	-
1941	1663	-	-	-	-	-
1942	955	-	-	-	-	-
1943	824	-	-	-	-	-
1944	678	-	-	-	-	-
1945	1148	-	-	-	-	-
1946	1362	-	-	-	-	-
1947	1437	-	-	-	-	-
1948	1987	-	-	-	-	-
1949	375	-	-	-	-	-
1950	2074	-	-	-	-	-
1951	2861	-	-	-	-	-
1952	2953	-	-	-	-	-
1953	2601	-	-	-	-	-
1954	4090	-	-	-	-	-
1955	3300	-	-	-	-	-
1956	3939	-	-	-	-	-
1957	4635	-	-	-	-	-
1958	4192	-	-	-	-	-
1959	7939	-	-	-	-	-
1960	10961	-	-	-	-	-
1961	11813	-	-	-	-	-
1962	13360	-	-	-	-	-
1963	14540	-	-	-	-	-
1964	40391	-	-	-	-	-

1965	34751	0.80	-	-	-	-
1966	26321	0.77	-	-	-	-
1967	24267	0.70	-	-	-	-
1968	26168	0.65	-	-	-	-
1969	43789	0.53	-	-	-	-
1970	89484	0.53	-	-	-	-
1971	79034	0.46	-	-	-	-
1972	43055	0.37	-	-	-	-
1973	29938	0.37	-	0.34	-	-
1974	37763	0.40	-	0.36	-	-
1975	38172	0.39	0.51	0.38	-	-
1976	36074	0.40	0.56	0.33	-	-
1977	28827	0.27	0.41	0.33	-	-
1978	24617	0.21	0.32	0.21	-	-
1979	17312	0.23	0.35	0.28	-	-
1980	13284	0.24	0.33	0.32	-	-
1981	15018	0.30	0.36	0.36	-	-
1982	16789	0.26	0.45	0.41	-	-
1983	22147	0.26	0.40	0.35	-	-
1984	21883	0.27	0.41	0.32	-	-
1985	19945	0.28	0.52	0.37	-	-
1986	22875	0.23	0.42	0.37	-	-
1987	19112	0.25	0.50	0.35	-	-
1988	19587	0.20	0.30	0.31	-	-
1989	20138	0.20	0.30	0.26	-	-
1990	23183	-	0.20	0.27	-	-
1991	33320	-	-	0.24	-	-
1992	8602	-	-	0.46	0.72	-
1993	11933	-	-	0.79	1.22	-
1994	9226	-	-	0.77	1.27	-
1995	11734	-	-	1.03	1.48	-
1996	14347	-	-	1.45	1.82	-
1997	9410	0.71	-	1.23	1.60	-
1998	11893	0.71	-	0.98	1.35	-
1999	19517	0.84	-	0.82	1.77	-
2000	14297	0.94	-	1.38	1.92	-
2001	16365	0.82	-	1.18	1.57	-
2002	13293	0.85	-	1.07	1.82	-
2003	13447	0.97	-	0.86	2.45	-
2004	18899	0.63	-	1.16	1.79	-
2005	18834	0.61	-	1.30	2.29	-
2006	17904	0.57	-	0.96	2.09	-
2007	15453	0.64	-	-	-	-
2008	13792	0.48	-	-	-	-
2009	12990	0.77	-	-	-	-
2010	15229	-	1.57	-	-	28
2011	16606	-	2.32	-	-	34.94545
2012	20288	-	2.06	-	-	34.06752
2013	22167	-	2.25	-	-	33.9525
2014	23025	-	2.52	-	-	37.65207

2015	24748	-	-	-	-	40.60682
2016	24948	-	-	-	-	48.92763
2017	26380	-	-	-	-	42.32766
2018	28543	-	-	-	-	39.56652

1 Side trawlers, 800–1000 hp. From 1983 onwards, stern trawlers (SRTM), 1,000 hp. From 1997 based on research fishing.
2 Stern trawlers, up to 2,000 HP.
3 Norwegian trawlers, ISSCFV-code 07, 250–499.9 GRT.
4 Norwegian factory trawlers, ISSCFV-code 09, 1000-1999.9 GRT

The production model [AFWG WD18] is based on the following equations of dynamics (1) and observation (2):

$$\ln \frac{B_{t+1}}{B_t} = F_{MSY}\left(\frac{1}{\gamma}\left(\gamma + 1 - \left(\frac{B_t}{B_{MSY}}\right)^{\gamma}\right)\right) - \frac{C_t}{B_t} + \varepsilon \quad (1)$$

$$\ln CPUE_{t,f} = \ln B_t + \ln q_f + \eta \quad (2)$$

Where C is the catch, q – the catchability, and η- residuals, and γ - the Pella-Thomlinson models[1970] coefficient (for Schaefer model [1954,1957] γ=1)
The reference points were among parameters estimated in this formulation of the production model.
To estimate the parameters were used winsorizated least mean square objective function, which provided more robustness.
The results for Schaefer model are summarized in the following table:
Table 2. Results of estimations

MSY (ktons)	B_{MSY} (ktons)	F_{MSY} (year^{-1})
34.52	499.67	0.069

The comparison with previous results with the previous results of the production model application [Mikhailov, 2015] [Mikhailov, 2016] [Mikhailov, 2017] is shown in the following table 3

Table 3. The comparison of results

	MSY(ktons)	B_{MSY} (ktons)	F_{MSY} (year^{-1})
Schaefer model (winsorizated least mean square) 1965-2018	34.52	499.67	0.069
Schaefer model with sex structure 1984-2015	36.00	577.40	0.06
Schaefer model (winsorizated least mean abs. value) 1965-2015	37.47	500.00	0.075
Production model with GADGET data 1992-2014	38.70	418.12	0.0925

We can see that the estimates are similar to each other, and therefore to some extent reflect the long-term characteristics of the stock and can be used to control. We can be more precautionary if we will limit top of the TAC by the lowest estimate of MSY on the level of 34.5 ktons and will be aimed at maintaining the stock level above the highest BMSY value of 577 ktons. In general, we can conclude that the stock can withstand the current fishing load and the fishing regime is approaching optimum.

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AFWG-2019 WD 22

Assessment of population recruitment abundance of Northeast Arctic cod considering the environment data

by

Oleg Titov

Abstract

Analysis of results of approbation of methods of abundance assessment of northeastern arctic (NEA) cod at the age of 3 with advance time of 1-4 years has been carried out (Titov, 1999, 2001, 2011, 2018).

Introduction

One of the most important practical and theoretical problems connected with studying of marine ecosystems is prediction of values of commercial fishes' population recruitment. At present, natural processes, influencing the dynamics of the marine ecosystem, are hardly taken into consideration when predicting values of the Barents Sea commercial fishes' population recruitment. This leads, in particular, to sufficient shortening of the advance time and to decrease of accuracy of predictions of recruitment abundances of NEA cod and, correspondingly, to errors at prognostication of TAC. One of experiments on application of the ecosystem approach to prediction of the Barents Sea capelin and NEA cod recruitment abundance was models with the use of data on physical and chemical status of environment as indices of long-term variations of the Barents Sea ecosystem as a single whole (Titov, 1999; Titov, 2001). The models, as well as several statistical models, which use multiple linear regressions, have been compared by the ICES AFWG (e.g. Bulgakova, 2005; Stiansen *et al*., 2005; Titov *et al*., 2005, Svendsen *et al*., 2007). In 2009 statistical models (Titov et al., 2005, Titov, 2008) were partially changed. Joint ecosystem autumn survey index for 0-group cod was replaced on 0-group cod abundance index, corrected for capture efficiency (Anon, 2009). The data till 1983 were excluded at calculation of statistical models in 2010. In order to improve prediction the water temperature data was added to one of the models in 2011. Because of the danger of over-fitting regression models, one should always strive for simplicity (Dingsør et al., 2010). Prediction capabilities of the models were improved by dropping one or more terms. This was done in 2011 in accordance with statistical criteria. All models are greatly simplified. In general, 7 independent variables were removed from the 5 models.

In 2016 - 2017 there was a significant break in the program for the implementation of the oceanographic section "Kola Meridian", the data of which are used in forecasting models. From June 2016 until the time of preparation of the forecasts on the AFWG (April 2017), the data from the oceanographic section was not received and there is no way to restore the break. It was decided to not publish the corresponding forecasts in 2017.

In accordance with the recommendations of AFWG 2016 (Anon., 2016), an alternative version of the forecast was presented in which the spawning biomass of NEA cod is used as a predictor.

In view of the significant correction of the historical series of biological data that occurred in 2017, the calculations of the retrospective forecast for 2016 was given. A comparative analysis of the forecasts made on the biological characteristics of the NEA cod for 2016 and 2017 was given (Anon, 2017).

In 2018 at the meeting of the AFWG, the correction of models was continued. Due to the fact that in 2017 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 the 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 parameters included in the model. The solution of the problem was found by increasing the retrospective database by almost 2 times, that is, from the beginning of the 80s to the beginning of the 60s of the last century. Accordingly, sets of predictor sets have been revised. As a result, after comparing the results of constructing independent retrospective forecasts using the methodology previously used in ICES SGRF (Anon. 2013), it was decided to abandon the use of biological predictors and to use only environmental data in the NEA cod recruitment forecasting models. The number of models was reduced from 5 to 2 and the names of the models were changed from Titov (0, 1, 2, 3, 4) to TitovES (environment, short prediction) and TitovEL (environment, long prediction).
In 2019, the models are designed for two cod recruitment abundance options.

Materials and methods

The initial information (legend is in brackets):

- (Ta) mean monthly anomalies of air temperature at the Murmansk station since 1979 by data from the information site of Internet (http:/www.ncdc.noaa.gov) averaged by 12 values in the end of the period of averaging;
- (Tw) mean monthly anomalies of water temperature at stations 3-7 of the Kola section (0-200 m layer) since 1981 by data of PINRO data base averaged 12 values in the end of the period of averaging;
- (I) mean monthly anomalies of ice coverage of the Barents Sea (percentage ratio between the area covered by ice and total area) since 1979 by data of the Murmansk UGMS averaged 12 values in the end of the period of averaging;
- (OxSat) mean monthly anomalies of saturation by oxygen of near-bottom water layers at 3-7 stations of the Kola Section since 1979 by data from the information base of PINRO averaged by 12 values in the end of the period of averaging;
- (Cod3) annual (start of year) values of abundance of cod at the age of 3 considering cannibalism since 1983 (Anon, 2018);
- (CodC0) annual values of 0-group cod abundance index, corrected for capture efficiency since 1980 (Anon, 2018);
- (CodB1) bottom trawl swept area abundance of cod at the age of 1 estimates in Joint winter (Februar) Barents Sea survey since 1981 (Anon, 2018)
- (CodB2) bottom trawl swept area abundance of cod at the age of 2 estimates in Joint winter Barents Sea (February) survey and the Norwegian Lofoten acoustic survey since 1982 (Anon, 2018)
- (CodB3) bottom trawl swept area abundance of cod at the age of 3 estimates in Joint winter (February) Barents Sea survey and the Norwegian Lofoten acoustic survey since 1983 (Anon, 2018)
- (SSB) annual (start of year) values of spawning part biomass of cod population since 1980 (Anon, 2018).

Calculation of indices ITw. As a characteristics of intensity of interaction between the arctic and boreal oceanic systems on the shelf of the Barents Sea the indice ITa was used which was calculated by the numerical comparison between variations of the thermal status of ocean in the southern part of the Barents Sea and its ice coverage by the method of linear regression (Titov, 1999; Titov, 2001). Parameters of the linear regression model, describing the changes of ice coverage of the Barents Sea, were calculated by variations of water temperature. After that the differences (remainders) of mean monthly values of ice coverage and analogous values derived by the known parameters of the regression equation were calculated. Time lag, at which maximum cross-correlation relationship between variations of the mentioned parameters appeared, was taken into consideration.

Lag constituted 3 months for ice coverage relatively to water temperature. Equations used for calculations were as follows:

$$ITw_t = I_t – (-12,017*Tw_{t-3}-0,0688) \quad (1)$$

Names of indices in equations are mentioned above in the text, low indices characterize time lags in months.

Calculation of index DOxSat. Earlier (Titov, 1999; Titov, 2001) it was shown that formation of cod year classes abundance (Cod3) was influenced by the airing of near-bottom layers (OxSat) in a complex manner. From one side, there is a feedback between these parameters at larger time lag and a direct link at the less time lag; correspondingly, the densest link is between Cod3 and velocity of change of oxygen saturation of near-bottom layers. On the other side, a direct link has an exponential character. For a full account of these links the index DOxSat was calculated by the formula:

$$DOxSat_t = \exp(OxSat_t) – OxSat_{t-26} \quad (2)$$

Names of indices in equations are mentioned in the text, low indices characterize the time lags in months.

Searching for nonlinear links. Searching for nonlinear links between abundance of year classes of cod with indices mentioned above was carried out. It was stated that some links are approximated best of all by the quadratic equations or in an exponential form.

Regression equation of link of Cod3 with abiotic and biotic parameters.
The final set of predictors was determined by the method of step-by-step multiple regression. Parameters were chosen on the basis of recommendations on the use of package Statgraphics Plus for Windows 2.1. It is allowed to enter all the variables into the model at one time. But because of the danger of over-fitting regression models, one should always strive for simplicity (Dingsør et al., 2010). Prediction capabilities of the models were improved by dropping one or more terms. This was done in accordance with statistical criteria on the basis of recommendations of Statgraphics Plus. In determining whether the model can be simplified, the
highest P-value on the independent variables was noticed. In case of P-value was greater or equal to 0.10 (no statistical significance at the 90% or higher confidence level), such independent variables remove from the model.

The parameters in the equations vary automatically.

The equation for the forecast of Cod3 with advanced time of 0 years (a), 1 year (b), 2 years (c), 3 years (d), 4 years (e) with meanings of parameters for April 2018 are shown below.
Due to the lack of data on oxygen and water temperature from the oceanographic section “Kola Meridian” since June 2016 to May 2017, in 2018 this data were restored be linear interpolation of its anomalies. The predictions of recruitment abundances of NEA cod, by using the models TitovES (a) for 2018, TitovEL (b) for 2020, 2021 should be used with caution.

(a) $Cod3_t = a*DOxSat_{t-13}\,\hat{}\,2 + b*ITw_{t-43} - c*10^{-6}*\exp(Ice_{t-40}) - d*Ice_{t-15} + e$

$R^2 = 0.64 – 0.66; n =57$

(b) $Cod3_t = - a*OxSat_{t-39} + b*ITw_{t-43} + c$

$R^2 = 0.40 - 0.42$; n =57

For all statistical models values P<0.01, that corresponds to the level of significance 99 % (all individual P<0.1).

Tables 1 present initial parameters used in modeling.

Table 1. Parameters of models (low indices correspond to the time lag (months from the start of the year to which the value Cod3 is attributed).

Year	$Cod3_t*10^6$ (SPALY run)	$Cod3_t*10^6$ (Final run)	$OxSat_{t-39}$	$DOxSat_{t-13}$	ITw_{t-43}	Ice_{t-15}	$expIce_{t-40}*10^6$
1962	1250450	1292322	-0,2	-6,6	1,9	0,5	0,00
1963	842509	828474	-0,9	-2,4	1,6	1,5	0,00
1964	485216	428596	1,6	1,2	2,5	9,0	0,00
1965	907526	873400	0,9	-0,2	3,9	15,7	0,00
1966	1899526	2240060	-1,1	-4,0	8,0	5,3	0,00
1967	1262674	1511690	-0,2	-2,8	8,2	5,0	9,28
1968	186334	169339	1,5	-0,1	3,8	15,5	0,00
1969	111350	95436	0,9	0,6	1,8	15,9	0,00
1970	213861	221996	-0,2	-0,2	3,5	19,8	7,86
1971	389450	383445	0,1	-0,1	-0,1	18,8	2,66
1972	994529	941651	-3,3	-6,6	14,5	-0,6	428,92
1973	1862348	2231117	-2,1	-10,4	19,1	1,8	768,62
1974	641060	579419	1,1	-1,7	2,4	2,0	0,00
1975	598801	570561	1,9	0,8	-2,6	-1,2	0,00
1976	609951	686700	1,3	-1,3	-3,1	-1,9	0,00
1977	373618	336354	-0,1	-1,8	-2,4	2,5	0,00
1978	627373	717515	1,2	0,1	1,1	-1,0	0,00
1979	209981	188057	0,5	-1,5	-0,1	3,5	0,00
1980	129936	120993	-0,3	-2,7	2,0	12,9	0,00
1981	159985	152874	0,8	-0,2	1,9	14,7	0,00
1982	174971	200438	0,8	0,6	-3,2	8,0	0,07
1983	156432	153254	0,8	0,2	1,9	12,2	8,54
1984	413732	392799	-2,2	-2,4	-3,1	12,9	0,00
1985	558141	623486	-0,1	-1,2	3,6	-1,2	0,09
1986	1118909	1046035	-2,1	-4,4	1,4	-8,5	2,89
1987	327381	315985	-0,3	-1,7	2,1	0,6	0,00
1988	297828	293648	0,9	-1,4	-2,3	3,8	0,00
1989	188918	193461	0,3	-3,4	-5,2	10,5	0,00
1990	155641	159980	1,1	-1,3	-4,2	10,5	0,00
1991	396154	383103	0,9	0,7	2,4	6,5	0,03
1992	735643	798991	1,3	0,5	1,4	-0,9	0,02
1993	927910	888841	-2,0	-3,9	6,1	-0,6	0,00

1994	732611	699632	-0,5	-2,3	8,3	-4,9	0,00
1995	500001	488242	0,8	-2,4	4,4	1,8	0,00
1996	410747	445026	0,9	-0,1	0,5	0,7	0,00
1997	671971	677708	0,9	0,2	3,1	-7,3	0,00
1998	956873	1052482	0,3	-6,1	-2,3	-2,5	0,00
1999	544727	529765	-0,7	-2,4	-6,8	2,9	0,00
2000	672798	629642	1,9	1,5	-2,3	13,6	0,00
2001	551468	578837	0,6	0,1	-6,0	2,3	0,00
2002	409501	394623	-0,9	-1,0	3,6	-9,9	0,76
2003	694292	743330	-0,4	-0,6	8,5	-5,8	0,00
2004	247602	252623	-2,2	-2,5	-4,6	-1,4	0,00
2005	633125	606471	-1,6	-1,8	-1,5	4,9	0,00
2006	542436	545107	-1,2	-1,7	-4,0	-6,0	0,00
2007	1421853	1470329	-1,4	-4,4	7,4	-12,3	0,00
2008	1248669	1185542	-1,1	-1,6	3,4	-18,0	0,00
2009	710394	678599	0,8	-1,8	-1,6	-17,5	0,00
2010	289761	293867	-0,4	-2,6	-8,9	-9,0	0,00
2011	479622	448443	0,8	-0,1	-5,0	-4,3	0,00
2012	563238	572835	0,9	-0,1	-5,1	-4,3	0,00
2013	628109	625805	0,0	-0,1	1,4	-10,5	0,00
2014	745585	771499	-0,5	-1,0	1,4	-17,8	0,00
2015	426911	447415	-1,3	-1,6	-2,2	-10,5	0,00
2016	269656	268554	-1,3	-1,9	-7,5	-5,8	0,00
2017	724455	750022	-0,3	-0,6	-1,7	-14,7	0,00
2018	431988	498154	-1,2	-1,4	0,1	-21,0	0,00
2019			-0,6	-1,1	-1,7	-13,4	0,00
2020			-2,0	-2,2	-6,3	-13,8	0,00
2021			-0,8		-1,4		0,00
2022			-1,6		-2,5		0,00

Results

Prognoses from models (a) – (b) are shown in Table 2.

Table 2. Recruitment models prognoses (Final run)

Model	Species	Variable	Years	Prognosis available	**2019**	**2020**	**2021**	**2022**	Unit
TitovEL	NEA cod	Age 3	4	At assessment	**543**	**460**	**570**	**585**	*10^6
		weight			*0,25*	*0,23*	*0,53*	*1,00*	
TitovES	NEA cod	Age 3	2	At assessment	**598**	**504**			*10^6
		weight			*0,54*	*0,59*			
RCT3	NEA cod	Age 3	3	At assessment	**977**	**742**	**728**		*10^6
		weight			*0,22*	*0,18*	*0,47*		

Hybrid	NEA cod	Age 3	4	At assessment	**667**	**537**	**644**	**585**	$*10^6$

Table 2. Recruitment models prognoses (SPALY run)

Model	Species	Variable	Years	Prognosis available	**2019**	**2020**	**2021**	**2022**	Unit
TitovEL	NEA cod	Age 3	4	At assessment	**544**	**434**	**573**	**582**	$*10^6$
		weight			*0,25*	*0,23*	*0,53*	*1,00*	
TitovES	NEA cod	Age 3	2	At assessment	**593**	**494**			$*10^6$
		weight			*0,54*	*0,59*			
RCT3	NEA cod	Age 3	3	At assessment	**955**	**736**	**725**		$*10^6$
		weight			*0,22*	*0,18*	*0,47*		
Hybrid	NEA cod	Age 3	4	At assessment	**660**	**524**	**644**	**582**	$*10^6$

[1] Model that are proposed to Hybrid 2018 (Anon, 2018)

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Consumption of various prey species by cod in the Barents Sea in 1984-2018

by

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Diet composition of cod in 1984-2018 is presented in Table 1.

Food consumption of various prey species by cod in 1984-2018 is presented in Table 2.

Consumption of cod and haddock by age group (biomass and abundance) is given in Tables 3-6.

The values of annual food rations by different age groups of cod are given in Table 7.

The main peculiarities of cod diet and consumption in 2018:

- Increasing of weight percent of herring (from 1.1-1.6 % in 2016-2017 to 6.2 % in 2018) and juvenile haddock (from 4.0-7.3 % in 2014-2017 to 13.1 % in 2018) in cod diet;
- Decsreasing of weight percent of capelin (from 31.3-32.9 % in 2016-2017 to 22.2 % in 2018) and juvenile cod (from 11.2 % in 2017 to 8.5 % in 2018) in cod diet;
- Decreased compared to the period 2008-2016, but still high total food consumption by cod (6.1 million tons) in 2018;
- Decreased consusmption of capelin – from 2 144-4 469 thousand tons in 2008-2017 to 1 614 thousand tons in 2018;
- Increased consusmption of herring – from 45-97 thousand tons in 2011-2017 to 217 thousand tons in 2018;
- High consumption of juvenile cod (from 175 thousand tons in 2015 to 353 thousand tons in 2018) and haddock (from 155-180 thousand tons in 2014-2016 to 484 thousand tons in 2018).

Table 1.

Food composition of the Barents Sea cod in 1984-2018, % by weight

Prey species	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Hyperiids	0,86	7,59	16,86	20,58	23,74	19,31	1,59	0,41	0,17	1,10	3,31	5,24	12,61	2,13	4,91	2,41	3,93
Euphausiids	0,49	0,06	0,74	1,28	8,18	5,80	0,38	0,15	0,27	0,20	2,44	2,73	6,57	4,39	3,07	2,35	1,33
Shrimp	23,31	6,26	11,32	10,73	5,76	6,53	6,25	2,12	9,24	3,51	7,82	6,00	5,08	6,12	11,23	8,86	10,49
Herring	3,00	1,94	2,60	0,30	0,96	0,16	0,94	1,16	7,44	7,48	5,25	8,12	4,39	2,79	2,63	2,05	1,11
Capelin	19,25	53,76	20,24	6,32	7,08	22,40	43,94	68,12	42,01	47,40	30,40	6,99	11,29	16,10	11,65	44,19	43,04
Polar cod	0,38	0,01	6,49	7,12	0,02	1,49	0,25	0,68	3,88	3,58	6,40	4,11	3,52	4,62	11,38	6,15	7,79
Cod	2,06	2,75	5,14	2,76	0,62	0,36	0,80	0,89	1,52	4,68	11,69	18,38	18,93	26,90	16,74	6,74	5,86
Haddock	1,90	1,44	3,54	1,41	2,95	0,30	0,56	0,72	2,29	3,55	4,22	5,92	4,48	2,78	2,20	0,73	1,31
Blue whiting	0,56	1,12	0,34	0,41	0,59	0,05	0,77	0,11	0,00	0,15	0,02	0,01	0,26	1,08	1,47	1,73	1,09
Norway pout	0,08	0,45	1,07	0,48	2,57	0,51	0,44	0,17	1,69	1,44	0,01	0,01	1,35	0,27	0,52	0,06	0,06
Redfish	15,08	3,49	8,57	18,61	5,28	7,68	4,62	2,33	4,72	1,36	2,35	4,94	2,77	3,00	1,57	0,95	0,31
Wolffish	0,01	0,02	0,03	0,01	0,03	0,37	0,16	0,01	1,16	0,08	0,11	0,02	0,89	0,21	0,06	0,03	0,00
Long rough dab	3,77	1,26	1,27	1,16	1,02	3,40	2,63	0,60	1,21	2,85	1,56	1,84	2,56	2,34	1,67	0,87	1,39
Greenland halibut	0,00	0,00	0,11	0,01	0,00	0,01	0,00	0,01	0,01	0,08	0,01	0,06	0,12	0,23	0,00	0,03	0,07
Other fish	20,54	15,40	17,01	16,23	24,61	18,45	28,87	21,00	11,99	6,12	9,14	10,11	10,91	13,51	11,96	10,56	12,49
Other food	8,71	4,45	4,67	12,59	16,12	13,18	7,66	1,51	12,40	16,29	15,19	25,39	14,17	13,53	18,94	12,29	9,73
Stomachs number	3729	4124	6042	5941	5688	8289	8443	6671	5217	7660	7554	10636	12207	12093	15102	14461	15692
Empty stomachs, %	20,1	29,8	19,6	23,9	17,5	16,8	14,3	16,9	36,7	32,2	29,2	23,0	24,0	29,7	27,4	26,8	22,2
Mean ball of fullness	2,7	2,6	2,3	1,8	2,5	2,6	2,7	3,2	2,4	2,8	2,3	2,8	2,6	2,4	1,4	2,6	2,8
Mean index of fullness	163,3	331,9	186,5	182,0	178,4	156,1	242,1	285,9	240,6	245,8	213,9	175,2	158,4	196,5	199,9	240,2	273,3

Table 1 (continued).

Food composition of the Barents Sea cod in 1984-2018, % by weight

Prey species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Hyperiids	0,65	0,39	2,55	12,23	4,41	1,20	2,91	0,06	0,83	0,92	0,34	0,61	0,58	0,34	4,24	2,18	0,26	0,47
Euphausiids	1,49	1,15	0,71	1,44	3,63	4,00	4,08	1,89	1,19	3,25	1,49	0,65	0,97	0,74	1,80	1,96	1,83	3,49
Shrimp	8,02	6,77	5,36	4,63	5,44	6,05	6,36	4,14	2,93	2,83	2,77	3,20	3,13	3,13	2,85	3,97	3,88	2,59
Herring	5,70	1,60	7,21	3,76	11,51	11,68	8,95	4,60	7,92	3,59	1,75	1,30	0,71	3,90	2,52	1,13	1,61	6,29
Capelin	39,19	45,52	22,84	23,43	10,91	26,30	19,30	25,65	23,94	31,30	29,78	17,65	24,13	27,94	28,16	31,33	32,90	22,12
Polar cod	2,85	7,87	4,42	7,39	8,12	2,03	6,01	6,09	7,80	9,79	4,44	4,22	3,02	0,64	2,36	4,31	1,27	2,25
Cod	5,12	5,73	10,39	6,01	6,93	5,88	6,15	5,74	4,96	6,42	7,65	6,86	11,24	10,10	5,92	7,52	11,17	8,52
Haddock	4,14	4,62	10,03	6,67	10,76	11,37	13,30	14,36	9,88	8,94	11,67	12,89	11,94	4,73	4,23	4,03	7,37	13,07
Blue whiting	7,47	4,40	1,40	1,62	4,00	5,22	1,66	1,27	0,18	0,10	0,35	0,47	0,26	0,37	0,82	1,39	0,32	1,15
Norway pout	1,17	0,09	0,35	0,50	0,66	2,22	0,66	0,56	1,04	0,77	0,89	0,82	0,73	0,47	0,38	0,15	0,17	0,25
Redfish	0,21	0,40	0,14	0,26	0,29	0,59	0,50	0,56	0,45	0,57	1,09	0,47	0,74	0,29	1,73	0,70	0,26	1,14
Wolffish	0,36	0,28	0,14	0,18	0,17	0,13	0,13	0,20	0,12	0,11	0,03	0,01	0,10	0,04	0,01	0,23	0,01	0,02
Long rough dab	2,02	1,29	2,49	3,64	2,68	2,00	3,21	2,55	1,92	2,39	3,25	3,38	3,82	2.99	3,65	4,95	5,00	2,94
Greenland halibut	0,01	0,01	0,00	0,27	0,74	0,02	0,04	0,44	0,07	0,21	0,09	1,16	0,42	0,35	1,40	0,13	0,37	1,68
Other fish	8,08	10,59	20,46	16,09	18,85	11,89	13,30	16,21	13,74	9,98	13,01	14,43	11,16	13,47	10,41	12,38	11,90	16,51
Other food	13,52	9,28	11,42	11,88	10,90	9,42	13,44	15,68	23,03	18,83	21,4	31,88	27,05	30,50	29,52	23,64	21,61	17,51
Stomachs number	15122	15800	12874	23124	18593	17352	12942	14224	12037	13657	11632	11469	12102	13825	11377	11098	12839	9019
Empty stomachs, %	36,40	26,4	30,3	26,2	26,7	32,4	26,6	29,0	25,7	26,5	29,4	25,3	23,6	24,1	22,4	22,8	25,20	23,90
Mean ball of fullness	2,0	1,8	1,5	1.5	1.5	1,5	1,80	1,70	1,90	1,80	1,60	1,6	1,7	1,4	1,5	2,0	1,7	1,4
Mean index of fullness	241,2	268,2	232,4	212.7	216.5	196,3	213,40	202,57	208,55	206,62	208,71	183,39	190,73	191,43	195,13	222,33	194,32	196,12

Table 2. Consumption of various prey species by the Barents Sea cod in 1984-2018, thousand tons

Year	Euphausiids	Hyperiids	Shrimp	Herring	Capelin	Polar cod	Cod	Haddock	Blue whiting	Norway pout	Redfish	Long rough dab	Greenland halibut	Other fish	Other food	Total consumption
1984	94.1	31.2	353.0	33.7	593.3	17.6	13.5	50.3	4.8	1.2	196.4	51.6	0.0	271.1	287.7	1999.3
1985	30.6	440.3	210.3	25.6	1039.2	0.0	89.2	35.4	17.5	13.5	99.5	21.9	0.0	545.6	206.4	2775.0
1986	66.0	948.2	159.1	50.8	854.6	169.1	25.7	99.1	3.1	26.0	165.8	26.0	0.8	401.3	187.6	3183.1
1987	78.5	592.4	232.9	8.9	175.3	117.4	23.0	2.4	9.7	14.9	119.5	5.2	0.5	306.0	219.7	1906.3
1988	238.6	195.8	146.4	20.8	348.3	0.0	20.5	76.5	0.0	0.0	133.1	21.6	0.0	262.3	282.3	1746.3
1989	190.6	324.4	116.8	4.3	768.1	37.1	34.7	1.9	0.0	0.0	178.3	63.9	0.0	219.5	277.0	2216.4
1990	104.7	30.8	265.8	65.3	1264.4	7.6	24.1	14.8	38.8	14.2	237.1	78.9	0.0	103.8	160.1	2410.3
1991	54.6	81.2	276.7	25.5	3205.3	45.2	52.0	21.7	5.7	5.8	141.5	45.8	5.4	128.2	154.7	4249.3
1992	211.0	38.0	257.4	334.7	2017.6	195.5	82.0	36.5	0.0	71.5	116.6	41.6	0.8	295.8	419.5	4118.6
1993	183.8	173.2	219.7	169.5	2738.8	169.6	143.7	148.1	3.6	24.3	40.0	47.4	4.9	159.6	378.3	4604.5
1994	358.3	296.0	457.7	101.8	1275.2	485.3	382.8	71.6	1.2	1.4	55.3	40.3	0.1	98.3	347.0	3972.4
1995	396.3	455.1	533.2	192.5	670.1	190.7	541.1	129.6	0.3	0.5	109.9	51.5	2.7	157.2	344.3	3775.0
1996	957.2	346.4	194.5	73.7	469.7	73.9	450.6	57.2	8.5	35.7	66.7	44.5	0.1	467.9	169.6	3416.3
1997	508.9	134.1	257.1	51.4	510.5	111.6	382.9	35.1	16.4	0.1	29.4	16.5	1.5	96.9	365.5	2518.1
1998	644.4	219.3	284.6	72.9	913.3	134.1	130.5	23.3	23.7	18.5	14.6	19.6	0.0	55.2	237.0	2791.1
1999	457.7	80.6	266.7	79.5	1536.2	176.3	49.3	16.0	27.2	0.9	13.5	8.7	0.4	60.3	117.8	2891.2
2000	436.6	122.3	393.2	52.5	1797.5	167.3	59.3	31.5	28.2	9.0	4.0	21.3	0.1	38.1	195.1	3356.1
2001	410.4	74.9	321.8	92.5	1520.7	147.4	62.2	51.8	144.8	30.4	4.1	30.8	2.3	156.5	196.5	3246.9
2002	285.8	45.2	201.3	54.8	2398.8	301.4	99.7	80.1	110.2	3.8	3.5	17.1	0.0	44.6	176.3	3822.6
2003	546.8	170.8	226.8	152.7	1218.7	220.5	131.9	330.9	27.6	5.2	1.6	51.5	0.0	96.9	298.0	3479.8
2004	477.4	392.7	255.8	129.1	1096.5	368.9	86.0	143.9	48.0	20.3	7.3	62.4	15.7	186.4	289.0	3579.4
2005	686.7	162.7	243.5	167.5	1022.0	320.1	112.6	270.8	67.1	39.6	7.3	46.9	2.2	340.3	239.5	3728.7
2006	1543.5	85.5	273.5	268.1	1339.6	124.7	95.5	285.5	103.1	107.1	17.2	148.7	0.6	127.7	550.5	5070.8
2007	1333.8	191.6	419.0	275.1	1875.0	288.9	68.3	330.1	32.0	26.0	29.1	72.9	0.8	281.3	521.6	5745.3
2008	999.3	50.9	342.7	122.1	3264.1	662.0	156.6	333.1	16.6	20.4	59.8	121.7	13.4	413.9	583.1	7159.7
2009	936.6	188.7	282.9	229.1	3349.0	826.9	142.0	347.8	7.8	121.1	28.4	285.0	0.4	170.0	754.2	7670.0
2010	1839.0	329.0	255.0	142.6	4115.9	513.2	181.0	248.3	15.9	66.3	162.8	136.8	1.1	249.9	657.2	8913.9

Table 2 (continued).

Year	Euphausiids	Hyperiids	Shrimp	Herring	Capelin	Polar cod	Cod	Haddock	Blue whiting	Norway pout	Redfish	Long rough dab	Greenland halibut	Other fish	Other food	Total consumption
2011	829.8	202.0	225.6	84.8	4469.0	422.9	260.4	361.9	57.5	95.7	142.9	171.6	1.6	208.3	949.5	8483.6
2012	599.0	164.2	272.1	96.6	2983.5	439.7	290.9	419.3	32.8	98.4	41.4	134.1	7.1	291.2	1381.3	7251.7
2013	642.0	208.6	332.2	45.1	3651.8	145.5	450.1	276.7	39.4	65.1	178.3	217.5	2.4	215.0	1084.3	7553.9
2014	735.8	119.2	205.6	55.4	3296.5	96.1	390.4	170.9	26.6	37.3	19.9	156.1	7.2	197.5	1148.3	6662.9
2015	1134.5	294.2	425.7	67.6	2621.8	157.3	174.7	179.6	38.0	26.5	85.8	118.0	14.0	179.5	903.9	6421.2
2016	750.3	642.8	205.4	83.0	2144.3	235.1	238.7	154.8	48.6	11.6	46.4	332.1	3.0	285.5	1210.9	6392.5
2017	648.7	80.6	296.9	92.1	2587.1	69.7	264.0	304.8	24.2	19.9	186.1	249.2	3.3	162.9	817.3	5806.7
2018	1577.6	149.4	183.8	271.2	1614.3	114.2	352.6	483.6	38.0	44.8	42.6	120.7	42.9	170.3	937.7	6143.6
Mean	614.6	236.2	271.8	110.6	1886.8	221.6	177.9	164.0	31.2	31.6	76.2	89.1	4.0	211.0	493.0	4544.6

Table 3. Biomass of cod consumed by cod in 1984-2018 (thousand tons)

Year	Age groups of cod							Sum
	0+	1	2	3	4	5	6	
1984	0.00	6.81	5.36	0.00	0.00	0.00	0.00	12.17
1985	5.46	13.39	33.28	30.39	6.67	0.00	0.00	89.19
1986	0.22	6.21	4.95	14.19	0.09	0.00	0.00	25.66
1987	3.25	4.31	1.16	8.16	6.09	0.00	0.00	22.96
1988	0.04	13.22	0.34	6.06	0.75	0.00	0.00	20.41
1989	0.08	31.78	2.36	0.47	0.00	0.00	0.00	34.69
1990	0.29	18.95	4.76	0.13	0.00	0.00	0.00	24.14
1991	15.19	21.92	8.49	6.18	0.26	0.00	0.00	52.04
1992	7.88	58.92	12.16	3.08	0.00	0.00	0.00	82.04
1993	11.75	84.36	36.35	8.69	4.14	1.35	0.33	146.96
1994	79.48	149.60	45.95	37.85	48.61	16.33	0.76	378.58
1995	66.23	330.23	21.06	56.12	51.98	10.90	1.99	538.52
1996	49.05	272.65	65.25	23.07	28.87	14.80	1.13	454.81
1997	21.69	152.53	143.72	48.72	12.81	2.75	0.70	382.94
1998	2.73	49.82	24.69	38.14	14.39	0.69	0.02	130.49
1999	0.78	20.57	12.41	13.11	2.42	0.00	0.00	49.29
2000	13.65	17.63	6.32	10.82	9.57	1.27	0.00	59.26
2001	1.66	30.36	10.43	13.39	6.13	0.23	0.00	62.19
2002	36.27	10.14	20.62	22.52	6.54	0.54	0.00	96.63
2003	14.03	48.42	42.48	25.23	1.75	0.00	0.00	131.90
2004	7.54	24.72	34.44	10.23	8.96	0.11	0.00	86.00
2005	0.37	21.59	24.56	29.53	12.56	22.06	1.94	112.62
2006	10.52	35.69	32.96	8.31	4.00	3.41	0.62	95.50
2007	1.85	15.89	18.69	24.38	6.98	0.46	0.03	68.27
2008	64.48	4.17	14.15	43.23	29.59	1.02	0.00	156.63
2009	20.17	94.79	12.00	10.33	3.74	0.97	0.03	142.03
2010	14.83	107.62	28.23	20.12	7.24	2.77	0.20	181.00
2011	61.63	52.96	54.49	38.93	10.62	23.62	18.11	260.36
2012	44.92	148.26	73.57	17.47	5.56	0.87	0.29	290.94
2013	28.93	120.82	220.40	17.05	25.79	31.90	5.20	450.09
2014	54.57	51.81	116.92	132.66	28.97	5.50	0.00	390.43
2015	4.44	71.89	62.27	23.05	9.64	3.33	0.06	174.68
2016	4.64	112.05	43.23	4.91	16.76	48.63	8.45	238.69
2017	26.42	86.21	33.14	42.63	20.80	29.61	25.14	263.96
2018	5.65	163.01	90.01	53.23	39.24	1.46	0.00	352.61
Mean	19.45	70.09	38.89	24.07	12.33	6.42	1.86	173.11

Table 4. Abundance of cod consumed by cod in 1984-2018 (millions individuals)

Year	Age groups of cod							Sum
	0+	1	2	3	4	5	6	
1984	0.0	200.3	41.1	0.0	0.0	0.0	0.0	241.4
1985	208.5	408.7	282.9	64.5	7.0	0.0	0.0	971.7
1986	8.6	201.9	51.3	42.4	0.1	0.0	0.0	304.4
1987	108.2	151.1	14.1	34.7	11.4	0.0	0.0	319.5
1988	1.6	416.5	3.5	24.2	1.6	0.0	0.0	447.4
1989	2.8	753.2	15.8	1.4	0.0	0.0	0.0	773.1
1990	10.9	440.8	24.2	0.3	0.0	0.0	0.0	476.2
1991	453.5	626.2	46.0	10.8	0.2	0.0	0.0	1136.8
1992	315.1	1988.9	86.3	5.8	0.0	0.0	0.0	2396.0
1993	451.8	5191.1	379.2	22.0	3.4	0.7	0.1	6048.4
1994	4967.7	8141.6	642.6	142.2	60.7	10.8	0.3	13965.9
1995	3311.5	16615.5	265.0	237.0	95.3	8.7	0.9	20533.8
1996	2096.1	14541.1	829.9	97.8	51.5	13.6	0.5	17630.5
1997	964.1	9533.3	1825.0	152.4	20.7	2.4	0.4	12498.3
1998	191.0	3113.9	266.7	157.0	22.9	0.6	0.0	3752.0
1999	38.6	1293.6	197.3	73.5	4.4	0.0	0.0	1607.3
2000	523.1	623.0	71.6	33.3	13.7	1.0	0.0	1265.7
2001	102.3	1434.9	84.1	28.7	7.0	0.1	0.0	1657.0
2002	2238.9	496.8	199.4	52.0	9.0	0.4	0.0	2996.5
2003	2192.2	2274.9	442.9	56.2	2.2	0.0	0.0	4968.4
2004	355.5	726.1	340.0	27.5	10.8	0.1	0.0	1459.9
2005	16.1	578.1	222.1	82.6	19.4	16.1	1.0	935.4
2006	459.2	1044.3	192.8	17.4	4.9	2.7	0.3	1721.6
2007	61.0	444.8	166.7	45.6	7.6	0.3	0.0	726.0
2008	9482.2	95.8	95.2	93.4	27.0	0.6	0.0	9794.1
2009	1371.9	3001.7	121.6	23.9	3.3	0.5	0.0	4522.8
2010	828.6	3785.1	200.6	46.7	7.6	1.6	0.1	4870.2
2011	6924.4	1676.3	523.3	119.2	13.7	16.9	9.2	9282.9
2012	5478.4	5172.6	593.6	31.3	5.0	0.5	0.1	11281.5
2013	3856.9	5742.0	1778.9	38.1	36.2	25.9	2.9	11481.0
2014	8025.0	2093.0	1156.5	480.5	33.0	3.1	0.0	11791.2
2015	189.7	3649.8	421.3	55.7	10.3	2.0	0.0	4328.9
2016	198.4	3581.8	440.5	12.8	22.3	33.9	3.5	4293.2
2017	1212.1	2178.2	153.2	96.0	25.9	20.2	11.2	3696.7
2018	241.6	5695.6	644.7	112.4	47.4	1.0	0.0	6742.7
Mean	1625.4	3083.2	366.3	72.0	16.7	4.7	0.9	5169.1

Table 5. Biomass of haddock consumed by cod in 1984-2018 (thousand tons)

Year	Age groups of haddock							Sum
	0+	1	2	3	4	5	6	
1984	4.55	45.69	0.04	0.00	0.00	0.00	0.00	50.27
1985	7.00	27.75	0.63	0.00	0.00	0.00	0.00	35.38
1986	0.59	11.65	20.70	65.44	0.67	0.00	0.00	99.05
1987	0.00	1.59	0.74	0.10	0.00	0.00	0.00	2.42
1988	0.00	6.12	6.37	20.85	30.48	12.24	0.45	76.51
1989	0.00	1.56	0.26	0.02	0.00	0.03	0.03	1.90
1990	1.18	6.68	2.39	3.48	0.19	0.00	0.00	13.92
1991	0.06	19.78	1.77	0.09	0.00	0.00	0.00	21.69
1992	1.19	25.35	9.56	0.40	0.00	0.00	0.00	36.50
1993	26.62	43.58	23.57	52.94	1.43	0.00	0.00	148.14
1994	15.89	15.60	7.04	19.28	11.51	1.34	0.53	71.19
1995	6.44	64.52	16.97	4.74	20.04	16.77	0.08	129.57
1996	7.55	25.95	7.71	5.30	0.91	5.08	4.67	57.16
1997	1.60	17.74	10.08	3.48	0.67	0.76	0.73	35.07
1998	7.74	10.72	2.80	0.73	1.16	0.12	0.02	23.30
1999	4.09	10.60	1.17	0.13	0.00	0.00	0.00	15.99
2000	10.68	14.31	6.16	0.35	0.01	0.00	0.00	31.50
2001	6.32	26.67	16.70	2.06	0.01	0.00	0.00	51.76
2002	4.60	44.97	22.95	7.00	0.22	0.28	0.06	80.09
2003	15.28	224.79	64.45	15.64	10.49	0.00	0.00	330.66
2004	27.43	68.58	27.47	12.38	4.90	3.16	0.04	143.95
2005	75.56	126.84	37.47	17.77	10.77	1.71	0.65	270.76
2006	76.57	143.07	47.07	12.62	3.57	1.86	0.72	285.48
2007	14.02	244.91	57.02	9.66	2.65	1.70	0.14	330.09
2008	50.18	44.50	123.97	102.59	39.13	3.10	7.13	370.61
2009	80.04	133.56	35.13	83.26	39.81	11.44	0.19	383.44
2010	18.92	74.42	45.78	21.33	47.74	33.30	6.81	248.30
2011	43.07	56.35	107.83	30.99	42.52	45.42	35.77	361.94
2012	5.23	296.73	17.73	46.40	4.28	7.64	41.32	419.33
2013	70.92	28.24	138.55	20.24	22.24	4.46	32.24	316.88
2014	51.91	64.48	25.09	35.24	3.03	18.41	3.65	201.81
2015	45.45	106.24	28.89	4.88	7.94	1.10	4.67	199.17
2016	48.40	55.37	16.08	6.19	3.58	31.90	6.00	167.52
2017	11.74	192.93	51.56	18.89	24.32	2.35	3.86	305.65
2018	17.04	154.22	196.73	81.55	24.13	9.93	0.00	483.59
Mean	21.65	69.60	33.67	20.17	10.24	6.12	4.28	165.73

Table 6. Abundance of haddock consumed by cod in 1984-2018 (millions individuals)

Year	Age groups of haddock							Sum
	0+	1	2	3	4	5	6	
1984	94.80	456.86	0.09	0.00	0.00	0.00	0.00	551.76
1985	191.30	267.90	2.28	0.00	0.00	0.00	0.00	461.48
1986	15.57	264.77	162.32	120.07	0.70	0.00	0.00	563.43
1987	0.00	40.14	7.95	0.40	0.00	0.00	0.00	48.49
1988	0.00	102.03	57.78	92.71	71.55	15.86	0.37	340.31
1989	0.00	17.88	1.97	0.09	0.00	0.03	0.03	20.00
1990	17.48	115.57	13.74	14.24	0.30	0.00	0.00	161.34
1991	0.76	197.76	10.28	0.18	0.00	0.00	0.00	208.99
1992	21.56	546.32	54.15	0.70	0.00	0.00	0.00	622.73
1993	733.22	726.35	195.62	124.46	1.67	0.00	0.00	1781.32
1994	131.33	286.17	84.10	107.97	36.72	1.15	0.33	647.78
1995	154.16	1597.03	168.39	24.15	55.90	19.59	0.05	2019.27
1996	160.21	648.84	48.31	24.87	1.75	5.99	3.82	893.79
1997	41.33	1108.73	128.06	11.22	1.18	0.86	0.62	1292.01
1998	184.80	248.73	19.01	2.91	2.31	0.12	0.02	457.90
1999	88.21	230.36	10.55	0.44	0.00	0.00	0.00	329.55
2000	262.99	453.34	36.46	0.95	0.01	0.00	0.00	753.75
2001	139.55	526.65	83.62	4.71	0.01	0.00	0.00	754.55
2002	101.61	1278.90	145.24	15.95	0.30	0.17	0.03	1542.19
2003	768.03	3700.72	411.95	43.00	13.65	0.00	0.00	4937.35
2004	721.76	1817.84	192.55	33.13	7.85	3.20	0.02	2776.35
2005	1978.13	2655.17	302.95	56.04	18.91	2.01	0.52	5013.74
2006	1668.22	2653.65	340.69	36.47	4.47	1.78	0.54	4705.82
2007	356.73	6138.04	282.73	17.99	3.15	1.52	0.10	6800.25
2008	2039.90	723.20	862.24	275.09	47.49	2.48	4.75	3955.14
2009	2910.67	3936.86	241.17	299.47	73.57	11.62	0.12	7473.47
2010	687.83	1681.54	441.75	70.31	82.73	35.07	5.30	3004.51
2011	1643.86	1195.53	709.25	113.89	78.12	49.93	30.16	3820.73
2012	176.72	5837.93	91.27	107.47	6.19	7.70	33.53	6260.80
2013	2533.00	384.99	845.94	43.43	30.39	4.57	25.53	3867.86
2014	2237.62	1683.91	241.12	106.35	4.37	17.85	2.89	4294.12
2015	1360.69	2881.62	202.03	15.06	11.26	0.86	2.58	4474.09
2016	1216.08	877.15	143.34	14.82	4.43	26.34	3.44	2285.60
2017	354.64	3454.35	276.32	40.43	30.68	2.10	2.38	4160.89
2018	571.91	3209.04	1386.92	181.15	35.38	9.16	0.00	5393.55
Mean	673.28	1484.17	234.35	57.15	17.86	6.29	3.35	2476.43

Table 7.

Total annual food rations of the Barents Sea cod in 1984-2018, grams per 1 individual

Age	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	262	295	179	145	183	282	288	241	178	133	180	194	170	119	232	261	186
2	895	753	526	432	704	909	1006	936	969	476	512	497	498	341	528	431	545
3	1611	1658	1455	852	1075	1465	1694	2670	2475	1512	1212	962	1028	992	1081	1128	1288
4	2748	2681	3455	1558	1628	2207	2693	4472	2866	2865	2402	1801	1916	1908	2016	2490	2551
5	3848	4264	5001	3073	2391	3243	3278	6037	3995	3944	3517	3204	3059	2668	2823	3676	4387
6	5486	6599	5991	4380	4386	4798	3833	7844	5137	5108	5359	4847	4189	3503	4089	5222	6559
7	6992	8241	6458	7357	8207	6578	5583	9590	6723	7372	7560	7332	6987	4954	5469	6398	8833
8	8561	9745	8157	9667	9978	8725	6870	11543	7414	8945	10001	9688	10212	7980	7346	8220	10483
9	10572	10974	9766	12705	10868	11134	10715	14969	8755	10343	11818	13835	12185	12174	9586	9194	11522
10	13166	14448	11457	14481	16536	15798	11426	19292	12303	11600	12896	15247	13614	16762	13012	13364	15132
11	13200	17327	13188	15899	14639	16313	13555	18590	14288	14835	14499	16899	14529	16710	14404	15268	17090
12	15547	17391	14621	16616	16046	18436	15964	21720	15184	16536	17656	19273	16275	18410	15640	16990	19793
13	17153	19186	16134	18318	17000	18041	17595	23960	16745	18249	19469	21254	17945	20308	17243	18727	21822
14	18707	20923	17599	19965	17423	18386	19175	26128	18256	19906	21223	23170	19561	22144	18794	20408	23787
15+	18707	20923	17599	19965	17423	18386	19175	26128	18256	19906	21223	23170	19561	22144	18794	20408	23787

Table 7 (continued).

Total annual food rations of the Barents Sea cod in 1984-2018, grams per 1 specimen

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	150	252	228	250	255	354	234	223	217	235	248	207	190	242	234	307	244	316
2	413	677	618	654	687	925	681	719	624	651	721	588	656	622	745	870	779	867
3	1163	1303	1296	1412	1514	1881	1874	1697	1495	1401	1497	1203	1641	1321	1390	1722	1582	1846
4	2110	2699	2028	2567	2504	2813	3128	2959	2526	2577	2513	2292	2552	2340	2406	2813	2531	2699
5	3430	3847	3547	3857	3896	4019	4459	4194	4304	4065	3859	3266	3809	3608	3915	3474	3748	3736
6	5571	5591	4716	5660	5264	5332	5893	6073	5623	5757	4963	4461	4952	4387	4922	4740	4943	5000
7	6835	7846	6684	7730	7192	7450	7563	7809	7855	8312	6848	5862	5791	5560	5960	6754	6601	6489
8	10233	10796	8905	11126	9395	10328	9178	10464	11490	11805	9213	7629	7757	7447	7505	9117	9180	9170
9	12457	13238	13418	15907	13163	13111	12032	13627	13341	16090	13799	11713	10881	9017	10265	10665	11302	11166
10	15130	18787	14492	20770	15981	17759	15919	17254	15988	16844	19074	16211	14989	12547	12116	14810	16016	14577
11	17341	17836	19480	21607	20628	19488	19961	21590	18770	20129	20784	19345	19785	16044	16245	19921	20086	18672
12	19307	20278	19309	24940	21448	22322	21644	23373	21866	23023	23791	21032	22386	18854	19978	24195	23464	21848
13	21345	22359	21292	27503	23639	24609	23863	25779	24111	25387	26241	23190	24691	20781	22023	26683	25870	24091
14	23337	24373	23212	29984	25760	26824	26011	28107	26285	27676	28611	25279	26923	22646	24002	29092	28198	26263
15+	23867	24373	23212	29984	25760	26824	26011	28107	26285	27676	28611	25279	26923	22646	24002	29092	28198	26263

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Report of the Portuguese fishery in 2018: ICES Div. I, IIa and IIb.

by

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A. Status of the fisheries

In 2018, the Portuguese nominal catches recorded 3,216 ton proceeding from the traditional grounds of both Divisions I and II (Norway and Svalbard) and 356 ton proceeding from the redfish pelagic fishery in the "Banana Hole" zone (international waters of Div. IIa) (Tab. I). In the traditional grounds, the nominal catches increased from 1993 (4,036 ton) to 1997 (8,661 ton) followed by a decline till 2003 (4,250 ton). In 2004 total catches increased and were maintained between 5,300 and 5,900 ton till 2010. From 2010 till 2018 catches decreased and have oscillated between 3,200 and 4,950 ton, 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 to 135 days. This decreased was in the Svalbard area. (Tab. I)

For the period 1993-2018, cod (*Gadus morhua*) was the most important species in the catches in Divisons I and II, exception for 1993 in Division IIa. Cod catches more than doubled from 2015 to 2016 but since then catches decrease to 2,672 ton in 2018. In 2018, the fishing effort (not including the fishery in the "Banana Hole" zone) was almost all in the Norwegian zone.

Redfish (*Sebastes mentella*) catches and effort in the international waters of Div. IIa decreased from 1697 ton in 2006 to values around 600-700 ton 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 ton. Both catch and effort increased in the two following years to 600 ton and 42 days in 2011 and 1038 ton and 139 days in 2012. In 2013-2015 effort was only 59 days but catches were 852 ton in 2013, 544 ton in 2014 and 678 ton in 2015. In 2016 although only 35 days were spent the catches increased to 822 ton, 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 ton and 31 days) (Tab. I).

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

B. Portuguese Annual Sampling Program

On 2018, like in 2015 and 2017, Portuguese cod fishery was not sampled on ICES Divisions I and II. Our National Sampling Programme on board is based on nurse men from the vessels to be monitored on NAFO, since their presence on board is mandatory on North West Atlantic trips. But that is not the case for North East Atlantic (partly due to shorter trips closer to shore) and so most Portuguese vessels fishing on ICES divisions don´t take a nurse man aboard. In order to meet the objectives of our National Sampling Program, the solution has been in recent years to contract the services of a company that provide experienced observers to work on board on behalf of either scientific or control national programmes. But on 2018, and despite our continuous efforts, we were not able to put an outsider scientific observer on any of the vessels with cod quotas on either ICES Divisions.

1. Catch and effort sampling.

Effort and cpue data for 2018 Portuguese trawl fishery on ICES Div. IIa (international waters) 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.

In the "Banana Hole" zone (Div. IIa international waters – outside Norwegian EEZ), all pelagic fishing effort was directed to redfish. 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).

1.1. Comments on redfish catch rate data.

Based on the observed vessel, the redfish catch rates decrease in July (0.23 ton/h) regards July 2017 (0.73 ton/h). In August, catch rates slightly increase (0.578 ton/h) regards the 2017 level but doubled the July 2018 value (Table II).

2. Biological Sampling

In 2018, biological sampling was obtained from one stern trawler fishing in ICES Div. IIa (July and August), with a pelagic trawl gear from 327 m to 442 m depths, outside Norwegian EEZ. Redfish was the only species sampled during this period (Tab III).

All commercial information is representative of the catch as a whole. The mean weights in the catch are derived from the calculated 2018 length-weight relationship (Tab. IV).

2.1. Comments on length composition of the 2018 trawl catches.

2.1.1 - Redfish (*S. mentella*)

In Div. IIa international waters (Tab. V, Fig. 1), lengths between 34 cm and 40 cm dominated catches, with a modal class at 36 cm (mean length and weight of 37 cm and 652 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.I and IIa), Svalbard (Div.I and IIb) and International waters (Div. IIa) regions, 2018.

SPECIES \ AREA	I and IIa Norway	I and IIb Svalbard	IIa International waters (Banana hole)	SUBTOTAL Norway + Svalbard	TOTAL 2018
Cod	2549.9	122.0		2671.9	2671.9
Redfish	391.5	0.0	356.4	391.5	747.9
American plaice	0.1	0.1		0.1	0.1
Greenland halibut	5.3	0.1		5.5	5.5
Atlantic halibut	5.5	0.1		5.6	5.6
Anarhichas spp.	8.1	1.0		9.1	9.1
Hadocck	70.3	10.7		81.1	81.1
Skates					
Pollock	50.7			50.7	50.7
Shrimp					
Monkfish					
Unidentified	0.7			0.7	0.7
TOTAL	3082.2	134.1	356.4	3216.2	3572.6
Fishing Days	130	5	31	135	166

TABLE I - B: Portuguese nominal trawl catches (ton) in Norway ZEE (Div. I and IIa) not including International waters of Div. IIa.

SPECIES / YEAR	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	2770.1	2522.0	1192.0	1819.9	2530.0	1515.0	1705.1	2559.7	3340.4	2567.2	2269.3	2558.2	2629.7	2670.5	2204	2205.1	2199.7	2184.4	2230.4	3494.6	4906.0	4380.9	3817.1	3253.5	27.3
Redfish	359.3	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	58.9	124.2	470.6	479.5	740.3	777.4	724.7
American plaice			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	1.2	18.6	3.7		0.86	0.05	0.2	0.1	9.2	1.3	1.8	7.6	13.4	24.2	9.6	4.6	12.5	18.1	33.1	80.0	40.9	55.1	75.2	26.1	16.5
Atlantic halibut	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.	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
Hadocck	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	59.8	33.4	34.0	10.8
Skates										2.0				1.5	3.1		0.5	6.2	2.9	38.4	14.7	7.6	9.8	3.5	0.1
Pollock	85.5	53.0	9.7	11.7	17.0	7.3	41.0	93.3	209.0	346.9	397	333.9	343.4	98.2	143.5	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											0.5		0.1								0.1	0.5	3.5	6.3	2.9
TOTAL	3308.8	2972.9	1244.9	1861.7	2591.7	1549.6	1783.5	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	99	121	81	56	74	60	76	132	274	271	278	333	298	284	179	169	267	399	327	748	494	350	306	-	-

TABLE I - C: Portuguese nominal trawl catches (ton) in Svalbard (Div. I and IIb).

SPECIES / YEAR	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	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	0.450	0.004		5.5	31.0	18.8	38.8	48.8	41.8	47.8	156.9	83.4	68.5	148.7	27.2	134.0	74.9	16.9	8.6	6.8	63.5	42.8	219.0	208.2	315.3
American plaice	2.5	4.3	0.0	6.2	12.5	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	10.5	29.0
Greenland halibut	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	0.1					0.3	0.8	1.3	1.5	1.1	4.8	3.6	1.4	0.1									0.1		
Anarhichas spp.	19.4	3.8	2.2	9.6	8.5	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	69.5	424.8	511.0	523.2
Hadocck	21.3	18.1		24.4	53.0	120.9	952.7	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	3.1			0.2	0.3		1.8		0.2	1.2	9.2	5.2	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	1.9	1.8	1.7	2.2
TOTAL	1259.5	1977.6	508.6	1585.1	2225.3	2095	2895.0	2549.4	1763.7	1944.5	2384.5	2047.1	2084.7	2171.2	1647.3	1772.7	1875.8	1842.7	2612.5	2369.4	2973.6	2688.3	3650.3	3861.0	3250.3
Fishing Days	93	76	15	65	40	85	133	130	106	150	280	213	145	202	98	125	188	235	484	370	325	137	252	-	-

TABLE I - D: Portuguese nominal trawl catches (ton) in Div. I and II, not including International waters of Div. IIa.

SPECIES / YEAR	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	3978.1	4470.6	1697.5	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	6765.3	6195.2	5644.0	1788.4
Redfish	359.8	244.8	0.1	7.2	39.0	23.2	43.4	76.6	134.3	160.4	246.6	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	2.5	4.3	0.2	6.2	12.5	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	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	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.	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	526.3
Hadocck	108.3	140.4	34.8	51.7	87.0	143.1	982.7	487.5	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	207.9	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	46.2	27.5	9.9	15.8	10.4	22.2
Pollock	88.6	53.0	9.7	11.9	17.3	7.3	42.8	93.3	209.2	348.1	406.2	339.1	354.5	104.8	146.5	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											0.5		0.1								0.2	2.3	5.3	8.1	5.1
TOTAL	4568.3	4950.5	1753.5	3446.9	4817.0	3644.6	4678.6	5372.6	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	192	197	96	121	114	145	209	262	380	421	558	546	443	486	277	294	455	634	811	1118	819	487	558	-	-

TABLE II: Portuguese trawl fishery cpue's and bycatch by month and division for 2018.

DIVISION	TARGET SPECIES	MONTH	DEPTH RANGE (m) MIN.	DEPTH RANGE (m) MAX.	CPUE (ton/hour)	MAIN BYCATCH SPECIES	MAIN BYCATCH %	TOTAL BYCATCH (%)
IIa (*)	RED	JUL	327	428	0.230	-	0.0	0.0
IIa (*)	RED	AUG	248	442	0.578	-	0.0	0.0

(*) - Banana Hole (International waters of division IIa)

TABLE III: Intensity of the trawl sampling during 2018, by species, division and month.

SPECIES	DIV.	MONTH	Nº OF SAMPLES	Nº FISH MEASURED	SAMPLING WEIGHT(Kg)	OTOLITHS Nº	OTOLITHS LENGTH RANGE (cm)
REDFISH (*S. mentella*)	IIa (*)	JUL	1	100	70	63	22-42
REDFISH (*S. mentella*)	IIa (*)	AUG	28	2804	1833	81	29-44

(*) - Banana Hole (International waters of division IIa)

TABLE IV: Length-weight relationship by species, stock and sex in 2018.

Species	Stock	Sex	a	b	n	r^2	Length interval (cm)
REB	IIa (*)	F	0.0132	2.9877	952	0.999	30-43
REB	IIa (*)	M	0.0177	2.9046	1951	0.993	29-44
REB	IIa (*)	T	0.0144	2.9621	2903	0.996	29-44

(*) - Banana Hole (International waters of division IIa)

TABLE V: REDFISH (*S. mentella*), International waters of DIV. IIa, 2018: length composition (0/000) of the trawl catches.

LENGTH GROUP	JUL	AUG	3rd Q. =YEAR	LENGTH GROUP
29		1.0	1.0	29
30		2.4	2.4	30
31		5.8	5.8	31
32	10.0	14.9	14.8	32
33	10.0	43.5	43.2	33
34	60.0	63.3	63.3	34
35	130.0	131.4	131.4	35
36	120.0	204.6	203.8	36
37	130.0	178.3	177.9	37
38	210.0	178.9	179.2	38
39	200.0	100.6	101.5	39
40	60.0	53.2	53.3	40
41	50.0	17.0	17.3	41
42	20.0	4.2	4.3	42
43		0.7	0.7	43
44		0.3	0.3	44
TOTAL	1000	1000	1000	
No. SAMPLES	1	28	29	
SAMPLING WEIGHT(kg)	70	1833	1903	
No. F.MEASURED	100	2804	2904	
MEAN LENGTH(cm)	37.9	37.2	37.2	
MEAN WEIGHT (g)	692	651	652	
DEPTH RANGE (m)	327/428	248/442	248/442	

Fig. 1- Annual length composition of redfish (*S. mentella*) International waters of Division IIa trawl fishery in 2018.

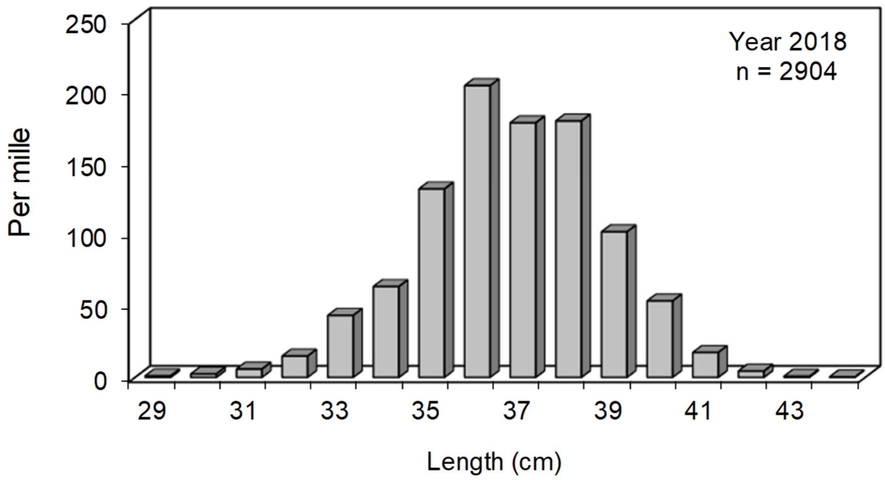


TABLE I - A: Portuguese provisional nominal trawl catches (ton) in Norway (Div.I and IIa), Svalbard (Div.I and IIb) and International waters (Div. IIa) regions, 2018.

SPECIES \ AREA	I and IIa Norway	I and IIb Svalbard	IIa International waters (Banana hole)	SUBTOTAL Norway + Svalbard	TOTAL 2018
Cod	2549.9	122.0		2671.9	2671.9
Redfish	391.5	0.0	356.4	391.5	747.9
American plaice	0.1	0.1		0.1	0.1
Greenland halibut	5.3	0.1		5.5	5.5
Atlantic halibut	5.5	0.1		5.6	5.6
Anarhichas spp.	8.1	1.0		9.1	9.1
Hadocck	70.3	10.7		81.1	81.1
Skates					
Pollock	50.7			50.7	50.7
Shrimp					
Monkfish					
Unidentified	0.7			0.7	0.7
TOTAL	3082.2	134.1	356.4	3216.2	3572.6
Fishing Days	130	5	31	135	166

TABLE I - B: Portuguese nominal trawl catches (ton) in Norway ZEE (Div. I and IIa) not including International waters of Div. IIa.

SPECIES / YEAR	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	2770.1	2522.0	1192.0	1819.9	2530.0	1515.0	1705.1	2559.7	3340.4	2567.2	2269.3	2558.2	2629.7	2670.5	2204	2205.1	2199.7	2184.4	2230.4	3494.6	4906.0	4380.9	3817.1	3253.5	27.3
Redfish	359.3	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	58.9	124.2	470.6	479.5	740.3	777.4	724.7
American plaice			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	1.2	18.6	3.7		0.86	0.05	0.2	0.1	9.2	1.3	1.8	7.6	13.4	24.2	9.6	4.6	12.5	18.1	33.1	80.0	40.9	55.1	75.2	26.1	16.5
Atlantic halibut	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.	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
Hadocck	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	59.8	33.4	34.0	10.8
Skates										2.0				1.5	3.1		0.5	6.2	2.9	38.4	14.7	7.6	9.8	3.5	0.1
Pollock	85.5	53.0	9.7	11.7	17.0	7.3	41.0	93.3	209.0	346.9	397	333.9	343.4	98.2	143.5	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											0.5		0.1								0.1	0.5	3.5	6.3	2.9
TOTAL	3308.8	2972.9	1244.9	1861.7	2591.7	1549.6	1783.5	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	99	121	81	56	74	60	76	132	274	271	278	333	298	284	179	169	267	399	327	748	494	350	306	-	-

TABLE I - C: Portuguese nominal trawl catches (ton) in Svalbard (Div. I and IIb).

SPECIES / YEAR	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	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	0.450	0.004		5.5	31.0	18.8	38.8	48.8	41.8	47.8	156.9	83.4	68.5	148.7	27.2	134.0	74.9	16.9	8.6	6.8	63.5	42.8	219.0	208.2	315.3
American plaice	2.5	4.3	0.0	6.2	12.5	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	10.5	29.0
Greenland halibut	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	0.1					0.3	0.8	1.3	1.5	1.1	4.8	3.6	1.4	0.1									0.1		
Anarhichas spp.	19.4	3.8	2.2	9.6	8.5	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	69.5	424.8	511.0	523.2
Hadocck	21.3	18.1		24.4	53.0	120.9	952.7	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	3.1			0.2	0.3		1.8		0.2	1.2	9.2	5.2	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	1.9	1.8	1.7	2.2
TOTAL	1259.5	1977.6	508.6	1585.1	2225.3	2095	2895.0	2549.4	1763.7	1944.5	2384.5	2047.1	2084.7	2171.2	1647.3	1772.7	1875.8	1842.7	2612.5	2369.4	2973.6	2688.3	3650.3	3861.0	3250.3
Fishing Days	93	76	15	65	40	85	133	130	106	150	280	213	145	202	98	125	188	235	484	370	325	137	252	-	-

TABLE I - D: Portuguese nominal trawl catches (ton) in Div. I and II, not including International waters of Div. IIa.

SPECIES / YEAR	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	3978.1	4470.6	1697.5	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	6765.3	6195.2	5644.0	1788.4
Redfish	359.8	244.8	0.1	7.2	39.0	23.2	43.4	76.6	134.3	160.4	246.6	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	2.5	4.3	0.2	6.2	12.5	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	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	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.	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	526.3
Hadocck	108.3	140.4	34.8	51.7	87.0	143.1	982.7	487.5	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	207.9	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	46.2	27.5	9.9	15.8	10.4	22.2
Pollock	88.6	53.0	9.7	11.9	17.3	7.3	42.8	93.3	209.2	348.1	406.2	339.1	354.5	104.8	146.5	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											0.5		0.1								0.2	2.3	5.3	8.1	5.1
TOTAL	4568.3	4950.5	1753.5	3446.9	4817.0	3644.6	4678.6	5372.6	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	192	197	96	121	114	145	209	262	380	421	558	546	443	486	277	294	455	634	811	1118	819	487	558	-	-

TABLE II: Portuguese trawl fishery cpue's and bycatch by month and division for 2018.

DIVISION	TARGET SPECIES	MONTH	DEPTH RANGE (m) MIN.	DEPTH RANGE (m) MAX.	CPUE (ton/hour)	MAIN BYCATCH SPECIES	MAIN BYCATCH %	TOTAL BYCATCH (%)
IIa (*)	RED	JUL	327	428	0.230	-	0.0	0.0
IIa (*)	RED	AUG	248	442	0.578	-	0.0	0.0

(*) - Banana Hole (International waters of division IIa)

TABLE III: Intensity of the trawl sampling during 2018, by species, division and month.

SPECIES	DIV.	MONTH	Nº OF SAMPLES	Nº FISH MEASURED	SAMPLING WEIGHT(Kg)	OTOLITHS Nº	OTOLITHS LENGTH RANGE (cm)
REDFISH (*S. mentella*)	IIa (*)	JUL	1	100	70	63	22-42
REDFISH (*S. mentella*)	IIa (*)	AUG	28	2804	1833	81	29-44

(*) - Banana Hole (International waters of division IIa)

TABLE IV: Length-weight relationship by species, stock and sex in 2018.

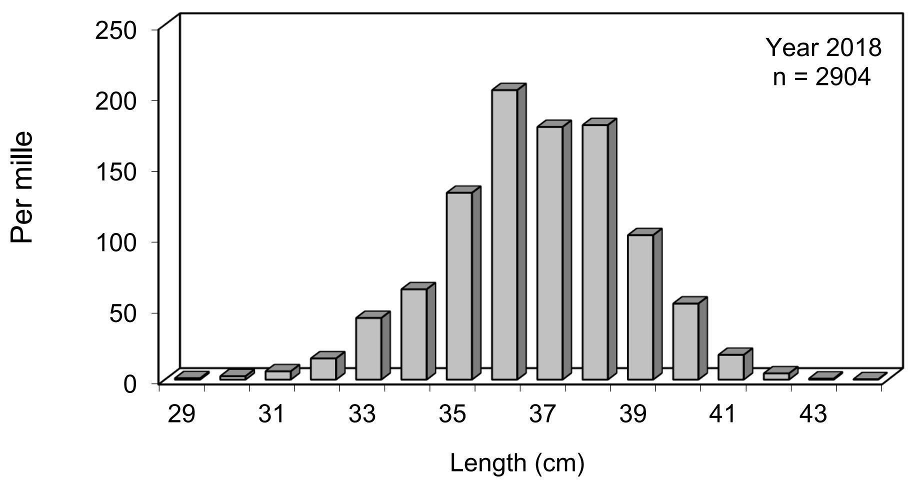
Species	Stock	Sex	a	b	n	r^2	Length interval (cm)
REB	IIa (*)	F	0.0132	2.9877	952	0.999	30-43
REB	IIa (*)	M	0.0177	2.9046	1951	0.993	29-44
REB	IIa (*)	T	0.0144	2.9621	2903	0.996	29-44

(*) - Banana Hole (International waters of division IIa)

TABLE V: REDFISH (*S. mentella*), International waters of DIV. IIa, 2018: length composition (0/000) of the trawl catches.

LENGTH GROUP	JUL	AUG	3rd Q. =YEAR	LENGTH GROUP
29		1.0	1.0	29
30		2.4	2.4	30
31		5.8	5.8	31
32	10.0	14.9	14.8	32
33	10.0	43.5	43.2	33
34	60.0	63.3	63.3	34
35	130.0	131.4	131.4	35
36	120.0	204.6	203.8	36
37	130.0	178.3	177.9	37
38	210.0	178.9	179.2	38
39	200.0	100.6	101.5	39
40	60.0	53.2	53.3	40
41	50.0	17.0	17.3	41
42	20.0	4.2	4.3	42
43		0.7	0.7	43
44		0.3	0.3	44
TOTAL	1000	1000	1000	
No. SAMPLES	1	28	29	
SAMPLING WEIGHT(kg)	70	1833	1903	
No. F.MEASURED	100	2804	2904	
MEAN LENGTH(cm)	37.9	37.2	37.2	
MEAN WEIGHT (g)	692	651	652	
DEPTH RANGE (m)	327/428	248/442	248/442	

Fig. 1- Annual length composition of redfish (*S. mentella*) International waters of Division IIa trawl fishery in 2018.



Annex 4: Audit reports

Audit of Northeast Arctic saithe (AFWG 2019)

Date: 03 May 2019
Auditor: Matthias Bernreuther

General

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

For single stock summary sheet advice:

1. **Assessment type**: update
2. **Assessment:** analytical
3. **Forecast**: presented
4. **Assessment model**: SAM – tuning by one acoustic survey (split in two time-series)
5. **Data issues:** The biological sampling from the fishery may have become 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 subarea 1 and age samples from purse seine fishery south of Lofoten and in quarter two in ICES Subarea 1. As in 2016 and 2017, the biological sampling has improved in 2018, but the relatively low level of sampling may still affect the precision of the catch, weight and maturity at age data. Lack of reliable recruitment estimates is still a major problem.
6. **Consistency:** Last year´s assessment was accepted. The assessment, recruitment and forecast models have been applied as specified in the stock annex.
7. **Stock status**: The SSB has been above B_{pa} since 1996, declined considerably from 2007 to 2011, then increased again and is presently (2018/2019) 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} in 2010 and 2011, but is presently estimated to be most likely below F_{pa}. The recruitment has since 2005 been at about the long-term geometric mean level.
8. **Management Plan**: Agreed 2011 (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% constrain 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 datasets described in the stock annex are available.

Technical comments

No technical comments.

Conclusions

The assessment has been performed correctly and gives a valid basis for advice. However, the low level of biological sampling is, despite an improvement in the last year, still a source of uncertainty in the assessment.

Audit of Greenland halibut (*Reinhardtius hippoglossoides*) in subareas 1 and 2 (Northeast Arctic)

Date: 03/05/2019
Auditor: Alfonso Pérez Rodríguez

General

The stock is assessed by a GADGET length-based model since 2015. There is no agreement on age-reading methodology between Norway and Russia and the model is tuned using only length data. This gives uncertainty on the absolute levels of modelled biomass and F. The peaks of recruitment identified by the model are corroborated by survey length distributions, but the weaker year classes may be poorly modelled. None of the surveys individually covers the complete stock distribution and there are discrepancies between the surveys, leading to high uncertainty and a marked retrospective pattern. The stock has biennial advice and the last advice was given in 2017 for 2018 and 2019. A new stock assessment is run in 2019 to provide advice for 2020 and 2021.

For single stock summary sheet advice:

1. **Assessment type**: update (benchmark in 2015)
2. **Assessment**: stock assessed by a GADGET length-based model since 2015
3. **Forecast**: not presented
4. **Assessment model**: In addition to GADGET, two production models (one of them SPICT) have been used to assessed the stock in the past, however production model was not updated for presentation at the current meeting.
5. **Data issues**: Data available and used as described in stock annex. There was a revision of the commercial fishing data, with minor discrepancies between the data sets after 2005. However, in relation to the survey data, there are problems with sex-split in the EcoJuv and EcoSouth indices, especially in 2016–2018. This has produced an increase in the estimated survey around the 10%.
6. **Consistency**: This year's assessment has been conducted in a manner consistent with last year (benchmark) and stock annex.
7. **Stock status**: This stock is assessed in relation to precautionary reference points. On this regard $B>B_{lim}$, however, it is warned that the lack of reliable age estimations involves that the current assessment has important uncertainties in relation to the actual absolute level of biomass and F level. It is concluded that all of the exploratory work indicates that the overall trends are robust, but that care should be taken in interpreting the absolute abundance estimates, and hence absolute estimates of harvest rate.
8. **Management Plan**: No

General comments

The assessment is well-documented and structured in the report. The update assessment gives a valid basis for advice. The current GADGET assessment model provides appropriate evaluation, however in order to make it more sounded from the quantitative side (absolute estimates of biomass and F levels), the current existing problem in relation to age reading needs to be solved.

Technical comments

The assessment is done according to decisions taken during benchmark in 2015 and according to the stock annex.

Conclusions

The assessment has been performed correctly

Audit of: had21.1-2 (Haddock in subareas 1 and 2)

Date: 9 May 2019
Auditor: Arved Staby

For single stock summary sheet advice:

1. **Assessment type**: update
2. **Assessment**: analytical
3. **Forecast**: presented
4. **Assessment model**: SAM; tuned by 3 research surveys (4 fleets). Data from the 2018 Joint Barent Sea Ecosystem survey and the Russian autumn survey not included in the tuning series. Haddock consumed by cod included in natural mortality, haddock consumption is estimated based on the final SAM assessment of cod.
5. **Data issues**: Missing the Russian trawl and acoustic survey in 2016 and 2018. Missing Barent Sea Ecosystem survey data from 2018 (due to insufficient coverage). It seems that the REC3 input table is missing the estimate from the NO_RU swept-area for age 3 in 2019.
6. **Consistency**: The SSB is estimated to have been halved compared to its peak in 2012. The retrospective runs show rather large discrepancies.
7. **Stock status**: SSB has been much larger then B_{lim} for more than 10 years.
8. **Management Plan**: Various MPs have been in use since 2004. The current HCR for haddock is as follows (see details in Protocol of the 46th Session of the Joint Russian–Norwegian Fisheries Commission, 14 October 2011): TAC for the next year will be set at level corresponding to F_{MSY}. The TAC should not be changed by more than ±25% compared with the previous year TAC. If the spawning stock falls below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from F_{MSY} at B_{pa} to F = 0 at SSB equal to zero. At SSB-levels below B_{pa} in any of the operational years (current year and a year ahead) there should be no limitations on the year-to-year variations in TAC. At the 46th Session of the Joint Russian–Norwegian Fisheries Commission in 2016 it was decided to keep the existing HCR for haddock in next five years. TAC in 2020 based on 25% constraint.

General comments

The survey data and catch data are correctly included and the analysis is correctly done.

Technical comments

Included in the report as comments.

Conclusions

The assessment is recommended as basis for the 2019 TAC advice.

Audit of Cod (*Gadus morhua*) in subareas 1 and 2 (Northeast Arctic)

Date: 20 May 2019

Auditor: Ross Tallman, Fisheries and Oceans Canada

General

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

For single stock summary sheet advice:

1. **Assessment type:** update
2. **Assessment**: analytical
3. **Forecast**: presented
4. **Assessment model:** SAM
   Four surveys were used for the assessment: (Barents Sea Joint bottom trawl (Feb-Mar, years 1981-2019), Barents Sea+Lofoten Joint acoustic survey (Feb-Mar, years 1985-2019), Russian bottom trawl survey (Oct-Dec, years 1982-2015,2017), Ecosystem survey (Aug-Sep, years 2004-2017)

a) SAM Parameter settings:

i. # Min Age (should not be modified unless data are modified accordingly)

3

ii. # Max Age (should not be modified unless data are modified accordingly)

15

iii. # Max Age considered a plus group (0=No, 1=Yes)

1

iv. # Coupling of correlation in observations

(NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA, NA),

(-1, 0, 1, 2, 3, 4, 4, 4, 4, -1, -1, -1),

(-1, 5, 6, 7, 8, 9, 10, 10, 10, -1, -1, -1),

(11, 12, 13, 14, 14, 14, 14, 14, 14, -1, -1, -1),

(15, 16, 17, 18, 19, 20, 20, 20, 20, -1, -1, -1)

v. # Coupling of OBSERVATION VARIANCES

(0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0),

(-1, 1, 1, 1, 1, 1, 1, 1, 1, 1, -1, -1, -1),

(-1, 2, 2, 2, 2, 2, 2, 2, 2, 2, -1, -1, -1),

(3, 3, 3, 3, 3, 3, 3, 3, 3, 3, -1, -1, -1),

(4, 4, 4, 4, 4, 4, 4, 4, 4, 4, -1, -1, -1)

vi. # Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)

0

vii. # Years in which catch data are to be scaled by an estimated parameter

0

viii. # Define Fbar range

5 10

A comparison with XSA was done.

Model options chosen for XSA
(used as an additional model for checking of results):
Tapered time weighting applied, power = 3 over 20 years
Catchability independent of stock size for ages > 12
Catchability independent of age for ages > 12
Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages
S.E. of the mean to which the estimate are shrunk = 1.5
Shrinkage to the population mean (p-shrinkage) not applied
Minimum standard error for population estimates derived from each fleet = 0.3
Prior weighting not applied

5. **Data issues:** Historically the plus group was age 13+ but with the current presence of abundant year classes close to the age 13 it was decided change to the plus group to age 15+. For age 12 and older some smoothing of data is needed but the procedure for that has not been settled yet.

Biological sampling from the Norwegian fishery and from the Russian trawl fishery has been low. In 2016 the sampling was low for Norwegian trawl catches in coastal areas in ICES area 2.a, thus samples for trawl here were merged with other similar gears when calculating age compositions. Also the split between NEA cod and coastal cod may have been affected by the sampling coverage, and possibly the amount of coastal cod catch is overestimated.

There is a concern that catch records have some contradictions in reporting depending on the source. There are discrepancies in catch by area depending on agency reported to (e.g. amounts from same area different depending on whether reporting is to ICES or Russian authorities). There is likely a problem with ICES inter-catch.

The 2014 Ecosystem Survey coverage was affected by ice in an area where there had been significant biomass recorded in previous years. It was decided to discard the results from the 2014 Ecosystem survey.

Updated mean ratios between the combined and Norwegian data on weight-at-age and maturity-at-age in Northeast Arctic cod

The Russian autumn trawl-acoustic survey (TAS) in the Barents Sea was not conducted in 2018. Russian cod abundance indices, weight at age and maturity-at-age data used for stock assessment were not available for 2018/2019.

Combined data on weight-at-age and maturity-at-age for 2018/2019 were adjusted using the same method as described in the WD 10 presented at the AFWG meeting in 2017. The mean 2019 ratios calculated between combined and Norwegian data differed slightly from the mean 2017 ratios (Table 1 -2).

6. **Consistency**: Last year's assessment was accepted.

   The assessment, recruitment and forecast models have been applied as specified in the stock annex.

7. **Stock status**: The SSB (currently, 1 233 772 t) has been above B_{pa} (460 000 t) since 2003 and F below or around F_{pa} since 2003. Recruitment is uncertain but reasonably stable. Total stock biomass in 2019 is estimated to 2 440 330 t which is somewhat above the long-term mean and well below the highest level observed (4 360 000 t in 2013).

8. **Man. Plan.**: Biomass reference points: The values adopted by ACFM in 2003 are B_{lim} = 220 000 t, B_{pa} = 460 000 t. (ICES CM 2003/ACFM:11). Fishing mortality reference points: The values adopted by ACFM in 2003 are F_{lim} = 0.74 and F_{pa} = 0.40. (ICES CM 2003/ACFM:11). Harvest control rule: At the 31st session of The Joint Norwegian-Russian Fishery Commission (JRNFC) in autumn 2002, the Parties agreed on a new harvest control rule. This rule was applied for the first time when setting quotas for 2004. The rule was somewhat amended at the 33rd session of The Joint Norwegian-Russian Fishery Commission in autumn 2004. The amended rule was evaluated by ICES in 2005 and found to be precautionary.

General comments

This was a well-documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

No technical comments.

Conclusions

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